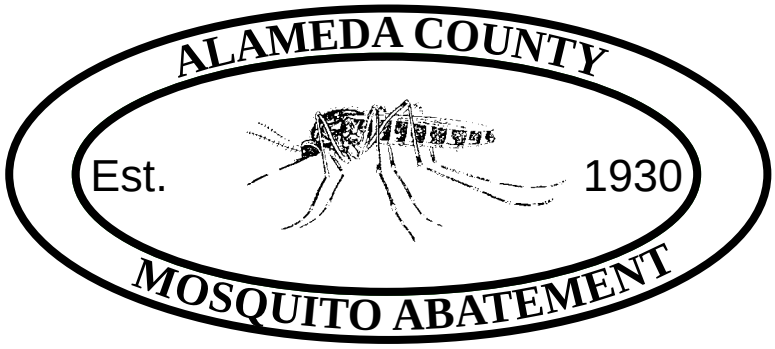
THE ALAMEDA COUNTY MOSQUITO ABATEMENT DISTRICT CONTROL PROGRAM



1999
Alameda County Mosquito Abatement District
23187 Connecticut Street
Hayward, California 94545-1605

THE ALAMEDA COUNTY MOSQUITO ABATEMENT DISTRICT CONTROL PROGRAM

This report is an overview of the mosquito control program conducted by the Alameda County Mosquito Abatement District. The report was originally prepared by and for the District as part of complicance with the California Environmental Quality Act.

Key Staff

John Rusmisel - District Manager
Vinay Davis - Administrative Assistant
Everett King - Environmental Specialist
Patrick Turney - Entomological Specialist

Phone: 510-783-7744
Fax: 510-783-3903
email: acmad@lanminds.com

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Alameda County Mosquito Abatement District

Mission and Vision Statement

ACMAD is a public agency serving the people of Alameda County, With responsibilities for:

- *controlling mosquitoes to enhance public health and comfort;*
- *acting as an information resource on mosquito biology, control and prevention; insect identification; and associated disease transmission; and*
- *operating in a safe, ecologically-sound and publicly accessible manner.*

In an era of constant change and increasing complexities, we the employees of ACMAD are dedicated to fulfilling these responsibilities by:

- *being a proactively adaptive learning organization;*
- *working together in an atmosphere of collaboration, trust, and mutual respect;*
- *developing technical and organizational skills to increase both personal as well as District effectiveness; and*
- *cooperating with other stake holders to develop appropriate long-term mosquito control strategies.*

We are committed to constantly monitoring and continually improving our performance through a process of shared decision-making.

Created May 4, 1994

GENERAL INFORMATION ABOUT THE DISTRICT

The Alameda County Mosquito Abatement District (ACMAD) is an independent, non-enterprise, special district, one of only fourteen independent special districts in Alameda County.

ACMAD serves a population of 1,400,300 over an area of 812 square miles. (All of Alameda County except the City of Albany.

Services are provided at a cost of 94¢ per person per year (1999-2000).

The District was formed in 1930 to control mosquitoes in Alameda County. Prior to that time hordes of vicious mosquitoes infested large sections of the county, particularly during the summer and fall months. The mosquitoes were so numerous that they hampered the sale of residential property, reduced labor efficiency, and kept people from using golf courses, playgrounds and parks.

The District is governed by a Board of Trustees comprised of representatives appointed from each member city and the County-at-large (14 total Trustees). The Trustees serve two-year terms and receive an in-lieu of travel expense of $50.00 per month for attending business meetings of the Board. The Board meets on the second Wednesday of each month at the District's office in Hayward at 5:00 p.m.

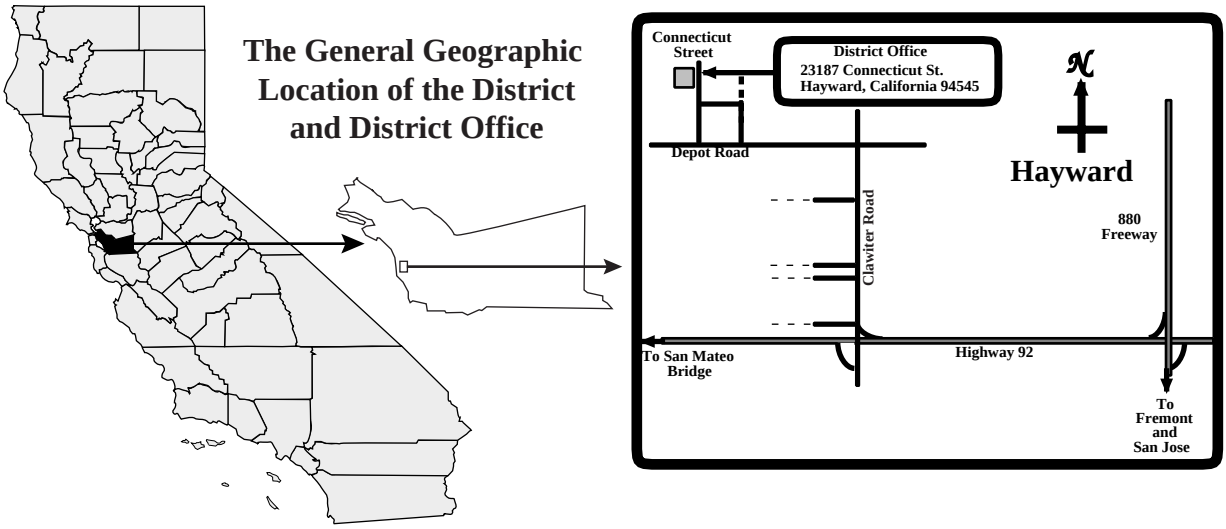
Funding is provided by a combination of *ad valorem* property tax and a special tax authorized by more than two thirds of the voters in 1982. The District has lost 40 per cent of the property tax since fiscal year 1993/1994 when the state permanently shifted those funds to schools.

We currently employ a full time staff of thirteen. Our field employees are certified by the California Department of Health Services in mosquito and vector control. The certification requires a minimum of 40 hours of continuing education every two years. Five of our staff have degrees in Entomology (3 with masters, 1 with a PhD) and three others have Biology degrees.

The District has a fleet of specialized mosquito control vehicles including four Argo All Terrain Vehicles for marsh inspections and treatments, two right-side-steering vehicles for treating stormdrains, one D-3 Caterpillar Bulldozer for source reduction work, and a Thiokol ditcher which is also used for installing mosquito control ditches in salt marshes.

It is the overall goal of the District to provide for the public's health and comfort by carrying out a program of mosquito abatement which is responsive to the public, cost effective, compatible with the environment, and consistent with land use planning or zoning. Assisting land owners and agencies in preventative planning, management or elimination of mosquito breeding areas.

GENERAL LOCATION OF THE DISTRICT



DISTRICT POWERS

The Alameda County Mosquito Abatement District ("District") is a regulatory agency formed pursuant to section 2200 et al of the California Health and Safety Code Section. Pursuant to Section 2270, the District Board may do all of the following:

(a) Take all necessary or proper steps for the control of mosquitoes, either in the district or in territory not in the district but so situated with respect to the district that mosquitoes may disperse from the territory into the district.

(b) Abate as nuisances all standing water and other breeding places for mosquitoes either in the district or in territory not in the district but so situated with respect to the district that mosquitoes from the territory disperse into the district.

(c) Purchase the supplies and materials, employ the personnel and contract for the services which may be necessary or proper in furtherance of the objects of this chapter.

(d) If necessary or proper in the furtherance of the objects of this chapter, build, construct, repair, and maintain the necessary dikes, levees, cuts, canals, or ditches upon any land and acquire by purchase, condemnation, or by other lawful means, in the name of the district, any lands, rights-of-way, easements, property, or material necessary for any of those purposes.

(e) Make contracts to indemnify or compensate any owner of land or other property for any injury or damage necessarily caused by the use or taking of property for dikes, levees, cuts, canals, or ditches.

(f) Enter upon any property without hindrance or notice, either within the district or so reasonably adjacent thereto that vectors may disperse into the district, for any of the following purposes:

(1) To inspect to ascertain the presence of vectors or their breeding places.

(2) To abate public nuisances in accordance with this article, either directly or by giving notice to the property owner to abate a nuisance.

(3) To ascertain if a notice to abate vectors has been complied with.

(4) To treat property with appropriate physical, chemical, or biological control measures.

(g) Sell or lease any service, land, nights-of-way, easements, property or material acquired by the district. Equivalent properties may be exchanged, if it is in the best interests of the district to do so.

(h) Borrow money in any fiscal year and repay it in the same or in the next ensuing fiscal year. The amount borrowed in any fiscal year shall not exceed fifteen cents ($0.15 on each one hundred dollars ($ 100) of assessed valuation of property in the district.

(1) Issue warrants payable at the time stated in the warrant to evidence the obligation to repay money borrowed or any other obligation incurred by the district. Warrants so issued shall draw interest at a rate fixed by the board not to exceed 5 percent per year, payable annually or semiannually as the board may prescribe. Provide a civil service system for any or all employees of the district.

(k) Assess civil penalties, as determined in the discretion of the board, but not to exceed five hundred dollars ($500) per day for each day that a notice or hearing order to abate a nuisance has not been complied with. Any sum which may be collected shall become part of the district's general fund to be used solely for vector control purposes.

(1) Levy, by resolution or ordinance, a service charge against any or all parcels of land within the district to pay for the cost of vector surveillance and control. The schedule of charges shall be made, reviewed, and adopted annually after notice and hearing in connection with the schedule. Following the hearing, the board may classify parcels of property according to their use in relation to the cost of vector surveillance and control. The board may bill for the charges annually or more frequently. The charges, shall be collected and paid by the county in the same manner as property taxes by the county. The service charge shall be reasonably related to the district's cost for providing vector surveillance and control and shall not be deemed a tax of any kind. Any sum collected shall be used solely for purposes of vector surveillance and control.

(m) Set the tax or assessment rates which are necessary to carry out the purposes of this article.

(n) Do any and all things necessary for, or incident to, the powers granted by, and to carry out the objects specified in, this chapter.

THE VALUE OF AN ORGANIZED MOSQUITO CONTROL DISTRICT

The question periodically arises as to why there is a need for a mosquito control district. Today most residents of Alameda County do not notice large numbers of mosquitoes. Many people have moved from parts of the country where there are large numbers of mosquitoes, and have the impression that California does not have mosquitoes! Mosquito control is sometimes perceived as unnecessary. At the District, the hope is that the perception and the low levels of mosquitoes are because of our continuous and ongoing efforts controlling the thousands of mosquito sources located in the County. Some of the reasons that it is valuable to have an organized, ongoing mosquito control district are:

Source Management: Most large mosquito sources (salt marshes, creeks, storm drain systems, gravel pits, etc.) are for the most part, permanent features of our landscape. These require continuous monitoring and control to maintain low mosquito populations. The ability of a control district to better manage the sources of mosquitoes is related to:

Access: The District has the legal ability to enter onto private and public properties in order to inspect for or control mosquitoes. Private citizens and private companies lack this ability and therefore are unable to apply control to properties they do not own or for which they are not contracted to provide control. The District very rarely needs to enforce its legal ability because the services are provided at no additional cost to property owners and in a spirit of cooperation.

Specialized Equipment: Related to access is the need for specialized equipment to accomplish inspections and control. A mosquito control district can own and maintain needed equipment.

Community Wide Sources: Many of the sources of mosquitoes are publicly owned or are wide spread throughout the community. These sources are owned by a variety of entities (cities, flood control districts, utility companies, park districts, water districts, etc.) and would require that each entity provide personnel and resources to control mosquitoes. Often mosquito problems originate many miles from residents' homes (e.g. salt marsh mosquitoes migrating to the hill areas). Control of mosquitoes on community-owned sources would require additional tax revenues to cover the costs. It is more economical to have a small District staff to manage all of the community sources than to have many separate staffs for control. Mosquito problems to residents many times (e.g. salt marsh mosquitoes migrating to the hill areas) occur miles from the actual mosquito production.

Prevention of Sources: The District focus is on larval mosquito control, not adult mosquito control and the minimizing of sources that produce mosquitoes. The District reviews development plans and provides informa-

tion to ensure that any potential mosquito problems are minimized. The District provides information to the public on the prevention of mosquitoes on private property and provides advice on source construction and maintenance.

Continuity of Operations: A permanent and ongoing control program can provide management as a process rather than single occurrences. Records of mosquito production are maintained allowing the work to be planned over time to maintain a high level of control.

Knowledge Base: The center of information about mosquito sources and the technology for their control is always available within an ongoing program. Personnel develop knowledge of their areas, the species that create problems and where to locate the sources. The District maintains detailed records of service calls, mosquito sources and potential sources, and can draw on these records to predict future control needs and economically schedule work loads (records exist back to 1930). Many sources are sensitive habitats and require technical knowledge to control without damage to the habitat. The District also maintains a professional library of resources providing access to applicable information.

Trained Personnel: A district can recruit and retain well educated and trained personnel to accomplish the tasks needed in mosquito control. District personnel are State Certified and specially trained. The focus of District personnel is control of the mosquitoes in Alameda County, and they become thoroughly familiar with the biology of the local species and control measures that are appropriate and environmentally safe for each species.

Reduction of Pesticide Use: When members of the public are bothered by mosquitoes there is a tendency to want to overuse pesticides. Many residents will have their yards sprayed when mosquitoes are present. The cost of a yard treatment by a private company is about what the resident pays the District for more than 20 years of control! The cost of one can of flying insect spray is the equivalent of almost 4 years payments to the District. These treatments exacerbate the environment's pesticide load and do little to stop the problem or prevent future occurrences. To the public, areas such as marshes, swamps, lakes, creeks or ponds are viewed as universal mosquito producers. The mosquito control professional maps these sources to locate the usually small area within them that actually requires treatment. This minimizes the costs and impact on the environment by reducing the amount of insecticides needed. The location and treatment of a small larval source may prevent problems for many residents in the area.

Disease Control: An organized district can continually monitor for disease potential and take action before an outbreak occurs. California has a history of encephalitis and malaria outbreaks. By monitoring for the virus that causes encephalitis, the District can take preventative action. The District also monitors cases of malaria arriving in the County to lessen the potential for transmission. There is always the possibility that other mosquito borne diseases may be introduced into California in the future.

Prevention of Foreign Introductions: With the tremendous amount of international travel and commerce there is always the possibility of foreign mosquito species being introduced into the County. The District monitors for any mosquitoes that are not native to this area. Other parts of the United States now have foreign mosquito species that have been "accidentally" introduced and have the potential to transmit fatal diseases. Larva and adult mosquitoes are identified in the District laboratory with a careful watch for the unknown.

DISTRICT GOALS AND SERVICES

As an independent non-enterprise special district, the District exists to provide direct service to the public. It is the overall goal of the District to provide for the public's health and comfort by carrying out a program of mosquito abatement which is responsive to the public, cost effective, environmentally safe, and consistent with land use planning or zoning. **The District offers a number of direct services to the public:**

- Respond to public complaints about mosquitoes or mosquito-like insects in the County and determine the source of the problem to correct as needed.
- Deliver mosquitofish to residents in the District free of charge.
- Monitor populations of disease carrying and pest mosquitoes.
- Inspect and treat mosquito sources.
- Identify mosquitoes and other insects.
- Public Education program to inform the public about mosquito biology and control.

SERVICE CALLS

During each year the District may receive several thousand or more calls from the public for service. District personnel routinely inspect and treat thousands of recorded mosquito sources, but new sources are constantly being found or created. These calls are an important source of information on new mosquito problems and a means of preventing mosquito production. Members of the public are encouraged to call the District for service. Every effort is made to rapidly respond to these calls, usually on the next business day. The District classifies these incoming calls as:

Mosquito Service Requests: These calls are from the public reporting mosquitoes. The caller is asked to provide a specimen and the technician checks for mosquitoes present in the area. Some of these calls are caused by insects which look like mosquitoes such as crane flies, midges or other insects.
Fish Requests: Fish Requests are requests to have fish (*Gambusia affinis*) stocked in ponds or containers.
Requests for Inspection: These calls are from the public to inspect water sources for the presence of mosquitoes.
Public Service: These calls are for information about source prevention and non-mosquito insect identification.

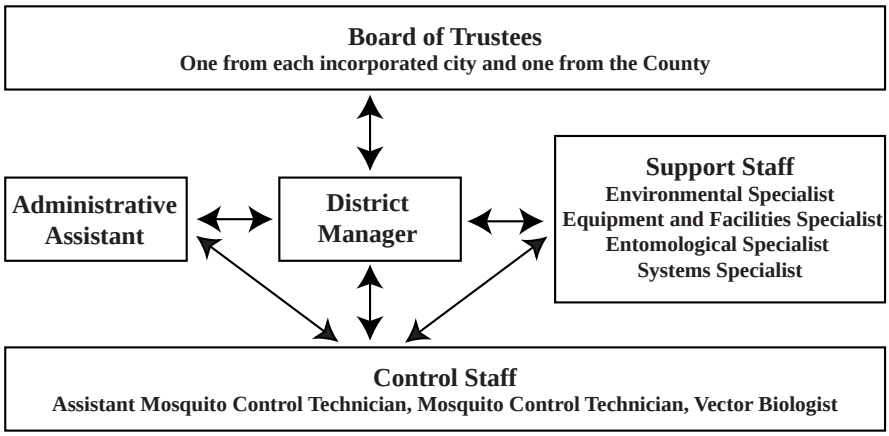
DISTRICT FINANCES

The District has two primary sources of revenue. The first is a share of the *ad valorem* property taxes collected by the County Tax Assessor and placed in a special fund for special districts. The second source of revenue is from a special tax passed by more than two-thirds of the voters in 1982 (Measure K on the ballot). This special tax allows the District to assess a tax on each parcel in the county. The maximum allowable rates are $1.75 per parcel, $3.50 per multiple unit (2-4 units), and $8.75 per multiple unit (5 or more units), or mobile home park. The current residential parcel (1999) is assessed $1.30 per year. A third minor source of revenues is interest earned on District moneys held for future expenditures.

DISTRICT ORGANIZATION

The District operates under the provisions of Sections 2200-2398 of the Health and Safety Code of California. It's governed by a Board of Trustees, consisting of fourteen members. The Board of Supervisors of Alameda County appoints one Trustee, and one Trustee is appointed by the City Council for each of the thirteen incorporated cities within the District. Each Trustee serves a two-year term.

The Trustees receive an in-lieu of travel expense of $50.00 per month for attending business meetings of the Board. The Board meets on the second Wednesday of each month at the District's office in Hayward at 5:00 p.m. The Board determines the general policies to be followed, employs the District manager, approves the annual budget and determines how much money shall be spent (and for what purposes), and controls the expenditures. Funds are raised by taxes levied by the Board of Supervisors, and a special tax collected with property tax bills by the County Tax Collector, held in a trust fund by the County Treasurer, and paid out on warrants approved by the Board of Trustees and authorized by the County Auditor. Each fiscal year the District accounts are audited by an independent accounting firm.



DISTRICT PERSONNEL ORGANIZATION

The District currently employs a full time staff of thirteen. District personnel are organized into positions with responsibilities for carrying out the District control program.

Manager: Under general administrative direction of the Board of Trustees the manager, plans, organizes and directs a comprehensive mosquito control program for the District; administers the policies of the Board and adheres to legal requirements affecting mosquito control activities; and does related work as required. Plans, evaluates and directs a mosquito control program and associated programs of the District. The manager develops a budget each fiscal year that functions within the constraints established by the Board and meets the needs of employees to control mosquitoes. Supervises the preparation of various reports to governmental agencies and the Board on control activities; coordinates salary negotiations with employees and serves as fact-finder for the Salary Committee; reviews environmental impact reports; arranges legal abatement procedures for noncomplying landowners; and resolves problems in the field. The manager is responsible for providing the Board with information and data that monitors the effectiveness and efficiency of the District operations. Represents the District, often serving on committees with local, regional, and State governmental agencies and the Mosquito and Vector Control Association of California. Attends meetings of the Board to support Board functions. Oversees the District's public relations and communications. Coordinates research and demonstration projects with State Agencies, colleges and universities.

Administrative Assistant: This position shares administrative tasks of Manager including but not limited to organization of administrative records and office management, performs a variety of administrative secretarial and clerical work requiring independent judgment and collaborative skills; performs accounting work in maintaining financial records; and does related work as required. Answers inquiries, records service requests by the public, and provides information where judgment, knowledge and interpretation of procedures is necessary; maintains calendars, schedules appointments, makes travel arrangements and sets up meetings; requisitions office supplies; transcribes from rough draft agendas, minutes, correspondence, resolutions, requests for proposals; sets up and maintains complex filing systems; composes correspondence on routine administrative matters; maintains personnel records and transactions; functions as Personnel Officer insuring that employees meet legal and policy requirements established by the District in the hiring process; maintains continuing education records for certification programs; audits bills and checks them against purchase orders, delivery tags and invoices; verifies prices, extensions, discount and statements; requisitions office supplies; prepares payroll and warrants and allocates charges to proper funds; maintains District revenue records; prepares all financial data for audit; makes timely deposits to Internal Revenue Service and the State of California; maintains a register of ledger and property records; prepares periodical reports as needed to the Internal Revenue Service, California State Franchise Tax Board, the California Department of Health Services; Mosquito and Vector Control Association of California, the American Mosquito Control Association, and the Vector Control Joint Powers Agency; functions as Health Benefits Officer to the employees of the District. Assists in the development of budgets and agendas, as well as completing inter-governmental reports in a timely manner; and maintains, updates, displays and audits District operational data. Acts as secretary to the Manager, supports Manager in administrative tasks and functions to support team members as appropriate. The Administrative Assistant is authorized to sign papers as necessary in the routine operations of the District, such as Federal exemption certificates, routine correspondence, state tax refund claims, deposit receipts, routine financial reports, etc., while keeping the Manager informed on these items.

Support Staff:

Entomological Specialist: The Entomological Specialist is responsible for the planning, organization, direction and evaluation of the mosquito control program of the District. Leads in the planning and implementation of the mosquito survey and monitoring program. Uses equipment such as New Jersey light traps, EVS CO_2. traps, and Faye traps to monitor adult mosquito populations. Larval mosquito population surveillance is accomplished by assisting technicians and vector biologists with monitoring in their zones. Pesticide efficacy and resistance studies are carried out to assure continued control of mosquitoes. Also responsible for biological and chemical pesticide purchases, inventory, storage, safety training and reporting. Monitors disease prevalence in the county through state morbidity reports, malaria case follow ups to verify that medical treatment has been completed, and by maintaining sentinel chicken flocks for testing for the presence of encephalitis virus. Coordinates helicopter contracts and usage with other districts in the region and schedules its use in the District. Monitors and coordinates employees'

continuing education units for the State Health Department. Responsible for the maintenance, budgeting and purchasing of equipment and supplies for the District laboratory, insectary, pesticide storage building and the mosquitofish holding tanks. Assists in media contacts and other public relations events. Completes reports for use by the manager and the Board of Trustees, articles for District publications and brochures as well as scientific journals. Involved in interagency planning and coordination by attending regional meetings, MVCAC quarterly committee meetings and other meetings as necessary. As a member of the support team, assists and supports technicians, vector biologists, administrative assistant and manager and accomplishes field work, facility and equipment maintenance as needed.

Environmental Specialist: The Environmental Specialist is responsible for the coordination and effective planning of the District's source prevention/reduction program and public relations program. Represents the District at planning, agency and public meetings with the objective of educating agency officials and the public about the ecologically-oriented methodologies used by the District to detect, monitor and control mosquitoes; secures permits, contracts, MOU's or cooperative agreements to prevent or eliminate mosquito sources; coordinates source prevention/ planning projects and public relations activities in an environmentally-sound and informed manner to meet the concerns of the public and other agencies; makes recommendations to planning agencies and landowners to prevent or eliminate mosquito sources; develops, implements and maintains a community education program to inform Alameda County residents, politicians and anyone interested about the District and its programs; participates in and/ or leads training sessions on wetlands laws, policies, agreements and identification; assists or leads team efforts to create or upgrade District brochures and handout materials. As a member of the support team, assists and supports technicians, vector biologists, administrative assistant and manager and accomplishes field work, facility and equipment maintenance as needed.

Equipment and Facilities Specialist: The Maintenance/ Equipment Specialist is responsible for the use, operation and maintenance of shop, tools, facilities and vehicles and is also responsible for the implementation and documentation of the District Safety Program. Plans and follows a preventive maintenance schedule for District facilities, equipment and vehicles. Contracts or makes repairs as necessary to facilities, vehicles and equipment. Maintains District's Hazardous Materials Management Plans and obtains all other permits required for operation of the District facility. Responsible for District Safety Program; insuring that employees are properly trained in all safety procedures and programs while working at the facility and in the field. Provides instruction in the proper use and care of shop equipment, spray equipment and driver safety. Provides safety equipment and instruction on its proper use. Conducts safety inspections of District facility including shop, equipment, vehicles and grounds. Maintains all District safety records in compliance with CAL OSHA standards. Responsible for budgeting, purchasing and preparation of proposals for the purchase of District equipment, tools, spray equipment, vehicles and supplies for equipment and facilities maintenance. Contracts with outside agencies for disposal of District equipment. Schedules shop projects consisting of routine maintenance and repairs of equipment and vehicles. Takes a leadership role in inquiring among District personnel to perform needed District job functions. As a member of the support team, assists and supports technicians, vector biologists, administrative assistant and manager and accomplishes field work, facility and equipment maintenance as needed.

Systems Specialist: The Systems Specialist is responsible for the coordination, maintenance, and development of the District's computer and information systems. Manages the computer operating system, installs initial and additional system software, adds and removes user accounts and files, ensures that system resources are efficiently distributed, provides level of security needed in system including passwords and backups. Operates as team leader in software and hardware research, purchasing, and development. Oversees the data systems, accomplishes program corrections, modifications, system development and documentation. Trains employees in the use of ACMAD data systems and creates user guides. With other support team members, participates in the development of Geographic Information System by the District. Interfaces with other agencies and statewide internet site and assists in public education programs. As a member of the support team, assists and supports technicians, vector biologists, administrative assistant and manager and accomplishes field work, facility and equipment maintenance as needed.

Control Staff:

Assistant Mosquito Control Technician (AMCT): The Assistant Mosquito Control Technician position is the entry level field position or on occasion may be a seasonal position. The AMCT carries out a thorough inspection program in locating mosquito breeding sources; identifies both larval and adult stages of the various species of mosquitoes and locates unknown sources of breeding; takes samples of suspected larvae and brings them into the laboratory for positive identification; distribute fish and other predators in breeding sources when biological control is needed; uses hand tools and mechanical equipment to drain breeding sources and mixes appropriate pest control agents and sprays breeding sources with mechanical sprayers, ULVs and other equipment; responds to requests from the public in surveying areas and adopting appropriate control measures for eliminating vectors; discusses mosquito control problems with the public and requests cooperation and assistance; participates in public education and public relations programs; uses a wide variety of hand tools and special equipment such as hand lens, sample bottles, dipper, sweep net, monitor traps (Fay, CDC, New Jersey, and Oviposition), thermometer, mechanical sprayers, hand sprayers, hand spreaders, measuring devices, microscope, drafting equipment, all terrain vehicle, and half-ton truck; assists with the maintenance and servicing of vehicles, equipment, and District facilities; assists in the design and construction of special equipment; prepares daily work sheets and record cards on activities; utilizes District data system reports and maintains zone records; and coordinates teamwork within assigned zone. A willingness to contribute individual skills, talents, and interests to District projects such as: heavy equipment operation, computer programming, mapping, research, insect collection, source reduction, and public education.

Mosquito Control Technician (MCT): Carries out a thorough inspection program in locating mosquito breeding sources; identifies both larval and adult stages of the various species of mosquitoes and locates unknown sources of breeding; takes samples of suspected larvae and brings them into the laboratory for positive identification; distribute fish and other predators in breeding sources when biological control is needed; uses hand tools and mechanical equipment to drain breeding sources and mixes appropriate pest control agents and sprays breeding sources with mechanical sprayers, mist blowers and other equipment; responds to requests from the public in surveying areas and adopting appropriate control measures for eliminating vectors; discusses mosquito control problems with the public and requests cooperation and assistance; participates in public education and public relations programs; uses a wide variety of hand tools and special equipment such as hand lens, sample bottles, dipper, sweep net, monitor traps (Fay, CDC, New Jersey, and Oviposition), thermometer, mechanical sprayers, hand sprayers, hand spreaders, measuring devices, microscope, drafting equipment, all terrain vehicle, and half-ton truck; assists with the maintenance and servicing of vehicles, equipment, and District facilities; assists in the design and construction of special equipment; prepares daily work sheets and record cards on activities; utilizes District data system reports and maintains zone records; and coordinates teamwork within assigned zone. A willingness to contribute individual skills, talents, and interests to District projects such as: heavy equipment operation, computer programming, mapping, research, insect collection, source reduction, and public education.

Vector Biologist: Carries out a thorough inspection program in locating mosquito breeding sources; identifies both larval and adult stages of the various species of mosquitoes and locates unknown sources of breeding; identifies other vectors; distributes fish and other predators in breeding sources when biological control is needed; directly or with the support team coordinates control activities with other agencies and property owners; uses hand tools and mechanical equipment to drain breeding sources and mixes appropriate pest control agents and sprays breeding sources with mechanical sprayers, mist blowers and other equipment; responds to requests from the public in surveying areas and adopting appropriate control measures for eliminating vectors; discusses mosquito control problems with the public and requests cooperation and assistance; participates in public education and public relations programs; uses a wide variety of hand tools and special equipment such as hand lens, sample bottles, dipper, sweep net, monitor traps (Fay, CDC, New Jersey, and Oviposition), radio, thermometer, mechanical sprayers, hand sprayers, hand spreaders, measuring devices, microscope, drafting equipment, all terrain vehicle, and half-ton truck; assists with the maintenance and servicing of vehicles, equipment and District facilities; assists in the design and construction of special equipment; prepares daily work sheets and maintains a record of activities; coordinates teamwork within assigned zone. A willingness to initiate and take responsibility for District projects such as: heavy equipment operation, computer programming, mapping, research, insect collection, source reduction, and public education and continue contributing individual skills, talents, and interests to other projects.

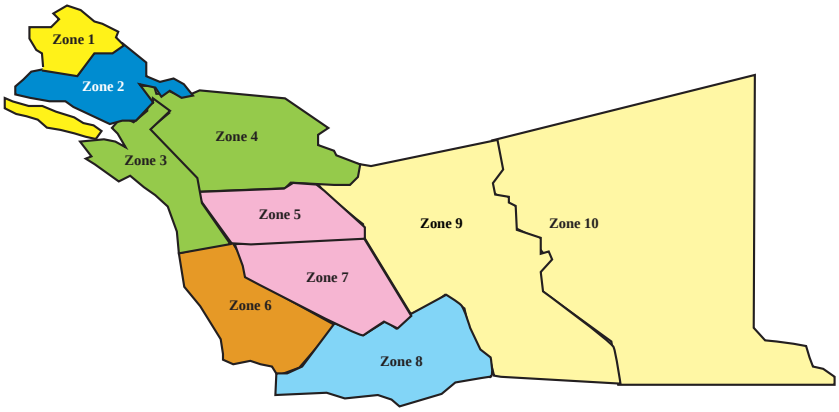
EDUCATION AND TRAINING

District field employees are certified by the California Department of Health Services in mosquito control. To obtain this certification an employee must pass one examination on pesticide laws, labels, practices and safety and a second examination on the biology and control of mosquitoes. The California Department of Health Services also certifies for invertebrate vector control and vertebrate vector control. Most of the District employees have all three certifications. To maintain their certification an employee is required to take a minimum of 40 hours of continuing education every two years.

District personnel also receive training in First Aid, driving safety, CPR, equipment operation and maintenance and operation of District shop equipment. The District also sends employees to special training that is of immediate operational use or long term skill development such as GIS mapping, environmental impact analysis, special equipment maintenance, welding, computer programing, etc. Nine of the District employees have college degrees. Five of our staff have degrees in entomology (2 with Masters Degrees and 1 with a PhD).

FIELD ORGANIZATION

To provide effective and efficient mosquito control, ACMAD is divided into ten zones. These zones tend to be divided along geographic, transportation and political lines. Zones are divided to distribute work load based on population, annual calls and source types. Each zone is assigned to a person who has the primary responsibility for control within the zone. Most control activities can be accomplished by one person. When more than one person is needed or specialized equipment (e.g., helicopter, heavy equipment or all-terrain vehicles) is required, the assigned person coordinates the activity. The assigned person maintains the source records, answers service calls, provides control activities and coordinates team control activities within his/her zone.



Generalized Map of Current Zones

The zone concept used for organization of control activities has proved valuable for many years. This concept provides:

Accountability: One assigned person is accountable for the effective and efficient control of mosquitoes within their zone.

Knowledge: It requires a number of years experience to acquire knowledge of the types of sources, species of mosquitoes, special problem areas and timing to control mosquitoes in a zone.

Continuity: This organization ensures continuity over the years in applying control measures and needed follow-up within each zone.

All of the District's field personnel have assigned zones and also team up to share efforts when needed or to serve as a substitute when the primary assigned person is not available. Thus, the work load on each person is kept more balanced. Zone assignments occasionally change, and many of the District's personnel have worked in different zones, giving them broader knowledge of the whole District.

In addition to zone assignments, many District personnel have specialized skills for serving the whole District. These skills include operation of heavy equipment, driving large vehicles, operation of specialized treatment equipment, making public presentations, repairing equipment, welding, working on data systems, doing needed research, maintaining reference insect collections, maintaining disease monitoring chicken flocks and creating maps or graphical and photographic work.

DISTRICT FACILITIES AND EQUIPMENT

In 1984 the District relocated to a centralized facility and disposed of three smaller branch facilities. The new facility has an office, laboratory, shop for maintenance, parking for District vehicles, pesticide storage building, employee and guest parking and fish holding tanks.

District Office:

The District office has a board meeting room, offices for support staff and manager, laboratory, lunch room, handicap-accessible restrooms and storage for supplies.

District Facilities:

Vehicle Parking: District facilities have ample parking for all Distric employee's and visitor's vehicles.

Maintenance Shop: The District has a large well equipped maintenance shop which includes a vehicle lift, overhead rolling crane, welding booth, lubricants dispenser, air compressor, tire changer, shop tools-(drills, cut off saws, grinders, hand tools, etc.) and storage for general supplies.

Storage Buildings: The facilities have specialized storage facilities for pesticides that meet the current requirements for safety. There is general storage for equipment and supplies.

Fish Tanks: The District has four tanks for holding fish stocks.

District Equipment

General Use Vehicles: The District maintains a fleet of vehicles for general mosquito control consisting of a van, eleven pick-up trucks and specialized vehicles. Pick-up trucks used for mosquito control in zones are generally equipped with gas powered 50-100 gallon spray rigs, lock boxes for storage, spill kits, collection equipment, tools, hand cans and/or backpack sprayers and fish transport containers. All are identified with the District logo on the door panels.

Right Hand Drive Pick-Ups: The District has two right hand drive pick-up trucks for use in inspecting and treating road side ditches and storm drains. These are equipped with electric spray rigs.

Boats: The District has two boats and an outboard motor for use in deep water sources - 14' aluminum and 12' wood.

ULV Leco: The District has two ultra low volume (ULV) applicators. One can be mounted in a truck and application is computer controlled based on truck speed. The other ULV is a hand held unit for use in small areas.

Flat Bed Truck and Trailer: The District has one large truck and trailer for transporting the tractor, Thiokel, disc or ditcher.

D3 Caterpillar Tractor: The District maintains this tractor for large scale ditching and earth moving operations. Most of the time this tractor is used for marsh restoration projects.

District all terrain vehicles: The District currently uses two types of all terrain vehicles to obtain access to mosquito producing sources.

Argo: Argos are eight wheeled, plastic body all terrain vehicles manufactured by Ontario Drive and Gear Limited. These are run with and without tracks depending upon local conditions. Ground pressure is 2.1 psi. These vehicles can carry two people and a 50 gallon spray rig. They are used for monitoring and treatment. The District currently owns 4 Argos.

DMC 1200: The De Lorean 1200 is used primarily by the District for speed scavel ditching and large treatment operations. The ground pressure is .87 psi. This vehicle can carry three people and a 100 gallon spray rig.

REGULATION, COOPERATION AND PARTICIPATION

The District is an Independent Special District created pursuant to state statute (Health and Safety Code division 3, chaper 5, commencing with section 2200). The District, as authorized by state law, and through its Board of Trustees and staff, governs the control of mosquitoes in the environment within the District's boundaries. This action is subject to and done in accordance with District criteria regarding mosquito control that guide when, where, whether and how to control mosquitoes. District actions are subject to various federal and state laws that regulate mosquito control and environmental protection. The District operates as a regulatory agency but is subject to regulations by:

Federal Agencies:

Army Corps of Engineers (ACE): District physical control projects involving wetlands and water courses are subject to ACE permit review and approval. The District also participates in the interagency review process within ACE, giving the District input during the planning stage of proposed projects to present guidelines on mosquito reduction techniques on wetlands.

Environmental Protection Agency (EPA): The District uses only pesticides registered by the EPA and complies with laws relating to pesticide usage. California EPA administers theses laws and some additional registration requirements put into place by the state to supplement federal laws and regulations.

Occupational Health and Safety Administration (OSHA): The District complies with OSHA regulations and requirements. The District participates in the small employer voluntary compliance program for safety, and voluntarily requests annual safety inspections to help prevent accidents. OSHA laws and regulations are administered by California OSHA.

United States Fish and Wildlife Service (USFWS): The District complies with laws and regulations relating to endangered and theatened wildlife and habitats. The District also coordinates with the Service about refuge lands located within Alameda County. Control on USFWS properties are subject to approval of Pesticide Use Proposals (PUPs) and local restrictions on entry related to nesting seasons.

State of California Agencies:

California Department of Fish and Game: The District complies with laws and regulations relating to transport and use of biological control organisms (fish) and endangered and threatened species protection. The District also coordinates with this Department in relations to refuge wetlands owned by the state.

California Environmental Protection Agency (Cal-EPA): This agency administers federal and state environmental laws and regulations.

California Department of Pesticide Registration (DPR): This agency is part of Cal-EPA and is responsible for all aspects of pesticide sales and use to protect public health and the environment. It is active in registering pesticides for use in California.

San Francisco Regional Water Quality Board: The Board is also part of Cal-EPA and has the mission to protect surface and ground waters of the San Francisco Bay region. They also issue permits for physical control projects.

Department of Motor Vehicles (DMV): The operation of District vehicles, material transport, insurance requirements and the driver licensing of all District employees is subject to regulation by DMV.

State Department of Health Services (DHS): The District enters into an annual Cooperative Agreement with DHS. The agreement determines how the District activities will comply with certain standards concerning mosquito control and pesticide use. It also requires recordkeeping and reporting pesticide use to the County Agricultural Commissioner each month as well as employee certifications as mosquito control technicians and continuing education training.

Regional Agencies:

East Bay Municipal Utilities District (EBMUD): This District is a major landowner and operates water treatment facilities.

East Bay Regional Park District (EBRPD): The Park District is a major landowner of wetlands. The District coordinates mosquito control activities with EBRPD.

Local Agency Formation Commission (LAFCO): LAFCO regulates and coordinates governmental services, consolidations and creation of new agencies.

San Francisco Bay Conservation and Development Commission (BCDC): Wetland projects along the Bay require a permit from BCDC. BCDC regulates all filling and dredging in San Francisco Bay, regulates new development within the first 100 feet inland from the Bay, maximizes public access to the bay and participates in planning.

Local Agencies:

County of Alameda:

Alameda County Agricultural Commissioner: The District provides the Agricultural Department with monthly reports of pesticide usage and is subject to periodic inspections of equipment, facilities and records.

Alameda County Flood Control District: This District is a major land owner of channels, creeks and flood control infrastructure

Alameda County Vector Control District: This District provides information and assistance for the control of non-mosquito vectors.

Cities: The District complies with specific city requirements relating to pesticide usage within their boundaries.

Hayward Area Shoreline Planning Agency (HASPA): This agency is responsible for protection and planning of development along the Hayward bay shoreline. The District participates in this process.

Hayward Fire Department: The District complies with local fire regulations and materials storage requirements and is subject to periodic facilities inspections.

Special:

Vector Control Joint Powers Agency (VCJPA): This is a special district formed by the participating vector and mosquito control districts in California to provide insurance pooling and administration for Worker's Compensation, vehicle insurance and general liability insurance. The District complies with their requirements and participates in the VCJPA training programs to reduce risks to the District.

Participation:

San Francisco Bay Joint Venture (SFBJV): This is a partnership of 22 public agencies, environmental organizations, business groups and agricultural interests working cooperatively to protect, restore, increase, and enhance wetlands, riparian habitat, and associated uplands throughout the San Francisco Bay Region. The District is an ex-officio member.

Seasonal Wetland Enhancement Committee (SWEC): A partnership of East Bay Reional Parks, Flood Control, Department of Fish and Game, BCDC, U. S. Army Corps of Engineers, U.S. Fish and Wildlife Service, and Our District to explore alternative mosquito control in salt marshes.

University of California Research: The District independently, and with the MVCAC, participates in supporting research related to mosquito biology and control.

Memberships:

American Mosquito Control Association (AMCA): The District is a member of the Association and generally sends one or more employees and trustees to the annual AMCA conference.

California Special Districts Association (CSDA): The District is an active member of this association.

Entomological Society of America: The District is an active member.

Mosquito and Vector Control Association of California (MVCAC): The District is a active member of the Association and participates in the committees, conferences and training programs. The Association and its member districts participate in the U. S. Environmental Protection Agencies Pesticide Environmental Stewardship Program. District employees have presented numerous papers before these conferences.

Society of Vector Ecologists (SOVE): The District is an active member of this society and participates in the organization's conferences.

DISTRICT PUBLIC INFORMATION PROGRAM

Public Contact

Field Personnel: Direct contact with the public during service calls, routine source inspections and informal contacts are one of the most important forms of public contact. These are person-to-person contacts that are generally problem oriented and information is of immediate interest and use to contacted persons. Each Technician comes into contact with many individuals during the course of their control and inspection activities.

Special Events: In an effort to reach as many people as possible, the District participates in a wide variety of special events. Such events are Home and Garden Shows, the Alameda County Fair, government information events, "Bug Days" at nature centers, watershed and wetland events or presentations to garden clubs etc. These type of events give the District a way to reach large numbers of citizens and provide information about District services.

Special Presentations: Periodic presentations are made to City Councils, government agencies and political representatives. The District occasionally provides speakers to organizations such as Pesticide Applicators Professional Association, Pacific Gas and Electric Company, Lawrence Laboratory and other government agencies. District personnel have also submitted and presented professional papers at the Mosquito and Vector Control Association of California annual conferences on research done by the District .

Miscellaneous Insect Identifications: One of the services provided by the District is the identification of insects submitted by the public. The District staff will examine specimens and provide indentification, biolological information (if available) and recommendations on where to obtain additional information or contact other agencies involved with the identified insect.

Media Contact:

Television and Radio: District personnel are available for interviews and provide special information for media stories. On some occasions the District will notify the media of upcoming projects, special problems or issues for the media to feature.

Newspapers and Magazines: District personnel are available for interviews and provide special information and photo opportunities for newspaper or magazine stories. On some occasions the District will notify the newspapers of upcoming projects, special problems or issues for the newspapers to feature. Newspapers are routinely supplied with copies of Board agendas, monthly reports and minutes.

Newsletters: District personnel are available for interviews and provide special information and photo opportunities for newsletter stories. On some occasions the District will notify groups of upcoming projects, special problems or issues for their newsletters to feature.

Public Information Publications

Biennial Reports: The District produces a biennial report at the end of each odd-numbered year. These are printed and generally available in January or February of even numbered years. The biennial reports are distributed to governmental organizations, newspapers, political representatives and upon request, to members of the public.

Board of Trustees Information: Three special items are produced for the meetings of the Board of Trustees - agenda, meeting minutes and an operations report for each month. Board meeting agendas are posted at the District office. Agendas, minutes and operational reports are mailed to newspapers, governmental agencies and requesting members of the public. Copies of these are also posted on the District web site.

Public Information Publications: The District produces a number of publications and provides some publications from other related agencies for distribution to the public. The District currently provides the publications below:

District Brochure (12 pages): This is a general publication about District services, miscellaneous mosquito-like insects, mosquito biology, mosquito prevention and a source checklist.

Mosquito Prevention for Fish Ponds (16 pages): General information of use to fish pond owners for managing their ponds to be free of mosquitoes. This publication discusses proper construction, maintenance, pond removal, mosquito biology, mosquitofish, natural predators and checklist of pond problems.

Homeowner's Guide to Mosquitofish (4 pages): This is a general guide to the use of mosquitofish for controlling mosquitoes in fish ponds.

Fish Ponds - Mosquito Prevention (trifold): This covers the same information as Mosquito Prevention for Fish Ponds, but in a brief summary format.

The Danger of Chloramines to Fish: A single sheet flier on chloramines (used to disinfect local water supplies) and what to do to prevent harm to fish by removing chloramines.

Are You Raising Mosquitoes in Your Yard? (4 pages): A general information summary of sources in backyards that produce mosquitoes and preventative measures.

Tree Hole Mosquitoes (4 pages): A specialized publication about the Western tree hole mosquito (*Aedes sierrensis*) and dog heartworm.

Visit Us on the Web: A single page handout to encourage visitation to the District web site.

Salt Marsh Mosquitoes of Alameda County: A two-sided single page handout providing information about *Aedes squamiger* and *Aedes dorsalis* and salt marsh mosquito control.

Biology Notes: These are single page handouts on specific mosquito species that the public may encounter. The District most commonly uses these for *Culex pipiens, Culiseta incidens, Culex tarsalis* and *Anopheles freeborni*. These fliers are produced by the Mosquito and Vector Control Association of California. The District also produces some specific one page handouts about midges, mayflies and crane flies. These notes are used to provide specific and more detailed information for service calls.

Specialized Information: The District maintains files of information sheets on specialized information such as other aquatic insects, standard recommendation for construction, reprints of journal articles, etc., and fliers from related agencies relating to insects or disease vectors. These items are available for specific requests or needs.

Educational Outreach:

Classroom presentations: District personnel will make presentations in school classrooms or on field trips to provide specialized information about the District and mosquito control. These are done on a time available basis at a teacher's request.

Special presentations: The District will provide speakers for teachers training work shops to familiarize classroom teachers with the District, mosquito biology, diseases transmitted by mosquitoes, aquatic biology and District services.

Teacher's packets: The District provides a special packet of information for classroom teachers. The packet contains the District biennial report, all of the District publications and specialized classroom materials such as pictures, puzzles, biology handouts and aquatic biology information. The District plans to produce a Teacher's Handbook for use in classroom teaching about mosquitoes and aquatic biology.

District Web Site:

The District maintains a web site to provide mosquito control and related information on the internet. The District web address is www. mosquitoes.org. The District has most of its publications on the site, Board of Trustees' documents (agendas, minutes and operational reports), specialized technical information (mosquito biology, bibliographies, and technical reports), a resource area for classroom teachers to find information about insects and mosquitoes on the internet, and additional general information about District services and links to other related web sites. The District web

site also supports the Mosquito and Vector Control Association of California by providing links and special information for the Association.

INTRODUCTION TO THE DISTRICT MOSQUITO CONTROL PROGRAM

In order to accomplish long-range, intelligent, and environmentally sound mosquito control, the management and manipulation of mosquitoes must be accomplished using not just one but all available pest control methods. This dynamic combination of methods into one thoughtful, ecologically-sensitive program is referred to as Integrated Pest Management (IPM). The District's mosquito control program employs IPM principles by first determining the species and abundance of mosquitoes through larval and adult surveys and then using the most efficient, effective and environmentally sensitive means of control. In some situations, water management or source reduction programs can be instituted to reduce breeding areas. The District also considers biological control such as the planting of mosquitofish (*Gambusia affinis*). When these approaches are not practical or otherwise appropriate, then a pesticide program is used so that specific breeding areas and/or adult mosquitoes that can be treated.

Alameda County contains many sources that act as mosquito and vector breeding areas near populated areas. Without ongoing and effective mosquito control, the human environment would be significantly and adversely affected by substantial mosquito activity. The District's mosquito control program, including biological and chemical control, is essential to abate the vectors in the environment to a tolerable level. The District's program will never alleviate all mosquitoes vectors. Rather, it is a resource maintenance program aimed at striking a balance to allow comfortable and healthful human existence within the natural environment, while protecting and maintaining the environment. History has shown us that the control and abatement of vectors are necessary for our human environment to continue to be habitable.

Program orientation:

The District mosquito control program/project is directed primarily at the larval stages of mosquitoes and the sources of mosquitoes. Control activities are contained to a localized area and have a lower impact utilitizing this approach. Although adult mosquitoes may be targeted for control, this is only in emergency and very localized situations, and it is not the emphasis of the District program. Using the larval source emphasis of mosquito control requires that control be effected in a number of different types of mosquito sources. Below is a listing of the basic types of sources targeted in the District control program.

Definitions of Source Types:

Sources are any place that hold water and provide a habitat for mosquito larvae to grow. The sources defined below are the types generally used by the Alameda County Mosquito Abatement District for describing the place where mosquito larvae are found or adult mosquitoes have emerged. The decision to control the mosquitoes found in a specific source is dependent upon the mosquito species, flight range of the mosquito species, distance to human or animal hosts, and the ability of the mosquito species to carry human or animal disease. Categorizing sources by Agricultural, Natural, Domestic or Commercial is loosely used to define where these sources are found, but is not restrictive in the use (e.g., a fish pond is a fish pond whether in a commercial establishment or at private residence).

AGRICULTURAL

Pastures:	Irrigated fields. Water source - irrigation water
Stock Ponds:	Artificially constructed ponds to catch and hold runoff water used for stock watering or irrigation. Source of water - natural runoff.
Dairy drains:	Holding ponds for polluted water from dairy operations Source of water - wash down and runoff from dairy operations
Duck ponds:	Ponds managed for attracting ducks for hunting. Source of water - rainfall, pumped in from wells or other source.
Agricultural drains:	Ditches used for draining excess water from agricultural operations. Source of water - irrigation.
Return Sumps:	Holding ponds used to collect excess agricultural water for return to fields or disposal to another source. Source of water - irrigation.
Watering troughs:	Tanks, troughs, or other containers used for watering stock. Source of water - pumped or rainfall.

Tail water: Water left in low portions of an agricultural field from irrigation. Source of water - irrigation.

Other Agricultural: This source is used for agricultural sources not covered above.

NATURAL

Creeks: Natural, or slightly modified main channels of creeks. Source of water - rainfall, natural runoff, domestic or agricultural runoff.

Creek potholes: Potholes holding water that are separated from main creek channel. Source of water - natural runoff, seepage from main channel.

Marshes (tidal): Marshes subject to natural tidal action. Source of water - tidal, rain.

Marshes (reclaimed): Marshes not subject to natural tidal action, usually contained by levees or other water control structures. Source of water - rain, tidal (control structures or overflow of levees).

Lakes: Large (20 acres+) natural or artificial bodies of water, usually deeper than 20 feet. Source of water - natural runoff, rainfall or pumped.

Ponds: Small (less than 20 acres) natural or artificial bodies of water, usually shallower than 20 feet. (this type includes vernal pools) Source of water - natural runoff, street drainage , rain or pumped.

Treeholes: Rot cavities or cavities caused by tree growth (pans). Source of water - rainfall and occasionally from irrigation.

Temporary pools, Storm water: Areas that collect rain water or in domestic areas occasionally collect irrigation water (includes rock pools). Source of water - rainfall and occasionally irrigation.

Marsh (freshwater): Shallow marshy areas, artificial or natural with emergent vegetation. Source of water - natural or artificial runoff and rainfall.

Other: This source is used for natural sources not covered above.

DOMESTIC

Fish ponds: Artificially constructed landscape ponds for fish or accent. Source of water - pumped or rainfall.

Septic tanks: Underground storage and processing tanks for sewage. Source of water - sewage.

Wells: Drilled or dug wells for water, usually old and no longer used. Source of water - natural water table level.

Swimming pools: In ground or above ground swimming pools. Source of water - pumped and/or rainfall.

Bird baths: Small pools or ornamental structures for bird bathing. Source of water - pumped and/or rain.

Cesspools: Open collection ponds for sewage (no longer legal). Source of water - sewage.

Flooded basements: Water in basements or under a structure. Source of water - sewage, seepage or runoff.

Domestic - containers: Any container - bucket, tub, boat, barrel, wheelbarrow, etc. found in a yard and containing water. Source of water - rainfall, irrigation or pumped.

COMMERCIAL

Catch basins, gutters: Basins or gutters used to collect and direct runoff water. Found in streets, parking lots, loading docks or private driveways. Source of water - rainfall, irrigation, seepage or pumped.

Storm drains: Underground structures for carrying runoff water. Source of water - rainfall, runoff from irrigation and/or seepage.

Gravel pit:	Pond or pit created to mine gravel. Source of water - pumped, rainfall and natural ground water.
Borrow pit:	Pits or depressions created to obtain soil for construction. Usually found along railroad tracks, highways or occasionally buildings. Source of water - rainfall and runoff.
Sewer ponds/ treatment plants:	Ponds and water holding structures used for sewage treatment. Source of water - sewage.
Utility vaults:	Underground structures constructed for utilities - PG&E, water departments, telephone, Western Union, or private. Source of water - rainfall, seepage and runoff.
Cemetery urns:	Containers provided for flowers at grave sites. Source of water - rainfall and irrigation.
Sumps:	Holding ponds or structures for collecting industrial waste water or runoff. Source of water - rainfall, runoff and industrial processes.
Sewer lines:	Underground structures for collecting and carrying sewage. Source of water - sewage.
Tanks, pickle vats:	Tanks and vats. Pickle vats are used in the production of pickles. Source of water - rainfall, pumped and irrigation.
Channel (lined):	Channels lined with rock or concrete used for flood control or to collect runoff. Source of water - rainfall and runoff.
Channel (unlined):	Channels with soil bottoms and sides used for flood control or to collect runoff. Source of water - rainfall and runoff.
Waste water marsh:	Marsh constructed to hold or treat waste water, usually sewage. Source of water - sewage, runoff and occasionally industrial waste water.
Tires:	Stored or discarded tires. Source of water - rain and irrigation.
Broken or Leaking pipes:	Water sources created by broken or leaking pipes. Source of water - pumped and sewage.
Seepage:	Water sources created by seepage from natural or unknown sources. Source of water - seepage from springs, ground water or subterranean runoff.
Commercial other:	Commercial sources not covered by above.

Water Source Definitions:

The source of the water providing habitat for mosquito immatures that are used throughout the above source descriptions. are defined below:

Irrigation:	Water used for irrigating crops or watering landscaping.
Rainfall:	Water accumulating directly or indirctly from rainfall.
Runoff:	Water from surface runoff from rain, irrigation, or other sources.
Pumped:	Water from municipal, well, or commercial source.
Sewer:	Water from black or gray water sewage.
Seepage:	Water from subterranean natural or unknown source.

MOSQUITOES TARGETED IN DISTRICT PROGRAM

The District targets mosquito species based upon their ability to carry human and animal disease and their ability to cause human discomfort. Some species do not come into contract with humans, cause discomfort or carry disease and are not generally considered targets in the District control program/project. Species not directly targeted in the District program are *Culex apicalis, Culex boharti, Culex stigmatasoma, Culiseta particeps*, and *Orthropodomyia signifera*. These species are many times found in association with targeted species.

Below is a list of the mosquito species that have been found within the District:

AEDES
- ***Aedes albopictus****
- ***Aedes dorsalis***
- ***Aedes melanimon***
- ***Aedes nigromaculis***
- ***Aedes sierrensis***
- ***Aedes squamiger***
- ***Aedes vexans****
- ***Aedes washinoi***

ANOPHELES
- ***Anopheles franciscanus***
- ***Anopheles freeborni***
- ***Anopheles occidentalis***
- ***Anopheles punctipennis***

CULEX
- ***Culex apicalis***
- ***Culex boharti***
- ***Culex erythrothorax***
- ***Culex pipiens***
- ***Culex stigmatosoma***
- ***Culex tarsalis***

CULISETA
- ***Culiseta incidens***
- ***Culiseta inornata***
- ***Culiseta particieps***

ORTHOPODOMYIA
- ***Orthopodomyia signifera****

*Twenty-two species of mosquitoes have been found in or are assumed to be in Alameda County. *Orthopodomyia signifera* has not been found in larval form, but is found in all the counties surrounding Alameda County. *Aedes vexans* was reported to have been found in Alameda County, but no identifications of this species has been made locally in the last 40 years. *Aedes albopictus* was found (one larva) in an imported tire, no other detections have been made. In addition to the above twenty-two mosquitoes, the District maintains surveillance for imported or introduced mosquito species that may have the potential to establish themselves in the Bay Area.

Mosquitoes of Alameda County

	Species	Most Common Larval Habitats	Adult Prevalence	Source of Blood Meal	Disease / Pest Significance	Notes
AEDES	**Salt marsh mosquito** *Aedes dorsalis*	Salt marshes	All Year	Animals and Man	High Pest Significance	Most common in the summer after high tides
	Asian tiger mosquito *Aedes albopictus*	Small Containers, Tires	Spring - Summer	Animals and Man	High Pest Significance Vector of Dengue	Found only once in an imported tire
	Aedes melanimon	Irrigated Fields	Spring - Summer	Animals and Man	High Pest Significance	
	Pasture mosquito *Aedes nigromaculis*	Irrigated Fields	Spring - Summer	Animals and Man	High Pest Significance	uncommon
	Tree hole mosquito *Aedes sierrensis*	Tree Holes, Tires, Miscellaneous Containers	Spring - Summer	Animals and Man	High Pest Significance Vector of Canine Heartworm	A small mosquito.
	Winter salt marsh mosquito *Aedes squamiger*	Salt Marshes Reclaimed Marshes	Spring	Animals and Man	High Pest Significance	targeted during winter months
	River mosquito *Aedes vexans*	Temporary Pools	Spring	Animals and Man	High Pest Significance Vector of Canine Heartworm	Has not been found since the 1950's
	Woodland pool mosquito *Aedes washinoi*	Temporary Woodland Pools	Spring	Animals and Man	High Pest Significance	
ANOPHELES	*Anopheles franciscanus*	Shallow Pools and Streams in Algae mats	Summer	Large Animals and Occasionally Man	Low to Moderate Pest Significance	
	Western malaria mosquito *Anopheles freeborni*	Seepages, Streams, Lakes, Gravel Pits	Summer	Animals and Man	Low Pest Significance Vector of Malaria	
	Anopheles occidentalis	Streams, Lakes, Pools Occasionally in Brackish Water	Summer	Animals and Occasionally Man	Low Pest Significance	
	Anopheles punctipennis	Temporary Pools, Streams	Summer	Animals and Man	Moderate Pest Significance Vector of Malaria	
CULEX	*Culex apicalis*	Woodland Creeks, Pools	Summer	Amphibians and Reptiles	No Pest Significance	
	Culex boharti	Slow Streams, Pools	Summer	Amphibians and Reptiles	No Pest Significance	Rarely found
	Tule mosquito *Culex erythrothorax*	Lakes and Ponds Associated with Tules	Spring - Summer	Birds, Animals, Man	High Pest Significance Vector of Encephalitis	
	House mosquito *Culex pipiens*	Storm Drain Systems, Septic Tanks, Roadside Ditches, Cemetery Urns, Flooded Basements, Utility Vaults	All Year	Birds, Animals, Man	High Pest Significance	Uusally bites indoors at night. common in urban areas.
	Foul water mosquito *Culex stigmatosoma*	Foul Water, Sewage, Temporary Pools	All Year	Birds, Rarely Feeds on Man	Low Pest Significance	
	Encephalitis mosquito *Culex tarsalis*	Creeks, Marshes, Temporary Pools, Roadside Ditches, Fresh Water	All Year	Birds, Animals, Occasionally Man	Moderate Pest Significance Vector of Encephalitis	
CULISETA	**Fish pond mosquito** *Culiseta incidens*	Fish Ponds, Temporary Pools, Catch Basins, Roadside Ditches	All Year	Large Animals and Man	High Pest Significance Possible Vector of Canine Heartworm	Common in urban areas.
	Winter marsh mosquito *Culiseta inornata*	Marshes, Temporary Pools, Roadside Ditches	Fall - Spring	Large Animals and Man	High Pest Significance	
	Culiseta particeps	Shaded Clean Pools, Streams	Fall - Spring	Animals and Occasionally Man	Low Pest Significance	
	Orthopodomyia signifera	Tree Holes	Spring - Summer	Animals and Occasionally Man	Low Pest Significance	Adults found in light trap larvae not found

MOSQUITO SPECIES

ALAMEDA COUNTY MOSQUITO ABATEMENT DISTRICT

✖ **Common**
❀ **Occasional**

Source Type	*Aedes*							*Anopheles*				*Culex*						*Culiseta*			Other
	dorsalis	*melanimon*	*nigromaculus*	*sierrensis*	*squamiger*	*vexans*	*washinoi*	*franciscanus*	*freeborni*	*occidentalis*	*punctipennis*	*apicalis*	*boharti*	*erythrothorax*	*pipiens*	*stigmatasoma*	*tarsalis*	*incidens*	*inornata*	*particeps*	*Orthopodomyia signifera*
AGRICULTURAL																					
Pastures		✖	✖														✖		✖		
Stock Ponds								✖	✖	✖	✖						✖	✖	✖		
Dairy drains															✖		✖		✖		
Duck ponds	✖				✖												✖		✖		
Agricultural drains								✖	✖	✖	✖				✖	❀	✖		✖		
Return sumps								✖	✖	✖	✖					❀	✖	✖	✖		
Watering troughs															❀		✖	✖	❀		
Tail water		✖	✖														✖				
NATUAL																					
Creeks						✖		✖	✖	✖	✖	✖	✖		❀		✖			✖	
Creek potholes							✖	✖	✖	✖	✖	✖	✖		❀		✖	✖		✖	
Tidal marshes	✖				✖														✖		
Reclaimed marshes	✖				✖												✖		✖		
Lakes								✖	✖	✖	✖	❀	❀	✖			✖			✖	
Ponds							✖	✖	✖	✖	✖	❀	❀	✖			✖		✖		
Treeholes				✖													❀	❀			✖
Temporary pools Storm water							✖					✖							✖		
Freshwater marshes							✖	✖	✖	✖	✖	✖		✖			✖		✖		
DOMESTIC																					
Fish ponds				❀											❀		❀	✖			
Septic tanks															✖						
Wells																					
Swimming pools																	❀	✖	❀		
Bird baths																					
Cesspools															✖	✖					
Flooded basements															✖						
COMMERCIAL																					
Domestic - containers				✖														✖			
Catch basins, gutters															✖			✖	❀		
Storm drains															✖			✖			
Gravel pits																	✖				
Barrow pits							✖										✖				
Sewer ponds															✖	✖	✖		❀		
Utility vaults															✖						
Cemetery urns				✖											✖	✖	✖	✖	❀		
Sumps															✖	✖					
Sewer lines															✖	✖					
Tanks, pickle vats															✖	✖		❀			
Channel - lined															✖	❀					
Channel - unlined								✖	✖	✖	✖				❀	❀					
Waster water marsh															✖	✖					
Tires				✖											❀	❀					
Broken, leaking pipes															✖	✖					
Seepage							❀	✖	✖	✖	✖				✖	❀					

ALAMEDA COUNTY MAD'S MOST IMPORTANT MOSQUITOES

(Causing over 99% of all service calls from the public)

Aedes dorsalis **(Salt marsh mosquito)**
This species is found year round in tidal salt marsh areas but is most common after summer high tides. The eggs are laid in the marsh and hatch when the marsh is filled by high tides. Control is by application of biorationals and physical modifications. Most of the sources are in ecologically sensitive areas and require great care to avoid damage. Adults are very aggressive, fly moderate distances, and are capable of producing very high numbers of service requests near marsh areas, especially in large grassy areas such as schools and parks.

Aedes squamiger **(Winter salt marsh mosquito)**
This species is produced in the marshes along the edges of the Bay. The eggs are laid on the marsh in the spring and hatch as soon as the marsh fills with rain water in the fall. Adults emerge the following spring. Most of the control effort occurs during the winter. Control is by physical modifications to the marshes and by spraying with biorational materials. Many of the marsh sources are ecologically sensitive areas requiring coordination with other agencies. Adults can fly long distances (up to 20 miles). The adult is a very aggressive biter and is very noticeable to the public. This species is capable of reaching very high numbers.

Aedes sierrensis **(Tree hole mosquito)**
This species breeds in tree holes (rot cavities or depressions in trees which hold water). Containers such as tires and buckets located near trees and partially filled with organic debris may also produce these mosquitoes. The eggs hatch when the tree hole or container fills with water. The adults hatch in March and remain in the area until early summer. This mosquito has a short flight range, is an aggressive biter, and is the primary vector of Canine Heartworm in Alameda County. It is found in any area where there are tree holes. This district is currently using biorational materials for control of this species.

Aedes washinoi **(Woodland pond mosquito)**
This mosquito is produced in woodland depressions that fill with water. Eggs are laid on the mud and organic material along the edges of receding water in these areas. Adults are generally present in the early spring, are very aggressive, and may be found in large numbers. Most of the control effort on this species is by use of biorational materials.

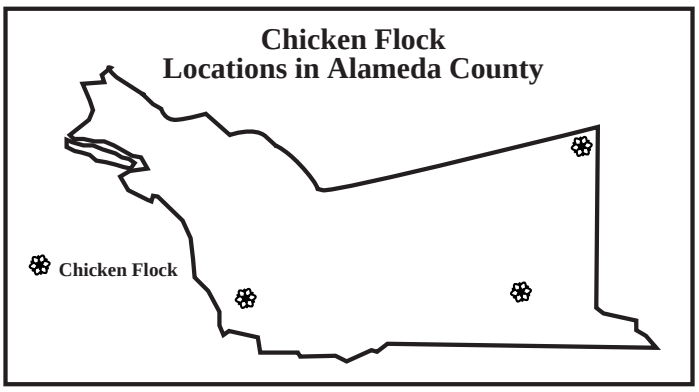
Culex pipiens **(House mosquito)**
This species causes the largest number of service requests in the District. This mosquito is generally an urban problem. The adult can be found all year and breeds in storm drains, catch basins, utility vaults, septic tanks, flooded basements, sumps, and in just about any water container found near human habitations. The adult readily enters homes and bites at night. Because of the type and variety of breeding sources, it can take many hours to locate the cause of a problem. Continual treatment and monitoring of sources is required to maintain control.

Culex tarsalis **(Encephalitis mosquito)**
This mosquito is produced in rain pools, marshes, swimming pools, ponds, and other fresh water sources. Although this species does not produce a large number of the District's service requests, it requires a large control effort to prevent the potential spread of encephalitis in Alameda County. This species feeds primarily on birds and is only moderately aggressive towards man. *Culex tarsalis* is capable of reaching very high numbers. Control is by application of biorational materials, stocking mosquito fish, and physical modifications to sources.

Culiseta inornata **(Winter marsh mosquito)**
This species rests during the summer and becomes active in the fall after the first rains. Eggs are laid on the surface of rain-filled ponds in the fall, and many generations can be produced in a single season. This mosquito bites at dusk in the fall and spring and is moderately aggressive, quite large, and may reach very high numbers. *Culiseta inornata* are very noticeable to the public because of their size and activity. This species is generally found close to temporary fresh water sources. Most of the control is by using biorational materials.

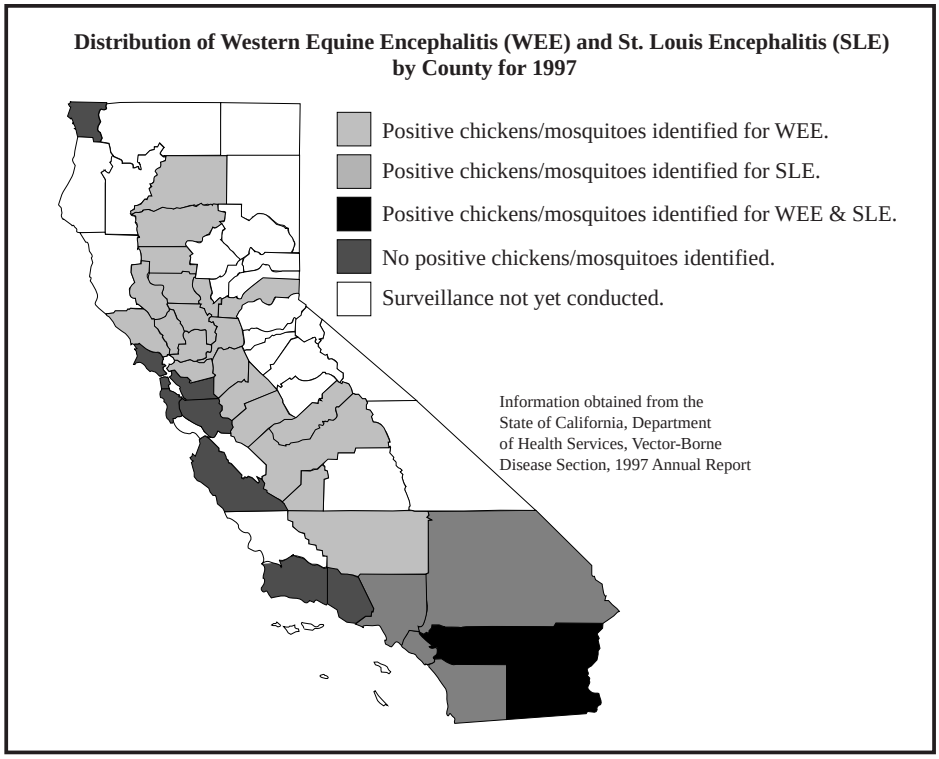
Culiseta incidens **(Fish pond mosquito)**
This mosquito is produced in fish ponds, creeks, and containers. It is the second major cause of service requests for the District. Small sources can produce sufficient numbers to cause discomfort in a neighborhood. This mosquito is moderately aggressive, bites in the evening or shade and is very noticeable because of its large size. It is primarily a problem of urban and suburban areas in summer and autumn. Control is by use of biorationals and mosquitofish.

MOSQUITO-BORNE DISEASES

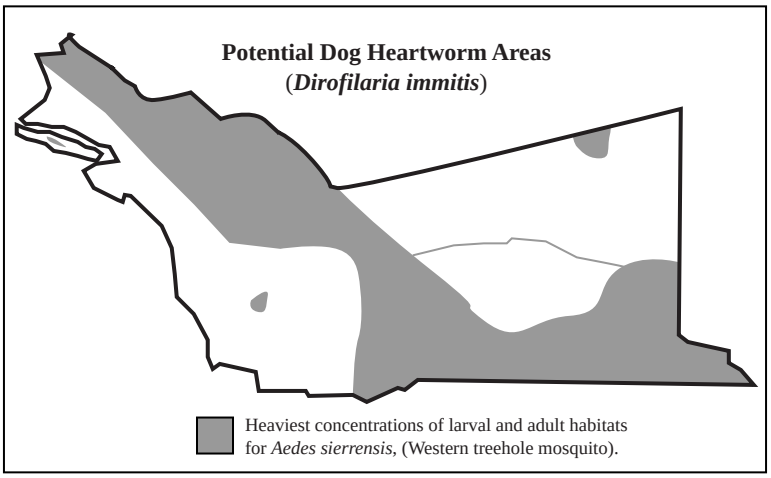


The District is concerned with a number of mosquito transmitted diseases that are endemic to California or could potentially be introduced into this County. The most important diseases are:

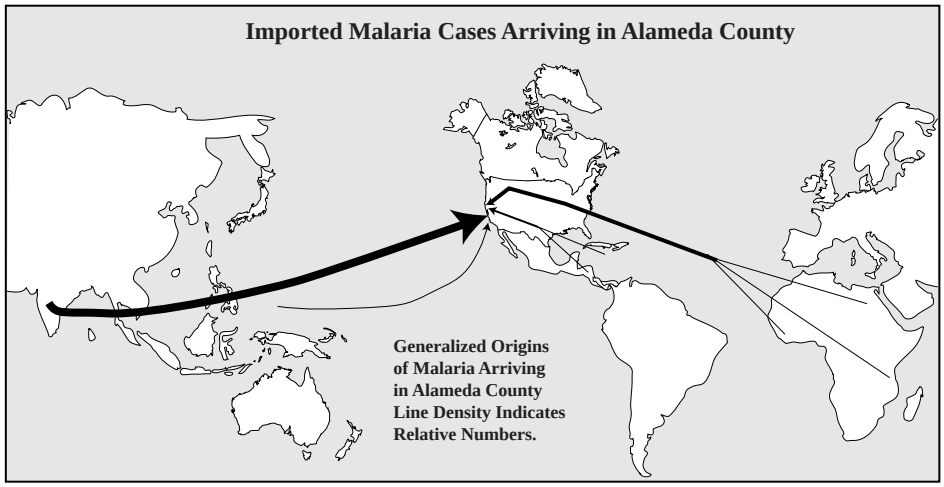
Viral Encephalitis: Viral Encephalitis is a disease affecting the brain transmitted primarily by *Culex tarsalis* (Encephalitis mosquito). California has two encephalitides - Western Equine Encephalitis (WEE) and St. Louis Encephalitis (SLE). The District maintains 8 permanent light traps and 3 sentinel chicken flocks as well as periodically using portable CO_2 baited light traps to monitor vector mosquito populations. The District monitors for the virus by collecting live adult mosquitoes with CO_2 baited light traps. Mosquitoes captured in the traps are sent to the State Department of Health Services to test for viral presence. The District also maintains three chicken flocks that are tested for antibodies to encephalitis virus. Samples of blood are taken from the chickens and are sent to the State Department of Health Services for testing. A positive test in a chicken flock can indicate that the mosquitoes near the flock are transmitting the virus. Surveillance activities are conducted throughout the State to determine if mosquitoes are infected with the encephalitis virus. The District places a high priority on control of *Culex tarsalis* found within the District.



Dog heartworm: This disease is transmitted from canine to canine (dogs, coyotes, foxes). The disease organism (*Dirofilaria immitis*) is transmitted primarily by the Western treehole mosquito (*Aedes sierrensis*). Several other species are currently under study as possible vectors of this disease. It can be transmitted to cats, but in felines it is a dead end disease and does not retransmit to other animals. Information on the distribution and incidence of this disease comes from veterinarians in the county. Prevention is provided by prophylactic drugs and mosquito control. The Western treehole mosquito is commonly found in the rot cavities that form in many local trees. It will also use discarded tires, old fishponds, and most backyard containers as breeding sites. It is most commonly found in hill and riparian areas where there are plenty of trees. The District controls this mosquito by seeking out treeholes near homes and treating them with Altosid®, an insect growth regulator (IGR) in January and February.



Malaria: Although malaria is not presently considered a problem in California, malaria was found in California until the 1940's when it was finally eradicated. California had a high incidence of malaria from the 1850's until about 1920. This disease played an important role in organizing mosquito control in the state. Currently the District monitors cases of malaria that arrive from other countries by immigration and travel. The number of cases arriving in the county has been rapidly rising in the past few years. Malaria is a reportable disease via the public health system. The public health departments monitor the patient to ensure treatment. All four forms of malaria have arrived in the County - Ovale, Malariae, Falciparum and Vivax. When a malaria case is reported, the District inspects all the sources of malaria vectors (*Anopheles freeborni, Anopleles punctipennis*) within 1 mile of the case. Field personnel determine if mosquitoes are present and what control may be needed.



MOSQUITO SURVEILLANCE

Introduction: The District is dedicated to protecting the public from both the discomfort of mosquito bites and potential mosquito-borne diseases. This responsibility involves monitoring (quantification) the abundance of adult and immature (larvae/pupae) mosquitoes, and mosquito-borne disease occurrence over time and space. The practice of monitoring both mosquito densities and the diseases they carry is termed surveillance. Applied properly, surveillance provides the District with valuable information on what mosquito species are present, when they occur, where they occur, how many there are, and if they are carrying disease that affect humans. Equally important is the use of surveillance in evaluating the effectiveness of control actions in reducing mosquitoes and mosquito-borne human diseases.

Mosquito Surveillance Methodologies: Mosquitoes in nature are distributed within their environment in a pattern that maximizes their survival to guarantee reproductive success. Simply stated, this means that mosquitoes occur where they are likely to survive, mate, and produce young. One aspect of mosquito biology is the fact that immature stages develop in water and mature into a winged adult that is capable of both long and short range dispersal. This duality of their life history presents mosquito control agencies with unique circumstances that require separate surveillance strategies for the aquatic versus terrestrial life stages.

Mosquito control staff involved with performing surveillance duties are aware of the consequences of their actions in the field. Staff are instructed to be respectful of the environment and associated wildlife and are to proceed with an attitude to limit their impact to only what is necessary to perform their assigned tasks. Disregard for the environment and attendant abuses are not tolerated in the District's mosquito control surveillance operations.

In our mosquito control work, the District uses, whenever possible existing roads, driveways and trails. The District strives to minimize any off-road vehicle travel. When off-road travel is necessary, District staff is instructed to avoid threatened and endangered plants and sensitive habitat areas and to minimize any environmental damage. Off road vehicle operation is avoided in areas where there is dry vegetation to avoid fire danger.

Non-invasive Sampling: Non-invasive sampling is considered a type of sampling that does not impact the environment directly. Low impact methods include the placement of host-seeking traps, light traps, and artificial resting units (ARUs). In this situation, existing roads, trails, and clearings can be utilized if acceptable for accommodating sufficient surveillance access. Clearings are necessary for the placement of sentinel chicken coops.

Invasive Sampling: Invasive sampling is considered a type of sampling that may impact the environment directly. Where roads, trails, and clearings have to be created to gain access to facilitate surveillance, the consequences may require removal of vegetation and grading to establish roads, trails, and minimal clearings. These actions are necessary to establish sites where routine surveillance actions are necessary based upon established environmental risk factors associated with mosquito breeding and previous history of disease transmission. The District avoids threatened and endangered plant habitat areas and minimizes the scope of the work to the smallest area feasible.

The District monitors mosquito levels in order to determine and track the quantity, location and spread of mosquitoes, to provide the necessary data to make decisions on control measures, and to assess the effectiveness of its control methods. The District staff conduct surveillance and monitoring activities in such a manner as to avoid any significant environmental impacts.

Immature stages: Mosquito immatures include the egg, four larval stages and a transitional pupal stage. ACMAD routinely targets the larval and pupal stages to preclude an emergence of adults. Documenting the presence and abundance of the immature stages is usually limited to the larval and pupal stages. Sampling is accomplished using field collection techniques or aquatic light traps. Operationally, the abundance of the immatures in any identifiable breeding source is measured as the number of immatures (includes numbers representing each individual instar-stage of larval development as well as pupae) per unit volume/area of the source or number per trap night.

Obtaining samples of immature mosquitoes involves removal of some negligible quantities of water. This water may also include nontarget organisms associated with the mosquito immatures. Technicians either will make a count of the immatures present or remove a small number for identification at the agency office laboratory, but then return the remaining contents of the dipper back into the source. Taking dipper samples also requires the technician to wade into the source and repetitively sample/dip along transects to assess the extent and magnitude of immature mosquito populations. Trampling of some vegetation can occur, but most sampling actions involve either walking the shore line or wading through open water gaps that border vegetation (grasses, tules, cattails, algae mats, aquatic plants, etc.) where mosquito immatures are most likely to be found. Technicians are advised not to penetrate dense vegetation for reasons of safety and unnecessary environmental impact.

Field sampling: Sampling for immature stages of mosquitoes is accomplished utilizing a standard dipper attached to a handle, basters for small sources (e.g., treeholes), buckets, aquatic sweep nets, hand strainers and bottom sampling dredge (used for larval midge sampling).

Aquatic larval trap: Aquatic light traps are set out in mosquito sources and left overnight. Generally these are used in marsh sources where dip sampling is not detecting larvae. Larva are attracted to a light source (low voltage battery powered grain-of-wheat lights or bioluminescent stick).

CDC Trap

Fay Trap

New Jersey Light Trap

Aquatic Larval Trap

Oviposition Trap

Adult Sampling: Adult mosquito populations are sampled by hand collection, light traps, CO_2 baited traps, and collections from Artificial Resting Boxes. The District uses New Jersey light traps in fixed locations in the county, Fay traps, CDC traps and ovipostition traps are used in varying locations. Hand collection occurs when field personnel catch adults in the field or during biting counts.

New Jersey Light Trap: This trap is used in fixed locations where 110v electrical service is available. The District maintains eight fixed traps sites that are serviced weekly. This trap captures a wide variety of insects that are attracted to light. *Aedes* mosquitoes are not highly attracted to these traps. Adult mosquitoes are killed in a holding jar using one inch squares of No-Pest Strip Insecticide (2,2-Dichlorovinyl Dimethyl Phosphate) as a killing agent. The traps are in secure locations and are locked to prevent tampering.

CDC Trap: This is a portable battery operated trap used to collect adults of all species. The traps are baited with dry ice giving off CO_2 which attracts adult mosquitoes to the trap. Live adults are captured in a mesh bag. These traps are generally left out overnight and then picked up the following morning. The collected mosquitoes may be frozen for shipment to the State Department of Health Services for virus testing.

Fay Trap: This is another portable battery operated trap used to collect adults of all species. The traps are baited with dry ice releasing CO_2 which attracts adult mosquitoes to the trap. Live adults are captured in a mesh bag. These traps are generally left out over night and then picked up the following morning. The collected mosquitoes may be frozen for shipment to the State Department of Health Services for virus testing.

Oviposition Trap: This is a portable battery operated trap used to collect gravid (egg laying) female mosquitoes. The bait for this trap is a solution created by mixing water, green alfalfa, brewers yeast and lactalbumin which is aged in a plastic garbage can in a sunny location. The odor from this mix attracts gravid female mosquitoes to the trap. The fan then pushes these mosquitoes into a mesh holding bag. This trap is primarily used to monitor *Culex pipiens* and catches some *Culiseta incidens*, *Culex stigmatosoma* and *Culex tarsalis*. These traps are left out overnight.

Artificial Resting Units: The District has occasionally used red boxes (a box with one open side - painted red) as collecting places. These were most often used to monitor anophelene mosquitoes.

Hand Collection: Adult mosquitoes can be collected by hand using nets, killing tubes or aspirators. Mosquitoes are caught in resting areas or during biting counts. The collector may be the primary bait to attract the adults for hand collection.

TRANSPORTATION AND ACCESS FOR MONITORING AND CONTROL

Access and transportation to potential and known mosquito producing sources is a necessity to accomplish surveillance and control treatments. It is necessary to be able to reach mosquito producing areas reliably, easily, safely and quickly with the minimum of environmental impact.

Normal mosquito surveillance and control necessitates the use of access roads, trails, and clearings to facilitate sampling. Roads allow vehicles to transport needed staff and equipment to specific sites. The ideal access is an all-weather surfaced road that then provides close foot access to all parts of a mosquito source. Vehicle access may necessitate requesting the owner to schedule periodic grading and gravel surfacing of roads or the periodic removal of some marginal vegetation and weed control on the median between the wheel ruts of established dirt/gravel roads. Foot access may require trails (2-3 feet in width) to the margins of wetlands, ponds, streams, and rivers that may require periodic vegetation removal by pruning if necessary.

The District depends on foot, general use vehicles, ATV (all terrain vehicle), boat and aerial travel access to mosquito producing areas for inspections and treatments. Below are descriptions of these and discussion on their uses, limitations, impacts and measures to avoid impacts.

Foot: Travel on foot is the most common access for inspections and treatments of small sources. Limited areas and distances can be covered on foot. There is always risk of injury from tripping and falling especially when carrying treatment equipment (hand cans, backpack sprayer, bulk materials such as granular insecticides) or crossing irregular or heavily vegetated areas. This form of travel causes the least environmental impacts due to the District's access Travel on foot is preferred when areas to be inspected or treated are of reasonable size. Foot travel allows careful avoidance of nests, critical micro habitats and endangered or threatened plants. Combined use of vehicles and foot travel can minimize vehicle impacts in sensitive habitats (entering sources on foot from vehicle or ATV access can be used to inspect and treat large areas). Mitigation: Personnel are provided with protective foot wear to minimize personal injury. Use foot access as much as possible from roads when checking or treating sensitive habitats. Remain out of areas when endangered or threatened birds are nesting. Change entry points when possible to avoid creating beaten paths.

General Use Vehicles: The District uses both two wheel and four wheel drive vehicles for field use to get close to mosquito sources. Two wheel drive vehicles are used in control areas that are primarily urban with little need for off road or dirt surfaced road driving (two of these vehicles are set up for right hand drive to facilitate urban storm drain inspection and treatment). Four wheel drive vehicles are provided for areas where dirt road and off road driving will be needed. Most of the District's field use vehicles are also equipped with electric or gas power spray rigs and are also able to pull a trailer with an ATV.

1. **Two wheel drive vehicles:** These are for urban and surfaced road use.
2. **Right hand drive vehicles:** Used in inspecting and treating road side ditches and storm drains.
3. **Four wheel drive vehicles:** These vehicles are used where off road or unsurfaced road travel is necessary. These vehicles may create impacts on the environment during their normal operation:

Dust: Unsurfaced roads develop a layer of dust that will be disturbed and become airborne when a vehicle passes over them. Depending upon air flow in the area the dust may drift and settle onto surrounding vegetation. Mitigation: Travel speed is set at a level for each situation that minimizes dust and dust drift or travel is done on less dusty accesses if possible.

Rutting: Unsurfaced roads or land, when wet from rain may become too soft to drive without creating ruts. Conditions sometimes occur with the first rains of the season arrive that create a layer on top of the road of wet dust (mud) with dry dust or ground underneath. This will stick to tires or tracks and "peel" off the road creating large clods and ruts (generally this will also stop the vehicle when the wheel wells fill with mud, requiring another vehicle for retrieval). Mitigation: Travel is restricted until area stabilizes after first seasonal rains. Personnel may utilize other access points or substitute foot or ATV travel for vehicle travel. No vehicle travel is done in sensitive habitat areas. No vehicle travel is done where endangered or threatened plants occur (e.g. Vernal pools in South Fremont area and in the Springtown area of Livermore).

Vegetation removal: Vegetation on the land or road may be removed by the scraping of the tires during driving or when making turns. Mitigation: Avoid fast or sharp turning and accelerate gently to avoid spinning tires. Personnel may utilize other access points or substitute foot or ATV travel for vehicle travel. No vehicle travel is done in sensitive habitat areas. No vehicle travel is done where endangered or threatened plants occur (e.g. Vernal pools in the Springtown are of Livermore).

Vegetation crushing: Whenever a vehicle drives over vegetation, pressure from the weight of the vehicle will crush down on any vegetation. The amount of any permanent damage depends on the type of vegetation and the condition of the vegetation. Most effects of crushing vegetation disappears as the vegetation returns to its normal stand or at worst last until the next growth season occurs. Mitigation: No vehicle travel is done where

endangered or threatened plants occur (e.g. Vernal pools in the Springtown area of Livermore). No vehicle travel is done on sensitive habitat areas or where vegetation is tender and subject to visible lasting damage.

Fire: California state law requires vehicles to be equipped with a catalytic converter that operates at high temperatures creating the potential for starting fires when driving in dry vegetation. Mitigation: Travel is not done in areas where dry vegetation is high enough to contact the converter and vehicles are not parked over dry vegetation. All vehicles are equipped with a fire extinquisher, a shovel and are in radio communication with the District office. No vehicle travel is done where endangered or threatened plants occur (e.g. Vernal pools in the Springtown area of Livermore).

Wildlife: The act of traveling in off road or unsurfaced road areas can disturb wildlife or cause injury or death. Most disturbance from vehicle travel is of no lasting impact to wildlife. Animals and birds move to avoid a perceived threat. Injury, death or damage to nests may occur from direct contact with the vehicle. Mitigation: Personnel travel at reduced speeds during off road and unsurfaced road travel to allow birds and animals time to adjust to the vehicle and move out of the way. Potential nesting areas on roads or areas to be traveled are avoided. Access within visibility and disturbance range of Snow plover nesting areas are off limits to travel during nesting season (areas are delineated by wildlife officials and fortunately there are very few mosquito producing habitats in the preferred nesting areas).

District ATV's: The District currently uses two types of all terrain vehicles .

Argo: Argos are eight wheeled, plastic body all terrain vehicles manufactured by Ontario Drive and Gear Limited. These are run with and without tracks depending upon local conditions. Ground pressure is 2.1 psi. These vehicles can carry two people and a 50 gallon spray rig. Argos will float and can be equipped with an outboard motor for deep water use. These vehicles are used for monitoring and treatment.

DMC 1200: The De Lorean 1200 is used primarily by the District for speed scavel ditching and large treatment operations. This vehicle is a "snow cat" modified for operations on soft mud. The ground pressure is .87 psi. This vehicle can carry three people and a 100 gallon spray rig.

All Terrain Vehicles (ATVs): The District relies upon the use of all terrain vehicles to facilitate access into areas that are not otherwise reasonably accessible by foot or general use vehicles. Some situations, where flooding and wetlands preclude access by 4-wheel drive or reasonable walking distance in waders/boots, require the use of an ATV. ATV's allow timely and effective inspection and treatment of large areas (over 5 acres) or areas where vehicle access cannot be used and greater distances need to be covered to reach mosquito sources. During the wet season, ATV's are used more extensively to enable personnel to cover more sources quickly. Overall, ATVs are used as transport of last resort. ATV's are used where:

1) existing passages are available,
2) vegetation does not impede mobility,
3) open water situations present the best course in which to proceed
4) size and distance makes the use of these vehicles necessary for effective and efficient use of time and
5) unacceptable environmental damage may occur if a general use vehicle is used.

The potential impacts from ATV use and the District's way of mitigating these impacts are discussed below:

Dust: Dust is generally never a problem as most ATV use is during the wet season.

Rutting: ATV travel is used because of the very low ground pressure from the vehicle on areas too soft for general use vehicle traffic. Even with the low ground pressure ruts can be created. Mitigation: Open mud and very soft areas are avoided during ATV use. Travel is done slowly and carefully on sensitive habitat areas (pickle weed marshes). No ATV travel is done where endangered or threatened plants occur (e.g. Vernal pools in the Springtown area of Livermore).

Vegetation removal: Vegetation may be removed by the scraping of the tires or tracks during operations or when making turns. Mitigation: Fast or sharp turning is avoided or turns are made on areas outside of the marsh such as levee roads. Personnel may utilize an ATV as a material supply point while inspecting or treating on foot. ATV travel is done slowly and carefully in sensitive habitat areas. No vehicle travel is done where endangered or threatened plants occur (e.g. Vernal pools in the Springtown area of Livermore).

Vegetation crushing: Whenever a vehicle drives over vegetation, pressure from the weight of the vehicle will crush down on some vegetation. The amount of any damage depends on the type of vegetation and the condition of the vegetation. Most effects of crushing vegetation disappears as the vegetation returns to its normal position or at worst last until the next growth season occurs. A study was done on ATV travel in salt marsh habitats by the University of California (Hannaford and Resh). The study did show impacts on marsh vegetation from travel. The study was done during the active growing season when vegetation was most susceptible to impacts. Most

of the travel done by the District is done during the dormant season before active growth occurs so impacts would be expected to be minimal. One of the impacts from ATV use is the visibility of track marks for a short period. The visibility is from wetting the vegetation as the vehicle drives over, the light coating of mud on the vegetation from the wetting and the temporary impression left in the vegetation. This visibility impact has caused occasional complaints to wildlife personnel about possible unauthorized vehicle travel in the marsh. Mitigation: No vehicle travel is done where endangered or threatened plants occur (e.g. Vernal pools in the South Fremont area or Springtown area of Livermore). ATV travel is kept to the minimum necessary and done slowly and carefully in marsh habitats. Areas where vegetation is tender and subject to lasting damage are avoided. Points of entry into sources are varied if possible to avoid multiple travel over the same area. ATV travel directions are adjusted to avoid causing visible disruptions.

Fire: Fire danger is not problem in the season ATV travel is necessary.

Wildlife: The act of traveling in many areas can disturb wildlife or cause injury or death. Most disturbance from ATV travel is of no lasting impact to wildlife. Animals and birds move to avoid a perceived threat. Injury, death or damage to nests may occur from direct contact with an ATV. Mitigation: ATV operations are normally done at low speeds allowing birds and animals time to adjust to the vehicle and move out of the way. Potential nesting and burrowing (burrowing owls) areas are avoided or carefully surveyed for nests. Travel in Snow plover nesting areas is not a problem for ATV operations because few mosquito producing habitats are found near the preferred nesting areas and ATV operations do not generally occur during nesting season.

Inspection using an Argo

Inspection using District Boat

Helicopter application

District Boat: District personnel use a 14' aluminum outboard equipped boat to inspect and treat large deep water bodies and islands. The most common areas of boat access are gravel pits, Alameda Creek and Arroyo Del Valle Creek. The boat is the best access to inspect and treat the aquatic plant mats, algae mats and islands for mosquitoes. Boat use minimizes vehicle travel in off road areas of the creek beds and hazardous terrain along shorelines for carrying treatment equipment on foot. Boat operations do not have any lasting environmental impacts.

Aerial: The District uses a contract agricultural application service to provide helicopter treatments to large source areas. Helicopter operations are done at very low altitude in areas away from people. The advantage of using a helicopter is speed of application to large areas without contact with the ground surface (no vegetation disturbances) at a reasonable per acre cost. A helicopter can treat up to 500 acres per hour. Helicopter applications are used when sources needing treatment are very large (200+ acres total) or the time constraints on personnel and equipment require its use. All Applications in the last 20 years have been during the winter months to salt marshes. The impacts from aerial operations are:

Wildlife: The act flying can disturb wildlife or cause injury or death. Most disturbance from helicopter operations is of no lasting impact to wildlife. Animals and birds move to avoid a perceived threat. Injury or death can occur from direct contact with helicopter rotors. Mitigation: The helicopter pilot avoids large concentrations of birds.

Noise: Helicopter operations can cause temporary higher than normal and distracting noise levels. These noise levels are of a very short duration (less than an hour). Mitigation: Plan operations to keep needed time for completion to a minimum.

Recreation and Access: Helicopter operations require the District to close walking trails and restrict access into flight areas for public safety. District personnel will ensure the area is clear before operations begin and prevent any entry during the operations. Personnel are in radio contact at all times during helicopter operations. Mitigation: Plan operations to keep needed time for completion to a minimum. District personnel will prevent entry during operations and explain the operation to the public ("watching the helicopter" is a recreational experience that appears to be enjoyed during these operations).

On the next page is a chart of the general accepted and non-accepted accessfor District field operations. This chart provides a general overview of the selection of the type of access and equipment for different conditions, sources and wildlife nesting. The notation "acceptable with care" requires full consideration of environmental impacts.

ACCESS SELECTION CRITERIA
ALAMEDA COUNTY MOSQUITO ABATEMENT DISTRICT

● ACCEPTABLE
◐ ACCEPTABLE WITH CARE
⊕ NOT ACCEPTABLE
BLANK = NOT APPLICABLE

		Access for Inspection and Treatment								
		Foot	2-wheel	Right Hand	4-wheel	Argo ATV	DMC ATV	Boat	Aircraft	
Road Condition & Type	Paved Urban Streets	●	●	●	●					
	All Weather Gravel Roads	●	●	●	●	●	●			
	Dry Dirt Roads	●	●	●	●	●	●			
	Wet Dirt Roads	●	◐	⊕	●	●	●			
	Soft Mud on Roads	●	⊕	⊕	◐	◐	◐			
General Source Conditions	Dry Surface Cross County Travel	●	●	●	●	●	●			
	Wet Surface Cross County Travel	●	⊕	⊕	◐	●	●			
	Soft Mud	●	⊕	⊕	⊕				●	
	Shallow Water to 3' Deep	●	⊕	⊕	◐	●		●	●	
	Deep Water Over 3' Deep	⊕	⊕	⊕	⊕	◐		●	●	
	Deep Dry Vegetation	●	⊕	⊕	⊕	⊕	⊕			
Special Sources	Vernal Pool Areas	◐	⊕	⊕	⊕	⊕	⊕			
	Salt Marshes	●	⊕	⊕	⊕	◐	◐		●	
	Temporary Water	●	⊕	⊕	◐	●	●		●	
	Creeks	●	⊕	⊕	◐	◐		◐		
Wildlife	Active Nesting Areas Endangered Species	◐	⊕	⊕	⊕	⊕	⊕		⊕	

BIOLOGICAL CONTROL OF MOSQUITOES.

Introduction: Biological control of mosquitoes is the intentional use of mosquito pathogens, parasites or predators to reduce the size of target mosquito populations. It is one of the principal components of a rational and integrated mosquito control program. As resistance to pesticides and environmental concerns become more prevalent, biological control will be used more often as a method of protecting the public from mosquitoes and the diseases they transmit.

Biological control of mosquitoes is a relatively recent development and can be traced to observations and ecological studies in the 1940s and 1950s. Early investigations studied the potential effects of predators on mosquitoes. Results of such studies have been adopted in developing strategies to use mosquito predators in providing economical and sustained levels of control.

Biological Control Agents: Biological control agents of mosquitoes include a wide variety of pathogens, parasites and predators. As a rule, mosquito pathogens and parasites are highly specific to their mosquito host, whereas predators are more general in their feeding habits and opportunistically feed on mosquitoes.

Mosquito Pathogens: Mosquito pathogens include an assortment of viruses and bacteria. They are highly host-specific and usually infect mosquito larvae when they are ingested. Upon entering the host, these pathogens multiply rapidly, destroying internal organs and consuming nutrients. The pathogen can be spread to other mosquito larvae in some cases when larval tissue disintegrates and the pathogens are released into the water to be ingested by uninfected larvae.

Examples of viruses that can infect mosquitoes are mosquito iridoviruses, densonucleosis virus, nuclear polyhedrosis viruses, cytoplasmic polyhedrosis viruses and entomopoxviruses. Examples of bacteria pathogenic to mosquitoes are *Bacillus sphaericus* and several strains of *Bacillus thuringiensis israelensis*. These two bacteria produce proteins that are toxic to mosquito larvae. Both are produced commercially as mosquito larvicides.

Mosquito Parasites: The life cycles of mosquito parasites are biologically more complex than those of mosquito pathogens and involve intermediate hosts, organisms other than mosquitoes. Mosquito parasites are ingested by the feeding larva or actively penetrate the larval cuticle to gain access to the host interior. Once inside the host, parasites consume the internal organs and food reserves until the parasites' developmental process is complete. The host is killed when the parasite reaches maturity and leaves the host (*Romanomermis culicivorax*) or reproduces (*Lagenidium giganteum*). Once free of the host, the parasite can remain dormant in the environment until it can begin its developmental cycle in another host. Examples of mosquito parasites are the fungi *Coelomomyces* spp., *Lagenidium giganteum, Culicinomyces clavosporus* and *Metarhizium anisopliae*; the protozoan *Nosema algerae, Hazardia milleri, Vavraia culicis, Helicosporidium* spp., *Amblyospora californica*, *Lambornella clarki* and *Tetrahymena* spp.; and the nematode *Romanomermis culicivorax*.

Mosquito Predators: Mosquito predators are represented by highly complex organisms, such as insects, fish, birds and bats, that consume larval or adult mosquitoes as prey. Predators are opportunistic in their feeding habits and typically forage on a variety of prey types. This allows the predators to build and maintain populations at levels sufficient to control mosquitoes, even when mosquitoes are scarce. Examples of mosquito predators include representatives from a wide variety of taxa: coelenterates (Hydra spp.); platyhelminths, *(Dugesia dorotocephala, Mesostoma lingua*, and Planaria spp.); insects, (Anisoptera, Zygoptera, Belostomidae, Geridae, Notonectidae, Veliidae, Dytiscidae and Hydrophilidae); arachnids, (Pardosa spp.); fish, *(Gambusia affinis, Gasterosteus aculeatus,* and *Poecillia reticula)*; bats; and birds, anseriformes, (apodiformes, charadriiformes and passeriformes).

Environmental Relationships in Biological Control: The effectiveness of a mosquito biological control agent lies in its ability to reduce mosquito numbers as quickly as possible. An ideal biological agent:

1) feeds preferentially on mosquitoes,
2) exhibits an extremely efficient hunting or parasitizing strategy, and
3) reproduces quickly.

These traits determine suitability for practical application.

New mosquito sources initially have few predators and other competing aquatic organisms. Mosquito control personnel use this knowledge to develop a control strategy that involves integrated pest management techniques.

Since mosquitoes are capable of colonizing sources within days of flooding, initial control efforts attempt to suppress the first generations of mosquitoes until natural predators or competitors can control them. Initial treatment includes the selective use

of pesticides and appropriate environmental manipulation, such as vegetation and water quality management. Once biological control is established in a managed source, periodic inspections at timely intervals are adequate to monitor changes in larval abundance. Periodically, the source may require treatments with pesticides when:

1) predators are not effective,
2) aquatic and shoreline vegetation provides too much shelter from predation,
3) the water level changes, or
4) water quality does not support predators

Conservation and Application of Predators: Predator effectiveness is enhanced when proper conditions are present. The ability of predators to control mosquitoes, is related to four factors:

1) whether mosquitoes are preferred prey,
2) whether the hunting strategy of the predator maximizes contact with mosquitoes,
3) whether the predator consumes large numbers of mosquitoes, and
4) whether the predator is present in sufficient numbers to control mosquitoes.

Within a typical aquatic environment that produces mosquitoes, predators are distributed among different substrates. For example the surface of the pond supports water striders, planaria and spiders. Below the water surface, backswimmers, predaceous diving beetles and water scavenger beetles live and feed. If the pond contains vegetation, then the plant surfaces (periphyton) will support Hydra, damselfly and dragonfly nymphs, and giant water bug nymphs and adults. The benthos supports dragonfly and damselfly nymphs that feed on organisms associated with silts and organic detritus. Together, the different predators form a spatial network that accounts for predation throughout the pond. Ideally an adequate variety of vegetation should be present to maintain sufficient levels of predator diversity. Greater potential for an acceptable level of mosquito control exists when more predators are present. Care should be taken so that mosquitoes do not have an advantage when too much or too little vegetation is removed.

Most of the currently registered mosquito larvicides minimally impact predators. Making applications at the lower end of the label rate can further minimize any undesirable impacts from these larvicides. The overall objective of using predators is to reduce the frequency of pesticide applications. This minimizes environmental impact and delays the development of mosquito resistance to pesticides.

Predation on mosquitoes is a natural process that will occur without human intervention. However, the level of mosquito control by natural predators can be increased by the conservation of predators in the environment and by augmentation of the predator population through stocking and habitat enhancement.

Practical Applications of Biological Control Agents: Relatively few biological control agents are currently being used in California, although a number have been studied and tested extensively in the laboratory and field. Many have shown potential, but have not been used for a variety of reasons, including:

1) difficulties in mass production,
2) failure to produce a consistent level of control,
3) expense, and
4) restricted application because of environmental concerns.

Most agents, particularly predators and parasites, are only effective in association with mosquitofish and larvicides. Currently, the only practical biological control agents available to vector control agencies in California are *Bacillus thuringiensis israelensis, Bacillus sphaericus, Lagenidium giganteum* and the mosquitofish *Gambusia affinis.*

Microbial Agents and Mosquito Control: Commercial formulations of *Bacillus sphaericus* and *Bacillus thuringiensis israelensis* are extensively used as mosquito larvicides. Both are highly selective for mosquitoes and are innocuous to associated non-target organisms and predators. *Bacillus thuringiensis israelensis* is also toxic to black flies, a pest and disease vector.

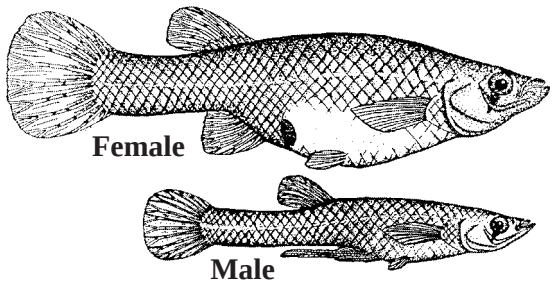
Bacillus thuringiensis israelensis and *Bacillus sphaericus* are often considered chemical control measures because they are available in commercial formulations that consist of granular, powdered or liquid concentrates. The use of these two microbials is also discussed under the chemical control section. (Part IV, pages IV-49-51).

***Lagenidium giganteum* and Mosquito Control:** *Lagenidium giganteum* is a fungal parasite of mosquito larvae. Motile zoospores enter mosquito larva either when ingested or by penetrating the cuticle. The fungus grows rapidly throughout the host body cavity and once the host dies, zoospores are released that can infect other larvae.

Lagenidium giganteum is a highly specific parasite of mosquito larvae. Other organisms are not susceptible and there is no mammalian toxicity. However, use of *L. giganteum* is limited because of environmental requirements for growth and development of the fungus.

Lagenidium giganteum is available commercially as an aqueous suspension. It contains 40% *L. giganteum* (California strain) mycelium (1010 CFU or Colony Forming Units, a concentration measure by cell counts per liter) and 60% inert ingredients. *Lagenidium giganteum* may be applied from ground or air. Label rates range from 9 to 180 fluid ounces per acre. Most treatments will require 20 to 80 fl. oz./acre, a common rate is 25 fl. oz./acre. Zoospores form within 16 hours after application and mortality occurs within 24 to 48 hours.

Mosquitofish and Mosquito Control: *Gambusia affinis* is the most commonly used biological control agent for mosquitoes all over the world. The mosquitofish was first introduced into California in the 1920's and has been used by the District since the 1930's. Correct use of this fish can provide safe, effective, and persistent suppression of a variety of mosquito species in many types of mosquito sources. As with all safe and effective control agents, the use of mosquitofish requires a good knowledge of operational techniques and ecological implications, careful evaluation of stocking sites, use of appropriate stocking methods, and regular monitoring of stocked fish.



Aquatic Habitats: Mosquitofish are used to control mosquitoes in a wide variety of mosquito sources. These sources include both artificial and natural water bodies: dairy, industrial and municipal wastewater ponds; flood control basins; neglected swimming pools, ornamental ponds and water troughs; irrigation and roadside ditches; and such wetlands areas as marshes, sloughs and stream seepages and potholes.

A high density of mosquitofish is required to control mosquitoes. In general, suitable habitats promote reproduction and recruitment rather than just sustaining the stocked mosquitofish population. Sources where conditions do not favor population growth may not be suitable for mosquitofish use, or may require stocking at substantially higher rates.

The principal habitat characteristic that affects the successful use of mosquitofish is its relative stability. Mosquitofish usually are not effective in intermittently flooded areas unless a refuge impoundment is provided. Because of this, mosquitofish are more effective against mosquitoes breeding in permanent and semi-permanent water, such as Culex spp., Anopheles spp., and Culiseta spp., than against floodwater species, like Aedes spp. Mosquitofish are best suited for use in shallow, standing water and are particularly useful in large sources such as gravel pits where the repeated use of chemical control is expensive or impractical.

Availability of food, other than mosquito larvae, and shelter are also important factors affecting the suitability of a site. Mosquitofish survival, growth, and reproduction are highly dependent on diet and feeding rates. Shelter to protect the young from cannibalistic adults is essential for population growth. Vegetation or other shelter may also reduce predation on adult mosquitofish by birds, larger fishes, and other predators.

Habitats in which the water quality conditions, particularly temperature, dissolved oxygen, pH, and pollutants, exceed the tolerance limits of mosquitofish are not suitable sites for biocontrol. In sources with poor but sublethal water quality, feeding, reproductive activity and consequently mosquito control, may be adversely affected. Use of mosquitofish is sometimes possible in suboptimal environments that inhibit reproduction, but special stocking and monitoring methods may be required.

Heavily shaded and cool water sources such as small creeks are not well controlled by mosquitofish. The fish tend to migrate to sunny pools and avoid the deep shade and cool water.

The presence of piscivorous fishes or other predators in the source habitat may rule out stocking with mosquitofish. High densities of invertebrate and vertebrate predators, such as notonectids and young game fish, which prey on both small mosquitofish and mosquito larvae, can prevent mosquitofish population growth.

Stocking Methods: Stocking methods can have significant effects on the degree of mosquito control achieved. In most cases, the objective is to release the minimum number of fish at the time when conditions within the source promote rapid population growth and at locations which facilitate dispersal throughout the source. The most appropriate methods depend on the type and location of the mosquito source, season, and the degree and duration of control desired.

Stocking Rate: Mosquitofish generally are released at densities lower than those necessary for mosquito control with the expectation that reproduction and recruitment will greatly increase the fish population within a few weeks. The best stocking rate depends primarily on the type of mosquito source, season, and mosquito control objective, for example immediate control vs.

control later in the season. Understocking can result in inadequate mosquito control whereas overstocking may result in excellent control, but is wasteful of the usually limited fish supply.

Stocking rates are usually reported as fish per acre, or pounds of fish per acre. The number of mosquitofish per pound depends on the population structure of the sample (e.g., a mixed population of adults and juveniles versus a sample containing only mature females), source (e.g., cultured vs. wild-caught fish), and even season (early versus late in the breeding season). In general, for a mixed population, there are approximately 600-1,300 fish/lb. The most common estimate is 1000 fish/lb.

For early season stocking of mosquito sources that contain healthy populations of food organisms and adequate vegetation to provide shelter for the small mosquitofish, 0.2-0.5 lb./acre is appropriate. Higher stocking rates are necessary in a variety of circumstances, including: late season stocking and/or short flooded season. In these situations, mosquitofish population growth is reduced as a result of a shorter breeding season and declining thermal and photoperiodic stimuli for breeding; poor quality environments which depress or inhibit reproduction and/or feeding, for example, habitats characterized by low temperature, low light, or high levels of chemical or organic pollution; sources in which immediate mosquito control is desired and sources which harbor high densities of mosquito larvae.

In artificial containers such as fish ponds, watering troughs, swimming pools, etc. the number of fish stocked needs to be sufficient to produce a stable population for long term control. Usually 10 or more fish per container arestocked.

Fish Supplies: The District generally does not have a large supply of fish for stocking until the late spring or early summer. Most of the sources to obtain local mosquitofish do not begin to produce quantities until that time. The District purchases fish for early season use from several other mosquito control agencies that have large scale rearing facilities. As a result of the short early season supplies, fish are not used for control of Aedes sources (e.g. *Aedes washinoi*) or generally in any temporary waters that will dry by early summer.

Stocking Date: Date of release of mosquitofish into a mosquito source affects biocontrol efficacy primarily through its influence on mosquitofish population growth. The age of the source affects its quality; both food and shelter may be sparse in new habitats. In mosquito sources stocked late in the season, population growth is reduced because of the shortened breeding season and declining reproductive stimuli. Stocking date necessarily varies with type of mosquito source but, in general, mosquitofish are to be released one to three weeks post-flooding. Mosquito sources that require late season stocking, such as duck club ponds usually should be stocked with higher numbers of fish or treated with supplemental larvicides.

Stocking Location: A sufficient number of mosquitofish must be stocked where mosquito larvae are present. Although mosquitofish can swim through dense vegetation, dispersal throughout a large habitat such as a gravel pit takes time and is slowed by the presence of additional barriers such as vegetation or complicated shorelines.

The size and complexity of a source are important considerations when determining the number and locations of release sites. In large, complicated habitats, such as gravel pits or wastewater marshes, mosquitofish are typically released at several locations. For small sources, all fish may be released at a single site.

Water flow may also be a consideration. In general, mosquitofish are stocked at the upstream end of the source since fish tend to move downstream from the release site.

Handling Release and Monitoring: Most mosquitofish are released by hand. Care is taken to minimize stress. Abrupt changes in water temperature are avoided. Fish are transported in water at a temperature similar to that at the end source. Mosquitofish are not stocked during extremely hot weather or when water temperature approaches the upper tolerance limits of the fish (>35C or 95˚F).

After stocking, mosquitofish populations are monitored regularly to assess fish density, population growth, and biocontrol efficacy. A low number of fish may necessitate restocking or alternative mosquito control efforts.

The minnow trap is the most commonly used tool for assessing mosquitofish populations in large sources and, when used properly, it is effective and reliable. A minnow trap consists of a fine mesh cage with one or two inset funnel-shaped openings oriented with the narrow ends pointed into the cage. Fish enter the trap easily; the outer opening is wide and directs the fish into the cage. Once inside, the only exit is the narrow opening and few fish escape. Minnow traps are set so that a portion of the trap is above the anticipated maximum water level. This insures that surface feeding mosquitofish are captured and allows captured fish access to the surface for survival during episodes of low dissolved oxygen (e.g., predawn hours).

The number of fish captured in a trap is positively correlated with the total number of fish in the habitat. Frequency of monitoring is optional but, for reliability between samples, minnow traps are deployed for equal amounts of time. The District generally leaves traps in place for 24 hours.

Advantages of Mosquitofish for Biological Control: Many species of larvivorous fish have been evaluated as agents to control mosquitoes, including various species of atherinids, centrarchids, cichlids, cyprinids, cyprinodontids, gasterosteids, and other poeciliids. However, mosquitofish are considered best suited from both biological and operational perspectives.

Mosquitofish possess characteristics which make them efficient predators of mosquito larvae. They thrive in shallow, calm, vegetated waters, which is the same environment where many mosquitoes prefer to lay eggs. Mosquitofish tolerate wide ranges of water temperature and quality. Mosquitofish are surface-oriented predators where mosquito larvae are an accessible prey. The small size of the fish enable them to penetrate vegetated and shallow areas within the mosquito source. Mosquitofish are live-bearers that grow rapidly, mature at a young age, and reproduce quickly. This allows the fish to establish a high population in the source shortly after stocking. In many sources, seasonal peaks in mosquitofish activity and population growth coincide with mosquito reproduction times. Because of their omnivorous feeding habits, mosquitofish can thrive in habitats where mosquitoes occur intermittently.

Mosquitofish are hardy and easy to handle, transport, and stock. As a result of extensive research and practical experimentation in California, mosquitofish can be reliably cultured in large numbers. Problems still exist in some areas with winter survival rates and inadequate supplies of fish in the spring. Because the fish reproduce where they are stocked, long-term control can be achieved by stocking relatively few fish, often in a single application. Compared to pesticides, which require repeated applications, mosquitofish can provide inexpensive and safe long-term control, sometimes within days after application. Although not all introductions are successful, mosquitofish are an effective biological control agent alone and as a component of an integrated pest management program.

Limitations to Use of Mosquitofish for Biological Control: Not all types of mosquito sources are suitable for stocking with mosquitofish and mosquitofish are not effective in all situations. Heavily polluted water such as sewer treatment plants will not support fish, but can still produce large populations of mosquitoes. Since mosquitofish usually are not stocked in numbers sufficient to cause an immediate effect, they do not control mosquitoes as quickly as pesticides do.

Deciding Whether or Not to Use Mosquitofish: Mosquito control and public health professionals believe the effectiveness and safety of mosquitofish to be ecologically preferable to the application of pesticides or draining of mosquito sources. The use of mosquitofish as a component of an integrated pest management program, particularly in domestic, commercial, urban, altered or artificial aquatic habitats, is increasingly more important with the limited availability of registered pesticides and as insect resistance to pesticides increases. As agents for biological control of mosquitoes, mosquitofish deserve consideration, and, in many specific situations, are the best choice for mosquito control.

Environmental Impacts of *Gambusia affinis*:

The mosquitofish is not a native to California and may have detrimental effects to native organisms by direct predation, competetion or displacement in an ecosystem. The potential impacts are below:

Direct damage to Endangered or Threatened Species: Endangered or threatened species such as fairy shrimp or tadpole shrimp may be readily consumed by mosquitofish. In close contact (small sources) they may bite or harass tadpoles.

Competition for food supply: Mosquitofish may compete for food with native fish.

Displacement: The mosquitofish may cause native fish to be displaced.

Mitigation:

Though mosquitofish are not native to California, they are now ubiquitous throughout most of the state's waterways and tributaries. In much of the state's wetland areas, mosquitofish are now part of the natural ecosystem. Also, much of the aquatic habitat that is highly productive for mosquitoes is disrupted habitat, with flora and fauna that are predominately nonnative species. In these areas, stocking of mosquitofish will have minimal impact on native non-target species.

Many precautions are taken to minimize the environmental impact in habitats where mosquitofish are introduced. Mosquitofish are introduced into wetland communities that are biologically complex. The impact on habitats that contain native fishes or native amphibian populations are especially considered and weighed prior to any introduction. Mosquitofish are stocked only in careful compliance with federal and state endangered species acts, so as to avoid the potential to harass or harm.

District policies on stocking mosquitofish (*Gambusia affinis*): The District has a policy on stocking mosquitofish to avoid adverse impacts on endangered or threatened species and habitats. Any areas identified as habitats for endangered or threatened species that can be impacted by the introduction of mosquitofish or are connected to these habitats are not considered for stocking. Species of special concern are fairy shrimp and tadpole shrimp. Although research by the University of California at Davis has indicated mosquitofish are not the major threat to amphibian species (red-legged frog, *Rana aurora draytonii*), stocking is avoided in areas where the red-legged frog and tiger

salamander occur.

District Mosquitofish Program: The District provides *Gambusia affinis* upon request without charge for uses compatible with environmental considerations. The District does not stock fish in vernal pools or in most temporary storm water areas. Stocking is not done in water sources which connect to areas where fairy shrimp or tadpole shrimp may occur. In the past (prior to the 1990's), mosquitofish were stocked in rural and natural areas. Currently stockings are avoided in these areas. As stock ponds, creeks and marshes in non-urban areas have dried out, mosquitofish populations have disappeared. Mosquitofish are not being restocked into these sources.

Reviewing data for the District from January1996 - June 1999, shows that locations of mosquitofish stockings were 89% domestic, 5% Agricultural, 3% commercial and 3% natural sources. There were 5092 domestic mosquitofish stockings of which 93% were fish ponds, 6% other (containers, spas, birdbaths, wells) and 1% were swimming pools. There were 260 agricultural stockings of which 88% were watering troughs, 12% stock ponds (records indicate that the stock pond code is used for retention ponds, golf course irrigation and water trap ponds). Commercial sources were lined and unlined channels, sumps, pickle vat-tanks, gravel pits, sewer ponds, and roadside ditches). Natural sources stocked with fish were creeks, lakes, small marshes. The location records for these natural sources indicate these stocking were within urban areas. When drying has occurred the District is not reintroducting mosquitofish into rural ponds, stock ponds, creeks or natural areas. The emphasis of the District program is on permanent and semi-permanent sources within urban areas.

District Fish Stocking Policy

(Provided to anyone requesting fish)

In an effort to minimize unwanted environmental impacts, mosquito abatement personnel do refrain from planting mosquitofish in sources known or thought to be habitats for endangered or threatened species. Care must be taken when planting mosquitofish in sources where fish can migrate to habitats used by endangered or threatened species. Mosquitofish can still be planted in ornamental fish ponds and swimming pools in urban and suburban areas without worrying about endangered species conflicts. It is against California Department of Fish and Game regulations for private citizens to plant mosquitofish in waters of the State without a permit. (Title 14 CCR, Fish and Game Code, Section 1.63, Section 6400, and Section 238.5).

Mosquitofish provided by Alameda County Mosquito Abatement District are intended for mosquito control purposes only and should not be planted in potential mosquito sources by anyone other than certified mosquito control technicians or Fish and Game personnel.

Moquitofish plants that should not be a problem for endangered species include:

Fish plants in residential ponds or swimming pools.
Fish plants in watering troughs.
Fish plants in flood control canals (by mosquito control technicians).
Fish plants in gravel pits (by mosquito control technicians).

Mosquitofish plants that require care to avoid conflicts with endangered species include:

Vernal pools and temporary rain filled low areas.
Seasonal stock ponds - in rural areas of the County.
Slow-moving seasonal creeks - especially those that connect to other potential habitats.

Other fish used by the District: Although the District does not directly control midges (*Chironomidae* sp.), the District has assisted in providing biological control using Sacramento blackfish (*Orthodon microlepidotus*) and Brown bullhead (*Ictalurus nebulosus*). Stocking of these fish requires a California State Department of Fish and Game permit and review by the California State Department of Fish and Game for their use. Operations involving stocking of these fish are done in coordination with private owners, generally recommended by an aquatic consultant and cleared by the California Department of Fish and Game. District involvement has occurred when the number of calls received and the nuisance level has been substantial from a midge producing source.

The District's biological control activities as described above assure the maintenance and protection of natural resources and the environment: Biological control, and principally the use of mosquitofish, controls the level of mosquito larvae in water sources. The mosquitofish effectively control the larvae in water sources that otherwise could produce substantial numbers of adult mosquitoes. Mosquitofish act as a natural predator of mosquitoes to better control their levels in the current District environment. This control method maintains water sources and protects the adjacent environment in a condition more safe, healthful and comfortable for humans.

The District contains many sources that act as mosquito and vector breeding areas near populated areas. Without ongoing

and effective vector control, the human environment would be significantly and adversely effected by substantial mosquito and other vector activity. The District's mosquito control program, including biological and chemical control, is essential to reduce the vectors in the environment to a tolerable and safe level. The District's program will never alleviate all mosquito vectors. Rather, it is a resource maintenance program aimed at striking a balance to allow comfortable and healthful human existence within the natural environment, while protecting and maintaining the environment. History has shown us that the control and abatement of vectors are necessary for our human environment to continue to be habitable.

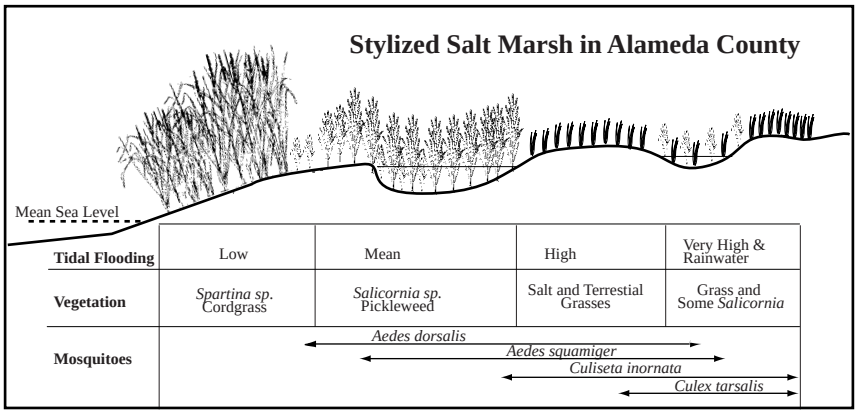
PHYSICAL CONTROL AND SOURCE REDUCTION

Description of activities: Physical control, also known as source reduction, environmental manipulation, or permanent control, is one part of the District's Integrated Pest Management (IPM) program. Physical control is usually the most effective of the mosquito control techniques available and is accomplished by eliminating mosquito breeding sites or modifying these sites to favor natural predation or to be unfavorable to mosquitoes. This can be as simple as properly discarding old containers such as tires or buckets or as complex a source reduction strategy that controls salt marsh mosquitoes (*Aedes squamiger* and *Aedes dorsalis*) utilizing tide control structures and or drainage. Source reduction is important in that its use can virtually eliminate the need for pesticide use in and adjacent to the affected habitat. Source reduction is appropriately touted for its effectiveness and economic benefits.

Mosquito Producing Habitats Considered for Source Reduction.

Freshwater Lakes, Ponds And Retention Areas: Description of sites. Typical sites in California include the margins of reservoirs with shallow water and emergent vegetation, artificial ponds for holding drinking water for livestock and retention ponds created for holding of rainwater. Some retention ponds have been constructed within freeway interchanges and others have been built in cities and towns to provide wildlife habitat and flood protection. Natural lakes are usually not a problem because most of the water is deep, and there may be little emergent vegetation. Seasonal ponds may produce large numbers of mosquitoes during part of the year. Vernal pools may produce mosquitoes and may be important habitats for rare and endangered species. Environmental laws greatly restrict habitat manipulations in these areas (which can produce *Culex*, *Anopheles*, and *Culiseta* species). Many of the vernal pools in Alameda County (Springtown, Livermore especially) are very alkaline and are not generally good mosquito producers unless the soil has been disturbed and annual grasses has become predominate. Consequently, the District does not usually undertake physical control projects in these areas. If it does so, the District would undertake separate CEQA assessment on a case by case basis or be assisting in implementing a plan produced by another lead agency.

Typical mosquito species: There are a number of species of mosquitoes that exploit this type of habitat. In lower elevations in California, Culex species such as *Culex tarsalis* and *Culex stigmatosoma* may be found. *Culiseta inornata* and *Culiseta incidens* also will breed in small ponds. *Aedes washinoi* is a persistent problem along large river valleys. Larvae of this species are found in borrow pits, flooded quarries, and other ponds of freshwater.



Salt marshes: Description of sites. These are marshes along the Bay edge that are subject to tidal action. In California's not so distant past, extensive coastal salt marshes produced enormous Aedes broods, making coastal human habitation virtually impossible. The Aedes species produced on salt marshes are very aggressive and have very long flight ranges. Several of the source reduction efforts described below have greatly reduced salt-marsh mosquito production in these marshes. These habitats are environmentally sensitive and are home to a number of endangered and threatened species.

Typical mosquito species: - In northern California, *Aedes squamiger* is the primary salt-marsh breeder, with *Aedes dorsalis* occurring sporadically. *Aedes squamiger* is a winter breeder and has a single generation per year. *Aedes dorsalis* adults occur in the spring and summer, and may have several generations per year. High tides that leave pools on the marsh trigger hatches of *Aedes dorsalis*. *Culiseta inornata* and *Culex tarsalis* are also found in these marshes in areas of lower salinity that rainfall or runoff contribute to the flooding.

Temporary standing water: While it can be possible to fill small artificial ponds that produce mosquitoes, it is usually impossible to do so in natural areas (however small), large permanent water bodies, or in areas set aside for stormwater or wastewater retention. In such situations, other options that are effective in controlling mosquitoes include periodic drainage, providing deepwater sanctuary for larvivorous fish, minimizing emergent and standing vegetation, and maintaining steep banks. Aedes, Culex and Anopheles mosquitoes are frequently produced in these habitats.

Improved drainage is one effective tool for source reduction in such habitats. The second is the use of microjet irrigation practices for those agricultural areas that require artificial watering.

Proper water management, land preparation, and adequate drainage are the most effective means of physically controlling mosquitoes in these types of sources. The District provides technical assistance to landowners that are interested in reducing mosquitoes by developing drainage systems on certain lands. Additionally, several state and federal programs provide both financial and technical assistance in developing efficient irrigation and drainage facilities for private land. These programs not only improve the value of the property, but assist in controlling mosquito development.

Wastewater treatment facilities: In many parts of Alameda County, clean freshwater for domestic, agricultural, or industrial uses is becoming a critical resource. Wastewater recycling and reuse help to conserve and replenish freshwater supplies. Citizens daily produce approximately 100 gallons of wastewater per capita from domestic sources alone. Concern for water quality conditions in lakes, rivers, and marine areas has resulted in the enactment of new state laws that will greatly limit future disposal of wastewater into these aquatic systems. To adjust to these changing conditions, many communities must implement wastewater reuse and recycling programs. Mosquito problems are frequently associated with some of the conventional wastewater treatment operations, and the expanded use of wastewater recycling and reuse may inadvertently create even more mosquito habitats.

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

Septic Systems: Many households in California, especially in rural areas, use on-site treatment systems, such as septic tanks and associated drain fields. With proper soil porosity, sufficient lateral fields, and low human congestion, these systems are safe and efficient. The waste water in a properly located and maintained septic tank system will percolate into the subsoil without causing surface water accumulation that may induce mosquito production. Yet, when these systems are placed in locations with inappropriate soil conditions, wastewater will flow laterally, often into nearby swales and ditches. Septic systems that have been opened and not properly resealed may produce large populations of mosquitoes (*Culex pipiens*). Physical control measures include repair and rebuilding of systems.

Municipal Treatment Facilities: In California, municipal treatment facilities may be associated with mosquito problems. These can stem from operation of both small (package plants) and large facilities. Package plants may result in mosquito production in holding ponds because they are poorly maintained or operated beyond their capacity (*Culex pipiens*, *Culex stigmatasoma, Culex tarsalis*, *Culiseta incidens*). Larger plants may use various methods to improve water quality conditions beyond the levels obtained in secondary treatment process. These methods include spray irrigation, rapid-dry ponds, aquatic plant waste water systems, and the use of natural or modified wetlands. Physical control methods include vegetation management, pond maintenance, structure repair, and improvement of pond substrates.

Spray-Irrigation Systems: Secondarily treated wastewater is used to irrigate golf courses, road medians, pastures, sod fields and crops. During the rainy season, these spray fields may become waterlogged, particularly those in low-lying areas with high water tables or in poorly drained soils. Under these conditions, the continued application of spray irrigation will result in the accumulation of surface water, thus providing aquatic habitats for a variety of mosquito species (*Culex pipiens*, *Culex stigmatasoma, Culex tarsalis*, *Culiseta incidens*). Physical control methods are employed by landowners, and include proper grading of irrigated lands, and better water management.

Wastewater/Aquatic Plant Systems: At some sewage treatment facilities in California, certain species of aquatic plants (e.g., water hyacinths) have been added to human-made ponds containing secondarily treated wastewater for nutrient removal and biomass production. Mosquito problems can be produced in this type of system if the inflow has received an inadequate secondary treatment. Effective nutrient removal requires periodic harvesting of a portion of the standing crop. These systems can produce mosquitoes (*Culex pipiens, Culex stigmatasoma, Culex tarsalis, Culiseta incidens*).

Stormwater and wastewater management: The management of stormwater and wastewater is very important, and when done without proper engineering, construction or maintenance, can result in considerable mosquito problems (*Culex pipiens, Culex stigmatasoma, Culex tarsalis, Culiseta incidens, Culiseta inornata, Anopheles* spp.). Because of recent restrictions on the flow of stormwaters into natural waterways, the question of design of stormwater retention facilities has become a critical issue. Physical control measures may be required, but proper design of facilities will be the most important factor. Mosquito production can be engineered out of stormwater and wastewater facilities but not always easily. Permanent water ponds can be kept clean of weeds with a water quality sufficient to support mosquito-eating fish. Dry facilities can be designed to dry down in three days to prevent floodwater mosquito production, but some standing water beyond the three-day period may occur due to intermittent rainfall common during the rainy season.

Agricultural and Industrial Wastewater: Many commercial operations have on-site treatment facilities for decreasing nutrient loads from their wastewater, and generally, they use techniques similar to those applied to domestic wastewater. The quantity of wastewater produced at some commercial locations, such as those processing certain crops, may be highly variable during the year. Therefore, the amount of surface water in the holding ponds or spray fields used in the wastewater treatment may fluctuate considerably, thereby contributing to the production of certain species of mosquitoes. Several mosquito species of the genus *Culex* can become extremely abundant in these ponds, especially in the absence of aquatic plant control.

Container habitats. **Containers:** Description of sites. - Containers such as flowerpots, barrels, water tanks, pickle vat tanks, wheel barrows, children's toys, wading pools, depressions in tarps or covers, boats, roof gutters, bird baths, pet dishes, water troughs, cans, treeholes, fountains, tires and almost anything that will hold water are excellent habitats for several *Aedes, Culex* and *Culiseta* species. Abandoned or poorly maintained swimming pools also fall into this category. Typically problems with container breeders occurs during the wetter parts of the year.

Typical mosquito species: Container-inhabiting mosquitoes of particular concern in the District are *Aedes sierrensis* and *Culiseta incidens*. Other mosquito species found in containers include *Culex pipiens, Culex stigmatosoma, Culex tarsalis and Culiseta inornata. Ae. sierrensis* is the most common treehole breeder in the District, and is the primary vector of dog heartworm (*Dirofilaria immitis*) in the District.

Tires: Waste tires have been legally and illegally accumulating in California for the past several decades. The legal accumulations usually take the shape of a somewhat organized pile containing up to several million tires. Illegally dumped tires may be scattered about singly or up to piles containing 40 to 50 thousand carcasses. Unfortunately, most of the problem tires are not in large piles, but scattered about, making removal difficult and, at best, labor intensive. Discarded tires may become covered by vegetation and are then difficult to locate.

The design of tires makes them ideal breeding sites for several species of mosquitoes, of which, some are very important vectors of disease. Until the mid-1980s, waste tires were considered more of a nuisance and environmental threat than the possible foci of mosquito-borne disease epidemics. This changed in 1985 when a substantial breeding population of *Aedes albopictus* was discovered in Houston, Texas. It is probable that this population arrived from Japan as eggs deposited inside used tires. Thus far, *Aedes albopictus* has not become established in California, and the dry summers here are not favorable to their establishment. However, their introduction poses a serious threat. Larvae have been recovered from imported tires arriving in Alameda County. California mosquitoes such as *Culiseta incidens*, *Culex pipiens* and *Aedes sierrensis* breed in tire carcasses.

For management of used tires, the California Integrated Waste Management Board oversees storage sites with more than 500 tires. That agency also has developed regulations regarding the storage of waste tires with regards to vector and mosquito control. These regulations include the provision of the local mosquito control agency being involved with the permit process required to store used tires. Shipments arriving from outside the United States are now required to be fumigated.

Physical control methods.

Source Reduction in Freshwater Habitats: Source reduction for mosquito control in freshwater habitats typically involves constructing and maintaining channels (ditches) to reduce mosquito production in areas such as flood plains, swamps, and marshes. The principle that directs source reduction work entails manipulating water levels and/or vegetation in low-lying areas to eliminate or reduce the need for pesticide applications. A number of different mosquito control strategies or approaches are considered when performing freshwater source reduction.

Planning Review: The District reviews plans for developments, marsh restorations, modifications to water systems and proposed water features to evaluate potential mosquito problems. Recommenations for ways to minimize or prevent mosquito problems and District needs for inspection and treatment access are made for proposed wetland projects.

Dewatering: Draining or emptying is a very effective way to prevent any mosquitoes. This is used for small sources such as containers, fish ponds, tanks, above ground swimming pools or other urban sources.

Ditching: This technique involves reducing the amount of standing water or reducing the length of time that water can stand in low areas following significant rainfall events. This type of strategy involves constructing channels, ditches or water control structures with control elevations low enough to allow for a certain amount of water to leave an area before immature mosquitoes can complete their life cycle.

At this time, the District is rarely involved in construction of new drainage or water control structure projects. When the District is involved in new construction, these projects are covered by CEQA processes and in many cases involve extensive projects with full Environmental Impact Statements produced by other lead agencies. In these cases the District is working as a "sub-contractor" to provide equipment and personnel to accomplish the goals of these projects and further the District's goals by insuring that mosquito control concerns are incorporated into the projects.

Fish Reservoir: This technique involves constructing a main central ditch or ponding area with smaller lateral ditches at the lowest elevations of intermittent wet areas to serve as a larvivorous fish reservoir. As the rainfall water level increases, larvivorous fish move outward to adjacent areas to prey on immature mosquitoes, and as water levels decrease, larvivorous fish retreat to water in the ditches or pond. Weirs may be constructed in main ditches to decrease water flow, decrease emergent aquatic weeds, prevent depletion of the water table, and allow larvivorous fish year-round refuge.

Pumping: The use of direct pumping to remove water will eliminate mosquito breeding area. This technique is currently only used by landowners on the advice of the District to remove water from small residential or commercial sources such as swimming pools, flooded basements, water under buildings, water tanks, and other small localized non-natural impoundments. The District does not do the pumping.

Vegetation Control: Controlling vegetation that provides protection for mosquito larvae and pupae from predation and or necessary treatments increases effectiveness. Vegetation control is effected by mowing, pruning, hand removal, water level variation or herbicide applications. These activities of vegetation control are performed by the property owner and the District is not usually directly involved.

Over the past several decades, urban development has occurred in areas where mosquito control drainage existed as the primary drainage systems. In many cases, maintenance responsibility for these control systems has been taken over by cities, flood control agencies, park districts, or county public works departments and integrated into their comprehensive stormwater management programs. Responsibility for vegetation control and maintenance rests with these controlling agencies. The District may make recommendations for such maintenance when mosquito problems develop.

Filling: Filling of depressions that hold water prevent mosquito production. Filling is subject to a CEQA process, except in small back yard applications. Filling is currently under research for control of treehole mosquitoes. The filling of treeholes is with insulating foam or Soil Moist™ (an expanding water holding product). The filling of treeholes is currently under review and research is in progress to determine any short or long term effects to trees. No large scale filling of treeholes will occur until determination is made that there will be no detrimental affect on the trees.

Exclusion: This is not really a source reduction technique, but a physical control to prevent mosquito problems. The most common use of this technique is the installation of screens on homes. In the field this may be used by owners to screen access to tanks, basements, containers, treeholes or other water holding site.

Aquatic Plant Management And The Effects On Mosquito Populations:

This section describes the practices used to control mosquitoes and aquatic plants associated with freshwater environments only. Salt marsh environments are discussed in other sections of this document.

Certain mosquito species use various aquatic plants as a primary habitat for egg deposition and larval development. Because aquatic plants can, at times, produce heavy stands covering the entire surface of the water and the use of conventional mosquito management techniques, such as biological and chemical control, may be ineffective. Therefore, removal or limiting of the vegetation may be the best means of reducing these mosquito populations to a desired level. Aquatic plant management can have a positive effect on the control of mosquito populations. District personnel maintain surveillance for introduced species of

aquatic plants that could have drastic effects on mosquito production (water hyacinth, hydrilla, water lettuce, frogbit, watermilfoil, parrotfeather, etc.). When introduced aquatic plants are encountered in small patches (usually planted by unknown members of the public), they are immediately hand removed and destroyed. If large a stand of introduced aquatic plants is detected, these are reported to the responsible resource agencies.

The most important aquatic plant species that provide habitat for mosquitoes are bulrush, cattails and algae mats. Permanent water bodies such as creeks, rivers, isolated oxbows, gravel quarries, ponds, golf course water traps, ornamental lakes, flood control channels, stock ponds, and stormwater or wastewater retention basins may develop stands of aquatic vegetation requiring management. *Aedes, Culex* and *Anopheles* mosquitoes are frequently produced in habitats with aquatic vegetation.

When eradication or maintenance of aquatic plants is needed for mosquito control, there are three basic types of aquatic plant management:

Physical control: Physical control methods include the use of equipment or tools to physically remove aquatic vegetation. Examples would include aquatic harvesters, bucket cranes, underwater weed trimmers, pruners, shovels, rakes, machetes and other hand equipment. Mechanical control is limited to areas that are easily accessible to equipment and personnel. Also, mechanical control is labor intensive and can be extremely expensive. The District is generally involved in physical aquatic plant control only on minor, localized problem areas.

Water level manipulation: Varying the water level in a body of water can reduce the amount of aquatic vegetation that is able to survive and can expose mosquito larvae to predation. Allowing a body of water to dry out periodically can reduce the surviving aquatic vegetation to acceptable levels.

Herbicide Control: Herbicides approved for aquatic vegetation control can be used to remove or reduce problems. The District does not currently use herbicides to control vegetation except where the District is working as a contractor for another lead agency (e.g. *spartina* control).

Current Salt marsh Source Reduction Techniques.

Environmental Considerations: Prior to the 1970s when the majority of mosquito control ditching, filling, and impoundment construction were completed, mosquito control was usually the primary consideration when manipulating salt marshes. Little concern was given to environmental issues. Today, minimizing adverse salt marsh ecological impacts must be considered when designing a source reduction project and has equal weight in the process of achieving regulatory approval. Minor hand ditching and maintenance of existing ditches by the District is subject to permitting and reporting process through the Army Corps of Engineers, in coordination with the land owner (usually a local, state or federal agency) and other federal, local and regional approvals.. Environmental regulatory agencies generally will consider ditching of impoundments because it usually will reduce pesticide use and will allow the maintenance of an impoundment in a free tidally exchanging condition for a longer period of the year. In some cases, it allows the impoundment to be opened permanently. Often the District is involved in ditching or modifications to marshes it is a part of a project for which there is a EIR written by another lead agency.

Ditching: Ditching can be used in both salt marsh or freshwater locations to control mosquitoes by:

1) enhancing drainage thus eliminating mosquito-producing sites, or,

2) allowing access of larvivorous fish to mosquito breeding locations (this can be enhanced through the creation of permanent water bodies which act as predatory fish reservoirs).

Cat ditching

Hand ditch cleaning

DMC 1200 scavel ditching

Ditching Used by the District: The District currently uses (or may use in the future) four types of ditch techniques:

1. Hand ditching
2. Scavel ditching
3. Blade scraped ditches
4. Rotary ditching (may be used in the future)

With the exception of minor hand ditching and cleaning, most projects are part of a restoration or maintenance project covered by another lead agency. The District is a "subcontractor" to accomplish part of the desired ditching.

Hand Ditching: Hand ditching is used to maintain existing ditches and do very minor ditch creation. Most of this type of ditching is to trim vegetation and keep small ditches open to tidal flow and keep access open for fish to move within the marsh. This type of ditching is done by hand using shovels, rakes, pitch forks, hoes, machetes and power weed cutters.

Benefits of Hand Ditching: This is a low impact type of ditching. Personnel walk to the site, spoils are spread by hand and removed vegetation is spread away from the ditch. Such work is only done on the parts of the existing ditch system that need maintenance.

Environmental Risks of Hand Ditching: Minor localized vegetation disruption along ditches from foot traffic during the maintenance, short term turbidity in ditches and possible disruption of wildlife.

Hand Ditching Applications: This is the technique used most often by the District. It is used to maintain existing small ditches covered by an Army Corp of Engineer's permit. The District may apply for up to 30,000 feet of maintenance on a permit. Actual maintenance depends upon the condition of the ditches, vegetation growth, mosquito production history of the area and localized blockages that occur from debris in ditches (old boats, lumber, stumps, mattresses, or other slimy items). In a typical year the District may maintain 2-5,000 feet of ditches. When maintenance is done the change in capacity of cleaned ditch is only negligible or insignificant, the surface area is restored, the spoil is deposited as authorized by the permit, and the work does not impact any mature trees, threatened or endangered plant species, or sensitive habitat areas.

Mitgation: To avoid adverse effects on the habitat, hand maintenance of ditches is done only when needed. The work is done when the tide is out and the water in the ditches is stationary or slow moving to prevent spread of the localized turbidity. Spoils and removed silt are spread evenly or as requested in the permit to avoid changes in the character of the marsh and to keep undesirable plant species from becoming established. The time of entry for maintenance is planned to avoid nesting seasons or critical times when wildlife would be disturbed from nesting. The entry is coordinated with land owners.

Scavel Ditching: Scavel ditching is a technique of pulling a scavel ditcher behind the District DMC 1200. This technique creates vertical sided ditches to about two feet deep and spreads the spoils to both sides of the ditch. Spoils are compacted by the vehicle tracks. This technique has been used by the District for many years in marsh areas.

Benefits of a Scavel Ditching Plan: Scavel ditches have been easy and inexpensive for the District to create because the District currently owns the equipment and has trained operators. The technique is adaptable to differing soil types and equipment is not damaged by hidden logs or concrete.

Environmental Risks of Scavel Ditching: Scavel ditching keeps the spoils rather close to the ditch and the compacted spoils may change the drainage characteristics of the marsh. Because the spoils are deposited to the side of the ditch and compacted there will be more time required for vegetation to rejuvenate. The tracks on the DMC 1200 have metal cleats that cut 6-8" into the soil and cut marsh vegetation.

Scavel Ditching Applications: This technique is used in restoration projects, in areas where ditches need to be connected and to create ditches into low areas of a marsh. This technique is used where it is requested by a landowning lead agency and is always covered in a separate CEQA project EIR. Generally, such ditching is directly supervised by Federal or State wildlife officials.

Blade Scraped Ditches: These ditches are created with a blade equipped crawler tractor. They are generally wide and can be deep. The spoils are many times pushed out to create "islands" for variations in marsh habitat and refugia.

Benefits of a Bladed Ditch: This technique works well for the creation of low areas and wide deep drainages. The District owns the equipment and has trained operators.

Environmental Risks of Blade Ditching: This would be a very disruptive type of ditching in established marshes. This would cause disruption to vegetation and exposure of subsurface soil levels. Areas disrupted by this type of operation need to be revegetated.

Blade Ditching Applications: This type of ditching is used in areas being prepared for tidal flooding. Generally these are areas that need to have lower grade levels, islands created and major preparation for restoration. Vegetation is usually of an upland variety. This technique is only used in new restoration areas covered by a separate CEQA project EIR, usually by another lead agency. Generally, such ditching is directly supervised by Federal or State wildlife officials.

Rotary Ditching: Over the past 20 years, rotary ditching has been implemented on both the east and west coasts of the United States. Rotary ditching involves the construction of shallow ditches usually 4 feet wide and 2-3 feet deep, using high-speed rotary equipment which broadcasts spoil evenly over the marsh surface. A ditching network frequently connects shallow ditches to permanent water habitats, whether they be ponds or canals. Where it is impossible or impractical to connect to major waterways, a permanent pond is constructed deep enough to hold water throughout the year to harbor fish, and radial ditches connect the mosquito-producing locations to the ponds.

Benefits of a Properly Designed Rotary Ditching Plan: Rotary ditching generally is considered more environmentally acceptable than deep ditching because spoil material from these shallow ditches is evenly distributed in a very thin layer over the marsh surface. Consequently, the problem of the accumulation of overburden, with the subsequent invasion of exotic vegetation, is eliminated. Impacts to vegetation are usually limited to the ditch itself, as the tractor will climb over the vegetation allowing it to spring back, causing little damage. Marsh ditching seems to affect the vegetation as only a top-dressing of dirt might affect a lawn. Experience repeatedly has demonstrated that a properly designed rotary ditching system can greatly decrease the need for larvicide applications on the affected marsh. Rotary ditching can be cost effective and of lower management intensity when used in areas where it can be physically installed.

Environmental Risks of Rotary Ditching: Rotary ditchers broadcast the spoil indiscriminately and can throw debris great distances. Therefore, great care is necessary when working in congested areas. In loose soils, the size and shape of the finished ditch will not be maintained due to erosion from water movement through the ditch. The depth fixes the width of the ditch; therefore, a shallow ditch is also narrow. Concerns have been raised about the possible marsh hydrological changes (i.e., dewatering) that may occur from the installation of rotary ditches. This dewatering concern has been typically addressed through the installation of ditch sills, the tops of which are usually set at mean high water. The installation of sills can result in water being retained in the ditch and on the marsh surface; however, this is not always the case with some dewatering of the marsh still occurring. Though more frequent flooding of the marsh could conceivably alter soil salinity, the possible impacts to the benthic invertebrate populations have not been thoroughly investigated. Soil salinity changes also may alter native plant communities, though the introduction of nonnative plants is restricted by marsh elevation.

Rotary-Ditching Applications: Basic limitations on the use of rotary ditching revolve around the size of the ditch needed, soil types, access, adjacent terrain, and vegetation present. Marsh type candidates for rotary ditching include grassy marshes, dredge spoils, temporary grassy ponds, scrub marsh, and savannas. Areas with sandy loose soil are not good ditching candidates. Ditch cleaning or new construction is possible in areas of limited woody vegetation if planned carefully. Experience has shown that poorly engineered ditches can produce more mosquitoes than preconstruction areas, as is true for any permanent control project. Because they distribute material evenly over the marsh surface, rotary ditches do not result in the formation of spoil piles. Therefore, rotary ditching receives serious consideration for any mosquito control ditch-construction project. Environmental regulatory agencies generally will consider rotary ditching of impoundments because it usually will reduce pesticide use and will allow the maintenance of an impoundment in a free tidally exchanging condition for a longer period of the year. In some cases, it allows the impoundment to be opened permanently. Rotary ditch projects are usually undertaken by mosquito control offices and require permits from the Army Corps of Engineers along with other federal, local and regional approval. Projects would be subject to separate CEQA processes such as an EIR by another lead agency and Army Corps of Engineers permit process. Generally, such ditching is directly supervised by Federal or State wildlife officials.

CHEMICAL CONTROL

Mosquito control operations use a combination of two basic chemical control methods to control mosquitoes: adulticiding and larviciding. Only those pesticides registered by the United States Environmental Protection Agency and California Environmental Protection Agency are used by the District for mosquito control. With the existing federal and state limitations and regulations, the pesticides available for mosquito control, when applied in accordance with legal requirements, are very environmentally sensitive and cause no or very minor and discrete ecological impact.

The Environmental Hazards section on labels of pesticides used for mosquito control instruct applicators about how to avoid and minimize environmental impacts. The District strictly follows label instructions and carefully monitors environmental and meteorological conditions to maximize effectiveness while avoiding and minimizing nontarget exposure and environmental effects. District personnel doing chemical treatments are certified by the State Department of Health Services as Mosquito Control Technicians.

Adulticiding: Our District considers adulticiding a treatment of " last resort". Adulticiding is the application of insecticides for control of adult mosquitoes. The most common form of adulticiding is the application of insecticide aerosols at very low dosages and using little or no diluent. This method is commonly called the ultra-low-volume (ULV) method. Ground adulticiding is almost exclusively conducted with specially designed ULV equipment. Adulticiding techniques are used only when necessary to obtain control.

Larviciding: Larviciding is the preferred chemical control strategy of our District when treatments are needed. Larviciding is a general term for the process of killing mosquitoes by applying natural agents or commercial products designed to control larvae and pupae (collectively called larvicides) to aquatic habitats. There are three general types of larvicides:

Stomach Toxins. The District makes use of two stomach toxins whose active ingredients are manufactured by bacteria. These control agents are often designated as Bacterial Larvicides. Their mode of action requires that they be ingested to be effective, which can make "them more difficult to use than the contact toxins and surface active agents.

Bacillus thuringiensis (Bt), is the most widely used (especially in agriculture) microbial pesticide in the world. It was originally isolated from natural Lepidopteran (butterflies and moths) die-offs in Germany and Japan. Various Bt products have been available since the 1950s, and in 1976, Dr. Joel Margalit and Mr. Leonard Goldberg isolated from a stagnant riverbed pool in Israel, a subspecies of B. thuringiensis that had excellent mosquito larvicide activities. It was named B.t. variety israelensis (B.t.i.) and later designated Bacillus thuringiensis Serotype H-14. Either of these two designations may be found on the labels of many bacterial mosquito larvicide formulations used today.

Bacillus sphaericus(Bs) is a commonly occurring spore-forming bacterium found throughout the world in soil and aquatic environments. Some strains produce a protein endotoxin at the time of sporulation.

Contact Pesticides: As the name implies, this loosely defined group of compounds is effective when mosquito larvae or pupae come in contact with it. Chemicals are absorbed through the insects outer skin or cuticle, and may be incidentally ingested or enter the body through other routes. Contact agents can be further subdivided into two subgroups used in mosquito control:

1) toxins primarily affecting an insects nervous system: pyrethrum
2) toxins primarily affecting an insects endocrine system: methoprene formulations

Surface Active Agents: Larvicides in this category include Oils and ethoxylated Isostearyl Alcohols. Unfortunately, none of the currently supported larvicides previously discussed act as pupacides. Therefore, pupal control must be achieved through the use of these products. Oils were first used as effective Anopheline larvicides for malaria control in California at the turn of the century. Commonly used larviciding oils kill larvae and pupae when inhaled into the tracheae along with air at the surface of the water.
The District generally uses surface oils in heavily polluted waters, areas where beneficial organisms are low or nonexistent, in areas with late (non-feeding) instar larvae or pupae, or in areas where other larvicides have proved ineffective.

MATERIALS USED BY THE DISTRICT

The following is a listing of the materials currently used by the District. This listing is followed by a general listing of the material types. The actual manufactured materials used by the District may vary depending upon price, availability, field effectiveness, registration with the U.S. and California EPA and non-target effects.

Adulticides:

Scourge® Insecticide with SBP - 1382 EPA#432-667
Manufacturer - Penick Corp
Method of application - Ultra Low Volume (ULV) hand held or turck mounted machine.

No-Pest Strip Insecticide EPA#3696-91
Manufacturer - Texize / Morton Thiokol Inc.
Method of application - used only in 1x1" pieces inside locked New Jersey light trap collection bottles.

Larvicides:

Liquid Bti's (*Bacillus thuringiensis israelensis*)

Acrobe® biolarvicide EPA #62637-1-241
Manufacturer - American Cyanamid Company
Method of application - handcan, backpack sprayer, ATV, truck or aerial mounted sprayers.

Teknar HP-D® EPA #2724-365-50809
Manufacturer - Zoecon
Method of application - handcan, backpack sprayer, ATV, truck or aerial mounted sprayers.

Vectobac 12 AS® EPA #275-66
Manufacturer - Abbott Laboratories
Method of application - handcan, backpack sprayer, ATV, truck or aerial mounted sprayers.

Solid (granular) Bti's

Vectobac G granules® EPA #275-50
Manufacturer - Abott Laboratories
Method of application - hand, seed spreader, aerial mounted spreader.

Bactimos granules® EPA #43382-16
Manufacturer - BioChem Products
Method of application - hand, ATV mounted seed spreader, aerial mounted spreader.

Liquid methoprene

Altosid Liquid Larvicide® EPA #2724-392-6483
Manufacturer - Wellmark International
Method of application - handcan, backpack sprayer, ATV, truck or aerial mounted sprayers.

Altosid Liquid Larvicide Concentrate®
Manufacturer - Wellmark International
Method of application - handcan, backpack sprayer, ATV, truck or aerial mounted sprayers.

Solid methoprene

Altosid Briquets® EPA #2724-375
Manufacturer - Wellmark International
Method of application - hand

Altosid XR Briquets® EPA #2724-421
Manufacturer - Wellmark International
Method of application - hand

Altosid Pellets® EPA #2724-448-64833
Manufacturer - Sandoz Agro Inc. or Wellmark International
Method of application - hand, seed spreader, aerial mounted spreader.

Surface Active Agents

Golden Bear - GB1111® EPA #8898-16
Manufacturer - Golden Bear
Method of application - handcan, backpack sprayer, ATV, truck or aerial mounted sprayers.

Agnique™ MMF Moquito Larvidide & Pupicide EPA #2302-14
Manufacturer - Henkel Corp.
Method of application - handcan, backpack sprayer, ATV, truck or aerial mounted sprayers.

Handcan Application

Handheld ULV

DMC 1200 Application

Helicopter Larvicide Application

There are a number of general considerations when pesticides are used for mosquito control. These involve the type of application (ground or aerial), target of applications (larval or adult), resistance development, weather considerations, non-target organisms and avoidance of chemically sensitive people. A variety of larviciding equipment is used for both aerial and ground applications, necessitated by the wide range of breeding habitats, target species, and budgetary constraints. There are advantages and disadvantages to each application system and to the aerial and ground treatments themselves.

Ground Application:

Application Equipment: The District uses open bed pickup trucks that have been modified for the particular task. A chemical container tank, high pressure, low volume electric or gas pump, and spray nozzle are mounted in the back of the bed, with a switch and extension hose allowing the driver to operate the equipment and apply the larvicide from the truck's cab. Specialized equipment, such as All Terrain Vehicles (ATVs) have a chemical container mounted on the vehicle, a 12 volt electric or gasoline engine powered pump supplying high pressure low volume flow, and a hose and spray tip allowing for application while steering the vehicle. ATVs are ideal for treating areas such as agricultural fields, pastures, salt marshes and other off-road sites. ATV application can generally treat about 5 acres per hour. Additional training in ATV safety and handling is provided to employees before operating these machines. Additional equipment used in ground applications include hand held sprayers, seeders and backpack sprayers. Hand held sprayers (hand cans) are standard one or two gallon garden style pump-up sprayers used to treat small isolated areas. Backpack sprayers are gas or hand powered sprayers with a chemical tank. Generally a pellet or small granular material is applied with a seeder designed to distribute pellets or granules. Hand applications can generally cover 2-4 acres per hour.

Advantages of ground application: There are several advantages to using ground application equipment, both when on foot and when conveyed by vehicles. Ground larviciding allows applications while in close proximity to the actual treatment area, and consequently treatments to only those micro habitats where larvae are actually present. This also reduces both the unnecessary pesticide load on the environment and the financial cost of it. Both the initial and the maintenance costs of ground equipment is generally reasonable. Ground larviciding applications are less affected by weather conditions than aerial applications.

Disadvantages of ground application: Ground larviciding is impractical for large or densely wooded areas. There is also a greater risk of chemical exposure to applicators than there is during aerial larviciding operations. Damage may occur from the use of a ground vehicle in some areas. Ruts and vegetation damage may occur, although both these conditions are reversible and generally short-lived. Technicians are trained to recognize sensitive areas and to use good judgement to avoid significant impacts (see discussion of these impacts on page IV-46).

Aerial Application:

Application Equipment: The District contracts with a commercial aerial applicator to provide needed aerial treatments. The equipment used is a helicopter equipped to apply liquid formulations or granular materials. Helicopter applications can effectively treat up to 500 acres per hour.

Advantages of aerial application: There are several advantages to using both fixed and rotary wing aerial larvicide application equipment. It is more economical for large application areas provided the entire site needs to be treated. It is easier to calibrate equipment and operators because the target area is generally mapped and the material is weighed or measured when loading. It is more practical for remote or inaccessible areas such as islands and marshes than ground larviciding. Equipment does not have to contact the marsh surface, so no track marks or surface disturbance occurs.

Disadvantages of aerial application: There is a greater risk of non-target impacts, especially with liquid aerial larviciding. Including the cost of the equipment, it is generally more expensive than a ground application. To ensure accuracy in hitting the target, either additional manpower for flagging or expensive electronic guidance systems are

needed. Application windows can be narrow due to weather conditions. Aerial applications are more prone to drift problems. Aerial applications require special FAA licenses, training of staff, and additional liability insurance.

Resistance:

Managing larvicide resistance:. Selecting the proper class of larvicide and the formulation are both important in pesticide resistance management. One way to encourage resistance is to use sublethal dosages. Insects with inherent tolerances for weakly applied pesticides may survive to produce tolerant offspring. Soon, an entire population of tolerant mosquitoes may arise, and then continued use of the material that caused the problem will affect only non-targets. Another way to potentially produce resistance is to depend on slow-release formulations beyond their recommended use period. Release rate studies have shown that the active ingredients are not available linearly, and that beyond the recommended time limits, they may be sublethal. The District acknowledges these issues, and takes measures to rotate pesticides used on larval sites to avoid this situation.

Currently used mosquito larvicides, when applied properly, are efficacious and environmentally safe. These agents have been successfully integrated into District programs. Compared to the adulticides, there is less concern for the drift of mosquito larvicides, primarily due to application techniques. Mosquito larvicides are usually applied directly into natural and man-made aquatic habitats as liquid or solid formulations, and aerial drift is negligible. Drift in water can result from flushing or rainwater runoff. Under these conditions, dilution greatly reduces the pesticide concentration and consequently reduces exposure to non-targets.

Choosing when to larvicide:

The District program is larvicide oriented when treatment is required. Larviciding is done whenever 1st through 4th instar larvae are present. Late 4th instar larvae do not feed so a pupicide will be needed to obtain control. Larviciding is typically not as effective or as economical as permanent source reduction or water management, but is more effective than adulticiding. When looking at breeding sites and their mosquito production on a case by case basis, this logic appears infallible. However, this view was derived long ago when wetlands were not considered to be as important as they are today, many of the compounds used were different, and costs were in terms of money, manpower, and equipment. It was easy to assume that it was cheaper in the long run to move dirt and change the hydrology of an area than it was to apply pesticides. Many districts are being forced to use chemical methods to control mosquitoes in areas where water management is not used or is prohibited.

An alternative view focuses on environmental costs, with the tenet that undisturbed wetlands should remain pristine, and that any disturbance will have long term effects on non-target species of plants and animals. The District avoids source reduction in these areas. The District carefully balances how to manage the already altered wetlands for mosquitoes and at the same time maximize their value to the ecosystem.

Choosing When to Adulticide:

The District uses adulticides when there are large numbers of adult mosquitoes that are known to be carrying disease or are in a concentrated area that will cause a problem for people if allowed to disperse. Our District is able to limit the amount of adulticiding to a very low percentage of our treatments.

Weather Considerations:

Applications of any type are not made during high winds. Rainfall can have major affect on the size and number of larval sources. The more rain, the more water in sources. Saltmarsh *Aedes* mosquitoes hatch from eggs left in the source when flooded. Larval development is slow during cold months, with 4th instar larva developing in late February. If rainfall occurs early in the saltmarsh season (November-January) more areas will produce larva, but if rains do not continue, sources may dry down requiring less area to be treated prior to adult emergence. The worst case, is late rains (February-March) combined with warm temperatures causing larval development to move very rapidly to 4th instar and will require more area to be treated prior to emergence. High rainfall years favor *Aedes* and flood water mosquitoes (*Aedes squamiger, Aedes washinoi*, *Culiseta inornata* and *Aedes sierrensis*). Low rainfall or drought years tend to favor urban container mosquitoes (*Culex pipiens* and *Culiseta incidens*).

Non-target Considerations:

The presence of non-target organisms that provide food for wildlife or are mosquito predators affect the type of control measures used. Materials are selected to have the minimum impact on non-targets as possible and still obtain control of the mosquito population. This can especially be important for conservation of mosquito predators.

Avoidance of Sensitives:

Applications are not made when known chemically sensitive individuals may be in contact with the area or chemicals. When adulticide applications are made, residents are notified and contacted prior to the application.

ADULTICIDING

Description of Adulticides & Adulticiding Activities: Adulticiding is the term used to describe treatments that are aimed at controlling adult mosquitoes. The most common form of adulticiding is the application of insecticide aerosols at very low dosages and using little or no diluent. This method is commonly called the ultra-low-volume (ULV) method. Ground adulticiding is almost exclusively conducted with specially designed ULV equipment.

The efficiency of adulticiding is dependent upon a number of integrated factors. First, the mosquito species to be treated must be susceptible to the insecticide applied. Second, insecticide applications must be made during periods of adult mosquito activity. This factor is variable with species. Some species of mosquitoes are diurnal (daytime biting), while others are crepuscular (dawn and dusk). Adulticiding should be timed when the mosquitoes are flying and/or exposed to the aerosol mist. The chemical application has its own set of conditions that determine success or failure. The application must be at a dosage rate that is lethal to the target insect and applied with the correct droplet size. It has been shown that droplets within the 10-25 micron range are most effective in controlling adult mosquitoes.

Sufficient insecticide must be distributed to cover the prescribed area with an effective dose. Ground applications with densely vegetated habitats may require a higher dosage rate than that of open areas. This is purely a function of wind movement and its ability to sufficiently carry droplets to penetrate foliage.

Environmental conditions may also affect the results of adulticiding. Wind determines how the ULV droplets will be moved from the output into the treatment area. Conditions of no wind will result in the material not moving from the application point. High wind, a condition that inhibits mosquito activity will quickly disperse the insecticide too widely to be effective. Light wind conditions (< 3 mph) are the most desirable, moving the material through the treatment area and are less inhibiting to mosquito activity.

A benefit of ULV applications is that they do not require large amounts of diluents and are therefore much cheaper and generally environmentally safer. The spray plume is nearly invisible and is applied at very low dosage rates (less than 0.007 lbs. per acre). Applications are made at times when mosquitoes are most active and when other beneficial insects are not, so any impacts that occur are minimal and quickly reversed.

ULV applications are generally avoided during hot daylight hours. Thermal conditions will cause small droplets to rise, moving them away from mosquito habitats and flight zones. Generally, applications are made between sunset and sunrise, depending upon mosquito flight activity. This practice minimizes exposure of non-target species such as bees or butterflies. Some mosquitoes (*Aedes* species) are most active during the daytime. Applications for these species should be made during the period of highest activity provided that meteorological conditions are suitable for application and care is made to avoid non-target impacts.

Ground Adulticiding Techniques and Equipment: Adulticide application made from hand carried or truck-mounted ULV equipment. This technique is often used as a perimeter treatment and is based on the natural history of and behavioral characteristics of the mosquito species treated. Ultra Low Volume (ULV) aerosol machines were developed to eliminate the need for great quantities of petroleum oil diluents necessary for earlier fogging techniques. These units are based on a design patented by the U.S. Army and are constructed by mounting a vertical nozzle on the forced air blower of a thermal fogger. Insecticide is applied as technical material or at moderately high concentrations (as is common with the pyrethroids) which translates to very small quantities per acre and is therefore referred to as ultra low volume (ULV). In agriculture, this rate is assumed to be less than 36 ozs./acre, but mosquito control ground adulticiding operations rarely exceed 1 oz./acre. The optimum sized droplet for mosquito control with cold aerosols applied at ground level has been determined to be in the range of 5- 20 microns.

Equipment: Ground adulticiding equipment is normally mounted on some type of vehicle, but smaller units are available that can be carried by hand or on a persons back. The District currently uses the Leco Model 1600 (truck mounted) and Leco Model P1 (hand held) manufactured by Clarke Engineering Technologies, The nozzles on these machines differ, but they all resemble the old Army patent vortical nozzle. The insecticide metering equipment available on the Leco Model is computer controlled, speed correlated, event recording and a programmable flow management systems.

Aerial Applications: The District does not use or anticipate aerial adulticiding operations, except in the event of a public health emergency.

Training and Maintenance: Operators of adulticiding equipment must be trained not only in the proper use and maintenance of the equipment, but also in the proper application of the insecticide which they are using. The pesticide labels specify details of the application including acceptable droplet spectra, flow rates, application rates, areas to avoid and target insects. State Law requires that operators be certified to apply pesticides, through the California Department of Health Services or be directly supervised by a certified person.

Machines are calibrated at least once a year. Measurements for output and droplet sizes of the pesticides being used are confirmed to maximize efficiency and minimize potential adverse impacts.

Only those pesticides registered by the United States Environmental Protection Agency and California Environmental Protection Agency are used for mosquito control in the State of California.

Potential Environmental Impacts: Chemical sensitivity can be a serious concern. Adulticides affect all small flying insects and therefore will affect non-target flying insects. Many of the adulticide materials are toxic to fish and invertebrates.

The Environmental Hazards section on labels of pesticides used as mosquito adulticides instructs applicators to avoid direct application over water or drift into sensitive areas (i.e. wetlands) due to a potentially high toxicity of these compounds to fish and invertebrates. Although there is some variation in the habitats to be avoided, they usually include lakes, streams and marshes. Any deposition of adulticides into these areas is indirect and unintentional. A fundamental conflict is evident when considering that applications of adulticides targets active adult mosquitoes that may have emerged from the same aquatic resources that are to be protected from exposure to these compounds. The District avoids these conflicts by strictly following label instructions and carefully monitoring meteorological conditions to maximize effectiveness while minimizing non-target exposure.

Mitigation: To avoid problems with chemical sensitivity the District conducts ULV operations in the early morning and late evenings, when people and most non-target flying insects will not be exposed to the pesticide . Applications made by the District are away from contact with people. The District does not perform ULV operations near commercial bee hives.

The District only uses adulticiding in very localized areas and generally only for emergency suppression of adults. Most applications made by the District have been less that 1 acre in areas where large numbers of adult mosquitoes produced by treeholes, flooded basements or marshes are present. These applications are on an emergency need when a hatch of adults has occurred. Adulticiding is considered the last course of action by the District. Larger areas could be treated if active cases of malaria or encephalitis created a risk to humans. Even with a disease emergency, only affected areas would be treated. Residents are notified and contacted prior to adulticide treatments.

Adulticides: Throughout the discussion of adulticide materials, signal words which may occur on the materials label are mentioned. Following is an explanation of these signal words:

CAUTION. This word signals that the product is slightly toxic. An ounce to more than a pint taken by mouth could kill the average adult. Any product which is slightly toxic orally, dermally, or through inhalation or causes slight eye and skin irritation will be labeled CAUTION.

WARNING. This word signals that the product is moderately toxic. As little as a teaspoonful to a tablespoonful by mouth could kill the average sized adult. Any product which is moderately toxic orally, dermally, or through inhalation or causes moderate eye and skin irritation will be labeled WARNING.

DANGER. This word signals that the pesticide is highly toxic. A taste to a teaspoonful taken by mouth could kill an average sized adult. Any product which is highly toxic orally, dermally, or through inhalation or causes severe eye and skin burning will be labeled DANGER.

In its mosquito control work, the District occasionally uses one or more of the following adulticides depending on availability, cost, effectiveness for the needed application and least non-target effects:

Pyrethrins and Pyrethroids - General Description: Natural pyrethrins (pyrethrum) are extracted from chrysanthemum flower heads grown commercially in parts of South America, Africa and Asia. Synthetic analogues of the natural pyrethrins reached commercial success in the 1950s. Like the natural pyrethrins, first generation synthetic pyrethroids such as phenothrin and tetramethrin, are relatively unstable to light. During the 1960s-1970s, great progress was made in synthetic light-stable pyrethroids. These photostable pyrethroids represent the second generation of these compounds.

Pyrethroids exhibit rapid knockdown and kill of adult mosquitoes, characteristics that are considered a major benefit of their use. The mode of action of these compounds relates to their ability to affect sodium channel function in the neuronal membranes. Most pyrethroids use piperonyl butoxide as a synergist to increase effectiveness.

Synthetic pyrethroids are not cholinesterase inhibitors, are non-corrosive and will not damage painted surfaces. They are less irritating than other mosquito adulticides and have a less offensive odor. In comparison to other adulticides, pyrethroids may be effectively applied at much lower rates of active ingredient per acre. The synthetic pyrethroids are mimics of natural pyrethrum, a botanical insecticide. Natural pyrethrum is used in agricultural areas and has a significantly higher cost. Natural pyrethrins are compounds that are not photostable.

Resmethrin:

Introduction: Resmethrin is another of the 1st generation synthetic pyrethroids used in California. Resmethrin, like permethrin, is a photolabile pyrethroid compound produced by AgrEvo and formulated as the active ingredient in products such as Scourge. Resmethrin is similar to the other pyrethroids in providing rapid knockdown and quick kill of adult mosquitoes. Resmethrin exhibits very low mammalian toxicity, degrades very rapidly in sunlight and provides little or no residual activity.

Formulations and dosages: Resmethrin products are available in several concentrations that range from 1.5% to 40% and may or may not contain piperonyl butoxide. Scourge products, containing resmethrin and piperonyl butoxide (a synergist), have a maximum rate of application of 0.007 lbs per acre of the active ingredient. Currently Scourge is a restricted use insecticide with labels that contain the signal word Caution.
Target species: Resmethrin is used against all California mosquitoes.

Permethrin:

Introduction: Permethrin, a second-generation pyrethroid, is a photostable pyrethroid compound and formulated as the active ingredient in products such as Punt, Permanone and Biomist. Permethrin is similar to other pyrethroids in providing rapid knockdown and quick kill of adult mosquitoes. However, permethrin also provides some residual activity when applied directly to surfaces. Permethrin is a general use pesticide with labels that may contain either the signal word WARNING or CAUTION depending on the particular product.

Formulations and dosages: Permethrin products are available in various concentrations, from 1.5% to 57% and may or may not be synergized with piperonyl butoxide. Synergized permethrin products may contain piperonyl butoxide in various ratios by weight but the maximum rate of application is 0.007 lbs. per acre of the active ingredient. Permethrin products, if labeled for this use, may be applied at a maximum of 0.1 lbs. of active ingredient per acre for a barrier effect, whereas rates up to 0.007 lbs. per acre may be used for vehicle mounted ULV applications.

Target species: Permethrin is used against all California mosquitoes.

LARVICIDING

Introduction: Larviciding is a general term for the process of killing mosquitoes by applying natural agents or commercial products designed to control larvae and pupae (collectively called larvicides) to aquatic habitats. Larvicide treatments can be made from either the ground or air.

A wide variety of aquatic habitats and communities, ranging from small domestic containers to larger agricultural and marshland areas, are treated with larvicides. Natural fauna inhabiting these sites may include amphibians, fish, vertebrates and invertebrates, particularly insects and crustaceans. Frequently, the aquatic habitats targeted for larviciding are temporary or semipermanent. Permanent aquatic sources usually contain natural mosquito predators such as fish and do not require further treatment, unless vegetation is so dense that it prevents natural predation. (e.g., algae mats providing shelter for *Anopheles* spp.). Temporary sites such as marshes and flooded agricultural areas or woodland depressions produce prolific numbers of floodwater mosquitoes. These sites are generally very low in species diversity due to the time needed for most species to locate and colonize them. While flood water mosquitoes develop during the first week post-inundation, it may take two to three weeks for the first macro invertebrate predators to become established. Many non-target species exploiting temporary aquatic habitats are capable of recovering from localized population declines via re-colonization from proximal areas. Many of these are mobile (can fly from location to location) and may leave the source temporarily when a surface film treatment is made.

Larvicides: Throughout the discussion of larvicide materials, signal words on the label are mentioned. Following is an explanation of these signal words:

CAUTION. This word signals that the product is slightly toxic. An ounce to more than a pint taken by mouth could kill the average adult. Any product which is slightly toxic orally, dermally, or through inhalation or causes slight eye and skin irritation will be labeled CAUTION.

WARNING. This word signals that the product is moderately toxic. As little as a teaspoonful to a tablespoonful by mouth could kill the average sized adult. Any product which is moderately toxic orally, dermally,

DANGER. This word signals that the pesticide is highly toxic. A taste to a teaspoonful taken by mouth could kill an average sized adult. Any product which is highly toxic orally, dermally, or through inhalation or causes severe eye and skin burning will be labeled DANGER.

Only those pesticides registered by the United States Environmental Protection Agency and California Environmental Protection Agency are used for mosquito control by the District. Commercially available and experimental larvicides plus natural control agents available in California are discussed below. Arbitrarily, they are loosely categorized by their modes of entry/action on target/non-target organisms: Contact Pesticides, Surface Active Agents, and Stomach Toxins. Registered trade names and active ingredients of products are used in the discussions.

The District regularly uses the following larvicides:

Contact Pesticides:

Methoprene:

Introduction: Methoprene does not produce nondiscriminatory, rapid toxic effects that are associated

with nervous system toxins. Methoprene is a true analogue and synthetic mimic of a naturally occurring insect hormone called Juvenile Hormone (JH). JH is found during aquatic life stages of the mosquito and in other insects, but is most prevalent during the early instars. As mosquito larva mature, the level of JH steadily declines until the 4th instar molt, when levels are very low. This is considered to be a sensitive period when all the physical features of the adult begin to develop.

Methoprene in the aquatic habitat can be absorbed on contact and the insect's hormone system becomes imbalanced. When this happens during the sensitive period, the imbalance interferes with 4th instar larval development. One effect is to prevent adults from emerging. Since pupae do not eat, they eventually deplete body stores of essential nutrients and then starve to death. For these and perhaps other reasons, s-Methoprene is considered an insect growth regulator (IGR).

Potential Environmental Impacts: There have been widely distributed reports regarding the effect methoprene may have on certain amphibians. Reports of frog abnormalities have been widely circulated, but these reports have not stood up to scientific scrutiny. Methopene is also currently registered in California for control of Chironomide midges. Midges can provide a food source for water fowl and other aquatic insects and fish.

Mitigation: Most of the District's use of methoprene is for urban sources, short term temporary water sources, treeholes, and storm drains where neither alleged affects on amphibians or known food supply for water fowl are an problem. Treatments of marsh areas occur during the winter months December-February when migratory water fowl are not plentiful. Open water sources, heavily used by water fowl are not major mosquito sources requiring treatment. Know areas of red-legged frog and tiger salamander are rarely if ever treated using this material. If detrimental effects are reported in future research, operations will be modified to minimize these effects.

Formulations and dosages: Currently, five methoprene formulations are sold under the trade name of Altosid. These include Altosid Liquid Larvicide (A.L.L.) and Altosid Liquid Larvicide Concentrate, Altosid Briquets, Altosid XR Briquets, and Altosid Pellets. Altosid labels contain the signal word CAUTION ALTOSID LIQUID LARVICIDE (A.L.L.) & A.L.L. CONCENTRATE. These two flowable formulations have identical components except for the difference in the concentration of active ingredients. A.L.L. contains 5% (wt./wt.) s-Methoprene while A.L.L. Concentrate contains 20% (wt./wt.) s-Methoprene. The balance consists of inert ingredients that encapsulate the s-Methoprene, causing its slow release and retarding its ultraviolet light degradation.

Dosages: Use rates are 3 to 4 ounces of A.L.L. 5% and .5 to 1 ounce of A.L.L. Concentrate (both equivalent to 0.01008 to 0.01344 lb. AI) per acre, mixed in water as a carrier and dispensed by spraying with conventional ground and aerial equipment. Because the specific gravity of Altosid Liquid is about that of water, it tends to stay near the target surface. No rate adjustment is necessary for varying water depths when treating species that breath air at the surface.

Target species: Liquid formulations are designed to control fresh and saline flood water mosquitoes with synchronous development patterns. Cold, cloudy weather and cool water slow the release and degradation of the active ingredient as well as the development of the mosquito larvae. Accordingly, formulation activity automatically tracks developing broods.

Altosid Briquet: The Altosid Briquet was the first solid methoprene product marketed for mosquito control beginning in 1978. It is made of plaster (calcium sulfate), 3.85 % (wt./wt.) methoprene, 3.85% methoprene (.000458 lb. AI/briquet) and charcoal (to retard ultra violet light degradation). Altosid Briquets release methoprene for about 30 days under normal weather conditions.

Dosages: Application should be made at the beginning of the mosquito season, and under normal weather conditions, repeat treatments should be carried out at 30 day intervals. The recommended application rate is 1 Briquet per 100 sq. ft. in non-flowing or low-flowing water up to 2 feet deep.

Target species: Flood water Aedes and permanent water Anopheles, Culex, and Culiseta larvae are usual targets. Typical treatment sites include storm drains, catch basins, roadside ditches, ornamental ponds and fountains, cesspools and septic tanks, waste treatment and settlement ponds, flooded crypts, transformer vaults, abandoned swimming pools, construction and other man-made depressions.

Altosid XR Briquet: It is made of hard dental plaster (calcium sulfate), 1.8% (wt./wt.) methoprene (.00145 lb. AI/briquet) and charcoal (to retard ultra violet light degradation). Despite containing only 3 times the AI as the 30-day briquet, the comparatively harder plaster and larger size of the XR Briquet change the erosion rate allowing sustained s-methoprene release up to 150 days in normal weather.

Dosages: XR Briquets should be applied 1 to 2 per 200 sq. ft. in no-flow or low-flow water conditions, depending on the species.

Target species: Targets are the same as for the smaller briquets. Appropriate treatment sites for XR Briquets include storm drains, catch basins, roadside ditches, ornamental ponds and fountains, cesspools and septic tanks, waste treatment settlement ponds, flooded crypts, transformer vaults, abandoned swimming pools, construction and other man-made depressions, cattail swamps and marshes, water hyacinth beds, pastures, meadows, rice fields, freshwater swamps and marshes, woodland pools, flood plains and dredge spoil sites.

Altosid Pellets: Altosid Pellets were approved for use in April 1990. They contain 4% (wt./wt.) methoprene (0.04 lb. AI/lb.), dental plaster (calcium sulfate), and charcoal. Like the Briquets discussed above, Pellets are designed to slowly release s-methoprene as they erode. Under normal weather conditions, control can be achieved for up to 30 days.

Dosages: Label application rates range from 2.5 lbs. to 10.0 lbs. per acre (0.1 to 0.4 lb. AI/acre), depending on the target species and/or habitat.

Target species: The species are the same as listed for the briquet formulations. Listed target sites include pastures, meadows, rice fields, freshwater swamps and marshes, salt and tidal marshes, woodland pools, flood plains, tires and other artificial water holding containers, dredge spoil sites, waste treatment ponds, ditches, and other man-made depressions, ornamental pond and fountains, flooded crypts, transformer vaults, abandoned swimming pools, construction and other man-made depressions, tree holes, storm drains, catch basins, and waste water treatment settling ponds.

Altosid XR G: Altosid Xr-G was approved for use in 1997. This product contains 1.5% (wt./wt.) methoprene. Granules are designed to slowly release methoprene as they erode. Under normal weather conditions, control can be achieved for up to 121 days.

Dosages: Label application rates range from 5 lbs. to 20.0 lbs. per acre, depending on the target species and/or habitat.

Target species: The species are the same as listed for the briquet formulations. Listed target sites include snow pools, meadows, rice fields, freshwater swamps and marshes, salt and tidal marshes, woodland pools, tires and other artificial water holding containers, dredge spoil sites, waste treatment ponds, ditches, and other natural and man-made depressions.

Surface Active Agents.

Introduction: Larvicides in this category include Oils and ethoxylated Isostearyl alcohols. Unfortunately, none of the currently supported larvicides previously discussed act as pupacides. Therefore, pupal control must be achieved through the use of these products. Oils were first used as effective Anopheline larvicides for malaria control in California at the turn of the century. Commonly used larviciding oils kill larvae and pupae when inhaled into the tracheae along with air at the surface of the water. With low dosages (1 gallon per acre), they can work very slowly, taking 4 to 7 days to give a complete kill. Higher dosage rates are usually used (up to 5 gallons per acre) to lower the kill time.

The District generally uses surface oils in heavily polluted waters, areas where beneficial organisms are low or nonexistent, in areas with late (non-feeding) instar larvae or pupae, or in areas where other larvicides have proven to be ineffective.

Target Species: These materials are used against all mosquito species. *Aedes squamiger* control is not very effective except in pupal stage and even then it is more effective during warm weather.

Potential Environmental Impacts: Surface active agents (especially oil such as GB1111) can cause impacts to non-target, air breathing insects such as aquatic beetles, backswimmers, waterboatmen and water striders. The affect is most commonly direct mortality or a forced exit from the source. This is not a desirable impact for mosquito control as the most affected insects are also major predators on mosquito larvae. The film left on the surface of the water may create an unsightly condition of “rainbowing”. Tender plants may be “burned” by contact with oil. The new ethoxylated isosteary alcohols are reported to last much longer in effectiveness than the oils (GB1111) and can continue to have detrimental impacts on other surface dependent insects.

Mitigation: These products are used as the last phase of the District larval control program. These are used only for late, non-feeding 4th instar larva and pupa, are used in highly polluted waters (e.g., sewer water, sumps, waters with large amounts of floating organic matter) or where other control materials have failed. If any detrimental effects are reported in future research, operations will be modified to minimize these effects. Usage of these materials by the District has been declining and efforts will continue to be made to reduce the use of suface active agents.

Mosquito larvicide GB-1111. This product is a petroleum based napthenic oil. The napthenic oil designation characterizes petroleum oil refining processes. The GB stands for Golden Bear and the product is most often referred to as Golden Bear 1111 or simply GB-1111. Another mosquito control product, GB-1356, was nearly identical to GB1111, but label support was withdrawn by Witco Chemical Company in the early 1990s. The label for GB-1111 contains the signal word CAUTION.

Dosages: GB-1111 contains 99% (wt./wt.) oil and 1% (wt./wt.) inert ingredients including an emulsifier. The nominal dosage rate is 3 gallons per acre or less. Under special circumstances, such as when treating areas with high organic content, up to 5 gallons per acre may be used.

Target species: GB-1111 is effective on a wide range of mosquito species. Applied to breeding areas, GB-1111 is an effective material against any mosquito larvae and pupae obtaining atmospheric oxygen at the water surface. It can even be effective in treating adult mosquitoes as they emerge. It is not very effective against Aedes squamiger except in pupal stage during warm weather.

Agnique MMF (monomolecular surface film): Pesticides that contain the active ingredient ethoxylated fatty alcohol, which includes Agnique" MMF (monomolecular surface film), have recently been registered in California. This type of pesticide reduces the surface tension of water and makes it difficult for mosquito larvae and pupae to attach. The film also blocks their breathing tubes and the larvae and pupae drown. Resting adult males and adult egg-laying females that come in contact with the film will also drown. This product can be used in virtually any source of water including potable water and biodegrades into carbon dioxide and water. The lethal inhalation concentration for mosquitoes during four hours of exposure is 1.5 to 3.0 milligrams per liter.

Ingestion of large quantities may cause gastrointestinal disturbances in humans. Contact with eyes causes irritation which subsides in seven days and prolonged or repeated exposure with skin causes irritation. Studies on non-target effects were conducted on the fresh-water green tree frog, two species of fresh water fish, five species of salt water fish, longnose killifish, grass shrimp, freshwater shrimp, fiddler crab, crayfish, freshwater amphipod, freshwater isopod, fairy shrimp, snails, polychaetes, mayfly nymphs, diving beetles, midges, clam shrimp, backswimmers, water boatmen, water striders, beetle larvae and adults, black mangrove, saltwort, cordgrass, arrowhead, and rice. The only non-target effects observed when the product was applied at label rates were dead adult midges and adult water striders. It may be used in environmental and non-environmental sites in place of GB-I 111. Based on technical data and scientific research, Agnique[tm] MMF has no significant or cumulative impact on the environment.

Dosages: Agnique contains 100% Poly(oxy-1,2-ethanediyl),α-isooctadecyl-ω-hydroxyl. The dose rate is .2-.5 gallons per acre.

Target Species: Agnique is effective on a wide range of mosquito species. Applied to breeding areas, Agnique is an effective material against any mosquito larvae and pupae obtaining atmospheric oxygen at the water surface. This is possible replacement for GB-1111 where non-target predatory aquatic insects are not present and longer control is needed.

Stomach Toxins.

Introduction: Mosquito control makes use of two stomach toxins whose active ingredients are manufactured by bacteria. These control agents are often designated as Bacterial Larvicides. Their mode of action requires that they be ingested to be effective, which can make them more difficult to use than the contact toxins and surface active agents. Bacteria are single- celled parasitic or saprophytic micro-organisms that exhibit both plant and animal properties, and range from harmless and beneficial to intensely virulent and lethal. A beneficial form, Bacillus thuringiensis (Bt), is the most widely used (especially in agriculture) microbial pesticide in the world. It was originally isolated from natural Lepidopteran (butterflies and moths) die-offs in Germany and Japan. Various Bt products have been available since the 1950s, and in 1976, Dr. Joel Margalit and Mr. Leonard Goldberg isolated from a stagnant riverbed pool in Israel, a subspecies of B. thuringiensis that had excellent mosquito larvicide activities. It was named B.t. variety israelensis (B.t.i.) and later designated Bacillus thuringiensis Serotype H-14. Either of these two designations may be found on the labels of many bacterial mosquito larvicide formulations used“ today. Another species of bacteria, B. sphaericus, also exhibits mosquito larvicide properties.

Potential Environmental Impacts: The materials currently used by the District have the least impact of available mosquito control products on non-target organisms. At label rates these materials do not have reported detrimental effects on wildlife or pose toxic threats to humans. They are not persistent in the environment.

Mitigation: Continue current usage and monitor new research. If any detrimental effects are found, operations will be modified to minimize these effects.

Bti (*Bacillus thuringiensis israelensis*)

Introduction: Each B.t.i. organism may produce, if the environmental conditions around it are favorable, five different microscopic protein pro-toxins packaged inside one larger protein container or crystal. The crystal is commonly referred to as delta (d-) endotoxin. If the d-endotoxin is ingested, these five proteins are released in the alkaline environment of an insect larva's gut. The five proteins are converted into five different toxins if specific enzymes also are present in the gut. Once converted, these toxins work alone or in combination to destroy the gut wall. This leads to paralysis and death of the larvae.

B.t.i. is grown commercially in large fermentation vats using sophisticated techniques to control environmental variables such as temperature, moisture, oxygen, pH and nutrients. The process is similar to the production of beer, except that B.t.i. bacteria are grown on high protein substrates such as fish meal or soy flour and the spore and delta endotoxin are the end products. At the end of the fermentation process, B.t.i. bacteria exhaust the nutrients in the fermentation machine, producing spores before they lyse and break apart. Coincidental with sporulation, the delta endotoxin is produced. The spores and delta endotoxins are then concentrated via centrifugation and microfiltration of the slurry. It can then be dried for processing and packaging as a solid formulation(s) or further processed as a liquid formulation(s). Since some fermentation medium (e.g. fish meal) is always present in liquid formulations, they generally smell somewhat like the medium.

Formulations and dosages: There are five basic B.t.i. formulations available for use: liquids, powders, granules, pellets, and briquets. Liquids, produced directly from a concentrated fermentation slurry, tend to have uniformly small (2-10 micron) particle sizes which are suitable for ingestion by mosquito larvae. B.t.i. granules, pellets, and briquets are formulated from B.t.i. primary powders and an inert carrier. B.t.i. labels contain the signal word CAUTION.

Since fourth instar mosquito larvae quit feeding prior to becoming pupae, it is necessary to apply B.t.i. prior to this point in their development. Although the details are poorly understood, evidence suggests that larvae also undergo a period of reduced feeding or inactivity prior to molting from 1ST to 2nd, 2nd to 3rd, and 3rd to 4th instars. If we apply B.t.i at these points in their development, the toxic crystals may settle out before the larvae resume feeding, and with synchronous broods of mosquitoes, complete control failures may result. With asynchronous broods, efficacy may be reduced. Kills are usually observed within 24 hours of toxin ingestion. As a practical matter, any residual pupae are treatmented will a surface active agent.

The amount of toxins contained within B.t.i. products are reported indirectly as the result of at least two different bioassays and are difficult to equate to one another. Prepared volumes of toxins are applied to living mosquito larvae and the resulting mortality produces through formulae numerical measures known as International Toxic Units (ITUs) and *Aedes aegypti* International Toxic Units (AA-ITUs). These measures are only roughly related to observed efficacy in the field, and are therefore inappropriate to consolidate and report on like other toxicants.

Bti Liquids: Currently, three commercial brands of B.t.i. liquids are available: Aquabac XT, Teknar HP-D, and Vectobac 12AS.

Formulations and dosages: Labels for all three products recommend using 4 to 16 liquid oz/acre in unpolluted, low organic water with low populations of early instar larvae (collectively referred to below as clean water situations). The Aquabac XT and Vectobac 12 AS (but not Teknar HP-D) labels also recommend increasing the range from 16 to 32 liquid oz/acre when late 3rd or early 4th instar larvae predominate, larval populations are high, water is heavily polluted, and/or algae are abundant. The recommendation to increase dosages in these instances (collectively referred to below as dirty water situations) also is seen in various combinations on the labels for all other B.t.i. formulations discussed below.

B.t.i. liquid may also be Duplexed (mixed) with the Altosid Liquid Larvicide discussed above. Because B.t.i. is a stomach toxin and lethal dosages are somewhat proportional to a mosquito larvaes body size, earlier instars need to eat fewer toxic crystals to be adversely affected. Combining B.t.i. with methoprene (which is most effective when larvae are the oldest and largest) allows a District to use less of each product than they normally would if they would use one or the other. Financially, most savings are realized for treatments of mosquitoes with long larval development periods, asynchronous broods or areas with multiple species of mosquitoes.

Bti powders: Aquabac Primary Powder, Vectobac TP and Bactimos WP brands of B.t.i. powders are available.

Formulations and dosages: The Vectobac TP label recommends using a calculated 3.2 to 6.4 oz (by weight)/ acre in clean water, and up to 12.8 oz/acre in dirty water situations. The Bactimos WP label correspondingly recommends using 2 to 6 oz/acre and up to 12 oz/acre. Aquabac Primary Powder currently is labeled for manufacturing use only. However, the label is currently being amended by the EPA to allow end user applications in quantities similar to those of the other powder formulations. The District does not currently use powdered Bti, but may in the future.

Bti Sand Granules: Until the latter part of 1996, commercial formulations of B.t.i. sand granules were not available. However, labeling was available for both Vectobac and Bactimos B.t.i. powders to guide end users in making their own on-site Sand Granules. Sand formulations require coating the particles with an oil, such as GB-1111, and then applying dry B.t.i. powder which will stick to the oil. In California, most target mosquito species graze the water surface or within the water column, and not the bottom. It is desirable to stick the powder to the sand in a way that B.t.i. is released upon contact with the water, and is thus available for the larvae. The District does not currently use Bti sand granules, but may in the future.

Bti corncob granules: Granular formulations use a carrier that is dense enough to penetrate heavy vegetation. There are currently two popular corncob granule sizes used in commercial formulations. Aquabac 200G, Bactimos G, and Vectobac G are made with 5/8 grit crushed cob, while Aquabac 200 CG (Custom Granules) and Vectobac CG are made with 10/14 grit cob. Aquabac 200 CG is available by special request. The 5/8 grit is much larger and contains fewer granules per pound. The current labels of all B.t.i. granules recommend using 2.5 to 10 lb./acre in clean water and 10 to 20 lb./acre in dirty water situations. The District uses this formulation as it is easy to apply by hand or seeder, clean to work with and easy to transport.

Bti pellets: Bactimos Pellets are the only extruded B.t.i. product on the market today. They are manufactured using a larval food as the B.t.i. carrier, and the manufacturer claims that this helps attract feeding larvae. The Pellets contain twice the amount of toxic units as Bactimos (corncob) Granules, and the label correspondingly recommends using only half as much by weight in both clean water and dirty water situations.

Bti briquets (donuts): B.t.i. donuts are a sole source product manufactured by Summit Chemical Company under a Bactimos B.t.i. subregistration. They are a mixture of B.t.i., additives, and cork. They are designed to float and slowly release B.t.i. particles for up to 30 days. They apparently are attractive to raccoons and possibly other wildlife because of their odor, and may sometimes be disturbed or carried off. Bti donuts may be staked in place to prevent wind from moving them from a sites littoral zone into open water. The use rate is one donut per 100 square feet in clean water and up to four donuts per 100 square feet in dirty water. Many districts have not found these to be practical in most larval sites due to their expense and the possibility of them being moved by wind or animals. Homeowners, however, may find practical uses for these in ornamental ponds or other very small habitats. The District does not currently use Bti pellets or donuts, but may in the future.

Target species: B.t.i. adversely affects larval stages of insect species in the Order Diptera, Suborder Nematocera, Families Culicidae (Mosquitoes) and Simuliidae (Black Flies). B.t.i. has been shown to be effective for numerous mosquito species, including members of the mosquito genera *Aedes, Anopheles, Culex*, and *Culiseta*, commonly targeted in California. Products containing B.t.i. are ideally suited for use in integrated pest management programs because the active ingredient does not interrupt activities of most beneficial insects and predators. Since B.t.i. has a highly specific mode of action, it is an insecticide of minimal environmental concern. B.t.i. controls all larval instars provided they have not quit feeding, and can be used in almost any aquatic habitat with no restrictions. It may be applied to irrigation water and any other water sites except treated finished drinking water. B.t.i. is fast acting and its efficacy can be evaluated almost immediately. It usually kills larvae within 1 hour after ingestion, and since each instar must eat in order for the larvae to grow, that means B.t.i. usually kills mosquito larvae within 24 hours of application. It leaves no residues, and it is quickly biodegraded. Resistance is unlikely to develop simultaneously to the five different toxins derived from the B.t.i. delta-endotoxin since they have five different modes of action. This suggests that this mosquito larvicide will continue to be effective for many years.

B.t.i. labels carry the CAUTION signal word, suggesting the material may be harmful if inhaled or absorbed through the skin. However, the 4-hr Inhalation LC 50 in rats is calculated to be greater than 2.1 mg/liter (actual) of air, the maximum attainable concentration. The acute Dermal LD 50 in rabbits is greater than 2,000 mg/kg body weight and is considered to be non-irritating to the eye or skin. That is equivalent to a 220 lb. individual spilling more than a half gallon of B.t.i. liquid onto himself or into his eyes. Toxicology profiles also suggest that the inert ingredients (not the B.t.i.) in liquid formulations, may cause minor eye irritations in humans. The acute Oral LD 50 in rats is greater than 5,000 mg/kg body weight (similar to an individual drinking over 5 quarts) suggesting the material is practically non-toxic in single doses. Common table salt has an LD 50 of 4,000 mg/kg of body weight.

B.t.i. applied at label rates has virtually no adverse effects on applicators, livestock, or wildlife including beneficial insects, annelid worms, flatworms, crustaceans, mollusks, fish, amphibians, reptiles, birds or mammals. However, non-target activity on larvae of insect species normally associated with mosquito larvae in aquatic habitats has

been observed. There have reported impacts in larvae in the Order Diptera, Suborder Nematocera, Families Chironomidae (midges), Ceratopogonidae (biting midges) and Dixidae (dixid midges). These non-target insect species, taxonomically closely related to mosquitoes and black flies, apparently contain the necessary gut pH and enzymes to activate delta-endotoxins. However, the concentration of B.t.i. required to cause these effects is 10 to 1,000 times higher than normal use rates. Further, studies report these impacts are short-lived, with the population of these species rebounding quickly.

Concerning the operational use of B.t.i., timing of application is extremely important. Optimal benefits are obtained when treating 2nd or 3rd instar larvae. Treatments at other development stages may provide less than desired results. Therefore a disadvantage of using B.t.i. is the limited treatment window available.

***Bacillus sphaericus* (Bs):**

Introduction: *Bacillus sphaericus* is a commonly occurring spore-forming bacterium found throughout the world in soil and aquatic environments. Some strains produce a protein endotoxin at the time of sporulation. It is grown commercially in fermentation vats and formulated for end use with processes similar to that of B.t.i. A standard bioassay similar to that used for B.t.i. has been developed to determine preparation potencies. The bioassay utilizes *Culex quinquefasciatus* 3rd-4th instar larvae. The endotoxin destroys the insects gut in a way similar to B.t.i. and has been shown to have activity against larvae of many mosquito genera such as *Culex*, *Culiseta*, and *Anopheles*. The toxin is only active against the feeding larval stages and must be partially digested before it becomes activated. At present, the molecular action of B. sphaericus is unknown. Isolation and identification of the primary toxin responsible for larval activity has demonstrated that it is a protein with a molecular weight of 43 to 55 kD.

Vectolex-CG: VectoLex-CG is the trade name for Abbott Laboratories granular formulation of *B. sphaericus* (strain 2362). The product has a potency of 50 BSITU/mg (*Bacillus sphaericus* International Units/mg) and is formulated on a 10/14 mesh ground corn cob carrier. The VectoLex-CG label carries the CAUTION hazard classification.

Dosages: VectoLex-CG is intended for use in mosquito breading sites that are polluted or highly organic in nature, such as dairy waste lagoons, sewage lagoons, septic ditches, tires, and storm sewer catch basins. VectoLex-CG is designed to be applied by ground (by hand or truck-mounted blower) or aerially at rates of 5-10 lb./acre. Best results are obtained when applications are made to larvae in the 1st to 3rd instars. Use of the highest rate is recommended for dense larval populations. Larval mortality may be observed as soon as a few hours after ingestion but typically takes as long as 2-3 days, depending upon dosage and ambient temperature. VectoLex-G should be stored in a cool, dry place, in an intact product package. Once the VectoLex-G package is opened, moisture can be absorbed by the product leading to loss of activity over time. Refrigeration is not necessary.

Target species: *B. sphaericus* adversely affects larval stages of insect species in the Order Diptera, Suborder Nematocera, Family Culicidae (mosquitoes). *Culex* species are the most sensitive to *Bacillus sphaericus*, followed by Anopheles and some *Aedes* species. In California, *Culex* spp. and *Anopheles* spp. may be effectively controlled. Several species of *Aedes* have shown little or no susceptibility, and salt marsh Aedes species are not susceptible. *Bacillus sphaericus*, in contrast to B.t.i., is virtually non-toxic to Black Flies (Simulidae).

B. sphaericus has demonstrated the unique property of being able to control mosquito larvae in highly organic aquatic environments, including sewage waste lagoons, animal waste ponds, and septic ditches. After a single application at labeled rates, field evaluations have shown VectoLex-CG to persist for 2-4 weeks. Field evaluations with VectoLex-CG have shown that Bacillus sphaericus may undergo limited recycling in certain organically rich environments. VectoLex-CG has been extensively tested and has had no adverse effects on mammals or non-target organisms. B. sphaericus technical material was not infective or pathogenic when administered as a single oral, intravenous or intratracheal installation in rats. No mortalities or treatment-related evidence of toxicological effects were observed. The acute oral and dermal LD 50 values are greater than 5000 mg/kg and greater than 2000 mg/kg, respectively. The technical material is moderately irritating to the skin and eye. Oral exposure of *B. sphaericus* is practically nontoxic to mallard ducks. No mortalities or signs of toxicity occurred following a 9000 mg/kg oral treatment. Birds fed diets containing 20% w/w of the technical material experienced no apparent pathogenic or toxic effects during a 30-day treatment period. Mallards given an intraperitoneal injection of *B. sphaericus* demonstrated toxicologic effects including hypoactivity, tremors, ataxia and emaciation. The LD 50 (lethal dose causing 50% mortality) value was greater than 1.5 mg/kg.

Acute aquatic fresh water fish toxicity tests were done on bluegill sunfish, rainbow trout and daphnids. The 96 hour LC 50 (Lethal concentration causing 50% mortality) and NOEC value for bluegill sunfish and rainbow trout was greater than 15.5 mg/liter; the 48 hour EC 50 and NOEC value for daphnids was greater than 15.5 mg/liter. Acute aquatic saltwater fish toxicity tests were done on sheep head minnows, shrimp and oysters. The 96 hour LC 50 value for

both sheep head minnows and shrimp was 71 mg/liter, while the NOEC (no observable effect concentration) value was 22 mg/liter for sheep head minnows and 50 mg/liter for shrimp. The 96-hour EC 50 value for oysters was 42 mg/liter with a NOEC of 15 mg/liter.

Invertebrate toxicity tests were done on mayfly larvae and honeybees. The LC 50 and NOEC value for mayfly larvae was 15.5 mg/liter. Honeybees exposed to l0E4-10E8 spores/ml for up to 28 days demonstrated no significant decrease in survival when compared to controls. Acute toxicity of B. sphaericus to non-target plants was evaluated in green algae. The 120-hour EC 50 and NOEC values were greater than 212 mg/liter.

Bacillus sphaericus will not regenerate in salt water, rendering its use impractical for control of salt water mosquitoes. Cycling is limited to permanent fresh water bodies, and if organics are very high, recycling may be minimal. The District does not currently us Bs, but may in the future.

TREATMENT DECISION MAKING

The District uses a phased approach to pesticide treatments. In the choice of material to use District personnel will use the material with the least impact to control larvae and as a last resort, localized adulticiding may be chosen. In general this progression of choices would be:

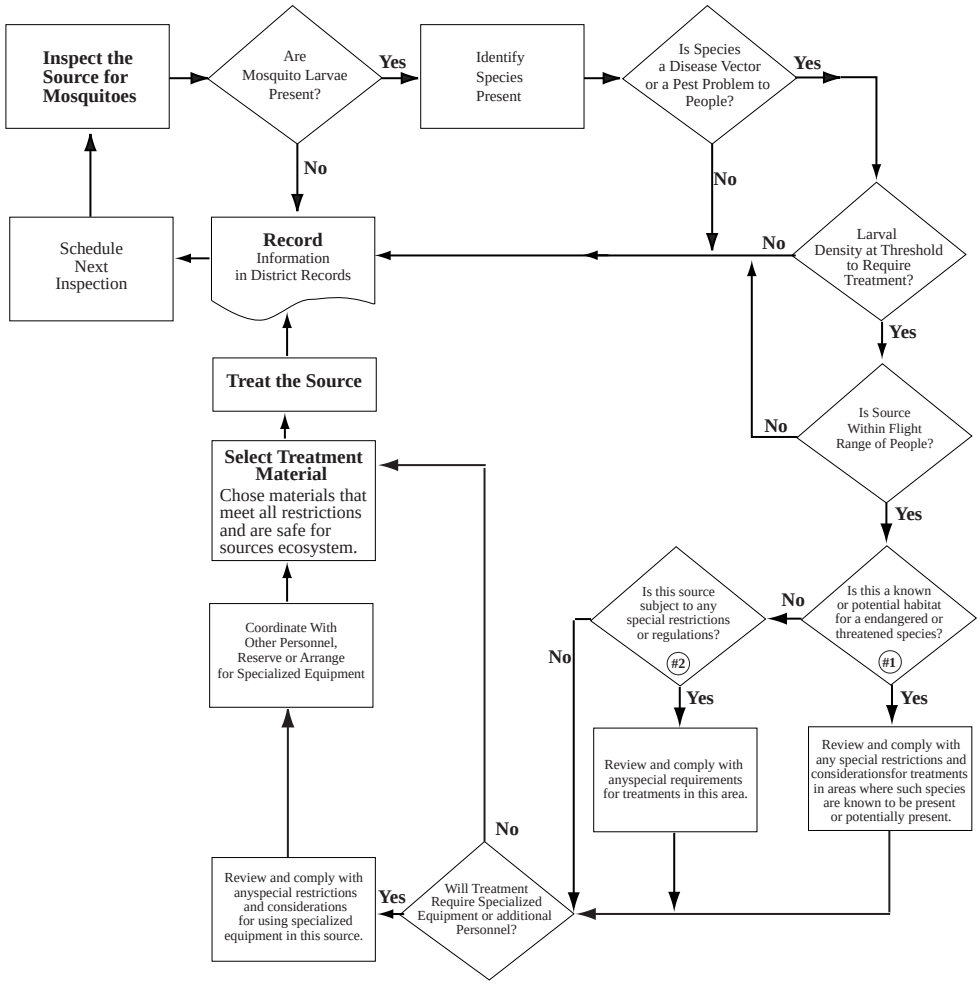
Bti → Duplex (Bti + methoprene) → Methoprene → Oil or Agnique → Pyrethroids

Decisions on where and when to treat are based on thresholds (see Larval Treatment Criteria chart, page IV-57). These thresholds are meant to be guidelines since each site is different and other factors play a role in the levels of mosquitoes that can be tolerated. Some of these factors are as listed:

The proximity of homes or heavy human use areas to the source.
The age and distribution of the immature mosquitoes in a source.
The number of mosquito service calls attributed to the source from previous seasons.
The expected weather conditions and the season of the year.
The accessibility to the source (including special restrictions).
The pest or disease significance of the mosquito to be controlled in the source.
The size of the source (staff and equipment needs increase with size).
The sampling method used to check the source.
The number of active sources and available personnel and equipment.

On the next page there is a general treatment decision chart showing the general way decisions are made for treatment. This is followed by two additional charts providing information on where the District uses the generalized treatment criteria for larval sources and various materials for mosquito control and the decision process for treatments.

Treatment Decision Model for Mosquito Sources



#1

Fairy shrimp
Tadpole shrimp
California Red-legged frog
Tiger salamader
Salt marsh harvest mouse
Bird's beak
Contra costa goldfields
California clapper rail

#2

Entry restrictions
(nesting season closures)
Pesticide use permits
Memorandums of understanding
District policies
Agricultural restrictions
(food crops, organic grower)
City ordinances (Berkeley)

Larval Treatment Criteria

	Species	Most Common Larval Habitats	Distance to Populated Area	Larval Treatment Threshold	Notes
AEDES	**Salt marsh mosquito** *Aedes dorsalis*	Salt marshes	0 meters - 2 miles	≥1 per 10 dips	High Pest Significance
	Asian tiger mosquito *Aedes albopictus*	Small Containers, Tires	**ANY DISTANCE**	**IMMEDIATE TREATMENT IF ANY DETECTED**	Found only once in an imported tire
	Aedes melanimon	Irrigated Fields	0 meters - 2 miles	≥1 per 10 dips	High Pest Significance
	Pasture mosquito *Aedes nigromaculis*	Irrigated Fields	0 meters - 2 miles	≥1 per 10 dips	High Pest Significance
	Tree hole mosquito *Aedes sierrensis*	Tree Holes, Tires, Miscellaneous Containers	0 - 300 meters	≥1 per dip or baster sample	High Pest Significance Vector of Canine Heartworm
	Winter salt marsh mosquito *Aedes squamiger*	Salt Marshes Reclaimed Marshes	0 meters - 10 miles	≥1 per 10 dips	High Pest Significance
	River mosquito *Aedes vexans*	Temporary Pools	0 meters - 1 mile	≥1 per 10 dips	Has not Been Found Since the 1950's
	Woodland pool mosquito *Aedes washinoi*	Temporary Woodland Pools	0 meters - 1 mile	≥1 per 10 dips	High Pest Significance
ANOPHELES	*Anopheles franciscanus*	Shallow Pools and Streams in Algae mats	0 - 500 meters	≥1 >3rd instar larva per dip	Low Pest Significance
	Western malaria mosquito *Anopheles freeborni*	Seepages, Streams, Lakes, Gravel Pits	0 meters - 1 mile	≥1 >3rd instar larva per dip	Low Pest Significance Vector of Malaria
	Anopheles occidentalis	Streams, Lakes, Pools Occasionally in Brackish Water	0 - 500 meters	≥1 >3rd instar larva per dip	Low Pest Significance
	Anopheles punctipennis	Temporary Pools, Streams	0 meters - 1 mile	≥1 >3rd instar larva per dip	Moderate Pest Significance Vector of Malaria
CULEX	*Culex apicalis*	Woodland Creeks, Pools	NO TREATMENT	NO TREATMENT	No Pest Significance
	Culex boharti	Slow Streams, Pools	NO TREATMENT	NO TREATMENT	No Pest Significance
	Tule mosquito *Culex erythrothorax*	Lakes and Ponds Associated with Tules	0 - 500 meters	≥1 per dip	High Pest Significance Vector of Encephalitis
	House mosquito *Culex pipiens*	Storm Drain Systems, Septic Tanks, Roadside Ditches, Cemetery Urns, Flooded Basements, Utility Vaults	0 meters - 1 mile	≥1 per 10 dips	High Pest Significance
	Foul water mosquito *Culex stigmatosoma*	Foul Water, Sewage, Temporary Pools	0 - 300 meters	≥1 per dip	Low Pest Significance
	Encephalitis mosquito *Culex tarsalis*	Creeks, Marshes, Temporary Pools, Roadside Ditches, Fresh Water	0 meters - 2 miles	≥1 per 10 dips	Moderate Pest Significance Vector of Encephalitis
CULISETA	**Fish pond mosquito** *Culiseta incidens*	Fish Ponds, Temporary Pools, Catch Basins, Roadside Ditches	0 meters - 1 mile	≥1 per dip	High Pest Significance Possible Vector of Canine Heartworm
	Winter salt marsh mosquito *Culiseta inornata*	Marshes, Temporary Pools, Roadside Ditches	0 meters - 1 mile	≥1 per dip	High Pest Significance
	Culiseta particeps	Shaded Clean Pools, Streams	0 - 300 meters	≥1 per dip	Low Pest Significance
	Orthopodomyia signifera	Tree Holes	NO TREATMENT	NO TREATMENT	Adults Found in Light Trap Larvae not Found

CONTROL SELECTION CRITERIA
ALAMEDA COUNTY MOSQUITO ABATEMENT DISTRICT

● DO NOT USE

⊕ USE ONLY AFTER BIOLOGICAL CONSULTATIONS AND ASSESSMENTS

	Chemical Control Materials										FISH
	Bti		Bs	Methoprene				Mono - Film	Oil	Pyrethrum	
	Liquid	Granular	Liquid	Liquid	Pellets	Briquets	XR Briquets	Agnique	GB1111	Scourge	
Water Temperature <65˚ F	●	●							●		
Water Temperature >65˚ F											
Larval Instar 1st - 2nd				●							
Larval Instar 4th - pupae	●	●									
Fresh Water											
Brackish Water											⊕
Low Organic Load											
High Organic Load											⊕
Emergent Vegetation <50%											
Emergent Vegetation >50%	●			●				●	●		
Predators Not Abundant											
Predators Abundant								●	●	●	⊕
Endangered Aquatic or Terrestrial Species Absent											
Endangered Aquatic Species Present				●	●	●	●		●	●	●
Endangered Aquatic Species Possible				⊕	⊕	⊕	⊕		⊕	⊕	⊕
Endangered Terrestrial or Avian Species Present									●		
Endangered Terrestrial or Avian Species Possible									⊕		

ADDITIONAL ENVIRONMENTAL CONSIDERATIONS

Hazardous and Toxic Materials:

In the normal operations of the District potentially hazardous or toxic materials are generated that must be disposed of or handled in special ways. The District has a California Environmental Protection Agency site number (#00055002) for disposal of wastes generated. Below is a listing and discussion of these:

Pesticides:

Storage: The District has a pesticide storage building conforming to current codes and laws for storage of bulk materials for future use. Larvicide oil is stored in a locked double walled above ground tank.
Transport: District vehicles are equipped with required secure storage for transport. Field operations vehicles are equipped with "spill kits" to deal with small spills should they occur. Personnel are in radio communications with the District and should a large spillage occur they can obtain rapid assistance. Personnel receive training in proper procedures for transport and spills.
Empty Pesticide Containers: The District stores empty pesticide containers until a reasonable quantity is on hand then they are taken for disposal in a State specified site. Several of the pesticide companies are currently working on a return plan to recycle the empty containers.
Unneeded Pesticide Materials: These are disposed of at a State specified site as required by law.

Hazardous Materials:

Used Oil: The District stores used motor oil in a double walled 55 gallon drum. When the drum in near full, a licensed disposal company is called to pick up the oil.
Used Oil Filters: The District drains the filters into the above mentioned drum and stores the filters in a special container for pick up by a licensed disposal company.
Miscellaneous Solvents: Paint thinner and other used solvents are stored in marked containers then taken to the County operated Household Hazardous Waste Station.
Miscellaneous Materials: Used cleaning supplies and other potentially toxic or hazardous waste are turned into the County operated Household Hazardous Waste Station. Empty paint, solvent and cleaning supplies containers are disposed of as required by law.

Runoff:

Vehicle Wash Water: Water from washing District vehicles is channeled into a drain leading to the municipal sewer. Vehicles are not washed where the runoff goes to storm drains. The heavy materials from vehicle cleaning (mud, sand, grit, etc.) is trapped in a basin and is pumped as needed by a licensed disposal company. Any spills of oil, pesticides or other materials are cleaned up to prevent their entering the storm drain.

Storage Tanks:

The District has completed removal of all underground storage tanks. When the District facility was constructed there were underground tanks installed for a hydraulic lift reservoir, gasoline, diesel, larvicide oil, waste oil and emergency drainage for the pesticide storage building.

Recycling:

The District recycles materials that can be recovered for reuse. Materials set aside for recycling are plastics, paper, miscellaneous metals, aluminum, glass and toner cartridges. Materials are put into the recycling stream at local receiving stations. Toner cartridges from the copier and laser printer are shipped to a company that accepts these.

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