ATTACHMENT E – NOTICE OF INTENT

WATER QUALITY ORDER 2016-XXXX-DWQ
GENERAL PERMIT CAG990004

STATEWIDE NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM PERMIT FOR BIOLOGICAL AND RESIDUAL PESTICIDE DISCHARGES TO WATERS OF THE UNITED STATES FROM VECTOR CONTROL APPLICATIONS

I. NOTICE OF INTENT STATUS (see Instructions)

Mark only one item	☒ A. New Applicator	☐ B. Change of Information: WDID# _____
	☐ C. Change of ownership or responsibility: WDID# _____	
	☐ D. Enrolled under Order 2011-0002-DWQ: WDID# _____	

II. DISCHARGER INFORMATION

A. Name: San Joaquin County Mosquito & Vector Control District			
B. Mailing Address: 7759 S. Airport Way			
C. City: Stockton	D. County: San Joaquin	E. State: CA	F. Zip Code: 95206
G. Contact Person: Eddie Lucchesi	H. Email address: elucchesi@sjmosquito.org	I. Title: Manager	J. Phone: 209-982-4675

III. BILLING ADDRESS (Enter Information *only* if different from Section II above)

A. Name			
B. Mailing Address			
C. City	D. County	E. State	F. Zip Code
G. Email address	H. Title	I. Phone	

IV. RECEIVING WATER INFORMATION

A. Biological and residual pesticides discharge to (check all that apply)*:

☐ 1. Canals, ditches, or other constructed conveyance facilities owned and controlled by Discharger.
Name of the conveyance system: _____

☒ 2. Canals, ditches, or other constructed conveyance facilities owned and controlled by an entity other than the Discharger.
Owner's name: Various - See Attachment A
Name of the conveyance system: Applications may be made to various Conveyance systems within San Joaquin County

☒ 3. Directly to river, lake, creek, stream, bay, ocean, etc.
Name of water body: Various - See Attachment A - Application have been made in the past to highwater marks of the Stanislaus and San Joaquin Rivers and their tributaries.
* A map showing the affected areas for items 1 to 3 above may be included.

B. Regional Water Quality Control Board(s) where application areas are located (REGION 1, 2, 3, 4, 5, 6, 7, 8, or 9): Region 5
(List all regions where pesticide application is proposed.)

A map showing the locations of A1-A3 in each Regional Water Board shall be included.

V. PESTICIDE APPLICATION INFORMATION

A. Target Organisms: ☒ Vector Larvae ☒ Adult Vector

B. Pesticides Used: List name, active ingredients and, if known, degradation by-products
See Attachment B

C. Period of Application: Start Date January 1 End Date December 31

D. Types of Adjuvants Added by the Discharger:

VI. PESTICIDES APPLICATION PLAN

A. Has a Pesticides Application Plan been prepared?*
☒ Yes ☐ No

If not, when will it be prepared? _____

* A copy of the Pesticides Application Plan shall be included with the NOI.

B. Is the applicator familiar with its contents?

☒ Yes ☐ No

VII. NOTIFICATION

Have potentially affected governmental agencies been notified?

☒ Yes ☐ No

* If yes, a copy of the notifications shall be attached to the NOI. See Attachment C

VIII. FEE

Have you included payment of the filing fee (for first-time enrollees only) with this submittal?

☒ Yes ☐ NO ☐ NA

IX. CERTIFICATION

"I certify under penalty of law that this document and all attachments were prepared under my direction and supervision in accordance with a system designed to ensure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine or imprisonment. Additionally, I certify that the provisions of the Order, including developing and implementing a monitoring program, will be complied with."

A. Printed Name: EDDIE LUCCHESI

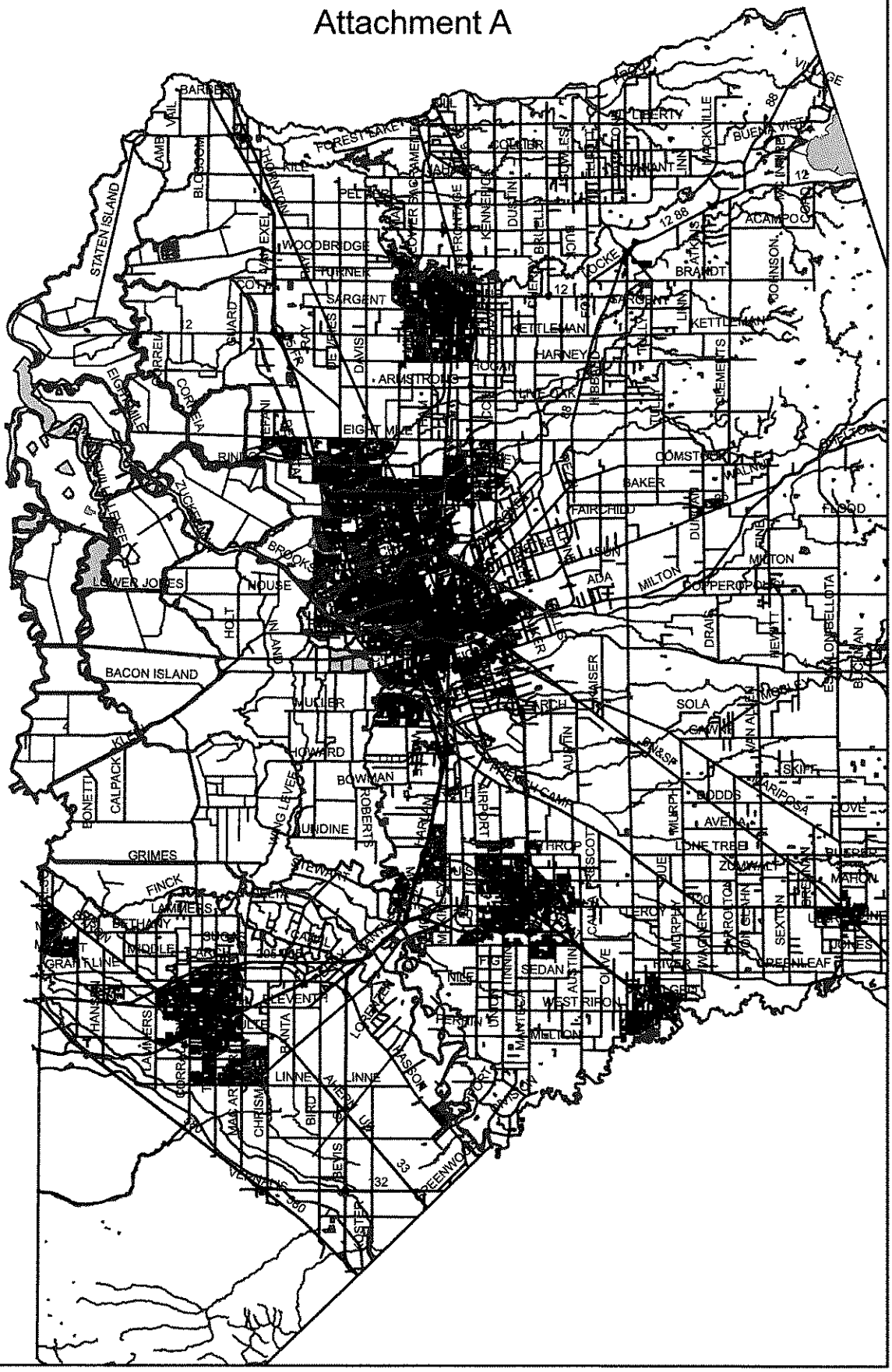
B. Signature: Eddie Lucchesi **Date:** 4/25/16

C. Title: MANAGER

X. FOR STATE WATER BOARD USE ONLY

WDID:	**Date NOI Received:**	**Date NOI Processed:**
Case Handler's Initial:	**Fee Amount Received:** $	**Check #:**

Attachment A



Attachment B
San Joaquin County MVCD NOI
V. Pesticide Application Information
List of Active Ingredients that may be used under NPDES Permit

Bacillus thuringiensis subs. Israelensis (Bti)
Bacillus shaericus (Bs) (Lysinbacillus sphaericus)
Methoprene
Monomolecular Films
Petroleum Distillates
Spinosad
Temephos
Deltamethrin
Etofenprox
Lambda-Cyhalothrin
Malathion
Naled
N-octyl bicycloheptene dicarboximide (MGK-264)
Piperonyl butoxide (PBO)
Permethrin
Prallethrin
Pyrethrin
Resmethrin
Sumithrin
Any minimum risk category pesticides that are FIFRA exempt and registered for use in California and used in a manner specified in 40 C.F.R. section 152.25.

Attachment C

SAN JOAQUIN COUNTY
MOSQUITO
& VECTOR
CONTROL DISTRICT

Protection Through Prevention

April 26, 2016

Dear Agency,

The San Joaquin County Mosquito & Vector Control District (District) may be making larvicide and/or adulticide applications to waters of the US under your jurisdiction for mosquito reduction purposes. The District is required to notify all Government Agencies that may be affected by these applications under the requirements of the Statewide National Pollutant Discharge Elimination System (NPDES) Permit for Biological and Residual Pesticide Discharges to Waters of the United States from Vector Control Applications.

Please contact Eddie Lucchesi at 209-982-4675 if you have additional questions.

Sincerely,

Eddie Lucchesi
Manager
San Joaquin County MVCD

7759 SOUTH AIRPORT WAY, STOCKTON, CALIFORNIA 95206-3918
(209) 982-4675 • FAX (209) 982-0120 • www.sjmosquito.org

April 26th, 2016

NOTICE OF INTENT TO APPLY PUBLIC HEALTH PESTICIDES FOR VECTOR CONTROL PURPOSES TO SURFACE WATERS AND WATERS OF THE U.S. WITHIN SAN JOAQUIN COUNTY, CA

1. The San Joaquin County Mosquito and Vector Control District (the District) intends to apply public health pesticides to, over and adjacent to canals, ditches, or other constructed conveyance facilities owned and controlled by an entity other than the District, as well as surface waters and waters of the U.S. for vector control purposes per the requirements of the General NPDES Permit for Biological and Residual Pesticide Discharges for Vector Control Applications (the Permit) issued by the State Water Resources Control Board (SWRCB).

2. The NPDES Permit requirements for listing of the Public Health Pesticides anticipated to be used were modified from the previous permit being issued in 2016. The newer requirements specify that any pesticide product can be used that contains approved active ingredients, provided all pesticide label restrictions and instructions are followed. In addition, pesticides which fall under the "minimal risk" category can be used. The minimum risk pesticides have been exempted from FIFRA requirements. The following tables list the active ingredients approved for the FIFRA regulated pesticides.

3.

Active Ingredients for larval mosquito control:
Bacillus thuringienses var. israelensis
Bacillus sphaericus (Lysinibacillus sphaericus)
Methoprene
Monomolecular Films
Petroleum Distilates
Spinosad
Temephos
Active Ingredients for adult mosquito control:
Deltamethrin
Etofenprox
Lmbda-Cyhalothrin
Malathion
Naled
N-octyl bicycloheptene dicarboximide (MGK-264)
Piperonyl butoxide (PBO)
Permethrin
Prallethrin
Pyrethrin
Resmethrin
Sumithrin

4. The purpose of the use of larvicide and adulticide pesticides containing these active ingredients is to control immature and adult mosquitoes. Controlling mosquitoes will reduce annoyance and disease transmission to humans, domestic animals, and wildlife.

5. The general time period for the application of the pesticides is January through December, 2016. The locations of expected use will be canals, ditches, or other constructed conveyance facilities owned and controlled by an entity other than the District, as well as surface waters and waters of the U.S. within San Joaquin County, CA where immature and adult mosquitoes are found at treatment threshold levels.

6. There are no known water use restrictions or precautions during treatment.

7. Interested persons may contact the District at (209) 982-4675 to obtain additional information.

Eddie Lucchesi, Manager
San Joaquin County Mosquito and Vector Control District
7759 S. Airport Way
Stockton, CA 95206-3918
(209) 982-4675
elucchesi@sjmosquito.org
www.sjmosquito.org

USFWS
850 S. Guild Ave Ste. 105
Lodi, CA 95240

CDFG
Bay-Delta Region
2109 Arch Airport Rd
Stockton, CA 95206

CDFG
North Central Region
1701 NIMBUS ROAD
RANCHO CORDOVA, CA 95670

CDPH-VBDS
8633 BOND ROAD
ELK GROVE, CA 95624

Central Valley Regional Water Quality Control Board
11020 Sun Center Drive, #200
Rancho Cordova, CA 95670-6114

COUNTY OF SAN JOAQUIN
44 N. SAN JOAQUIN STREET
STOCKTON, CA 95202

CITY OF ESCALON
1854 MAIN STEET
ESCALON, CA 95320

CITY OF LATHROP
390 TOWNE CENTRE DRIVE
LATHROP, CA 95330

CITY OF LODI
221 W. PINE STREET
LODI, CA 95241-1910

CITY OF MANTECA
1001 W. CENTER STREET
MANTECA, CA 95337

CITY OF RIPON
259 NORTH WILMA AVE.
RIPON, CA 95366

CITY OF STOCKTON
425 N. EL DORADO STREET
STOCKTON, CA 95202

CITY OF TRACY
333 CIVIC CENTER PLAZA
TRACY, CA 95376

BYRON-BETHANY IRRIGATION DISTRICT
7995 BRUNS ROAD,
BYRON, CA 94514

BANTA-CARBONA IRRIGATION DISTRICT
3514 WEST LEHMAN ROAD
TRACY, CA 95304

NAGLEE-BURK IRRIGATION DISTRICT
18961 S LAMMERS ROAD
TRACY, CA 95304-9492

NEW DEL PUERTO WATER DISTRICT
PO BOX 1596
PATTERSON, CA 95363

NORTH SAN JOAQUIN WATER CONSERVATION DISTRICT
P.O. Box E
VICTOR, CA 95253

NYJO WATER DISTRICT

OAKDALE IRRIGATION DISTRICT
1205 East F STREET
OAKDALE, CA 95361-4198

SOUTH SAN JOAQUIN IRRIGATION DISTRICT
PO BOX 747
RIPON, CA 95366

STOCKTON EAST WATER DISTRICT
PO BOX 5157
STOCKTON, CA 95205

WOODBRIDGE IRRIGATION DISTRICT
18777 N. LOWER SACRAMENTO ROAD
WOODBRIDGE, CA 95258-9122

WESTSIDE IRRIGATION DISTRICT
1320 N TRACY BLVD.
TRACY, CA 95376-3436

WEST STANISLAUS IRRIGATION DISTRICT
1800 EAST WEST STANISLAUS ROAD
WESTLEY, CA 95387

RECLAMATION DISTRICT #1
311 EAST MAIN STREET, SUITE 504
STOCKTON, CA 95202

RECLAMATION DISTRICT #2
311 EAST MAIN STREET, SUITE 504
STOCKTON, CA 95202

RECLAMATION DISTRICT #17
PO BOX 844
STOCKTON, CA 95201-0844

RECLAMATION DISTRICT #38
PO BOX 408
WALNUT GROVE, CA 95960

RECLAMATION DISTRICT #348
1048 W. Robinhood Dr., #7364
STOCKTON, CA 95267-1612

RECLAMATION DISTRICT #403
PO BOX 20
STOCKTON, CA 95201-3020

RECLAMATION DISTRICT #404
PO BOX 1461
STOCKTON, CA 95201-1461

RECLAMATION DISTRICT #524
Middle Roberts Island
7540 Shoreline Dr
Stockton, CA 95219

RECLAMATION DISTRICT #544
311 EAST MAIN STREET, SUITE 504
STOCKTON, CA 95202

RECLAMATION DISTRICT #548
PO BOX 1461
STOCKTON, CA 95201-1461

RECLAMATION DISTRICT #684
PO BOX 1461
STOCKTON, CA 95201

RECLAMATION DISTRICT #756
311 EAST MAIN STREET, SUITE 504
STOCKTON, CA 95202

RECLAMATION DISTRICT #773
PO BOX 20
STOCKTON, CA 95201-3020

RECLAMATION DISTRICT #828
PO Box 20
STOCKTON, CA 95201

RECLAMATION DISTRICT #1007
PO BOX 1129
TRACY, CA 95378

RECLAMATION DISTRICT #1608
PO BOX 20
STOCKTON, CA 95201-3020

RECLAMATION DISTRICT #2023
PO BOX 1461
STOCKTON, CA 95201-1461

RECLAMATION DISTRICT #2027
PO BOX 1461
STOCKTON, CA 95201-1461

RECLAMATION DISTRICT #2028
311 EAST MAIN STREET, SUITE 504
STOCKTON, CA 95202

RECLAMATION DISTRICT #2029
421 SOUTH EL DORADO STREET, SUTIE E
STOCKTON, CA 95203

RECLAMATION DISTRICT #2033
165 WEST CLEVELAND STREET
STOCKTON, CA 95204

RECLAMATION DISTRICT #2037
PO BOX 7424
STOCKTON, CA 95267

RECLAMATION DISTRICT #2038
PO BOX 1461
STOCKTON, CA 95201

RECLAMATION DISTRICT #2039
235 E. Weber Ave
P.O. Box 1461
STOCKTON, CA 95201

RECLAMATION DISTRICT #2040
PO BOX 1461
STOCKTON, CA 95201-1461

RECLAMATION DISTRICT #2041
PO BOX 1461
STOCKTON, CA 95201-1461

RECLAMATION DISTRICT #2042
311 EAST MAIN STREET, SUITE 504
STOCKTON, CA 95202

RECLAMATION DISTRICT #2044
421 SOUTH EL DORADO STREET, SUITE E
STOCKTON, CA 95203

RECLAMATION DISTRICT #2058

3650 WEST CANAL BOULEVARD
TRACY, CA 95304

RECLAMATION DISTRICT #2062
73 WEST STEWART ROAD
LATHROP, CA 95330

RECLAMATION DISTRICT #2064
C/O Alan R. Coon
421 S. El Dorado Street, STE. E
STOCKTON, CA 95203

RECLAMATION DISTRICT #2072
PO BOX 1461
STOCKTON, CA 95201-1461

RECLAMATION DISTRICT #2074
3425 Brookside Road "A"
STOCKTON, CA 95219

RECLAMATION DISTRICT #2075
311 EAST MAIN STREET, SUITE 504
STOCKTON, CA 95202

RECLAMATION DISTRICT #2085
7541 W. Rena Dr
Tracy, CA 95304

RECLAMATION DISTRICT #2086
11292 N. ALPINE ROAD
STOCKTON, CA 95212

RECLAMATION DISTRICT #2089
311 EAST MAIN STREET, SUITE 504
STOCKTON, CA 95202

RECLAMATION DISTRICT #2094
PO BOX 871
MANTECA, CA 95336

RECLAMATION DISTRICT #2095
PO BOX 844
STOCKTON, CA 95201-0844

RECLAMATION DISTRICT #2096
PO BOX 909
MANTECA, CA 95337

RECLAMATION DISTRICT #2101
6130 HUNTINGTON CIRCLE
STOCKTON, CA 95219-1906

RECLAMATION DISTRICT #2107
311 EAST MAIN STREET, SUITE 504

STOCKTON, CA 95202

RECLAMATION DISTRICT #2108
ST FRANCIS YACHT CLUB, ON THE MARINA
SAN FRANCISCO, CA 94123

RECLAMATION DISTRICT #2113
PO BOX 1461
STOCKTON, CA 95201

RECLAMATION DISTRICT #2114
LEGAL DEPARTMENT
10100 TRINITY PARKWAY, 5TH FLOOR
STOCKTON, CA 95219

RECLAMATION DISTRICT #2115
PO BOX 20
STOCKTON, CA 95201-3020

RECLAMATION DISTRICT #2116
PO BOX 1461
STOCKTON, CA 95201

RECLAMATION DISTRICT #2118
PO BOX 1267
HOLLISTER, CA 95024

RECLAMATION DISTRICT #2119
PO BOX 1461
STOCKTON, CA 95201

RECLAMATION DISTRICT #2126
PO BOX 4776
STOCKTON, CA 95204

AVENA DRAINAGE DISTRICT

NEW MARIPOSA DRAINAGE DISTRICT

San Joaquin County Mosquito & Vector Control District (District)
Pesticide Application Plan (PAP):

1. Description of all target areas, if different from the water body of the target area, in to which larvicides and adulticides are being planned to be applied or may be applied to control vectors. The description shall include adjacent areas, if different from the water body of the target areas;

Please see the attached boundary map of San Joaquin County. In prior years, the District has applied adulticides and/or larvicides directly to or in the vicinity of many of the waters described on the map.

2. Discussion of the factors influencing the decision to select pesticide applications for vector control;

The prevalence of mosquito-borne diseases, mosquito populations, growth stage of mosquitoes, location of breeding sources, habitat type and the ability or inability to initiate source reduction or biological control all influence the decision to select applications for vector control.
Please see the following enclosed references that identify the factors influencing the decision to select pesticide applications for vector control.

2a. Best management Practices for Mosquito Control in California. July 2012. California Department of Public Health, Vector-Borne Disease Section: ***see page 31, Mosquito Surveillance, for surveillance information that determines the need for mosquito control; see pages 27-30, Chemical Control, for information on chemical control as part of an IPM plan; see pages 35-39, Appendix B, Compounds Approved for Mosquito Control in California, for information on the selection and use of pesticides used for mosquito control.***

2b. California Mosquito-Borne Virus Surveillance & Response Plan. May 2012. California Department of Public Health, Vector-Borne Disease Section; ***see pages 8-11, Mosquito Control, for information on larval and adult mosquito control based on surveillance; see pages 16-18, Characterization of Conditions and Responses, for information on larval and adult mosquito control based on risk evaluation (normal season, emergency planning, and epidemic conditions).***

2c. Integrated Pest management Plan for Certain Vectors in San Joaquin County, CA. 2008. San Joaquin County Mosquito and Vector Control District; ***see pages 18-21, Surveillance, for information on how surveillance information is used to determine a mosquito control strategy, including chemical control; see pages 22-23, Thresholds, for information on thresholds used to determine when mosquito control is warranted' see pages 27-31, Chemical Control, for information on chemical control as a component of the IPM plan.***

3. Pesticide products or types expected to be used and if known, their degradation by-products, the method in which they are applied, and if applicable the adjuvants and surfactants used;

The NPDES Permit for Biological and Residual Pesticide Discharges to Waters of the U.S. from Vector Control Applications was amended to list the approved active ingredients rather than having specific products named. All pesticide label restrictions and instructions will be followed for pesticides which contain the active ingredients listed below. In addition, pesticides which fall under the "minimum risk" category may be used. The minimum risk pesticides have been exempted from FIFRA requirements. Products will be applied by truck, backpack, hand can and airplane.

Active Ingredients:
Bacillus thuringienses var. israelensis
Bacillus sphaericus (Lysinibacillus sphaericus)
Methoprene
Monomolecular Films
Petroleum Distillates
Spinosad
Temephos
Deltamethrin
Etofenprox
Lmbda-Cyhalothrin
Malathion
Naled
N-octyl bicycloheptene dicarboximide (MGK-264)
Piperonyl butoxide (PBO)
Permethrin
Prallethrin
Pyrethrin
Resmethrin
Sumithrin

4. Description of ALL the application areas and the target areas in the system that are being planned to be applied or may be applied. Provide a map showing these areas;

Following is a general description and listing of the application areas and the target areas in San Joaquin County that are being planned to be applied or may be applied. Aquatic sources, such as surface water, waters of the US, water bodies, canals, ditches, or other constructed conveyance facilities that are governed by the NPDES permit are within the boundaries of the District. Any site that holds water for more than 4 days can produce mosquitoes.
Please see Agency Boundary Map and list of waterways and in response to Question Number 1.

5. Other control methods used (alternatives) and their limitations;

- Biological Control. The use of biological control is a primary method of control if the use of other control methods presents environmental concern and current vector populations are low or tolerable. The use of biological control organisms and strategies is limited to those that have been researched and field tested against target and non-target organisms.
- The District operates a large-scale aquaculture facility that produces several thousand pounds of mosquitofish annually. The fish are planted in aquatic sites in agriculture, environmental, residential and industrial sources.
- Legal abatement. Legal abatement is the process of preventing vectors through the enactment of legislation that enforces control measures or imposes regulations to prevent the production, introduction, or spread of pests and vectors. Legal abatement includes the use of federal, state and local guidelines and laws designed to prevent the creation and/or harborage of pests and vectors. The District regularly enforces the California Health and Safety Code, which specifically

addresses the creation and/or harborage of vectors and vector breeding sites. The District uses a process to work with landowners to limit mosquito production. Initially the District provides the landowner with information that acknowledges their creation of a public nuisance and then provides specific recommendations to fix the problem. If the problem continues the landowner can be cited per California health and Safety Code.

- Physical Control. The primary operational objective of physical control is to reduce the vector carrying capacity of a site to preclude the use of control methods that would adversely impact the environment and wildlife. Additionally, the District routinely reviews and comments on proposed projects with the County being considered by the various city and county departments, thus providing opportunities to "design out" vector breeding conditions prior to construction and development.

6. How much product is needed and how this amount was determined;

Material	Pounds	Gallons
Bti/Bs Graunule	5300	
Bti Granule	3900	
Bs WDG	10	
Bti Liquid		175
Methoprene Pellets 30 day	60	
Methoprene Briquets 30 day	6	
Methoprene Briquets 120 day	11	
Naled		1250
5% Pyrethrin		286
Spinosad 30 day Granule	40	

The above totals represent estimated pesticide applications within the District boundaries to Waters of the U.S. for 2015. Annual variability will occur due to conditions such as; vector abundance, weather and mosquito-borne disease activity.

7. Representative monitoring locations and the justification for selecting these locations;

Please see the MVCAC NPDES Coalition Monitoring Plan.

8. Evaluation of available BMP's to determine if there are feasible alternatives to the selected pesticide application project that could reduce potential water quality impacts:

Items 2.a. through 2.c. (above) were used in the evaluation of available BMPs for the determination of feasible alternatives to selected pesticide applications that could reduce potential water quality impacts.

The District has long emphasized an adherence to IPM (Integrated Pest Management) for the control of mosquitoes. As such, District policies emphasize training, vector and pathogen surveillance, the integration of biological and physical control practices with chemical control, and judicious use of appropriate control tools only when vectors exceed specific thresholds.

Biological Control of Mosquitoes
The District has traditionally implemented a four-pronged approach to biological control of mosquitoes. The general elements of biological control used by the District are 1) rearing, stocking, and providing for limited public use mosquitofish to eat larval mosquitoes in sites where they are unlikely to cause significant impacts on native species; 2) support of programs to identify and evaluate additional biocontrol agents that can be produced at reasonable cost; 3) collaboration with land-owners and managers to implement land and water management practices that protect and support populations and dispersal of native mosquito predators; 4) policies and training designed to protect native predators.

The District collaborates with land-owners to improve land and water management to reduce mosquito production. Target sites include storm water treatment facilities, irrigated pastures, duck clubs, and sewer treatment mashes, etc.

Training and treatment protocols for pesticide use emphasize protection of predators when they are present in sites with mosquito larvae. Periodic review of mosquito breeding sites helps determine if large populations of predators are present and larvicides are chosen that will not negatively impact those populations.

Physical Control
The District routinely works with landowners to encourage mosquito prevention flooding regimes, water circulation, and predator dispersal in sites that are likely to produce high mosquito populations. Development proposals from cities and the county that include aquatic features are routinely commented on by staff, and recommendations to include mosquito prevention BMP's are required for project permits.

Vegetation Management
The amount of herbicides used by the District for vegetation thinning in selected high-producing mosquito sites has traditionally been very limited. Vegetation management is conducted with hand tools as needed to allow access for vector surveillance.

9. Description of the BMPs to be implemented. The BMPs shall include, at the minimum:

Measures to prevent pesticide spill
District staff monitors application equipment on a daily basis to ensure it remains in proper working order. Spill mitigation devices are placed in all spray vehicles and pesticide storage areas to respond to spills. Employees are trained on spill prevention and response annually.

Measures to ensure that only a minimum and consistent amount is used
Application equipment is calibrated at least annually as required by the Department of Pesticide Regulations and the terms of a cooperative agreement with California Department of Public Health.

A plan to educate Coalition's or Discharger's staff and pesticide applicators on any potential adverse effects to waters of the U.S. from the pesticide application
This is included in our pesticide applicators annual pesticide application and safety training and CDPH Vector Control Technicians License continuing education programs.

Descriptions of specific BMPs for each application mode, e.g. aerial, truck hand, etc.
The District calibrates truck-mounted and handheld larviciding equipment each year to meet application specifications. Supervisors review application records daily to ensure appropriate amounts of material are being used. Ultra-low volume (ULV) application equipment is calibrated for output and droplet size to meet label requirements. Aerial adulticiding and larviciding equipment is completed by the contractor. Aerial adulticide equipment is calibrated regularly and droplet size is periodically monitored by the District to ensure droplets meet label requirements. Aerial ULV contractors utilize advanced guidance and drift management software to ensure the best available technology is being used to place the appropriate amount of product in the intended area.

Descriptions of specific BMPs for each pesticide product used
Please see the *Best management Practices for Mosquito Control in California* July 2012 and Appendix 2 for general pesticide application BMPs, and the current approved pesticide labels for application BMPs for specific products.

Descriptions of specific BMPs for each type of environmental setting (agricultural, urban, and wetland)
Specifically, employees will evaluate the ability of a given mosquito breeding source to be reduced or eliminated per biological and/or physical control strategies outlined in the District's IPM Plan after determining: 1) the species of mosquito 2) the immediate population of mosquitoes, and 3) the current public health threat posed by the mosquito specie(s), the current mosquito population, and related arbovirus activity. Additional information regarding arbovirus activity is also used in determining what type of control technique should be implemented and when.

10. Identification of the problem. Prior to the first pesticide application covered under this General Permit that will result in a discharge of biological and residual pesticides to waters of the U.S., and at least once each calendar year thereafter prior to the first pesticide application for that calendar year, the Discharger must do the following for each vector management area:

The District utilizes densities for larval and adult vector populations identified in the District's IPM plan (Item 2.c. above) for implementing pest management strategies.

a. If applicable, establish densities for larval and adult vector populations to serve as action threshold(s) for implementing pest management strategies;
Please see *the Districts IPM Plan, pages 22-23* for thresholds

b. Identify target vector species to develop species-specific pest management strategies based on developmental and behavioral considerations for each species;
Please see the *District IPM Plan, pages 22-31*

c. Identify known breeding areas for source reduction, larval control program, and habitat management; and
Any site that holds water for more than 4 days can produce mosquitoes. Source reduction is the District's preferred solution, and regularly works with landowners and managers to work on long-term solutions to reduce or eliminate mosquito production. **Please *see the Best Management Practices for Mosquito Control in California, July 2012: Executive Summary, page v., Section 3; Appendix A, page 26, Environmental Management; Appendix A, page 27, Biological Control; Appendix A, page 27, Chemical Control; see District IPM Plan, 2008: Combining and integrating control tactics, pages 6-7***

d. **Analyze existing surveillance data to identify new or unidentified sources of vector problems as well as areas that have recurring vector problems;**
Utilize the District's GIS mosquito surveillance and control record keeping system (Sentinel), the University of California/CVEC Gateway system, and the California Department of Public Health's data sets to analyze existing surveillance data for the identification of unidentified sources of vector problems as well as areas that may have recurring vector problems.

11. Examination of Alternatives. Dischargers shall continue to examine alternatives to pesticide use in order to reduce the need for applying larvicides that contain temephos and or for spraying adulticides. Such methods include:
a. Evaluating the following management options, in which the impact to water quality, impact to non-target organisms, vector resistance, feasibility, and cost effectiveness should be considered:

- **No action**
- **Prevention**
- **Mechanical**
- **Cultural Methods**
- **Biological control agents**
- **Pesticides**

If there are no alternatives to pesticides, dischargers shall use the least amount of pesticide necessary to effectively control the target pest.
b. Applying pesticides only when vectors are present at a level that will constitute an nuisance.

The District will utilize the resources identified in 2.a. through 2.c. (above) in the examination of alternatives to pesticides. If there are no alternatives to pesticides, the District, to the extent practical, will use the least amount of pesticide necessary to control the target pest, and will only apply pesticides when vectors are present at levels identified in the IPM plan (item 2.c. above).

The District's interpretation of IPM, is a sustainable approach to managing public health pests, by combining biological, chemical, legal, natural and physical control tactics in a way that minimizes economic, health and environmental risks.

12. Correct Use of Pesticides

Coalition's or Discharger's use of pesticides must ensure that all reasonable precautions are taken to minimize the impacts caused by pesticide applications. Reasonable precautions include using the right spraying techniques and equipment, taking account of weather conditions and the need to protect the environment.

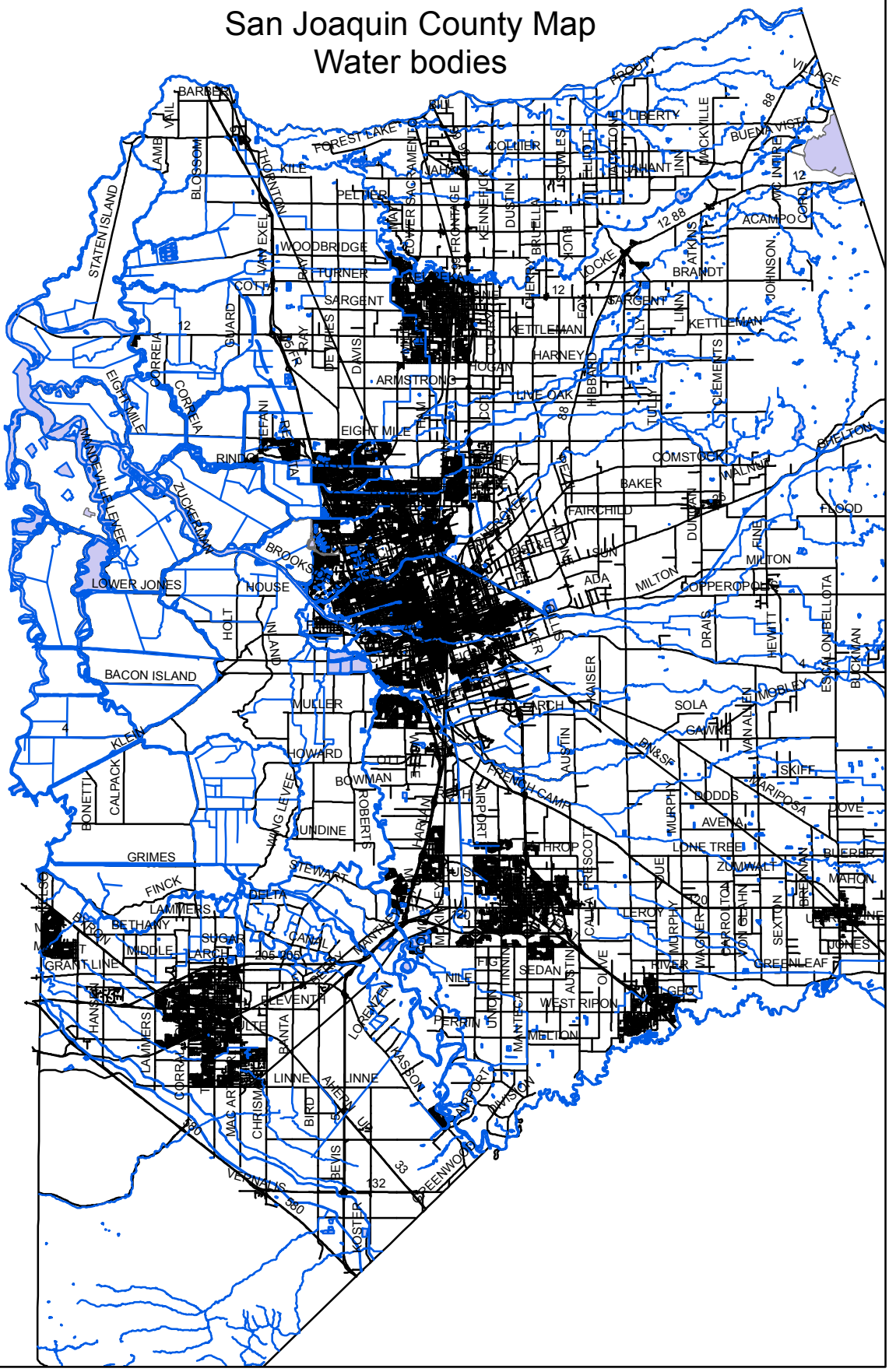
The District will ensure that all reasonable precautions are taken to minimize the impact caused by pesticide applications, and will comply with all regulations related to pesticide application, mixing, storing, and transport. The District is signatory to a cooperative agreement administered by the California department of Public health76 regarding pesticides, and agrees to: 1) calibrate all application equipment, 2) seek assistance from the County Agriculture Commissioner (CAC) for interpretation of pesticide labeling, 3) maintain records of each pesticide application for two or more years, 4) to submit monthly pesticide use reports to the CAC and CDPH-VBDS, 5) to report to the CAC and CDPH-VBDS any suspected adverse issues resulting from a pesticide application, 6) to certify and routinely train pesticide

applicators, and 7) to be inspected by the CAC and CDPH-VBDS to ensure that our activities are in compliance with laws and regulations related to pesticide application.

13. If applicable, specify a website where public notices, required in Section VIII.B, may be found.

www.sjmosquito.org

San Joaquin County Map
Water bodies



INTEGRATED PEST MANAGEMENT PLAN FOR CERTAIN VECTORS IN SAN JOAQUIN COUNTY, CA 2008

San Joaquin County
Mosquito & Vector Control District
7759 South Airport Way
Stockton, CA 95206

Table of contents Page

Integrated Pest Management (IPM)

Integrated pest management, referred to as IPM, is a sustainable approach, or plan, to managing public health pests and vectors, by combining biological, chemical, legal, natural and physical control tactics in a way that minimizes economic, health and environmental risks. IPM can also be considered as a systematic approach to public health pest management, which combines a variety of surveillance and control practices. With regards to implementing a plan to control vectors, IPM can be defined as socially acceptable, environmentally responsible and economically practical protection of the public's health and well being.

For the purposes of this plan, a pest is defined as any organism that is unacceptably abundant. A vector is an organism (such as an insect or other arthropod) which 1) transports and transmits a parasite (including disease causing pathogens) from one host to another, 2) causes direct harm or injury without transmitting a parasite, or 3) causes significant annoyance to humans and/or animals. The words pest and vector are used interchangeably for the purposes of the District's surveillance and control plans for specific vectors.

History of IPM for vector control within the San Joaquin County Mosquito and Vector Control District

The development of integrated pest management strategies for control of certain vectors found in the District is due mainly to pesticide resistance, potential or probable effects of certain pesticides on non-target organisms, government regulation, and public awareness.

Pesticide resistance

Most pest and vector species have short life cycles, a wide geographic range, and large populations. Consequently, there is a substantial genetic diversity found in vector populations. When these populations are all treated with the same chemical (or class of chemical), a few individuals are not killed because they are genetically resistant. These individuals survive to reproduce, quickly resulting in localized resistant populations, which can then spread. Consequently, higher and higher doses of chemicals are needed to control vector populations, and finally new chemicals must be developed. Then the cycle begins again, resulting in increased costs, increased amount of chemical-use, and decreasing effectiveness of products. Resistance to organochlorine and organophosphate insecticides has been detected in several species of mosquitoes in San Joaquin County.

Potential effect(s) of pesticides on non-target organisms

An important aspect of the potential effects of pesticides on non-target organisms is the loss of non-pest, or beneficial organisms. Some organisms that are killed at the time of a pesticide application can be actual parasites or predators of the target species. When the beneficial specie(s) population is impacted, the imbalance can then create larger outbreaks of the target specie. Other potential effects include groundwater contamination and wildlife kills.

Government regulation

Because of the problems associated with pesticides, there has been an increase in environmental activism, education, and regulation. Periodic modifications of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), and the development and implementation of the Federal Environmental Pesticide Control Act (FEPCA) have restricted the re-registration and availability of many pesticides.

Public awareness

People are becoming more aware of and concerned about the potential negative effects of chemicals on our environment. The impact of the use of pesticides on drinking water and food production, as well as the impact in homes and landscapes has become a significant social concern. Many people have begun to wonder if there are ways to reduce or eliminate pesticide use in non-agricultural settings.

Important IPM plan components

The District's IPM plan includes the components of information, thresholds, and surveillance.

Information

Information is a fundamental component of the District's IPM program for two reasons. First, because an understanding of the local ecosystem and environment is essential to preventing vector problems. Second, because IPM relies upon close monitoring of vector populations in order to determine when a population has reached a public health or nuisance threshold.

Thresholds

Thresholds are developed from research that takes into account the potential public health threat caused by the presence of the vector at a known level of population and incidence of arbovirus transmission. Other information used in developing thresholds includes human and domestic animal population data, complaints and/or requests for service, weather conditions, local and state-wide arbovirus data, vector competence, vector population dynamics and control costs.

Surveillance

Surveillance is the primary method of monitoring vector populations to determine if a public health or nuisance threshold is reached. It refers to the periodic and systematic sampling of vectors in the field in order to estimate population levels. Past surveillance records and field inspection data, current and future weather conditions and other factors are used to predict the onset and severity of a vector outbreak. In some cases, monitoring of populations of beneficial organisms is performed as well.

Combining and integrating control tactics

As a concept and practice, there is an emphasis on the combination and integration of pest management tactics, such as biological control, chemical control, legal abatement, natural control, and physical control (habitat modification). Following is basic information about each type of control tactic:

Biological control

Biological control is the intentional use of natural predators, parasites or pathogens to achieve desired reductions in pest and vector population levels. The use of biological control is a primary method of control if the use of other control methods presents environmental concern and current vector populations are low or tolerable.

The use of biological control organisms and strategies is limited to those that have been researched and field tested against target and non-target organisms. In addition, any biological control organism to be considered for use by the District will also be recognized and authorized by appropriate federal, state, and local agencies.

Chemical control

Chemical control is the intentional use of specific chemical compounds (pesticides) to quickly kill a known vector population. Chemical control is performed to obtain immediate control when biological and physical control methods fail to maintain vector populations at or below a tolerable level. Chemical control is also used to prevent an epidemic of vector-borne disease when emergency control measures are needed to rapidly suppress vector populations to levels that either disrupt or terminate disease transmission to humans or domestic animals.

The use of conventional pesticides in the District's IPM program may differ from that of a "traditional" chemical-based pest control program. Under the District's IPM plan, an attempt is made to choose materials that are:

- ***Only one of the many actions taken during the arbovirus or pest cycle to manage vector species***
- ***Specific, as near as possible, to the vector species***
- ***Used at the lowest effective rate***
- ***Short-lived in the environment***
- ***Be least toxic to beneficial organisms and humans***
- ***To the extent possible, alternated with other chemicals and techniques to help prevent resistance***
- ***Formulated, labeled and accepted for use as a vector control agent by regulatory agencies in California and the U.S.***
- ***Capable of being tested in a controlled environment prior to full-scale field use***

Combining and integrating control tactics (continued)

Legal abatement

Legal abatement is the process of preventing vectors through the enactment of legislation that enforces control measures or imposes regulations to prevent the production, introduction, or spread of pests and vectors. Legal abatement includes the use of federal, state and local guidelines and laws designed to prevent the creation and/or harborage of pests and vectors.

The District regularly enforces the California Health and Safety Code, which specifically addresses the creation and/or harborage of vectors and vector breeding sites.

Natural control

Natural control is a pest management strategy in which the environment is disturbed as little as possible. Reliance is placed on naturally occurring parasites, predators, and diseases to control vectors.

One scientific definition of natural control is "… the maintenance of a fluctuating population density within definable upper and lower limits over a period by the combined affects of abiotic and biotic elements in the environment".

Natural control is sometimes difficult to implement or assess due to the amount of man-made or manipulated vector sources found in the District. Natural control is advocated for sites that are remote and undisturbed, to the least amount practical, for the individual vector specie being contemplated for control.

Physical control

Physical control, or habitat modification, is achieved by altering the major ecological components of the vector's environment associated with the establishment and production of the vector's immature stages. The primary operational objective of physical control is to reduce the vector carrying capacity of a site to preclude the use of control methods that would adversely impact the environment and wildlife.

The District complies with requirements, as specified, of any general permit issued to the California Department of Health Services as the lead agency, pertaining to physical environmental modification to achieve pest and vector prevention. Additionally, the District routinely reviews and comments on proposed projects within San Joaquin County being considered by the various city and county departments, thus providing opportunities to "design out" vector breeding conditions prior to construction and development.

IPM in practice

By carefully monitoring vector populations, arbovirus activity and complaints from San Joaquin County-area residents, the District, using IPM, institutes management measures when specific conditions indicate that they are needed. In other words, the District determines how serious a problem is and what management options are available before any action is taken. This contrasts with routine, or "calendar" preventive chemical treatments, treatments performed "just in case", or treatments in response to any pest or vector presence regardless of how small the infestation or population.

Using IPM requires the District to understand the biology and ecology of locally and regionally found pests and vectors, and how different pest and vector populations develop. Additionally, the District must know what the control options are in each specific pest and vector management case, and what the return on investment of these control options is along with the potential impact on the environment and public health.

This means that the District will spend more time observing and interpreting the potential impact of pest and vector populations. The resulting benefits from reduced costs of chemical inputs, a cleaner environment, and decreased resistance problems can offset the extra work.

Quality assurance, quality control

The District utilizes quality assurance and control measures to insure that the IPM plan is administered and operated properly.

- The individual plan components of Information, Thresholds, and Surveillance are reviewed periodically to insure they are relevant and effective.
- Individual control tactics are continually evaluated with and against known and suspect vector species.
- Supervisory, management and professional staff oversees specific field operations routinely.
- District employees and contractors responsible for the administration and implementation of the IPM plan are certified by either the California Department of Public Health or the California Department of Pesticide Regulation in one or more areas of pest or vector control, and receive ongoing training in current vector control and integrated pest management techniques.
- The San Joaquin County Agriculture Commissioner and California Department of Public Health inspect the District's administration and operations for compliance with local, state and federal laws and regulations.
- The District routinely evaluates materials and methods used in vector control to insure they are of high quality and effectiveness. Testing of control agents and techniques are performed in a controlled setting prior to full field implementation.
- The District is an active member of the American Mosquito Control Association (AMCA), the Mosquito and Vector Control Association of California (MVCAC), and the Society of Vector Ecologists (SOVE); organizations committed to the development and promotion of integrated pest management techniques for its member agencies and the public.
- The District receives feedback from vector control service recipients and local residents regarding the level and quality of service provided. This information is received from complaints, requests for service, and other forms of communication with the public.
- The District collaborates with the California Department of Public Health and the University of California on various research and surveillance programs with regards to vector surveillance and control, endangered species, arbovirus detection, and integrated pest management program development.

Vector biology and control

Vector species in San Joaquin County are numerous and are considered in the District's operational surveillance and control procedures. Currently (2008), the District provides operational surveillance and/or control for multiple species of mosquitoes and ticks. Other pests and vectors are considered on a case-by-case basis by the District's Board of Trustees and professional staff.

Within San Joaquin County, mosquitoes are considered vectors because of their ability to cause annoyance and potentially transmit diseases such as encephalitis, heartworm, and malaria. Additionally, certain species of ticks are known vectors of babesiosis, ehrlichiosis, and Lyme disease.

The biology of vectors is a broad subject relating to life processes, structure, physiology, behavior, environmental adaptation, population dynamics, and genetics. Individual vector behavior in the environment is discussed in further detail in the following modules on mosquitoes and ticks. Also described in the modules is biological descriptions and identification of individual species.

MODULE 1
MOSQUITOES

IPM plan for the control of mosquitoes

This section is intended to serve as basic information needed to implement the District's integrated pest management program for mosquitoes. Full consideration must be given to threatened and endangered species, natural and cultural resources, and human health and safety. Recommendations herein must be evaluated and applied in relation to these broader considerations.

Biology and identification of mosquitoes

There are five (5) genera of mosquitoes in San Joaquin County: *Aedes, Anopheles, Culex, Culiseta, and Orthomodomyia.* Within these genera, there are 17 individual mosquito species. Listed below are the individual genus and species descriptions:

Genus *Aedes* Meigen:

Aedes dorsalis (Meigen) – the brackish water mosquito
Aedes melanimon Dyar
Aedes nigromaculis (Ludlow) – the irrigated pasture mosquito
Aedes sierrensis (Ludlow) – the western tree hole mosquito
Aedes vexans (Meigen) – the inland floodwater mosquito
Aedes washinoi Lanzaro and Eldridge

Genus *Anopheles* Meigen:

Anopheles franciscanus McCracken
Anopheles freeborni Aitken – the western malaria mosquito
Anopheles punctipennis (Say) – the woodland malaria mosquito

Genus *Culex* Linnaeus:

Culex erythrothorax Dyar – the tule mosquito
Culex pipiens Linnaeus – the northern house mosquito
Culex stigmatosoma Dyar – the banded foul water mosquito
Culex tarsalis Coquillett – the western encephalitis mosquito

Genus *Culiseta* Felt:

Culiseta incidens (Thompson) – the cool weather mosquito
Culiseta inornata (Williston) – the large winter mosquito
Culiseta particeps (Adams)

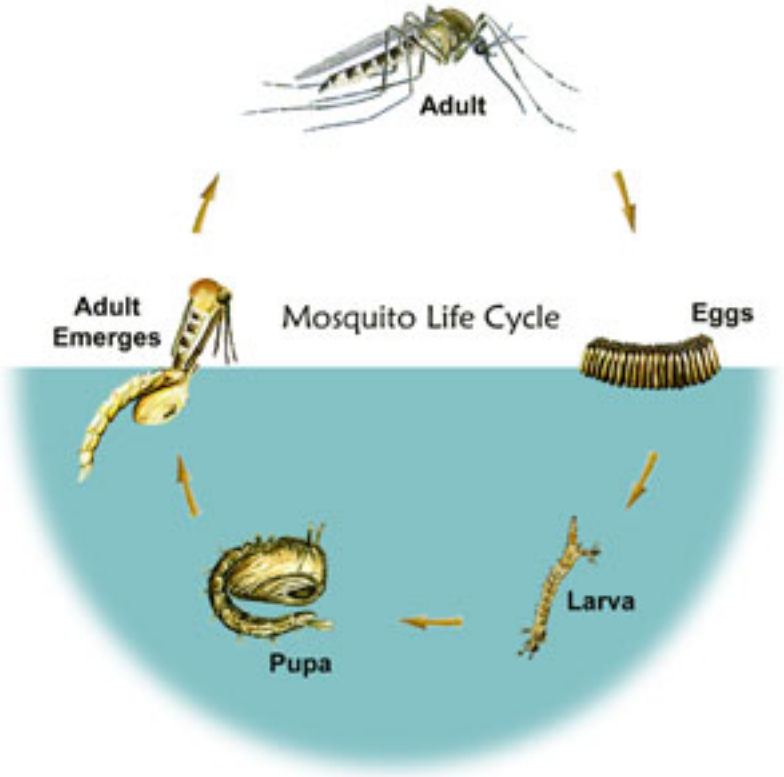
Genus *Orthopodomyia* Theobald:

Orthopodomyia signifera (Coquillett)

General information

Mosquitoes present both a pest and public health problem for humans, domestic animals, and wildlife within San Joaquin County. Several locally found species are involved in the transmission of important pathogens, including West Nile virus (WNV), western equine encephalitis (WEE), St. Louis encephalitis (SLE), malaria, and canine heartworm. Other species, although not involved with direct transmission of pathogens, create annoyance and discomfort to humans and animals. Additionally, mosquitoes can create economic losses, due to weight loss in livestock, loss of recreation opportunities, medical costs due to disease, and reduced real estate values.

Because mosquitoes breed in aquatic sites, these locations are considered the primary surveillance area for their immature stages, and thus are targeted as the preferred mosquito control zone. Adult mosquitoes will migrate from the site where they emerged from their immature stage for the purpose of seeking a blood meal, mating, laying eggs, and completing their life cycle.



Benefits and risks of mosquito control

Benefits - mosquito control for pest species

A benefit of mosquito control which has greatly contributed to San Joaquin County's growth and prosperity is the tremendous progress made in controlling pestiferous mosquito species, especially those that breed in irrigated agricultural sources, industrial and municipal waste sites, and more recently, in areas used as wildlife habitat and managed wetlands. Although some of these mosquito species do not always present an acute threat of arbovirus transmission to humans, they significantly affect human comfort, animal health, and the local economy. The fact that much development occurs near mosquito producing and environmentally sensitive habitats puts increasing pressure on the District to maintain an effective control program.

Benefits - mosquito control for disease vectors

The most important benefit of mosquito control is the targeting of mosquito species that transmit mosquito-borne diseases.

- San Joaquin County is considered an endemic area for West Nile Virus (WNV), western equine encephalomyelitis (WEE), St. Louis encephalitis (SLE), and canine heartworm and has experienced several outbreaks of these diseases in both humans and animals since 1930. The primary vector of WNV and WEE is the encephalitis mosquito *Culex tarsalis,* which is found throughout the District and all adjacent counties. In 1930 and 1931, there were approximately 170 cases of encephalomyelitis in horses and mules. Between 1939 and 1941, there were five (5) human cases of WEE reported. During the period 1945 to 1950, San Joaquin County experienced 22 human cases of WEE and 11 human cases of SLE. Another disease outbreak in 1952 resulted in 48 cases of WEE and three (3) cases of SLE in humans. Human cases of mosquito-borne encephalitis during the period 1945 to 1984 for San Joaquin County totaled 80 for WEE and 36 for SLE. WEE virus was detected in sentinel chicken flocks and adult mosquito pools during the period 1993 – 1997, but no human or equine cases were reported. WNV was originally detected in the USA in 1999 in New York City. The virus was first detected in San Joaquin County in 2004 and resulted in three (3) human and 19 equine cases that year. WNV has been routinely detected in mosquito pools, dead birds, sentinel chicken flocks, humans and equines throughout most of San Joaquin County and adjacent counties since 2004.
- Imported (exotic) cases of human malaria are reported to the District periodically by San Joaquin County Public Health Services. The malaria vector, *Anopheles freeborni*, is found throughout the District and in several adjacent counties.
- The western tree-hole mosquito, *Aedes sierrensis*, is the primary vector of canine heartworm and is found throughout most of San Joaquin County and several adjacent counties. Canine heartworm, *Dirofilaria immittis,* is

endemic to the Central Valley and adjacent Sierra Nevada mountain range. Locally-transmitted cases of canine heartworm are routinely reported to the District by local veterinarians.

Risks - human health concerns

A consideration associated with the overall use of pesticides, of which mosquito control is a part, is the potential human health risk of pesticide exposure. In the last several years, more evidence has been evaluated concerning the impact on humans from a half-century of exposure to synthetic chemicals and other environmental contaminants. Human health problems associated with the affects of severe exposure to organophosphate pesticides include irreversible neurological defects, memory loss, mood changes, infertility, and disorientation. However, this is seen as an example of chemical misuse, not a result of mosquito control applications.

Idiopathic Environmental Illness (IEI), often referred to as multiple chemical sensitivity (MCS), is now a recognized medical phenomenon. A working definition of IEI is: An acquired disorder with multiple recurrent symptoms, associated with diverse environmental factors, tolerated by the majority of people, and not explained by any known medical or psychiatric/psychological disorder. As much as 10% of the U.S. population could be described as having some degree of IEI. However, as yet there is no clinical medical test to demonstrate pesticide sensitivity. There is no reason to doubt that IEI individuals can become ill from mosquito control spraying. Thus, mosquito control operations are potential targets for disputes with chemically sensitive individuals. IEI persons typically become ill following exposure to irritating agent(s). It is unknown whether this illness is physiological, psychological, or both.

Chemical trespass

The concept of chemical trespass (i.e., applying chemicals to an individual or their property against their wishes) is a very sensitive and sometimes controversial issue. However, statutory law permits the applications of mosquito control chemicals in the public domain. The potential for conflict is obvious, and this has been the basis for some claims or complaints in the past (e.g., beekeepers, organic growers).

Adulticide (chemicals applied to control adult mosquitoes) drift in particular invites claims of chemical trespass. Most agricultural and structural pest control pesticide labels specify minimal or no drift, yet, in certain situations, mosquito control technicians realize that effective adult mosquito control is achieved when there is drift. Adulticides, when applied with ultra-low volume (ULV) sprayers, have been shown to drift beyond the primary target zone. Ecologically sensitive “No Spray Areas”, as well as other sites, are candidates for inadvertent drift. Such data suggest the need for buffer areas around no spray zones and careful attention to meteorological conditions when spraying to minimize drift to areas not intended for such treatment. In certain conditions, District technicians implement the “spray on, spray off” technique to avoid direct treatments to sites where residents have requested limited spraying of their property. Additionally,

the District maintains a list of names and addresses of residents who wish to be notified in advance of operational spray activities.

Potential problems of chronic chemical exposure

Problems resulting from chronic exposure to chemicals are a general public health issue, because everyone is exposed daily to chemical and pesticide residues in food, water, and air. In regard to chronic exposure to chemicals, animal endocrine and immune system dysfunction studies have provided evidence that synthetic pesticides and industrial chemicals in very low quantities, after repeated exposures, may affect these functions. While mosquito control is implicated in these instances, it is part of the total chemical and insecticide use picture. However, it should be noted that organophosphate insecticides, such as malathion and naled, have been used routinely for over 50 years in San Joaquin County without any documented chronic affects.

Since it is currently impossible to predict the long-term consequence of human exposure to synthetic mosquito control compounds, a prudent strategy is for the District to reduce all unnecessary chemical applications. To this degree, the District should apply pesticides after adequate surveillance verifies its need, and to also consider alternatives that reduces the need for chemical applications.

Comparing adulticiding versus larviciding

Both adulticide and larvicide chemicals may impact non-target species. Larvicides, which can be quite target specific (e.g., *Bacillus sphaericus*, methoprene), are used in specific habitats and under certain conditions. ULV applications of adulticides are more broadly distributed thus impacting both the target area and potentially other nearby areas through drift. Such movement can be a problem when the spray drifts into environmentally sensitive lands where chemicals are restricted or not allowed. It is generally believed that larvicides impact the environment less than adulticides. The District will continue its efforts in developing larval surveillance and control programs and minimize any adulticide drift to non-target areas to the extent practical. This can be achieved by continually reviewing and improving tactical mosquito control operations. When larval or adult control has not worked effectively, a thorough assessment will be conducted, so that the overall level of control can be improved. Larval control will almost always allow some mosquitoes to emerge, mostly due to the failure of the inspection program to identify a mosquito brood or a lack of thorough treatment coverage. Likewise, adulticiding is by no means 100% effective.

Risks of adulticiding

Adulticides are dispersed primarily with aircraft and vehicle-mounted ULV equipment, with the sprays capable of drifting beyond the target zone. ULV adulticides used in San Joaquin County are either organophosphate, botanical pyrethrin or synthetic pyrethroids, with pyrethrin and pyrethroid adulticides generally synergized with piperonyl butoxide (PBO). These materials are applied

during periods of adult mosquito activity and favorable meteorological conditions. Some residents of the District and local special interest groups have provided comments about potential human and environmental hazards associated with the use of chemicals to control mosquitoes, including ULV applied adulticides. However, the District regularly receives requests from individuals and groups requesting ULV spraying in their area. Comments from special interest groups and requests for service from local residents have generated greater accountability by the District when applying pesticides and some tighter environmental restrictions have occurred at the federal and state levels.

Bees, other pollinators, and insectivores may be impacted by adulticiding also. The District adulticides when most bees, other pollinators, and insectivores are at rest or inactive, generally late night (after sunset) or early morning (before sunrise), and at very low pesticide dosage and application rates. It is assumed that these actions reduce the impact to known non-target populations.

Risks of larviciding

Controlling a brood of mosquitoes in the larval stage when concentrated in the water is easier and more efficient than controlling dispersed adults. Some of the environmental risks associated with the use of larvicides include both direct and sub-lethal toxicity to non-target organisms. However, using biorational materials (e.g., Bti, Bs) minimizes non-target effects because of the specificity of these materials to mosquito larvae.

Surveillance

Mosquito surveillance is a prerequisite to an effective, efficient, and environmentally sound mosquito control program. Surveillance is used to define the nature and extent of the mosquito population and as a guide to daily mosquito control operations. It provides the data needed to comply with state regulations regarding the justification for treatments, and it provides a basis for evaluating the potential for transmission of mosquito-borne diseases.

Surveillance is combined with an on-going program for monitoring meteorological and environmental factors that may influence mosquito population change; for example: rainfall and ground water levels, temperature, relative humidity, tidal changes, storm water and wastewater management, and land use patterns.

The program that monitors the transmission of mosquito-borne encephalitis virus and other arbovirus' is described in a separate section (see California Mosquito-Borne Virus Surveillance & Response Plan, April 2008).

Mosquito surveillance program

The District has taken the following steps to develop the mosquito surveillance program, as part of the overall mosquito control effort:

1. Definition of the mosquito problem(s)
2. Definition of the parameters on which the control program is based
3. Identification of the appropriate survey methods as decision-making aids regarding where and when to implement control

Defining the mosquito problem(s)

There are 17 known species of mosquitoes found in San Joaquin County. All are important enough as pests or vectors to warrant control. Most species are found throughout the District for the majority of the calendar year. Most species are found in developed areas, including urban, suburban, and rural residential. The entire area of San Joaquin County (approximately 1,400 square miles) is considered viable for human use and/or habitation. Mosquitoes are monitored throughout the year.

Control efforts are justified when mosquito populations create a nuisance, or are determined to be capable of vectoring an arbovirus. A nuisance mosquito bothers people and domestic animals, typically in or around homes and other developed areas, and in recreational areas. Economically, mosquitoes can reduce property values, slow economic development of an area, reduce tourism, or adversely affect the health of pets and livestock and poultry production.

One definition of a health-related mosquito problem is the ability of a mosquito to transmit infectious disease. In San Joaquin County, this definition includes mosquitoes that can vector canine heartworm, malaria, St. Louis encephalitis (SLE), western equine encephalitis (WEE), and West Nile virus (WNV). Any mosquito that bites or annoys humans can be considered a health problem, particularly for individuals that are allergic to mosquito bites or which suffer from entomophobia (i.e., a fear of insects).

Surveillance of mosquito problems

In addition to identifying the target mosquito species, the District collects information as to the type and kind of mosquito problems that are created. In San Joaquin County, temporal and spatial changes in mosquito populations and the problems that mosquitoes cause, are measured by monitoring three (3) factors: immature mosquito populations, adult mosquito populations, and resident complaints and requests for service.

Monitoring immature mosquito populations

Typically, the application of biological control agents and larvicides in locations where physical control is not an option is preferred to adulticiding. This procedure minimizes the area treated and the amount of resources (bio-control agents or chemicals) required. Because the District's mosquito control program utilizes several different types of control strategy, information and data regarding mosquito breeding sites and larval monitoring are collected. The District maintains a permanent record of each mosquito-breeding site, along with information on larval development found at each inspection.

Immature mosquitoes are sampled using a variety of methods and equipment. Mosquito larvae and pupae are collected with dippers, suction devices, and container evacuation methods. The most commonly used apparatus is the standard one-pint dipper, using standardized dipping techniques. The dipper is used as a survey tool simply to determine the presence of larvae. Standardized dipping methods are used when mosquito densities are to be quantified, usually in values taking additional dipper samples from specific areas in the counting habitat and number of larvae in each dip. In most cases, the District's control program uses the measure of larval density as a basis for control action. At this time (2008), the District utilizes a threshold value of 0.1 larvae per dip (≥1 larvae in 10 dips) for consideration of a form of mosquito control, i.e., mosquito fish planting, larviciding, etc.

To maximize the usefulness of immature mosquito surveillance data, the District monitors certain environmental parameters such as rainfall and mountain snow pack. In certain areas of San Joaquin County, tide levels are also monitored. Rainfall and tide changes dictate when certain areas will need to be inspected for mosquito larvae. Mountain snow pack levels can translate to adequate agriculture irrigation supplies and river flows capable of creating seepage problems.

Monitoring adult mosquito populations

The District uses one or more methods to measure adult mosquito populations before a control decision is made. The two (2) methods used most often are landing/resting rates and mechanical trap counts. The purpose of monitoring adult mosquitoes is 1) to determine where adults are most numerous, 2) to substantiate telephone service request claims of a mosquito problem, 3) to provide data that satisfies District policy and

state regulation for applying adulticides (e.g., the pest or vector must be present at the treatment site), and 4) to determine the effectiveness of different control methods.

Landing/resting rates are a frequently used method for measuring adult mosquito activity. For the mosquito genera *Aedes* and *Anopheles*, the landing rate technique comprises a count of the number of mosquitoes that land on a person in a given amount of time. Resting rates are a method of measuring the activity of *Culex*, and to a lesser degree, *Anopheles* and *Culiseta* species of mosquitoes. The quantity of adult mosquitoes found resting on walls, under eaves, in culverts and pipelines, and in dense vegetation is measured by area, i.e., the number of mosquitoes per square foot. The specific method used to determine landing or resting rates could vary. Important variables are the time of day at which observations are made, the length of time an observation is made, and the portion of body and/or number of sites examined. Emphasis is placed on using the same protocol at given sites, and to use the same inspector to assess landing or resting counts at the same site from one date to the next.

Mechanical traps are used extensively throughout the District on a continuous, year-round basis to monitor adult mosquito populations. Mechanical traps include the standard New Jersey-style light trap (NJLT), encephalitis virus surveillance (EVS) trap, baited Fay trap, and gravid trap.

- Up to 48 EVS traps are used at different times during the year. The traps are used to collect adult *Culex pipiens and Cx. tarsalis* mosquitoes for use as mosquito pools, which are either tested in the District's laboratory or sent to the CDPH Viral and Rickettsial Disease Laboratory for encephalitis virus detection. EVS traps are also used to assess pre- and post-treatment populations of adult mosquitoes to determine control effectiveness.
- Fay traps are used for special purpose monitoring, i.e., in the spring to measure localized populations of *Aedes sierrensis.*
- Gravid traps can be used to selectively sample gravid female mosquitoes that are seeking suitable oviposition sites and are generally used in urban and suburban settings where *Culex pipiens* have been detected.

Monitoring telephone service requests and resident complaints

The third method of ascertaining a mosquito problem is through telephone and website service requests and resident complaints. The District maintains several different listed telephone numbers, including a toll-free line that residents and visitors can call to request mosquito control services; additionally, residents are encouraged to use District's website at www.sjmosquito.org to seek assistance also. Service requests are also received at numerous community fairs where the District operates an information booth. The District responds to an average of 1,000 service requests per year.

Service requests generally are related to specific mosquito species, although the mosquitoes that cause service requests vary considerably from one area to the next. Telephone service requests and citizen complaints are always verified as to their validity prior to any control action being implemented. District personnel substantiate mosquito activity by assessing larval and adult mosquito populations using the techniques described earlier.

Thresholds

The District utilizes the term “tolerance threshold” when determining if or when mosquito control should be implemented. Tolerance threshold is the population density of mosquitoes at which control measures should be implemented to prevent an increasing population from reaching an intolerable level. The data from sampling and monitoring is used to help decide at which infestation level to initiate control activities. This decision level is based on larval and adult mosquito populations, citizen complaints, and the potential for disease outbreaks, and the risk of control activities to non-target organisms.

Action levels are different for each situation. In some areas, a public health or general annoyance condition does not occur until the number of adult female mosquitoes exceeds 10 per trap night. Other action levels that have been used are landing rates averaging more than two mosquitoes in one minute, and dipper counts averaging 0.1 larvae per dip. Action levels for urban, suburban, and rural residential areas can be lower than for remote, uninhabited areas, or areas of low human use.

Adult mosquito threshold(s)

Adult mosquitoes are measured by the use of the three techniques identified in the section “Surveillance”. Because the District operates the mosquito surveillance and control program year round, the tolerance threshold can be changed by many factors. Examples of the many factors that change the adult mosquito tolerance threshold are listed below:

- As weather conditions change in late fall and early winter, human activity in the outdoors is reduced, and arbovirus activity in the environment less important. Although the adult mosquito population is at or above a tolerance threshold for other conditions, the District may not implement certain control actions because the mosquito population will not create an annoyance or public health problem.
- Generally, adult mosquito control is implemented when populations of the encephalitis mosquito *Culex tarsalis* reach a level of 10 females per trap night. However, if encephalitis virus has been detected in humans, domestic animals, mosquito pools, dead birds or sentinel chicken flocks, the District may initiate adulticiding at a lower number of adult mosquitoes per trap night.
- High populations (≥10 mosquitoes/trap night) of certain species, i.e., *Culex erythrothorax*, would not necessarily require control action if the population were found in a low human-use or remote area.

Immature mosquito threshold(s)

Immature mosquitoes are generally measured by the use of the dipping technique identified in the section “Surveillance”. Because the District operates the mosquito surveillance and control program year round, the tolerance threshold can be changed by many factors. Examples of the many factors that change the immature mosquito tolerance threshold are listed below:

- Although an immature mosquito population of 0.1 larvae per dip (one larvae in 10 dips) is not seen as a large problem with certain species, i.e., *Culiseta inornata*, in the winter months, it would be a significant public health risk for the species *Culex tarsalis* during the months of April through November.
- Relatively small populations of larvae (<1 larvae per dip) of the species *Culex pipiens* can be tolerated in a rural waste water impoundment, but would be unacceptable if found in a suburban area swimming pool.
- The larvae of the mosquito species *Aedes nigromaculis* can develop rapidly into more mature stages in warm weather, generally requiring immediate treatment with the use of a larvicide. Larvae of the species *Aedes sierrensis* can mature much slower, allowing for aspects of naturalistic control to be considered as a method of IPM.

Biological control

The use of biological organisms or their byproducts to control mosquitoes is termed biological control, or biocontrol. Biocontrol is defined as the study and utilization of parasites, pathogens, and predators to control mosquito populations. Generally, this definition includes natural and genetically modified organisms, and means that the agent must be alive and able to attack the mosquito. The overall premise is simple: biocontrol agents that attack mosquitoes naturally are grown in a controlled or cultured environment, and then released into the environment, usually in far greater numbers than they normally occur, and often in habitats that previously were devoid of them, so as to control targeted mosquito species.

Biocontrol is not a "magic bullet" for the District's mosquito control program, now or in the near future. It is considered a set of tools that are used when it is economically feasible. When combined with other control methods, i.e., chemical, legal, physical, etc., biocontrol agents can provide short, and occasionally, long-term control. Biocontrol, as a conventional control method, is aimed at the weakest link of the life cycle of the mosquito. In most cases, this is the larval stage. The most commonly used biocontrol agents used by the District is the mosquitofish *Gambusia affinis.*

Biological control utilizing mosquito-eating fish

The District utilizes two (2) species of mosquito-eating fish as biocontrol agents, the western mosquitofish *Gambusia affinis*, and to a lesser extent, the guppy *Poecilia reticulata.* The mosquitofish is the most extensively used biocontrol agent for mosquitoes in San Joaquin County and most of California. This fish, which feeds on mosquito larvae and other small aquatic invertebrates, can be placed in a variety of permanent and semi-permanent fresh water habitats. In areas where water quality is substandard, i.e., untreated sewage water, the District can incorporate the use of guppies. During the 1990's, concerns of placing mosquito-eating fish in habitats where endangered or threatened species exist were raised by the United States Fish and Wildlife Service. In response to those concerns, the District sponsored both University of California, as well as in-house research into the ecological relationships of mosquito fish and other aquatic species. The results of this research were used to identify appropriate and inappropriate sites for use of mosquitofish as a biocontrol agent. Care is taken to place mosquitofish in habitats where endangered or threatened species are sensitive to further environmental perturbation. An example of an area considered inappropriate for use with mosquito fish is seasonally flooded vernal pools. These sites may contain populations of *Lepidurus packardi*, the vernal pool tadpole shrimp, *Branchinecta lynchi,* the vernal pool fairy shrimp, *Branchinecta longiantenna*, the longhorn fairy shrimp, and *Branchinecta conservatio*, the conservancy fairy shrimp. These shrimp are federally listed species, and must be protected from District control procedures.

The District utilizes both cultured as well as semi-naturally occurring supplies of mosquitofish. Mosquitofish were originally introduced into California in the 1920's, and have been dispersed throughout the state for mosquito control purposes ever since. Although the fish is considered non-native specie, mosquitofish are endemic throughout San Joaquin County and most of California's Central Valley. Locally, mosquitofish are found in rivers, creeks, sloughs, reservoirs, drainage canals, irrigation ditches, stock ponds, and other similar aquatic sites. District personnel routinely collect mosquitofish from these types of sites for use in mosquito breeding sources such as temporarily flooded agricultural lands, rice fields, agriculture ponds and ditches, and other similar sources. Also, the District has constructed and operates a mosquito fish rearing facility at the City of Lodi's White Slough Water Treatment Plant. This facility is used to mass rear mosquito fish for use in residential, commercial and agricultural mosquito sources. The site utilizes reclaimed municipal wastewater as the growing medium for the fish.

Advantages of using mosquito-eating fish compared with other control methods

Fish are suitable for controlling mosquito strains resistant to chemical insecticides. *Gambusia* and *Poecilia* have other advantages for mosquito control:

- Their small size (usually less than 5 cm) allows them to penetrate easily most sites of pool-inhabiting mosquito larvae.
- They feed heavily on mosquito larvae and pupae when these are available; they are diverse feeders, capable of persisting at high densities when mosquito larvae are absent.
- They multiply rapidly; under favorable conditions, a single female produces an average of 200-300 young per season.
- Being live bearers, *Gambusia* and *Poecilia* do not require special oviposition (egg-laying) site.
- They tolerate wide ranges of temperatures and salinity, as well as moderate sewage pollution.
- They may be used effectively in combination with other control techniques, such as bacterial pesticides, other biological control organisms, and some chemical pesticides.

Limitations of using mosquito-eating fish compared to other control methods

Mosquitofish have definite limitations. For example:

- They can seldom inhabit two important larval sites: small containers and highly polluted water. In temporary water sites, repeated introduction of fish will be required.
- Mosquito-eating fish can harm beneficial organisms (e.g., other fish or insect predators) by eating their eggs and young or by superior competition for food. Their release carries the potential to reduce or eliminate non-target species.

- Larvivorous fish may be preyed upon by larger fish. Their vulnerability to fungi and other pathogens may keep their populations in check.
- Where larvivorous fish are harvested or removed, their populations could be reduced to a level inadequate for mosquito control.
- Mosquito-eating fish may prefer food other than mosquito larvae. In some situations, mosquito larvae production outruns the increase in fish population that would be necessary for control.

Biocontrol utilizing other agents and organisms

The District has tested the water mold fungus *Lagenidium giganteum* as a biocontrol agent in freshwater wetlands and rice fields. Because *L. giganteum* has been proven non-toxic to mammals, plants, fish, birds, and non-target aquatic organisms, this material has the potential to be used as a mosquito larvicide. To date (2008), there is no commercially-available material for use on a broad scale basis.

There is ongoing research on other biocontrol agents and organisms for mosquito control. Species of predacious mosquitoes in the genus *Toxorhyncites* have been studied in several eastern states with various levels of success reported. Predacious copepods, other species of freshwater fish and invertebrates are also being investigated. If other agents or organisms are proven capable and cost-effective for use in San Joaquin County mosquito habitats, the District will incorporate them as they become available.

Chemical control

Chemical control is the intentional use of specific chemical compounds (insecticides) to quickly kill adult and immature mosquitoes. Insecticides labeled for mosquito control fall into two (2) categories, adulticides (applied to control adult mosquitoes), and larvicides (applied to control larvae and/or pupae). These compounds consist of the insecticide groups of organophosphate, pyrethroid, microbial, thin film larvicides, and insect growth regulators. Organophosphate and pyrethroid compounds are used mainly for controlling adult mosquitoes, while microbial, thin film larvicides and insect growth regulators are used for controlling immature mosquitoes.

Chemical control utilizing adulticides

Adulticides are used to quickly kill adult mosquito populations. Adulticides are applied by aircraft, hand-held, and vehicle mounted-sprayers. Aircraft spraying is performed using conventional and specialized ULV spray equipment, and is typical of what is used in agricultural and public health pest control spraying. The District utilizes professional contract aerial spraying companies for this operation. The District also uses hand-held and vehicle-mounted conventional low-volume (LV) and ultra-low-volume (ULV) sprayers to apply adulticides. Hand-held and vehicle-mounted sprayers are operated by District personnel.

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. Some species of mosquitoes in San Joaquin County and surrounding areas are resistant to certain classes of pesticides used as adulticides, thus affecting the selection of chemicals. Insecticide applications must be made during periods of adult mosquito activity. This factor is variable with mosquito species. For example, *Culex erythrothorax* is diurnal (most active during the day and up to dusk), while *Aedes vexans* is active both day and night. Treatments directed at *Cx. erythrothorax* could miss major portions of the *Ae. vexans* population if commingled. Adulticiding should be timed when the mosquitoes are flying and exposed to the applied chemicals.

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 specie and applied with the correct droplet size. Whether the treatment is ground or aerial applied, it must distribute sufficient insecticide to cover the prescribed area with an effective dose. Typically with ground applications, highly vegetated or residential habitats may reduce the effectiveness of control even with the maximum insecticide dosage applied, due to the obstructions preventing the function of wind movement and its ability to sufficiently carry insecticide droplets to the target specie.

Environmental conditions may also affect the results of adulticiding. Wind determines how the ULV droplets will be moved from the sprayer 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

are the most desirable, moving the material effectively through the treatment area and proving less inhibiting to mosquito activity.
ULV applications are generally not performed during warm daylight hours. Thermal conditions cause the small (<30 microns in diameter) droplets to quickly rise, moving them away from the target zone. Generally, applications are made at sunset or at sunrise, depending on mosquito species activity and the application site conditions. Ideal ULV adulticiding conditions usually include moderate air temperature (60-80ºF), relative humidity of 30-80%, the presence of a thermal inversion layer above ground level, and wind currents of 10 mph or less. These conditions keep the spray or fog in close ground contact and allow for a semi-uniform downwind dispersal of material. Air temperatures and wind speed/direction information is determined prior to application using several available weather websites. Wind direction and speed are also measured and recorded by the applicator at the treatment site.
District operations, maintenance and technical staff routinely inspect and calibrate adulticiding equipment to insure proper insecticide flow rates and droplet size development. Periodically, caged adult mosquitoes, as sentinels, are staged in an area planned for adulticiding treatment. Upon completion of the treatment, the sentinel mosquitoes are collected and analyzed in the District's laboratory to determine individual species susceptibility, overall population mortality, and to assess the swath dimensions of the equipment used.

Insecticides used as adulticides

Insecticides used as adulticides by the District must be labeled for use as a mosquito control agent and be registered for sale and use in California. In addition, insecticides selected must be considered as the least toxic for the intended use and target area. Insecticides are generally ranked by their toxicity, ranging from slightly toxic to highly toxic, and the individual insecticide labels include the signal words "Caution", "Warning", or "Danger", which corresponds to their level of toxicity. The District generally utilizes adulticides that are labeled with the signal word Caution, which is considered the least toxic.

Techniques used to adulticide

Aerial and ground adulticiding are the most commonly used methods of controlling adult mosquitoes in San Joaquin County. Aerial and ground adulticiding generally consists of dispersing an insecticide as a space spray in the air column which then drifts through the habitat where adult mosquitoes are flying, or in some cases, where they are resting. Much of the language on insecticide labels does not address the requirement for drift. This type of application is contradictory to everything agricultural applicators strive for when trying to stick pesticides to plants. The District utilizes the technique of ultra low volume (ULV) cold aerosol spraying as a mosquito control insecticide space spray.
Another form of treatment for adults from the ground is conventional space spraying, using conventional spray equipment such as compressed air hand sprayers, vehicle-mounted wind turbine (blower) sprayers, and vehicle-mounted

power sprayers. This type of application is for small sites with light infestations of adult mosquitoes. Applications of insecticide are generally made during daylight hours in various types of weather conditions.

The District adulticides only when it has been determined that control is essential for the health and welfare of the public. To this extent, at least one of the following criteria is met and documented prior to the implementation of adulticiding:

- When a population of adult mosquitoes is either demonstrated by a quantifiable increase in, or sustained elevated mosquito population level as detected by standard surveillance methods.
- Where adult mosquito population(s) build to levels exceeding ten (10) mosquitoes per trap night in urban, suburban, and rural residential areas. When service requests for adult mosquitoes from the public have been confirmed by one or more recognized surveillance techniques.
- When an arbovirus (e.g. WNV) has been detected in an area where vector species are evident.

Risks and benefits of ground ULV adulticiding

Any mosquito adulticiding activity that does not follow reasonable guidelines including timing of application, avoiding sensitive areas, and strict adherence to the pesticide label, risks affecting non-target insect species. Aerial and ground adulticiding, however, is a very effective technique for controlling most mosquito species in most areas economically and with negligible non-target effects. It is the methodology normally recognized by most mosquito control programs in California.

A benefit of ULV aerosols is that they do not require large amounts of diluents for application and are therefore much cheaper, and may be environmentally safer. The spray plume is nearly invisible, does not create a traffic problem, and may not be perceived as an undesirable function.

Risks associated with ULV aerosols include the problems related to applying pesticides undiluted. The material is being handled and transported in a concentrated form. The droplet spectrum is rather wide (sub-micron to ~50 microns in diameter), can be difficult to change and may settle into non-target areas more readily than other types of sprays.

Any discussion of risk versus benefits needs to note that this form of control has been in extensive use throughout California for many years. There have not been any glaring adverse impacts attributed to adulticiding when it is done properly. The simple observance of population growth in San Joaquin County and the state's high standing in tourism destinations speak loudly of the benefits of this technique and mosquito control in general.

Chemical control using larvicides

The District relies almost exclusively on larviciding as the primary means of chemical mosquito control, and resorts to adulticiding when all other IPM methods fail. The overall success of the District's mosquito control program is sometimes measured by the frequency of larviciding compared to adulticiding. Larvicides are used to kill immature mosquito populations. Larvicides are applied by aircraft, vehicle-mounted, and hand-held sprayers. Aircraft spraying is performed using conventional spray equipment, and is typical of what is used in agricultural spraying. The District utilizes professional contract aerial spraying companies for this operation. The District also uses hand-held and vehicle mounted conventional low- and high-volume sprayers to apply larvicides. Hand-held and vehicle-mounted sprayers are operated by District personnel.

The efficiency of larviciding is dependent upon a number of integrated factors. First, the mosquito species to be treated must be susceptible to the insecticide applied. Currently (2008), all species of mosquitoes in San Joaquin County are susceptible to the larvicides registered for use in California and used by the District. Insecticide applications must be made during periods of immature mosquito susceptibility, i.e., larvae too young or old may not be affected by the larvicide; this factor is variable with mosquito species. For example, during warm summer months the pasture mosquito *Aedes nigromaculis* is capable of complete metamorphosis in less than four days, while the northern house mosquito *Culex pipiens* would require up to 10 days to complete its life cycle. Certain larvicides used to treat *Cx. pipiens* would not be as effective as for *Ae. nigromaculis.* Larviciding should be timed when the mosquitoes are susceptible and in an environment allowing exposure to the applied chemicals.

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 specie and applied with the correct formulation, i.e., liquid, granule, dust, etc. Whether the treatment is ground or aerial applied, it must distribute sufficient insecticide to cover the prescribed area with an effective dose. Typically with both air and ground applications, highly vegetated habitats may reduce the effectiveness of control even with the maximum insecticide dosage applied, due to the obstructions preventing the material from reaching the target site and specie.

Environmental conditions may also affect the results of larviciding. Wind and air temperatures may affect the deposition of droplets on the target site, and water quality can affect the chemical's viability to adequately kill the larvae. Conditions of no wind will result in the material reaching the intended application site.

District operations, maintenance, and technical staff routinely inspect and calibrate larviciding equipment to insure insecticide flow rates and swath size. Periodically, caged immature mosquitoes, as sentinels, are staged in an area planned for larviciding treatment. Upon completion of the treatment, the sentinel mosquitoes are collected and analyzed to determine individual species susceptibility, overall population mortality, and to assess the swath dimensions of the equipment used.

Insecticides used as larvicides

Insecticides used as larvicides by the District must be labeled for use as a mosquito control agent and be registered for sale and use in California. In addition, insecticides selected must be considered as the least toxic for the intended use and target area. Insecticides are generally ranked by their toxicity, from slightly to highly toxic, and the individual insecticide labels include the signal words “Caution”, “Warning”, and “Danger”, which corresponds to their level of toxicity. The District utilizes larvicides that are labeled with the signal word Caution, which is considered the least toxic.

Legal Abatement

The District relies on local, state, and federal statutes to regulate excessive mosquito breeding on private and public lands. Using provisions of the California Health and Safety Code, the District can legally require property owners to reduce or eliminate mosquito breeding when it becomes a public nuisance.

Legal abatement of mosquitoes generally follows a multi-step process, whereby the owner of mosquito-producing land is contacted and asked to take steps to reduce the occurrence of mosquito development. In most cases, this request is performed in an informal meeting between District staff and the landowner on the property where the problem exists. Generally, the landowner is given a reasonable amount of time (10 – 30 days) to correct the problem. In the event the problem continues, the District will notify the landowner in writing that the problem still exists, and the mosquito breeding conditions must be corrected immediately. If the problem is not corrected, the District can initiate legal abatement proceedings per the California Health and Safety Code.

Mosquito sources that can require legal abatement resolution generally involve aquatic conditions that are man-made/managed. Examples of mosquito breeding conditions that have required legal abatement in the past include:

- Over-irrigation of pasture land, resulting in excessive mosquito breeding conditions and multiple broods of mosquitoes per irrigation.
- Poor maintenance and management of agricultural, industrial and municipal waste ponds, resulting in excessive weed growth and mosquito development.

To insure that residents and landowners of San Joaquin County receive proper information on water management, irrigation techniques, waste pond management, etc., the District maintains a collection of reference materials regarding mosquito control. Recommendations and information from the University of California Cooperative Extension and other agencies is made available to anyone needing information on preventing mosquitoes in various situations.

Additionally, the District annually notifies each known owner of an agricultural, industrial or municipal waste pond of the pond management criteria to prevent mosquito development.

Physical control

Physical control, also known as source reduction or habitat modification, is another form of control utilized in the District's IPM plan. Physical control is usually the most effective of the mosquito control techniques available and is accomplished by eliminating, or significantly reducing, mosquito breeding sites. The primary operational objective of physical control is to reduce the mosquito carrying capacity of a source to preclude the use of control methods that would adversely impact the environment and wildlife. This can be as simple as properly discarding old containers which hold water or as complex as developing a regional drain system for storm water. Physical control is important in that its use can virtually eliminate the need for pesticide use in and adjacent to the affected habitat.

From a historical perspective, the development and implementation of large-scale physical control projects occurred in San Joaquin County between 1945 and 1978. Initially, these projects were designed to reduce the production of *Aedes, Anopheles,* and *Culex* mosquito species in agricultural and natural mosquito breeding sources. Entomological data was used to support and justify the merits of each project. In certain cases, other government agencies (e.g. California Department of Public Health, U.S. Agricultural Stabilization and Conservation Service, local reclamation districts) assisted with the design and implementation of the projects.

At this point in time (2008), the District is not involved in the development of new physical control projects because of environmental restrictions associated with obtaining permits. However, the District is involved in performing maintenance on existing physical control projects. This maintenance includes vegetation control within drainage channels and along access roads and trails. To prevent damage to endangered plants during maintenance activities, the District reviews each site and identifies specific species requiring protection. The District uses the documents *Endangered Plants of California* published by California Department of Fish and Game, and *San Joaquin County Multi-Species Habitat Conservation and Open Space Plan* published by San Joaquin Council of Governments.

Over the past several decades, urban development has occurred in areas of San Joaquin County where drainage ditches have existed as the primary method of physical mosquito control. As these drainage systems are expanded to meet modern storm water management specifications, maintenance by the District may no longer be necessary. In many cases, maintenance responsibility has been taken over city and county public works departments and integrated into their comprehensive storm water management programs.

Mosquito producing habitats considered for physical control

There are many types of mosquito breeding sources in San Joaquin County capable of being reduced by physical control techniques. Generally, only man-made or managed mosquito sources are considered for physical control. Following is a representative listing of mosquito breeding sources and recommendations for physical control:

- Artificial containers, such as flowerpots, cans, barrels, and tires. Mosquito species found in these types of artificial containers include *Culex pipiens, Culex stigmatosoma, Culex tarsalis, Culiseta incidens,* and *Culiseta inornata.* A container breeding mosquito problem can be solved by properly disposing of such materials, covering them or tipping them over to ensure that they do not collect water.
  The District has an extensive program that addresses urban container mosquito breeding problems through house-to-house surveillance and formalized education programs. 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 control. These regulations include the provision of the local vector control agency being involved with the permit process required to store used tires. For individual household waste systems in unincorporated areas, the District coordinates with San Joaquin County Public Health Services, Environmental Health Division to correct leaking plumbing systems and septic tanks.
- Agricultural, industrial, and municipal storm water and waste ponds and retention basins. Mosquito species found in these types of sources are generally *Culex pipiens, Culex stigmatosoma,* and to a lesser degree, *Culex tarsalis.* 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. In addition, the District provides localized vegetation management on most ponds to discourage mosquito oviposition sites.
- Irrigated agriculture lands. Almost all of the 17 local mosquito species are found in these sources. 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.

Recommendations for future physical control projects

Because of the comprehensive nature of physically manipulating mosquito-breeding sources, the following recommendations are made with regards to future physical control projects.

With regards to development of environmentally sensitive sites, such as seasonal wetlands and endangered species habitat that is capable of breeding mosquitoes:

1. The landowners should be required to work with the District in developing Best Management Practices (BMPs) for the prevention of mosquitoes.
2. Continued research on the ecosystem effects of physical control on fresh water wetlands is needed.
3. A federal and state mandate for interagency cooperation and understanding to insure that both mosquito control and natural resource aspects of development are fully considered, and that BMPs are implemented. This is especially important given the current federal, state, and local efforts to implement mitigation banking as a permitting tool in local and regional development.
4. Urban and suburban development should not be planned for areas being contemplated for wetland development. Although each city and the county have created a general plan, development is planned near environmentally sensitive sites and current and future wetland areas.

With regards to development of storm water and wastewater facilities capable of breeding mosquitoes:

1. Ideally, all agencies or parties involved in regulating storm water and wastewater facilities should add BMPs to minimize, and where possible eliminate, mosquito production in those facilities.
2. All agencies involved with regulating storm water and wastewater facilities should recognize that the use of reclaimed water wetlands, while providing habitat for fish and wildlife as well as other ecological benefits can create mosquito-breeding habitat. This fact should be taken into account in system design and management.

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CALIFORNIA MOSQUITO-BORNE VIRUS SURVEILLANCE & RESPONSE PLAN

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May 2012

CALIFORNIA MOSQUITO-BORNE VIRUS SURVEILLANCE AND RESPONSE PLAN

TABLE OF CONTENTS

Objectives

The California Mosquito-borne Virus Surveillance and Response Plan was developed to meet several objectives. Specifically, the Plan:

- Provides guidelines and information on the surveillance and control of mosquito-borne viruses in California, including West Nile, St. Louis encephalitis, and western equine encephalomyelitis viruses;
- Incorporates surveillance data into risk assessment models;
- Prompts surveillance and control activities associated with virus transmission risk level;
- Provides local and state agencies with a decision support system; and
- Outlines the roles and responsibilities of local and state agencies involved with mosquito-borne virus surveillance and response.

This document provides statewide guidelines, but can be modified to meet local or regional conditions.

Introduction

California has a comprehensive mosquito-borne disease surveillance program that has monitored mosquito abundance and mosquito-borne virus activity since 1969 (Reeves et al. 1990) and is an integral part of integrated mosquito management programs conducted by local mosquito and vector control agencies. Surveillance and interagency response guidelines have been published previously by the California Department of Public Health formerly known as the California Department of Health Services (Walsh 1987) and the Mosquito and Vector Control Association of California (Reisen 1995). The detection of West Nile virus (WNV) in New York, a virus not recognized in the Western Hemisphere prior to 1999, prompted the review and enhancement of existing guidelines to ensure that surveillance, prevention, and control activities were appropriate for WNV. From New York, WNV spread rapidly westward and by 2004 had been detected in all 48 states in the continental United States. In addition to WNV, California is vulnerable to introduction of other highly virulent mosquito-borne viruses of public and veterinary health concern, such as Japanese encephalitis, dengue, yellow fever, Rift Valley fever, chikungunya and Venezuelan encephalitis viruses. If an existing or introduced virus is detected, it is critical that local and state agencies are prepared to respond in a concerted effort to protect people and animals from infection and disease. The current document describes an enhanced surveillance and response program for mosquito-borne viruses in the State of California. Its contents represent the collective effort of the California Department of Public Health (CDPH), the Mosquito and Vector Control Association of California (MVCAC), and the University of California at Davis (UCD).

Background

Mosquito-borne viruses belong to a group of viruses commonly referred to as arboviruses (for **ar**thropod-**bo**rne). Although 12 mosquito-borne viruses are known to occur in California, only WNV, western equine encephalomyelitis virus (WEE) and St. Louis encephalitis virus (SLE) are significant causes of human disease. WNV is having a serious impact upon the health of humans, horses, and wild birds throughout the state. Since 2004, there have been 3,146 WNV human cases with 110 deaths and 1,167 horse cases. Consequently, the California Arbovirus Surveillance Program emphasizes forecasting and monitoring the temporal and spatial activity of

WNV, WEE, and SLE. These viruses are maintained in wild bird-mosquito cycles that do not depend upon infections of humans or domestic animals to persist. Surveillance and control activities focus on this maintenance cycle, which involves primarily *Culex* mosquitoes, such as the western encephalitis mosquito, *Culex tarsalis*, and birds such as house finches and house sparrows.

Immature stages (called larvae and pupae) of *Culex tarsalis* can be found throughout California in a wide variety of aquatic sources, ranging from clean to highly polluted waters. Most such water is associated with irrigation of agricultural crops or urban wastewater. Other mosquito species, such as *Culex pipiens, Culex quinquefasciatus*, and *Culex stigmatosoma*, play an important role in WNV, and possibly SLE, transmission cycles in urban and suburban areas. Historically, *Aedes melanimon*, a floodwater mosquito, played a role in a secondary transmission cycle of WEE involving rabbits. Additional mosquitoes such as *Aedes vexans* and *Culex erythrothorax* also could be important bridge (i.e. bird to mammal) vectors in transmission.

Mosquito control is the only practical method of protecting the human population from infection. There are no known specific treatments or cures for diseases caused by these viruses and vaccines are not available for public use. Infection by WEE virus tends to be most serious in very young children, whereas infections caused by WN and SLE viruses affect the elderly most seriously. WNV also kills a wide variety of native and non-native birds. There are WEE and WNV vaccines available to protect horses since both viruses can cause severe disease in horses. Mosquito-borne disease prevention strategies must be based on a well-planned integrated pest management (IPM) program that uses real-time surveillance to detect problem areas, focus control, and evaluate operational efficacy. The primary components of an IPM program include education, surveillance, and mosquito control.

Education

Residents, farmers, and duck club owners can play an important role in reducing the number of adult mosquitoes by eliminating standing water that may support the development of immature mosquitoes. For instance, residents can help by properly disposing of discarded tires, cans, or buckets; emptying plastic or unused swimming pools; and unclogging blocked rain gutters around homes or businesses. Farmers and ranchers can be instructed to use irrigation practices that do not allow water to stand for extended periods, and duck club owners can work with mosquito control agencies to determine optimal flooding schedules. Educating the general public to curtail outdoor activities during peak mosquito biting times, use insect repellents, and wear long-sleeved clothing will help reduce exposure to mosquitoes. Clinical surveillance is enhanced through education of the medical and veterinary communities to recognize the symptoms of WEE, SLE, and WNV and to request appropriate laboratory tests. Public health officials need to be alerted if a mosquito-borne viral disease is detected, especially if the public health risk is high.

Surveillance

Surveillance includes the monitoring, visualization, and analysis of data on climatic factors, immature and adult mosquito abundance, and virus activity measured by testing mosquitoes, sentinel chickens, wild birds (including dead birds for WNV), horses, and humans for evidence

of infection. Surveillance must focus not only on mosquito-borne viruses known to exist in California, but be sufficiently broad to also detect newly introduced viruses.

Climate Variation

The California Mediterranean climate provides ideal opportunities for forecasting mosquito abundance and arbovirus activity, because most precipitation falls during winter, as rain at lower elevations or as snow at higher elevations. Spring and summer temperatures then determine the rate of snow pack melt and runoff, mosquito population growth, the frequency of blood feeding, the rate of virus development in the mosquito, and therefore the frequency of virus transmission. In general, WEE virus outbreaks have occurred in the Central Valley when wet winters are followed by warm summers, whereas SLE and WN virus outbreaks seemed linked to warm dry conditions that lead to large populations of urban *Culex*. Although climate variation may forecast conditions conducive for virus amplification, a critical sequence of events is required for amplification to reach outbreak levels.

Mosquito Abundance

Mosquito abundance can be estimated through collection of immature or adult mosquitoes. The immature stages (larvae and pupae) can be collected from water sources where mosquitoes lay their eggs. A long-handled ladle ("dipper") is used to collect water samples and the number of immature mosquitoes per "dip" estimated. In most local mosquito control agencies, technicians search for new sources and inspect known habitats for mosquitoes on a 7 to 14-day cycle. These data are used to direct control operations. Maintaining careful records of immature mosquito occurrence, developmental stages treated, source size, and control effectiveness can provide an early warning to forecast the size of the adult population.

Adult mosquito abundance is a key factor contributing to the risk of virus transmission. Monitoring the abundance of adult mosquito populations provides important information on the size of the vector population as it responds to changing climatic factors and to larval control efforts. Four adult mosquito sampling methods are currently used in California: New Jersey light traps, carbon dioxide-baited traps, gravid (egg-laying) traps, and resting adult mosquito collections. The advantages and disadvantages of these sampling methods, and guidelines for the design, operation, and processing of the traps have been discussed in Guidelines for Integrated Mosquito Surveillance (Meyer et al. 2003) and are summarized in Appendix A.

Mosquito Infections

Virus activity can be monitored by testing adult mosquitoes for virus infection. Because *Culex tarsalis* is the primary rural vector of WNV, SLE, and WEE, and *Culex quinquefasciatus* and *Culex pipiens* are important urban vectors of WNV and SLE, surveillance efforts emphasize the testing of these species. Another species that should be tested is *Culex stigmatosoma*, which is a highly competent but less widely distributed vector of WNV and SLE that feeds on birds and is probably important in enzootic transmission where it is found in high abundance. Female mosquitoes are trapped, usually using carbon dioxide-baited or gravid traps, identified to species, and counted into groups (pools) of 50 females each for testing at the Center for Vectorborne Diseases (CVEC) at UC Davis. Procedures for submitting and processing mosquitoes for detecting virus infection are detailed in Appendix B. The current surveillance system is designed

to detect and measure levels of infection with WNV, SLE, and WEE. Although generally less sensitive than sentinel chickens, mosquito infections may be detected earlier in the season than chicken seroconversions and therefore provide an early warning of virus activity. Testing adult mosquitoes for infection is one of the best methods to detect newly introduced or emerging mosquito-borne viruses. Testing mosquito species other than *Culex* may be necessary to detect the introduction of viruses that do not have a primary avian-*Culex* transmission cycle.

Avian Infections

Detection of arboviral transmission within bird populations can be accomplished by 1) using caged chickens as sentinels and bleeding them routinely to detect viral antibodies (seroconversions), 2) collecting and bleeding wild birds to detect viral antibodies (seroprevalence), and 3) testing dead birds reported by the public for WNV.

In California, flocks of ten chickens are placed in locations where mosquito abundance is known to be high or where there is a history of virus activity. Each chicken is bled every two weeks by pricking the comb and collecting blood on a filter paper strip. The blood is tested at the CDPH Vector-Borne Disease Section for antibodies to SLE, WEE, and WNV. Some agencies conduct their own testing, but send positive samples to CDPH for confirmation and official reporting. Because SLE cross-reacts with WNV in antibody testing, SLE or WNV positive chickens are confirmed and the infecting virus is identified by western blot or cross-neutralization tests. Frequent testing of strategically placed flocks of sentinel chickens provides the most sensitive and cost-effective method to monitor encephalitis virus transmission in an area. Because chickens are continuously available to host-seeking mosquitoes, they are usually exposed to more mosquitoes than can be collected by trapping, especially when adult mosquito abundance or viral infection rates are low. Sentinel housing, bleeding instructions, and testing protocols are provided in Appendix C.

Virus activity in wild bird populations can be monitored by bleeding young (hatching year) birds to detect initial virus infection or by bleeding a cross-section of birds in an area and comparing seroprevalence among age strata to determine if the prevalence of the virus in the region has changed. Elevated seroprevalence levels ("herd immunity") among key species during spring may limit virus transmission and dampen amplification. New infections also can be detected by bleeding banded birds in a capture-recapture scheme. In contrast to the convenience of using sentinel chickens, the repeated collection and bleeding of wild birds generally is too labor intensive, technically difficult, and expensive for most local mosquito control agencies to perform routinely. In addition, the actual place where a wild bird became infected is rarely known, because birds may travel over relatively long distances and usually are collected during daylight foraging flights and not at nighttime roosting sites where they are bitten by mosquitoes.

Unlike WEE and SLE, WNV frequently causes death in North American birds, especially those in the family Corvidae (e.g. crows, ravens, magpies, jays). Dead bird surveillance was initiated by CDPH in 2000 to provide early detection of WNV. Dead bird surveillance has been shown to be one of the earliest indicators of WNV activity in a new area. Birds that meet certain criteria are necropsied at the California Animal Health and Food Safety Laboratory and kidney snips tested for WNV RNA by RT-PCR at CVEC or oral swabs of American crows tested by rapid antigen tests by local agencies. Dead birds are reported to CDPH's dead bird hotline (1-877-WNV-BIRD) or via the website, http://westnile.ca.gov. Beginning in 2010, results from RT-

PCR testing at CVEC distinguished between WNV recent and chronic positive birds based on cycle threshold (Ct) values. In general, birds tested by RT-PCR with a Ct value of <30 and those positive by antigen tests are considered to be recently infected, whereas those with Ct values >30 are considered to have been chronically infected and the time since infection unknown. Chronic positive birds did not likely die from WNV infection and are of limited value for surveillance. The communication and testing algorithm for the dead bird surveillance program is detailed in Appendix D.

Tree Squirrel Infections

In 2004, tree squirrels were included as a WNV surveillance tool, based upon evidence that they were susceptible to WNV and could provide information on localized WNV transmission (Padgett et al. 2007). In conjunction with dead birds, tree squirrels were reported to the California WNV hotline, necropsied at the California Animal Health and Food Safety Laboratory and kidney tissue was tested by RT-PCR at CVEC. Tree squirrels will continue to be tested for WNV in 2012 and are included in the submission protocol in Appendix D.

Equine Infections

Currently, equine disease due to WEE and WNV is no longer a sensitive indicator of epizootic activity (unusually high incidence of infections in animals other than humans) in California because of the widespread vaccination or natural immunization of equids (horses, donkeys, and mules). Nevertheless, confirmed cases in horses can indicate that WEE or WNV has amplified to levels where tangential transmission has occurred and risk to humans is elevated in that region of the State. Each year, CDPH and the California Department of Food and Agriculture (CDFA) alert veterinarians of the risk of WNV to horses, advocate for vaccination, and provide information on diagnostic services that are available for suspected cases of WEE or WNV encephalitis. Other mosquito-borne viruses may also cause encephalitis in horses and testing of equine specimens for these other viruses is available (see Appendix E).

Human Infections

Local mosquito control agencies rely on the rapid detection and reporting of confirmed human cases to plan and implement emergency control activities to prevent additional infections. However, human cases of arboviral infection are an insensitive surveillance indicator of virus activity because most persons who become infected develop no symptoms. For those individuals who do become ill, it may take up to two weeks for symptoms to appear, followed by additional time until the case is recognized and reported. No human cases of SLE or WEE have been reported in California in recent years. However, a total of 3,146 cases of WNV have been reported in California from 2003-2011.

To enhance human WNV testing and surveillance efforts throughout the state, a regional public health laboratory network was established in 2002. The laboratory network consists of the state Viral and Rickettsial Disease Laboratory (VRDL) as well as 26 county public health laboratories that are able to conduct WNV testing. Providers are encouraged to submit specimens for suspect WNV cases to their local public health laboratories. Specimens for patients with encephalitis may also be submitted directly to Neurologic Surveillance and Testing, which is based in the VRDL and offers diagnostic testing for many agents known to cause encephalitis, including

WNV and other arboviruses. In addition, VRDL collaborates with reference laboratories such as the regional laboratories of Kaiser Permanente to ascertain additional suspect WNV cases.

In accordance with Title 17 of the California Code of Regulations (Sections 2500 and 2505), physicians and laboratories are required to report cases of WNV infection or positive test results to their local health department. Positive WNV or other arbovirus test results are investigated by local health department officials to determine whether a patient meets the clinical and laboratory criteria for a WNV diagnosis. If so, the local health department collects demographic and clinical information on the patient using a standardized West Nile virus infection case report, and forwards the report to the state health department. The local health department also determines whether the infection was acquired locally, imported from a region outside the patient's residence, or acquired by a non-mosquito route of transmission such as blood transfusion or organ transplantation. Appendix F contains the protocol for submission of specimens to the regional public health laboratory network for WNV testing. Appendix G provides the national surveillance case definition for arboviral disease, including WNV infection.

Mosquito Control

Problems detected by surveillance are mitigated through larval and adult mosquito control. Mosquito control is the only practical method of protecting people from mosquito-borne diseases. Mosquito control in California is conducted by approximately 80 local agencies, including mosquito and vector control districts, county environmental and health departments, and county agriculture departments. Agencies applying pesticides directly to a water of the United States, or where deposition may enter a water of the United States, must obtain a National Pollutant Discharge Elimination System (NPDES) Permit for Biological and Residual Pesticide Discharges to Waters of the United States from Vector Control Applications (Vector Control Permit). Agencies must comply with provisions of the permit, including use of approved pesticides, pesticide use reporting, and visual, chemical, and toxicity monitoring requirements included in the permit. http://www.swrcb.ca.gov/water_issues/programs/npdes/aquatic.shtml

Compounds currently approved for larval and adult mosquito control in California are listed in Appendix H. Please refer to the Vector Control Permit, Attachments E and F, for a list of vector control pesticides that may be applied to waters of the United States, unless the receiving water has an existing impairment from a pesticide with the same active ingredient. Please review the California State Water Resources Control Board listing of impaired water bodies (303d list) prior to applying any pesticide.
http://www.swrcb.ca.gov/rwqcb4/water_issues/programs/303d_list.shtml

Additional considerations regarding adult mosquito control in urban areas are described in Appendix I.

Larval Control

Mosquito larval and pupal control methods are target-specific and prevent the emergence of adult female mosquitoes which are capable of transmitting pathogens, causing discomfort, and ultimately producing another generation of mosquitoes. For these reasons, most mosquito control agencies in California target the immature stages rather than the adult stage of the

mosquito. Larval mosquito control has three key components: environmental management, biological control, and chemical control.

Environmental management decreases habitat availability or suitability for immature mosquitoes, and may include water management, such as increasing the water disposal rate through evaporation, percolation, recirculation, or drainage. Laser-leveling of fields minimizes pooling at low spots, allows even distribution of irrigation water, and precludes standing water for long periods. Controlled irrigation or the careful timing of wetland flooding for waterfowl can reduce mosquito production or limit emergence to times of the year when virus activity is unlikely. Environmental management may include vegetation management because emergent vegetation provides food and refuge for mosquito larvae. Management strategies include the periodic removal or thinning of vegetation, restricting growth of vegetation, and controlling algae.

Biological control uses natural predators, parasites, or pathogens to reduce immature mosquito numbers. Mosquitofish, *Gambusia affinis*, are the most widely used biological control agent in California. These fish are released annually in a variety of habitats, such as rice fields, small ponds, and canals.

There are several mosquito control products that are highly specific and thus have minimal impact on non-target organisms. These include microbial control agents, such as *Bacillus thuringiensis israelensis* (Bti) and *Bacillus sphaericus*, and insect growth regulators, such as methoprene, that prevent immature mosquitoes from developing into adults. Surface films are very effective against both larvae and pupae, but also may suffocate other surface breathing aquatic insects. Organophosphate pesticides are used infrequently because of their impact on nontarget organisms and the environment.

Adult Control

When larval control is not possible or more immediate control measures are needed, adult mosquito control may be required to suppress populations of infected mosquitoes and interrupt epidemic virus transmission. Adult mosquito control products may be applied using ground-based equipment, fixed wing airplanes, or helicopters. Products applied in ultralow volume [ULV] formulations and dosages include organophosphates, such as malathion and naled, pyrethroids, such as resmethrin, sumithrin, and permethrin, and pyrethrins such as Pyrenone crop spray. Factors to consider when selecting an adulticide include: 1) efficacy against the target species or life cycle stage, 2) resistance status, 3) pesticide label requirements, 4) availability of pesticide and application equipment, 5) environmental conditions, 6) cost, and 7) toxicity to nontarget species, including humans.

For more information about mosquito control please see "Best Management Practices for Mosquito Control in California". http://www.westnile.ca.gov/resources.php

Response Levels

The California Mosquito-borne Virus Surveillance and Response Plan was developed to provide a semi-quantitative measure of virus transmission risk to humans that could be used by local mosquito control agencies to plan and modulate control activities. Independent models are presented for WEE, SLE and WNV to accommodate the different ecological dynamics of these

viruses (Barker et al. 2003). SLE and WN viruses are closely related, require similar environmental conditions, and employ the same *Culex* vectors. Seven surveillance factors are measured and analyzed to determine the level of risk for human involvement and thereby gauge the appropriate response level:

1. Environmental or climatic conditions (snowpack, rainfall, temperature, season)
2. Adult *Culex* vector abundance
3. Virus infection rate in *Culex* mosquito vectors
4. Sentinel chicken seroconversions
5. Fatal infections in birds (WNV only)
6. Infections in humans
7. Proximity of detected virus activity to urban or suburban regions (WEE only)

Each factor is scored on an ordinal scale from 1 (lowest risk) to 5 (highest risk). The mean score calculated from these factors corresponds to a response level as follows: normal season (1.0 to 2.5), emergency planning (2.6 to 4.0), and epidemic (4.1 to 5.0). Table 1 provides a worksheet to assist in determining the appropriate rating for each of the risk factors for each of the three viruses. Appendix J shows sources of data useful in the calculation of risk in Table 1.

For surveillance factor 2 (vector abundance), abundance is scaled as an anomaly and compared to the area average over 5 years for the same preceding two week period. The area typically encompasses the boundaries of a local mosquito and vector control district. The mosquito virus infection rate should be calculated using the most current data (prior two week period) and expressed as minimum infection rate (MIR) per 1,000 female mosquitoes tested. Calculations can also use maximum likelihood estimate (Biggerstaff 2003), which accounts for varying numbers of specimens in pools and the possibility that more than one mosquito could be infected in each positive pool when infection rates are high. For WNV and SLE, risk may be estimated separately for *Cx. tarsalis* and the *Cx. pipiens* complex, respectively, because these species generally have different habitat requirements and therefore spatial distributions (e.g., rural vs. urban).

Each of the three viruses differs in its response to ecological conditions. WEE activity typically is greatest during El Niño conditions of wet winters, excessive run-off and flooding, cool springs, and increased *Culex tarsalis* abundance. Historically, WEE virus spillover into a secondary *Aedes*-rabbit cycle was common in the Central Valley, but has not been detected for the past 25 years. In contrast, SLE and perhaps WNV activity appears to be greatest during La Niña conditions of drought and hot summer temperatures and both SLE and WNV transmission risk increases when temperatures are above normal. Abundance and infection of the *Culex pipiens* complex are included in both SLE and WNV estimates of risk because these mosquito species are important vectors, particularly in suburban/urban environments. The occurrence of dead bird infections is included as a risk factor in the WNV calculations. For surveillance factors 4-6 (chickens, birds, humans), specific region is defined as the area within the agency's boundary and the broad region includes the area within 150 miles (~241 km) of the agency's boundary.

Proximity of virus activity to human population centers is considered an important risk factor for all three viruses of public health concern. In the risk assessment model in Table 1 this was accommodated in two different ways. WEE virus transmitted by *Culex tarsalis* typically amplifies first in rural areas and may eventually spread into small and then larger communities. A risk score was included to account for where virus activity was detected. WNV and SLE virus

may be amplified concurrently or sequentially in rural and urban cycles. The rural cycle is similar to WEE virus and is transmitted primarily by *Cx. tarsalis*, whereas the urban cycle is transmitted primarily by members of the *Culex pipiens* complex. If the spatial distributions of key *Culex* species differ within an area (e.g., rural vs. urban), it may be advantageous to assess risk separately by species for abundance and infection rates in *Cx. tarsalis* and the *Cx. pipiens* complex. This would result in two estimates of overall risk for the areas dominated by each species.

Each of these surveillance factors can differ in impact and significance according to time of year and geographic region. Climatic factors provide the earliest indication of the potential for increased mosquito abundance and virus transmission and constitute the only risk factor actually measured from the start of the calendar year through mid-spring when enzootic surveillance commences in most areas. Climate is used prospectively to forecast risk during the coming season. Other factors that may inform control efforts as the season progresses are typically, in chronological order: mosquito abundance, infections in non-humans (e.g., dead birds for WNV, mosquitoes, sentinel chickens), and infections in humans. Enzootic indicators measure virus amplification within the *Culex*-bird cycle and provide nowcasts of risk, whereas human infections document tangential transmission and are the outcome measure of forecasts and nowcasts. Response to the calculated risk level should consider the time of year; e.g., epidemic conditions in October would warrant a less aggressive response compared to epidemic conditions in July because cooler weather in late fall will contribute to declining risk of arbovirus transmission.

The ratings listed in Table 1 are benchmarks only and may be modified as appropriate to the conditions in each specific region or biome of the state. Calculation and mapping of risk has been enabled by tools included in the CalSurv Gateway. Roles and responsibilities of key agencies involved in carrying out the surveillance and response plan are outlined in "Key Agency Responsibilities."

Table 1. Mosquito-borne Virus Risk Assessment.

WNV Surveillance Factor	Assessment Value	Benchmark	Assigned Value	
1. Environmental Conditions High-risk environmental conditions include above-normal temperatures with or without above-normal rainfall, runoff, or snowpack. Weather data link: http://ipm.ucdavis.edu	1	Avg daily temperature during prior 2 weeks ≤ 56 °F		
	2	Avg daily temperature during prior 2 weeks 57 – 65 °F		
	3	Avg daily temperature during prior 2 weeks 66 – 72 °F		
	4	Avg daily temperature during prior 2 weeks 73 – 79 °F		
	5	Avg daily temperature during prior 2 weeks > 79 ° F		
			Cx tars	*Cx pip*
2. **Adult *Culex tarsalis* and *Cx. pipiens* complex relative abundance*** Determined by trapping adults, enumerating them by species, and comparing numbers to those previously documented for an area for the prior 2-week period.	1	Vector abundance well below average (≤ 50%)		
	2	Vector abundance below average (51 - 90%)		
	3	Vector abundance average (91 - 150%)		
	4	Vector abundance above average (151 - 300%)		
	5	Vector abundance well above average (> 300%)		
3. **Virus infection rate in *Culex tarsalis* and *Cx. pipiens* complex mosquitoes*** Tested in pools of 50. Test results expressed as minimum infection rate per 1,000 female mosquitoes tested (MIR) for the prior 2-week period.	1	MIR = 0		
	2	MIR = 0.1 - 1.0		
	3	MIR = 1.1 - 2.0		
	4	MIR = 2.1 - 5.0		
	5	MIR > 5.0		
4. **Sentinel chicken seroconversion** Number of chickens in a flock that develop antibodies to WNV during the prior 2-week period. If more than one flock is present in a region, number of flocks with seropositive chickens is an additional consideration. Typically 10 chickens per flock.	1	No seroconversions in broad region		
	2	One or more seroconversions in broad region		
	3	One or two seroconversions in a single flock in specific region		
	4	More than two seroconversions in a single flock or two flocks with one or two seroconversions in specific region		
	5	More than two seroconversions per flock in multiple flocks in specific region		
5. **Dead bird infection** Number of birds that have tested positive (recent infections only) for WNV during the prior 3-month period. This longer time period reduces the impact of zip code closures during periods of increased WNV transmission.	1	No positive dead birds in broad region		
	2	One or more positive dead birds in broad region		
	3	One positive dead bird in specific region		
	4	Two to five positive dead birds in specific region		
	5	More than five positive dead birds in specific region		
6. **Human cases** Do not include this factor in calculations if no cases are detected in region.	3	One or more human infections in broad region		
	4	One human infection in specific region		
	5	More than one human infection in specific region		
			Cx tars	*Cx pip*
<u>Response Level / Average Rating:</u> Normal Season (1.0 to 2.5) Emergency Planning (2.6 to 4.0) Epidemic (4.1 to 5.0)		**TOTAL**		
		AVERAGE		

* Calculation of separate risk values for *Cx. tarsalis* and the *Cx. pipiens* complex may be useful if their spatial distributions (e.g., rural vs. urban) differ within the assessment area.

SLE Surveillance Factor	Assessment Value	Benchmark	Assigned Value	
1. Environmental Conditions High-risk environmental conditions include above-normal temperatures with or without above-normal rainfall, runoff, or snowpack. Weather data link: http://ipm.ucdavis.edu	1	Avg daily temperature during prior 2 weeks ≤ 56 °F		
	2	Avg daily temperature during prior 2 weeks 57 – 65 °F		
	3	Avg daily temperature during prior 2 weeks 66 – 72 °F		
	4	Avg daily temperature during prior 2 weeks 73 – 79 °F		
	5	Avg daily temperature during prior 2 weeks > 79 ° F		
			Cx tars	*Cx pip*
2. **Adult *Culex tarsalis* and *Cx. pipiens* complex relative abundance*** Determined by trapping adults, enumerating them by species, and comparing numbers to those previously documented for an area for the prior 2-week period.	1	Vector abundance well below average (≤ 50%)		
	2	Vector abundance below average (51 - 90%)		
	3	Vector abundance average (91 - 150%)		
	4	Vector abundance above average (151 - 300%)		
	5	Vector abundance well above average (> 300%)		
3. **Virus infection rate in *Culex tarsalis* and *Cx. pipiens* complex mosquitoes*** Tested in pools of 50. Test results expressed as minimum infection rate per 1,000 female mosquitoes tested (MIR) for the prior 2-week collection period.	1	MIR = 0		
	2	MIR = 0.1 - 1.0		
	3	MIR = 1.1 - 2.0		
	4	MIR = 2.1 - 5.0		
	5	MIR > 5.0		
4. **Sentinel chicken seroconversion** Number of chickens in a flock that develop antibodies to SLEV during the prior 2-week period. If more than one flock is present in a region, number of flocks with seropositive chickens is an additional consideration. Typically 10 chickens per flock.	1	No seroconversions in broad region		
	2	One or more seroconversions in broad region		
	3	One or two seroconversions in a single flock in specific region		
	4	More than two seroconversions in a single flock or two flocks with one or two seroconversions in specific region		
	5	More than two seroconversions per flock in multiple flocks in specific region		
5. **Human cases** Do not include this factor in calculations if no cases are detected in region.	3	One or more human cases in broad region		
	4	One human case in specific region		
	5	More than one human case in specific region		
			Cx tars	*Cx pip*
Response Level / Average Rating: Normal Season (1.0 to 2.5) Emergency Planning (2.6 to 4.0) Epidemic (4.1 to 5.0)		**TOTAL**		
		AVERAGE		

* Calculation of separate risk values for *Cx. tarsalis* and the *Cx. pipiens* complex may be useful if their spatial distributions (e.g., rural vs. urban) differ within the assessment area.

WEE Surveillance Factor	Assessment Value	Benchmark	Assigned Value
1. **Environmental Conditions** High-risk environmental conditions include above normal rainfall, snow pack, and runoff during the early season followed by a strong warming trend. Weather data link: http://ipm.ucdavis.edu	1	Cumulative rainfall and runoff well below average	
	2	Cumulative rainfall and runoff below average	
	3	Cumulative rainfall and runoff average	
	4	Cumulative rainfall and runoff above average	
	5	Cumulative rainfall and runoff well above average	
2**. Adult *Culex tarsalis* abundance** Determined by trapping adults, enumerating them by species, and comparing numbers to averages previously documented for an area for the prior 2-week period.	1	*Cx. tarsalis* abundance well below average (≤ 50%)	
	2	*Cx. tarsalis* abundance below average (51 - 90%)	
	3	*Cx. tarsalis* abundance average (91 - 150%)	
	4	*Cx. tarsalis* abundance above average (151 - 300%)	
	5	*Cx. tarsalis* abundance well above average (> 300%)	
3. **Virus infection rate in *Cx. tarsalis* mosquitoes** Tested in pools of 50. Test results expressed as minimum infection rate per 1,000 female mosquitoes tested (MIR) for the prior 2-week collection period.	1	*Cx. tarsalis* MIR = 0	
	2	*Cx. tarsalis* MIR = 0.1 - 1.0	
	3	*Cx. tarsalis* MIR = 1.1 - 2.0	
	4	*Cx. tarsalis* MIR = 2.1 - 5.0	
	5	*Cx. tarsalis* MIR > 5.0	
4. **Sentinel chicken seroconversion** Number of chickens in a flock that develop antibodies to WEEV during the prior 2-week period. If more than one flock is present in a region, number of flocks with seropositive chickens is an additional consideration. Typically 10 chickens per flock.	1	No seroconversions in broad region	
	2	One or more seroconversions in broad region	
	3	One or two seroconversions in a single flock in specific region	
	4	More than two seroconversions in a single flock or two flocks with one or two seroconversions in specific region	
	5	More than two seroconversions per flock in multiple flocks in specific region	
5. **Proximity to urban or suburban regions** (score only if virus activity detected) Risk of outbreak is highest in urban areas because of high likelihood of contact between humans and vectors.	1	Virus detected in rural area	
	3	Virus detected in small town or suburban area	
	5	Virus detected in urban area	
6. **Human cases** Do not include this factor in calculations if no cases found in region or in agency.	3	One or more human cases in broad region	
	4	One human case in specific region	
	5	More than one human case in specific region	
<u>Response Level / Average Rating:</u> Normal Season (1.0 to 2.5) Emergency Planning (2.6 to 4.0) Epidemic (4.1 to 5.0)		**TOTAL**	
		AVERAGE	

General suggestions for applying the risk assessment model locally

- Use a consistent time period for environmental conditions, adult mosquito abundance, mosquito infection rates, and human cases. If you use a period that differs from the prior two-week period defined in the risk assessment -- such as the prior month -- use the same period for all other relevant measures. Note that sentinel seroconversions and dead bird infections may need special treatment to accommodate bleeding schedules and zip code closures, respectively. For sentinel seroconversions, use the sentinel seroconversions from the most recent collection.
- If you have multiple trap types in your surveillance program, determine the vector abundance anomaly for each trap type and species and use the most sensitive trap type's value in the risk assessment.
- When determining the vector abundance anomaly, there should be at least two and preferably five years of prior data to provide a comparative baseline for the particular trap type. Ideally, the prior years should be contiguous and immediately precede the time period being evaluated.

Risk assessment as implemented by the CalSurv Gateway (http://gateway.calsurv.org)

- Assessment reports will be generated and delivered to the primary contacts of each agency by email every Monday.
- The time frame of each assessment report will be for the prior two-week period ending on the previous Saturday.
- Only those agencies with active Gateway accounts and active surveillance programs will receive the reports.
- All calculations are done at the agency level, thus the specific region is the area within the agency's boundary and the broad region includes the area within 150 miles (~241 km) of the agency's boundary.
- Due to privacy concerns and delays in detection and reporting, human cases are not part of the Gateway's risk assessment.
- All of the general suggestions from the prior section are used in the Gateway's implementation.
- Risk estimates based on mosquito abundance and infection rates will be calculated separately for the key mosquito species, *Cx. tarsalis* and the *Cx. pipiens* complex.
- For sentinel seroconversions, flavivirus positives are treated as WNV positives. If SLE is found, this will be adjusted accordingly.

Characterization of Conditions and Responses

Level 1: Normal Season

Risk rating: 1.0 to 2.5

CONDITIONS
• Average or below average snowpack and rainfall; below or average seasonal temperatures (<65F) • *Culex* mosquito abundance at or below five year average (key indicator = adults of vector species) • No virus infection detected in mosquitoes • No seroconversions in sentinel chickens • No recently infected WNV-positive dead birds • No human cases
RESPONSE
• Conduct routine public education (eliminate standing water around homes, use personal protection measures) • Conduct routine mosquito and virus surveillance activities • Comply with National Pollutant Discharge Eliminations System (NPDES) permit if applying pesticides to waters of the United States • Conduct routine mosquito control, with emphasis on larval control • Inventory pesticides and equipment • Evaluate pesticide resistance in vector species • Ensure adequate emergency funding • Release routine press notices • Send routine notifications to physicians and veterinarians • Establish and maintain routine communication with local office of emergency services personnel; obtain Standardized Emergency Management System (SEMS) training

Level 2: Emergency Planning

Risk rating: 2.6 to 4.0

CONDITIONS
• Snowpack and rainfall and/or temperature above average (66-79F) • Adult *Culex* mosquito abundance greater than 5-year average (150% to 300% above normal) • One or more virus infections detected in *Culex* mosquitoes (MIR / 1000 is <5) • One or more seroconversions in single flock or one to two seroconversions in multiple flocks in specific region • One to five recently infected WNV-positive dead birds in specific region • One human case in broad or specific region • WEE virus detected in small towns or suburban area
RESPONSE
• Review epidemic response plan • Enhance public education (include messages on the signs and symptoms of encephalitis; seek medical care if needed; inform public about pesticide applications if appropriate) • Enhance information to public health providers • Conduct epidemiological investigations of cases of equine or human disease • Increase surveillance and control of mosquito larvae • Increase adult mosquito surveillance • Increase number of mosquito pools tested for virus • Conduct or increase localized chemical control of adult mosquitoes as appropriate • Contact commercial applicators in anticipation of large scale adulticiding • Review candidate pesticides for availability and susceptibility of vector mosquito species • Ensure notification of key agencies of presence of viral activity, including the local office of emergency services

Level 3: Epidemic Conditions

Risk rating: 4.1 to 5.0

CONDITIONS
• Snowpack, rainfall, and water release rates from flood control dams and/or temperature well above average (>79F) • Adult vector population extremely high (>300%) • Virus infections detected in multiple pools of *Culex tarsalis* or *Cx. pipiens* mosquitoes (MIR / 1000 > 5.0) • More than two seroconversions per flock in multiple flocks in specific region • More than five recently infected WNV-positive dead birds and multiple reports of dead birds in specific region • More than one human case in specific region • WEE virus detection in urban or suburban areas
RESPONSE
• Conduct full scale media campaign • Alert physicians and veterinarians • Conduct active human case detection • Conduct epidemiological investigations of cases of equine or human disease • Continue enhanced larval surveillance and control of immature mosquitoes • Broaden geographic coverage of adult mosquito surveillance • Accelerate adult mosquito control as appropriate by ground and/or air • Coordinate the response with the local Office of Emergency Services or if activated, the Emergency Operation Center (EOC) • Initiate mosquito surveillance and control in geographic regions without an organized vector control program • Determine whether declaration of a local emergency should be considered by the County Board of Supervisors (or Local Health Officer) • Determine whether declaration of a "State of Emergency" should be considered by the Governor at the request of designated county or city officials • Ensure state funds and resources are available to assist local agencies at their request • Determine whether to activate a Standardized Emergency Management System (SEMS) plan at the local or state level • Continue mosquito education and control programs until mosquito abundance is substantially reduced and no additional human cases are detected

For more detailed information on responding to a mosquito-borne disease outbreak, please refer to:

Operational Plan for Emergency Response to Mosquito-Borne Disease Outbreaks, California Department of Public Health (supplement to California Mosquito-Borne Virus Surveillance and Response Plan). http://www.westnile.ca.gov/resources.php

Key Agency Responsibilities

Local Mosquito and Vector Control Agencies

- Gather, collate, and interpret regional climate and weather data.
- Monitor abundance of immature and adult mosquitoes.
- Collect and submit mosquito pools to CVEC for virus detection.
- Maintain sentinel chicken flocks, obtain blood samples, and send samples to VBDS.
- Pick-up and ship dead birds for necropsy and WNV testing, or test oral swabs from American crows locally via rapid antigen screening assays.
- Update CDPH weekly of all birds that are independently reported and/or tested by VecTest, RAMP or immunohistochemistry.
- Update the surveillance gateway weekly with mosquito pool results that are independently tested by RAMP or PCR.
- Conduct routine control of immature mosquitoes.
- Comply with NPDES permit if applying pesticides to waters of the United States
- Conduct control of adult mosquitoes when needed.
- Educate public on mosquito avoidance and reduction of mosquito breeding sites.
- Coordinate with local Office of Emergency Services personnel.
- Communicate regularly with neighboring agencies

Mosquito and Vector Control Association of California

- Coordinate purchase of sentinel chickens.
- Receive, track, and disperse payment for surveillance expenses.
- Coordinate surveillance and response activities among member agencies.
- Serve as spokesperson for member agencies.
- Establish liaisons with press and government officials.

California Department of Public Health

- Collate adult mosquito abundance data submitted by local agencies; provide summary of data to local agencies.
- Maintain a WNV information and dead bird reporting hotline, 1-877-WNV-BIRD, and a WNV website: http://westnile.ca.gov.
- Coordinate submission of specimens for virus testing.
- Provide supplies for processing mosquito pool and sentinel chicken diagnostic specimens
- Test sentinel chicken sera for viral antibodies.
- Test human specimens for virus.
- Distribute a weekly bulletin summarizing surveillance test results.
- Send weekly surveillance results to the UC Davis interactive website.
- Immediately notify local vector control agency and public health officials when evidence of viral activity is found.
- Conduct epidemiological investigations of cases of human disease.
- Coordinate and participate in a regional emergency response in conjunction with California Emergency Management Agency.
- Conduct active surveillance for human cases.

- Provide oversight to local jurisdictions without defined vector-borne disease control program.
- Maintain inventory of antigens and antisera to detect exotic viruses.
- Provide confirmation of tests done by local agencies.

University of California at Davis

- Conduct research on arbovirus surveillance, transmission of mosquito-borne diseases, and mosquito ecology and control.
- Test mosquito pools and dead birds for endemic and introduced viruses.
- Provide a proficiency panel of tests for identification of viruses from human, equine, bird, or arthropod vectors to local agencies to ensure quality control.
- Maintain an interactive website (http://gateway.calsurv.org) for dissemination of mosquito-borne virus information and data.
- Maintain inventory of antigens, antisera, and viruses to detect the introduction of exotic viruses.
- Provide confirmation of tests done by local or state agencies.

California Department of Food and Agriculture

- Notify veterinarians and veterinary diagnostic laboratories about WEE and WNV and testing facilities available at UCD Center for Vectorborne Disease Research.
- Provide outreach to general public and livestock and poultry producers on the monitoring and reporting of equine and ratite encephalitides.
- Facilitate equine and ratite sample submission from the field.
- Conduct investigations of equine cases.

California Animal Health and Food Safety Laboratory

- Identify species of dead birds submitted for WNV testing.
- Conduct necropsies and testing on dead birds.
- Submit bird tissues to CVEC for testing.
- Test equine specimens for WNV.

Local Health Departments and Public Health Laboratories

- Test human specimens for WNV.
- Refer human specimens to CDPH for further testing.
- Notify local medical community, including hospitals and laboratories, if evidence of viral activity is present.
- Collect dead birds and ship carcasses to testing laboratories when needed.
- Test American crows via rapid assay or RT-PCR as resources allow.
- Participate in emergency response.
- Conduct epidemiological investigations of cases of human disease.
- Report WNV cases to CDPH.
- Conduct public education.

California Emergency Management Agency

- Coordinate the local, regional, or statewide emergency response under epidemic conditions in conjunction with CDPH via the Standardized Emergency Management System (SEMS).
- Serve as liaison with the Federal Emergency Management Agency (FEMA) in the event that a federal disaster has been declared.

Federal Centers for Disease Control and Prevention

- Provide consultation to state and local agencies in California if epidemic conditions exist.
- Provide national surveillance data to state health departments.

State Water Resources Control Board

- Review NPDES permit applications and respond in a timely manner.
- Review vector control pesticides registered by the California Department of Pesticide Regulation for inclusion on the Vector Control NPDES permit.

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Appendix A: Guidelines for Adult Mosquito Surveillance

The objective of Appendix A is to standardize mosquito sampling and reporting procedures to provide comparable and interpretable abundance measures among collaborating mosquito control agencies in California. This section summarizes information from Integrated Mosquito Surveillance Program Guidelines for California that has been adopted by the Mosquito and Vector Control Association (MVCAC) (Meyer et al. 2003). The MVCAC guidelines recommend stratifying the use of different sampling methods in rural, small town, and urban environments for each of the major biomes of California and provide a listing of target vector and nuisance mosquito species. The stratified sampling approach monitors vector populations and virus activity in rural enzootic foci, agricultural or suburban amplification sites, and densely populated urban centers to provide estimates of early, eminent, and current epidemic risk.

The four sampling methods currently used by mosquito control agencies are: 1) New Jersey (American) light trap, 2) CDC/ EVS style, or other CO_2-baited trap, 3) gravid trap, and 4) adult resting collections. Collection location sites should be geocoded and registered using the Surveillance Gateway [http://gateway.calsurv.org/]. Studies comparing trap design and efficiency for surveillance purposes have been published (Reisen et al. 2000; Reisen et al. 2002). These guidelines describe: 1) a comparison of the sampling methods, 2) equipment design, 3) operation, 4) specimen processing, 5) data recording and analysis, and 6) data usage.

Advantages and Disadvantages of Mosquito Sampling Methods:

New Jersey Light Trap	
Pros	**Cons**
• All female metabolic states and males collected • Minimal collection effort (can be run nightly without service) • Long history of use in California	• Selective for phototactic nocturnally active mosquitoes • Ineffective in the presence of competing light sources • Sorting time excessive because of other insects in traps • Specimens dead; less useful for virus detection • Collects comparatively few specimens
CDC/EVS CO_2 Trap	
Pros	**Cons**
• Samples biting population • Collects large numbers of virus vector species • Specimens alive; suitable for virus detection • Without light, collects mostly mosquitoes thus reducing sorting time • Battery operated, portable	• Collects >50% nullipars (females that have never blood fed or laid eggs) • Must be set and picked-up daily • Dry ice cost high; availability can be a problem • Does not collect males or bloodfed or gravid females
Gravid Trap	
Pros	**Cons**
• Collects females that have bloodfed and digested the blood meal; may have higher infection rate than CO_2 trap • Specimens alive; suitable for virus detection • Extremely sensitive for *Cx.quinquefasciatus* in urban habitat • Bait inexpensive • Battery operated, portable	• Collects only foul-water *Culex* [mostly *pipiens* complex] • Bait has objectionable odor • Must be set and picked-up daily

Resting Catches	
Pros	**Cons**
• All metabolic states collected • Minimal equipment needed • Specimens alive; suitable for virus detection • Blooded and gravid specimens can be tested to improve sensitivity of virus surveillance	• Standardization is difficult due to: 1. Variable shelter size and type 2. Variable collector efficiency • Labor intensive; difficult to concurrently sample a large number of sites

New Jersey (American) Light Trap (NJLT)

Operation

At a minimum, one trap should be located in each principal municipality of a district or have a distribution of one trap/township (36 sq. mi.). Correct placement of the NJLT is a critical factor in its performance as an effective surveillance mechanism for measuring the relative abundance of phototaxic mosquitoes. Place the traps at six-foot height. This can be done by using a metal standard, or by hanging the traps from tree limbs or roof eaves. These distances should maximize attractancy over a 360 degree radius. The trap should be placed on the leeward side of a structure or tree line to decrease the influence of wind on trap catch.

Traps should be kept away from smoke or chemical odors that may be repellent to the mosquitoes. Traps should be away from buildings in which animals are housed and not be in the immediate vicinity of sentinel flocks to diminish attractancy competition. Traps should be placed away from street and security lights that may diminish attractancy of the trap bulb. A trap should be placed approximately 100-200 feet from each sentinel chicken flock when possible.

Traps should be operated from week 14 to week 44 of the calendar year for districts north of the Tehachapi Mountains and all year long for districts south of the Tehachapi. Ideally, the traps should run for four to seven nights before the collection is retrieved (Loomis and Hanks 1959). The trap should be thoroughly cleaned with a brush to remove spider webs or any other debris that may hinder airflow through the trap. A regular cleaning schedule should be maintained during the trapping season to maintain trap efficiency.

Processing

Adult mosquitoes from the NJLT collection should be sorted from the other insects in an enamel pan before being identified and counted at 10x magnification under a dissecting microscope. Counting aliquots or subsamples of all specimen samples should be discouraged, because vector species may comprise only a small fraction of the total mosquito collection.

CDC style CO_2-baited trap

Operation

Carbon dioxide-baited traps can be used for abundance monitoring or capturing mosquitoes for virus testing. Traps should be hung from a 6-foot tall standard (approximately 4 feet above ground level) to standardize trap placement for population and virus infection rate monitoring. Knowledge of the host-seeking patterns of the target species is essential in determining CO_2-baited trap placement in the habitat to enhance catch size and therefore sampling sensitivity. *Culex tarsalis* primarily bloodfeed on birds and hunt along vegetative borders and tree canopies where birds roost and nest. *Culex erythrothorax* are best collected within wetland areas near

dense stands of tules and cattails. In large, open breeding sources such as rice fields, CO_2-baited traps could be hung on standards on the up-wind side of the source for *Culex tarsalis* and *Anopheles freeborni* collections. *Aedes melanimon* and *Aedes nigromaculis* are mammal feeders and typically seek hosts over open fields.

When used to supplement sentinel chickens for arbovirus surveillance, traps should be operated at different locations to enhance geographical coverage and thus surveillance sensitivity. Labor and time constraints determine the extent of sampling. When used to monitor population abundance, traps should be operated weekly or biweekly at the same fixed stations. Temperature, wind speed, wind direction, and rainfall should be recorded because these factors affect catch size. The mini-light may be removed, because it attracts other phototactic insects that may hinder sorting and/or damage female mosquitoes in the collection container and may repel members of the *Culex pipiens* complex. The CO_2-baited trap should not be placed in immediate proximity to the sentinel chicken flock because it will compete with, and therefore lessen, exposure of the sentinel birds, but may be placed within a 100-200 foot radius of the sentinel flock site, but no closer than 100 feet from the flock.

Processing

Mosquitoes collected for arbovirus surveillance should be processed according to the procedures outlined in Appendix B. If possible, ten pools of a species (*Culex tarsalis*, *Culex pipiens, Culex quinquefasciatus, Culex stigmatosoma, Aedes melanimon*, and *Aedes dorsalis*) should be submitted for virus testing from a given geographical location at a given time. Only live mosquitoes should be pooled for virus testing. Dead, dried specimens should be counted and discarded. Only whole specimens should be submitted; avoid including detached body parts (which may be from other mosquito species) or other Diptera (i.e., *Culicoides*, etc.) in the pool to prevent sample contamination. Avoid freezing specimens before sorting and counting. Mosquitoes collected for population monitoring should be anesthetized in a well-ventilated area or under a chemical hood using triethylamine, identified to species under a dissecting microscope, counted, pooled and immediately frozen at -80C or on dry ice for later virus testing.

Reiter/Cummings gravid traps

Trap design and components

The Reiter/Cummings gravid traps consist of a rectangular trap housing [plastic tool box] with an inlet tube on the bottom and an outlet tube on the side or top. The rectangular housing is provided with legs to stabilize the trap over the attractant basin containing the hay-infusion mixture. (Cummings 1992). The oviposition attractant consists of a fermented infusion made by mixing hay, Brewer's yeast and water. The mixture should sit at ambient temperature for a minimum of three to four days prior to allow fermentation and increase attractancy. New solutions should be made at least biweekly to maintain consistent attractancy.

Operation

The Reiter/Cummings gravid trap is primarily used in suburban and urban residential settings for surveillance of gravid females in the *Culex pipiens* complex. The trap is placed on the ground near dense vegetation that serves as resting sites for gravid females. Specimens may be retrieved on a one to three day basis.

Processing

Culex pipiens complex females collected with the gravid trap for arbovirus surveillance should be retrieved daily and the protocol for mosquito pool submission as outlined in Appendix B should be followed. For population monitoring of the *Culex pipiens* complex, collections may be retrieved every third day. The females are killed, identified and counted before being discarded. Autogenous females may also be attracted to the gravid trap.

Adult resting collections

Trap design and operation

A flashlight and mechanical aspirator can be used to collect adult mosquitoes resting in habitats such as shady alcoves, buildings, culverts, or spaces under bridges. Highest numbers usually are collected at humid sites protected from strong air currents. Adults resting in vegetation may be collected using a mechanical sweeper such as the AFS (Arbovirus Field Station) sweeper (Meyer et al. 1983). For quantification, time spent searching is recorded and abundance expressed as the number collected per person-hour.

Red boxes were developed to standardize collections spatially. Different researchers have used red boxes of varying dimensions. Largest catches are made in semi-permanent walk-in red boxes which measure 4' x 4' x 6' (Meyer 1985). Smaller 1' x 1' x 1' foot boxes typically collect fewer specimens, but are readily portable. The entrance of the walk-in red box should be left open, draped with canvas, or closed with a plywood door. The canvas or plywood door should have a 1 or 2 ft gap at the bottom to allow entry of mosquitoes, while affording some protection from the wind and decreasing the light intensity within the box. The box entrance should not face eastward into the morning sun or into the predominant wind direction.

Processing

Mosquitoes should be anesthetized with triethylamine, identified under a dissecting microscope, sorted by sex and female metabolic status (i.e., empty or unfed, blood fed or gravid), and counted. Females may be counted into ten pools of approximately 50 females per site per collection date for virus monitoring (see Appendix B). Only living females should be used for arbovirus surveillance. Data on metabolic status may indicate population reproductive age as well as diapause status.

Data recording and analysis

Counts from NJLTs, EVS, and gravid traps and information on pools submitted for testing or tested locally should be entered directly in electronic format through the California Vectorborne Disease Surveillance Gateway (http://gateway.calsurv.org/). Import from local or proprietary data systems is available. For comparisons of abundance over time, space, or collection methods, refer to Biddlingmeyer (1969).

Data usage

Mosquito collections from some or all of the four sampling methods collectively can be used to:

1. Assess control efforts.

2. Monitor arbovirus vector abundance and infection rates.
3. Compare mosquito abundance from collections with the number of service requests from the public to determine the tolerance of neighborhoods to mosquito abundance.
4. Determine proximity of breeding source(s) by the number of males present in collections from the NJLTs and red boxes.
5. Determine age structure of females collected by CO_2 traps and resting adult collections; such data are critical to evaluating the vector potential of the population.

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Appendix B: Procedures for Processing Mosquitoes for Arbovirus Detection

1. Collect mosquitoes alive and return them immediately to the laboratory. Collections should be kept humid during transport with moist toweling to prevent desiccation. Females should be offered 5-10 percent sucrose if held overnight or longer before processing.

2. Anesthetize mosquitoes by cold, carbon dioxide, or triethylamine (TEA). TEA is recommended because specimens are permanently immobilized with minimal mortality and with no loss of virus titer. TEA should be used either outdoors or under a chemical hood. Collections can be anesthetized outdoors using a few drops of TEA, the specimens transferred to Petri dishes, and then taken into the laboratory for processing. If refrigerated and kept humid, mosquitoes will remain alive in covered Petri dishes for one or two days without additional anesthesia. If mosquitoes are frozen before processing, sorting to species and enumeration must be done on a chill table to prevent virus loss.

3. Sort mosquito collections to species under a dissecting microscope at 10X to ensure correct identification and to make sure that extraneous mosquito parts (i.e., legs, wings) or other small insects such as chironomids or *Culicoides* are not inadvertently included in the pools. This is extremely important because diagnostics have transitioned from virus isolation to sensitive RT-PCR methods of viral detection. Count and discard dead and dried mosquitoes. Lots of 50 females per pool of each vector species from each collection site are then counted into individual polystyrene vials with snap caps containing two 5mm glass beads. Recommended sampling effort is ten pools of 50 females of each species from each site per week to detect minimum infection rates (MIRs) ranging from 0 to 20 per 1,000 females tested. Vials with pools should be labeled sequentially starting with #1 each year after the site code; e.g., KERN-1-12; where 12 refers to year 2012. Data on each pool can be entered directly in electronic format through the California Vectorborne Disease Surveillance Gateway (http://gateway.calsurv.org/). POOLS MUST BE ACCOMPANIED BY "MOSQUITO POOLS SUBMITTED FORM MBVS-3" AND CAN ONLY BE TESTED FROM REGISTERED SITES. Surveillance sites should be registered online at: **http://gateway.calsurv.org/.** Faxed registration forms (MBVS-1) will be accepted from agencies without adequate internet access.

   List the site code for each pool that consists of a designated four-letter agency code followed by six digits identifying the site, i.e., KERN000001. Keep the pool numbers in sequence for the whole year regardless of the number of site codes: e.g., pool #1 may be from KERN000001, and pool #2 may be from KERN000004.

4. Freeze pools immediately at -70°C either on dry ice in an insulated container or in an ultra-low temperature freezer. Pools should be shipped frozen on dry ice to CVEC for testing by real time multiplex RT-PCR. Pools received by noon on Wednesday will be tested and reported by Friday or sooner using the Gateway website and automated email notification, in addition to the routine reporting within the weekly Arbovirus Surveillance Bulletin. Each pool is screened for WNV, SLE, and WEE viruses by a multiplex assay, with positives confirmed by a singleplex RT-PCR. Pools from selected areas also are screened for additional viruses using Vero cell culture with isolates identified following sequencing. Care must be taken

not to allow pools to defrost during storage or shipment, because each freeze-thaw cycle may result in a 10-fold decrease in viral titer, and all virus will be lost if the specimens sit at room temperature for extended periods. Address shipment to: Ying Fang, Center for Vectorborne Diseases, VM: // PMI, 3336 VetMed 3A, University of California, Davis, , Davis CA 95616. Pools received by Wednesday will be tested and reported through the Gateway the same week.

5. Local agencies that conduct their own testing by RT-PCR or RAMP® tests need to complete and pass a proficiency panel each year for the results to be reported by CDPH.

Appendix C: Procedures for Maintaining and Bleeding Sentinel Chickens

1. Procure hens in March or when they become available as notified by MVCAC when the chickens are 14-18 weeks of age to ensure minimal mortality during handling. Hens at this age have not yet begun to lay eggs, but they should have received all their vaccinations and been dewormed.
2. Ten sentinel chickens can be housed in a 3Wx6Lx3H ft coop framed with 2x2 and 2x4 inch construction lumber and screened with no smaller than 1x1 inch welded wire. It is critical that the wire mesh be large enough to allow the mosquitoes to easily enter the coop and the coops be placed in locations with a history of arbovirus transmission and/or high mosquito abundance. The site of and band numbers located at each coop must be registered online at: http://gateway.calsurv.org/. Faxed registration forms (MBVS-1) will be accepted from agencies without adequate internet access. Coops should be at least two feet off the ground to reduce predator access, facilitate capture of the birds for bleeding, and allow the free passage of the feces through the wire floor to the ground. A single, hinged door should be placed in the middle of the coop, so that the entire coop is accessible during chicken capture. After construction, the lumber and roof should be protected with water seal. A self-filling watering device should be fitted to one end of the coop and a 25 lb. feeder suspended in the center for easy access. In exchange for the eggs, a local person (usually the home owner, farm manager, etc.) should check the birds (especially the watering device) and remove the eggs daily. If hung so the bottom is about four inches above the cage floor and adjusted properly, the feeder should only have to be refilled weekly (i.e., 100 lb. of feed per month per flock of ten birds). Therefore, if proper arrangements can be made and an empty 55-gallon drum provided to store extra feed, sentinel flocks need only be visited bi-weekly when blood samples are collected.
3. Band each bird in the web of the wing using metal hog ear tags and appropriate pliers. This band number, the date, and site registration number must accompany each blood sample sent to the laboratory for testing.
4. Bleed each hen from the distal portion of the comb using a standard lancet used for human finger "prick" blood samples. The bird can be immobilized by wedging the wings between the bleeder's forearm and thigh, thereby leaving the hand free to hold the head by grabbing the base of the comb with the thumb and forefinger. Use alcohol swabs on comb before bleeding. Blood samples are collected on half-inch wide filter paper strips, which should be labeled with the date bled and wing band number. The comb should be "pricked" with the lancet and blood allowed to flow from the "wound" to form a drop. Collect the blood by touching the opposite end of the pre-labeled filter paper strip to the wound. THE BLOOD MUST COMPLETELY SOAK THROUGH ON A ¾ INCH LONG PORTION OF THE STRIP. Place the labeled end of the strip into the slot of the holder (or "jaws" of the clothes pin) leaving the blood soaked end exposed to air dry.
5. Attach the completely dry filter paper strips to a 5x7 card in sequential order, from left to right by stapling the labeled end towards the top edge of the card, and leaving the blood soaked end free so that the laboratory staff can readily remove a standard punch sample. Write the County, Agency Code, Site, and Date Bled onto the card and place it into a zip lock plastic bag. Do not put more than one sample card per bag. It is important that blooded ends do not become dirty, wet, or touch each other. VERY IMPORTANT: CHICKEN SERA MUST BE ACCOMPANIED BY SENTINEL CHICKEN BLOOD

FORM (MBVS- 2) OUTSIDE THE ZIP-LOCK BAG. Do not staple the form to the bag. Samples from each bleeding date then can be placed into a mailing envelope and sent to:

Department of Public Health, Richmond Campus
Specimen Receiving Unit Room B106 **(ATTN: ARBO)**
850 Marina Bay Parkway
Richmond, CA 94804

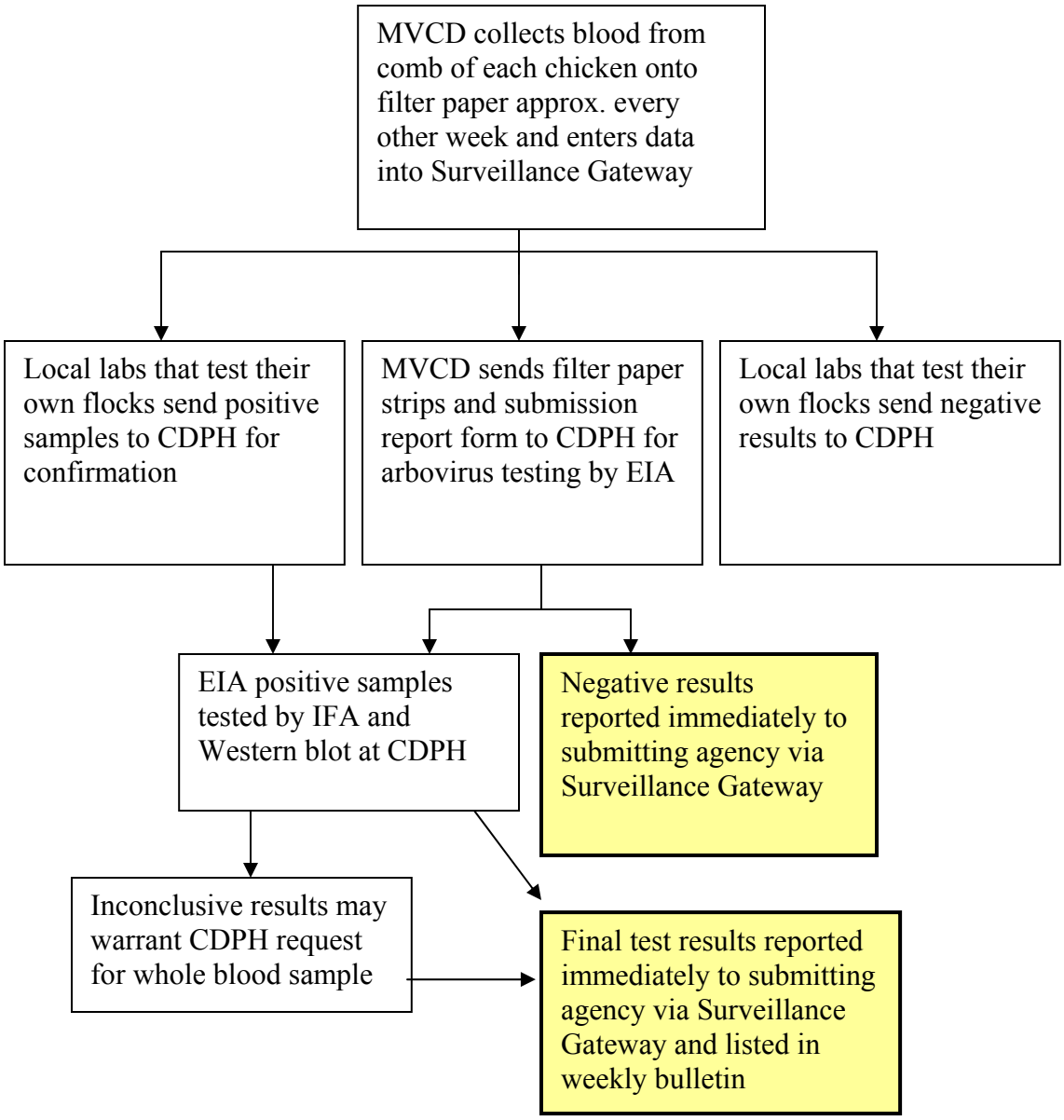
Specimens will be tested within 1-3 days upon receipt by the laboratory.

6. In the laboratory, a single punch is removed from the blooded end of the paper and placed into one well of a 96-well plate with 150 µl of diluent. Specimens are allowed to soak for 2 hours on a rotator and the eluate is tested for WEE, SLE, and WNV IgG antibody using ELISA. Positive specimens are tested further with an indirect fluorescent antibody test and confirmed with a Western blot. Inconclusive SLE or WNV positives are confirmed and identified by cross-neutralization tests. Test results are made available online at: http://gateway.calsurv.org/.

Reference

Reisen, W.K. 1995. Guidelines for Surveillance and Control of Arboviral Encephalitis in California, In: Interagency Guidelines for the Surveillance and Control of Selected Vector-borne Pathogens in California, Mosquito and Vector Control Association of California, Sacramento.

California Procedure for Testing Sentinel Chickens for the Presence of Antibodies to Flaviviruses (SLE and WNV) and WEE



Key:

EIA:	Enzyme immunoassay test
IFA:	Indirect fluorescent antibody test
MVCD:	Local Mosquito and Vector Control District/Health Dept.
SLE:	St. Louis encephalitis
CDPH:	CDPH Vector-Borne Disease Section, Richmond
WEE:	Western equine encephalitis
WNV:	West Nile virus encephalitis

Surveillance for Mosquito-borne Viruses
Registration of Agencies and Sites

1. Participation of agencies

Agencies interested in participating in the statewide surveillance program for mosquito-borne viruses should place orders for mosquito pool testing by UC Davis Center for Vectorborne Diseases (CVEC) through the Mosquito and Vector Control Association (MVCAC). Sentinel chicken testing should be ordered through the California Department of Public Health (CDPH). Agencies will be billed in advance for the number of samples to be tested.

Agencies are responsible for registering and maintaining updated information for their sites online at: http://gateway.calsurv.org/.

2. Registration of sentinel flock sites and wing band numbers

Agencies must use the unique band numbers assigned to their district by CDPH each year. Prior to submitting any sentinel chicken blood samples to CDPH, each agency must ensure that each flock site and accompanying band numbers are registered online at: http://gateway.calsurv.org/. CDPH will only test samples if they are accompanied by the form "SENTINEL CHICKEN BLOOD – 2012" (MBVS-2) for each flock site, which includes the registered agency code, the registered site code (assigned by local agency), the wing band numbers assigned to that site, and date bled. **Also, the form should indicate any changes made and match the sample card exactly.**

3. Registration of mosquito sampling sites

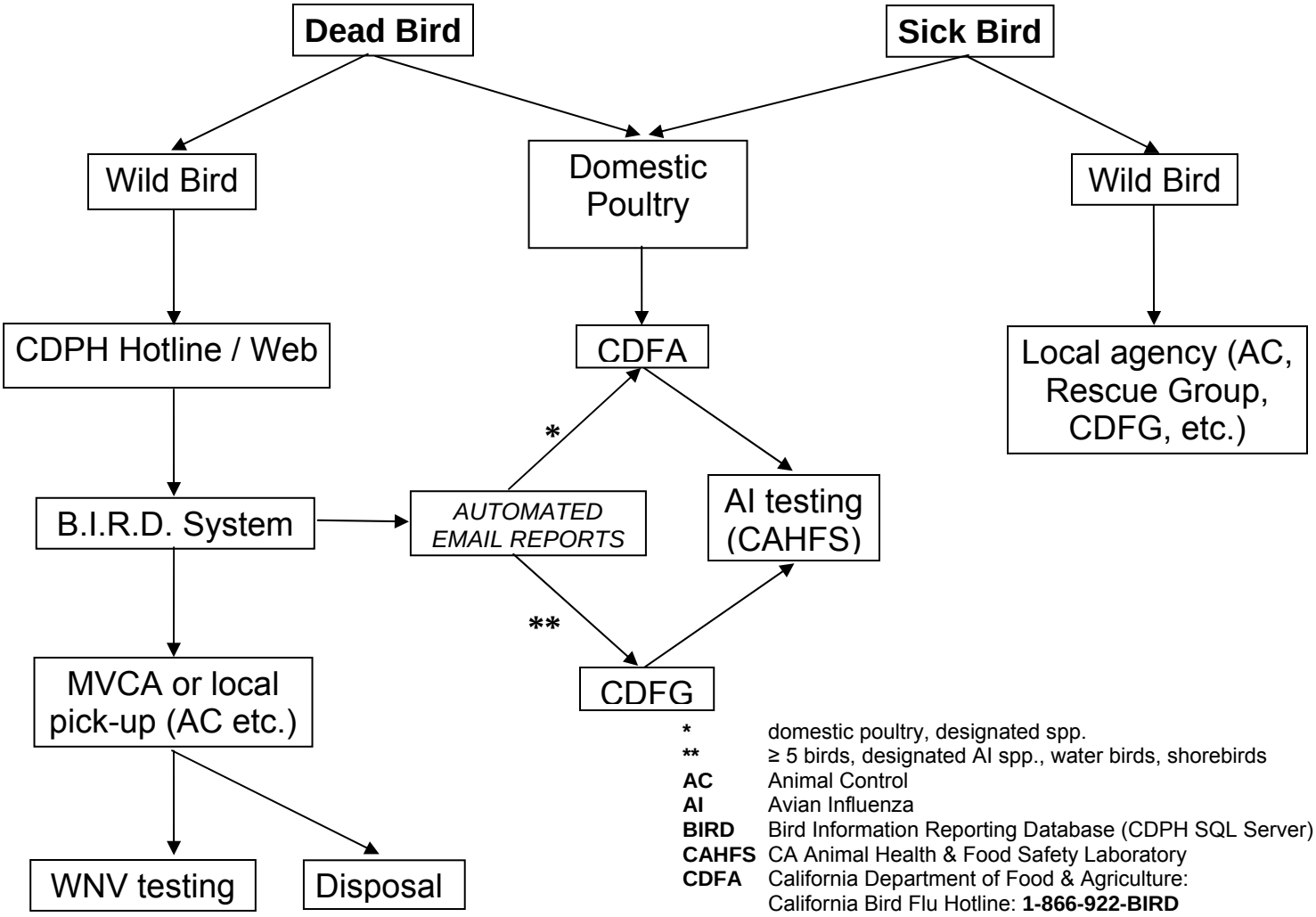
Registration of new sites used for collection of mosquitoes for virus testing may be accomplished by accessing the California Vectorborne Disease Surveillance Gateway http://gateway.calsurv.org/. Since 2010, the CalSurv Gateway has included enhanced spatial capabilities that allow users the option of directly entering geographic coordinates for sites or interactively selecting the location using a new Google Maps-based interface. The laboratory will test the pools provided that adequate information is provided on the "MOSQUITO POOL SUBMISSION" form (MBVS-3, revised 01/12/06), including your agency code, your site code for the site and geographic coordinates.

The geographic coordinates will be used to generate computer maps that show all registered sites and test results for each site. Also, as part of a collaborative effort, CVEC will host real-time maps in ArcGIS format at http://maps.calsurv.org. In addition to these maps, agencies can access maps using Google Earth through the California Vectorborne Disease Surveillance Gateway (http://gateway.calsurv.org) that provide enhanced functionality and detail.

Appendix D: Procedures for Testing Dead Birds and Squirrels

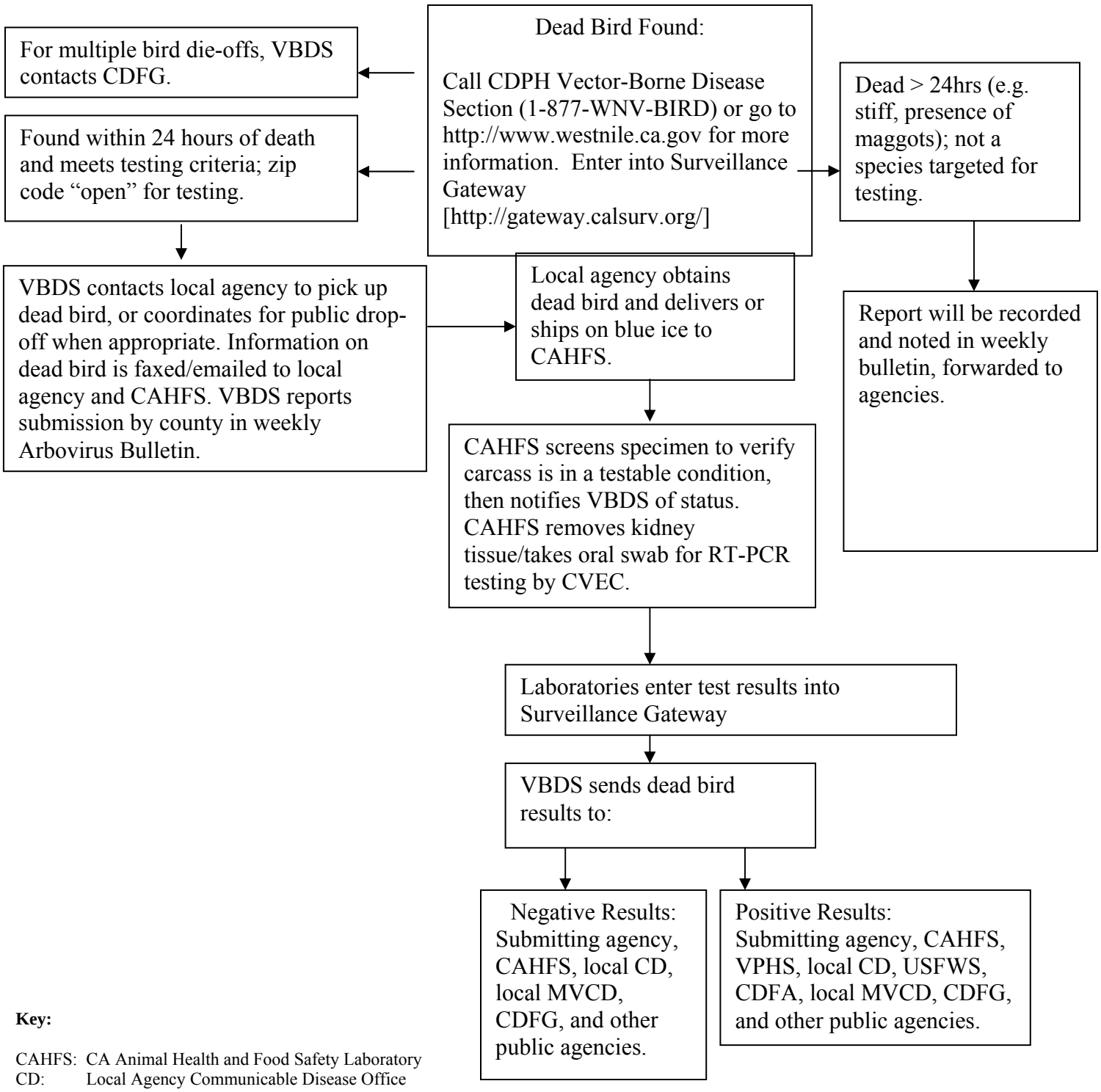
In 2000, CDHS initiated a dead bird surveillance program in collaboration with other public agencies. CDPH annually notifies about 600 agencies, organizations, and veterinarians involved with wildlife, including rehabilitation centers, about the program. The public is also notified about the program through the media and outreach materials. Dead birds and squirrels are reported to CDPH or data entered electronically through the Surveillance Gateway [http://gateway.calsurv.org/] and shipped to the California Animal Health & Food Safety (CAHFS) laboratory at UC Davis for screening and removal of kidney tissue (an oral swab is taken instead if the bird is an American Crow), which is then sent to the UC Davis Center for Vectorborne Diseases (CVEC) for WNV RNA detection via RT-PCR. Beginning in 2010, results from RT-PCR testing at CVEC distinguished between WNV recent and chronic positive birds based on cycle threshold (Ct) values. Chronic positive birds did not likely die from WNV infection and are of limited value for surveillance. Overviews of the dead bird reporting and testing algorithms are provided below.

Sick / Dead Bird Reporting Protocol for Public and Local Agencies



*	domestic poultry, designated spp.
**	≥ 5 birds, designated AI spp., water birds, shorebirds
AC	Animal Control
AI	Avian Influenza
BIRD	Bird Information Reporting Database (CDPH SQL Server)
CAHFS	CA Animal Health & Food Safety Laboratory
CDFA	California Department of Food & Agriculture: California Bird Flu Hotline: **1-866-922-BIRD**
CDFG	California Department of Fish & Game http://www.dfg.ca.gov/regions/index.html
CDPH	California Department of Public Health West Nile virus & Dead Bird hotline: **1-877-968-BIRD** website: www.westnile.ca.gov
MVCA	Mosquito & Vector Control Agency

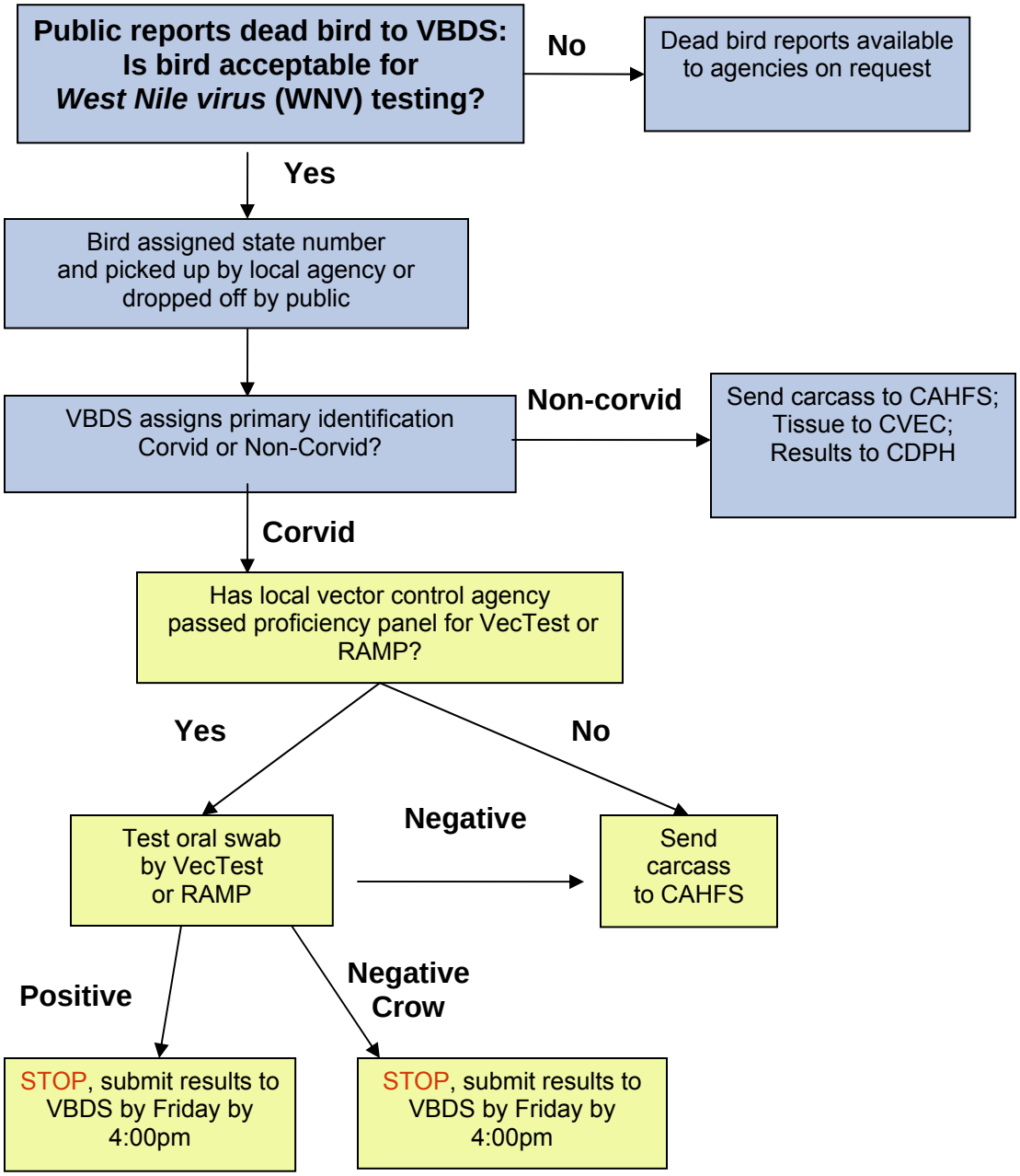
Procedures for Testing Dead Birds: RT-PCR



Key:

CAHFS: CA Animal Health and Food Safety Laboratory
CD: Local Agency Communicable Disease Office
CDFA: CA Dept. of Food and Agriculture
CDFG: CA Dept. of Fish and GameCVEC: UC Davis Center for Vectorborne Diseases
MVCD: Local Mosquito and Vector Control District
USFWS: US Fish and Wildlife Service
VBDS: CDHS Vector-Borne Disease Section, Richmond
VPHS: CDHS Veterinary Public Health Section, Sacramento
IHC: Immunohistochemistry

Procedures for Testing Dead Birds: Rapid Assays



CVEC = Center for Vectorborne Disease Research
VBDS = Vector-Borne Disease Section, California Department of Public Health
CAHFS = California Animal Health and Food Safety Laboratory

VBDS

Local Agencies

Dead Bird and Tree Squirrel Reporting and Submission Instructions for Local Agencies
California West Nile Virus (WNV) Dead Bird & Tree Squirrel Surveillance Program
California Department of Public Health (CDPH)
Division of Communicable Disease Control

When your agency receives a call from the public about a dead bird (especially recently dead crows, ravens, magpies, jays, or raptors) or dead tree squirrel, or one of your staff finds any dead bird, please immediately refer them to the **CDPH West Nile Virus and Dead Bird Hotline at 1-877-968-BIRD (2473)**.

The Dead Bird Hotline is monitored **8am - 5pm, 7 days a week.** CDPH will assess the suitability of the dead bird or tree squirrel for testing and contact your agency only if the carcass is approved for pickup. Any carcasses sent without prior notification will not be tested.

Only agencies listed under the permit issued to CDPH from the California Department of Fish & Game are authorized to pick up dead birds and tree squirrels. The agencies covered include local mosquito abatement districts, environmental health departments, and other designated agencies.

Members of the public may salvage dead birds found on their property or place of residence. **The public must first call the Dead Bird Hotline and obtain a Dead Bird Number**; a corresponding public salvage submission form will then be faxed to the appropriate agency. The public will be instructed by the hotline staff to double-bag the carcasses and drop them off at the designated agency within 24 hours, between 9 am - 3 pm, Monday – Friday, and **only in areas where local agencies are not picking up dead birds** (e.g., closed zip codes), unless otherwise requested by the local agency. **Note: only dead birds may be brought in by the public to local agencies for shipping. We discourage public salvage of all squirrels because ground squirrels, which could be infected with plague, may be misidentified as tree squirrels.**

***web links*:** bird and tree squirrel ID chart (pdf) tree squirrel surveillance Q&A (pdf)

Once the submission is approved, your agency can ship the carcass to the California Animal Health & Food Safety laboratory at UC Davis (CAHFS Central). CAHFS Central removes specific tissues and forwards the samples to the UC Davis Center for Vectorborne Diseases (CVEC) for WNV testing. Shipping and testing expenses will be paid by CDPH. Carcasses are considered **Category B, Biological Substances.** This replaces the old designation, "Diagnostic Specimen".

To ensure the carcass arrives at CAHFS in a testable condition, to protect your safety, and to comply with shipping regulations, please follow these instructions:

- Only dead birds and tree squirrels can be picked up under our permit.

- Wear rubber or latex gloves when handling all carcasses. If gloves are not available, use a plastic bag -- turned inside out -- over your hand and invert the bag to surround the carcass. Do not touch a carcass with bare hands.

- **Collect fresh carcasses.** Badly decomposed or scavenged carcasses are of limited diagnostic value. Signs that a bird or squirrel has been dead for too long (over 24-48 hours) are the presence of maggots, an extremely lightweight carcass, missing eyes, skin discoloration, skin or feathers that rub off easily, strong odor, or a soft, mushy carcass.

- **If upon pick-up the carcass is found to be unacceptable (e.g. a species your agency or CDPH is not accepting or a badly decomposed specimen), please collect the carcass, double-bag it, and dispose of it in a secure garbage can or dumpster.** California Department of Fish & Game prefers that you burn or bury the carcass, but disposing of it in a dumpster is also acceptable. **Please call CDPH immediately and notify us that the animal will no longer be submitted.**

- Place each carcass into two sealed (zip-locked) plastic bags. **Double-bagging prevents cross-contamination and leakage**. **There should always be two bags separating the carcass from shipping documents.**

- Enclose the shipping documents into a SEPARATE ZIP-LOCK BAG. The primary shipping document is a copy of the dead bird submission form which contains the dead bird number and which is located on the Surveillance Gateway [http://gateway.calsurv.org/] or faxed by CDPH. CAHFS prefers that you put this separate zip-lock bag inside the outer bag containing the dead bird or squirrel.

- **Pack the carcass with blue ice packs.** Please limit the number of ice packs to the number required to keep the carcass fresh, as the weight of extra ice packs add to the shipping charges. In accordance to shipping regulations, an absorbent material such as newspaper must be included in the box to prevent any leakage.

- Ship the carcass in a hard-sided plastic cooler or a styrofoam cooler placed in a cardboard box. Unprotected styrofoam containers cannot be shipped without an outer box or container, as they may break into pieces during shipment. **Contact UPS/GSO directly to arrange for carrier pickup Monday through Thursday; this guarantees arrival at CAHFS before the weekend.**

- Contact **UPS** to pick up carcasses either by web (https://wwwapps.ups.com/pickup/schedule?loc=en_US) or by phone **1-800-PICK UPS** (1-800-742-5877)**. Select "UPS Next Day Air"** and **estimate the weight of the box** (generally 10 lbs for a single large bird packed with ice). Please DO NOT UNDER-ESTIMATE the weight of a package. For billing, the **UPS account number is: 23219W.**

- Carcasses that need to be stored for an extended time period (over 2 days) should be put on dry ice or stored at -70ºC. If it is not possible to store carcass at -70ºC, a carcass may be stored at 0ºC (regular freezer) for a short period of time. **Refrigerating** the carcass is recommended for **overnight storage only** (this slows virus deterioration, but does not stop it).

- CDPH will provide prepared shipping boxes with appropriate labels. Any empty boxes shipped to your agency from CDPH will have its caution labels covered by a sheet of paper with "EMPTY BOX" printed on it. Please discard this sheet of paper before using the box to ship out a dead bird. If you need additional boxes, please contact VBDS at (510) 412-6251 or email arbovirus@cdph.ca.gov.

- Once West Nile virus is found in an area, agencies may test corvids via VecTest or RAMP assays. While results can be entered directly into the Surveillance Gateway, please **notify CDPH with results by 4:00pm Friday of each week to have results included in reports for the following week's State WNV updates.** Reporting forms can be found at (http://www.westnile.ca.gov/resources.php). **Note: any positive bird must be disposed of as biomedical waste (incineration).**

Dead Bird Shipping List

Please verify that your agency has the following items:

- CAHFS Address (see below)
- UPS preprinted labels
- WNV hotline number (877-968-BIRD; manned 8am - 5pm, 7 days a week)
- Crumpled newspapers or another absorbent material
- Rubber or Latex Gloves
- Packing tape
- Dead Bird Shipping Boxes
  - inner zip-lock bag
  - outer zip-lock bag
  - inner styrofoam box
  - outer cardboard box
  - blue ice packs

California Animal Health & Food Safety (CAHFS) laboratories:

CAHFS Central (530) 754-7372
ATTN: WNV
Jacquelyn Parker
University of California, Davis
West Health Science Drive
Davis, CA 95616

Appendix E: Procedures for Testing Equines and Ratites

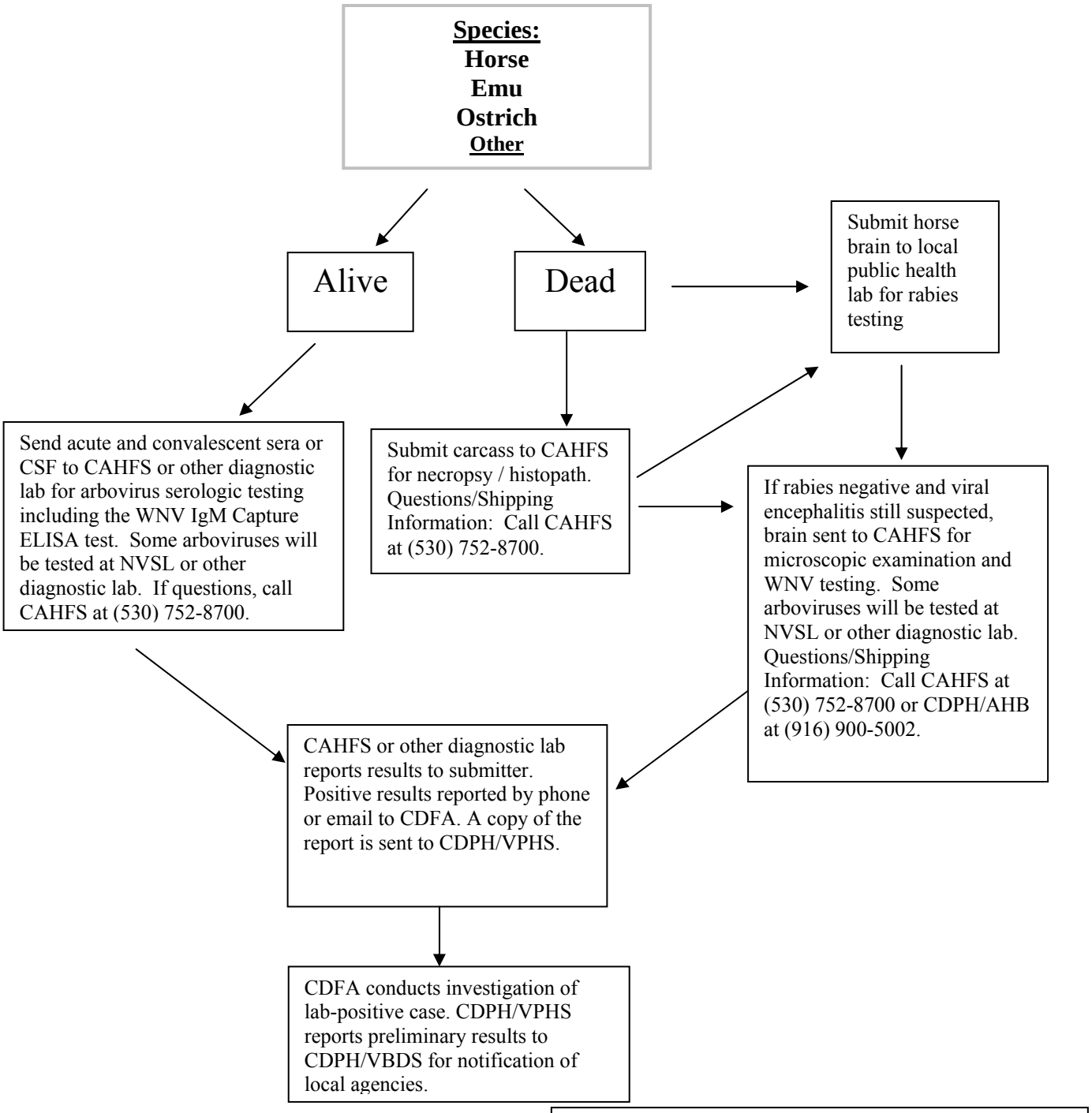
The California Departments of Public Health (CDPH) and Food and Agriculture (CDFA) developed a cooperative passive surveillance program for equine and ratite encephalomyelitis. Primary responsibility for equine and ratite West Nile virus (WNV) surveillance rests with CDFA. Equine encephalomyelitides are legally reportable to CDFA by veterinarians and diagnostic laboratories pursuant to Section 9101 of the Food and Agricultural Code. Venezuelan equine encephalomyelitis is an emergency animal disease that must be reported to CDFA by telephone within 24 hours.

This appendix contains information sent to veterinarians, public health lab directors, local health officers, public health veterinarians, animal health branch personnel, and interested parties every spring to inform them about the California Equine and Ratite Arbovirus Surveillance Program. The mailing includes a case definition for equine encephalomyelitides and instructions for specimen collection and submission for both equine and ratite samples. The information is distributed to approximately 1,200 practitioners, equine organizations, and other interested parties. Specimen submission is coordinated through the California Animal Health and Food Safety Laboratory System's (CAHFS) and other laboratories or individual veterinarians. Equine serum and cerebrospinal fluid are tested by CAHFS using the ELISA test to detect anti-WNV IgM. Equine neurologic tissue specimens are also sent to CAHFS for microscopic examination and, as indicated by clinical findings, forwarded to the USDA National Veterinary Services Laboratories (NVSL) for further arbovirus testing. All fatal cases of equine encephalitides are first evaluated for rabies at the local public health laboratory. An algorithm outlining the protocol for specimen submission and reporting is available for participants in the program and is included in this appendix.

Outreach is an important component of the program. CDPH and CDFA have developed and distributed educational materials concerning the diagnosis and reporting of arboviruses in equines and ratites.

Additional information on WNV for veterinarians, horse owners, and ratite owners, is available from CDFA, Animal Health Branch (916) 900-5002, and at the CDFA website: http://www.cdfa.ca.gov/AHFSS/Animal_Health/WNV_Info.html. Information on submission of laboratory samples is available from CAHFS (530) 752-8700 and at CAHFS website: http://cahfs.ucdavis.edu. A brochure containing facts about California WNV surveillance and general information about prevention and control is available from CDPH (916) 552-9730 and at CDPH's website: http://www.westnile.ca.gov; a special section for veterinarians and horse owners is available at: http://www.westnile.ca.gov/resources.php.

Algorithm for Submission of Specimens from Domestic Animals with Neurologic Symptoms



Key:
AHB: Animal Health Branch
CAHFS: California Animal Health and Food Safety Laboratory
NVSL: National Veterinary Services Laboratory
VBDS: CDPH Vector-Borne Disease Section
VPHS: CDPH Veterinary Public Health Section
CDFA: California Department of Food and Agriculture
CDPH: California Department of Public Health

SURVEILLANCE CASE DEFINITIONS FOR WEST NILE VIRUS DISEASE IN EQUINES

NOTE: A HORSE WITH SIGNS OF ENCEPHALITIS MAY HAVE RABIES – TAKE PROPER PRECAUTIONS

CONFIRMED CLINICAL CASE:

A horse with compatible clinical signs including ataxia (stumbling, staggering, wobbly gait, or in-coordination) or at least two of the following: fever, circling, hind limb weakness, inability to stand, multiple limb paralysis, muscle fasciculation, proprioceptive deficits, blindness, lip droop/paralysis, teeth grinding, acute death.

Plus one or more of the following:

- Isolation of West Nile (WNV) virus from tissues[1]
- Detection of IgM antibody to WNV by IgM-capture ELISA in serum or CSF
- An associated 4-fold or greater change in plaque-reduction neutralization test (PRNT) antibody titer to WNV in appropriately timed[2], paired sera
- Positive polymerase chain reaction (PCR)[3] for WNV genomic sequences in tissues[1]
- Positive IHC for WNV antigen in tissue (Note: this test has low sensitivity in equids)

SUSPECT CLINICAL CASE[4]:

- Compatible clinical signs

EXPOSED EQUID:

- Detection of IgM antibody to WNV by IgM-capture ELISA in serum or CSF without any observable or noted clinical signs.

Assumptions on which case definition is based:

- Antibody in serum may be due to vaccination or a natural exposure; additional testing must be done to confirm WNV infection in a vaccinated horse.
- IgM antibody in equine serum is relatively short-lived; a positive IgM-capture ELISA means exposure to WNV or rarely a closely related flavivirus (SLE) has occurred, very likely within the last three months.

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[1] Preferred diagnostic tissue are equine brain or spinal cord; although tissues may include blood or CSF, the only known reports of WNV isolation or positive PCR from equine blood or CSF have been related to experimentally infected animals.

[2] The first serum should be drawn as soon as possible after onset of clinical signs and the second drawn at least seven days after the first.

[3] For horses it is recommended that RT-nested polymerase chain reaction assay be used to maximize sensitivity of the test (Emerg. Infect. Dis. 2001 Jul-Aug; 7(4):739-41)

[4] An equine case classified as a suspect case should, if possible, undergo further diagnostic testing to confirm or rule out WNV as the cause of the clinical illness.

Protocol for Submission of Laboratory Specimens for Equine Neurological Disease Diagnosis and Surveillance

Complete information on specimen collection and submission is available on the CDFA website at: http://www.cdfa.ca.gov/ahfss/Animal_Health/WNV_Lab_Submission.html

1. Specimen collection and submission:

A. Blood

- Acute sample (5-10 ml) / no later than 7 days after onset
- Convalescent sample (5-10 ml) / 14-21 days after onset
  Red top tubes of whole blood or serum (no preservatives or anticoagulants) should be submitted at ambient temperature to the California Animal Health and Food Safety (CAHFS) Laboratory* in your area. Do not freeze whole blood.
- **NOTE**: For WNV, an acute sample only is required since the assay used detects IgM (and vaccine does not interfere). For the other encephalitis viruses, the acute sample should be submitted immediately, and a convalescent sample may be requested later to assist with the interpretation and differentiation of vaccine titers from active infection.

B. Brain

- The local health department and CDFA/Animal Health District Office should be contacted if rabies is suspected.
- **The animal or intact head should be submitted to a CAHFS laboratory in your area as quickly as possible.** The intact head should be refrigerated, *not* frozen, immediately after removal using a leak-proof insulated transporting container with "cold packs" to keep the specimen at 4^{o} C while in transit. *When it is impossible for the CAHFS Laboratory to receive the carcass or chilled intact head within 48 hours, the submission protocol should be coordinated with the CAHFS Laboratory.* Submission of the head intact is preferable to removal of the brain because: 1) the brain is better preserved (anatomically and virus titer) when left in the skull during transport, 2) specimens may be compromised if removal is not performed correctly, and 3) brain removal in field conditions may increase the risk of exposure to rabies.
- All equine specimens submitted first to the CAHFS Laboratory will be forwarded to: 1) a Public Health Laboratory to initially confirm or rule out rabies, then to 2) The National Veterinary Services Laboratories (NVSL) for arboviral testing, in addition to a complete diagnostic work-up at the CAHFS.
- All equine specimens submitted first to local public health laboratories for rabies testing and found to be negative should be forwarded to the local CAHFS Laboratory for arboviral testing.

C. Other specimens for differential neurological diagnoses

- Protocol for submission of these specimens may be coordinated through the CAHFS Laboratory, and may include sampling for equine herpes virus, EPM, or other agents associated with clinical neurological presentations.

2. Submission forms: Complete and include the transmittal forms supplied by the CAHFS Laboratory. See attached sample or download the form from their website: http://cahfs.ucdavis.edu/. The submittal form for each specimen should be placed in a leak-proof plastic bag and attached to the corresponding container.

3. Imperative information to include on the submission forms if West Nile virus is suspected: Precision case reporting by the veterinary practitioner is critical to mosquito control efforts that prevent WNV infection in both horses and humans. It is very important that each laboratory submission form is completed in its entirety. More specifically, it is imperative to include and communicate to us:

- The location(s) of the horse during the two weeks prior to the onset of clinical disease. (Please ensure that this information is included in addition to the "owner's address")
- Detailed clinical signs.
- The present condition of the horse (including dead and euthanized).
- An accurate vaccination history.

4. Shipment: For information on sample shipping including regulations governing the transportation of infectious materials contact CAHFS at 530-752-7578.

Appendix F: Protocol for Submission of Laboratory Specimens for Human West Nile Virus Testing

West Nile virus (WNV) testing within the regional public health laboratory network (i.e., the California Department of Public Health Viral and Rickettsial Disease Laboratory and participating local public health laboratories) is recommended for individuals with the following symptoms, particularly during West Nile virus "season," which typically occurs from July through October in California:

A. Encephalitis
B. Aseptic meningitis (Note: Consider enterovirus for individuals ≤ 18 years of age)
C. Acute flaccid paralysis; atypical Guillain-Barré Syndrome; transverse myelitis; or
D. Febrile illness*
   - Illness compatible with West Nile fever and lasting ≥ 7 days
   - Must be seen by a health care provider

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* The West Nile fever syndrome can be variable and often includes headache and fever (T ≥ 38°C). Other symptoms include rash, swollen lymph nodes, eye pain, nausea, or vomiting. After initial symptoms, the patient may experience several days of fatigue and lethargy.

Required specimens:

- Acute serum: ≥ 2cc serum

If a lumbar puncture is performed and residual CSF is available:

- Cerebral spinal fluid (CSF): 1-2cc CSF for further testing at CDC (N.B. these results may not be available for several weeks)

If West Nile virus is highly suspected and acute serum is negative or inconclusive, request:

- 2^{nd} serum: ≥ 2cc serum collected 3-5 days after acute serum

Contact your local health department for instructions on where to send specimens.

Appendix G: Surveillance Case Definition for West Nile Virus Infection in Humans

West Nile virus infection is reportable to local health departments under Title 17 of the California Code of Regulations. Below is the case definition for West Nile virus disease as summarized by the Centers for Disease Control and Prevention (CDC) [available at http://www.cdc.gov/ncidod/dvbid/westnile/clinicians/surveillance.htm#casedef]. Blood donors that test positive for West Nile virus through blood bank screening should also be reported to CDPH, regardless of clinical presentation.

CASE DEFINITION: West Nile Virus

NOTE: This definition is for public health surveillance purposes only. It is not intended for use in clinical diagnosis.

Clinical Description

Arboviral infections may be asymptomatic or may result in illnesses of variable severity sometimes associated with central nervous system (CNS) involvement. When the CNS is affected, clinical syndromes ranging from febrile headache to aseptic meningitis to encephalitis may occur, and these are usually indistinguishable from similar syndromes caused by other viruses. Arboviral meningitis is characterized by fever, headache, stiff neck, and pleocytosis. Arboviral encephalitis is characterized by fever, headache, and altered mental status ranging from confusion to coma with or without additional signs of brain dysfunction (e.g., paresis or paralysis, cranial nerve palsies, sensory deficits, abnormal reflexes, generalized convulsions, and abnormal movements).

Laboratory Criteria for Diagnosis

- Fourfold or greater change in virus-specific serum antibody titer, or
- Isolation of virus from or demonstration of specific viral antigen or genomic sequences in tissue, blood, cerebrospinal fluid (CSF), or other body fluid, or
- Virus-specific immunoglobulin M (IgM) antibodies demonstrated in CSF by antibody-capture enzyme immunoassay (EIA), or
- Virus-specific IgM antibodies demonstrated in serum by antibody-capture EIA and confirmed by demonstration of virus-specific serum immunoglobulin G (IgG) antibodies in the same or a later specimen by another serologic assay (e.g., neutralization or hemagglutination inhibition).

Case Classification

- *Probable:* An encephalitis or meningitis case occurring during a period when arboviral transmission is likely and with the following supportive serology: 1) a single or stable (less than or equal to twofold change) but elevated titer of virus-specific serum antibodies; or 2) serum IgM antibodies detected by antibody-capture EIA but with no available results of a confirmatory test for virus-specific serum IgG antibodies in the same or a later specimen.
- *Confirmed:* An encephalitis or meningitis case that is laboratory confirmed.

Comment

- Because closely related arboviruses exhibit serologic cross-reactivity, positive results of serologic tests using antigens from a single arbovirus can be misleading. In some circumstances (e.g., in areas where two or more closely related arboviruses occur, or in imported arboviral disease cases), it may be epidemiologically important to attempt to pinpoint the infecting virus by conducting cross-neutralization tests using an appropriate battery of closely related viruses. This is essential, for example, in determining that antibodies detected against St. Louis encephalitis virus are not the result of an infection with West Nile (or dengue) virus, or vice versa, in areas where both of these viruses occur.
- The seasonality of arboviral transmission is variable and depends on the geographic location of exposure, the specific cycles of viral transmission, and local climatic conditions.

Asymptomatic West Nile Virus Infection: Asymptomatic infection with WNV, which is generally identified in blood donors, is also reportable. WNV-positive blood donors detected by blood banks are reported directly to local health departments. Blood donors who test positive for WNV may not necessarily be ill, nor will they initially have positive IgM or IgG antibody test results. Local health departments should report blood donors who meet the following criteria for being a presumptively viremic donor to CDPH:

A presumptively viremic donor (PVD) is a person with a blood donation that meets at least one of the following criteria:

a) One reactive nucleic acid-amplification (NAT) test with signal-to-cutoff (S/CO) $\geq$ 17
b) Two reactive NATs

Additional serological testing is not required. Local health departments should follow up with the donor after two weeks of the date of donation to assess if the patient subsequently became ill. If the donor did become ill as a result of WNV infection, an updated case report form should be sent to CDPH so that the blood donor may be reclassified as a clinical case.

Note: Due to the continued risk of unintentional or intentional introduction of exotic arboviruses into the United States (e.g., Venezuelan equine encephalitis virus), or the reemergence of indigenous epidemic arboviruses (e.g., St. Louis encephalitis and western equine encephalitis viruses), physicians and local public health officials should maintain a high index of clinical suspicion for cases of potential exotic or unusual arboviral etiology, and consider early consultation with arboviral disease experts at state health departments and CDC.

Appendix H: Compounds Approved for Mosquito Control in California

Label rates and usage vary from year to year and geographically; consult your County Agricultural Commissioner and the California Department of Fish and Game before application. Examples of products containing specific active ingredients are provided below, but this is not an inclusive list nor constitutes product endorsement. For more information on pesticides and mosquito control, please refer to the Environmental Protection Agency (EPA) Web site:
http://www.epa.gov/opp00001/factsheets/westnile.htm

Larvicides:

1. *Bacillus thuringiensis* subspecies *israelensis* (Bti: e.g. Aquabac 200G, VectoBac® 12AS, Teknar HP-D)
   Use: Approved for most permanent and temporary bodies of water.
   Limitations: Only works on actively feeding stages. Does not persist well in the water column.

2. *Bacillus sphaericus* (Bs: e.g. VectoLex® CG)
   Use: Approved for most permanent and temporary bodies of water.
   Limitations: Only works on actively feeding stages. Does not work well on all species. May persist and have residual activity in some sites.

3. Spinosad (e.g. Natular™ G30)
   Limitations: Effective against all larval stages and moderately effective against pupal stage. Toxic via ingestion and contact. Some formulations approved for use in OMRI certified organic crops.

4. IGRs (Insect Growth Regulators)
   a. (S)-Methoprene (e.g. Altosid® Pellets)
   Use: Approved for most permanent and temporary bodies of water.
   Limitations: Works best on older instars. Some populations of mosquitoes may show some resistance.
   b. Diflurobenzamide (e.g. Dimilin®25W)
   Use: Impounded tail water, sewage effluent, urban drains and catch basins.
   Limitations: Cannot be applied to wetlands, crops, or near estuaries.

5. Larviciding oils (e.g.Bonide)
   Use: Ditches, dairy lagoons, floodwater. Effective against all stages, including pupae.
   Limitations: Consult with the California Department of Fish and Game for local restrictions.

6. Monomolecular films (e.g. Agnique® MMF)
   Use: Most standing water including certain crops.
   Limitations: Does not work well in areas with unidirectional winds in excess of ten mph.

7. Temephos (e.g. Abate® 2-BG)
   Use: Non-potable water; marshes; polluted water sites

Limitations: Cannot be applied to crops for food, forage, or pasture. This material is an organophosphate compound and may not be effective on some *Culex tarsalis* populations in the Central Valley. May require sampling and testing per General Vector Control NPDES permit requirements if applied to waters of the United States.

Adulticides:

1. Organophosphate compounds
   Note: Many *Culex tarsalis* populations in the Central Valley are resistant at label OP application rates.
   a. Malathion (e.g. Fyfanon® ULV)
      Use: May be applied by air or ground equipment over urban areas, some crops including rice, wetlands.
      Limitations: Paint damage to cars; toxic to fish, wildlife and bees; crop residue limitations restrict application before harvest.
   b. Naled (e.g. Dibrom® Concentrate, Trumpet® EC)
      Use: Air or ground application on fodder crops, swamps, floodwater, residential areas.
      Limitations: Similar to malathion.

2. Pyrethrins (natural pyrethrin products: e.g. Pyrenone® Crop Spray, Pyrenone® 25-5, Evergreen)
   Use: Wetlands, floodwater, residential areas, some crops.
   Limitations: Do not apply to drinking water, milking areas; may be toxic to bees, fish, and some wildlife. Some formulations with synergists have greater limitations.

3. Pyrethroids (synthetic pyrethrin products containing deltamethrin, cyfluthrin, permethrin, resmethrin, sumithrin or etofenprox: e.g. Suspend® SC, Tempo Ultra SC, Aqua-Reslin®, Scourge® Insecticide, Anvil® 10+10 ULV, Zenivex E20, and Duet – which also contains the mosquito exciter prallethrin)
   Use: All non-crop areas including wetlands and floodwater.
   Limitations: May be toxic to bees, fish, and some wildlife; avoid treating food crops, drinking water or milk production.

PESTICIDES USED FOR MOSQUITO CONTROL IN CALIFORNIA

Larvicides

Active Ingredient	Trade name	EPA Reg. No.	Mfgr.	Formulation	Application	Pesticide classification
Bacillus sphaericus, (Bs)	VectoLex CG / WSP	73049-20	Valent BioSciences	Granule Water soluble packet	Larvae	Biorational
Bacillus sphaericus, (Bs)	VectoLex WDG	73049-57	Valent BioSciences	Water dispersible granule	Larvae	Biorational
Bacillus thuringiensis var. *israelensis* (Bti)	VectoBac WDG	73049-56	Valent BioSciences	Water dispersible Granules	Larvae	Biorational
Bacillus thuringiensis var. *israelensis* (Bti)	VectoBac 12AS	73049-38	Valent BioSciences	Liquid	Larvae	Biorational
Bacillus thuringiensis var. *israelensis* (Bti)	VectoBac AS	275-52	Abbott Labs	Liquid	Larvae	Biorational
Bacillus thuringiensis var. *israelensis* (Bti)	VectoBac G	73049-10	Valent BioSciences	Granule Flake	Larvae	Biorational
Bacillus thuringiensis var. *israelensis* (Bti)	VectoBac GS	73049-10	Valent BioSciences	Granule Flake	Larvae	Biorational
Bacillus thuringiensis var. *israelensis* (Bti)	VectoBac Tech. Pdr.	73049-13	Valent BioSciences	Technical powder	Larvae	Biorational
Bacillus thuringiensis var. *israelensis* (Bti)	Aquabac 200G	62637-3	Becker Microbial	Granule	Larvae	Biorational
Bacillus thuringiensis var. *israelensis* (Bti)	Consume MP	62637-3	Spartan Chemical	Granule	Larvae	Biorational
Bacillus thuringiensis var. *israelensis* (Bti)	Aquabac XT	62637-1	Becker Microbial	Liquid	Larvae	Biorational
Bacillus thuringiensis var. *israelensis* (Bti)	Bactimos PT	73049-452	Valent BioSciences	Granular flake	Larvae	Biorational
Bacillus thuringiensis var. *israelensis* (Bti)	Teknar HP-D	73049-404	Valent BioSciences	Liquid	Larvae	Biorational
Bacillus thuringiensis var. *israelensis* (Bti)	Fourstar SBG	85685-1	Fourstar Microbials LLC	Granule	Larvae	Biorational
Bti / Bs combination	Vectomax G, CG, WSP	73049-429	Valent BioSciences	Granular and water soluble packet	Larvae	Biorational
Bti / Bs combination	Fourstar Briquettes	83362-3	Fourstar Microbials LLC	Briquette	Larvae	Biorational
Spinosad	Natular 2EC	8329-82	Clarke	Liquid concentrate	Larvae and pupae	Biorational
Spinosad	Natular G	8329-80	Clarke	Granule	Larvae and pupae	Biorational
Spinosad	Natural G30	8329-83	Clarke	Granule	Larvae and pupae	Biorational
Spinosad	Natular T30	8329-85	Clarke	Tablet	Larvae and pupae	Biorational
Spinosad	Natular XRT	8329-84	Clarke	Tablet	Larvae and pupae	Biorational
Monomolecular film	Agnique MMF	53263-28	Cognis Corp.	Liquid	Larvae and pupae	Surface film
Monomolecular film	Agnique MMF G	53263-30	Cognis Corp.	Granular	Larvae and pupae	Surface film

Monomolecular film	Agnique MMF G Pak 35	53263-30	Cognis Corp.	Water soluble pack	Larvae and pupae	Surface film
Petroleum oil	Masterline Kontrol	73748-10	Univar	Liquid	Larvae and pupae	Surface film
Petroleum oil	BVA 2	70589-1	B-V Assoc.	Liquid	Larvae and pupae	Surface film
Petroleum oil	GB-1111	8329-72	Clarke	Liquid	Larvae and pupae	Surface film
Dimilin	Dimilin 25W	400-465	Uniroyal Chemical	Wettable powder	Larvae	IGR
S-Methoprene	Altosid ALLC	2724-446	Wellmark-Zoecon	Liquid concentrate	Larvae	IGR
S-Methoprene	Altosid ALL	2724-392	Wellmark-Zoecon	Liquid concentrate	Larvae	IGR
S-methoprene	Altosid Briquets	2724-375	Wellmark-Zoecon	Briquet	Larvae	IGR
S-methoprene	Altosid Pellets / WSP	2724-448	Wellmark-Zoecon	Pellet-type granules / water soluble packet	Larvae	IGR
S-methoprene	Altosid SBG	2724-489	Wellmark-Zoecon	Granule	Larvae	IGR
S-methoprene	Altosid XR Briquets	2724-421	Wellmark-Zoecon	Briquet	Larvae	IGR
S-methoprene	Altosid XR-G	2724-451	Wellmark-Zoecon	Granule	Larvae	IGR
Temephos	Abate 2-BG	8329-71	Clarke	Granule	Larvae	OP
Temephos	5% Skeeter Abate*	8329-70	Clarke	Granule	Larvae	OP
Temephos	Abate 4E	8329-69	Clarke	Liquid	Larvae	OP

PESTICIDES USED FOR MOSQUITO CONTROL IN CALIFORNIA

Adulticides

Active Ingredient	Trade name	EPA Reg. No.	Mfgr.	Formulation	Stage	Pesticide classification
Malathion	Fyfanon® ULV	67760-34	Cheminova	Liquid	Adults	OP
Naled	Trumpet™ EC	5481-481	AMVAC	Liquid	Adults	OP
Prallethrin Sumithrin	AquaDuet Adulticide	1021-2562-8329	Clarke	Liquid	Adults	Pyrethroid
Prallethrin Sumithrin	Duet Dual Action Adulticide	1021-1795	Clarke	Liquid	Adults	Pyrethroid
Deltamethrin	Suspend® SC	432-763	Aventis	Liquid	Adults	Pyrethroid
Cyfluthrin	Tempo SC Ultra	432-1363	Bayer	Liquid	Adults	Pyrethroid
Permethrin	Aqua-Kontrol	73748-1	Univar	Liquid	Adults	Pyrethroid
Permethrin	Aqualeur 20-20	769-985	Value Garden Supply	Liquid	Adults	Pyrethroid
Permethrin	Aqua-Reslin®	432-796	Bayer	Liquid	Adults	Pyrethroid
Permethrin	Biomist® 4+4	8329-35	Clarke	Liquid	Adults	Pyrethroid
Permethrin	Biomist® 4+12 ULV	8329-34	Clarke	Liquid	Adults	Pyrethroid
Permethrin	Evoluer 4-4 ULV	769-982	Value Garden Supply	Liquid	Adults	Pyrethroid
Permethrin	Kontrol 2-2	73748-3	Univar	Liquid	Adults	Pyrethroid
Permethrin	Kontrol 4-4	73748-4	Univar	Liquid	Adults	Pyrethroid
Permethrin	Kontrol 30-30	73748-5	Univar	Liquid	Adults	Pyrethroid
Permethrin	Permanone 31-66	432-1250	Bayer	Liquid	Adults	Pyrethroid
Permethrin	Permanone® Ready-To-Use	432-1277	Bayer	Liquid	Adults	Pyrethroid

Permethrin	Perm-X UL 4-4	655-898	Prentiss	Liquid	Adults	Pyrethroid
Pyrethrins	Aquahalt	1021-1803	Clarke	Liquid	Adults	Pyrethroid
Pyrethrins	Evergreen 60-6	1021-1770	MGK	Liquid	Adults	Pyrethroid
Pyrethrins	Pyrenone® 25-5	432-1050	Bayer	Liquid	Adults	Pyrethroid
Pyrethrins	Pyrenone® Crop Spray	432-1033	Bayer	Liquid	Adults	Pyrethroid
Pyrethrins	Pyrocide® 7453	1021-1803	MGK	Liquid	Adults	Pyrethroid
Pyrethrins	Pyrocide® 7395	1021-1570	MGK	Liquid	Adults	Pyrethroid
Pyrethrins	Pyrocide® 7396	1021-1569	MGK	Liquid	Adults	Pyrethroid
Pyrethrins	Pyronyl Crop Spray	655-489	Prentiss	Liquid	Adults	Pyrethroid
Pyrethrins	Pyronyl Oil 525	655-471	Prentiss	Liquid	Adults	Pyrethroid
Pyrethrins	Pyronyl Oil 3610A	655-501	Prentiss	Liquid	Adults	Pyrethroid
Resmethrin	Scourge® Insecticide (4%)	432-716	Bayer	Liquid	Adults	Pyrethroid
Resmethrin	Scourge® Insecticide (18%)	432-667	Bayer	Liquid	Adults	Pyrethroid
Sumithrin	Anvil 2+2 ULV	1021-1687	Clarke	Liquid	Adults	Pyrethroid
Sumithrin	Anvil® 10+10 ULV	1021-1688	Clarke	Liquid	Adults	Pyrethroid
Sumithrin	AquaANVIL	1021-1807	Clarke	Liquid	Adults	Pyrethroid
Etofenprox	Zenivex E4 RTU	2724-807	Wellmark Intl.	Liquid	Adults	Pyrethroid
Etofenprox	Zenivex E20	2724-791	Wellmark, Intl.	Liquid	Adults	Pyrethroid
Lambda-cyhalothrin	Demand CS	100-1066	Syngenta	Liquid	Adults	Pryethroid

Appendix I: Adult Mosquito Control in Urban Areas

Adult mosquito control via ultra low volume (ULV) application is an integral part of an integrated mosquito management program. This response plan recommends the consideration of adult mosquito control to break local virus transmission cycles and reduce the risk of human infection. The following provides guidelines for local agencies considering ground or aerial ULV control of adult mosquitoes. Agencies should ensure they are complying with NPDES permit requirements.

Preparatory steps for aerial application contracts

- Send out request for proposals (RFP) to commercial applicators well in advance of any potential need for actual treatment. Specify required equipment and abilities in the RFP such as: 1) application equipment capable of producing desired droplet spectrum and application rate, 2) aircraft availability time frames, and 3) the demonstrated ability to apply the chosen product to the target area in accordance with label requirements.
- Outline the desired capabilities and equipment within the RFP such as: 1) onboard real time weather systems, and 2) advanced onboard drift optimization and guidance software.
- Determine in advance whether the vector control agency or contractor will secure and provide pesticides. If the contractor will supply the pesticide, verify their knowledge of and ability to comply with regulations regarding the transport, use, and disposal of all pesticide and containers.
- Enter into a contingency contract with the commercial applicator.
- Consider acquiring non-owned, multiple engine aircraft insurance with urban application endorsement for added protection.
- Determine product and application rate to be used, along with a contingency plan. The product choice may be subject to change depending on product availability, the determination of resistance, labeling restrictions, environmental conditions, or other unforeseen factors.

Preparatory steps for ground-based applications

- Ensure that application equipment has been properly calibrated and tested for droplet size and flow rate. The vector control agency should have enough equipment, operators, and product available to finish the desired application(s) between sunset and midnight, or within 2-3 hours pre-sunrise (or when mosquitoes are demonstrated to be most active) to maximize efficacy.
- Ensure that vehicles are equipped with safety lighting and appropriate identifying signs; use sufficient personnel.
- Contact local law enforcement and provide them with locations to be treated and approximate time frames.
- Consider using lead and trailing vehicles particularly if the area has not been treated before and personnel are available.

Implementing an aerial application contract

- Contact commercial applicator and determine availability.
- Review long-term weather forecasts. Ideally applications should be scheduled during periods of mild winds to avoid last minute cancellations.

Contractor should:

- Contact Local Flight Standards District Office (FSDO) for low flying waiver.
- Arrange for suitable airport facilities.
- Contact local air traffic control.
- Locate potential hazards prior to any application and implement a strategy to avoid those hazards during the application – often in darkness.
- Provide equipment and personnel for mixing and loading of material (if previously agreed upon in contract).
- Register with applicable County Agricultural Commissioners office.

Vector control agency should:

- Delineate treatment block in a GIS format and send to contractor.
- Identify areas that must be avoided during an application and include detailed maps of those areas to contract applicators (e.g. open water, registered organic farms, any area excluded by product label).
- Send authorization letter to FSDO authorizing contractor to fly on the agency's behalf; contractor should provide contact information and assistance.
- Send map of application area and flight times / dates to local air traffic control; contractor should provide contact information and assistance.
- Consult with County Agricultural Commissioners office. Commissioner's office can provide guidance on contacting registered bee keepers and help identify any registered organic farms that may need to be excluded from application.
- If vector control agency is providing material, ensure adequate quantity to complete mission and that the agency has means to transport material.

Efficacy evaluation for aerial or ground based application

- Choose appropriate method(s) for evaluating efficacy of application
  - Determine changes in adult mosquito population via routine surveillance.
  - Conduct three day pre and post-trapping in all treatment and control areas.
  - Set out bioassay cages with wild caught and laboratory reared (susceptible) mosquitoes during application.
- Ensure adequate planning so surveillance staff is available and trained, equipment is available, and trap / bioassay cage test locations are selected prior to application.
- Ensure efficacy evaluation activities are timed appropriately with applications.
- Enlist an outside agency such as CDPH and/or university personnel to help evaluate efficacy of application as appropriate.

Actions at time of application

- Confirm application rate with contractor.
- Confirm treatment block.
- Coordinate efficacy evaluations.

Public notification

Notification of the public prior to a mosquito control pesticide application by a vector control agency signatory to a Cooperative Agreement with CDPH, or under contract for such agency is not a legal requirement in California (California Code of Regulations – Title 3: Food and Agriculture: Division 6. Pesticides and Pest Control Operations: Section 6620a). However, public notification of pending adult mosquito control is recommended as early as possible prior to the treatment event.

Basic notification steps

- Provide notification of pending application as early as possible.
- Post clearly defined treatment block map online or through appropriate media outlet.
- Post product label and material safety data sheet (MSDS) online or through appropriate media outlet.
- Post and/or have available scientific publications regarding the efficacy of aerial or ground based applications (as appropriate), including effects on non-target organisms and risk-assessments.

Public relations considerations

- Ensure staffing is adequate to handle a significant increase in phone calls.
- Ensure website capability is adequate to handle a rapid increase in visitors.
- Train personnel answering phones to address calls from citizens concerned about personal and environmental pesticide exposure.
- Ensure adequate follow-through for calls related to sporting events, concerts, weddings, and other outdoor events that may be scheduled during the application and within the treatment block

Appendix J: Websites Related to Arbovirus Surveillance, Mosquito Control, Weather Conditions and Forecasts, and Crop Acreage and Production in California

Website	URL	Available information
California West Nile Virus Website	http://westnile.ca.gov	Up to date information on the spread of West Nile virus throughout California, personal protection measures, online dead bird reporting, bird identification charts, mosquito control information and links, clinician information, local agency information, public education materials.
UC Davis Center for Vectorborne Diseases	http://cvec.ucdavis.edu/	Frequently updated reports and interactive maps on arbovirus surveillance and mosquito occurrence in California.
Mosquito and Vector Control Association of California	http://www.mvcac.org	News, membership information, event calendars, and other topics of interest to California's mosquito control agencies.
California Vectorborne Disease Surveillance Gateway	http://gateway.calsurv.org	Data management system for California's mosquito control agencies.
California Data Exchange Center	http://cdec.water.ca.gov	Water-related data from the California Department of Water Resources, including historical and current stream flow, snow pack, and precipitation information.
UC IPM Online	http://www.ipm.ucdavis.edu	Precipitation and temperature data for stations throughout California; also allows calculation of degree-days based on user-defined data and parameters.
National Weather Service – Climate Prediction Center	http://www.cpc.ncep.noaa.gov/products/predictions/	Short-range (daily) to long-range (seasonal) temperature and precipitation forecasts. Also provides El Niño-related forecasts.
California Agricultural Statistics Service	http://www.nass.usda.gov/Statistics_by_State/California	Crop acreage, yield, and production estimates for past years and the current year's projections. Reports for particular crops are published at specific times during the year – see the calendar on the website.
State Water Resources Control Board	http://www.swrcb.ca.gov/water_issues/programs/npdes/aquatic.shtml	National Pollutant Discharge Elimination System (NPDES) permit for vector control information.
US Environmental Protection Agency – Mosquito Control	http://www.epa.gov/pesticides/health/mosquitoes	Describes the role of mosquito control agencies and products used for mosquito control.
US Centers for Disease Control and Prevention – West Nile Virus	http://www.cdc.gov/ncidod/dvbid/westnile/index.htm	Information on the transmission of West Nile virus across the United States, viral ecology and background on WNV, and personal protection measures in various languages.

Photo Courtesy Sacramento-Yolo MVCD

Best Management Practices for Mosquito Control in California

Recommendations of the
California Department of Public Health
and the
Mosquito and Vector Control Association of California

MVC Association of California

July 2012

CDPH California Department of PublicHealth

BEST MANAGEMENT PRACTICES
FOR MOSQUITO CONTROL IN CALIFORNIA

An electronic version of this manual and the companion document “Best Management Practices for Mosquito Control on California State Properties” are available from the California West Nile virus website at http://www.westnile.ca.gov/resources.php. Please see Table 1, page 22, for a list of California mosquito control agencies or visit http://mvcac.org.

For more information, please contact:

Vector-Borne Disease Section
California Department of Public Health
vbds@cdph.ca.gov
(916) 552-9730
http://www.cdph.ca.gov
http://www.westnile.ca.gov

Purpose of this Manual

This manual provides landowners with Best Management Practices (BMPs) for mosquito control. The term BMP is used to describe actions landowners can take to reduce mosquito production from permanent water sources, reduce or eliminate mosquito production from temporary water sources, and reduce the potential for disease transmission to humans on their property.

General Recommendations

- **Implement universal BMPs**
  - Use personal protective measures
  - Eliminate unnecessary standing water

- **Identify and implement applicable mosquito control BMPs**
  - Reduce stagnation by providing water flow and manage vegetation in ponds or other water bodies.
  - Collaborate with local vector control agencies to develop and implement appropriate Integrated Pest Management (IPM) strategies that are most suitable for specific land-use type(s).

Use personal protective measures when potentially exposed to adult mosquitoes.

Eliminate unnecessary standing water, reduce stagnation by providing water flow, and manage vegetation in ponds or other water bodies.

Collaborate with local vector control agencies to coordinate activities on your property within a larger Integrated Pest Management mosquito control program.

Table of Contents

Executive Summary

The California Department of Public Health (CDPH) in collaboration with the Mosquito and Vector Control Association of California (MVCAC) developed this Best Management Practices (BMPs) plan to promote mosquito control on California properties, and enhance early detection of West Nile virus (WNV).

This plan describes mosquito control BMPs to be implemented by property owners and managers. These recommended practices, when properly implemented, can reduce mosquito populations through a variety of means including: 1) reducing or eliminating breeding sites, 2) increasing the efficacy of biological control, and 3) decrease the amount of pesticides applied while increasing the efficacy of chemical control measures. It is critical that property owners and managers communicate regularly with local vector control agencies regarding control practices on lands that are located within or near a local agency's jurisdiction. Local vector control agencies may have more specific policies regarding the implementation of BMPs and other control operations, which may include use of enforcement powers authorized by the California Health and Safety Code.

There are many different BMPs included in this document and they are intended to provide overall guidance to reduce mosquito production on properties throughout California, though not all mosquito sources and land uses will be addressed in this document. If it is deemed necessary, site-specific BMP plans may be developed in collaboration with CDPH and the respective local mosquito and vector control agency.

Effective mosquito-borne disease surveillance and mosquito control to protect public health are dependent upon factors that may fluctuate temporally and regionally. Such factors include mosquito and pathogen biology, environmental factors, land-use patterns, resource availability; strategies that incorporate BMPs are the most effective means by which mosquito control can be conducted and individualized to specific situations. Best management practices included in this plan emphasize the fundamentals of integrated pest management (IPM) which include:

1. Knowledge of mosquito species composition and corresponding mosquito behavior and habitat, for both immature and adult stages.

2. Detecting and monitoring WNV activity by testing mosquitoes, birds, sentinel chickens, horses, and humans. Identifying the mosquito species present, locations, densities, and disease potential.

3. Managing mosquito populations by source reduction, habitat modification, and biological control (e.g., introduced predators and parasites). Pesticides are used to target immature and, when indicated, adult stages of the mosquito. Mosquito control products are selected and applied in a manner that minimizes risks to human health, beneficial and non-target organisms, and the environment.

4. Educating the general public about reducing mosquito production and minimizing their risk of exposure to WNV.

RECOMMENDATIONS FOR PROPERTY OWNERS AND MANAGERS

- Use this plan to identify and implement appropriate Best Management Practices to control mosquitoes.
- Eliminate unnecessary standing water, reduce stagnation by providing water flow, and manage vegetation in ponds or other water bodies.
- Collaborate with local vector control agencies to develop and implement appropriate integrated pest management strategies that are most suitable for specific land-use type(s).
- Ensure individuals use personal protective measures when potentially exposed to adult mosquitoes.

Introduction

Controlling mosquitoes is critical to maintaining both a high quality of life and protecting people from mosquito-transmitted (vectored) diseases such as West Nile virus (WNV). In many parts of California, residents have voted to form local mosquito control programs or agencies. As a result, approximately half the land area and 85% of the population of California are within the boundaries of a mosquito control program. Landowners and land managers have a responsibility to minimize mosquito production on their lands and play a key role in reducing mosquito populations throughout the State, regardless whether their property is inside or outside the jurisdiction of a mosquito control program. Information about mosquito surveillance, mosquito-borne diseases, and mosquito control is available in Appendices A and B.

Best Management Practices (BMPs) are defined as actions landowners can take to reduce or eliminate mosquito production from water sources on their property in an environmentally and fiscally responsible manner, and to reduce the potential for transmission of disease from mosquitoes to humans.

Each property is unique, and the BMPs listed in this manual will apply to some properties, but not others. Landowners should implement universally applicable BMPs and after evaluating their own property, also employ the mosquito control BMPs that are applicable to their situation.

Landowner Responsibility

According to the California Health and Safety Code, landowners in California are legally responsible to abate (eliminate the source of) a public nuisance arising from their property, including mosquitoes [H&S Code Sections 2001 - 4(d); 2002; 2060 (b)]. In areas that are within the jurisdictional boundaries of a mosquito control program, landowners should work with staff to address mosquito problems, particularly in areas where irrigation is used for agricultural purposes. Landowners that are not within the jurisdictional boundary of an established mosquito control program should seek advice from the nearest mosquito control agency or health department. Landowners may also contact the California Department of Public Health (CDPH) or consult the CDPH West Nile virus website for additional information about mosquitoes and mosquito control. http://www.westnile.ca.gov/resources.php.

Mosquito control programs have substantial authority to access private property, inspect known or suspected sources of mosquitoes, abate the source of a mosquito problem, and charge the landowner for work performed and/or charge fees if a landowner is unwilling or unable to address a mosquito problem arising from their property [H&S Code sections 2060-2067, 100170, and 100175]. Applicable sections of the California Health and Safety Code are summarized in Appendix C.

Mosquito Biology

The more than 50 species of mosquitoes in California share one common life history trait: the mosquito life cycle requires standing water. Management of standing water is the key to most of the mosquito control BMPs presented in this manual and is one of the oldest and most cost effective forms of mosquito control.

Mosquito species are broadly separated into two groups according to where they lay eggs, floodwater mosquitoes and standing water mosquitoes. Adult female floodwater mosquitoes lay eggs on mud or previously submerged vegetation. The eggs may remain dormant for days, months, or even years until they are flooded, at which time larvae hatch. Standing water mosquitoes lay eggs on the water surface. The eggs float on the surface for a few hours to a few days until the larvae hatch into the water.

Floodwater mosquito larval development (breeding) sites include irrigated pastures, rice fields, seasonally flooded duck clubs and other managed wetlands, tidal wetlands, riparian corridors, and snowmelt pools. These intermittent or seasonally flooded habitats can be among the most productive sources of mosquitoes because they are often free of natural predators.

Standing water mosquito breeding sites include artificial containers, treeholes, catch basins, open ditches, retention/detention ponds, natural or constructed ponds and wetlands, stormwater management devices, and along the edges of flowing streams. Sources are found everywhere from highly urban areas to natural wetlands and often produce multiple generations of mosquitoes each season. In southern California, urban sources can produce some species of mosquitoes year round.

Landowners or land managers can identify the presence of immature mosquitoes in water on their property. Mosquito larvae breathe air from above the water surface and most hang at an angle from or lay parallel with the surface of the water while consuming small bits of organic matter. When disturbed, larvae swim down into the water column in a serpentine motion. Mosquitoes may live as larvae from a couple of days to more than a month depending on the species, water temperature, and the amount of food available.

Mosquitoes then go through a non-feeding stage called a pupa. During this stage the mosquito changes into the winged adult form. The easily identified comma-shaped pupae hang from the water surface and move down through the water column in a rolling or tumbling motion when disturbed. This life stage typically lasts about a day, with the mosquito emerging from the back of the pupal case (above the water) as a flying adult. (See Figure 1: Mosquito Life Cycle).

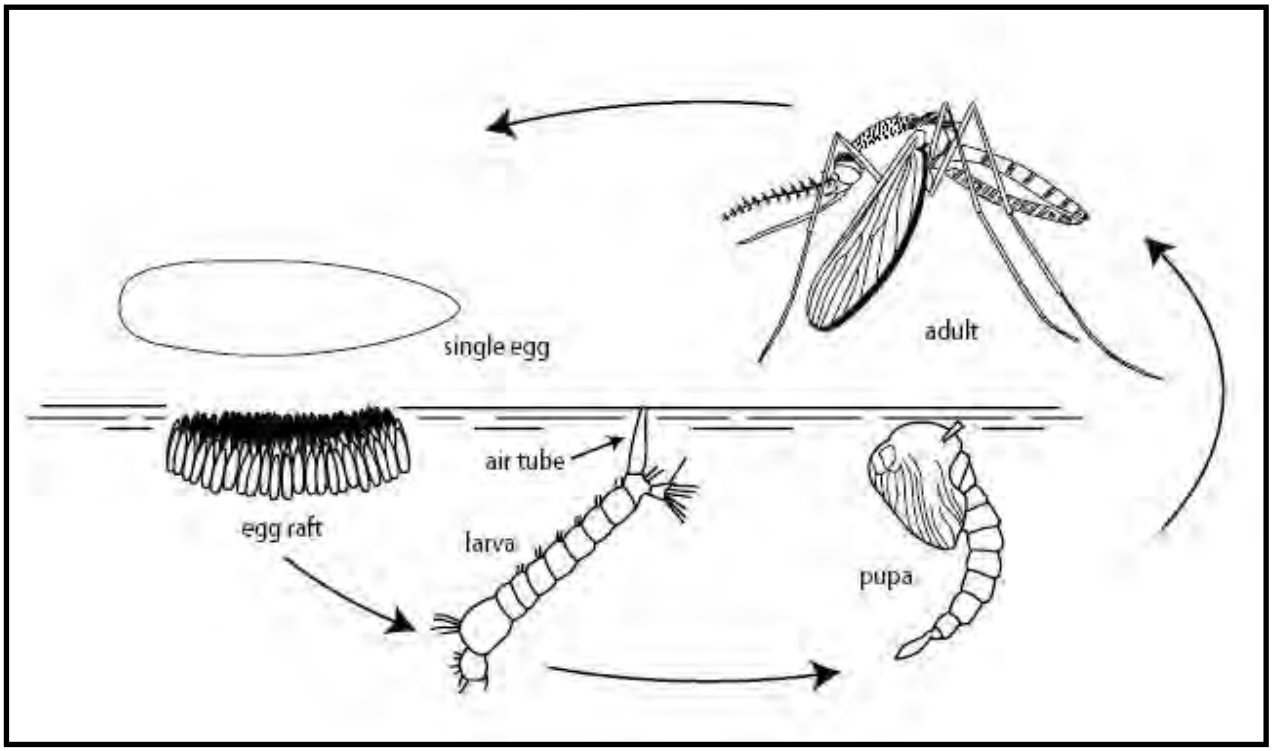

Figure 1. The life cycle of all mosquito species consists of four stages: egg, larva, pupa, and adult.

All adult mosquitoes feed on plant nectar; however blood is essential for female mosquitoes to produce eggs. To take a blood meal, the female's mouth parts pierce the skin, inject saliva, and suck blood out. It is through the injection of saliva that a mosquito causes the typical itchy bump and can infect a person or domestic animal with a disease causing organism. Depending on an individual's immune response, even a single bite can be a significant nuisance.

For more information on mosquito biology and key mosquito species found in California, please see Appendix D.

For additional information on the larval habitats of California mosquitoes, please see Appendix E.

Best Management Practices (BMPs)

Mosquito Control Best Management Practices At-A-Glance

- Eliminate artificial mosquito sources.
- Ensure man-made temporary sources of surface water drain within four days 96 hours) to prevent development of adult mosquitoes.
- Control plant growth in ponds, ditches, and shallow wetlands.
- Design facilities and water conveyance and/or holding structures to minimize the potential for producing mosquitoes.
- Use appropriate bio-rational products to control mosquito larvae.
- Use personal protective measures to prevent mosquito bites.

Each property is unique. Landowners should implement universally applicable mosquito control BMPs, and after evaluating their own property, also employ the mosquito control BMPs that are applicable to their property and circumstances. Using appropriate BMPs is an efficient and effective way to help prevent a mosquito problem.

Universally Applicable Mosquito Control BMPs

Eliminate Artificial Mosquito Breeding Sites and Harborage

- Examine outdoor areas and drain temporary and unnecessary water that may stand longer than 96 hours.
- Dispose of unwanted or unused artificial containers.
- Properly dispose of old tires.
- If possible, drill drainage holes, cover, or invert any container or object that holds standing water that must remain outdoors. Be sure to check for containers or trash in places that may be hard to see, such as under bushes or buildings.
- Clean clogged rain gutters and storm drains. Keep outdoor drains flowing freely and clear of leaves, vegetation, and other debris.
- Aerate ornamental ponds to avoid letting water stagnate.
- Change water in birdbaths, fountains, and animal troughs at least once per week.
- Ensure rain and/or irrigation water does not stand in plant containers, trash cans, boats, or other containers on commercial or residential properties.
- Regularly chlorinate swimming pools and keep pumps and filters operating. Unused or unwanted pools should be kept empty and dry, or buried.
- Maintain irrigation systems to avoid excess water use and runoff into storm drains.
- Minimize sites mosquitoes can use for refuge (harborage) by thinning branches, trimming and pruning ornamental shrubs and bushes, and keeping grass mowed short.

Use Personal Protective Measures

- Apply an EPA-registered mosquito repellent when outdoors; especially around dusk and dawn when mosquitoes are most active (see Appendix F for additional information on insect repellents).
- Wearing loose-fitting protective clothing including long sleeves and pant legs.
- Install and properly maintain fine mesh screens on windows and doors to prevent mosquito entry into homes.

Provide Mosquito Management Related Information to Property Managers

- Off-site landowners should provide property managers with basic information about mosquitoes and appropriate measures to minimize mosquito habitats.

Contact Local Mosquito Control Program

- Contact the local mosquito control program to evaluate your property for mosquito breeding sites and work cooperatively to prevent a mosquito problem on your property. A contact list for mosquito control programs is provided in Table 1.

Where local mosquito control programs do not exist, landowners may contact CDPH for assistance or consult the California West Nile virus website for additional information about mosquito control: http://www.westnile.ca.gov/resources.php

Mosquito Control BMPs for Residential and Landscaped Properties

Many residential and commercial properties have potential mosquito sources around buildings and grounds associated with excess or poorly managed irrigation, poor drainage, and miscellaneous landscape features. Mosquitoes can develop in the standing water associated with over-irrigation, irrigation breaks and/or runoff, clogged gutters, stormwater management structures, ornamental ponds, swimming pools, trash cans and flower pots, low areas or holes in turf where water collects and stands and low areas underneath pier and beam homes or buildings.

Mosquito sources can be minimized by taking precautions such as regular inspection and proper maintenance of irrigation systems and other water features, and elimination of unwanted standing water.

- Avoid over-irrigating to prevent excess pooling and runoff.
- Routinely inspect, maintain, and repair irrigation system components.

- All underground drain pipes should be laid to grade to avoid low areas that may hold water for longer than 96 hours.
- Back-fill tire ruts or other low areas that hold water for more than 96 hours.
- Improve drainage channels and grading to minimize potential for standing water.
- Keep drainage ditches free of excessive vegetation and debris to provide rapid drainage.
- Check and repair leaky outdoor faucets.
- Report any evidence of standing water to responsible maintenance personnel.
- Use waterfalls, fountains, aerators and/or mosquitofish in ponds and ornamental water features. Land owners must consult with the local mosquito control agencies or California Fish and Game regarding proper use of mosquitofish.
- Prevent mosquito breeding in rain barrels by properly screening all openings, preventing mosquito access to the stored water.
- For ponds and ornamental water features where mosquitofish cannot be used, landowners should use one of several readily available larval mosquito control products to treat water when they see immature mosquitoes.

Landowners should also review the stormwater runoff section of this manual because building rooftops, parking lots, etc. may have associated stormwater management features that produce mosquitoes.

Mosquito Control BMPs for Rural Properties

Mosquito breeding on rural properties is highly variable due to differences in location, terrain, and land use. This list is intended to provide general guidance, not site-specific requirements. BMPs that are most applicable and relevant to a specific mosquito source may be selected from the list and incorporated into the overall property management plan. Ideally, activities should be coordinated with those of a local mosquito control program.

Flood irrigation is a common practice in rural areas throughout California and always poses the potential for creating mosquito breeding sites. Mosquitoes commonly develop within irrigation infrastructure including in ditches clogged with vegetation, irrigation tail water areas and return sumps, blocked ditches or culverts, vegetated ditches; and leaking irrigation pipes, head gates, pumps, stand pipes, etc. The fields, orchards, and pastures being irrigated may also produce mosquitoes, particularly where natural undulation or poor grading create low lying areas where water collects and stands.

Recommendations for rural properties are based on “Mosquito Control Best Management Practices” produced by the Sacramento-Yolo Mosquito and Vector Control District, and from Lawler and Lanzaro (2005).

Mosquito Control BMPs for Ditches and Drains

- Construct or improve large ditches to a slope of at least 2:1 (vertical: horizontal) and a minimum 4 foot wide bottom. Consider a 3:1 slope or greater to discourage burrowing animal damage, potential seepage problems, and prevent unwanted vegetation growth.
- Keep ditches clean and well-maintained. Periodically remove accumulated sediment and vegetation. Maintain ditch grade and prevent areas of standing water.
- Design irrigation systems to use water efficiently and drain completely to avoid standing water.
- Prevent wet areas associated with seepage by repairing leaks in dams, ditches, and drains.

Mosquito Control BMPs for Irrigated Pastures and Cropland

- Grade to eliminate standing water from pastures and fields. Use Natural Resource Conservation Service (NRCS) guidelines: Laser leveling and periodic maintenance may be needed to allow proper drainage, efficient water flow, and reduce low-lying areas where standing water may accumulate.
- Reuse wastewater through return flow systems to effectively minimize mosquito production and conserve water. Eliminate and reuse excess water that may typically stagnate and collect at lower levels of irrigated fields.
- Irrigate only as frequently as is needed to maintain proper soil moisture. Check soil moisture regularly.
- Drain water as quickly as possible following irrigation. Check slopes may be used to direct water movement and drainage. Drainage ditches may be used to remove water from the lower end of the field.
- Install surface drains to remove excess water that collects at lower levels of irrigated fields.
- Inspect fields for drainage and broken checks to see whether re-leveling or reconstruction of levees is needed. Broken checks create cross-leakage that may provide habitat for mosquitoes.
- If possible, use closed conduits instead of open canals for water conveyance.
- Do not over fertilize. Over-fertilization can leach into irrigation run-off making mosquito production more likely in ditches or further downstream.
- When possible, use sprinklers or drip systems rather than flood irrigation.
- Keep animals off the pasture while the soil is soft. Mosquito habitat is created in irrigated pastures when water collects in hoof prints.

Mosquito Control BMPs for Rice Fields

Flooded rice fields can always support the development of mosquitoes. As the rice stand develops and grows denser, the production of mosquitoes tends to increase while the ability for chemical control agents to penetrate the canopy decreases. The BMPs

presented in this section attempt to balance the needs of the grower with the need to control mosquitoes.

In California there is a long-standing cooperative effort among the Rice Commission, individual growers, and mosquito control agencies to manage mosquitoes on rice lands. Close cooperation between growers and vector control is particularly important with organic rice producers. With severe limits on chemical control options and greater expense for organic-compatible larvicides, organic rice growers should implement as many mosquito control BMPs as possible.

- Wherever feasible, maintain stable water levels during mosquito season by ensuring constant flow of water into ponds or rice fields to reduce water fluctuation due to evaporation, transpiration, outflow, and seepage.
- Inspect and repair levees to minimize seepage.
- Drain and fill in borrow pits and seepage areas external to the fields.
- Wherever feasible, maintain at least 4" – 6" (10-15 cm) of water in the rice field after rice seedlings have begun to stand upright. Any drainage should be coordinated with local vector control (where possible). Restocking of mosquitofish or use of alternative mosquito control measures should be instituted as soon as possible when fields are re-flooded.
- Whenever feasible, remove vegetation on the outer-most portions of field levees and checks, specifically where they interface with standing water.
- Control algae and weed growth as effectively as possible.
- Communicate frequently with your local mosquito control program regarding your crop management activities.
- Wherever feasible, maintain borrow pits (12" – 18" deep) (30-45 cm) on both sides of each check throughout rice fields to provide refuge for mosquitofish during low water periods.
- If a pyrethroid pesticide is to be applied to the fields stocked with mosquitofish, contact your local mosquito control program for advice on minimizing fish mortality.
- If a pesticide is applied, fields should be inspected for mosquitofish afterward and if needed, fish should be restocked as soon as feasible.

Mosquito Control BMPs for Dairies and Animal Holding Operations

Frequently infrastructure associated with dairies, feedlots, or other animal holding facilities can produce mosquitoes. Watering troughs and irrigated fields associated with the operation can create mosquito problems. Animal washing areas may also create mosquito problems, particularly drains and ditches, sumps, ponds, and wastewater lagoons.

The following activities can reduce mosquito production and simplify control activities around dairies and animal holding operations:

- All holding ponds should be surrounded by lanes of adequate width to allow safe passage of mosquito control equipment. This includes keeping the lanes clear of any materials or equipment (e.g. trees, calf pens, hay stacks, silage, tires, equipment, etc.).
- If fencing is used around the holding ponds, it should be placed on the outside of the lanes with gates provided for vehicle access.
- Large ponds should be divided into a series of smaller ponds that can be drained for removal of solid waste material.
- Ponds and lagoons should be narrow enough to allow solid waste removal after drying.
- All interior banks of the holding ponds should have a grade of at least 2:1.
- If possible, an effective solids separation system should be utilized such as a mechanical separator or two or more solids separator ponds. If ponds are used, they should not exceed 60' (18m) in surface width.
- Drainage lines should never by-pass the separator ponds, except those that provide for normal corral run-off and do not contain solids.
- When possible, floating debris should be removed from ponds prior to crust formation.
- If a thick crust exists (grass growing on crust), it should be left intact until the pond can be drained and the solid material removed.
- Vegetation should be controlled regularly to prevent emergent vegetation and barriers to access. This includes access lanes, interior pond embankments, and any weed growth that might become established within the pond surface.
- Dairy wastewater discharge for irrigation purposes should be managed so it does not stand for more than 4 days.
- Tire sidewalls or other objects that will not hold water should be used to hold down tarps (e.g. on silage piles). Whole tires or other water-holding objects should be replaced.

Mosquito Control BMPs for Wetlands

Wetlands are an important source of mosquito production on public and privately owned lands. Under the California Wildlife Protection Act, the term "wetlands" is defined as any lands which may be covered periodically or permanently with shallow water, which

include freshwater and saltwater marshes, open or closed brackish water marshes, swamps, mudflats, fens, and vernal pools (Fish & Game Code Section 2785). Many wetlands are protected by federal and state laws.

By definition, “natural” wetlands are not intensely managed and options for implementing mosquito control BMPs in these areas are very limited. Even in managed wetlands, not all BMPs listed below may be suitable for use in all wetlands. It is the responsibility of the landowner to become informed on timing and extent of acceptable activities in a given wetland habitat. Intermittently or seasonally flooded wetlands can produce formidable numbers of mosquitoes, whereas well-managed semi-permanent and permanent wetlands usually produce fewer mosquitoes because of their limited acreage, stable water levels, and abundance of natural predators of mosquito larvae.

Information within this section has been partially adapted from Kwasny et al. (2004). Based on the site activities and potential for mosquito production, the existing BMPs may need to be modified or supplemented to address public health risk, goals and management strategy issues, and requirements of California Department of Fish and Game (DFG), the local mosquito and vector control program, and CDPH.

Due to the delicate and sometimes protected wetlands ecosystems, landowners, biologists, managers, and staff from mosquito control programs should collaborate to control mosquitoes. Source reduction and source maintenance can be combined with the judicious use of specific larvicides to minimize mosquito production from these wetlands.

General Mosquito Control BMPs for Wetlands

- Manage vegetation routinely; activities such as annual thinning of rushes and cattails and removing excess vegetative debris enables natural predators to hunt mosquito larvae more effectively in permanent wetlands. Vegetation in shallow, temporary wetlands can be mowed when dry.
- Time flooding of seasonal wetlands to reduce overlap with peak mosquito activity.
- Flood wetlands from permanent-water sources containing mosquito predators (e.g., mosquito-eating fish or invertebrate predators) to passively introduce mosquito predators. Permanent wetlands and brood ponds can be stocked with mosquitofish or native predatory species.
- Maintain permanent or semi-permanent water within the wetland to maintain populations of larval mosquito predators. Discourage the use of broad spectrum pesticides.
- Use fertilizers conservatively and manage irrigation drainage to prevent or minimize fertilizer and/or manure flowing into wetlands. Buffers between agriculture fields and wetlands should be established.
- Comply with all Federal and State Environmental Laws and the California Health and Safety Code to prevent environmental harm while reducing or eliminating mosquito production.

Mosquito Control BMPs for Design and Maintenance of Wetlands

- Provide reasonable access on existing roads and levees to allow for monitoring, abatement, and implementation of BMPs. Make shorelines of natural, agricultural, and constructed water bodies accessible for periodic maintenance, mosquito monitoring and abatement procedures, and removal of emergent vegetation.
- Construct, improve, or maintain ditches with 2:1 slopes and a minimum 4 foot (1.2 m) width at the bottom. Consider a 3:1 slope or greater to discourage burrowing animal damage, potential seepage problems, and prevent unwanted vegetation growth.
- Construct, improve, or maintain levees to quality standards that ensure stability and prevent unwanted seepage. Ideally build levees with >3:1 slopes and > 80% compaction; consider 5:1 slope or greater in areas prone to overland flooding and levee erosion.
- Provide adequate water control structures for complete draw-down and rapid flooding.
- When possible, include independent inlets and outlets in the design of each wetland unit.
- Construct or enhance swales so they are sloped from inlet to outlet and allow maximum draw-down.
- Excavate deep channels or basins to maintain permanent water areas (>2.5 feet deep) within a portion of seasonal managed wetlands. This provides year-round habitat for mosquito predators that can inoculate seasonal wetlands when they are irrigated or flooded.

Wetland Infrastructure Maintenance Mosquito Control BMPs

- Inspect levees at least annually and repair as needed.
- Periodically inspect, repair, and clean water control structures.
    - Remove all debris, including silt and vegetation, which can impede drainage and water flow.
    - Ensure water control structures are watertight to prevent unnecessary water flow or seepage.
- Regularly remove trash, silt and vegetation from water delivery ditches to allow efficient water delivery and drainage.
    - Remove problem vegetation that inhibits water flow using herbicides or periodic dredging.
    - If possible, use closed conduits instead of open canals for water conveyance.
- Periodically test and repair pumps used for wetland flooding to maximize pump output.

Water Management Mosquito Control BMPs for Seasonal Wetlands

- Timing of flooding
    - Delay or “phase” fall flooding of wetlands as long as possible in consultation with local vector control agencies. Fall flooding is known to produce large numbers of mosquitoes and/or those in close proximity to urban areas to minimize late season mosquito production.
    - Strategically locate wetlands identified for early flooding. Wetlands that are flooded in early fall should not be close to urban areas or historically produce great numbers of mosquitoes.
    - When possible, water in managed wetlands should be drawn-down in late March or early April.
    - Use a flood-drain-flood regime to control floodwater mosquitoes; flood to trigger hatching of dormant mosquito eggs, drain water and larvae into an area where they can be easily treated, drowned in moving water, or consumed by predators, and immediately re-flood wetland. This water management regime should be used only when it does not conflict with water quality regulations.
- Speed of flooding
    - Flood wetlands as quickly as possible to reduce the potential for large numbers of mosquitoes. Coordinate flooding with neighbors and/or the water district to maximize flood-up rate.
- Water source
    - Flood wetlands with water from permanent water sources containing mosquito predators (i.e., mosquito-eating fish or invertebrate predators) to passively introduce mosquito predators. Permanent wetlands and brood ponds used as flooding sources can be stocked with mosquito-eating fish or maintained to encourage natural predator populations.
    - Maintain a separate permanent water reservoir that conveys water to seasonal wetlands that provides year-round habitat for mosquito predators that can inoculate seasonal wetlands when they are irrigated or flooded.
- Frequency and duration of irrigation
    - When possible, reduce the number and duration of irrigations to minimize standing water. The need to irrigate should be evaluated based on spring habitat conditions and plant growth. If extended duration irrigation

(generally 14-21 days) is considered for weed control (e.g., cocklebur),
    - additional measures to offset the potential for increased mosquito production may be needed.
    - Irrigate managed wetlands before soil completely dries after spring draw-down to discourage floodwater mosquitoes from laying eggs in the dry, cracked substrate.
    - Drain irrigation water into ditches or other water sources with mosquito predators instead of nearby dry fields.
    - Maintain high ground water levels by keeping channels or deep swales permanently flooded for subsurface irrigation to reduce the amount of irrigation water needed during the mosquito season.
- Communicate with your local mosquito control agency (if there is one)
    - Advise your local mosquito control agency when you intend to flood so that they can make timely applications of larvicide if necessary.
- Emergency preparedness
    - Whenever feasible, have an emergency plan that provides for immediate drainage into acceptable areas if a mosquito-borne disease related public health emergency occurs.

Vegetation Management Mosquito Control BMPs

- Control floating vegetation conducive to mosquito production (i.e., water hyacinth, water primrose, parrot feather, duckweed, and filamentous algae mats).
- Perform routine maintenance to reduce problematic emergent plant densities to facilitate the ability of mosquito-eating fish to move through vegetated areas and allow good penetration of chemical control agents.
- Manage vegetation based on local land management objectives and associated habitat uses to minimize mosquito production. Methods of vegetation control for managed wetlands include mowing, burning, disking, and grazing.
- Manage the spread and density of invasive, non-native emergent wetland vegetation to increase native plant diversity, increase the mobility of larval mosquito predators, and allow for more efficient penetration of chemical control agents.

Additional Water Management BMPs for Permanent Wetlands

- Maintain stable water levels in wetlands that are flooded during summer and early spring to prevent intermittent flooding of shoreline areas favorable to mosquito production. Water level fluctuation can be minimized by continuing a constant flow of water into the wetland.
- Circulate water to avoid stagnation (e.g., provide a constant influx of water equal to the net loss or discharge of water).
- Maintain water depths as deep as possible (18” – 24” [45-60 cm] or more) during the initial flood-up to minimize shallow habitats preferred by mosquito larvae. Shallow water levels can be maintained outside of the mosquito breeding season.

Additional Mosquito Control BMPs for Saltwater Marsh

- Improving water flow through the wetland system minimizes stagnant water and facilitates movement of fish and other natural predators. For example, mosquitoes in coastal tidal wetlands can be managed by constructing and maintaining ditches that drain off the water when the tide falls.

Mosquito Control BMPs for Stormwater Management and Associated Infrastructure

Federal and state environmental regulations require mitigation of the harmful effects of runoff water from storms, irrigation or other sources prior to entering natural waterways from point and non-point sources. Mitigation may include water capture, slowing flow velocity, reducing volume, and removal of pollutants. The term “stormwater” is used as a generic term for runoff water, regardless of source.

Stormwater infrastructure typically includes conveyance systems (e.g. drain inlets, catch basins, pipes, and channels), storage and infiltration systems (e.g. flood control basins, percolation basins), and more recently, structural treatment devices designed and installed specifically to remove suspended and dissolved pollutants from runoff (e.g., vegetated swales, dry detention basins, ponds and constructed wetlands, media filtration devices, and trash capturing devices). The size and variability of stormwater infrastructure, inconsistent quantity and timing of water flows, and propensity to carry and accumulate sediment, trash, and debris, makes these systems highly conducive to holding areas of standing water ideal for production of mosquitoes. Identification of the potential mosquito sources (often belowground) found within stormwater infrastructure is often more difficult than the solutions needed to minimize mosquitoes. Some of the information within this section has been adapted from Metzger (2004).

General Stormwater Management Mosquito Control BMPs

- Manage sprinkler and irrigation systems to minimize runoff entering stormwater infrastructure.
- Avoid intentionally running water into stormwater systems by not washing sidewalks and driveways, washing cars on streets or driveways, etc.
- Inspect facilities weekly during warm weather for the presence of standing water or immature mosquitoes.
- Remove emergent vegetation and debris from gutters and channels that accumulate water.
- Consider mosquito production during the design, construction, and maintenance of stormwater infrastructure.
- Design and maintain systems to fully discharge captured water in 96 hours or less.
- Include access for maintenance in system design.

- Design systems with permanent water sources such as wetlands, ponds, sumps, and basins to minimize mosquito habitat and plan for routine larval mosquito inspection and control activities with the assistance of a local mosquito control program.

Stormwater Conveyance

- Provide proper grades along conveyance structures to ensure that water flows freely.
- Inspect on a routine basis to ensure the grade remains as designed and to remove accumulations of sediment, trash, and debris.
- Keep inlets free of accumulations of sediment, trash, and debris to prevent standing water from backing up on roadways and gutters.
- Design outfalls to prevent scour depressions that can hold standing water.

Stormwater Storage and Infiltration Systems (Aboveground)

- Design structures so that they do not hold standing water for more than 96 hours to prevent mosquito development. Features to prevent or reduce the possibility of clogged discharge orifices (e.g., debris screens) should be incorporated into the design. The use of weep holes is not recommended due to rapid clogging.
- Provide a uniform grade between the inlets and outlets to ensure that all water is discharged in 96 hours or less. Routine inspection and maintenance are crucial to ensuring the grade remains as designed.
- Avoid the use of electric pumps. They are subject to failure and often require permanent-water sumps. Structures that do not require pumping should be favored over those that have this requirement.
- Avoid the use of loose rock rip-rap that may hold standing water.
- Design distribution pumping and containment basins with adequate slopes to drain fully. The design slope should take into consideration buildup of sediment between maintenance periods.

Stormwater Structures with Permanent-Water Sumps or Basins (Belowground)

- Where possible, seal access holes (e.g., pickholes in manhole covers) to belowground structures designed to retain water in sumps or basins to minimize

entry of adult mosquitoes. If using covers or screens, maximum allowable gaps of 1/16 inch (2 mm) will exclude entry of adult mosquitoes. Inspect barriers frequently and replace when needed.

- If the sump or basin is completely sealed against mosquitoes, with the exception of the inlet and outlet, the inlet and outlet should be completely submerged to reduce the available surface area of water for mosquitoes to lay eggs (female mosquitoes can fly through pipes).
- Where possible, design belowground sumps with the equipment necessary to allow for easy dewatering of the unit.
- Contact the local mosquito control program for advice with problem systems.

Stormwater Treatment Ponds and Constructed Treatment Wetlands

- Whenever possible, stock stormwater ponds and constructed wetlands with mosquito-eating fish available from local mosquito control programs.
- Design and maintain accessible shorelines to allow for periodic maintenance and/or control of emergent and shoreline vegetation, and routine monitoring and control of mosquitoes. Emergent plant density should be routinely managed so mosquito predators can move throughout the vegetated areas and are not excluded from pond edges.
- Whenever possible, design and maintain deep zones in excess of four feet (1.2 m) to limit the spread of invasive emergent vegetation such as cattails. The edges below the water surface should be as steep as practicable and uniform to discourage dense plant growth that may provide immature mosquitoes with refuge from predators and increased nutrient availability.
- Use concrete or liners in shallow areas to discourage plant growth where vegetation is not necessary.
- Whenever possible, provide a means for easy dewatering if needed.
- Manage the spread and density of floating and submerged vegetation that encourages mosquito production (i.e., water hyacinth, water primrose, parrot's feather, duckweed, and filamentous algal mats).
- If possible, compartmentalize managed treatment wetlands so the maximum width of ponds does not exceed two times the effective distance (40 feet [12 m]) of land-based application technologies for mosquito control agents.

General Access Requirements for Stormwater Treatment Structures

- All structures should be easily and safely accessible, without the need for special requirements (e.g., Occupational Safety and Health Administration - OSHA - requirements for "confined space"). This will allow for monitoring and, if necessary, abatement of mosquitoes.
- If utilizing covers, the design should include spring-loaded or lightweight access hatches that can be easily opened.
- Provide all-weather road access (with provisions for turning a full-size work vehicle) along at least one side of large aboveground structures that are less

than seven meters wide, or both sides if shore-to-shore distance is greater than seven meters. *Note:* Mosquito larvicides are applied with hand held equipment at small sites and with backpack or truck mounted high-pressure sprayers at large sites. The effective swath width of most backpack or truck-mounted larvicide sprayers is approximately 20-25 feet (6-7meters) on a windless day.
- Build access roads as close to the shoreline as possible to allow for maintenance and vector control crews to periodically maintain, control and remove emergent vegetation and conduct routine mosquito monitoring and abatement. Remove vegetation and/or other obstacles between the access road and the structure that might obstruct the path of larvicides to the water.
- Control vegetation (by removal, thinning, or mowing) periodically to prevent barriers to access.

Mosquito Control BMPs for Right of Ways and Easements

Right of ways and easements for a variety of infrastructure exist throughout California. Roadways, power lines, pipelines, canals, bike paths, utility access, railroads, etc. have lands associated with them that may produce mosquitoes. It is the responsibility of the company or individual associated with the infrastructure to prevent a public nuisance arising from the property, including a mosquito problem. The lands are as varied as the terrain in California, but the mosquito breeding sites found on these properties will be similar to those found in other sections of this manual.

Inspection of Property and Identification of Mosquito Sources

- Inspect property for standing water or evidence of standing water that may become mosquito sources.

Review and Implement Mosquito Control BMPs as Appropriate

Some rights of way and easements are very long and may have multiple types of mosquito breeding sites that fall within every category listed below, others will have none. After inspecting the property, implement mosquito control BMPs found in the sections below.

- If the property is in an urban area and is managed as commercial property, please refer to the following section:
  - *Residential and landscaped properties*, see page 5.

- If the property is associated with an irrigation canal or similar rural water conveyance, please refer to the following sections:
  - *Rural properties*, see page 6.
  - *Wetlands*, see page 9.

- If the property is associated with a variety of habitats like a railroad or pipeline

right of way, please refer to the following sections:
  - *Rural* properties, see page 6.
  - *Wetlands*, see page 9.

- If the property is associated with a roadway or other structure that would require management of runoff water, please refer to the following section:
  - *Stormwater management* (associated BMPs), see page 14.

In many instances, right of ways and easements will simply fall to the local mosquito and vector control program or go completely unmanaged because they are very large and it is not possible to determine the responsible party.

Mosquito Control BMPs for Wastewater Treatment Facilities

Wastewater treatment facilities are designed to collect, treat, and release nutrient rich highly organic water. These facilities implement practices appropriate to removing contaminants from wastewater, but which may be in direct conflict with BMPs intended to prevent development of mosquito larvae. Further, managers are under intense pressure to meet water quality standards in effluent water and are frequently concerned that mosquito control BMPs will jeopardize compliance with effluent standards.

Wastewater facilities often include features that can produce mosquitoes. Examples include 1) a series of treatment or evaporation ponds, 2) the use of tules or other emergent vegetation to remove contaminants, 3) aerated and non-aerated ponds with emergent vegetation around the edges or throughout, 4) cracks and openings in crusted waste matter on the surface of treatment ponds, and 5) abandoned or unused pond basins that frequently hold shallow water. Certain activities may also create or enhance mosquito habitat including 1) allowing evaporation of wastewater from treatment ponds for maintenance or as a standard treatment method, 2) release of wastewater into marshes or floodplains for evaporation or infiltration, and 3) distribution of sludge onto irrigated agricultural lands.

For mosquito control around buildings and grounds, consult the *residential and landscape* section of this document. Similarly, many BMPs included in the *wetlands and dairy* sections of this document are pertinent to wastewater management facilities, particularly those sections related to construction and management of treatment ponds and wetlands and the use and distribution of wastewater or sludge onto agricultural lands. For mosquito control related to wastewater collection, conveyance, and distribution consult the *stormwater management* section of this manual.

- Monitor all treatment ponds for mosquito larvae – particularly in areas of emergent vegetation.
- Remove emergent vegetation from edges of aerated ponds.
- Immediately incorporate sludge into soil through plowing or disking.
- Insure all water distributed onto evaporation ponds dries completely in less than 96 hours.

- Check abandoned ponds or tanks weekly to ensure they are completely dry.
- Use mechanical agitation to prevent the formation of any crust on treatment ponds or tanks.
- Work closely with a local vector control program. If there is no local vector control agency, consult the closest vector control program, the local public health officer, or CDPH to prevent or abate a mosquito problem from the facility.

Mosquito Control BMPs for Wildlands – Undeveloped Areas

California encompasses about 100 million acres (40 million hectares) of land. Approximately 75 million acres (30 million hectares) are classified as wildlands, which include all undeveloped and non-cultivated property in the state. In many cases the properties are remote and mosquito control is neither feasible nor warranted. However, if you own a property that is near a town or are aware of a mosquito problem at the property, you may wish to contact the closest vector control program or CDPH to determine what if anything can be done to alleviate the problem.

Mosquito Control BMPs that May be Applicable to Wildlands

- Conduct routine mosquito surveillance by looking for immature mosquitoes in the water. Apply EPA-registered products (typically containing Bti, Bs, or methoprene) to control mosquito larvae.
- Evaluate reports of mosquito annoyance from visitors or the public, and if possible work with a local mosquito control program to be notified if there is an adult mosquito problem on or near your property.
- After a rainfall, pay particular attention to temporary water sources and ponds that rise. Treat sources with mosquito control products if needed.
- Stock ornamental ponds and other water features with mosquitofish available from local mosquito control programs. However, their use is restricted in natural bodies of water or in water features that drain into natural bodies of water. Land managers must consult with the local mosquito control agencies regarding proper use of mosquitofish or other available biological control agents.
  Work closely with a local mosquito control program to accurately identify, map, and monitor areas that may produce mosquitoes; and tailor control measures for each site, contingent on the species of mosquitoes that are present.
- Implement personal protective measures
  - Provide visitors and guests with information regarding the risk of mosquito-borne disease transmission and personal protective measures.
  - Install and maintain tight-fitting window and door screens on buildings.
  - If possible, minimize outdoor activities at dawn and dusk when mosquitoes are the most active.
  - Wear protective clothing such as long-sleeved shirts and long pants when going into mosquito-infested areas.
  - Use mosquito repellent when necessary, carefully following the directions on the label.

Evaluation of the Efficacy of BMPs

Landowners can easily evaluate the efficacy of the mosquito control BMPs they have implemented. You can do a simple evaluation as follows:

- Immature mosquitoes: Look for immature mosquitoes in standing water on your property – if the number is decreasing noticeably or immature mosquitoes can not be found, the BMPs you have implemented are working.
- Adult mosquitoes: Simply be aware of the level of mosquito annoyance you experience and ask guests or employees about their experience with regard to mosquitoes. People become accustomed to a certain level of mosquito activity and commonly notice increases or decreases in that level. If the annoyance level is increasing, you have more work to do; if the number is decreasing or mosquitoes are not noticeable – good job! The BMPs you have implemented are working.

The best way to evaluate the effectiveness of BMPs is through a comprehensive surveillance program of larval dipping and adult mosquito trapping, including species identification. Some important strengths of local mosquito control programs are their ability to evaluate treatment options, estimate treatment costs, recommend and implement those BMPs most appropriate for a property. Local mosquito abatement programs also are familiar with indigenous mosquito species and therefore know the type of habitat those mosquitoes come from, often monitor adult populations, and can identify if there is a mosquito problem in a particular area. Landowners can make substantial progress in solving mosquito problems on their own, but if possible, they should work closely with a local mosquito control program to implement and evaluate mosquito control BMPs.


Vector Control Service Coverage in California
Vector Service Area
Del Norte
Siskiyou
Modoc
Humboldt
Trinity
Shasta
Lassen
Tehama
Plumas
Glenn
Butte
Sierra
Mendocino
Nevada
Lake
Colusa
Yuba
Placer
Sutter
El Dorado
Yolo
Sacramento
Alpine
Sonoma
Napa
Amador
Solano
Calaveras
Marin
San Joaquin
Tuolumne
Contra Costa
Mono
San Francisco
Alameda
Stanislaus
Mariposa
San Mateo
Santa Clara
Merced
Madera
Santa Cruz
Fresno
San Benito
Inyo
Monterey
Kings
Tulare
San Luis Obispo
Kern
Santa Barbara
Ventura
Los Angeles
Orange
Riverside
San Diego
Imperial
CDPH disclaims any warranty or warranty for fitness of use for a particular purpose, expressed or implied, with respect to this data.CDPH disclaims any responsibility for the accuracy or completeness of this data. The mapped data does not constitute a legal survey.
CDPH-VBDS
NAD83 California Teale Al
last update: March 2012

Table 1: Mosquito Control Agencies in California

COUNTY	AGENCY	WEBSITE or ADDRESS	TELEPHONE
ALAMEDA	ALAMEDA CO MAD	http://www.mosquitoes.org	(510) 783-7744
ALAMEDA	ALAMEDA CO VCSD	http://www.acvcsd.org	(510) 567-6800
AMADOR	AMADOR CO ENV HEALTH DEPT	http://www.co.amador.ca.us/index.aspx?page=385	(209) 223-6487
BUTTE	BUTTE CO MVCD	http://www.bcmvcd.com/	(530) 533-6038
BUTTE	DURHAM MAD	PO Box 386, Durham, CA 95938	(530) 345-2875
BUTTE	OROVILLE MAD	PO Box 940, Oroville, CA 95965	(530) 534-8383
CALAVERAS	SADDLE CREEK CSD	http://www.saddlecreekcsd.org	(209) 785-0100
COLUSA	COLUSA MAD	PO Box 208, Colusa, CA 95932	(530) 458-4966
CONTRA COSTA	CONTRA COSTA MVCD	http://www.contracostamosquito.com/	(925) 771-6100
EL DORADO	CO OF EL DORADO CO ENV. MGT. DEPT.	http://www.edcgov.us/VectorControl/	(530) 573-3450
FRESNO	COALINGA-HURON MAD	P. O. Box 278, Coalinga, CA 93210	(559) 935-1907
FRESNO	FRESNO MVCD	http://www.fresnomosquito.org	(559) 268-6565
FRESNO	FRESNO WESTSIDE MAD	PO Box 125, Firebaugh, CA 93622	(559) 659-2437
FRESNO / KINGS	CONSOLIDATED MAD	http://www.mosquitobuzz.net	(559) 896-1085
GLENN	GLENN CO MVCD	165 County Rd. G, Willows, CA 95988	(530) 934-4025
IMPERIAL	IMPERIAL CO VCP	http://www.icphd.org/sub.php?menu_id=307	(760) 336-8530
INYO	INYO COUNTY DEPT OF AG OWENS VALLEY MAP	http://www.inyomonoagriculture.com/ovmap.html	(760) 873-7853
KERN	DELANO MAD	PO Box 220, Delano, CA 93216	(661) 725-3114
KERN	KERN MVCD	4705 Allen Road, Bakersfield, CA 93314	(661) 589-2744
KERN	SOUTH FORK MAD	P. O. Box 750, Kernville, CA 93238	(760) 376-4268

COUNTY	AGENCY	WEBSITE or ADDRESS	TELEPHONE
KERN	WEST SIDE MVCD	PO Box 205, Taft, CA 93268	(661) 763-3510
KINGS	KINGS MAD	PO Box 907, Hanford, CA 93232	(559) 584-3326
LAKE	LAKE CO VCD	http://www.lcvcd.org	(707) 263-4770
LOS ANGELES	ANTELOPE VALLEY MVCD	http://www.avmosquito.org	(661) 942-2917
LOS ANGELES	COMPTON CREEK MAD	1224 S. Santa Fe Avenue, Compton, CA 90221	(310) 933-5321
LOS ANGELES	GREATER LOS ANGELES CO VCD	http://glacvcd.org	(562) 758-6501
LOS ANGELES	LONG BEACH CITY DHHS	http://www.longbeach.gov/health/eh/vector/	(562) 570-4170
LOS ANGELES	LOS ANGELES CO DHS, VMP	http://www.lapublichealth.org/eh/SSE/Vector_Management/vecman.htm	(626) 430-5450
LOS ANGELES	LOS ANGELES CO WEST VCD	http://www.lawestvector.org	(310) 915-7370
LOS ANGELES	PASADENA CITY HD	http://www.cityofpasadena.net/publichealth/environmental_health_sevices/	(626) 744-6062
LOS ANGELES	SAN GABRIEL VALLEY MVCD	http://www.sgvmosquito.org	(626) 814-9466
MADERA	MADERA CO MVCD	http://maderamosq.org/	(559) 674-6729
MARIN / SONOMA	MARIN / SONOMA MVCD	http://www.msmosquito.com/	(707) 285-2204
MERCED	MERCED CO MAD	http://mcmosquito.org/	(209) 722-1527
MODOC	CA PINES CSD	HCR Box 43002, Alturas, CA 96101	(530) 233-2766
MODOC	CITY OF ALTURAS	http://www.cityofalturas.org	(530) 223-2377
MONO	JUNE LAKE PUD	P. O. Box 99, June Lake, CA 93529	(760) 648-7778
MONO	MAMMOTH LAKES MAD	PO Box 1943, Mammoth Lakes, CA 93546	(760) 924-8240
MONTEREY	NORTHERN SALINAS VALLEY MAD	http://www.montereycountymosquito.com/Site/Welcome.html	(831) 422-6438
NAPA	NAPA CO MAD	http://www.napamosquito.org	(707) 553-9610
NEVADA	NEVADA COUNTY COMMUNITY DEVELOPMENT AGENCY	http://www.mynevadacounty.com/nc/cda/eh/Pages/West-Nile-virus-Information.aspx	(530) 265-1500
ORANGE	ORANGE CO VCD	http://www.ocvcd.org	(714) 740-4150

COUNTY	AGENCY	WEBSITE or ADDRESS	TELEPHONE
PLACER	PLACER MVCD	http://www.placermosquito.org	(916) 380-5444
RIVERSIDE	BLYTHE CITY PWD	http://www.cityofblythe.ca.gov/index.aspx?NID=108	(760) 922-6611
RIVERSIDE	COACHELLA VALLEY MVCD	http://www.cvmvcd.org	(760) 342-8287
RIVERSIDE	NORTHWEST MVCD	http://www.northwestmosquitovector.org/Northwest_MVCD/Home.html	(951) 340-9792
RIVERSIDE	RIVERSIDE CITY PWD	http://www.riversideca.gov/pworks/vector-control.asp	(909) 351-6127
RIVERSIDE	RIVERSIDE CO DEH, VCP	http://www.rivcoeh.org/opencms/rivcoeh/ProgServices/Food_Program/Vector.html	(909) 358-5172
SACRAMENTO / YOLO	SACRAMENTO-YOLO MVCD	http://www.fightthebite.net	(916) 685-1022
SAN BERNARDINO	SAN BERNARDINO CO VCP	http://www.sbcounty.gov/ehlus/Depts/VectorControl/mosquito_and_vector_control_home.aspx	(909) 387-4688
SAN BERNARDINO	WEST VALLEY MVCD	http://www.wvmosquito.org	(909) 635-0307
SAN DIEGO	SAN DIEGO CO DEH, VSC	http://www.sdcounty.ca.gov/deh/pests/vector_disease.html	(858) 694-2888
SAN FRANCISCO	SAN FRANCISCO DPH	http://www.sfdph.org/dph/EH/Vector/default.asp	(415) 252-3988
SAN JOAQUIN	SAN JOAQUIN CO MVCD	http://sjmosquito.org	(209) 982-4675
SAN MATEO	SAN MATEO CO MVCD	http://www.smcmad.org	(650) 344-8592
SAN MATEO	SOUTH BAYSIDE SYSTEM AUTHORITY	http://www.sbsa.org/	(650) 594-8411
SANTA BARBARA	SANTA BARBARA COASTAL VCD	http://www.sbcvcd.org	(805) 969-5050
SANTA CLARA	SANTA CLARA CO VCD	http://www.sccgov.org/portal/site/vector	(408) 918-4770
SANTA CRUZ	SANTA CRUZ CO MVCD	http://www.agdept.com/mvc.html	(831) 454-2590
SHASTA	BURNEY BASIN MAD	PO Box 1049, Burney, CA 96013	(530) 335-2133
SHASTA	PINE GROVE MAD	PO Box 328, MacArthur, CA 96056	(530) 336-5740
SHASTA	SHASTA MVCD	http://www.shastamosquito.org/	(530) 365-3768
SOLANO	SOLANO CO MAD	http://www.solanomosquito.com	(707) 437-1116

COUNTY	AGENCY	WEBSITE or ADDRESS	TELEPHONE
STANISLAUS	EAST SIDE MAD	http://www.eastsidemosquito.com	(209) 522-4098
STANISLAUS	TURLOCK MAD	http://mosquitoturlock.com	(209) 634-8331
STATEWIDE	CALIFORNIA DEPARTMENT OF PUBLIC HEALTH VECTOR-BORNE DISEASE SECTION	http://www.westnile.ca.gov/	(916) 552-9730
SUTTER / YUBA	SUTTER-YUBA MVCD	http://www.sutter-yubamvcd.org/	(530) 674-5456
TEHEMA	TEHAMA CO MVCD	PO Box 1005, Red Bluff, CA 96080	(530) 527-1676
TULARE	DELTA VCD	http://www.deltavcd.com	(559) 732-8606
TULARE	TULARE MAD	6575 Dale Fry Road, Tulare, CA 93274	(559) 686-6628
VENTURA	MOORPARK CITY VCD	http://ci.moorpark.ca.us/cgi-bin/htmlos.exe/03565.1.14766059450000012944	(805) 517-6248
VENTURA	VENTURA CO EHD	http://www.ventura.org/rma/envhealth/technical-services/vector/index.html	(805) 654-2818

Appendix A
Mosquito Control and Arbovirus Surveillance

Mosquito Control Practices

Mosquito control agencies and private landowners in California work cooperatively to implement an integrated pest management (IPM) approach to mosquito control. Source reduction (eliminating the places where mosquito larvae hatch and develop) is the most effective way of preventing adult mosquitoes; however, it may be possible to eliminate mosquito production from a source through other modifications of habitat and/or water management. Biological control agents, including native or introduced predators, are often utilized in combination with water management practices. Pesticides are an important part of an IPM program and mosquito specific larval control pesticides are often used to supplement other source reduction activities. When source reduction and larval control have not adequately reduced the mosquito population, the application of pesticides to control adult mosquitoes may be necessary. Personnel working for vector control agencies who apply pesticides in California are certified by California Department of Public Health (CDPH) after demonstrating the knowledge necessary to control mosquitoes safely and effectively using IPM techniques.

Larval Control

Larval control is the foundation of most mosquito control programs in California. Whereas adult mosquitoes are widespread in the environment, larvae must have water to develop; control efforts therefore can be focused on aquatic habitats. Minimizing the number of adults that emerge is crucial to reducing the incidence and risk of disease. The three key components of larval control are environmental management, biological control, and chemical control.

Environmental Management

Manipulating or eliminating potential mosquito breeding sources can provide dramatic reductions in mosquito populations. There are three levels of environmental management.

1. Source elimination: This approach completely eliminates potential habitats for mosquitoes. This strategy is generally limited to artificial habitats created by urbanization. Examples of source elimination include emptying or turning over containers holding water, filling in holes containing water with sand or gravel, cleaning drainage ditches of debris, and covering or inverting structures and vessels that could hold water.

2. Source reduction: This strategy aims to alter and sometimes eliminate available habitat for larvae which substantially reduces mosquito breeding and the need for

repeatedly applying pesticides. Unlike source elimination, standing water may exist but the total amount of water, or the time the water is left standing, is greatly reduced. Source reduction may require some maintenance (see below) to prevent further mosquito breeding. Examples of source reduction include limiting the growth of emergent vegetation in wetlands and ponds, constructing drainage ditches to remove water from areas prone to flooding, and clearing stormwater channels of silt and debris. Routine larval monitoring can indicate whether these efforts are effective or need further action.

3. Source maintenance: When eliminating or significantly altering mosquito breeding sources is prohibited and/or inappropriate, reducing the number of sheltered, predator-free habitats while having minimal impact on the surrounding environment can make an area unsuitable for mosquitoes. Source maintenance can include water management, vegetation management, wetland infrastructure maintenance, and wetland restoration. Strategic, focused plans must be developed for each site.

Biological Control

Biological control uses predators, parasites, or pathogens to reduce populations of mosquito larvae and is often combined with environmental management to enhance results. The mosquitofish (*Gambusia affinis)* has been used to control mosquitoes in California since 1921 and is the most widely used biological control agent in the world. These small fish are effective against mosquito larvae because they grow and reproduce rapidly, feed at the water surface where mosquito larvae are found, and tolerate a wide range of temperature and water quality.

Other fish are occasionally used with mixed success. Fish are most effective in permanent ponds and wetlands, but are also used in rice fields and stormwater canals with permanent water. Many local mosquito control agencies propagate mosquito-eating fish.

Although many other animals have been tested for mosquito control, and in natural wetlands predation is an important factor in reducing mosquito production, biological control by the intentional addition of mosquito predators other than mosquitofish is largely experimental rather than operational.

Chemical Control

Pesticides that control mosquito larvae are called larvicides. Four types of larvicides (bio-rational, surface films, growth regulators, and chemical products) encompassing seven active ingredients are registered for use in California. Larvicides are applied by hand, from hand-held or vehicle-mounted engine-driven blowers, or by aircraft, depending on the product, the formulation, and the target habitat. Applicators of any of these products must be certified by the CDPH or an appropriate regulatory authority.

1. Bio-rational products

Bio-rational products exploit insecticidal toxins found in certain naturally occurring bacteria. These bacteria are cultured in mass and packaged in various formulations. The bacteria must be ingested by mosquito larvae so the toxin is released. Therefore bio-rational products are only effective against larvae since pupae do not feed. The bacteria used to control mosquito larvae have no significant effects on non-target organisms when applied for mosquito control in accordance with product labels.

Two products that are used against mosquito larvae singly or in combination are *Bacillus thuringiensis israelensis* (Bti) and *Bacillus sphaericus* (Bs). Manufactured Bti contains dead bacteria and remains effective in the water for 24 to 48 hours; some slow release formulations provide longer control. In contrast, Bs products contain spores that in favorable conditions remain effective for more than 30 days. Both products are safe enough to be used in water that is consumed by humans.

Another bio-rational product available for mosquito control is derived from the soil bacterium *Saccharopolyspora spinosa,* which produces natural metabolites called spinosyns during fermentation. These metabolites are lethal to mosquito larvae when ingested or by contact. The most active metabolites are formulated into a product called “spinosad”. The product affects the central nervous system of the mosquito causing uncontrolled nervous impulses, ultimately killing the larvae.

2. Surface agents

Mosquito larvae and pupae breathe through tubes called “siphons” that extend above the water surface. Surface agents such as highly refined mineral oils or monomolecular films (alcohol derivatives) can spread across the surface of the water to prevent mosquitoes from breathing. Depending on the product, the film may remain on the water’s surface from a few hours to a few days. Surface films are the only available products that are effective against very late stage larvae and pupae.

3. Insect growth regulators

Insect growth regulators (IGRs) disrupt the physiological development of larvae thus preventing adults from emerging. The two products currently used for controlling mosquito larvae are methoprene and diflubenzuron.

The effective life of these products varies with the formulation. Methoprene can be applied in granular, liquid, pellet, or briquette formulation. Methoprene has minimal non-target effects and no use restrictions. Diflubenzuron is rarely used in California because it may affect growth of non-target aquatic invertebrates. IGRs for mosquito control can be used in sources of water that are consumed by humans.

4. Chemical larvicides

Chemical pesticides are rarely used to control mosquito larvae. Organophosphate larvicides are used infrequently because of their potential non-target effects and label restrictions. The organophosphate pesticides temephos and malathion are registered for use as larvicides in California. However, malathion is currently used exclusively for adult mosquito control in the state. Temephos can be safely and effectively used to treat temporary water or highly polluted water where there are few non-target organisms and/or livestock are not allowed access. The efficacy of temephos may be up to 30 days depending on the formulation.

Adult Control

IPM mosquito control programs initiate adult mosquito control when action levels or thresholds are reached or exceeded. Thresholds are based on local sampling of the adult mosquito population and/or when the risk of mosquito-borne disease increases above levels established by a local agency, often following guidelines established in the California Mosquito-borne Virus Surveillance and Response Plan. Thresholds are an integral component of mosquito control because they provide a range of predetermined actions based on quantified data. Thresholds also establish expectations and boundaries for responses that ensure appropriate mosquito control activities are implemented at the appropriate time. The threshold for adult mosquito control depends on several factors including:

- How local citizens tolerate nuisance mosquitoes by evaluating public service requests.
- Overall mosquito abundance.
- Presence of mosquito-borne disease in the region.
- Abundance of mosquito species that are vectors of disease.
- Local acceptance of adult mosquito control activities.
- Climate data.

Adult mosquitoes can only be controlled with adulticides. Many mosquito control programs in California include adulticiding as an integral component of their IPM program. Adulticiding falls into two categories – barrier applications and ultra-low volume (ULV) applications. Barrier applications target resting mosquitoes by applying pesticides to vegetation and structures. Barrier applications typically cover relatively small areas and are applied to alleviate specific problems rather than an area wide adult mosquito problem.

ULV applications are used to control adult mosquitoes over large areas. An “ultra-low volume” (typically less than 2 oz / acre [140 ml / ha] total volume) of tiny oil or water droplets carrying an insecticide are emitted from specialized equipment mounted to trucks or aircraft. The droplets kill adult mosquitoes on contact. ULV applications are made after sunset or before sunrise to coincide with the time that mosquitoes are most

active, when non-target insects are least active, and when temperature inversions are most likely to occur. These applications are employed when mosquito populations must be reduced immediately to halt disease transmission. Multiple applications in a particular area may be utilized when the objective is to kill a high enough proportion of older adult mosquitoes to break a disease transmission cycle.

Adverse effects from ULV applications are rare; however, people with health problems should be aware when and where the applications are being conducted. This information can be obtained by contacting the local vector control agency. Chemicals currently registered for ULV applications against mosquitoes in California (as of June, 2010) include organophosphates (e.g., malathion and naled), pyrethrins, (e.g., pyrethrum) and pyrethroids (e.g., resmethrin, sumithrin, permethrin, and etofenprox). With the exception of the active ingredient etofenprox, formulations of both pyrethrins and pyrethroids include the synergist piperonyl butoxide (PBO), which increases their activity against mosquitoes.

1. Organophosphates

   Malathion and naled are neurotoxins that act by blocking the enzyme cholinesterase, inhibiting neurologic transmission. Malathion or naled may be used as rotational products with pyrethroid insecticides to help prevent development of pesticide resistance.

2. Pyrethrins

   Pyrethrins and pyrethroids are neurotoxins that act by causing uncontrolled firing of neurons. Pyrethrum is a natural insecticide derived from chrysanthemum flowers. Adult mosquitoes are rapidly paralyzed and killed on contact. Pyrethrins are degraded rapidly by sunlight and chemical processes. Residual pyrethrins from ULV applications typically remain less than one day on plants, soil, and water.

3. Pyrethroids

   Pyrethroids are manufactured pyrethrins. They have very low toxicity to birds and mammals but are toxic to fish if misapplied.

Compounds currently approved for larval and adult mosquito control in California are listed in Appendix B.

Mosquito Surveillance

Mosquito and Mosquito-Borne Disease Monitoring

Monitoring mosquito populations and mosquito-borne disease levels provides the necessary data to make informed management decisions.

The application of any pesticide to control mosquitoes in an IPM program is done after establishing the need to do so through mosquito population monitoring (surveillance).

Larval mosquito surveillance is the process of identifying and checking likely larval developmental sites for immature mosquitoes and treating the water to kill the mosquitoes prior to them emerging as flying, biting adults.

Adult mosquito surveillance is accomplished through a network of traps and through mosquito annoyance reports. Adult mosquito surveillance is a critical component of determining where mosquitoes are coming from, the potential for disease transmission in an area, and the need for adult mosquito control. Districts also use adult surveillance as a feedback or quality control mechanism to determine how effective the overall program is in reducing mosquito populations. Trapping adult mosquitoes and submitting those mosquitoes to test for diseases is often one component of a mosquito-vectored disease surveillance program. Collecting baseline data on mosquito populations and mosquito-borne disease also helps target educational efforts.

Mosquito Surveillance Techniques

1. Larval surveillance

   Larval surveillance is the routine sampling of aquatic habitats for developing mosquitoes. The primary tool is the “dip count” which indicates whether a habitat is producing mosquitoes and estimates larval density. A one-pint cup attached to a long handle is used to collect a standard volume of water (“dip sample”). The “dip count” may be expressed as the number of immature (larvae and pupae) mosquitoes per dip, per unit volume, or per unit surface area of the site.

2. Adult surveillance

   Several types of traps are used for adult surveillance, because mosquitoes are attracted to different traps depending on their species, sex, and physiological condition. The most common traps use light, carbon dioxide, water for egg laying, and a resting area. Trapped adults provide information about local distribution,

density, and identity. The size of an adult mosquito population can also be assessed by the number and distribution of service requests from the public. Data are used to help locate new sources of mosquitoes or known sources with a recurrent problem

Annoyance Biting

Many species of mosquitoes are not important as vectors of disease, but can cause serious injury and discomfort to humans and animals. Each time a female mosquito pierces the skin to take blood, she contaminates the wound with her saliva, creating the potential for a mild allergic reaction. The common symptom of mosquito bites is irritated and swollen skin surrounding the bite with persistent itching for several days. Scratching these bites to alleviate the itching can result in secondary bacterial infections. In addition, when mosquito populations explode, the sheer number of mosquitoes attempting to bite can make life miserable.

Mosquitoes as Disease Vectors

Mosquitoes are the most important insect vectors of disease worldwide, causing millions of human deaths every year. Mosquito-borne pathogens are typically transmitted or “vectored” when a mosquito ingests a disease causing organism, the organism reproduces inside the mosquito, and is subsequently injected along with saliva into another animal or human host. The potential or “competence” to vector any particular disease causing organism varies greatly among mosquito species.

California has a long history of mosquito-borne disease. Mosquito control programs were first developed in the early 1900s to combat malaria and other diseases, and to reduce populations of nuisance mosquitoes. Currently, there are 12 mosquito-borne viruses recognized in California; however, only West Nile virus (WNV), western equine encephalomyelitis (WEE), and Saint Louis encephalitis (SLE) are significant threats to public health. Global trade and travel will continue to provide an avenue for introducing or re-introducing other mosquito-borne pathogens and their vectors into California and the United States. The diseases of greatest concern include Japanese encephalitis, dengue, yellow fever, Rift Valley fever, chikungunya, Venezuelan encephalitis, and malaria.

Virus Surveillance

In 2000, CDPH collaborated with the University of California, Davis, the California Department of Food and Agriculture, local mosquito and vector control agencies, and other state and local agencies to develop a comprehensive statewide surveillance program to detect and monitor WNV activity. More than 70 local mosquito and vector control districts and agencies, environmental health agencies, and county public health departments throughout California routinely contribute to the program. Surveillance includes testing for WNV infections in humans, horses, mosquitoes, wild birds, and “sentinel” chicken flocks located throughout California. The program also includes

testing dead birds reported by the public for infections with WNV. A special website (http://www.westnile.ca.gov/) and toll-free hotline (877-WNV-BIRD) were created and are maintained by CDPH to support this surveillance program. The information from the program allows CDPH and local agencies to identify conditions conducive to WNV transmission and areas with elevated risk. This information is used by local mosquito control agencies to reduce the threat of WNV transmission to humans.

Mosquito Transmitted Diseases

Landowners throughout California, mosquito and vector control agencies, health departments, and CDPH work together to protect Californians from mosquito-borne diseases. Work to minimize the risk of disease transmission includes 1) comprehensive mosquito surveillance and control efforts on private and public lands, 2) agencies providing technical guidance and information to the medical and veterinary communities, and 3) educating the public about mosquitoes, the diseases they carry, and personal protective measures.

Encephalitis

Several mosquito-borne viruses that occur in California can cause encephalitis. The majority of human infections with these viruses have no symptoms. Those with so-called mild symptoms can still have significant illness and face prolonged recovery, and severe cases can be fatal or cause permanent neurological damage. There are several species of mosquitoes in California that can transmit WNV, SLE, and WEE viruses to people and animals. The most important species belong to the genus *Culex*. Specifically *Cx. tarsalis*, *Cx. pipiens*, and *Cx. quinquefasciatus* are significant public health concerns because of their widespread distribution throughout the state, their proximity to humans, and their capacity as very efficient vectors.

West Nile Virus

West Nile virus has become an endemic disease in California and like other encephalitic viruses, can cause serious illness. Many people who are infected do not get sick or may have a variety of symptoms that can include fever, head and body aches, nausea, vomiting, swollen lymph glands, and skin rash. Only about one in 150 infected people will develop a serious illness that may require hospitalization. Elderly people are at highest risk of developing the severe form of WNV and are at an increased risk of long-lasting physical and mental disorders. The severe form of the disease can be fatal.

Malaria

Malaria is caused by four species of protozoa. The parasites destroy red blood cells causing severe fever and anemia. Left untreated, malaria can cause kidney failure, coma, and death. Malaria was once a common public health threat in California and

much of the southern United States, but it was eradicated by intensive mosquito control efforts and the discovery of anti-malarial drugs. However, the disease still occurs in many other countries worldwide, creating a perpetual risk of re-introduction, especially from infected travelers and immigrants. The *Anopheles* mosquitoes capable of transmitting malaria still occur in many areas of California.

Canine Heartworm

Canine heartworm occurs worldwide. It is caused by a filarial nematode transmitted by *Aedes* and some *Culex* mosquitoes that can infect domestic dogs, wild canines (e.g., foxes, coyotes, wolves), and cats. The tiny worms migrate through the body to the heart and cause thickening and inflammation of the heart, which can lead to difficulty in breathing, chronic cough, vomiting, and can sometimes be fatal.

Appendix B
Compounds Approved for Mosquito Control in California

Pesticides used for mosquito control have been evaluated for this purpose by the U.S. Environmental Protection Agency (EPA) and found to pose minimal risks to human health and the environment when used according to label directions. For updated information on specific products approved for use in California, please refer to the California Department of Pesticide Regulation website: http://www.cdpr.ca.gov/docs/label/labelque.htm.

Mosquito and vector control programs that apply pesticides to a water of the United States for the purpose of controlling any vector are required to obtain a National Pollution Discharge Elimination System (NPDES) Permit for Biological and Residual Pesticide Discharges to Waters of the United States. More information on the permit, issued by the State Water Resources Control Board, can be found at: http://www.waterboards.ca.gov/water_issues/programs/npdes/aquatic.shtml#davcp.

The components of this appendix have been adapted from the California Mosquito-Borne Virus Surveillance and Response Plan; please refer to the following website for more information: http://www.westnile.ca.gov.

The use of pesticides to control mosquitoes should be the last resort after BMPs outlined in this manual have been implemented. Individuals considering applying a pesticide must be adequately trained and always apply pesticides according to label directions. In California, local mosquito control agency employees must pass a testing and certification process through CDPH before they can apply pesticides to control mosquitoes. Similarly, commercial pesticide applicators must be appropriately certified by the California Department of Pesticide Regulation. Private landowners applying general use pesticides to control mosquitoes solely on their own property are not required to be certified; however, landowners have the same legal responsibility with regard to pesticide and environment related laws. Private citizens considering using pesticides should consult their County Agricultural Commissioner and the California Department of Fish and Game before application.

Examples of products containing specific active ingredients are provided below, but this is not an inclusive list nor constitutes product endorsement. For more information on pesticides and mosquito control, please refer to the U.S. EPA website: http://www.epa.gov/pesticides/health/mosquitoes/mosquito.htm.

Larvicides

1. *Bacillus thuringiensis*, subspecies *israelensis* (Bti: e.g., Aquabac 200G, VectoBac® 12AS, Teknar HP-D)
   Use: Approved for most permanent and temporary bodies of water.

Limitations: Only works on actively feeding stages. Does not persist well in the water column.

2. *Bacillus sphaericus* (Bs: e.g., VectoLex® CG)
   Use: Approved for most permanent and temporary bodies of water.
   Limitations: Only works on actively feeding stages. Does not work well on all species. May persist and have residual activity in some sites.

3. Spinosad (bacteria derived natural insecticide: e.g., Natular G)
   Use: Approved for most permanent and temporary bodies of water.
   Limitations: Only works on mosquito larvae.

4. IGRs (Insect Growth Regulators)
   a. (S)-Methoprene (e.g., Altosid® Pellets)
   Use: Approved for most permanent and temporary bodies of water.
   Limitations: Works best on older instars. Some populations of mosquitoes may show some resistance.
   b. Diflurobenzuron (e.g., Dimilin®25W)
   Use: Impounded tail water, sewage effluent, urban drains and catch basins.
   Limitations: Cannot be applied to wetlands, crops, or near estuaries.

5. Larviciding oils (e.g., GB-1111, BVA 2 Mosquito Larvicide Oil)
   Use: Ditches, dairy lagoons, floodwater. Effective against all stages, including pupae.
   Limitations: Consult with the California Department of Fish and Game for local restrictions.

6. Monomolecular films (e.g., Agnique® MMF)
   Use: Most standing water including certain crops.
   Limitations: Does not work well in areas with unidirectional winds in excess of 10 mph.

7. Organophosphate compounds
   Temephos (e.g., Abate® 2-BG)
   Use: Non-potable water; marshes; polluted water sites
   Limitations: Cannot be applied to crops for food, forage, or pasture. This material may not be effective on some *Culex tarsalis* populations in the Central Valley.

Adulticides

1. Organophosphate compounds
   Note: Many *Culex tarsalis* populations in the Central Valley have shown resistance to OP pesticides at approved label rates.
   a. Malathion (e.g., Fyfanon® ULV)
      Use: May be applied by air or ground equipment over urban areas, some

crops including rice, wetlands.
Limitations: Paint damage to cars; toxic to fish, wildlife and bees; crop residue limitations restrict application before harvest.

b. Naled (e.g., Dibrom® Concentrate, Trumpet® EC)
Use: Air or ground application on fodder crops, swamps, floodwater, residential areas.
Limitations: Similar to malathion.

c. Chlorpyrifos (e.g., Mosquitomaster 412)
Use: Air or ground application in urban or recreational areas
Limitations: Not registered for use over agricultural commodities or grazing lands and may be toxic to bees, fish, and some wildlife.

2. Pyrethrins (natural pyrethrin products: e.g., Pyrenone® Crop Spray, Pyrenone® 25-5, Evergreen®)
Use: Wetlands, floodwater, residential areas, some crops.
Limitations: Do not apply to drinking water, milking areas; may be toxic to bees, fish, and some wildlife. Some formulations with synergists have greater limitations.

3. Pyrethroids (synthetic pyrethrin products containing deltamethrin, cyfluthrin, permethrin, resmethrin, sumithrin, or etofenprox: e.g., Suspend® SC, Tempo Ultra SC, Aqua-Reslin®, Scourge® Insecticide, Anvil® 10+10 ULV, and Duet, which also contains the mosquito exciter prallethrin)
Use: All non-crop areas including wetlands and floodwater.
Limitations: May be toxic to bees, fish, and some wildlife; avoid treating food crops, drinking water or milk production.

PESTICIDES USED FOR LARVAL MOSQUITO CONTROL IN CALIFORNIA

LARVICIDES

For updated information on specific products approved for use in California, please refer to the California **Department of Pesticide Regulation website: http://www.cdpr.ca.gov/docs/label/labelque.htm**

Active Ingredient	Trade name	EPA Reg. No.	MFG	Formulation	Application	Pesticide classification
Bacillus sphaericus, (Bs)	Spheratax SPH (50G) and WSP	84268-2	Adapco	Granule and Water soluble packet	Larvae	Biorational
Bacillus sphaericus, (Bs)	VectoLex CG and WSP	73049-20	Valent BioSciences	Granule and Water soluble packet	Larvae	Biorational
Bacillus sphaericus, (Bs)	VectoLex WDG	73049-57	Valent BioSciences	Water dispersible granule	Larvae	Biorational
Bacillus thuringiensis var. *israelensis* (Bti)	Aquabac 200G and Consume MP	62637-3	Becker Microbial	Granule	Larvae	Biorational
Bacillus thuringiensis var. *israelensis* (Bti)	Aquabac XT	62637-1	Becker Microbial	Liquid	Larvae	Biorational
Bacillus thuringiensis var. *israelensis* (Bti)	Bactimos PT	73049-452	Valent Biosciences	Granule	Larvae	Biorational
Bacillus thuringiensis var. *israelensis* (Bti)	Fourstar SBG	85685-1	Fourstar Microbials	Granule	Larvae	Biorational
Bacillus thuringiensis var. *israelensis* (Bti)	Summit Bti Briquets	6218-47	Summit Chemical	Briquet	Larvae	Biorational
Bacillus thuringiensis var. *israelensis* (Bti)	VectoBac 12AS	73049-38	Valent BioSciences	Liquid	Larvae	Biorational
Bacillus thuringiensis var. *israelensis* (Bti)	VectoBac G and GS	73049-10	Valent BioSciences	Granule	Larvae	Biorational
Bacillus thuringiensis var. *israelensis* (Bti)	VectoBac Tech. Powder	73049-13	Valent BioSciences	Technical powder	Larvae	Biorational
Bacillus thuringiensis var. *israelensis* (Bti)	VectoBac WDG	73049-56	Valent BioSciences	Technical powder	Larvae	Biorational
Bacillus thuringiensis var. *israelensis* (Bti)	Teknar HP-D	73049-404	Valent BioSciences	Liquid	Larvae	Biorational
Bacillus thuringiensis var. *israelensis* (Bti)	Teknar SC	73049-435	Valent BioSciences	Liquid	Larvae	Biorational
Bs and Bti	Vectomax G, CG, WSP	73049-429	Valent BioSciences	Granule and Packet	Larvae	Biorational
Bs and Bti	Fourstar Briquettes	83362-3	Fourstar Microbials	Briquette	Larvae	Biorational
Spinosad	Natular G	8329-80	Clarke	Granule	Larvae	Biorational
Spinosad	Natular 2EC	8329-82	Clarke	Liquid	Larvae	Biorational
Spinosad	Natular G30	8329-83	Clarke	Granule	Larvae	Biorational

Active Ingredient	Trade name	EPA Reg. No.	MFG	Formulation	Application	Pesticide classification
Spinosad	Natular T30	8329-85	Clarke	Tablet	Larvae	Biorational
Spinosad	Natular XRT	8329-84	Clarke	Tablet	Larvae	Biorational
Monomolecular film	Agnique MMF	53263-28	Cognis Corp.	Liquid	Larvae and pupae	Surface film
Monomolecular film	Agnique MMF G	53263-30	Cognis Corp.	Granule	Larvae and pupae	Surface film
Monomolecular film	Agnique MMF GPak 35	53263-30	Cognis Corp.	Water soluble packet	Larvae and Pupae	Surface film
Petroleum oil	BVA 2	70589-1	BVA Oils	Liquid	Larvae and pupae	Surface film
Petroleum oil	BVA Spray 13	55206-2	BVA Oils	Liquid	Larvae and pupae	Surface film
Petroleum oil	GB 1111	8329-72	Clarke	Liquid	Larvae and pupae	Surface film
Petroleum oil	Masterline Kontrol	73748-10	Univar	Liquid	Larvae and pupae	Surface film
Diflubenzuron	Dimilin 25W	400-465	Uniroyal Chemical	Wettable powder	Larvae	IGR
S-Methoprene	Altosid ALL	2724-392	Wellmark-Zoecon	Liquid	Larvae	IGR
S-Methoprene	Altosid Liquid Larvicide Concentrate	2724-446	Wellmark-Zoecon	Liquid concentrate	Larvae	IGR
S-methoprene	Altosid Briquets	2724-375	Wellmark-Zoecon	Briquet	Larvae	IGR
S-methoprene	Altosid Pellets	2724-448	Wellmark-Zoecon	Pellet-type granules	Larvae	IGR
S-methoprene	Altosid SBG	2724-489	Wellmark-Zoecon	Granule	Larvae	IGR
S-methoprene	Altosid XR	2724-421	Wellmark-Zoecon	Briquet	Larvae	IGR
S-methoprene	Altosid XR-G	2724-451	Wellmark-Zoecon	Pellet	Larvae	IGR
S-methoprene	Metalarv S-PT	73049-475	Wellmark-Zoecon	Pellet	Larvae	IGR
Temephos	Abate 2-BG	8329-71	Clarke	Granule	Larvae	OP

Active Ingredient	Trade name	EPA Reg. No.	MFG	Formulation	Application	Pesticide classification
Temephos	AllPro Provect 1G Larvicide	769-723	AllPro	Granule	Larvae	OP
Temephos	AllPro Provect 5G Larvicide	769-722	AllPro	Granule	Larvae	OP
Temephos	5% Skeeter Abate	8329-70	Clarke	Granule	Larvae	OP

PESTICIDES USED FOR ADULT MOSQUITO CONTROL IN CALIFORNIA
ADULTICIDES

For updated information on specific products approved for use in California, please refer to the California Department of Pesticide Regulation website: http://www.cdpr.ca.gov/docs/label/labelque.htm

Active Ingredient	Trade name	EPA Reg. No.	MFG	Formulation	Application	Pesticide classification
Malathion	Fyfanon® ULV	67760-34	Cheminova	Liquid	Adults	OP
Naled	Dibrom Concentrate	5481-480	AMVAC	Liquid	Adults	OP
Naled	TrumpetÔ EC	5481-481	AMVAC	Liquid	Adults	OP
Cyfluthrin	Tempo Ultra SC	432-1363	Bayer	Liquid	Adults	Pyrethroid
Deltamethrin	Suspend® SC	432-763	Bayer	Liquid	Adults	Pyrethroid
Permethrin	Aqua-Kontrol	73748-1	Univar	Liquid	Adults	Pyrethroid
Permethrin	Aqualeur 20-20	769-985	Value Garden Supply	Liquid	Adults	Pyrethroid
Permethrin	Aqua-Reslin®	432-796	Bayer	Liquid	Adults	Pyrethroid
Permethrin	Biomist® 4+4 ULV	8329-35	Clarke	Liquid	Adults	Pyrethroid
Permethrin	Biomist® 4+12 ULV	8329-34	Clarke	Liquid	Adults	Pyrethroid
Permethrin	Evoluer 4-4 ULV	760-982	Value Garden Supply	Liquid	Adults	Pyrethroid
Permethrin	Evoluer 30-30 ULV	760-983	Value Garden Supply	Liquid	Adults	Pyrethroid
Permethrin	Kontrol 2-2	73748-3	Univar	Liquid	Adults	Pyrethroid
Permethrin	Kontrol 4-4	73748-4	Univar	Liquid	Adults	Pyrethroid
Permethrin	Kontrol 30-30	73748-5	Univar	Liquid	Adults	Pyrethroid
Permethrin	Permanone® Ready-To-Use	432-1277	Bayer	Liquid	Adults	Pyrethroid
Permethrin	Permanone 31-66	432-1250	Bayer	Liquid	Adults	Pyrethroid
Permethrin	Perm-X UL 4-4	655-898	Prentiss	Liquid	Adults	Pyrethroid
Pyrethrins	Aquahalt	1021-1803	Clarke	Liquid	Adults	Pyrethroid
Pyrethrins	Evergreen 60-6	1021-1770	MGK	Liquid	Adults	Pyrethroid
Pyrethrins	Pyranone® 25-5	432-1050	Bayer	Liquid	Adults	Pyrethroid
Pyrethrins	Pyrenone® Crop Spray	432-1033	Bayer	Liquid	Adults	Pyrethroid
Pyrethrins	Pyrocide® 7067	1021-1199	Adapco	Liquid	Adults	Pyrethroid
Pyrethrins	Pyrocide® 7453	1021-1803	MGK	Liquid	Adults	Pyrethroid

Active Ingredient	Trade name	EPA Reg. No.	MFG	Formulation	Application	Pesticide classification
Pyrethrins	Pyrocide® 7395	1021-1570	MGK	Liquid	Adults	Pyrethroid
Pyrethrins	Pyrocide® 7396	1021-1569	MGK	Liquid	Adults	Pyrethroid
Pyrethrins	Pyronyl Crop Spray	655-489	Prentiss	Liquid	Adults	Pyrethroid
Pyrethrins	Pyronyl Oil 525	655-471	Prentiss	Liquid	Adults	Pyrethroid
Pyrethrins	Pyronyl Oil 3610A	655-501	Prentiss	Liquid	Adults	Pyrethroid
Resmethrin	Scourge® Insecticide (4%)	432-716	Aventis	Liquid	Adults	Pyrethroid
Resmethrin	Scourge® Insecticide (18%)	432-667	Aventis	Liquid	Adults	Pyrethroid
Sumithrin	Anvil® 2+2 ULV	1021-1687	Clarke	Liquid	Adults	Pyrethroid
Sumithrin	Anvil® 10+10 ULV	1021-1688	Clarke	Liquid	Adults	Pyrethroid
Sumithrin	AquaAnvil®	1021-1807	Clarke	Liquid	Adults	Pyrethroid
Prallethrin Sumithrin	Duet	1021-1795	Clarke	Liquid	Adults	Pyrethroid
Prallethrin Sumithrin	AcuaDuet	1021-2562-8329	Clarke	Liquid	Adults	Pyrethroid
Etofenprox	Zenivex E4 RTU	2724-807	Wellmark, Intl.	Liquid	Adults	Pryethroid
Etofenprox	Zenivex E20	2724-791	Wellmark, Intl.	Liquid	Adults	Pryethroid
Lambda-cyhalothrin	Demand CS	100-1066	Syngenta	Liquid	Adults	Pryethroid

Appendix C
Health and Safety Codes Pertinent to Mosquito Control

In California, mosquito and vector control agencies are regulated by sections of the California Health and Safety (H&S) Code, Food and Agriculture Code, California Code of Regulations, and others. The following components of this appendix have been adapted from the Overview of Mosquito Control Practices in California, California Department of Public Health: http://www.westnile.ca.gov/resources.php

Governing laws and regulations

Many federal and state laws govern the activities of vector control agencies, including the Clean Water Act (CWA), the Endangered Species Act (ESA), and the Federal Insecticide Fungicide and Rodenticide Act (FIFRA). Pesticide application by vector control agencies in California is regulated under FIFRA. FIFRA is administered through the U.S. Environmental Protection Agency, and regulates the registration, labeling, and sales of pesticides in the United States.

The California H&S Code encourages the formation of local mosquito control programs to protect the public health, safety, and welfare (H&S Code Section 2001-b) Website link: http://leginfo.ca.gov/cgi-bin/displaycode?section=hsc&group=01001-02000&file=2000-2007. The legal responsibility of landowners in California to avoid causing a public nuisance, including mosquitoes is implied in the section. The potential consequences of failing to prevent a public nuisance are described in the Code sections listed below.

Under the H&S Code, local vector control agencies have the authority to conduct surveillance for vectors, prevent the occurrence of vectors, and legally abate production of vectors or public nuisance defined as “Any water that is a breeding place for vectors” and “Any activity that supports the development, attraction, or harborage of vectors, or that facilitates the introduction or spread of vectors.”(H&S Code Section 2002(j) and 2040). Vector control agencies also have authority to participate in review, comment, and make recommendations regarding local, state, or federal land use planning and environmental quality processes, documents, permits, licenses, and entitlements for projects and their potential effects with respect to vector production. (H&S Code Section 2041) Website link: http://caselaw.lp.findlaw.com/cacodes/hsc/2040-2055.html

Additionally, agencies have broad authority to influence landowners to reduce or “abate” the source of a vector problem. Actions may include imposing civil penalties of up to $1000 per day plus costs associated with controlling the vector. Agencies have authority to “abate” vector sources on private and publicly owned properties. (H&S Code Sections 2060-2065). Website link: http://caselaw.lp.findlaw.com/cacodes/hsc/2060-2067.html

Mosquito and vector control programs that enter into a cooperative agreement with the California Department of Public Health are exempted from some pesticide related laws under Title 3 of the California Code of Regulations Section 6620. Specifically, these agencies are exempted from "Consent to Apply" (Title 3, California Code of Regulations, Section 6616), "Notice" (Title 3, California Code of Regulations, Section 6618), and the "Protection of Persons, Animals, and Property" (Title 3, California Code of Regulations, Section 6614). Essentially, these provisions obviate the vector control agency from having to notify or get permission from landowners prior to applying a pesticide to their property in the interest of preserving the public health. Website link: http://www.cdpr.ca.gov/docs/legbills/calcode/030201.htm#a6620

A vector control technician working at a vector control agency must be a "certified technician" or work under the direct supervision of a "certified technician" to apply pesticides. Vector control technicians achieve certification through an examination process administered by the California Department of Public Health.

Vector control agencies cannot use any pesticide not registered for use in California, and are required to keep detailed records of each pesticide application, including date, location, and amount applied. All pesticides must be applied in accordance with the labeling of the product as registered with the U.S. EPA.

Appendix D
Mosquitoes of California

The biology and key characteristics of the four major mosquito genera in California are described below.

Aedes

There are about 80 species of *Aedes* mosquitoes in the continental United States; 24 species occur in California. Certain species are widespread, may occur in very large numbers, and are among the worst biting pests. *Aedes* mosquitoes do not lay their eggs directly on the surface of standing water. Instead, they lay single eggs on intermittently flooded surfaces such as the damp soil around irrigated pastures and fields, along the edges of coastal tidal marshes, and inside dry treeholes and containers. Eggs are extremely resistant to drying and will lie dormant on dry surfaces until flooding occurs (eggs of *Ae. vexans* have been documented to lie dormant for up to three years). This can lead to many generations of eggs in a given habitat if female mosquitoes lay successive batches of eggs before the area is flooded. When flooding occurs, large numbers of eggs hatch spontaneously and develop rapidly to adults. Although larval developmental sites vary greatly, the most productive include transient ground pools, flooded areas along overflowing streams, flood and stormwater control basins, intermittently flooded agricultural lands, and container habitats such as tree holes, wheel ruts, and discarded tires.

Aedes are primarily summer-breeding mosquitoes. Because of their rapid larval development in newly-flooded habitats, adults often emerge before predators can colonize the water source. Most *Aedes* complete two to several generations per year depending on the frequency of habitat flooding from natural and artificial events. Adults cannot survive in colder weather. Therefore the majority of *Aedes* overwinter as eggs.

Typically, *Aedes* mosquitoes found in California will not enter buildings and homes; however, they are strong fliers and are known to travel many miles from their aquatic developmental sites to search for hosts. *Aedes* mosquitoes are diurnal (i.e., active during the day) during mild weather, especially around shaded areas, but will also bite at dusk. Most *Aedes* females feed on large mammals like cattle and horses, but will readily feed on humans. *Aedes* mosquitoes are aggressive and persistent biters causing people and animals to avoid areas where their numbers are great. One example is the species *Ae. nigromaculis*, which are currently not known to vector disease, but are considered a serious pest because they will seek out human hosts and bite during the day when people are most likely to be outdoors and active.

Anopheles

Approximately 22 species of *Anopheles* are found in the continental United States and of these, 5 occur in California. When feeding, *Anopheles* adults rest with their abdomens positioned at a distinct angle to the surface of the skin, whereas other species orient their bodies parallel. Females lay single floating eggs directly on the

surface of permanent or semi-permanent standing water. A female can lay successive batches of up to 300 eggs during the breeding season. Eggs are not resistant to drying and typically hatch within two-three days, although hatching may take up to two-three weeks in colder climates. Larvae develop in 12 to 20 days, but can take longer in cooler weather. Preferred larval habitats include clear, fresh seepage water in sunlit or partly shaded pools, wetlands, roadside ditches, rice fields, and poorly maintained water troughs.

Adult females bite at dusk and dawn and prefer to feed on mammals. Many *Anopheles* mosquitoes prefer to feed on rabbits, but will also feed on large mammals such as livestock and humans. In California, *Anopheles* species may undergo two or more generations per year. Most species over-winter in protected areas as mated females, resuming activity the following spring. These are among the first mosquitoes to emerge and bite humans each year.

Historically, *Anopheles freeborni*, the western malaria mosquito, was a vector of malaria in California. Currently, with the disease eradicated from California and the United States, it is considered a nuisance mosquito. This species is widespread throughout California and females will lay their eggs in any standing fresh water, although it is abundant in rice fields or other wetlands during late summer. While most adult mosquitoes stay within a few miles of their breeding source, they will migrate further when seeking hibernation sites in fall. This can lead to a large influx of mosquitoes from uncontrolled areas to residential areas during September and October.

Culex

Culex, with 11 species found throughout the state is the second largest genus of mosquitoes in California, second only to *Aedes*. Females can lay up to seven rafts of eggs over a two-month life span; each raft contains from 100-300 eggs which are laid on the surface of standing water. *Culex* larvae occur in a broad range of aquatic sites ranging from containers such as discarded tires, water barrels, and flower pots to clogged gutters, catch basins, and water for irrigation and urban wastewater. During summer and periods of drought, areas without regularly flowing water, street drainage systems, and contaminated streams, ponds and pools become productive larval habitats. *Culex* larvae are known for thriving in polluted sources of water with a high organic content.

Culex mosquitoes prefer to take blood meals at dusk or after dark and can be painful and persistent biters. *Culex* preferably feed on birds but also feed on mammals including humans and horses. They readily enter houses and buildings in search of a suitable host. Two or more generations of *Culex* can occur per year. Females that emerge in late summer will mate and overwinter until the following spring or mid-summer.

Several species of *Culex* can transmit viruses that can cause encephalitis (i.e., inflammation of the brain), including WNV, SLE, and WEE. These mosquitoes are

efficient and effective vectors of these diseases among birds, humans, horses and many other wild and domestic animals.

Culex tarsalis

Culex tarsalis, the Western encephalitis mosquito, is one of California's most important and efficient vectors of WNV, SLE, and WEE. This species is widespread in California. *Cx. tarsalis* prefer to lay their eggs on fresh or lightly polluted standing water such as rice fields, ditches, pastures, waste water ponds, and seasonal wetlands. Other more urban freshwater sources include ornamental ponds, storm drains, and flood control channels. Larvae usually develop into adults in approximately 8-14 days; warmer water can shorten the developmental period. *Cx. tarsalis* are active from spring through fall; however the population in the Central Valley peaks in June to July with a secondary, smaller peak in September coinciding with flooding of seasonal wetlands. *Cx. tarsalis* survive through the winter as adults in barns, culverts, caves, and similar dark, protected places.

Adult *Cx. tarsalis* can disperse a great distance up to 10-15 miles (16-24 km) in search of blood meals, generally traveling along riparian corridors, but most stay close to the site where they emerged. Adults rest by day in shaded areas such as animal burrows and treeholes. Females prefer feeding between dusk and dawn but may bite during the day in deep shade. Females obtain blood meals from birds or mammals and can transmit diseases between these groups.

Culex pipiens* and *Culex quinquefasciatus

Culex pipiens (the northern house mosquito) and *Culex quinquefasciatus* (the southern house mosquito) appear to be identical. *Cx. quinquefasciatus* occurs in Southern California, whereas *Cx. pipiens* is found along the coastal regions and in Northern California and is the most widely distributed mosquito species in the world. Both species can transmit encephalitis viruses. They are common in and around households and prefer to lay eggs in polluted water that is high in organic content such as dairy runoff, wastewater catchment basins, stormwater ponds, dirty flower pots, bird baths, or any drainage systems where standing water exists.

In California, *Cx. pipiens* and *Cx. quinquefasciatus* typically do not disperse from where they emerged. Females feed at dusk or after dark, readily enter homes and prefer avian hosts but will also feed on large mammals including humans. *Cx. pipiens* and *Cx. quinquefasciatus* are vectors of WNV and SLE virus, and have also been implicated in transmitting canine heartworm.

Other *Culex* mosquitoes.

Culex stigmatosoma, the foul water mosquito, *Cx restuans* and *Cx. erythrothorax* can also be infected with WNV, but their distributions are limited (e.g., *Cx. erythrothorax* is mainly found close to bodies of water with tules).

Culiseta

Only eight species of *Culiseta* mosquitoes occur in the continental United States, of which four are found in California. Females lay clusters of floating eggs (rafts) on the surface of standing water. *Culiseta* mosquitoes are moderately aggressive biters, attacking in the evening hours or in shade during the day. Peak populations occur during the cooler months. These mosquitoes prefer to feed on larger domestic animals, such as cattle and horses, but will also feed on humans. The distribution of *Cs. inornata*, an unusually large mosquito, is widespread and can be found at elevations of up to 10,000 feet. Larvae of *Cs. inornata* develop in permanent water habitats, including shallow marshes, peat bogs, roadside ditches, abandoned gravel pits, and in standing water in soil cavities left by fallen trees. The common name of this mosquito—the Large Winter mosquito—reflects that it is most active in cool weather habitats.

Appendix E
Typical Larval Habitats of California Mosquitoes*

Riparian	Vernal Pools	Foul Water	Salt Marsh	Treehole
Aedes atropalpus	*Aedes bicristatus*	*Culex pipiens*	*Aedes dorsalis*	*Aedes deserticola*
Aedes washinoi	*Aedes campestris*	*Culex restuans*	*Aedes squamiger*	*Aedes purpureipes*
Aedes pullatus	*Aedes fitchii*	*Culex stigmatosoma*	*Aedes taeniorhynchus*	*Aedes sierrensis*
Aedes sticticus	*Aedes hemiteleus*	*Culex tarsalis*	*Anopheles occidentalis*	*Orthopodomyia signifera*
Aedes vexans	*Aedes increpitus*	*Culiseta impatiens*	*Culex tarsalis*	
Anopheles franciscanus	*Aedes niphadopsis*	*Culiseta incidens*	*Culiseta incidens*	
Anopheles occidentalis	*Aedes ventrovittis*	*Culiseta inornata*	*Culiseta inornata*	
Anopheles punctipennis	*Aedes washinoi*			
Culex apicalis	*Culex tarsalis*			
Culex boharti	*Culiseta incidens*			
Culex reevesi	*Culiseta inornata*			
Culex tarsalis	*Psorophora columbiae*			
Culex territans	*Psorophora signipennis*			
Culex thriambus				
Culiseta impatiens				
Culiseta incidens				
Culiseta particeps				
Culiseta inornata				
Small Container	**Freshwater Marsh**	**Rock Pools**	**Pools and Ponds**	**Snow Melt Pools**
Aedes sierrensis	*Aedes flavescens*	*Aedes sierrensis*	*Aedes sierrensis*	*Aedes cataphylla*
Culex pip/quinq	*Anopheles freeborni*	*Anopheles punctipennis*	*Culex pip/quinq*	*Aedes clivis*
Culiseta incidens	*Anopheles hermsi*	*Culex tarsalis*	*Culex stigmatosoma*	*Aedes communis*
	Anopheles occidentalis	*Culiseta impatiens*	*Culex tarsalis*	*Aedes hexodontus*
	Coquillettidia perturbans	*Culiseta incidens*	*Culiseta impatiens*	*Aedes increpitus*
	Culex erythrothorax		*Culiseta incidens*	*Aedes pullatus*
	Culex tarsalis		*Culiseta inornata*	*Aedes schizopinax*
	Uranotaenia anhydor		*Culiseta particeps*	*Aedes sticticus*
				Aedes tahoensis
				Aedes ventrovittis
				Culiseta incidens
Woodland Pools	**Irrigated Pastures**	**Permanent Ponds**		
Aedes bicristatus	*Aedes dorsalis*	*Aedes niphadopsis*		
Aedes increpitus	*Aedes melanimon*	*Aedes schizopinax*		
Aedes washinoi	*Aedes nigromaculis*	*Anopheles occidentalis*		
Aedes punctipennis	*Aedes thelcter*	*Culex anips*		
Culex apicalis	*Aedes vexans*	*Culex erythrothorax*		
Culex tarsalis	*Anopheles freeborni*	*Culex reevesi*		
Culex thriambus	*Culex tarsalis*	*Culex tarsalis*		
Culiseta incidens	*Culiseta inornata*	*Culiseta impatiens*		
Culiseta inornata	*Psorophora columbiae*	*Culiseta incidens*		
Culiseta particeps	*Psorophora signipennis*	*Culiseta particeps*		
		Culiseta inornata		
		Coquillettidia perturbans		
		Uranotaenia anhydor		

*Compiled from: Identification of the Mosquitoes of California. Rev. 1998. Mosquito and Vector Control Association of California.

Appendix F
Insect Repellents

A number of products have been developed and registered by the Environmental Protection Agency for human use that repel adult mosquitoes and thus reduce the chances of mosquito bites. The most commonly used mosquito repellents contain the active ingredient DEET (N,N-diethyl-meta-toluamide), which has been formulated and sold under a variety of trade names. Repellents are available in a variety of concentrations and are formulated as aerosol sprays (most commonly at 15%), lotions, and solids (up to 100%). Spray repellents can be used on outer clothing as well as sparingly on the skin to ensure complete coverage. Repellents should not be used under clothing. The percentage of DEET in the repellent reflects the approximate length of time the product will repel mosquitoes (e.g., 23.8% DEET = about five hours of protection, 20% = about four hours, and 6.6% DEET = about two hours).

Topical repellents that contain picaridin, IR-3535, and oil of lemon eucalyptus are similar in efficacy to those with DEET, but often require more frequent application. Clothing and other materials impregnated with permethrin during manufacture are also available. It is important to always carefully read and understand the benefits and limitations of repellents listed on the product label before use. By law, all repellent products must be used according to their labels.

Appendix G
Additional Resources and Information

Mosquito Biology

Additional information on mosquitoes and mosquito-borne diseases is easily obtainable from a variety of reputable sources. More information on mosquito biology and ecology is available on the American Mosquito Control Association (AMCA) and the Mosquito and Vector Control Association of California (MVCAC) websites. Local mosquito and vector control agencies and their respective websites can provide detailed information about local mosquito species. Information on mosquito-borne diseases is available from the Centers for Disease Control and Prevention (CDC) and the CDPH websites. Contact information for local mosquito and vector control agencies in California can be found through the CDPH website by entering the zip code of the location of interest under "**Locate Your Local Mosquito and Vector Control Agency**" at http://www.westnile.ca.gov/; more information is available on the MVCAC website.

Monitoring Mosquitoes and Diseases

More information about reporting dead birds and WNV surveillance in California can be found at http://www.westnile.ca.gov/.
Methods for sampling adult mosquitoes and guidelines for designing, operating, and processing of traps are discussed in Guidelines for Integrated Mosquito Surveillance (Meyer et al. 2003) and are summarized in Appendix B of the California Mosquito-Borne Virus Surveillance and Response Plan which can be found at: http://www.westnile.ca.gov/resources.php

The Centers for Disease Control and Prevention, Epidemic/Epizootic West Nile Virus in the United States: Guidelines for Surveillance, Prevention and Control http://cdc.gov/ncidod/dvbid/westnile/resources/wnv-guidelines-aug-2003.pdf

- Walton WE. 2005. Protocol for Mosquito Sampling for Mosquito Best Management Practices on State of California-Managed Wildlife Areas. University of California.

Health Department Websites

California Department of Public Health West Nile virus (WNV) website: http://www.westnile.ca.gov

United States Center for Disease Control and Prevention website: http://cdc.gov

US Centers for Disease Control and Prevention – West Nile Virus website: http://cdc.gov/ncidod/dvbid/westnile/index.htm

Disease Surveillance Websites

UC Davis Center for Vectorborne Diseases website: http://cvec.ucdavis.edu

California Vectorborne Disease Surveillance Gateway website: http://www.calsurv.org/

Best Management Practices

Best Management Practices for Mosquito Control on California State Properties: http://www.westnile.ca.gov/resources.php

- For additional information on personal protective measures and the use of chemical repellents, go to the Centers for Disease Control and Prevention (CDC) web site at: http://www.cdc.gov/ncidod/dvbid/westnile/RepellentUpdates.htm
- For more information on evaluating the efficacy of BMPs on state of California-managed Wildlife Areas, see Walton 2005.

Mosquito Control

American Mosquito Control Association website: http://www.mosquito.org

Mosquito and Vector Control Association of California website: http://www.mvcac.org

University of California at Davis Center for Vectorborne Diseases website: http://cvec.ucdavis.edu

University of California IPM Online website: http://www.ipm.ucdavis.edu/

State Water Resources Control Board NPDES General Permits: http://www.waterboards.ca.gov/water_issues/programs/npdes/aquatic.shtml#davcp

Additional Online Resources

Climate Information

National Weather Service – Climate Prediction Center website: http://www.cpc.ncep.noaa.gov/products/predictions

Water Related Information

California Data Exchange Center website: http://cdec.water.ca.gov

Pesticide and Insect Repellent Information

National Pesticide Telecommunications Network website: http://npic.orst.edu/factsheets/DEETgen.pdf

National Pesticide Information Center website: http://npic.orst.edu/

Agriculture and Crop Related Information

California Agricultural Statistics Service website: http://www.nass.usda.gov/ca

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List of Acronyms

AMCA	American Mosquito Control Association
BMP	Best Management Practices
Bs	Bacillus sphaericus
Bti	Bacillus thuringiensis israelensis
CDC	Centers for Disease Control and Prevention
CDPH	California Department of Public Health
CVEC	Center for Vectorborne Diseases (UC Davis)
DFG	California Department of Fish and Game
CDPR	California Department of Pesticide Regulation
EPA	Federal Environmental Protection Agency
H&S Code	California Health and Safety Code
MVCAC	Mosquito and Vector Control Association of California
NPDES	National Pollution Discharge Elimination System
SLE	St. Louis encephalitis virus
SWRCB	State Water Resources Control Board
UCD	University of California, Davis
WEE	Western equine encephalomyelitis virus
WNV	West Nile virus