ADDENDUM to Santa Cruz County Mosquito and Vector Control (MVC) Pesticides Application Plan (PAP) for General Permit No. CAG 990004

*The following **boldface text** was excerpted from pages 16-18 (VIII. C) of the Draft NPDES Permit for Vector Control, which specifies what must be included in the PAP and BMPs*

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**;

   See attached Santa Cruz County Hydrography map. The target area is potentially any fresh or brackish water within the boundaries of the County of Santa Cruz that are still or standing water sites for more than 96 hours (4 days), permanent or temporary, natural or man-made, that may or may not have potential inflow or outflow, high wetland or wildlife values or be hydrologically connected to other sites. A majority of these sites are subject to disturbance that makes them attractive to mosquitoes, such as by flooding by natural event or artificial means, or be subject to high organic nutrient load and reduced animal and plant diversity. Within this area there are also discrete artificial and natural containers that breed mosquitoes. Historically, most larvicides used by Santa Cruz County Mosquito and Vector Control (MVC) have been applied to areas of the 700 acre Watsonville Slough system, primarily to areas within the flight range of mosquito species of public health significance to human habitation and activity, heavily vegetated with poor circulation and low diversity. Some other sites requiring frequent treatment are inlet arms of Pinto Lake County Park that receive high nutrient runoff, and other margins and inlets of inland lakes with invasive floating and emergent vegetation such as Lake Tynan and Atkinson Lake, seasonal water bodies such as woodland pools, College Lake and the Ellicott Slough NWR ditches, terminal oceanside ponds and estuaries such as Neary Lagoon, Sunset State Beach marsh, Schwann Lake and the Watsonville Slough estuary at the Pajaro River. Most suburban drainages and streams and the San Lorenzo River require treatment of cut-off ponding and oxbows and because of seasonal low-flow ponding adjacent to man-made or natural obstructions.

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

   Please see the attached Statement of Best Management Practices for Santa Cruz County Mosquito and Vector Control and Best Mosquito Management – Santa Cruz County (see References). Both documents describe surveillance methods conducted by MVC to monitor abundance and distribution of the many mosquito species found in the County, and the reason why, after practicing or considering other Integrated Vector Management (IVM) options, mosquitocide intervention is sometimes appropriate and required to manage them once populations are found to exceed public health nuisance or disease thresholds or in response to requests for relief from pestiferous biting, strictly following pesticide labeling. Also attached is a schematic of the MVC's Mosquito Control Strategy and graphs of Larval Treatment Criteria and Control Selection Criteria (see References).

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 adjuvents and surfactants used;**

   The following list of products may be used by the MVC for larval or adult control. This list is directly from Attachment E and F within the NPDES Permit for Biological and Residual Pesticide Discharges to Waters of the U.S. for Vector Control Applications. Products may be applied by

hand, truck, backpack, hand can, boat , ATV, helicopter, or airplane and are used according to label directions. *Please note that the MVC has not used organophosphate mosquitocides and has not used adulticides since 1995. See also the MVC CEQA Technical Review (Section VI or 6) at http://www.agdept.com/content/MAD_techrev.pdf

List of Permitted Larvicide Products

Larvicide Product Name	Registration Number
Vectolex CG Biological Larvicide	73049-20
Vectolex WDG Biological Larvicide	73049-57
Vectolex WSP Biological Larvicide	73049-20
Vectobac Technical Powder	73049-13
Vectobac-12 AS	73049-38
Aquabac 200G	62637-3
Teknar HP-D	73049-404
Vectobac-G Biological Mosquito Larvicide Granules	73049-10
Vectomax CG Biological Larvicide	73049-429
Vectomax WSP Biological Larvicide	73049-429
Vectomax G Biological Larvicide/Granules	73949-429
Zoecon Altosid Pellets	2724-448
Zoecon Altosid Pellets	2724-375
Zoecon Altosid Liquid Larvicide Mosquito Growth Regulator	2724-392
Zoecon Altosid XR Entended Residual Briquets	2724-421
Zoecon Altosid Liquid Larvicide Concentrate	2724-446
Zoecon Altosid XR-G	2724-451
Zoecon Altosid SBG Single Brood Granule	2724-489
Mosquito Larvicide GB-1111	8329-72
BVA 2 Mosquito Larvicide Oil	70589-1
BVA Spray 13	55206-2
Agnique MMF Mosquito Larvicide & Pupicide	53263-28
Agnique MMF G	53263-30
Abate 2-BG	8329-71
5% Skeeter Abate	8329-70
Natular 2EC	8329-82
Natular G	8329-80
Natular XRG	8329-83
Natular XRT	8329-84
FourStar Briquets	83362-3
FourStar SBG	85685-1
Aquabac xt	62637-1
Spheratax SPH (50 G) WSP	84268-2

Larvicide Product Name	Registration Number
Spheratax SPH (50 G)	84268-2

List of Permitted Adulticide Products*

Adulticide Product Name	Registration Number
Pyrocide Mosquito Adulticiding Concentrate for ULV Fogging 7395	1021-1570
Evergreen Crop Protection EC 60-6	1021-1770
Pyrenone Crop Spray	432-1033
Prentox Pyronyl Crop Spray	655-489
Pyrocide Mosquito Adulticiding Concentrate for ULV Fogging 7396	1021-1569
Aquahalt Water-Based Adulticide	1021-1803
Pyrocide Mosquito Adulticide 7453	1021-1803
Pyrenone 25-5 Public Health Insecticide	432-1050
Prentox Pyronyl Oil Concentrate #525	655-471
Prentox Pyronyl Oil Concentrate or 3610A	655-501
Permanone 31-66	432-1250
Kontrol 30-30 Concentrate	73748-5
Aqualuer 20-20	769-985
Aqua-Reslin	432-796
Aqua-Kontrol Concentrate	73748-1
Kontrol 4-4	73748-4
Biomist 4+12 ULV	8329-34
Permanone RTU 4%	432-1277
Prentox Perm-X UL 4-4	655-898
Allpro Evoluer 4-4 ULV	769-982
Biomist 4+4	8329-35
Kontrol 2-2	73748-3
Scourge Insecticide with Resmethrin/Piperonyl Butoxide 18%+54% MF Formula II	432-667
Scourge Insecticide with Resmethrin/Piperonyl Butoxide 4%+12% MF Formula II	432-716
Anvil 10+10 ULV	1021-1688
AquaANVIL Water-based Adulticide	1021-1807
Duet Dual-Action Adulticide	1021-1795
Anvil 2+2 ULV	1021-1687
Zenivex E20	2724-791
Trumpet EC Insecticide	5481-481
Fyfanon ULV Mosquito	67760-34

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

Please see answer to Item #1. The MVC treated 1,706 sites with larvicides in 2010, many of which could meet the definition of waters of the U.S. Any standing water site that holds water for more than 96 hours (4 days) can produce mosquitoes. Source reduction is the MVC's preferred solution, and whenever possible the MVC works with property owners to effect long-term solutions to reduce or eliminate the need for continued applications as described in Best Management Practices for Mosquito Control in California and the MVC CEQA Technical Review (see References). Please see the attached Hydrography map of the County/application area. The typical sources treated by MVC include:

Habitat Type			
TYPE CODE	**HABITAT TYPE**	**ABBREVIATION**	**DESCRIPTION**
0	CATCH BASIN	CB	INCLUDES GUTTERS, STREET DRAINS AND BMPs
1	PERMANENT POND	PD	PONDS THAT HOLD WATER YEAR ROUND
2	EPHEMERAL POND	EP	NATURAL SEASONAL PONDING
3	FRESHWATER MARSH	MA	LOWLYING AREA OF SOFT WATERLOGGED GROUND, STANDING WATER, characterized by a growth of grasses, sedges, cattails, and rushes
4	BRACKISH MARSH	BM	SOMEWHAT SALTY MARSH
5	FLOODED AREA	FA	ANY AREA THAT EXPERIENCES INFREQUENT OR SEASONAL FLOODING FROM NATURAL OR IRRIGATION SOURCES
6	CHANNEL, DITCH	CH	MAN-MADE CONCRETE, WOODEN OR EARTHEN CHANNELS FOR WATER DIVERSION
7	AGRICULTURAL USE	AG	ALL MAN-MADE SOURCES CREATED FOR AGRICULTURAL USE
8	ARTIFICIAL CONTAINER	AC	KIDDIE POOLS, HORSE TROUGHS, JUNKYARD ITEMS, BOATS, BUCKETS, TARPS, ROOF TOPS, URNS, ORNAMENTAL PONDS, ETC.
9	MISCELLANEOUS PONDING	MP	RUTS, UNDER HOUSES, RAILROAD TRACKS
10	TREEHOLE	TH	HOLES IN THE TREE ITSELF
11	CREEK/STREAM/ NATURAL DRAINAGE	CK	NOT MAN-MADE; STAGNANT EDGES AND CUT-OFF SECTIONS
12	GREEN POOLS & JACUZZIS	GP	NEGLECTED
13	SEWAGE/SEPTIC	SE	INCLUDES PONDS, SEPTIC TANKS, DRAINS, TREATMENT PLANTS

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

With any mosquito or other vector source, the MVC's first goal is to look for ways to eliminate the source, or, if that is not possible, for ways to reduce the vector potential. The most commonly used methods and their limitations are included in the Best Management Practices for Mosquito Control in California (pages 9-19 and Appendix A) and attached Statement of Best Management Practices for Santa Cruz County Mosquito and Vector Control and Best Mosquito Management – Santa Cruz County (see References).

Specific BMP's incorporating IVM methods used by the MVC include collaborating with other agencies to improve wetland diversity, water quality and circulation (MVC is member of Watsonville Slough Stewardship Committee), stocking mosquito fish (*Gambusia affinis*) where this biological control method is appropriate, educating residents that mosquitoes develop in standing water and encouraging them to remove sources of standing water on their property (County Fair and Earth Day booths, radio advertising, press releases, etc.), and working with property owners to find long-term water and vegetation management strategies that meet their needs while minimizing the need for public health pesticide applications. The MVC also reviews development plans that create, restore or affect wetlands or stormwater BMP's to evaluate and consult on their vector potential. The MVC works with property owners, municipalities and agencies to use BMP's to reduce mosquitoes. Some examples include:

1. A trial to reduce invasive, exotic parrotfeather (*Myriophyllum* sp.) from Lake Tynan using aquatic glyphosate herbicide, leading to property owners controlling the weed with minimal herbicide use and reducing mosquito trap counts from thousands per night to tens.
2. Advising City of Santa Cruz on Jessie Street marsh management to reduce breeding habitat (See Comments on Jessie Street Marsh Management Plan, 2002 in References).
3. The MVC also reviews and comments on development plans that create, restore or affect wetlands or stormwater BMP's to evaluate, consult and reduce their vector potential. (Two examples: City of Watsonville - Slough housing developments; NPDES Phase II)
4. University of California – Santa Cruz, Arboretum pond mosquito reduction strategy implementing access improvements to target highest breeding areas with selective applications; advised clean-out of stormwater drains to reduce necessary treatments. (See University of California – Santa Cruz, Mosquito Monitoring and Treatment in References)
5. Using CA Conservation Corps grant and labor, collaborated to mechanically remove vegetation in trial to reduce mosquito breeding to area of Pinto Lake, 2010. Using CalFire trail crews, cut trail into and reduced vegetation within flood retention basin at Scotts Valley High School, 2010. Collaborated with SC Land Trust and used CalFire to cut perimeter trail around section of Hanson Slough for access to high breeding area, reducing need for repeated applications to larger area, 2010.

Pesticide use by MVC is only one aspect of an IVM strategy. This strategy, utilizing vector ecology, includes the use of physical and biological control techniques whenever possible and is based on a program of continuous monitoring of both adult and immature mosquito populations.

Ironically, increased regulation tends to increase reliance on responsive rather than preventive mosquito control. Permitting increases layers of complexity and costs for small public health pest

agencies like MVC and could reduce resources available for non-pesticide IVM methods such as source reduction and education. Monitoring and administrative requirements of the weed permit inhibit MVC from pursuing judicious management of invasive weeds that harbor breeding mosquitoes, therefore mosquitocide use could potentially increase in necessary response. In addition, hindrances in obtaining source reduction permits impact MVC's ability to maintain access trails within wetlands, hindering surveillance to establish breeding above threshold levels, reducing ability to conduct minimized, targeted applications, potentially increasing pesticide use over broader areas. Likewise, this Vector Control General Permit requires redundant monitoring and testing already required by FIFRA labeling compliance, re-directing taxpayer funding away from managing mosquitoes and other vectors without substantial environmental benefit.

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

Estimate for mosquitocide use by the district is based upon our PUR for 2010**.**

SANTA CRUZ COUNTY MOSQUITO & VECTOR CONTROL MOSQUITOCIDE USE 2010

SUM	UNIT	EPA_REG_NO	DESCRIPTION	ACTIVE INGREDIENT
0.49	gal	73049-38	Vectobac 12AS	*Bacillus thuringiensis israelensis*
4254.42	lbs	73049-10	Vectobac Granule	*Bacillus thuringiensis israelensis*
49.00	lbs	53263-30	Agnique MMF G	Isostearyl alcohol ethoxylate
0.27	gal	53263-28	Agnique MMF Mosquito Larvicide	Isostearyl alcohol ethoxylate
4.36	lbs	73049-20	Vectolex WSP	*Bacillus sphaericus*
222.02	lbs	73049-429	VectoMax G	*Bti / Bs*
2086.10	lbs	73049-20	Vectolex CG Biological Larvicide	*Bacillus sphaericus*
15.83	gal	8329-72	Mosquito Larvicide Golden Bear 1111	Aliphatic Petroleum Hydrocarbons
13.01	lbs	2724-375	Zoecon Altosid Briquets	s-Methoprene
68.09	lbs	2724-421	Zoecon Altosid Ext. Residual Briquets	s-Methoprene
0.04	gal	2724-392	Zoecon Altosid Liquid Larvicide	s-Methoprene
5.34	lbs	2724-448	Zoecon Altosid Pellets	s-Methoprene
25.92	lbs	2724-448	Zoecon Altosid Pellets WSP	s-Methoprene
890.31	lbs	2724-489	Zoecon Altosid Single Brood Granule	s-Methoprene

Note: Amounts include larvicides reported separately to the Agricultural Commissioner by R&B Helicopters under contract to Santa Cruz County Mosquito and Vector Control.

This chart reports all mosquito larvicides used by Santa Cruz County Mosquito and Vector Control, for the purpose of estimating use in 2011. Other public health pesticides in addition to those listed above may be used as part of the agency's best management practices. The need to apply product is determined by surveillance. Actual use varies annually depending on mosquito

abundance. No adulticides were used in 2010. All materials have signal word Caution. These larvicide amounts reflect the total used both in waters of the U.S. and in other County sites. 2011 larvicide applications would be limited to those permitted products listed on the attachment.

7. **Representative monitoring locations* and the justification for selecting these locations;**
   Please see the MVCAC NPDES Coalition Monitoring Plan (see References). However, note that the MVC has not used organophosphates and has not used adulticides since 1995, although it may potentially if mosquito-borne virus or severe nuisance conditions warrant.

8. **Evaluation of available BMPs to determine if there are feasible alternatives to the selected pesticide application project that could reduce potential water quality impacts; and**
   Please see answers to Item #5; the MVC frequently will use larvicides to reduce immediate mosquito problem, then work with the landowner or responsible agencies to pursue a long-term or preventive source reduction, educational or biological solution. Surveillance using trap monitoring, resident complaints and dipper counts provide measurements of success. See the Best Management Practices for Mosquito Control in California (pages 9-19 and Appendix A) for relevant statewide BMPs and the Statement of Best Management Practices for Santa Cruz Mosquito and Vector Control and Best Mosquito Management – Santa Cruz County and also Ellicott Slough NWR – CDFG Ecological Reserve: Draft Monitoring and Treatment Plan 2010 (see References). Ironically, increased permit requirements could reduce access to available feasible alternatives such as source reduction (including invasive vegetation management) that reduces mosquito breeding and mosquitocide use for reasons stated in answer to Item #5.

9. **Description of the BMPs to be implemented. The BMPs shall include at a minimum:**
   Please see the Best Management Practices for Mosquito Control in California (pages 9-19 and Appendix A) and in the California Mosquito-borne Virus Surveillance and Response Plan (pages 3-9) and in the MVC Statement of Best Management Practices and in some detail throughout the MVC CEQA Technical Review (see References).
   a. **measures to prevent pesticide spill;**
      All pesticide applicators receive annual spill prevention and response training. District employees ensure daily that application equipment is in proper working order. Spill mitigation devices are placed in all vehicles and pesticide storage areas.

   b. **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 (DPR) and the terms of a cooperative agreement with the California Department of Public Health (CDPH). MVC provides larval mosquito samples for statewide pesticide resistance studies and rotates larvicides types to forestall resistance. MVC applicators are trained to properly follow label, accurately measure and mix dosages and precisely measure areas to be treated. Areas of breeding over intervention thresholds are determined by dipper counts, then measured with GPS and/or using Geographic Information System map layers.

   c. **a plan to educate Coalition's or Discharger's staff and pesticide applicator on any potential adverse effects to waters of the U.S. from the pesticide application;**
      This has been an element of our Cooperative Agreement with the CA Department of Public Health and will be included in our pesticide applicators annual pesticide application and

safety training, continuing education programs, and/or regional NPDES Permit training programs.

d. **descriptions of specific BMPs for each application mode, e.g. aerial, truck, hand, etc.;**
The MVC calibrates larviciding equipment each year to meet application specifications. Supervisors review application records to ensure appropriate amounts of material are being used. Aerial larviciding equipment is calibrated by the contractor with MVC oversight. Ultra-low volume (ULV) adulticide application equipment, if needed, would be calibrated by the contractor for output and droplet size to meet label requirements. Aerial adulticide equipment, if needed, would be calibrated and droplet size will be monitored by the contractor to ensure droplets meet label requirements. Airplanes contracted for ULV applications, if needed, would be equipped with advanced guidance and drift management equipment to ensure the best available technology is being used to place product in the intended area.

e. **descriptions of specific BMPs for each pesticide product used; and**
Please see the Best Management Practices for Mosquito Control in California for general pesticide application BMPs, and the current approved pesticide labels for application BMPs for specific products. See also the MVC's Statement of Best Management Practices, the Best Mosquito Management – Santa Cruz County and the link to the MVC CEQA Technical Review (Section VI or 6) referenced.

f. **descriptions of specific BMPs for each type of environmental setting (agricultural, urban, and wetland).** See responses to Item #5. Please see also the Best Management Practices for Mosquito Control in California for setting-specific, for MVC-specific see Best Mosquito Management – Santa Cruz County and MVC's Statement of Best Management Practices and for wetlands see Ellicott Slough NWR – CDFG Ecological Reserve: Draft Monitoring and Treatment Plan 2010 (attached), for a specific urban site see Comments on Jessie Street Marsh Management Plan, 2002 (in References).

10. **Identification of the problem. Prior to first pesticide application covered under this General Permit that will result in a discharge of biological and residual pesticides to waters of the US, 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:**
    a. **If applicable, establish densities for larval and adult vector populations to serve as action threshold(s) for implementing pest management strategies;**

The MVC staff only applies pesticides to sources of mosquitoes that represent imminent threats to public health or quality of life. The presence of any mosquito may necessitate treatment (example: Asian Tiger mosquito *Aedes albopictus*), low thresholds may be established for vector species in close proximity to human activities, however different thresholds may be applied depending on MVC's resources, disease activity, or local needs. For this section, see the attached Mosquito Management Criteria page, the attached Larval Treatment Criteria page and Control Selection Criteria page. Treatment thresholds are based on a combination of one or more of the following criteria:

- Mosquito species present
- Mosquito stage of development
- Pest, nuisance, or disease potential
- Disease activity
- Mosquito abundance

- Flight range
- Proximity to populated areas
- Size of source
- Presence/absence of natural enemies or predators
- Presence of sensitive/endangered species or habitats.

b. Identify target vector species to develop species-specific pest management strategies based on developmental and behavioral considerations for each species;

Please see response to Item #1 and #2, Appendix D of the Best Management Practices for Mosquito Control in California and the California Mosquito-borne Virus Surveillance and Response Plan. Also visit last page of MVC's 2010 Annual Report, and also Ellicott Slough NWR – CDFG Ecological Reserve: Draft Monitoring and Treatment Plan 2010 (attached), and Larval Treatment Criteria chart and MVC CEQA Technical Review (page 42) on MVC website link (See References) .

c. Identify known breeding areas for source reduction, larval control program, and habitat management; and

Any site that holds water for more than 96 hours (4 days) can produce mosquitoes. Source reduction is MVC's preferred solution, and whenever possible MVC works with property owners to implement long-term solutions to reduce or eliminate the need for continued applications as described in the response to Item 2 above and Appendix E in Best Management Practices for Mosquito Control in California.

d. Analyze existing surveillance data to identify new or unidentified sources of vector problems as well as areas that have recurring vector problems.

This is described in the Best Management Practices for Mosquito Control in California and the California Mosquito-borne Virus Surveillance and Response Plan that MVC uses. The District continually collects adult and larval mosquito surveillance data, dead bird reports, and sentinel chicken test results and uses these data to guide mosquito control activities. The MVC uses Geographic Information Systems interactive with our trap surveillance, service request and work records databases to analyze changes in abundance and distribution of mosquitoes and uses spreadsheets and graphs to analyze trends. Also, periodic aerial photo surveillance reveals possible neglected pools, flooded areas and ponds.

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 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 or physical methods**
- **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.

The MVC uses the science of vector ecology and the principles of integrated vector management (IVM) as described schematically in the attached Mosquito Control Strategy and as described in the MVC Statement of Best Management Practices and Best Mosquito Management-Santa Cruz County (referenced). The MVC has never used organophosphates such as temephos and not used adulticides since one occurrence in 1995. The Santa Cruz County IPM-Departmental Advisory Group has exempted the MVC's public health pesticide applications from required reductions and considers MVC to be an IPM model program.

b. Applying pesticides only when vectors are present at a level that will constitute a nuisance.

The MVC uses the principles of IVM as described in the MVC Statement of Best Management Practices and Best Management Practices – Santa Cruz County, prioritizing education of property owners to abate and reduce sources of breeding. The MVC conducts surveillance for larval and adult mosquitoes and intervenes with mosquitocides only when public health or human activities are threatened and levels of breeding exceed the action threshold, as described in the attached Mosquito Management Criteria page (referenced). See also response to Item #2.

A "nuisance" is specifically defined in California Health and Safety Code (HSC) §2002(j). This definition allows vector control agencies to address situations where even a low number of vectors may pose a substantial threat to public health and quality of life. In practice, the definition of a "nuisance" is generally only part of a decision to apply pesticides to areas covered under this permit. As summarized in the California Mosquito-borne Virus Surveillance and Response Plan, the overall risk to the public when vectors and/or vector-borne disease are present is used to select an available and appropriate material, rate, and application method to address that risk in the context of our IVM program.

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.

This is an existing practice of the MVC, and is required to comply with the Department of Pesticide Regulation's (DPR) requirements and the terms of our California Department of Public Health (CDPH) Cooperative Agreement. All pesticide applicators receive annual safety and spill training in addition to their regular continuing education.

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

http://www.agdept.com/mvc.html

References:

Statement of Best Management Practices for Santa Cruz County Mosquito and Vector Control. See attached copy. Reviewed each year, updated as necessary. Available on website for download. http://www.agdept.com/mvc.html

Best Mosquito Management – Santa Cruz County. Prepared by MVC in 2010 for the USFWS to assist with their preparation of a mosquito management plan for their Ellicott Slough refuge property. Available on website for download. http://www.agdept.com/mvc.html

Ellicott Slough NWR - CDFG Ecological Reserve: Draft Monitoring and Treatment Plan 2010. Prepared to augment the above document. Copies may be requested by calling the Santa Cruz County Mosquito VC at (831)454-2590.

Comments on Jessie Street Marsh Management Plan, 2002, see http://www.agdept.com/mvc.html

University of California – Santa Cruz, Mosquito Monitoring and Treatment Plan, 2010. Copies may be requested by calling the Santa Cruz County Mosquito VC at (831)454-2590.

Best Management Practices for Mosquito Control in California. 2010. Available by download from the California Department of Public Health at http://www.cdph.ca.gov/HealthInfo/discond/Pages/MosquitoBorneDiseases.aspx or http://www.westnile.ca.gov/resources.php under the heading Mosquito Control and Repellent Information. Copies may be also requested by calling the California Department of Public Health—Vector-Borne Disease Section at (916) 552-9730 or the Santa Cruz County Mosquito VC at (831)454-2590.

California Mosquito-borne Virus Surveillance and Response Plan. 2011. [Note: this document is updated annually by CDPH]. Available by download from the California Department of Public Health—Vector-Borne Disease Section at http://www.cdph.ca.gov/HealthInfo/discond/Pages/MosquitoBorneDiseases.aspx or http://www.westnile.ca.gov/resources.php under the heading Response Plans and Guidelines. Copies may be also requested by calling the California Department of Public Health—Vector-Borne Disease Section at (916) 552-9730 or the Santa Cruz County Mosquito VC at (831)454-2590.

Mosquito Vector Control Association of California (MVCAC) NPDES Coalition Monitoring Plan. 2011. In development at the time of this addendum submission. To be posted at http://mvcac.org/ prepared by MVCAC with assistance from URS http://www.urscorp.com/Markets/index.php?s=16.

Santa Cruz County Mosquito and Vector Control website at http://www.agdept.com/mvc.html See the CEQA Negative Declaration Technical Review at http://www.agdept.com/content/MAD_techrev.pdf and the 2010 Annual Report.

Santa Cruz County Arbovirus Surveillance and Response Plan (2006) prepared at County Board of Supervisor request by the West Nile Virus Technical Advisory Committee (see attached).

Santa Cruz County Hydrography map dated 3/12/2009 showing pesticide application area which encompasses entire County.

Santa Cruz County Mosquito and Vector Control – Mosquito Control Strategy, schematic. Copies available at MVC website http://www.agdept.com/mvc.html under Main Menu.

Mosquito Management Criteria, determination of mosquitocide intervention threshold. Copies may be requested by calling the Santa Cruz County Mosquito VC at (831)454-2590.

Larval Treatment Criteria, chart developed for MVC CEQA neg-dec 2005. Copies may be requested by calling the Santa Cruz County Mosquito VC at (831)454-2590.

Control Selection Criteria, chart developed for MVC CEQA neg-dec 2005. Copies may be requested by calling the Santa Cruz County Mosquito VC at (831)454-2590.

Revised November 2, 2010

University of California – Santa Cruz, Mosquito Monitoring and Treatment Plan

Santa Cruz County Mosquito and Vector Control - Paul Binding, Manager 831-454-2590

The ecologically important wetland sites on the University of California – Santa Cruz campus are historical sources of mosquito breeding. To assist the UCSC to facilitate mosquito management required by State Health and Safety Code law for the campus ponds we have developed this BMP for the area.

While the primary mission of the Santa Cruz County Mosquito and Vector Control (MVC) is to protect the public from vector-borne diseases, the MVC is also required to be a good environmental steward. The MVC operates under an integrated pest management (IPM) program that manages mosquitoes while minimizing environmental impacts. The mosquito larvicides used by the MVC are applied to water bodies with the purpose and intent of killing mosquito larvae; they are reduced risk pesticides and extensive research has indicated that little or no lasting environmental impacts are imparted, as explained further in this report.

Our continued and regular mosquito monitoring through the 2010 season will help us to better establish threshold levels for appropriate response at each site in relation to larval and adult mosquito counts of various mosquito species. The predominant mosquito species in the arboretum area is the floodwater mosquito, *Aedes washinoi*.

Mosquito Surveillance

Surveillance of pest populations is essential for assessing the necessity, location, timing and choice of appropriate control measures. It reduces the aerial extent and duration of pesticide use by restricting treatments to areas where mosquito populations exceed established thresholds. Field data, such as species, density, and stages present are used to select an appropriate control strategy from integrated pest management alternatives.

When a site is surveyed, water is sampled with a 1 pint dipper at determined distance intervals to check for the presence of mosquito eggs, larvae and pupae. Adult mosquitoes are sampled using standardized trapping techniques (i.e., New Jersey light traps, carbon dioxide-baited traps and oviposition traps). Mosquitoes collected by these techniques are counted and identified as to species. The spatial and seasonal abundance of adult mosquitoes is monitored on a regular basis and compared to historical data.

Mosquito Control

Treatment thresholds are established for mosquito developmental sites where potential disease vector and/or nuisance risks are evident. Therefore, only those sources that represent imminent threats to public health or quality of life are treated. Treatment thresholds are based on the following criteria:

- Mosquito species present
- Mosquito stage of development
- Nuisance or disease potential
- Mosquito abundance
- Flight range
- Proximity to populated areas
- Size of source
- Presence/absence of natural enemies or predators
- Presence of sensitive, threatened or endangered species

Selection of Control Strategy

- When thresholds are exceeded an appropriate control strategy is implemented. Control strategies are selected to minimize potential environmental impacts while maximizing efficacy.

In other campus sites we would respond to high larval counts that exceed threshold determinations with a larvicide intervention as appropriate, following notification and consultation with the appropriate UCSC personnel. Stormwater drains should be maintained free of silt and debris to reduce mosquito breeding and necessity of treatments.

Treatment Strategy for Arboretum Pond

For sites with known California Red-legged frog (CRLF), federally listed as threatened, if mosquito abundance exceeds treatment thresholds we would intervene with bacterial insecticide treatments as the preferred larviciding response, following notification and consultation with appropriate UCSC personnel and adhering to the Fish and Wildlife Service (USFWS) established treatment and disinfection protocol. The biorational larvicidal treatment materials most suitable for control at the Arboretum ponds are *Bacillus thuringiensis* var. *israelensis*, approved by USFWS for use in the ponds in 2008, 2009 and 2010, and the juvenile mosquito hormone mimic methoprene also used in 2010.

Properly applied, Bacillus treatments are effective, selective, and sustainable, utilizing naturally occurring soil bacteria that will interrupt the mosquito breeding cycle in the larval stage. When they are ingested by immature mosquitoes, Bacillus proteins bind with digestive enzymes, destroying the gut wall. These materials will have no foreseeable impact on populations of CRLF in the ponds, biological diversity, nor have long-term effects on the food web. A duplex liquid mixture of Bti and methoprene controls a broader amount of mosquito larval stages while reducing the dosage needed of each larvicide.

Although methoprene has been shown to also temporarily reduce some non-target chironomid midge populations, a recent EPA effects determination stated that a Section 7 consultation is not recommended as their “assessment resulted in a determination that the use of (methoprene) is not likely to adversely affect the CRLF” and “registered uses”…

"will not modify critical habitat" and "there should not be an indirect affect to potential terrestrial food items". However, USFWS has requested that methoprene not be used, for unstated reasons. The USFWS is involved in a Section 7 for methoprene.

The following measures will be implemented to avoid injuries or mortality to CRLF:
- Only Bti will be applied as mosquito control agent
- To facilitate access to the maximum extent of shoreline, some vegetation clearing may occur to provide a pathway around the ponds
- Vegetation clearing will be limited to allow cover for amphibians and birds
- After initial trail clearing, only hand tools such as machetes and pruning shears will be used to clear vegetation
- Brett Hall, a USFWS approved biologist, will be present for all vegetation clearing and Bti application activities and is qualified to conduct the CRLF monitoring associated with the proposed mosquito abatement activities at the UCSC Arboretum ponds.
- Mr. Hall will lead mosquito abatement technicians during all activities and will monitor for the presence of CRLF
- If any CRLF are found, they will not be moved, disturbed, or have their natural behavior altered in any way
- To avoid transferring disease or pathogens between aquatic habitats, mosquito abatement technicians will follow the Declining Amphibian Population Task Force's Code of Practice.

Consultation by the MVC and UCSC with the USFWS should ensure that mosquito abatement activities can occur without risk to CRLF or other sensitive species but it is understood that such agreement does not authorize injury, mortality, or other adverse effects to CRLF. If a CRLF is found injured or dead, MVC /UCSC will cease all activities and contact USFWS immediately.

To assist in assessing the efficacy of treatments, MVC can make contact with neighboring residents and Arboretum personnel and arrange reporting of complaints. These complaints could be dated, documented and compared with CO2 - baited adult trap counts.

Tentative treatment thresholds for larval counts in the Arboretum pond:
Aedes (Ochlerotatus) washinoi - $\geq$ 2 per 10 dips

Notes on Materials
Bacterial insecticides contain naturally produced bacterial proteins that are toxic to mosquito larvae when ingested in sufficient quantity. Although they are biological agents, such products are labeled and registered by the Environmental Protection Agency as pesticides and are considered by some to be a form of Chemical Control.

***Bacillus thuringiensis* var. *israelensis* (Bti)**

Product names:, Vectobac 12AS, Vectobac G.

Advantages: Bti is highly target-specific and has been found to only have significant effects on mosquito larvae and closely related insects (eg., blackflies and some midges). It is available in a variety of liquid, granular and pelleted formulations which provide some flexibility in application methods and equipment. Bti has no measurable toxicity to vertebrates and is classified by EPA as "Practically Non-Toxic" (Caution). Bti formulations contain a combination of five different proteins within a larger crystal. These proteins have varying modes of action and synergistically act to reduce the likelihood of resistance developing in larval mosquito populations.

Barriers to Use: Bacterial insecticides must be fed upon by larvae in sufficient quantity to be effective. Therefore applications must be carefully timed to coincide with periods in the life cycle when larvae are actively feeding. Pupae and late 4th stage larvae do not feed and therefore will not be controlled by Bti. Low water temperature inhibits larval feeding behavior, reducing the effectiveness of Bti during the cooler months. High organic conditions also reduce the effectiveness of Bti.

Solutions to Barriers: An increased frequency of surveillance of larvae ensures that bacterial insecticides can be applied during the appropriate stages of larval development to prevent adult mosquito emergence.

Impact on water quality: Bti contains naturally produced bacterial protein toxins generally regarded as environmentally safe. It leaves no residues and is quickly biodegraded. At the application rates used in mosquito control programs, Bti is unlikely to have any measurable effect on water quality. There are no established standards, tolerances or EPA-approved tests. Other naturally occurring strains of this bacterium are commonly found in aquatic habitats.

Methoprene

S-Methoprene (known simply as Methoprene or as its trade name, Altosid) is a synthetic analogue (mimic) of a naturally occurring insect hormone called Juvenile Hormone (JH). JH is found during aquatic life stages of the mosquito and in other insects, but is most prevalent during the early instars. As mosquito larvae mature, the level of JH steadily declines until the 4^{th} instar molt, when levels are very low. This is considered to be a sensitive period when all the physical features of the adult begin to develop. s-Methoprene in the aquatic habitat can be absorbed on contact and the insect's hormone system then becomes unbalanced. When this happens during the sensitive period, the imbalance interferes with 4^{th} instar larval development. One effect is to prevent adults from emerging. Since pupae do not eat, they eventually deplete body stores of essential nutrients and then starve to death. Based on its mode of action, s-Methoprene is considered an insect growth regulator (IGR). This material has no effect on mosquito pupae and must be contacted by larvae to be effective.

FORMULATIONS AND DOSAGES: s-Methoprene has a half-life of about two days in water, two days in plants, and ten days in soil (Wright 1976 in Glare & O'Callaghan

1999, La Clair et al 1998). The manufacturer has developed a number of formulations to maintain an effective level of the active material in the mosquito habitat (0.5-3.0 parts per billion = ppb[3]; (Ross et al., 1994) for a practical duration, thus minimizing the cost and potential impacts associated with high-frequency repeat applications. Altosid labels contain the signal word “CAUTION”.

ENVIRONMENTAL IMPACTS: Reviews of the published literature on this material found minimal environmental impact at the dosages used. There is evidence of some sensitivity of crustaceans (Mian & Mulla 1982, Scientific Peer Review Panel, Minnesota, 1996 (Attachment 10) Glare & O’Callaghan 1999, Office of the Minnesota Legislative Auditor 1999). For further information, see http://extoxnet.orst.edu/pips/methopre.htm. For environmental fate see http://www.cdpr.ca.gov/docs/empm/pubs/methofate

Ellicott Slough NWR - CDFG Ecological Reserve:
Draft Monitoring and Treatment Plan 2010

Santa Cruz County Mosquito and Vector Control - Paul Binding, Manager. 831-454-2590

The ecologically important wetland sites that make up the jointly managed protected areas for the endangered Santa Cruz Long-toed salamander (SCLTS) are historical sources of mosquito breeding that influenced the area being included in the formation of Santa Cruz County Mosquito and Vector Control (MVC) in 1993. There is anecdotal evidence of residents conducting illegal pesticide treatments to control mosquitoes on the refuge prior to this date. The MVC is developing this Best Management Plan (BMP) for the Ellicott Slough National Wildlife Refuge (ESNWR) in collaboration with the US Fish and Wildlife Service (FWS), to respond to mosquito management required by State Health and Safety Code laws while adhering to Environmental Species Act objectives for protection of species at risk. This BMP could assist in establishing sustainable mosquito management objectives for the FWS to include within the Comprehensive Conservation Plan and/or a Special Use Permit.

While the primary mission of the Santa Cruz County Mosquito and Vector Control (MVC) is to protect the public from vector-borne diseases, the MVC is desirous as well as required to be a good environmental steward. The program is based on integrated mosquito management methods that minimize environmental impacts. Mosquito control is not a use of the refuge, but a public safety benefit and service that is in response to threats to health of humans and wildlife posed by the wetland and therefore a compatible refuge activity. Mosquito breeding is not unlike wildfire in this respect. USFWS likewise has an obligation to the neighboring community and properties for maintaining the public benefit by reducing nuisance impacts caused by the refuge.

Public Health Impact

Although floodwater mosquito species are not known to transmit disease, when a mosquito bites, a person becomes sensitized to the foreign proteins, and small, itchy, red bumps appear within 24 hours. This is the most common reaction in adults and children. After more bites, a pale, swollen hive, or wheal, begins to appear within minutes after a bite -- followed by the red bump 24 hours later. Sometimes the protein in the mosquito's saliva can cause an exaggerated immune response such as blisters or persistent swelling. Increased Immunoglobulin E (IgE) antibody to mosquito saliva develops in people with mosquito allergy, causing more severe reactions at the sites of the mosquito bites. These allergic reactions, such as a large red swelling, a skin blister, bruise or hives, may last for a week or more. Rarely, severe acute allergic reactions involving many body systems may occur. A few people can develop a life threatening reaction known as anaphylactic shock.
(http://www.aaaai.org/patients/advocate/2005/summer/mosquito.stm)
(http://www.acaai.org/public/linkpages/bug_bites.htm)
(http://allergies.about.com/od/insectallergies/a/mosquitoallergy.htm)

Beyond annoyance, mosquitoes can make the most routine human activities unbearable. They can disrupt sleep, field work and education, and even the buzzing sound made while in flight can cause distraction and anxiety. Babies and small children are defenseless and can be traumatized by bites. Mosquitoes can make potential recreation areas unsuitable and interfere with normal living and work, reducing economic values of surrounding properties. Their bites can weaken nestling birds, irritate horses and pets and reduce production from domestic

animals. For these reasons, MVC recommends FWS collaborate with us on mosquito management for situations far short of disease emergencies.

The warm-weather *Culex* species are more likely to vector viruses such as West Nile and encephalitis (St. Louis, Western Equine). Santa Cruz County has had confirmed West Nile virus-infected dead wild birds since 2004. Although human cases are usually flu-like, mild or asymptomatic, a few victims have long bouts of febrile illness or neurological damage and some have died.

Mosquito Surveillance

Surveillance of pest populations is essential for assessing the necessity, location, timing and choice of appropriate control measures. Surveillance aides us to identify breeding mosquito populations that exceed established thresholds within defined areas. By doing so we are able to target breeding sites, thereby reducing the need for large area larvicidal treatments. Field data, such as species, density, and life stages present are used to select an appropriate reduction strategy utilizing integrated pest management alternatives.

Continued and regular mosquito monitoring through the season helps us to better establish threshold levels for appropriate intervention at each site in relation to larval and adult mosquito counts for various mosquito species. Surveillance via adult traps has the least impact on the refuge ecology, as it is unnecessary to get near the water. However this approach is not effective for floodwater mosquitoes because if the count is high it is too late to reduce immature populations.

In order to best establish a treatment threshold based primarily on adult monitoring we would need to collect and count samples of larvae over several years and compare larval numbers to the number of adults subsequently caught in traps. This would assist us in determining mosquito survivorship through emergence and assess the effects of predation. Adult mosquito counts could also be compared with surveys or complaints of local residents, Renaissance High School staff and KOA campers and staff about the level of biting nuisance they experience in order to make a correlation between number of adult mosquitoes per night and the public nuisance in the adjacent area. However, this tactic of monitoring without control intervention could have unfavorable public reaction, as an historical annoyance precedent has already been established for this area.

The predominant mosquito species in the temporarily-flooded sites is the floodwater mosquito, *Aedes washinoi*, a species not known to vector disease. This is a univoltine species with a winter hatch, or closely spaced cohort hatchings contingent on water level. The eggs are laid in the drying mud of ephemeral ponds by the gravid female prior to winter rains. The eggs hatch and the larvae go through late-stage diapause then pupate and adults emerge with longer, warmer days in March. To interrupt development in the vulnerable larval stages prior to emergence and dispersal as adults, larval monitoring is necessary following flooding to establish treatment timing. The KOA ditch and Railroad ponds historically have had the highest counts.

When a site is surveyed, water is sampled with a twelve ounce dipper at determined distance intervals to check for the presence of eggs and immature mosquitoes. Monitoring by dipper counts to establish abundance and distribution in the ponds requires foot access but with care

and mitigation has little impact on the refuge ecology. Mosquito survivorship is affected by predation, but as the species is a pioneering species it is often ahead of predator development. Adult mosquito emergence through the spring is partially synchronous and can lead to pestilent levels of active biting daytime nuisance in the localized area, but the species are weak flyers with a maximum dispersal of 1 ½ miles.

Intervention Decisions

Treatment thresholds are established for mosquito developmental sites where potential disease vector and/or nuisance risks are evident. Therefore, only those sources that represent imminent threats to public health or quality of life are treated. Treatment thresholds are based on the following criteria that individually can influence the action threshold:

- Mosquito species present
- Mosquito stage of development
- Nuisance or disease potential
- Mosquito abundance
- Flight range
- Proximity to populated areas
- Size of source
- Presence/absence of natural enemies or predators
- Presence of sensitive/endangered species
- Water quality and aquatic vegetation type and coverage

Selection of Control Strategy

When thresholds are exceeded an appropriate control strategy is implemented. Control strategies are selected to minimize potential environmental impacts and resistance while maximizing efficacy. Rotation of two or more larvicides (such as Bti and methoprene) helps forestall resistance.

For sites with known Santa Cruz Long-toed Salamander breeding such as Ellicott Pond and Calabasas Pond, intervention and reduction with biorational larvicide treatments would only be performed at the upper larval counts that exceed threshold determinations. In such cases we would consult with FWS. In non-breeding SCLTS sites such as the KOA ditch, Prospect Pond and Railroad Ponds we would respond to high larval counts with an appropriate reduced risk larvicide after notification of FWS and CDFG and adhering to the established treatment and disinfection protocol. To assist in establishing intervention thresholds the following surveillance methods would be utilized:

Adult Mosquito Monitoring

Three established CO2 trap locations are sited within a ¼ mile of the three sources:

Trap # 1.42 - KOA Campground, 1186 San Andreas Rd
Approx. 1500’ from the NE end of Ellicott
Approx 150’ from NE end of KOA ditch

Trap # 1.423 Across from RR ditch, Crest Lane neighborhood
Approx 800’ from N end of RR ditch
Approx 1000’ form S end of Ellicott

Trap # 1.08 Peaceful Valley Rd
Approx 400' from S end of Ellicott
Approx 600' form N end of RR ditch

Trap season traditionally begins in March and concludes in November. Traps would be inspected every two weeks.

Tentative public health risk thresholds for adult trap counts:

- Female competent West Nile virus vectors including *Culex tarsalis* and *pipiens* $\geq$ 15 per night.
- All other female mosquito species including *Aedes washinoi* and *Culiseta* spp. $\geq$ 50 per night.

Nuisance Monitoring

MVC documents complaints received from area residents, personnel and campers at KOA and Renaissance High School staff. Any complaints are followed up with CO2 trapping and count verification. Three indicators: complaints, high trap counts and high dip counts can initiate our contact with FWS or CDFG to recommend intervention. At this time, adulticiding or fogging of nuisance mosquito species is considered a last resort by the MVC.

Larval Monitoring

Source inspections are accomplished by dip-sampling the sites (twelve ounce standard dipper) at fixed distance intervals to determine an average dip count. Pre and post-treatment larval counts could be compared to subsequent adult counts. Disinfection protocol for amphibian protection is practiced by MVC.

Tentative treatment thresholds for larval counts:
Aedes (Ochlerotatus) washinoi - $\geq$ 1 per 10 dips
Culex tarsalis - $\geq$ 1 per 10 dips
Culiseta spp.- $\geq$ 1 per dip

If beneficial predators present:
Aedes (Ochlerotatus) washinoi - $\geq$ 2 per 10 dips
Culex tarsalis - $\geq$ 2 per 10 dips
Culiseta spp.- $\geq$ 3 per dip

Larval Treatment

Larval treatments to the sites without documented SCLTS will follow protocol and conditions arranged with USFWS and documented in correspondence of March 8, 1996 Noda, March 6, 2000 Barr, March 23, 2007 Hurt and March 9, 2009 Cooper, in addition to other oral and written correspondences. MVC in the past has contacted FWS prior to treatment and post treatment maps were provided. Disinfection to protect amphibians before moving to new sites will generally follow USFWS recommendations. Larvicides will not be applied to the SCLTS breeding ponds on the State reserve without FWS concurrence.

The following measures will be implemented to avoid injuries or mortality to SCLTS:
- Only Service-approved mosquito control agents will be applied. Currently this includes only *Bacillus thuringiensis israelensis* liquid or granular formulations.
- Applications should be made from the shoreline without entry into the ponds. To facilitate access to shoreline, some vegetation clearing may occur to provide a pathway to various points around the non-SCLTS breeding ponds.
- Vegetation clearing will be limited to no lower than knee high length; no ground level vegetation clearing will occur; selective cutting avoiding oaks, sticky monkeyflower, coffeeberry and live limbs over 6" diameter.
- When feasible, hand tools, such as machetes and pruning shears, will be used to clear vegetation, and cut vegetation and limbs will be left in situ.
- A FWS biologist will be notified for opportunity to be present for larval dip monitoring in sensitive sites, vegetation clearing and larvicide application activities to monitor SCLTS.
- If any SCLTS or their eggs are found, they will not be moved, disturbed, or have their natural behavior altered in any way. Dipper samples are returned to the pond.
- All MVC staff sampling for mosquito larvae with a dipper shall be trained in amphibian identification and informed of the appropriate techniques for avoiding the capture of larvae and dislocating eggs and egg masses of the Santa Cruz long-toed salamander or threatened amphibians and for their release if they are inadvertently netted. Workers conducting monitoring activities shall not enter the water and take great care in their approach.
- To avoid transferring disease or pathogens between aquatic habitats, mosquito abatement technicians will follow the Declining Amphibian Population Task Force's Code of Practice.
- An annual pesticide use report will be provided to USFWS at the beginning of the year.

Consultation by the MVC with the FWS should ensure that mosquito abatement activities can occur without risk to SCLTS or other sensitive species but it is understood that such agreement does not authorize injury, mortality, or other adverse effects to SCLTS. If a SCLTS is found injured or dead, MVC will cease all activities and contact FWS immediately.

MVC advises that the Service manage aquatic vegetation growth to encourage diversity and water circulation and prevent monoculture coverage or invasive exotics that could lead to reduced water quality and mosquito harborage.

Attachments

See the Mosquito Management Criteria explanation of 'threshold' attached; also the Larval Treatment Criteria table and the Control Selection Criteria table which are useful as guidelines. A discussion of larvicides is also attached.

Technical information about the MVC's program can be found in the CEQA review documents on our website. http://www.agdept.com/mvc.html

Best Mosquito Management - Santa Cruz County

For our full Environmental Review go to http://www.agdept.com/mvc.html

Paul L. Binding, Manager, Santa Cruz County Mosquito and Vector Control CSA 53

The Santa Cruz County Mosquito and Vector Control County Service Area 53 (MVC) has provided mosquito control services to Santa Cruz County since 1994. Our formation came about as a result of prodigious public and local government support following years of complaints about biting mosquitoes. MVC was formed through the Government Code, though responsibilities are similar to those outlined within the California Health and Safety Code (Section 2000 *et seq.*). The language contained in these codes underscore the landowner's responsibility to manage their property, including wetlands, to prevent mosquito breeding.

A **vector** is any insect, rodent, or other arthropod or animal that can threaten health by transmitting disease agents or causing discomfort.

Our public health program employs sustainable **Integrated Mosquito Management (IMM)** methods and emphasizes the prevention of mosquito production by reducing breeding sources and the control of aquatic stages to interrupt the mosquito cycle. This includes the use of least-toxic biorational materials selected on the basis of maximum safety to the public, applicator and environment, and otherwise follows general guidelines of the California Department of Public Health (CDPH), the Mosquito and Vector Control Association of California (MVCAC), the American Mosquito Control Association (AMCA) and the University of California (UC).

California has had periodic outbreaks of mosquito-borne encephalitis and malaria, and currently is involved in an outbreak of West Nile virus. Although human cases have not yet been documented in this County, we have the mosquito vectors that can transmit these diseases and dead wild bids submitted for virus testing have been confirmed positive every year since 2004. As well as the dead bird submission program, the MVC currently maintains two sentinel chicken flocks as part of a statewide disease surveillance program. The birds are tested routinely and these and trapped adult mosquito samples are sent to a laboratory, allowing early warning of the presence of virus in local mosquitoes.

The sources of mosquitoes will always be with us, as a result of rainfall and myriad natural, residential and agricultural standing water sources. With a warming climate and vulnerable population, it is important that this MVC be increasingly diligent in providing reduction of mosquitoes, protection from mosquito-borne diseases and relief from annoyance and biting nuisance. We continue to strive for the support from property owners and residents, regulators and government officials that is necessary for us to be successful in this endeavor.

Seasonality and Variability

Wetlands have the potential to produce large outbreaks of mosquitoes at certain times of year. This MVC, through education and pro-active aerial, boat and ground-based treatments of larval stages, can reduce significantly but not eliminate the nuisance. The MVC makes frequent outreach appeals to the public to reduce standing water and artificial container breeding on their property, but the **proximity** of residents to large bodies of standing water increases their chance of exposure to mosquitoes and mosquito-borne diseases.

Restoration, enhancement and disturbance of wetlands for wildlife can produce mosquitoes as an unintended byproduct. Also, mosquitoes are often the pioneering species in newly flooded or disturbed sites. They can spike to high levels and disperse before a diverse aquatic regime and stasis through predation and competition is established. At least a dozen mosquito species can

exploit sites as diverse as tree holes, neglected septic systems and swimming pools, small containers, stormwater systems, sloughs and brackish marshes in the mild climate of our County.

Our Vector Control Specialists follow a route list of known breeding sources on a routine basis. The water sources are dip sampled to determine breeding using a standard twelve ounce dipper cup. Treatment decisions are determined by a **threshold** established for the source on the basis of species type, number per dip, distance to residents, larval age, the presence of predators, presence of sensitive species and other factors. The attached Treatment Criteria table illustrates problem species type and uses human proximity, breeding density and source size as a general basis on which the threshold analysis is built.

Even when protected species are not present, marshes have great ecological and educational value as suburban wetlands, a rarely encountered environment whose biological diversity must be protected. Yet it is because of this proximity to human habitation and activity that management of mosquitoes is occasionally required to protect human health and the annoyance associated with the nuisance species. Selective reduction of mosquito populations in this protected environment is a marsh management element that increases the benefit values to the surrounding community and has benefits to avian life, particularly nestlings and species susceptible to West Nile virus. West Nile Virus has the potential to cause human, wildlife and equine mortality in this area.

Materials and Techniques

There have been remarkable advances in mosquito control materials and methodology, incorporating IMM approaches anchored around the use of public education, source reduction and biocontrols. When appropriate, larvicides are employed, preferably the selective and non-persistent mosquito growth regulator methoprene (synthesized juvenile hormone) and organic microbials (*Bacillus thuringiensis israelensis* and *B. sphaericus*). These are “least toxic” materials that provide maximum safety for the applicator, non-target organisms, residents and their pets and property, with minimum impact on the food web of the marsh. Dosage rates must be both sufficiently high to kill targeted species (and delay resistance) and sufficiently low to minimize non-target effects. Also, it is important that materials be rotated periodically to forestall resistance.

To achieve satisfactory, sustainable and consistent results with these materials, it is essential that they be alternated and used in conjunction with a comprehensive monitoring and application program, and with other elements incorporating Best Management Practices. Knowledge of the biology of the target species and habitat, the timing of the application and other environmental factors related to operational success is crucial to obtaining cost-effective results of a reduction in the mosquito population. MVC staff is experienced in non-intrusive monitoring and treatments of mosquito larvae and adults, and in determining threshold levels for different species that would initiate treatments.

Treatments are conducted on foot using backpack sprayers for liquids or backpack blowers for granular materials, from a marsh boat or by contracted helicopter. Pesticides are applied when winds are less than 10 mph to avoid drift. Compromises are made in sensitive sites, such as a less intrusive management protocol arranged with the Fish and Wildlife Service for the federal refuge (see Wildlife Refuges section or Draft Monitoring and Treatment Plan). Temporary trails may be cut to less accessible areas, invasive plants reduced and poison oak kept at bay with spot treatments of herbicide, where appropriate. If brushing a trail is necessary, care is taken to reduce impact to green limbs or saplings.

The MVC is involved in the development review process in a pro-active role as part of our source reduction program. Due to the potential disruption and public health threat that infestations of mosquitoes could cause residents of this area, their existence is a **significant biological hazard** that requires mitigation, and should be included on initial study checklists.

Intense efforts are made to monitor mosquito breeding through trapping of adult mosquitoes, and inspecting breeding sites by sampling water for larvae and treating when necessary to reduce emergence. Alternative management strategies and biological control methods are first considered. Some sources require checking and treatment several times a year. Pre-treatment and post-treatment larval counts are taken to measure effectiveness and detect resistance. The contents of adult mosquito monitoring traps are also identified and counted to determine abundance and distribution of species.

Quality of life would seriously be impacted without mosquito reduction measures. With present or even increased levels of service, surviving mosquitoes in some years could still be numerous enough to result in complaints because breeding sites are frequently in close proximity to human activity and mosquitoes can disperse long distances. Priority is placed upon requests for service from residents, ahead of our other routine operations.

The MVC would rarely consider adulticiding measures (fogging), as it is more selective and effective to control larvae before they emerge and disperse as adults. Although fogging is perceived by some citizens as offering the best relief, it is unacceptable to others and is not a pro-active strategy. It would be considered by the MVC as a last alternative and after approval by the West Nile Virus Technical Advisory Committee and the County Board of Supervisors, in cases of public health emergency.

Mosquitoes of Santa Cruz County / Establishing the Treatment Threshold

The floodwater mosquito, ***Aedes washinoi***, is a day-biting species whose aquatic larvae appear in temporary pools in late winter, emerging to seek blood meals in the spring. This mosquito results in more complaints than any other does. *A. washinoi* is an aggressive daytime biting pest in the spring, and breeds densely in flooded willows and brackish marshes.

The County is home to a dozen mosquito species, but of particular concern is ***Culex tarsalis***, the encephalitis mosquito, which breeds through summer and fall and has the potential of transmitting the disease to humans. They can be found among emergent vegetation such as smartweed and flooded grasses, algal mats and inundated blackberry thickets. The increase in warm-season human activity at dusk in areas surrounding the sloughs requires that we lower the threshold at which treatments are initiated in order to reduce mosquito breeding to acceptable levels. Criteria used to determine the threshold are larval density, species significance (nuisance or disease), flight range, dispersal patterns and other environmental and meteorological factors.

Treatment decisions are based on threshold levels of larvae determined for particular sites by evaluating species risk, proximity to residents, stage of development and abundance, ecological value, presence, number and type of predators and other aquatic life and other environmental factors. This number is dynamic, based on qualitative as well as quantitative observation and may change spatially and temporally. When threshold levels are exceeded, larviciding ensues using material appropriate for larval instars present: either the microbial formulations described below, or the insect growth regulator methoprene, or a duplex combination of the two. Pre-flood treatments are employed in some seasonal sources where historical breeding has existed and access is a problem post-flooding.

At present the program makes maximum effort to use *Bacillus thuringiensis israelensis* larviciding products for their efficacy and selectivity. A similar microbial larvicide, *Bacillus sphaericus* is used increasingly in highly organic sources such as sewage, dairy and apple processing ponds because the live bacteria recycles in the mosquito larvae it controls, thereby providing residual control. This is also OMRI accepted for use around organic crops. A new minimum risk biological larvicide, spinosad, is expected to be registered for mosquitoes in 2010.

The larvicide methoprene is used with water or granular carriers (for penetration of vegetation), or in pellet or briquet form for residual slow release and pre-flood. This insect juvenile growth hormone mimic prevents emergence of live adult mosquitoes and so requires post-treatment collection and emergence of pupae to determine efficacy. These products and the bacilli are applied to larger aquatic areas by contracted helicopter, by boat or on foot by backpack sprayer or motorized backpack blower.

Mature marshes with diverse species seldom contain many mosquitoes, as predators, parasites and competing invertebrates keep them in check. Open water areas with good circulation seldom breed because of wave action and access by predators. Permanent aquatic sources usually contain natural mosquito predators and do not require treatment, unless vegetation is so dense that it prevents natural predation.

Mosquitoes are often the pioneer species, which accounts for their peak density in disturbed aquatic environments. Frequently, the aquatic habitats targeted for larviciding are temporary or semi-permanent. Temporary sites such as marshes and flooded agricultural areas or woodland depressions produce prolific numbers of floodwater mosquitoes. These sites are generally very low in species diversity and mosquito predators, due to the time needed for most species to locate and colonize them.

While floodwater mosquitoes start development during the first week post-inundation, it may take two to three weeks for the first macro invertebrate predators to become established. Microbials and the growth hormone work effectively in the first week or so against larval mosquito stages. If ponds are treated late in the mosquito cycle for pupal mosquitoes by using less selective surface films, non-target aquatic invertebrates may also be killed. Although these are capable of eventually recovering from localized population declines via recruitment and re-colonization from proximal areas, surface films are usually used only in stagnant conditions where mosquitoes are the dominant organisms.

Mosquito management and source reduction decisions are enhanced by knowledge of the distribution and life stage of protected species. The most important aim is to reduce mosquitoes below the nuisance threshold without harm to the environment, with emphasis on targeting vector species. The MVC is signatory to CDPH compliance agreements (H&S Code section 116180) including the reporting of any adverse pesticide-related effects. We give high consideration to the direction and research provided by vector ecologists and IPM specialists within the UC system, and consultation with wetland managers and health authorities.

The MVC is committed to improving the quality of life and economic productivity of area residents and the habitability of the surrounding community. A wide variety of aquatic habitats, ranging from residential receptacles to larger agricultural and marshland areas, may be treated with larvicides. Fauna inhabiting the latter sites may include amphibians, fish, other vertebrates and invertebrates, particularly insects and crustaceans. The use, description, and safety of our selected larviciding materials are detailed in the attached appendix and in our environmental review documents online at http://www.agdept.com/mvc.html.

Other Biological Control

Although established in California in many permanent natural sources, mosquitofish are non-native and it is **not** the policy of the MVC to stock these opportunistic feeders in natural sources. The MVC warns against the re-release of *Gambusia affinis* before stocking these useful fish for the public in ornamental ponds, swimming pools and troughs.

Bats have proven their usefulness against arthropod pests when they can be lured to stay in properly built bat-houses. However, besides preferring larger (sometimes beneficial) flying prey

to maximize protein intake vs. energy expenditures, bats feed at dusk. The primary mosquito problem following winter rains are day-feeding *Aedes spp*. The CDPH warns that a small percentage of bats are rabid, and that bats often prefer attics to a bat-house.

Violet-green swallows are likewise often recognized as a supplement to mosquito management when they can be established, but are likewise not preferential in feeding or nest sites, and their mud homes, mites and excrement can, unfortunately, be a nuisance around structures.

Environmental Protection

Our area has myriad mosquito breeding sites near and within populated areas. Without ongoing and effective vector control, substantial mosquito activity would significantly and adversely effect the human environment. The MVC's mosquito control program, including chemical materials, is essential to maintain the vectors in the environment at a tolerable level. The MVC's program will never alleviate all mosquitoes. Rather, it is a resource maintenance program aimed at striking a balance to allow comfortable and healthful human existence within the natural environment, while protecting and maintaining the environment.

History has shown us that the control and abatement of vectors are necessary for our human environment to continue to be habitable. Malaria was largely responsible for the tragic and precipitous decline of native Californians in the 19th century, and with yellow fever, encephalitis and dengue continued to sicken thousands of Americans into the 20th century. Mosquito-borne diseases are currently a leading cause of human mortality worldwide. Modern recognition of the value of wetlands should not overshadow their potential for pestilence.

The Endangered Species Act has language that limits the regulations from placing undue burden upon essential local operations, including mosquito management, and places the burden of proof of harm on the regulators. Indirect effects causing harm must be close and actual, without remote causal links (effect on effect on effect). Ecologists recognize that the value to the food web of mosquitoes is not substantially missed when they are reduced in wetlands close to human activity, as that niche is adequately filled by other invertebrate scavengers.

In addition to the environmental protection measures and procedures inherent in the MVC's IMM program as discussed above, there are other practices unique to the MVC's chemical control program that protect the environment:

There are numerous federal and state laws and regulations that strictly control and regulate the storage, transport, handling, use and disposal of the pesticides in order to protect against surface and groundwater contamination and other impacts to the environment and public health. (E.g., Federal Insecticide, Fungicide and Rodenticide Act; Cal. Food & Agric. Code divisions 6 & 7; Cal. Code of Regs., title 3, division 6.) The MVC applies aquatic larvicides under an NPDES permit required in waters of the U.S. and reports use to the Central Coast Regional Water Quality Control Board and has a Best Management Plan on file with that agency. The MVC and its staff consistently comply with these laws and regulations.

The MVC uses only pesticides registered by the U.S. Environmental Protection Agency and California Department of Pesticide Regulation. The MVC then strictly complies with the pesticide label restrictions and requirements concerning the storage, transport, handling, use and disposal of the pesticides.

Consistent with the MVC's integrated mosquito management principles, when using pesticides, the MVC selects the least hazardous material that will meet its goals and the MVC avoids using restricted materials-type pesticides.

The MVC is an active member of the MVCAC, a statewide association representing the interests of vector control districts throughout the state. The Association, and its member districts, participates in the U.S. Environmental Protection Agency's Pesticide Environmental Stewardship Program, a program to encourage less pesticide use and greater environmental stewardship by vector control districts.

Pesticides are applied only by CDPH-certified and trained vector control technicians. The frequent training includes continuing education on appropriate practices to avoid environmental impacts and assure compliance with regulatory requirements.

The MVC regularly calibrates its pesticide application equipment to ensure that it distributes the proper quantities of material. It stores the material safely and under scrutiny of the Agricultural Commissioner and Environmental Health departments. Pesticide use is well documented and overseen by the Agricultural Commissioner. Application sites are measured and digitized into geographic information systems maps and related to trap monitoring and field records in the database, which is shared on a UC server with MVCAC and CDPH.

Wildlife Refuges

The MVC maintains good communication and cooperation with environmental regulatory agencies. Consultation is provided to these agencies for their wetlands restoration projects to ensure compatibility with mosquito management goals.

In our current Zones of Benefit, there are about 15 acres of wetland within the 300 acre Ellicott Slough Refuge/Reserve jointly managed by U.S. Fish and Wildlife Service (USFWS) and California Fish and Game (CDFG) that offers protection for the endangered Santa Cruz long-toed salamander and threatened red-legged frog and tiger salamander, and another 130 acres managed by CDFG as ecological reserve in the Watsonville Slough. The MVC also reports pesticide applications to the State Park system on its coastal freshwater marshes at Sunset State Beach, Twin Lakes and Natural Bridges.

In 2000 the MVC met with USFWS representatives and it was determined to defer using the larvicide methoprene in the Santa Cruz Long-toed Salamander ponds on the Ellicott Slough State Ecological Reserve and at the Calabassas unit of the Ellicott Slough National Wildlife Refuge (ESNWR) pending a USFWS Section 7 (inter-agency consultation) for the Refuge, which will result in a permit or Comprehensive Conservation Plan that will determine mosquito management alternatives. The MVC has since submitted Pesticide Use Proposals (PUP's) to the USFWS for larviciding materials to be used in the ESNWR. The PUP's outline application rates, target mosquito species, methods of application and the listed sensitive species and helps to ensure compatible use through the MVC conforming to Best Management Practices (BMP) in the Refuge area. A draft Monitoring and Treatment Plan has recently been submitted.

A protocol agreed upon with the USFWS for treatment of mosquito larvae in ponds and ditches of the Ellicott area amphibian refuge reduces the possibility of non-target impacts. Applications are made under the following conditions:

- Applications are made from shorelines of ponds. The MVC staff does not enter the water.
- The San Francisco Bay Area National Wildlife Refuge office is notified so that a USFWS biologist can be present when larvicides are applied.
- All staff sampling for mosquito larvae with a dipper are informed of the appropriate techniques for avoiding the capture of amphibian larvae or dislocating eggs and egg masses and for their release if they are inadvertently caught. Staff conducting monitoring activities does not enter the water.

Note: In addition, the MVC informs USFWS of surveillance activities at Ellicott and faxes a treatment map following applications. Similarly, amphibian protection measures are taken on a voluntary basis on other properties where amphibian recovery efforts are being conducted. Currently, the USFWS is reviewing mosquito management in its refuge. Other areas within the South County are being considered for acquisition within the federal refuge and State reserve systems.

Previously Submitted to the USFWS:

1. Appendix: The use, description, and safety of methoprene and microbial materials
2. Treatment Criteria table used as basis for building treatment threshold determination.
3. "Long-term effects of the mosquito control agents Bti and methoprene on non-target macro-invertebrates in wetlands in Wright County, MN (1997-98)", Lake Superior Research Institute.
4. USGS News Release: X-ray Studies Shed Light on Frog Deformities.
5. "Methoprene concentrations in freshwater microcosms treated with sustained-release Altosid formulations", Ross, Judy, Jacobsen and Howell, 1994.
6. "Nontarget effects of mosquito larvicides used on national wildlife refuges", Lawler, Jensen and Dritz, 1997.
7. "Laboratory and field evaluation of the efficacy of four insecticides for *Aedes vigilax* and toxicity to the non-target shrimp *Leander tenuicornis*." Brown, Thomas, Mason, Greenwood and Kay, 1999.
8. "Insect developmental inhibitors. 3. Effects on nontarget aquatic organisms." Miura and Takahashi, 1973.
9. "Field evaluation of the effects of slow-release wettable powder formulation of Altosid on nontarget organisms." Creekmur, Russell and Hazelrigg.
10. "Potential effects of Altosid briquet treatments on *Eubranchipus bundyi."* Batzer and Sjogren.
11. "Environmental degradation of the insect growth regulator methoprene. II. Metabolism by aquatic microorganisms." Schooley, Bergot, Dunham and Siddall.
12. "Effects of methoprene on nontarget organisms when applied as a mosquito larvicide." Hester, Rathburn and Boike.
13. Report for the Ministry of Health (New Zealand): Environmental and health impacts of *Bacillus thuringiensis israelensis*. Glare and O'Callaghan, 1998.
14. Report for the Ministry of Health (New Zealand): Environmental and health impacts of the insect juvenile hormone analogue, s-methoprene. Glare and O'Callaghan, 1999.

APPENDIX

More about Methoprene

INTRODUCTION. s-Methoprene does not produce non-discriminatory, rapid toxic effects that are associated with nervous system toxins. s-Methoprene is a true analogue and synthetic mimic of a naturally occurring insect hormone called Juvenile Hormone (JH). JH is found during aquatic life stages of the mosquito and in other insects, but is most prevalent during the early instars. As mosquito larva mature, the level of JH steadily declines until the 4th instar molt, when levels are very low. This is considered to be a sensitive period when all the physical features of the adult begin to develop.

s-Methoprene in the aquatic habitat can be absorbed on contact and the insect's hormone system becomes unbalanced. When this happens during the sensitive period, the unbalance interferes with 4th instar larval development.

One effect is to prevent adults from emerging. Since pupae do not eat, they eventually deplete body stores of essential nutrients and then starve to death. For these and perhaps other reasons, s-Methoprene is considered an insect growth regulator (IGR). An advantage that methoprene has over other larvicides is that the mosquito immatures remain alive as prey for aquatic predators.

There have been widely distributed reports regarding the effect methoprene may have on certain amphibians. Reports of frog abnormalities have been widely circulated, but these reports have not stood up to scientific scrutiny.

FORMULATIONS AND DOSAGES. Currently, seven s-methoprene formulations are sold under the trade name of Altosid. These include Altosid Liquid Larvicide (A.L.L.) and Altosid Liquid Larvicide Concentrate, Altosid Briquets, Altosid XR Briquets, Altosid SBG (single-brood granules), Altosid XR-G and Altosid Pellets. Altosid labels contain the signal word "CAUTION" and all products are Category 4.

ALTOSID LIQUID LARVICIDE (A.L.L.) & A.L.L. CONCENTRATE. These two flowable formulations have identical components except for the difference in the concentration of active ingredients. A.L.L. contains 5% (wt./wt.) s-Methoprene while A.L.L. Concentrate contains 20% (wt./wt.) s-Methoprene. The balance consists of inert ingredients that encapsulate the s-Methoprene, causing its slow release and retarding its ultraviolet light degradation.

DOSAGES. Use rates are 3 to 4 ounces of A.L.L. 5% and ¾ to 1 ounce of A.L.L. Concentrate (both equivalent to 0.01008 to 0.01344 lb. AI) per acre, mixed in water as a carrier and dispensed by spraying with conventional ground and aerial equipment. Because the specific gravity of Altosid Liquid is about that of water, it tends to stay near the target surface. No rate adjustment is necessary for varying water depths when treating species that breathe air at the surface.

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

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

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

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

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

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

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

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

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

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

ALTOSID SBG is the newest formulation, at 1.5% (wt./wt.) s-methoprene it has a five to seven day residual for use with mosquitoes having synchronous development patterns (single-brood). It has a small particle size but high density and a broad target site list.

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

ALTOSID XR-G was approved for use in 1997. This product contains 1.5% (wt./wt.) s-methoprene. Granules are designed to slowly release s-methoprene as they erode. Under normal weather conditions, control can be achieved for up to 21 days.

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

TARGET SPECIES AND APPLICATION SITES. The species are the same as listed for the briquet formulations. Listed target sites include snow pools, meadows, rice fields, freshwater

swamps and marshes, salt and tidal marshes, woodland pools, tires and other artificial water holding containers, dredge spoil sites, waste treatment ponds, ditches, and other natural and man-made depressions.

More About Bacillus Products

Mosquito control makes use of two stomach toxins whose active ingredients are manufactured by bacteria. These control agents are often designated as Bacterial Larvicides. Their mode of action requires that they be ingested to be effective, which can make them more difficult to use than the contact toxins and surface-active agents. Bacteria are single-celled parasitic or saprophytic microorganisms that exhibit both plant and animal properties, and range from harmless and beneficial to intensely virulent and lethal.

A beneficial form, *Bacillus thuringiensis* (Bt), is the most widely used (especially in agriculture) microbial pesticide in the world. It was originally isolated from natural Lepidopteran (butterflies and moths) die-offs in Germany and Japan. Various Bt products have been available since the 1950's, and in 1976, Dr. Joel Margalit and Mr. Leonard Goldberg isolated from a stagnant riverbed pool in Israel, a subspecies of *B. thuringiensis* that had excellent mosquito larvicide activities. It was named B.t. variety israelensis (B.t.i.) and later designated *Bacillus thuringiensis* Serotype H-14. Either of these two designations may be found on the labels of many bacterial mosquito larvicide formulations used today. Another species of bacteria, *B. sphaericus*, also exhibits mosquito larvicide properties.

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

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

FORMULATIONS AND DOSAGES. There are five basic B.t.i. formulations available for use: liquids, powders, granules, pellets, and briquets. Liquids, produced directly from a concentrated fermentation slurry, tend to have uniformly small (2-10 micron) particle sizes, which are suitable for ingestion by mosquito larvae. Powders, in contrast to liquids, may not always have a uniformly small particle size. Clumping, resulting in larger sizes and heavier weights, can cause particles to settle out of the feeding zone of some target mosquito larvae, preventing their ingestion as a food item. Powders must be tank mixed before application to an inert carrier or to the larval habitat, and it may be necessary to mix them thoroughly to achieve a uniformly small consistency. B.t.i. granules, pellets, and briquets are formulated from B.t.i. primary powders and an inert carrier. B.t.i. labels contain the signal word "CAUTION"and B.t.i. is Category 4.

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

The amount of toxins contained within B.t.i. products are reported indirectly as the result of at least two different bioassays and are difficult to equate to one another. Prepared volumes of toxins are applied to living mosquito larvae and the resulting mortality produces through formulae numerical measures known as International Toxic Units (ITU's) and *Aedes* aegypti International Toxic Units (AA-ITU's). These measures are only roughly related to observed efficacy in the field, and are therefore inappropriate to consolidate and report on like other toxicants.

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

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

B.t.i. liquid may also be "Duplexed" with the Altosid Liquid Larvicide discussed above. Because B.t.i. is a stomach toxin and lethal dosages are somewhat proportional to a mosquito larvae's body size, earlier instars need to eat fewer toxic crystals to be adversely affected. Combining B.t.i. with methoprene (which is most effective when larvae are the oldest and largest) allows a public health agency to use less of each product than they normally would if they would use one or the other. Financially, most savings are realized for treatments of mosquitoes with long larval

BTI CORNCOB GRANULES. Granular formulations use a carrier that is dense enough to penetrate heavy vegetation. There are currently two popular corncob granule sizes used in commercial formulations. Aquabac 200G, Bactimos G, and Vectobac G are made with 5/8 grit crushed cob, while Aquabac 200 CG (Custom Granules) and Vectobac CG are made with 10/14 grit cob. Aquabac 200 CG is available by special request. The 5/8 grit is much larger and contains fewer granules per pound. The current labels of all B.t.i. granules recommend using 2.5 to 10 lb./acre in clean water and 10 to 20 lb./acre in highly organic water situations.

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

BTI BRIQUETS (donuts). B.t.i. donuts are a sole source product manufactured by Summit Chemical Company under a Bactimos B.t.i. subregistration. They are a mixture of B.t.i., additives, and cork. They are designed to float and slowly release B.t.i. particles for up to 30 days. They apparently are attractive to raccoons and possibly other wildlife because of their odor, and may sometimes be disturbed or carried off. Donuts may be staked in place to prevent wind from moving them from a site's littoral zone into open water. The use rate is one donut per 100 square feet in clean water and up to four donuts per 100 square feet in dirty water. Many districts

have not found these to be practical in most larval sites due to their expense and the possibility of them being moved by wind or animals. Homeowners, however, may find practical uses for these in ornamental ponds or other very small habitats.

TARGET SPECIES. B.t.i. adversely affects larval stages of insect species in the Order Diptera, Suborder Nematocera, Families Culicidae (Mosquitoes) and Simuliidae (Black Flies). B.t.i. has been shown to be effective for numerous mosquito species, including members of the mosquito genera *Aedes*, *Anopheles*, *Culex*, and *Culiseta*, commonly targeted in California.

Products containing B.t.i. are ideally suited for use in integrated pest management programs because the active ingredient does not interrupt activities of most beneficial insects and predators. Since B.t.i. has a highly specific mode of action, it is an insecticide of minimal environmental concern. B.t.i. controls all larval instars provided they have not quit feeding, and can be used in almost any aquatic habitat with no restrictions. It may be applied to irrigation water and any other water sites except treated finished drinking water. B.t.i. is fast acting and its efficacy can be evaluated almost immediately. It usually kills larvae within 1 hour after ingestion, and since each instar must eat in order for the larvae to grow that means B.t.i. usually kills mosquito larvae within 24 hours of application. It leaves no residues, and it is quickly biodegraded. Resistance is unlikely to develop simultaneously to the five different toxins derived from the B.t.i. delta-endotoxin since they have five different modes of action. This suggests that this mosquito larvicide will continue to be effective for many years.

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

B.t.i. applied at label rates has virtually no adverse effects on applicators, livestock, or wildlife including beneficial insects, annelid worms, flatworms, crustaceans, mollusks, fish, amphibians, reptiles, birds or mammals. However, non-target activity on larvae of insect species normally associated with mosquito larvae in aquatic habitats has been observed. There have reported impacts in larvae in the Order Diptera, Suborder Nematocera, Families Chironomidae (midges), Ceratopogonidae (biting midges) and Dixidae (dixid midges). These non-target insect species, taxonomically closely related to mosquitoes and black flies, apparently contain the necessary gut pH and enzymes to activate delta-endotoxins. However, the concentration of B.t.i. required to cause these effects is 10 to 1,000 times higher than normal use rates.

Further, studies report these impacts are short-lived, with the population of these species rebounding quickly. **See study "Long-term effects of the mosquito control agents Bti and methoprene on non-target macroinvertebrates in wetlands in Wright County, Minnesota (1997-1998)".**

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

INTRODUCTION. ***Bacillus sphaericus*** is a commonly occurring spore-forming bacterium found throughout the world in soil and aquatic environments. Some strains produce a protein endotoxin at the time of sporulation. It is grown in fermentation vats and formulated for end use

with processes similar to that of B.t.i. A standard bioassay similar to that used for B.t.i. has been developed to determine preparation potencies. The bioassay utilizes *Culex quinquefasciatus* 3rd-4th instar larvae. The endotoxin destroys the insect's gut in a way similar to B.t.i. and has been shown to have activity against larvae of many mosquito genera such as *Culex, Culiseta*, and *Anopheles*. The toxin is only active against the feeding larval stages and must be partially digested before it becomes activated. At present, the molecular action of *B. sphaericus* is unknown. Isolation and identification of the primary toxin responsible for larval activity has demonstrated that it is a protein with a molecular weight of 43 to 55 kD.

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

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

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

B. sphaericus has demonstrated the unique property of being able to control mosquito larvae in highly organic aquatic environments, including sewage waste lagoons, animal waste ponds, and septic ditches. After a single application at labeled rates, field evaluations have shown VectoLex-CG to persist for 2-4 weeks. Field evaluations with VectoLex-CG have shown that *Bacillus sphaericus* may undergo limited recycling in mosquitoes in certain organically rich environments.

VectoLex-CG has been extensively tested and has had no adverse effects on mammals or non-target organisms. *B. sphaericus* technical material was not infective or pathogenic when administered as a single oral, intravenous or intratracheal installation in rats. No mortalities or treatment-related evidence of toxicological effects were observed. The acute oral and dermal LD 50 values are greater than 5000 mg/kg and greater than 2000 mg/kg, respectively. The technical material is moderately irritating to the skin and eye. Oral exposure of *B. sphaericus* is practically nontoxic to mallard ducks. No mortalities or signs of toxicity occurred following a 9000 mg/kg oral treatment. Birds fed diets containing 20% w/w of the technical material experienced no apparent pathogenic or toxic effects during a 30-day treatment period. Mallards given an intraperitoneal injection of *B. sphaericus* demonstrated toxicologic effects including hypoactivity, tremors, ataxia and emaciation. The LD 50 value was greater than 1.5 mg/kg.

Acute fresh water fish toxicity tests were done on bluegill sunfish, rainbow trout and daphnids. The 96-hour LC 50 and NOEC value for bluegill sunfish and rainbow trout was greater than 15.5 mg/liter; the 48-hour EC 50 and NOEC value for daphnids was greater than 15.5 mg/liter. Acute aquatic saltwater fish toxicity tests were done on sheep head minnows, shrimp and oysters. The 96 hour LC 50 value for both sheep head minnows and shrimp was 71 mg/liter, while the NOEC (no observable effect concentration) value was 22 mg/liter for sheep head minnows and 50

mg/liter for shrimp. The 96-hour EC 50 value for oysters was 42 mg/liter with a NOEC of 15 mg/liter.

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

Bacillus sphaericus will not regenerate in salt water, rendering its use impractical for control of salt-water mosquitoes. Cycling is limited to permanent fresh water bodies, and if organics are very high, recycling may be minimal.

VectoMax™ is a biological larvicide that combines B.t.i. and *Bacillus sphaericus* in one homogenous formulation. These two bacteria are combined in one molecule which ensures that larvae feed on both at the same time. VectoMax offers the faster, broad spectrum control of VectoBac® (B.t.i.), with the residual control of VectoLex® (*B. sphaericus*).

B.t.i. and *B. sphaericus* are naturally occurring bacteria that have insecticidal activity on mosquitoes. This bacteria contain protein crystals that, when ingested by mosquito larvae, will rupture the gut wall or the larvae. This results in rapid death of the larvae. Can be used in wide range of sources and habitat. Urban and rural, agricultural sites, crop and non-crop, lakes, ponds, wetland and marshes, catch-basins and swimming pools, etc.

Spinosad is biologically derived from the fermentation of *Saccharopolyspora spinosa*, a naturally occurring soil organism. This Group 5, organic-rated larvicide overstimulates the nervous system of mosquito larvae. *Available in CA by summer 2010.*

* Criteria used to determine the action threshold are larval density, species significance (nuisance or disease), flight range, dispersal patterns and other environmental and meteorological factors combined with human and domestic animal activity, injury and proximity. Treatment decisions are based on threshold levels of larvae determined for particular sites by evaluating species, proximity to residents, stage of development and abundance, ecological value, presence, number and type of predators and other aquatic life and other environmental factors.