

# Final Mosquito Management Plan and Environmental Assessment

For The

## San Pablo Bay National Wildlife Refuge



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Fish and Wildlife Service  
Pacific Southwest Region

**FINDING OF NO SIGNIFICANT IMPACT**

**Environmental Assessment for Mosquito Management on  
San Pablo Bay National Wildlife Refuge  
Sonoma, Napa, and Solano Counties, California**

The U.S. Fish and Wildlife Service (Service) has completed the Mosquito Management Plan (Plan) and Environmental Assessment (EA) for the San Pablo Bay National Wildlife Refuge (Refuge). The Plan and EA prescribes mosquito management activities on the Refuge as conducted by local mosquito abatement districts, and also analyzes the associated effects on the human environment under the proposed alternatives, including the no action alternative.

**Decision**

Following comprehensive review and analysis, the Service selected Alternative A for implementation because it is the alternative that best provides for mosquito control when needed using the most effective means that pose the lowest risk to wildlife and their associated habitats.

**Alternatives Considered**

The following is a brief description of the alternatives considered in the Mosquito Control Plan, including the selected alternative (Alternative A). For a complete description of each alternative, see the final EA.

*Alternative A (Selected Alternative)*

Under Alternative A, the Service would implement a mosquito management plan that permits the local mosquito abatement districts (MADs) to conduct a phased approach to mosquito management. The alternative emphasizes design, restoration, and management of wetlands in a manner to benefit wildlife and minimize mosquito production. The improvement of hydrology within wetlands would be the primary mechanism for enhancing habitat and reducing mosquito production.

While the emphasis of this alternative is tidal marsh enhancement, the phased approach also includes monitoring, surveillance and the potential application of pesticides. Application of pesticides would be approved based on the phased approach. Larvicides, pupacides, and in certain cases, adulticides would be permitted. Because occurrence of arboviruses and other human health issues resulting from mosquitoes are sporadic, phases of mosquito management implemented on the Refuge would vary through time. The selected alternative includes a number of best management practices (BMPs) that will be implemented during monitoring and surveillance activities, as well as during pesticide application. Those BMPs are described in detail in the final EA, which is incorporated by reference, and summarized in the discussion below. In addition, because the emphasis of this alternative is the restoration and enhancement of wetlands on the Refuge, site specific projects will be developed at a later date. As restoration

and enhancement projects are developed, additional site-specific analysis will be completed and construction related BMPs will be identified.

#### *Alternative B*

Like Alternative A, monitoring and disease surveillance would be allowed in documented mosquito production areas of the Refuge under Alternative B. However, use of chemical pesticides to reduce mosquito populations would not be permitted on the Refuge under this alternative. Mosquito populations would be managed primarily through enhancement or restoration of hydrology where possible. Use of a biological agent larvicide (Bti) would be permitted in areas where hydrological improvements have not been conducted or are not biologically, physically or economically feasible. Eliminating the use of chemical pesticides would require that mosquito populations are always controlled at the larval level, requiring intensified monitoring efforts by the MADs.

#### *Alternative C*

Under this alternative, mosquito population monitoring, disease surveillance or mosquito control using biological or chemical methods by the MADs would not be permitted on Refuge. Efforts to enhance and restore wetlands would necessarily be increased with a focus on design, management and maintenance that reduces mosquito populations to below threshold treatment levels.

#### *Alternative D (No Action Alternative)*

Under the No Action Alternative, the MADs would continue to operate in a manner similar to the past ten years in which mosquito monitoring and disease surveillance is followed by control with larvicides (excluding surface oils) and alcohol-based surfactants (e.g., Agnique) when action thresholds have been exceeded and all other reasonable IPM actions, such as tidal marsh enhancement projects, have been explored. The MADs would coordinate with the Refuge manager prior to surveillance, control, and monitoring activities on the Refuge. The No Action alternative is a phased approach similar to the Selected Alternative with the exception that adulticides are not permitted on the Refuge.

### **Effects of management of the Refuge on the human environment**

As described in the EA, implementing the Selected Alternative is not expected to have significant impacts on any of the environmental resources identified in the EA. The following resources are not affected by any of the alternatives and are therefore not summarized below: climate, soils and geology, environments (open water, mudflats, tidal marsh, and seasonal wetlands), noxious weeds, land use, cultural and historic resources, socioeconomics, and environmental justice. A summary of the impacts analysis and conclusions follows:

#### *Air Quality*

Monitoring, surveillance, and pesticide application are not expected to impact air quality. Vehicle emissions from these activities would be no different from the current No Action Alternative. Pesticide application by aircraft, vehicle, and backpack sprayer are expected to be low to the ground in discrete areas. Pesticide application will not occur in certain weather conditions (rain or high wind) to avoid the possibility of drift. Tidal marsh enhancement activities could result in increased, localized construction-related dust and tailpipe emissions

from heavy equipment operation. As site specific restoration and enhancement projects are identified, air quality effects would be further analyzed. The Service has concluded that implementation of the Plan will have no significant impact to air quality of the area.

### *Topography*

Monitoring, surveillance, and pesticide application are not expected to result in any physical changes to the existing topography. Tidal marsh enhancement projects will result in localized change to specific sites and are expected to have a positive benefit to hydrologic patterns of tidal marshes where little water circulation has resulted in high mosquito production. As site specific restoration and enhancement projects are identified, localized changes would be further evaluated. The Service has concluded that implementation of the Plan will have no significant impact to topography.

### *Water Quality*

Monitoring and surveillance consists of walking, driving, or kayaking to sample sites and would have no impact on water quality. Only pesticides approved for aquatic environments would be permitted and are expected to degrade quickly. Pesticide application would be in accordance with the summary of BMPs (listed at the end).

Tidal marsh enhancement activities may result in short-term erosion and increased turbidity in waterways. However, in the long-term these activities will improve tidal exchange of water through the tidal marshes that will improve overall water quality. As site specific restoration and enhancement projects are identified, water quality effects would be further analyzed. Best management practices to minimize air quality effects would be identified in the project-specific document. The Service has concluded that implementation of the Plan will have no significant impact to water quality.

### *Human Health and Safety*

Monitoring and surveillance activities would have no impact human health and safety. No public access would be permitted in areas where tidal marsh enhancement is under construction. Although it is possible for staff and visitors to be exposed to pesticides, the following best management practices will be implemented to avoid any exposure: the Refuge Manager will post a notice at the Refuge Office and parking area with information on the dates and location of adulticide application and the Refuge Manager will close all treatment areas where adulticides are going to be applied.

The Service has concluded that implementation of the Plan will have no significant impact to human health and safety.

### *Vegetation*

Monitoring, surveillance, and pesticide application are not expected to significantly impact vegetation. Monitoring by foot and truck on levees will have minimal effects to vegetation. Use of all-terrain vehicles (ARGO) may trample vegetation temporarily, but is not expected to result in permanent vegetation loss. ARGOS can also introduce and spread invasive weeds. ARGO use will be generally limited to large (greater than 100 acre) sites. Best management practices will be implemented for ARGO use (listed at the end) and include operating vehicles at slow

speeds; driving slow, several point turns; and using existing levees or upland to travel through sites when possible. Refuge staff and MADs will develop and implement measures to reduce the introduction and spread of invasive weeds by mosquito management activities. Best management practices will also include control of invasive weeds through manual removal and chemical control where possible.. Tidal marsh enhancement activities will improve hydrology to the tidal marsh that will result in higher quality vegetation. The Service has concluded that implementation of the Plan will have no significant impact to native vegetation.

### *Wildlife*

Monitoring, surveillance, and pesticide application are not expected to significantly impact wildlife. Monitoring and surveillance activities may trample vegetation (by foot or by ARGO vehicle), injuring or flushing wildlife that are present. Vehicle routes may increase pathways for predators. Best management practices to minimize these impacts are listed below. Pesticide application is not expected to directly harm mammals, birds, reptiles, and amphibians, based on toxicity studies by the U.S. Environmental Protection Agency. Pesticide application may result in indirect effects to bird, reptile, and amphibian species by reducing their invertebrate prey base. Adverse impacts to invertebrates are expected from pesticide application. However, the application of pesticides on discrete areas of the Refuge is meant to lower mosquito numbers, but not to eliminate mosquito populations entirely (or other invertebrate species), ensuring food availability for birds. Also, application of pesticides will occur in site specific locations and will not be applied indiscriminately across the entire Refuge. Best management practices (listed at the end) would also reduce impacts to wildlife.

Tidal marsh enhancements would result in short-term construction impacts to wildlife including flushing, possible injury to wildlife, and temporary loss of habitat. As site-specific projects are identified, potential impacts will be further analyzed. Improved tidal circulation will improve vegetation which in turn will benefit wildlife. The Service has concluded that implementation of the Plan will have less than significant impact to wildlife.

### *Fish*

Monitoring, surveillance, and pesticide application are not expected to significantly impact fish. Monitoring and surveillance is not conducted in navigable waters. Larvicides and pupacides are not expected to directly affect fish, based on toxicity studies by the U.S. Environmental Protection Agency. Adulticides are highly toxic to fish and additional criteria are placed on permitting the use of adulticides including data supporting presence of an arboviral disease on the Refuge or within flight range of the vector mosquito species on the Refuge. Best management practices (listed at the end) would reduce impacts to fish including limiting adulticide application to specific mosquito-producing sites, generally away from navigable waters.

Pesticide application may result in indirect effects to fish species by reducing their invertebrate prey base. Adverse impacts to invertebrates are expected from pesticide application. However, the application of pesticides on discrete areas of the Refuge is meant to lower mosquito numbers, but not to eliminate mosquito populations entirely (or other invertebrate species), ensuring food availability for fish. Also, application of pesticides will occur in site specific locations and will not be applied indiscriminately across the entire Refuge.

Tidal marsh enhancements could result in entrapment of fish during low tide conditions. Mitigation elements include avoiding construction activities during migration periods and use of water control structures to prevent entrapment. The Service has concluded that implementation of the Plan will have less than significant impact to fish.

### *Endangered Species*

Monitoring, surveillance, and pesticide application are not expected to significantly impact endangered species. Several threatened and endangered species are or may be present on the Refuge: the California clapper rail, salt marsh harvest mouse, California red-legged frog, steelhead, Chinook salmon, delta smelt, and green sturgeon. The Federally listed plant, soft bird's-beak, may also be present on the Refuge but individuals have not been identified. The California red-legged frog is not present in the areas where monitoring, surveillance, and pesticide application will take place. Trampling of vegetation by foot or ARGO from monitoring and surveillance activities may cause temporary disturbance to the clapper rail and salt marsh harvest mouse. Monitoring and surveillance by foot and ARGO may result in trampling of soft bird's-beak individuals, though none have been detected in previous vegetation surveys. Pesticides are not expected to have any direct impact to the clapper rail, salt marsh harvest mouse, and soft bird's-beak. Pesticides may have indirect effects to the clapper rail and California red-legged frog by lowering their invertebrate prey base. However, the application of pesticides on discrete areas of the Refuge is meant to lower mosquito numbers, but not to eliminate mosquito populations entirely (or other invertebrate species). Adulticides are highly toxic to fish and could adversely affect steelhead, Chinook salmon, delta smelt, and green sturgeon. Additional criteria are placed on permitting the use of adulticides including data supporting presence of an arboviral disease on the Refuge or within flight range of the vector mosquito species on the Refuge. Best management practices (listed at the end) would also reduce impacts to listed species.

Tidal marsh enhancement may result in disturbance to individuals or temporary loss of habitat. Potential mitigation measures to reduce impact to individuals may include surveying for presence or absence of individuals; providing a buffer near nest locations; avoiding activities during the nesting season; avoiding activities during fish migration periods; using water control structures to prevent entrapment; trapping and transplanting individuals to other sites; installing barrier fence to prevent re-entry; and slow flooding to allow mammals to seek refugia in higher elevation pickleweed.

Refuge staff is in consultation with the Sacramento Fish and Wildlife Office under Section 7 of the Endangered Species Act regarding the potential effects of implementing the Plan on the California clapper rail, salt marsh harvest mouse, California red-legged frog, delta smelt, and soft bird's-beak. In addition to the mitigation measures identified in the EA, we will implement any reasonable and prudent measures, and terms and conditions in the Intra-Service biological opinion. No new activities under the Plan will be initiated until this consultation is complete. As tidal restoration projects are developed in the future, the Service will consult with the Sacramento Fish and Wildlife Office to ensure that all measures to minimize potential impacts to listed species are included in the project design. Therefore, we have concluded that

implementing the Plan will have no significant adverse impact to threatened and endangered species under the jurisdiction of the Service.

Steelhead, Chinook salmon, and green sturgeon are under the jurisdiction of the National Marine Fisheries Service. The Service is in Section 7 consultation with National Marine Fisheries Service regarding the effects of implementing the Plan on the steelhead, Chinook salmon, and green sturgeon. No new activities under the Plan will be initiated until this consultation is complete. We will implement any reasonable and prudent measures and terms and conditions in the National Marine Fisheries Service biological opinion. As tidal restoration projects are developed in the future, the Service will consult with the National Marine Fisheries Service to ensure that all measures to minimize potential impacts to listed fish species are included in the project design. Tidal restoration projects will have long-term beneficial effects for fish species. Therefore, we have concluded that implementing the Plan will have no significant adverse impact to threatened and endangered species under the jurisdiction of the National Marine Fisheries Service.

### *Best Management Practices*

We will ensure impacts to the human environment are minimal and less than significant by implementing best management practices. The following is a summary of the BMPs described in the final EA. These BMPs will be required as a condition for allowing mosquito control on the Refuge.

#### Monitoring and Surveillance

- Access (via foot or mechanized vehicle) to tidal marsh for the purpose of mosquito management would be seasonally limited (e.g., reduced access during high tide events, use of biological monitor, use of ARGO only as a nurse rig) from January 15 to September 1 in areas that are known to be occupied by California clapper rails and along slough and channel edges (30-m buffer) which supply essential habitat components to many estuarine dependent species such as rails.
- ARGO access along tidal channels and sloughs will be prohibited within 30 meters of occupied rail habitat to reduce impacts to vegetation and provide escape to wildlife.
- Use of mechanized vehicles will be permitted only in wetland mosquito production areas greater than 100-acres in size, unless coordinated with Refuge staff.
- The number of travel pathways used by mechanized vehicles will be limited within the marsh and existing pathways will be used when possible.
- We will provide the mosquito abatement districts (MADs) with training on ways to avoid impacts to wetland wildlife.
- To limit vegetation impacts, mechanized vehicles will drive slowly, make several point turns, and use existing levees or uplands to travel through sites when possible.
- Refuge staff and MADs will develop and implement measures to reduce the introduction and spread of invasive weeds by mosquito management activities.
- Control of invasive weeds including manual removal and chemical control.

### Pesticide Application

- Where mosquito control is needed, the MADs will use the most effective means that pose the lowest risk to abiotic and biotic resources.
- Pesticide application during high tides and on open water areas of the Refuge will be avoided.
- Aerial pesticide application (larvicide or pupacide) is encouraged over ground-based application methods.
- Wind speed restrictions will be employed on spraying activities.
- Prior to the application of any pesticide, the MAD must identify the treatment locations, treatment schedule, and identify the pesticide to be used. The MAD must provide this information to the Refuge Manager at least 48 hours prior to the proposed application.
- The MADs will be required to minimize the use of pesticides and continually investigate formulations and compounds that are less damaging to fish and wildlife populations.
- Each MAD will be required to review the past year's pesticide proposal and submit any changes in the pesticides or formulations of pesticides that they expect to use in the upcoming year. This information should be made available at or before the time of the annual meeting.
- Pesticides will be applied according to pesticide label instructions and per habitat types.
- MADs will adapt methods to reduce ecological risk to the environment (e.g. boom height, droplet size, application rate) as new information on ecological risk and avoidance measures are identified by appropriate regulatory agencies.
- In a season when a risk of serious human disease or death, or high risk to public health is documented, the application of pyrethrins must be limited to reduce impacts to habitat and wildlife, but sufficient to ensure effective mosquito control.
- The application of pyrethrins will only occur in rare instances when a mosquito-borne disease incidence has been documented on the Refuge or within flight range of vector mosquito species present on the Refuge; adult vector mosquito thresholds are exceeded on the Refuge; and when there are no practical and effective alternatives to reduce a mosquito-borne, disease-based health threat.
- The application of pyrethrins should occur at an ultra-low volume (according to pesticide label instructions and per habitat type).
- If beneficial, the MAD should conduct simultaneous application of larvicides with adulticide application to prevent future adult outbreaks.

### **Public Review**

The planning process incorporated public involvement in developing and reviewing the Plan. This included a public scoping, public review and comment on the draft Plan. The details of the Service's public involvement process are described in the Plan.

### **Conclusions**

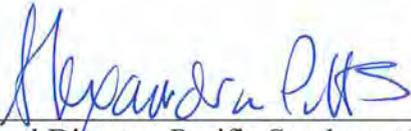
Based on review and evaluation of the information contained in the supporting references, I have determined that implementing Alternative A as the Plan for mosquito management of San Pablo

Bay National Wildlife Refuge is not a major Federal action that would significantly affect the quality of the human environment, within the meaning of section 102(2) (c) of the National Environmental Policy Act of 1969, as amended. Accordingly, the Service is not required to prepare an environmental impact statement.

This Finding of No Significant Impact and supporting references are on file at the U.S. Fish and Wildlife Service, San Francisco Bay National Wildlife Refuge Complex, 1 Marshlands Road, Fremont, California, 94536 (telephone 510/ 792 0222) and the U.S. Fish and Wildlife Service, San Pablo Bay National Wildlife Refuge, 7715 Lakeville Highway, Petaluma, California, 94954 (telephone 707/ 769 4200). These documents can also be found on the Internet at <http://www.fws.gov/cno/refuges/planning.html>. These documents are available for public inspection. Interested and affected parties are being notified of this decision.

**Supporting References**

U.S. Fish and Wildlife Service. 2011. Final Mosquito Management Plan and Environmental Assessment for the San Pablo Bay National Wildlife Refuge.

Acting   
Regional Director, Pacific Southwest Region  
Sacramento, California

  
Date

## Table of Contents

Chapter 1	PURPOSE AND NEED FOR PROPOSED ACTION	1
1.1	Introduction	1
1.2	Refuge Location and Site Description	1
1.3	Proposed Action	1
1.3.1	Purpose and Need for Proposed Action	1
1.3.2	Historical Perspective of Need	2
1.3.3	Historical Mosquito Production Areas of the Refuge	4
1.3.4	How the Proposed Action would be Accomplished	5
1.3.5	Objectives of the Proposed Action	5
1.4	Issues and Concern	6
1.4.1	Public Participation	6
1.4.2	Issues Related to the Proposed Action	6
1.5	Summary of Laws, Regulations, and Policies Governing the Proposed Action	6
1.5.1	Legislative Acts	6
1.5.2	Executive Orders	9
1.5.3	Service and Refuge Missions and Policies	9
1.6	Decision to be Made	11
Chapter 2	ALTERNATIVES INCLUDING THE PROPOSED ACTION	12
2.1	The Process Used to Develop the Alternatives	12
2.2	Description of Alternatives, Including the Proposed Action and No Action	12
2.2.1	Factors Common to All Alternatives	12
2.2.2	Alternative A – Proposed Action – Phased Approach to Mosquito Control	12
2.2.3	Alternative B – Non-chemical Mosquito Control	21
2.2.4	Alternative C – No Mosquito Management	22
2.2.5	Alternative D – No Action	22
2.2.6	Alternatives Summary	22
Chapter 3	AFFECTED ENVIRONMENT	23
3.1	Physical Environment	23
3.1.1	Climate	23
3.1.2	Topography	23
3.1.3	Soils and Geology	23
3.1.4	Air Quality	24
3.1.5	Water and Water Quality	24
3.2	Biological Considerations	25
3.2.1	Environments, Vegetation, and Associated Resources	25
3.2.2	Special Biological Communities/Critical Wildlife Habitat	26
3.2.3	Noxious Weeds/Exotic Plants	26
3.2.4	Wildlife	26
3.2.4.1	Birds	27
3.2.4.2	Mammals	27
3.2.4.3	Reptiles and Amphibians	27
3.2.4.4	Fisheries	27
3.2.4.5	Invertebrates	28
3.3	Socioeconomic Considerations	29
3.3.1	Cultural Resources	29
3.3.2	Socioeconomics and Environmental Justice	29
3.3.3	Land Use	30
3.3.4	Human Health and Safety Concerns	31
3.3.5	Aesthetics	32

3.3.5.1	Scenery .....	32
3.3.5.2	Noise.....	32
Chapter 4	ENVIRONMENTAL CONSEQUENCES .....	33
4.1	Effects on the Physical Environment.....	34
4.1.1	Air Quality.....	34
4.1.2	Topography.....	34
4.1.3	Water .....	35
4.2	Effects on Biological Resources.....	36
4.2.1	Vegetation.....	37
4.2.2	Effects on Mammals.....	38
4.2.3	Effects on Birds .....	40
4.2.4	Effects on Reptiles and Amphibians .....	42
4.2.5	Effects on Fisheries .....	43
4.2.6	Effects on Invertebrates.....	44
4.3	Effects on the Social Environment .....	46
4.3.1	Effects on Cultural and Historic Resources.....	46
4.3.2	Effects on Human Health and Safety Concerns .....	46
4.3.3	Effects on Aesthetics .....	47
4.4	Cumulative Effects .....	47
Chapter 5	COMPLIANCE, CONSULTATION, AND COORDINATION WITH OTHERS .....	49

**TABLES**

Table 1.	Phased-response mosquito management guidelines for San Pablo Bay National Wildlife Refuge. ....	14
Table 2.	Common pesticides used for mosquito control in wetlands by the Solano, Napa, and Marin/Sonoma County Mosquito Abatement Districts.....	21
Table 3.	Summary of mosquito management activities permitted under each alternative.....	22
Table 4.	Impaired water bodies in the vicinity of San Pablo Bay.....	25
Table 5.	Federal and State listed wildlife and plant species that occur or have the potential to occur on the San Pablo Bay National Wildlife Refuge.....	26
Table 6.	Summary of fate and biological effects of common pesticides used for mosquito control in wetlands by the Marin/Sonoma and Solano Mosquito Abatement Districts.....	37

**FIGURES**

Figure 1.	Approved Acquisition Boundary of the San Pablo Bay National Wildlife Refuge.....	50
Figure 2.	Map of San Pablo Bay National Wildlife Refuge showing areas that trigger management by local mosquito abatement districts. Current mosquito production areas of the Refuge are shown as red ellipses. Tidal marsh along the perimeter of Skaggs Island also includes areas that consistently produce mosquito larvae according to the MSMAD.....	51

**LITERATURE CITED**

**GLOSSARY**

## **APPENDICES**

- APPENDIX A. USFWS Interim Guidance for Mosquito Management on National Wildlife Refuges
- APPENDIX B. Statement of Best Management Practices and Proposed Monitoring Plan for Coastal Region Mosquito and Vector Control Districts
- APPENDIX C. USFWS Compatibility Determination
- APPENDIX D. USFWS Pesticide Use Proposal
- APPENDIX E. USFWS Special Use Permit
- APPENDIX F. California Mosquito-Borne Virus Surveillance and Response Plan
- APPENDIX G. Criteria for Use of Pesticides, Larvicides, and Equipment
- APPENDIX H. Public Health Authorities: Marin, Sonoma, and Solano Counties
- APPENDIX I. Monitoring and Surveillance Protocols
- APPENDIX J. Effects of Larvicides on Non-Target Organisms
- APPENDIX K. Environmental Effects of Mosquito Control
- APPENDIX L. Mosquito-borne Virus Risk Assessment from the California Mosquito-Borne Virus Surveillance and Response Plan
- APPENDIX M. Threshold Limits for Adult Mosquitoes on the San Pablo Bay National Wildlife Refuge
- APPENDIX N. Mosquito Biology
- APPENDIX O. Pyrethrins and Pyrethroids
- APPENDIX P. Marin/Sonoma Mosquito and Vector Control District Summary of West Nile Virus Testing in Marin and Sonoma Counties 2004-November 2, 2010
- APPENDIX Q. Public Comment and Response



## **Chapter 1 PURPOSE AND NEED FOR PROPOSED ACTION**

### **1.1 Introduction**

Mosquito management activities occur throughout the San Francisco Bay region where a large (over 7 million) human population occurs and a long history of mosquito management and documented mosquito-borne disease transmission to humans and wildlife exists. Since establishment of the Refuge in 1974, mosquito management has been monitored and regulated through annual US Fish and Wildlife Service (Service) Pesticide Use Proposals and SUPs. The San Pablo Bay National Wildlife Refuge (Refuge) lies within the jurisdiction of three mosquito abatement districts (MADs): Solano County Mosquito Abatement District, Napa County Mosquito Abatement District, and Marin/Sonoma Mosquito and Vector Control District (MSMVCD). Budgets for these mosquito abatement districts have not been comparable but each district operates under the California Health and Safety Code (Section 2000-2910) as well as similar policies and management directives set by their individual boards. The disparity in budgets leads to different approaches to mosquito management on the Refuge, particularly with reference to source reduction projects.

Mosquito management on the National Wildlife Refuge System (NWRS) has been a controversial issue with some segments of the public for many years. In response to requests by local residents and/or political officials, mosquito abatement districts (MADs) have routinely requested access to the NWRS to control mosquitoes. Access has been granted as refuge management allows, for public health concerns. However, requests for control solely to address annoyance mosquitoes have raised a myriad of concerns and, as a result, access for mosquito control on refuges has varied across the NWRS. Refuge managers are concerned about introducing toxic substances onto refuges in general, and specifically direct effects of mosquito management techniques on non-target invertebrates and other species. Concerns have also been raised with effects associated with reductions in mosquito populations and other non-target invertebrate species that are part of the food chain.

### **1.2 Refuge Location and Site Description**

The Refuge is located at the northern extent of the San Francisco Estuary within San Pablo Bay (Figure 1). The Refuge is 16,500 acres in size and encompasses open bay, mudflats, tidal wetlands, seasonal wetlands, and uplands (primarily former agriculture and military lands). The Refuge lies within the boundaries of Marin, Sonoma, Napa, and Solano Counties. The Refuge was established in 1974 under authority of the Migratory Bird Conservation Act "...for use as an inviolate sanctuary, or for any other management purpose, for migratory birds." (16 U.S.C. 715d). Additional tidal wetlands were acquired for their "...particular value in carrying out the national migratory bird management program." (16 U.S.C. 667b). In 1991, the Cullinan Ranch Unit was acquired under authority of the Endangered Species Act "...to conserve fish or wildlife which are listed as endangered species or threatened species...or plants..." (16 U.S.C. 1534).

### **1.3 Proposed Action**

The Refuge proposes to implement a mosquito management plan (Plan) that consists of a phased approach to mosquito management and is consistent with the principles of integrated pest management. The Plan includes ongoing coordination with the Solano, Napa, and Marin/Sonoma County Mosquito Abatement Districts and incorporates the interim guidance issued by the U.S. Fish and Wildlife Service (Service) for mosquito-borne disease management pursuant to the NWRS (Appendix A).

#### **1.3.1 Purpose and Need for Proposed Action**

The purpose of the Proposed Action is to ensure that activities to survey and control mosquito populations on the Refuge are compatible with the establishing purposes of the Refuge. With the spread of West Nile Virus (WNV) and the potential for spread of other mosquito-borne disease, there is increasing pressure to manage mosquito populations that occur on lands of the National Wildlife Refuge System (NWRS), especially in urban areas such as the San Francisco Bay region. The Refuge considers mosquitoes a natural component of tidal wetlands but also recognizes that mosquitoes may pose a threat to human and/or wildlife health.

A "Draft Mosquito and Mosquito-Borne Disease Management Policy" was published by the Service in October

2007, but has not yet been finalized. The Service's "Interim Guidance for Mosquito Management on National Wildlife Refuges" finalized in April 2005, provides guidance for mosquito management that is currently conducted on national wildlife refuges. The interim guidance provides a standard process for refuges to follow and criteria to consider when making decisions regarding management of mosquitoes and mosquito-borne disease. Mosquito control management plans and documentation of management actions on refuges are necessary to protect both threatened and endangered plants, fish, and wildlife and to ensure the health and welfare of surrounding human populations.

Mosquitoes (members of the Phylum Arthropoda) are well known vectors of disease to both humans and wildlife and in some cases can cause death. "Arthropod-borne viruses (termed "arboviruses") are viruses that are maintained in nature through biological transmission between susceptible vertebrate hosts by blood-feeding arthropods (mosquitoes, sand flies, ceratopogonids "no-see'ems", and ticks). Vertebrates can become infected when an infected arthropod bites them to take a blood meal" (CDC 2010). Recently, the arbovirus labeled West Nile virus (WNV) has been of particular concern across the United States and in the San Francisco Bay region. With the swift westward advance of WNV across the United States, concern by the public and the Service over mosquito management and disease prevention has intensified. As a result, Service personnel across the refuge system have undertaken a number of actions, including: stepping-up coordination and communication with mosquito experts in MADs, universities, and elsewhere; increasing communication with public health officials; participating in mosquito management seminars and workshops; initiating mosquito management-oriented research on refuges; and conducting restoration that benefits natural resources and reduces the need for mosquito management.

Measures to control mosquitoes in wetlands of the Bay Area have a long history dating back to the early 1900s when the first mosquito district was formed in Marin County, California. The association between mosquitoes and certain vector-borne diseases is also well known (e.g., West Nile virus). Historic measures for reducing mosquitoes included draining or filling wetlands, but today, a suite of other measures are now in place and include the placement and maintenance of mosquito ditches and application of pesticides (Resh 2001). The placement and maintenance of ditches in salt marsh is a physical technique used throughout the Estuary to reduce mosquito production where water collects in depressions. The purpose of ditching is to increase tidal flushing and permit access by fish that can predate upon mosquito larvae (Resh 2001). Ditches were placed throughout the Refuge over the last century but results are typically short-lived (e.g., 10 years). Today the Refuge and the MADs that operate in San Pablo Bay advocate for an integrated approach to mosquito management that includes a range of tools to improve habitat conditions for estuarine wildlife while reducing threats to public health from mosquito species capable of transmitting disease to humans.

*West Nile Virus.* In the United States, WNV is transmitted by infected mosquitoes, primarily members of the *Culex* and *Aedes* species, although 64 species have been identified in WNV positive mosquito pools in the United States since 1999 (CDC, June 2010). Ten California species of mosquito that are known vectors of arboviruses or as major pests were evaluated for WNV transmission in 2002. All 10 species were infected with WNV and were able to transmit the disease at some level (Goddard, et al. 2002). *Culex tarsalis* is considered one of the most efficient laboratory vectors of WNV tested from North America, is abundant in California and much of western North America, and is involved in the maintenance and amplification of western equine encephalomyelitis virus (WEEV) and Saint Louis encephalitis virus (SLEV) (Goddard et al. 2002). *Culex tarsalis* larvae are typically found in irrigation ditches, ponds, and storm sewers, and other areas that usually contain abundant organic material. Of the 10 mosquito species studied by Goddard et al. 2002, *Culex tarsalis* showed the greatest potential to amplify and maintain WNV in California. Mosquito species most abundant on the Refuge in 2005 were *Aedes dorsalis*, *A. squamiger* and *Culiseta inornata* (MSMAD 2009). In 2010, there were four human cases of WNV reported in Contra Costa County ([http://westnile.ca.gov/case\\_counts.php?year=2010&option=print](http://westnile.ca.gov/case_counts.php?year=2010&option=print)). Positive WNV results have been reported in 2010 for birds and mosquitoes within the nine county bay area region.

### **1.3.2 Historical Perspective of Need**

Historic documents concerning mosquitoes and mosquito-borne diseases in California focus on the presence of malaria and large nuisance populations of mosquitoes affecting the first immigrants and settlers. The most severe

mosquito disease and pest outbreaks of the 1800s occurred in the Central Valley of California (Fontaine 1980).

When California became one of the first states to launch mosquito control in early 1900s, the project was not for disease control, but to abate severe nuisance infestations of salt-marsh mosquitoes in the San Francisco Bay Area that were adversely affecting development (Fontaine 1980, Peters 1966). During this period, environments characterized by native estuarine and riverine systems were rapidly being altered or replaced by new irrigation systems, mining operations, and diked tidelands for agriculture (e.g., transition from tidal to seasonally flooded and shallow open water environments). These alterations expanded existing habitat for mosquitoes and likely altered mosquito population diversity and abundance in the region. The first campaigns to control mosquitoes were funded mainly by subscriptions from private individuals (Gray and Fontaine 1957, Fontaine 1980). Support for the creation of governmental control units and expenditure of public funds was not supported by public health agencies but came from real estate developers who were losing profits due to a perceived “excessive prevalence” of salt marsh mosquitoes (Gray and Fontaine 1957). In 1915, the real estate lobby introduced a bill to provide for the organization of mosquito abatement districts (MADs) in the State Legislature. The law passed and was incorporated into the State Health and Safety Code that serves as the legal authority under which most mosquito control work is performed (Gray and Fontaine 1957). The first district organized was the Marin County District in December 1915. Other Bay area districts formed after 1920 (Gray and Fontaine 1957).

Since establishment in 1915 and through the 1940s, the MADs of the San Francisco Bay region relied heavily upon physical controls to manage mosquitoes (Gray and Fontaine 1957, Woodworth 1915). Controls included ditching, levee building, and the installation of culverts. The Districts owned and rented heavy equipment and employed engineers, inspectors and laborers to accomplish their mission (Alameda Co. MAD 1992). Chemical controls (distillate and crude oils) were also used during this period to prevent larvae and pupae from reaching adult stages (Woodworth 1915).

During World War II, a fear of the return of large numbers of military personnel infected with mosquito-borne diseases stimulated the legislature in 1945 to provide special funds for mosquito control by the State Department of Public Health (Gray and Fontaine 1957). The program was oriented toward better control of pest mosquitoes, and of the vector of viral encephalitis, *Culex tarsalis* (Gray and Fontaine 1957). The traditional pre-World War II methods were largely suspended and mosquito control programs became increasingly dependent on routine spraying of (dichlorodiphenyltrichloroethane) DDT (Fontaine 1980). By 1954, the major pest and vector mosquitoes developed a resistance to DDT and led to use of organophosphorous compounds (Fontaine 1980). During the late 1960s and 1970s, the Bay Area Districts began to implement Integrated Pest Management programs to counter-attack the development of insecticide resistance by some species of mosquitoes, and to address the environmental concerns of pesticides (Alameda Co. MAD 1992). District employees began to select control methods appropriate to each source of mosquitoes and the use of mosquito-eating fish became an integral part of mosquito control programs (Alameda Co. MAD 1992).

By the mid-1980s most districts in the Bay area had replaced the majority of chemical controls with materials that are biologically-derived with few ecological side-effects called biorationals. Principle biorational materials used today are Bs (*Bacillus sphaericus*), Bti (*Bacillus thuringiensis* var. *israelensis*), and methoprene which is an insect growth regulator. However, the shift to biorationals resulted in significant increases in labor and material costs.

Today, MADs of the San Francisco Bay region employ an Integrated Pest Management approach to mosquito control that emphasizes permanent solutions such as wetland restoration, mechanical control of water levels or exchange, and/or includes the use of biorational larvicides (Appendix B).

The history of disease-carrying mosquito populations within the Bay area continues to cause concern among the MADs and local health departments. A positive mosquito pool for SLE was detected in 1969 in Solano County, and Western Equine encephalitis (WEE) has been detected in Napa County (1995), Contra Costa County (mosquito pool:1993) and Sonoma County (sentinel chicken flock:1997) (C. Krause, Marin/Sonoma MAD, pers. comm.; Napa MAD, pers. comm.; and Hui et al. 1999). From 1990 through 1999, 82 cases of arbovirus diseases were diagnosed in California and comprised <1% of patients hospitalized with acute encephalitis (Trevejo 2004). Western Equine encephalitis and St. Louis Encephalitis (SLE) viruses, both of which can be transmitted by

mosquitoes, are important causes of encephalitis in California residents. Since the 1960s, incidence of WEE and SLE has decreased significantly in California although sporadic cases are still reported (Trevejo 2004). Since introduction to North America in 1999, WNV has now reached California, and is transmitted to humans by infected mosquitoes. Mosquitoes become infected with WNV when they feed on the blood of infected birds. The recent spread of the WNV to the Bay Area, and the increased number of vectors possible for WNV, has led to increases in mosquito monitoring and control activities by regional MADs to ensure public health and safety. Napa County had one human case in 2006 and again in 2007 (<http://www.westnile.ca.gov>, accessed May 3, 2011). In 2010 there were three human cases of WNV reported for Contra Costa County (pers. comm., Solano County MAD). Further information on West Nile Virus is available in Appendix P for Marin and Sonoma Counties (2004-2010) and Solano County (1945-2010). No human cases were reported for the other eight counties surrounding the Bay Area. Positive mosquito or sentinel chicken pools for WNV were reported in five of the nine counties surrounding the Bay Area in 2009 (Napa, Solano, Contra Costa, Alameda, and Santa Clara).

### **1.3.3 Historical Mosquito Production Areas of the Refuge**

Units of the Refuge that produce above average mosquito populations during some part of the year include Cullinan Ranch, Strip Marsh, Sonoma Creek, Lower Tolay Creek, Lower Tubbs Island, and south of Sonoma Baylands (Figure 2). These units are characterized as tidal marsh except Cullinan Ranch which is a seasonal wetland. Characteristics of elevated mosquito production areas include rapid marsh expansion over the last century (“centennial marsh”), shallow swales within the marsh plain (4-6’ NGVD29) that hold water for extended periods following high tides and precipitation, and a lack of tidal channels that permit drainage. These characteristics, in combination with emergent vegetation, encourage above average mosquito production. Rapid sedimentation has reduced the efficacy and longevity of historic ditching efforts (by MADs) to increase tidal flushing in these areas. In addition to the above characteristics, these sites generally exhibit poor habitat quality for estuarine wildlife and plants, including threatened and endangered species, relative to other tidal marsh areas of the Refuge.

Mosquito monitoring of production areas by foot and mechanized vehicles (ARGO) occurs year round. Typically, high production of *Aedes*, *Culiseta*, and *Culex* species results in mosquito control actions.

The Cullinan Ranch unit is a 1,500-acre historic tidal marsh that was diked and drained for agriculture in the late 1800s and early 1900s. Since Refuge acquisition in 1994, agricultural pumping ceased and resulted in a seasonal wetland dominated by *Typha latifolia*- common cattail. Winter rains result in large shallow ponded areas that persist until mid- to late summer. The shallow ponds intermixed with emergent vegetation result in mosquito production at levels above average for the region and trigger control actions by the Napa and Solano County MADs. The typical size of mosquito production areas at Cullinan ranges from 200-500 acres annually. Planning is underway to restore the Cullinan Ranch unit to tidal wetlands. This action will eliminate mosquito production at current levels and will reduce the need for surveillance and control. Reintroduction of tidal waters to Cullinan Ranch will result in an open deep body of water for approximately 20 to 30 years until sediments accrete to levels where marsh vegetation can colonize. The restoration project encourages development of complex channel systems that will enhance tidal flushing.

The Strip Marsh East (SME) unit of the Refuge contains one of the largest water impoundment and related mosquito management areas of the Refuge. Tidal marsh here has rapidly expanded southward from historic borders (e.g., pre-1900s), once occurring where Highway 37 is today. This rapid expansion precluded channel formation, leaving behind large areas of marsh that are unable to drain following high tides. The marsh also features a natural berm along the edge of San Pablo Bay. Bay water tops the berm during high tides but cannot retreat, leaving behind large areas of impounded water. The degree of impoundment varies annually with tides and precipitation. The expansion of marsh within this unit is due to changes in abundance of sediment and patterns of sediment distribution as a result of human activities (e.g., gold mining, Mare Island southern rock spit). Decades of impoundment have led to poor health and mortality of marsh vegetation within the northern half of the unit. Above average mosquito production over 400 to 600-acres annually is not uncommon. Over 1,400 acres has been detected in the past. Efforts to improve drainage over the last few decades have not been successful, likely due to inadequate size and placement of drainage structures within the marsh.

Tidal marsh along the western mouth of the Sonoma Creek, referred to here as the “Sonoma Creek” unit, has a long history of mosquito production. This unit contains shallow swales or depressions where water accumulates over a 100- to 400-acre area within the marsh following high tides and winter rains. Stagnant shallow water combined with emergent vegetation here provide optimum habitat for mosquito production and associated reduction in plant health. The MSMAD has expended significant resources to increase tidal flushing at Sonoma Creek since the early 1980s. Short-term results are measurable, but long-term (over 10-yr) solutions have not been realized. The Refuge and the MSMAD are currently working on a project to restore tidal flushing to this area of the Refuge.

Portions of the Tolay Creek and Lower Tubbs Island units have historically produced elevated mosquito populations. Restoration and enhancement projects conducted by Refuge staff in partnership with the MSMVCD from 1999 to 2009 have significantly reduced mosquito production (e.g., <1 acre) and have improved estuarine habitats (Takekawa et al. 2004). Surveillance is expected to continue in these areas for several years to ensure stable mosquito populations at or below treatment threshold levels.

Immediately south of Sonoma Baylands is an approximately 60-acre area that has historically produced high levels of mosquitoes following high tides and precipitation. Historic ditching by the MSMVCD has been successful in the tidal marsh south of Sonoma Baylands. However, in recent years, a portion of the marsh has retained water, provided mosquito habitat, and required larvicide treatment. Like other production areas of the Refuge, tidal waters are trapped following higher high tides and precipitation, resulting in optimal conditions for mosquitoes. A collaborative project is needed to enhance and create circulation channels in order to reduce, and perhaps eliminate, mosquito production.

#### **1.3.4 How the Proposed Action would be Accomplished**

The Proposed Action provides a phased approach for surveillance, monitoring, and control of mosquitoes on the Refuge in a manner consistent with the Service interim guidance and the California Mosquito-Borne Virus Surveillance and Response Plan. A Compatibility Determination for mosquito management activities is included in Appendix C. The Refuge has made a determination that the proposed mosquito management plan is appropriate and compatible with the Refuge purposes.

Each year the Refuge will work with the MADs to develop the Special Use Permit (SUP) that will cover the surveillance, monitoring, and control activities allowed on the Refuge that year. An annual meeting between the Refuge and MAD district managers will ensure that permits are current, communication is continuous, and concerns related to mosquito populations and other biological resources of the Refuge are addressed. Vital to the mission of our respective agencies is maintaining a positive and productive working relationship. Pesticide Use Permits (PUP) and Pesticide Use Reports will be prepared annually by Refuge staff with data support from the MADs. In addition, prior to issuing the SUP, we will review the Section 7 consultation, cultural resource compliance, and this Environmental Assessment to determine if any additional documentation will be necessary.

#### **1.3.5 Objectives of the Proposed Action**

- Protect public from mosquito-borne diseases
- Protect threatened and endangered species, migratory birds, and other wildlife and their habitats from mosquito-borne diseases
- Allow compatible surveillance of mosquito populations on the Refuge
- Development of refuge-based phased response plan
- Where mosquito control is needed, use the most effective means that pose the lowest risk to wildlife and associated habitats
- If other control methods have not been successful, allow the use of adulticides only when there are no practical and effective alternatives to reduce a refuge-based mosquito-borne disease public health threat
- Identify priority areas for enhancement or restoration to reduce the need for mosquito management and improve habitat for native wildlife, fisheries and plants

## **1.4 Issues and Concern**

### **1.4.1 Public Participation**

Public Participation was solicited through public review of this draft management plan and environmental assessment from September 17, 2010 through October 18, 2010. After public request, the comment period was extended another 30 days until November 18, 2010. This document was made available via the Internet and various regional MADs, experts in the field of mosquito biology and control, neighboring land management agencies, and other concerned parties were notified to provide comment. Comments were incorporated into the final document as appropriate. The final plan and EA will also be available online.

### **1.4.2 Issues Related to the Proposed Action**

Specific issues associated with mosquito population management on the Refuge include:

- Understanding how Refuge-based mosquito populations contribute to or pose a mosquito-borne disease threat to surrounding human developments.
- Effects of mosquito population monitoring, disease surveillance and control activities on migratory birds, endangered species, and other wildlife and associated habitats.
- Inter- and intra- agency communication regarding mosquito management activities.
- Planning and implementation of wetland enhancement and restoration projects that reduce the persistence of above normal mosquito populations.
- Disparity in resources between individual mosquito abatement districts that conduct mosquito management on the Refuge.
- Reliable, consistent management of mosquito program by MADs and the Refuge.

## **1.5 Summary of Laws, Regulations, and Policies Governing the Proposed Action**

### **1.5.1 Legislative Acts**

Activities of the Service are governed by Acts of Congress. The proposed action must comply with the following legislative acts, executive orders, laws and regulations.

(1) Endangered Species Act (ESA) of 1973 as amended. The Endangered Species Act (ESA - 16 U.S.C.1531-1544) provides for the identification, protection, and recovery of species approaching extinction. One of the means used to protect such species is found in Section 7 of the Act. This section requires Federal agencies to consult with the Fish and Wildlife Service's Ecological Services (ES) Program, or the U.S. Department of Commerce's National Marine Fisheries Service (NMFS) whenever an action is proposed which may affect a threatened or endangered species or the species critical habitat. Consultation is with NMFS for marine species, including anadromous fish, most marine mammals, and sea turtles.

All mosquito management activities conducted on the Refuge will be in compliance with the ESA. The Refuge will determine whether Section 7 consultation is required for specific wetland restoration or enhancement projects.

(2) National Wildlife Refuge System Administration Act of 1966, as amended. The most important Federal statute guiding management of the NWRS and units is the National Wildlife Refuge System Administration Act of 1966, as amended (Refuge Administration Act - 16 U.S.C. 668dd-668ee). This law was significantly amended in 1997 with passage of the National Wildlife Refuge System Improvement Act of 1997 (Refuge Improvement Act). This amendment provides the NWRS with the following statutory mission statement: "The mission of the System is to administer a national network of lands and waters for the conservation, management, and where

appropriate, restoration of the fish, wildlife, and plant resources and their habitats within the United States for the benefit of present and future generations of Americans.” The law makes clear that the NWRS is to be managed first and foremost for wildlife conservation. The Refuge Improvement Act also requires that six wildlife-dependent public uses be given priority consideration in refuge planning and management over all other general public uses. In essence, the law establishes a management hierarchy by declaring that refuges are to be managed first for wildlife, second for the six wildlife-dependent priority public uses identified in the Refuge Improvement Act (when compatible), and last for other general uses requested from the public (which would include mosquito control). Several substantive and procedural requirements associated with compatibility determinations form a major feature of the law. This is because all public uses must first be determined compatible with the purpose(s) of the refuge and the NWRS mission before they are allowed on a refuge. The law also requires monitoring of the status and trends of refuge fish, wildlife, and plants; as well as maintenance of the NWRS’ biological integrity, diversity, and environmental health.

(3) Biological Integrity, Diversity, and Environmental Health Policy. National guidance has been developed to implement some of the key provisions of the 1997 amendments to the Refuge Administration Act. This includes the Biological Integrity, Diversity, and Environmental Health policy (601 FW 3). Consistent with the Refuge purpose(s), this policy provides for maintenance and restoration of healthy, functioning biological communities composed of native species and habitats comparable with historic conditions. The policy favors refuge management which restores or mimics natural ecosystem processes or functions. The policy generally discourages use of chemical pesticides and removal of native species, although the policy acknowledges that these actions may at times be necessary and appropriate. A key to proper implementation of this policy is evaluating how proposed actions would affect achievement of the Refuge purpose(s).

(4) Compatibility Policy. Another significant piece of national guidance developed in response to the Refuge Improvement Act is the Compatibility policy (603 FW 2). If a MAD or other appropriate authority is proposing to conduct mosquito management activities on a refuge in support of the refuge purpose(s) and in the role of a Service-authorized agent, then that use be considered a “refuge management activity” and compatibility does not apply. Otherwise, mosquito control or other mosquito management activities proposed by a MAD or other non-NWRS party would qualify as a “refuge use” and the compatibility regulations and policy would require that a compatibility determination be made. This determination would be for the purpose of determining whether, based on the Refuge Manager’s sound professional judgment, the proposed mosquito management activities would materially interfere with or detract from the refuge purpose(s) or the NWRS mission. The determination would need to be made in writing and would have to allow an opportunity for public comment.

The Compatibility policy also states that a use must be determined not compatible if we have insufficient information to determine the use as compatible. In addition, if we have insufficient management resources (e.g., funds, staff, facilities, and equipment) to ensure that a use would occur in a compatible manner, then the use is not compatible. Finally, the Compatibility policy states that a use would not be compatible if the use conflicts with maintenance of refuge biological integrity, diversity, and environmental health (See Biological Integrity, Diversity, and Environmental Health Policy). A refuge mosquito management program needs to be carefully planned and implemented to ensure that this last policy requirement is not violated. Appendix C includes a copy of the compatibility determination for mosquito management on the Refuge.

(5) National Environmental Policy Act. The National Environmental Policy Act of 1969, as amended (NEPA - 42 U.S.C. 4321-4347) is another important Federal statute that would be triggered by a proposed refuge mosquito management program. NEPA’s requirements are primarily procedural in nature. Among other things, NEPA requires that Federal agencies “Utilize a systematic, interdisciplinary approach...in planning and decision-making...” and “...insure that presently unquantified environmental amenities and values... [are]...given appropriate consideration in decision-making along with economic and technical considerations....” Prior to making a decision to undertake a proposed action, agencies are to consider a range of reasonable alternatives and the effects of their implementation. We have prepared this environmental assessment and made a finding of no significant impact in compliance with NEPA.

(6) Federal Water Pollution Control Act as amended in the Clean Water Act of 1977. Section 404 of the Clean

Water Act regulates the placement of fill or the dredging of wetlands under the jurisdiction of the U.S. Army Corps of Engineers or the Environmental Protection Agency. The MADs possess a permit for the maintenance of existing mosquito abatement ditches on the Refuge.

Section 401 of the Clean Water Act requires a water quality certification from the State for all Section 404 Permit activities. The MADs have obtained a water quality certification from the Regional Water Quality Control Board for the maintenance of the mosquito abatement ditches on the Refuge.

The Clean Water Act (CWA - 33 U.S.C. 1251-1387) provides for the restoration and maintenance of the Nation's water quality. One provision of the Act, section 402, applies to point source discharges of pollutants into waters of the United States. The Act established the National Pollutant Discharge Elimination System (NPDES). A recent court decision held that NPDES permits were required for the discharge of pesticides into waters of the U.S., even if the pesticides were applied consistent with label requirements legally established under the Federal Insecticide, Fungicide, and Rodenticide Act (*Headwaters, Inc. v. Talent Irrigation District*, 9<sup>th</sup> Cir. 2001, 243 F.3d 526). The U.S. Environmental Protection Agency (EPA) since issued memoranda commenting on the court decision and stating that enforcement of the decision was not a high priority. States are variously interpreting this court order and EPA's response (National Pollutant Discharge Elimination System Permits). Some States (including California and Washington in the Pacific Region) have adopted statewide general NPDES permits covering application of pesticides to water, including for mosquito control purposes. Refuges are encouraged to add stipulations to compatibility determinations and associated SUPs for mosquito control requiring MADs or other permittees to satisfy all relevant legal requirements for conduct of their work, including water quality permits, and training and certification requirements for any pesticide applicators.

(7) National Historic Preservation Act of 1966, as amended. Section 106 of the National Historic Preservation Act requires Federal agencies to consider how their actions could affect historic properties. Compliance with Section 106 will be completed according to the Programmatic Agreement between the Service and the California State Historic Preservation Officer as ground disturbing activities are identified.

(8) Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), as amended. This law regulates all activities related to pesticides, including development, registration and classification, production, storage and transport and applications. Section 18, as amended, provides for exemption of State or Federal agencies from all requirements in cases where the Governor or head of that agency requests and secures such an exemption. This constitutes declaration of official emergency conditions (such as an imminent human health hazard).

(9) Pesticide Use Proposals (Appendix D). Both the Department of the Interior and Service has policies which address management of pests and application of pesticides on national wildlife refuges. These policies can be found at 517 DM 1, 30 AM 12, and 7 RM 14. The policies are based on integrated pest management (IPM) principles and allow use of pesticides only after evaluation of a range of alternatives (including physical and cultural methods, biological controls, and no action); and full consideration of safety, environmental effects, efficacy, specificity, and costs. In order to provide assistance with refuge pest management programs and evaluate proposed pesticide applications, policy requires Refuge Project Leaders to develop and submit Pesticide Use Proposals (PUPs) for approval. This requirement includes pesticides that MADs or other permittees propose for use as part of a refuge mosquito management program. Depending on the pesticide proposed for use and the proposed application method(s), approval of PUPs may reside with the Refuge Project Leader, Regional Office, National IPM Coordinator, or Headquarters Office. Appendix D is an example of the information contained in a PUP. A PUP would be prepared each year that pesticides are used on the Refuge.

(10) Special Use Permits (Appendix E). Long-standing NWRS policy addressing Administration of Specialized Uses (5 RM 17) guides issuance of SUPs for economic uses, special events, access to closed areas, and other privileged uses. If a MAD or other appropriate authority is conducting mosquito management on a refuge in support of the refuge purpose(s) and in the role of a Service-authorized agent, then an agreement or contract is an appropriate instrument to guide their activities. Otherwise, conduct of mosquito management on a refuge by a MAD or other party is a specialized use and requires issuance of a special use permit. Requests by MADs or other non-NWRS parties to control mosquitoes on a refuge trigger requirements to comply with several,

potentially all, of the laws and policies briefly discussed above. According to the Refuge Administration Act, such a request for mosquito control would be considered a general public use, which is the lowest of the three tiers in the NWRS management hierarchy. Implementation of the Proposed Action includes developing a SUP each year. In addition, prior to issuing the SUP, we will review the Section 7 consultation, cultural resource compliance, and this Environmental Assessment to determine if any additional documentation will be necessary.

### **1.5.2 Executive Orders**

#### **(1) Protection of Wetlands (EO 11990)**

This order directs Federal agencies to minimize the destruction, loss or degradation of wetlands and preserve and enhance the natural beneficial value of wetlands in the conduct of the agency.

#### **(2) Floodplain Management (EO 11988)**

This requires federal agencies to avoid construction or management activities that would adversely affect floodplains. The order directs agencies to restore and preserve the natural and beneficial values served by floodplains when carrying out their responsibilities, minimize the effect of floods on human safety, and reduce the risk of flood loss.

#### **(3) Protection and Enhancement of the Cultural Environment (EO 11593)**

This Executive Order directs agencies to inventory historic, archeological, and paleontological properties for inclusion on the National Register of Historic Places. Archeological sites may be in existence on the Refuge. Any actions that include disturbing the ground will be reviewed by a qualified archaeologist for archeological significance prior to approvals.

#### **(4) Intergovernmental Review of Federal Programs (EO 12372)**

A Notice of Availability for this EA will be sent to local county and city governments, regional and state agencies, other Federal agencies and interested parties.

### **1.5.3 Service and Refuge Missions and Policies**

#### ***(1) The mission of the U.S. Fish and Wildlife Service is:***

“...to conserve, protect, and enhance fish and wildlife and their habitats for the continuing benefit of the American people.” (1 RM 4.3)

#### ***(2) The mission of the National Wildlife Refuge System is:***

“... to administer a national network of lands and waters for the conservation, management, and where appropriate, restoration of the fish, wildlife, and plant resources and their habitats within the United States for the benefit of present and future generations of Americans.” (Public Law 105-57)

#### ***(3) The goals of the National Wildlife Refuge system are:***

A. To preserve, restore and enhance in their natural ecosystems (when practicable) all species of animals and plants that are endangered or threatened with becoming endangered. (2 RM 1)

B. To perpetuate the migratory bird resource.

C. To preserve a natural diversity and abundance of fauna and flora on refuge lands.

D. To provide an understanding and appreciation of fish and wildlife ecology and man's role in his environment, and to provide refuge visitors with high quality, safe, wholesome, and enjoyable recreational experiences oriented toward wildlife to the extent these activities are compatible with the purposes for which the refuge was established.

**(4) *The Purpose of the San Pablo Bay National Wildlife Refuge is:***

- A. For use as an inviolate sanctuary, or for any other management purpose, for migratory birds. 16 U.S.C. (Migratory Bird Conservation Act)
- B. Particular value in carrying out the national migratory bird management program. 16 U.S.C. 667b
- C. To conserve (A) fish or wildlife which are listed as endangered species or threatened species...or (B) plants. 16 U.S.C 1534 (Endangered Species Act of 1973)

**(5) *Pest Control Policy - Refuge Manual (7 RM 14.2)***

"Control programs must be designed to maintain environmental quality and to conserve and protect the nation's wildlife resources. They will be based upon a broad, systematic approach utilizing all available information on the ecology of the plant or animal pest, the factors that increase or decrease its capacity for damage, the nature and extent of damage that can be tolerated, and the effects of various damage control options upon other organisms inhabiting the managed environment.

No animal or plant that is a pest will be subject to control unless the following conditions are met:

- A. The pest organism represents a threat to human health and well-being, or private property, the acceptable level of damage by the pest has been exceeded, or State or local governments have designated the pest as noxious;
- B. The pest organism is detrimental to primary refuge objectives; and
- C. The planned control program will not conflict with attainment of refuge objectives of the purposes for which the refuge is managed.

**(6) *Objectives for Pest Management Activities (7 RM 14.3)***

- A. To protect human health and well-being;
- B. To prevent substantial damage to significant resources;
- C. To protect newly introduced or re-established species;
- D. To control exotic species and to allow normal populations of native species to exist;
- E. To prevent damage to private property;
- F. To provide individuals with quality wildlife-oriented recreational experiences.

**(7) *Department of the Interior Policy for use of Pesticides (517 DM Section 1.2.A)***

"To use pesticides only after full consideration of alternatives - based on competent analysis of environmental effects, safety, specificity, effectiveness, and costs. The full range of alternatives including chemical, biological, and physical methods, and no action will be considered. Upon determination that a pesticide must be used in order to meet important management goals, the least hazardous material that will meet such goals will be chosen."

The Refuge will follow this policy in the following order of no action followed by physical, biological/biorational and chemical methods.

## **1.6 Decision to be Made**

The Service must decide whether implementing the Proposed Action would have a significant impact to the human environment. If we conclude that the Proposed Action does not have a significant impact to the human environment then we will sign a finding of no significant impact (FONSI) and begin implementation immediately.

## **Chapter 2 ALTERNATIVES INCLUDING THE PROPOSED ACTION**

### **2.1 The Process Used to Develop the Alternatives**

Alternatives were developed to meet the purpose and need, using guidance from several pertinent information sources. These include the Service's Interim Guidance for Mosquito Management on National Wildlife Refuges (Appendix A) and the California Mosquito-Borne Virus Surveillance and Response Plan (Appendix F). A significant amount of information was provided by the Solano, Napa, and Marin/Sonoma County MADs and included mosquito ecology, history of mosquito populations and their management on the Refuge, cultural tolerances for mosquitoes, past and current historical human health threats, monitoring techniques, treatment thresholds and disease surveillance.

### **2.2 Description of Alternatives, Including the Proposed Action and No Action**

#### **2.2.1 Factors Common to All Alternatives**

Actions that are common to all alternatives are described below and are not repeated in each alternative description.

**2.2.1a General Permits.** The Refuge, in cooperation with the MADs, must obtain all permits required for state and federal endangered species compliance before allowing mosquito management activities in endangered species habitat on the Refuge. Other general permits may also be required such as an NPDES permit, depending on the scope of the action proposed each year.

**2.2.1b Special Use Permits.** Each MAD must obtain an annual refuge Special Use Permit if they will be conducting mosquito management activities on the Refuge. A SUP will be issued, renewed, and/or revised annually and will document all uses on the Refuge and provide clear guidance for activities on the Refuge. To ensure that mosquito management activities are compatible with the Refuge purposes, permitted activities must meet the stipulations listed in the Compatibility Determination.

**2.2.1c Supplemental NEPA Documentation.** Each of the alternatives described below may require a supplemental NEPA depending on the scope of the action proposed each year.

**2.2.1d Education and Outreach.** Where appropriate, we will collaborate with Federal, State, and/or local wildlife agencies, public health authorities, agriculture departments, and vector control agencies to conduct education and outreach activities aimed at protecting human and wildlife health from threats associated with mosquitoes. Where appropriate, we will provide access to information materials about mosquito-associated threats to our visitors and employees (e.g., refuge office, internet sites, and signage). The Refuge will prepare an instructional package for employees on personal protection measures to minimize their exposure to mosquito-borne diseases.

#### **2.2.2 Alternative A – Proposed Action – Phased Approach to Mosquito Control**

The Proposed Action is to develop and implement a mosquito management plan (Plan) that consists of a phased approach to mosquito management and is consistent with the principles of integrated pest management. The Proposed Action emphasizes design, restoration, and management of wetlands in a manner to benefit wildlife and minimize mosquito production. Wetland restoration or enhancement projects would be implemented as funding becomes available. The improvement of hydrology within wetlands would be the primary mechanism for enhancing habitat and reducing mosquito production. Restoration projects would be focused on improving habitat for native wildlife and plants as well as decreasing mosquito production.

This alternative is consistent with an IPM approach. IPM is a sustainable approach to managing pests by combining biological, cultural, physical, and chemical tools in a way that minimizes economic, health, and environmental risks. When practical, the approach may include compatible actions that reduce mosquito

production and do not involve pesticides. We consider the procedures described below as long-term practices to reduce persistent potential mosquito-associated health threats that Federal, State, and/or local public health authorities have identified.

While the emphasis of this alternative is restoring wetlands, the phased approach also includes monitoring, surveillance and the potential application of pesticides. Application of pesticides would be approved based on the phased approach outlined below. The principle goal of a phased approach to mosquito management is to minimize effects on refuge resources while addressing legitimate human, and fish and wildlife health concerns and complying with Service regulations and policy. The implementation of a phased-response program represents a standardized approach that would result in a consistent mosquito management program that adheres to Service and California state guidelines. Because occurrence of arboviruses and other human health issues resulting from mosquitoes are sporadic, phases of mosquito management implemented on the Refuge would vary through time.

The following phased mosquito management program is dependent upon communication and cooperation with public health agencies and MADs. The Refuge would actively engage in the implementation of a mosquito management program with regional MADs. Although the MADs would have the lead for monitoring, disease surveillance, and pesticide applications, evaluation of monitoring data and approval for each management action would be the responsibility of the Refuge. Although additional staff time would be required to oversee the mosquito management program, due diligence is necessary to ensure that the conditions for compatibility are met and the program is implemented so as to avoid or minimize effects on Refuge resources.

Table 1 below provides abbreviated descriptions and responses associated with each of the mosquito management phases. Because of the nature of mosquito-borne diseases, as well as the limited information available regarding the effects of these diseases on wildlife of the Refuge, this approach focuses on the implementation of a mosquito management program to protect the public from mosquito-borne disease.

Mosquito monitoring represents the baseline activity of mosquito management on the Refuge and would occur prior to and along with the following management phases. Monitoring is required to determine mosquito population estimates and locations of infestations. Because the local MADs would have the lead for monitoring mosquito populations, communication and cooperation are imperative to develop reliable information to determine appropriate management level(s). All mosquito management decisions would be made in consultation with the Refuge and appropriate health and vector control districts using monitoring data collected on and within the vicinity of the Refuge.

The foundation for the following phased mosquito management approach is a series of IPM options that are intended to minimize effects of mosquito management to refuge resources while protecting human health.

The first 2 phases require use of indirect approaches (e.g., source reduction, adjustments in habitat management programs) to reduce mosquitoes with little or no effect to refuge resources. The last 3 phases allow the use of certain pesticides (e.g., larvicides, pupacides, and adulticides) to address threats to human and wildlife health. Phase 5 allows for the use of adulticides when mosquito-borne disease activity is documented on the Refuge or within flight range of vector mosquito species present on the Refuge; mosquito monitoring on the Refuge indicates adult vector populations have exceeded the thresholds identified in Appendix M; there are no practical and effective alternatives to reduce the health threat; and the National IPM Coordinator has approved the use of the adulticide. To avoid the use of adulticides the approach favors an early response with larvicides (See Appendix G for sample response protocols). Early response with larvicides can be directed at specific locations with high concentrations of larva. The delayed use of larvicides may result in the need for adulticides that pose the greatest potential threat to Refuge resources.

**Table 1. Phased-response mosquito management guidelines for San Pablo Bay National Wildlife Refuge.**

Phase	Condition	Response
1	No documented existing health threat <sup>1</sup> . Mosquito management issues have not been reported or identified by the appropriate public health authority <sup>3</sup> or vector control district(s).	Monitoring and surveillance of areas surrounding the Refuge to inform management actions on the Refuge. Remove/manage artificial breeding sites such as tires, tanks, or similar debris/containers. Consult with MADs when planning wetland enhancement or restoration projects.
2	Potential human or wildlife (incl. threatened and endangered species) health threat <sup>1</sup> (presence of vector spp, historical health threat, etc.), as documented by appropriate public health authority(ies) or vector control district(s).	Response as in threat level 1, plus: allow compatible monitoring and disease surveillance. Consider compatible non-pesticide management options to reduce the potential for above-normal mosquito production (e.g., restore/enhance tidal marsh hydrology).
3	Mosquito larvae threshold <sup>2</sup> exceeded for human and/or wildlife health on the Refuge as determined by standardized monitoring. Documented potential human or wildlife health threat (historic health threat, presence of vector species).	Response as in threat level 2, plus: allow compatible site-specific application of larvicide in areas with above average mosquito populations, as determined by monitoring. Conduct post larvicide monitoring to determine efficacy.
4	Mosquito larvae have begun to reach last instar stages or pupate reducing the efficacy of larvicides. Mosquito larval and pupal population thresholds <sup>2</sup> exceeded on the Refuge. Mosquitoes produced by the Refuge pose a health threat <sup>1</sup> as determined by the appropriate public health authority(s).	Response as in threat level 3, plus: if appropriate, increase the intensity and frequency of larvicides, allow compatible site-specific use of pupacides in areas with above average mosquito populations, determined through monitoring to be beyond control with larvicides. Increase monitoring and disease surveillance. Conduct post larvicide and pupacide monitoring to determine efficacy.
5	Exceedance of larval, pupal, and adult mosquito population thresholds <sup>2</sup> on the Refuge. High risk for mosquito-borne disease (imminent risk of serious human disease or death, or an imminent risk of serious disease or death to populations of wildlife) within communities surrounding the Refuge has been documented by the appropriate public health authority <sup>3</sup> .	Response as in threat level 4, plus: Consider site-specific adulticiding in areas with above average mosquito populations as determined by monitoring. Conduct post adulticide monitoring to determine efficacy.

<sup>1</sup>An adverse impact to the health of human or wildlife populations from mosquito-borne disease identified and documented by Federal, State, and/or local public health authorities. Health threats are locally derived and are based on the presence of endemic or enzootic mosquito-borne diseases, including the historical incidence of disease, and the presence and abundance of vector mosquitoes. Health threat levels are based on current monitoring of vectors and mosquito-borne pathogens.

<sup>2</sup>Human and wildlife health threshold (e.g., numbers per dip) is determined by considering several factors as determined by Appendix L. Larval thresholds are presented in Appendix G.

<sup>3</sup>Appropriate public health authority(s) is a Federal, State, or local public health or wildlife management authority with jurisdiction inclusive of Refuge boundaries and/or neighboring public health authorities (Appendix H).

### Phase 1

In Phase 1, a health threat has not been identified and mosquito management issues have not been reported or identified by the appropriate public health authority or MADs. To avoid any possible mosquito management issues, artificial mosquito breeding habitat throughout the Refuge, such as tires, open containers, and other equipment or objects that pool water where mosquitoes may breed, should be eliminated.

The Refuge would consult with the MADs when wetland enhancement or restoration projects are being planned on the Refuge. Consultation would allow Refuge staff and the MADs to identify potential issues or opportunities related to mosquito production and management in the future. Monitoring and surveillance of mosquito abundance and disease prevalence in areas similar and near the Refuge would be conducted by the MADs which would inform the potential for mosquito management needs on the Refuge.

## **Phase 2**

In Phase 2, the refuge manager is contacted by the appropriate public health authority(ies) or MAD(s) regarding a potential human health threat posed by mosquitoes harbored or produced on the Refuge. In response, Refuge staff may increase compatible mosquito population monitoring and disease surveillance by the MADs. The initial step to developing a proactive prevention and management program for mosquitoes is to determine mosquito species presence and abundance on refuge lands, and to identify potential or documented vectors of mosquito-borne diseases that represent a potential human health threat. In addition to a species list of mosquitoes, the survey or inventory should determine locations on the Refuge being used for breeding and/or resting mosquitoes (harboring). See Mosquito Monitoring and Disease Surveillance, Appendix I. Monitoring and surveillance activities should be well-documented and presented to Refuge staff by the MADs.

In order to avoid or minimize the use of pesticides, habitat management practices or wetland enhancement/restoration projects that improve wildlife habitat and reduce seasonal abundance of larval and adult mosquitoes should be implemented where possible.

Refuge staff and visitors would be informed of an increased health threat associated with mosquito-borne disease activity. Personal protection measures such as wearing mosquito repellent would be recommended to staff and visitors.

## **Phase 3**

If non-pesticide attempts to reduce mosquito populations are unsuccessful or are not feasible and mosquito larvae thresholds have been exceeded (Appendix G), application of larvicides would be considered. Locations of larvicide treatments would be based on standardized monitoring results (see Mosquito Monitoring and Disease Surveillance, Appendix I). The preferred larvicide treatments are biorationals (biological agents) Bti, Bs, and methoprene because of limited non-target effects (Appendix J, K). Post larvicide monitoring would be conducted to determine efficacy.

## **Phase 4**

If appropriate, the intensity and frequency of larvicides would be increased. Larvicides (Bti or Bs, and methoprene) are only effective on mosquitoes during early instar stages (up to the fourth) and do not control pupae. If developing mosquitoes have reached the last instar stages or have pupated, then we would consider site-specific pupacides in areas with above average mosquito populations (determined through monitoring). Because pupacides can negatively affect all invertebrates that require surface air (e.g., act as surfactants), the use of these pesticides should be carefully considered. For this reason, pupacides (Agnique) would only be used if large numbers of mosquitoes are considered an immediate threat to human health and thresholds developed by the appropriate public agency have been exceeded (there is active transmission of mosquito-borne disease from Refuge based mosquitoes or within flight range of vector mosquito species present on the Refuge). Post larvicide and pupacide monitoring would be conducted to determine efficacy and any adverse impacts.

## **Phase 5**

In this phase, mosquito-borne disease activity has been documented on the Refuge or within flight range of vector mosquito species present on the Refuge. A risk of serious mosquito-borne human disease or death has been documented by the appropriate public health authority. Disease surveillance determines that there is a high risk for mosquito-borne disease within the vicinity of the Refuge. For example, pathogen presence in mosquito pool(s), wild birds, sentinel chicken flock(s), horses, or humans has been documented within the flight range of vector mosquito species present on the Refuge. These conditions in combination with adult mosquito populations above thresholds levels (Appendix M) on the Refuge would trigger consideration of a more aggressive treatment strategy, including the use of adulticides. If larvicide and/or pupacide treatments fail, pyrethrin-based adulticides would be considered for use on the Refuge to suppress populations of infected mosquitoes and interrupt epidemic virus transmission. Because the efficacy and effects of adulticides are variable, adulticides should not be applied broadly without site-specific data indicating a need for control. Further, the use of adulticide would be considered in concert with the Mosquito-borne Virus Risk Assessment in the California Mosquito-borne Virus Surveillance and Response Plan (Appendix L). The MADs would be required to prepare a Risk Assessment as part of their request to apply adulticides. The Risk Assessment evaluates a number of factors including environmental

conditions, species presence, virus infection rate, sentinel chicken seroconversion, dead bird presence, and human cases to determine whether adulticide should be considered. We would only consider application in areas where a pathogen is present and mosquito population thresholds have been exceeded on the Refuge that can be effectively treated while minimizing non-target effects, especially to threatened and endangered species. However, specific areas treated and the extent of treatment would vary from year to year depending on mosquito populations and environmental conditions.

In order to limit human contact with adulticides, visitors would not be allowed in those parts of the Refuge that are being treated with adulticides. Information about treatment scheduling, location, and pesticide would be posted on the Refuge website, at the Refuge Headquarters, and at the treatment location. Post adulticide monitoring would be conducted to determine efficacy and any adverse impacts.

In summary, application of adulticides on the Refuge would require the following steps:

- Prior approval from the National IPM Coordinator via an approved Pesticide Use Proposal
- The MAD must present the Refuge manager with data supporting presence of a arboviral disease on the Refuge or within flight range of the vector mosquito species on the Refuge, including a Risk Assessment in the region
- The MAD must provide the Refuge manager with types/quantities of adulticides proposed and locations
- If beneficial, the MAD should conduct simultaneous application of larvicides with the adulticide application to prevent future adult outbreaks

**Access.** Access for the purposes of mosquito management (e.g., monitoring, surveillance, control) would be limited in areas known to support California clapper rails (*Rallus longirostris obsoletus*) and in close proximity to sloughs and channels.

The following access limitations apply:

- Motorized access (e.g., ARGO) would not be permitted within 700' of a known clapper rail occurrence during the breeding season.
- Motorized ground access (e.g., ARGO) within tidal marsh should be limited to production areas >100 acres in size, unless coordinated with Refuge staff.
- Unless permitted by the Refuge manager, mosquito management activities should not occur within 100 feet of natural sloughs and channels.
- All personnel entering the wetlands would be trained by Refuge staff to avoid disturbance to endangered, threatened or other sensitive species of the Refuge.
- Motorized access would only be used when no other practical means of conducting mosquito management is available.

These access limitations would limit direct and indirect (e.g., habitat) negative effects on sensitive species. Access within sensitive areas would be identified by the Refuge manager in coordination with the MADs and designated in the annual Special Use Permit.

**Mosquito Monitoring and Surveillance.** We would allow compatible monitoring and surveillance of larval and adult mosquito populations on the Refuge under a Refuge Special Use permit. To avoid harm to wildlife or habitats, access to traps and sampling stations must meet the compatibility requirements found in 603 FW 2 and may be subject to refuge-specific restrictions.

Mosquito population monitoring involves activities associated with collecting quantitative data to determine mosquito species composition and to estimate relative changes in mosquito populations over time. The objectives of mosquito population monitoring are to:

1. Establish baseline data on species and abundance,
2. Map breeding and/or harboring habitats, and

3. Estimate relative changes in population sizes for making IPM decisions to reduce mosquito populations when necessary.

The purpose of mosquito-borne disease surveillance involves activities associated with detecting pathogens causing mosquito-borne diseases, such as testing adult mosquitoes for pathogens or testing reservoir hosts for pathogens or antibodies. These activities assist in determining public health risks associated with mosquito-borne pathogens on or near the Refuge.

Monitoring of immature mosquitoes on the Refuge would be conducted by the MADs. Field technicians within these agencies maintain a list of known mosquito developmental sites on the Refuge and visit them during predominant periods of mosquito production. The timing and frequency of monitoring is based on a number of factors including history of mosquito production, tidal cycles, precipitation levels, and available resources. Mosquito populations are sampled using established protocols (Appendix I). Samples are examined in the field or laboratory by the MADs to determine the abundance, species, and life-stage of mosquitoes. This information is compared to historical records and established thresholds (Appendix G, M) and would be used as a tool for treatment decisions.

Although larval mosquito control is preferred, identifying all larval sources in a timely manner is not possible. Therefore, adult mosquito monitoring is also needed to pinpoint problem areas and locate previously unrecognized or new larval developmental sites. Adult mosquitoes are sampled using standardized trapping techniques (i.e., New Jersey light traps, carbon dioxide-baited traps and oviposition traps; Appendix I). Mosquitoes collected using these methods are counted and identified to species. Information on adult mosquito abundance from traps is augmented by tracking mosquito complaints from local residents. Analysis of requests for mosquito control allows district staff to gauge the success of control efforts and locate undetected sources of mosquito development. All MADs conduct public outreach programs and encourage local residents to contact them to request services.

A more detailed presentation of monitoring and disease surveillance protocols used by the regional MADs is presented in Appendix I.

**Wildlife Monitoring and Surveillance.** Wildlife monitoring will be conducted to assess any potential impacts from mosquito management activities. The Refuge and the MADs will monitor for impacts to listed species, particularly rail and mouse populations, due to mosquito control (including mosquito monitoring and surveillance).

**Pesticide Approval Process.** As a result of its statute authority under the Migratory Bird Treaty Act, the Endangered Species Act and Service policy, the Service is required to consider whether use of specific pesticides would harm trust species. The Service evaluates approval of specific pesticide use based on its history of adverse effects on non-target species and persistence in the environment.

Refuge staff would prepare Pesticide Use Proposals (PUPs) on an annual basis (in coordination with the MADs) for Service approval. The PUP's would include pesticides that MADs or other permitted groups propose for use as part of a refuge mosquito management program. Pesticide Use Reports (PUR) would be prepared by Refuge staff in coordination with the MADs on an annual basis following application of pesticides to control mosquitoes on the Refuge. To assist in tracking mosquito management activities, the MADs would prepare an annual quantitative summary of refuge mosquito monitoring and surveillance results, control activities on the Refuge (e.g., pesticides applied, amount of pesticides applied, locations of application, method of application), and regional disease surveillance. The report should be accompanied by maps showing specific areas where management activities occurred. All surveillance and control activities would be spatially referenced as technologies develop at regional MADs (e.g., use of GPS, GIS). Comparisons of mosquito management within and among years should be presented to permit analysis of patterns that may indicate success of habitat management efforts or suggest the need for a new management approach.

Methods used to reduce mosquito populations are primarily based on efficacy, cost, and minimal ecological

disruption, including minimum effects on non-target organisms and natural systems of the Refuge. Chemical pesticides should be used only where practical physical, cultural, and biological alternatives or combinations thereof, are impractical or incapable of providing adequate mosquito population control. Furthermore, chemical pesticides would be used primarily to supplement, rather than as a substitute for, practical control measures of other types. Whenever a chemical is needed, the most narrow ranging and specific pesticide available for the target organism in question should be chosen, unless consideration of persistence or other hazards would preclude that choice." (7 RM 14.2).

**Mosquito Control Pesticides.** Mosquito control pesticides can be categorized into 3 groups: larvicides, pupacides (surface films/surfactants), and adulticides. Compared with other forms of pest control, there are relatively few pesticides available within each of these categories, and all differ with regard to efficacy and effects on non-target organisms. Additional information on pesticides presented here can be found in Appendices J, K, and O. Pesticides commonly used by local MADs are presented in Table 3.

The use of larvicides and pupacides would be routinely approved subject to review by the Regional Office Integrated Pest Management Coordinator acting under the Service's Washington Office. Data from various sources (e.g., scientific literature) would be used to identify whether new preferred chemicals exist, as they become available. New control products will be considered based on their effects compared to those products identified in the plan.

Before applying pesticides to Refuge lands in a non-emergency situation Refuge staff must:

1. Use current monitoring data for larval, pupal, and adult mosquitoes which documents the need for mosquito management.
2. Determine the most appropriate pesticide treatment options based on monitoring data for the relevant mosquito life stage.
3. Consider whether use of pesticide would harm trust species.
4. Have an approved pesticide use proposal (PUP) in place.

Larvicides. Larvicides are materials that affect the four larval stages of mosquitoes known as instars. They can be applied through a wide variety of methods including hand application and backpack sprayers, amphibious tracked vehicle, truck-mounted equipment and aerial sprayers. Mosquito larvicides relevant to this EA include Bti (*Bacillus thuringiensis* var. *israelensis*), methoprene, and surface films. Larvicides may be approved through a PUP by the Project Leader of the San Francisco Bay NWR Complex. Bti and methoprene are the most common larvicides that would be applied on the Refuge. Refer to Appendix J for a more detailed account of non-target effects of larvicides used for mosquito control.

*Bacillus thuringiensis* (Bt) is a natural soil bacterium that acts as a larval stomach poison. Bt must be ingested by the larval form of the insect in order to be effective. Bt contains crystalline structures containing protein endotoxins that are activated in the alkaline conditions of an insect's gut. These toxins attach to specific receptor sites on the gut wall and, when activated, destroy the lining of the gut and eventually kill the insect. The toxicity of Bt to an insect is directly related to the specificity of the toxin and the receptor sites. Without the proper receptor sites, the Bt will simply pass harmlessly through the insect's gut. Several varieties of Bt have been discovered and identified by the specificity of the endotoxins to certain insect orders. *Bacillus thuringiensis* var. *kurstaki*, for example, contains toxins that are specific to Lepidoptera (butterflies and moths), while Bti (variety is specific only to certain primitive dipterans (flies), particularly mosquitoes, black flies, and some chironomid midges. Bti is the form used on the Refuge. Bti is not known to be directly toxic to non-dipteran insects.

Because Bti must be ingested to kill mosquitoes, the treatment is much more effective on first-, second-, and early third-instar larvae than on late third and fourth instars since the earlier instars feed at a faster rate (fourth instar larvae feed very little). The pesticide is completely ineffective on pupae because they do not feed at all. Formulated products may be granular or liquid, and potency is expressed in International Toxicity Units (ITU), usually ranging from 200-1200 ITU. The concentrations of Bti in water necessary to kill mosquito larvae vary with environmental conditions, but are generally 0.05-0.10 ppm. Higher concentrations (0.1->0.5 ppm) of Bti are

necessary when there is a high amount of organic material in the water, late-third and early fourth instar larvae predominate, larval mosquito density is high, or water temperature is low (Nayar et al. 1999). Operationally, Bti is applied within a range of volume or weight of formulated product per acre as recommended on the pesticide label, with the goal to achieve an effective concentration. The label recommended range of application rates under most conditions varies by a factor of 4 for most formulations (e.g., for granular formulations, 2.72-11.12 kg/ha (2.5-10 lb/acre)). For later instar larvae and water with a high organic content, higher application rates are recommended that may reach 8 times the lowest rate (e.g., for granular formulations, the higher rate is 11.1-22.5 kg/ha (10-20 lb/acre)). Mosquito control agencies use the recommended label rates, along with previous experience, to administer an effective dose. Because water depths even within a single wetland can vary greatly, field concentrations of Bti can vary widely, especially when the pesticide is applied aerially. Efficacy is monitored by post-application reductions in mosquito larval density, but the actual concentration of Bti following an application is not measured. Thus, an insufficient concentration of Bti can be detected by low mortality of mosquito larvae, but an overdose (i.e., a concentration greater than necessary to kill mosquito larvae) of the pesticide is rarely monitored for.

*Insect Growth Regulators (Methoprene).* Methoprene (e.g., trade name Altosid®) is a synthetic mimic of a naturally produced insect hormone, juvenile hormone (JH). All insects produce JH in the larval stages, with the highest levels occurring in the early developmental stages. As an insect reaches its final stage of larval development, the level of JH is very low. This low level of JH triggers the development of adult characteristics. When an insect is exposed to methoprene, a hormonal imbalance in the development of the insect results, thus failing to properly mature into an adult. The insect eventually dies in the pupal stage. The most susceptible stages of development to methoprene are the later instars (for mosquitoes, third and fourth instars). In mosquito control applications, methoprene is applied directly to the larval breeding habitat. Larvae will continue to feed and may reach the pupal stage, but they will not emerge as adults. Methoprene is completely ineffective on mosquito pupae and adults. The treatment is available in several formulations: liquid, granular, pellet, and briquette. There are several micro-encapsulated and extended-release formulations that remain effective for up to 150 days.

The amount of methoprene necessary for mosquito control is < 1.0 part per billion (ppb). The initial concentrations of methoprene when applied to aquatic habitats may reach 4-10 ppb, but residual concentrations are approximately 0.2 ppb (Ross et al. 1994). Once released into the aquatic environment, the treatment is non-persistent, with a half-life of about 30-40 hours. Micro-encapsulated and extended-release formulations will, of course, be present in the water longer as the pesticide is slowly released over time, 7-150 days, depending on the formulation. In field applications, efficacy is determined only by an observed inhibition of emergence of adults, since larvae are not directly killed by the pesticide.

*Pupicides (Surface Oils and Films).* Surface oils and films are applied to mosquito breeding sites to kill mosquito larvae and pupae. The products create a barrier to the air-water interface and suffocate insects, which require at least periodic contact with the water surface in order to obtain oxygen. The oils are mineral oil based and are effective for 3-5 days. Surface films are alcohol based and produce a monomolecular film over the water surface.

Both oils and the films are potentially lethal to any aquatic insect that lives on the water surface or requires periodic contact with the air-water interface to obtain oxygen. Studies have demonstrated significant negative effects on water surface-dwelling insects from applications of oils (Mulla and Darwazeh 1981; Lawler et al. 1998). Surface oils may also adversely affect wildlife by wetting the feathers of young waterfowl. This may be of particular concern at low temperatures when the oil could affect thermoregulation (Lawler et al. 1998).

*Golden Bear 1111.* Golden Bear 1111 is the only petroleum product registered for larval mosquito control in California at this time. The product is considered an effective control agent that acts on the pupal stage of mosquitoes to prevent adult mosquito emergence. This surface oil is effective against all immature stages by acting as a suffocant. Golden Bear 1111 disrupts the surface tension of water by preventing female mosquitoes from landing to lay eggs. In some cases control with this material has been demonstrated for up to two weeks (Mulla and Darwazeh 1981). The use of petroleum distillate products is prohibited on the Refuge although used

as a pesticide within the region.

*Agnique Monomolecular Film (MMF)* is a non-ionic surfactant that has an alcohol base. The film produced by MMF reduces the surface tension of the water making mosquito larvae and pupae unable to attach, thus causing them to drown. Emerging adult mosquitoes or midges are unable to fully emerge and will drown. The film produced by Agnique is not visible on the water surface and should not be used in areas that are subject to unidirectional winds greater than 10 mph or where surface water overflow or runoff is an issue. See Appendix J for non-target effects of Agnique.

Adulticides. Adulticides are pesticides used to kill adult mosquitoes. All pesticides used to kill adult mosquitoes are broad-spectrum insecticides. The only selective aspect of these pesticides is in the manner in which they are applied. Most adulticides under use in the Bay Area are applied as ultra-low volume (ULV) sprays and they are sprayed as very fine droplets (aerial 30-50 microns; ground 8-30 microns). Small droplet size allows the spray to drift for a relatively longer period of time compared to larger droplets, and the small size delivers an appropriate dose of the pesticide to kill an adult mosquito. Drift is a necessary component of adulticiding because these sprays are most effective on flying insects. For this reason, adulticide applications generally would occur in the evening or early morning hours when the majority of mosquito species are most active. Adulticides would be primarily applied by truck-mounted or backpack sprayers on the Refuge.

There are 3 general classes of adulticides: organophosphates, pyrethroids and pyrethrins/pyrethroids. These pesticides work on the nervous system although they have different modes of action. Only pyrethrin based adulticides are being considered for use on the Refuge at this time. Organophosphates are cholinesterase inhibitors while pyrethroids and pyrethrins are sodium channel blockers. Organophosphates are not used by the regional MADs for mosquito control and they are not permitted for use on the Refuge. Pyrethrins are naturally occurring compounds extracted from chrysanthemum plants and have been used to make pesticides (McLaughlin 1973, Klassen et al. 1996, Todd et al. 2003). Pyrethroids are synthetic products that have the same basic chemical make-up as pyrethrins but are not naturally occurring. Pyrethrum is the general term covering pyrethrins and pyrethroids.

The most common pyrethroids are the synthetic pyrethroids, permethrin, resmethrin, and sumethrin. Both pyrethroids and pyrethrins are usually combined with the synergist piperonyl butoxide, which interferes with an insect's detoxifying mechanisms (Tomlin 1994). Nontarget toxicity from pyrethroids may occur in either terrestrial or aquatic habitats as a result of deposition, runoff, inhalation, or ingestion (Appendix K, O). In general, pyrethroids have lower toxicity to terrestrial vertebrates than the organophosphates. Pyrethroids, although less toxic to birds and mammals, are toxic to fish and aquatic invertebrates (Anderson 1989, Siegfried 1993, Tomlin 1994, Milam et al. 2000). The actual toxicity of pyrethroids in aquatic habitats, however, is less than may be anticipated because of the propensity of these pesticides to adsorb to organic particles in the water (Hill et al. 1994). There are also data that indicate synthetic pyrethroid degradates have endocrine disrupting properties (Tyler et al. 2000).

The natural pyrethrins are non-systemic contact poisons which quickly penetrate the nerve system of the insect causes paralysis and subsequent death (EXTOXNET 1994, and Tomlin 1994). A few minutes after application, the insect cannot move or fly away, but a "knockdown dose" does not mean a killing dose. The natural pyrethrins are swiftly detoxified by enzymes in the insect. Thus, some pests will recover. To delay the enzyme action so a lethal dose is assured, commercial products are formulated with synergists, e.g. piperonyl butoxide, which inhibit detoxification (Tomlin, 1994). Pyrethrins are generally considered less toxic to invertebrates and are less persistent in the environment relative to synthetic pyrethroids although data on toxicity are lacking (Spurlock 2006). Studies of pyrethrin have shown low toxicity to birds and mammals but higher levels of toxicity among aquatic species such as fish and invertebrates (e.g., Gunasekara 2005).

**Table 2. Common pesticides used for mosquito control in wetlands by the Solano, Napa, and Marin/Sonoma County Mosquito Abatement Districts.**

Name	Trade Name	Formulation <sup>a</sup>	Application
Methoprene	Altosid	G, B, P, LC	Larvae
Monomolecular film	Agnique	Liquid	Larvae, pupae
<i>Bacillus thuringiensis israelensis</i> (Bti)	Aquabac, Bactimos, LarvX, Teknar, Dunks	WDG, AS, P, G, B	Larvae
Pyrethrins	MGK Pyrocide	ULV, EC	Adults, larvae

Table adapted from Rose (2001) (<http://www.cdc.gov/ncidod/eid/vol7no1/rose.htm>)

<sup>a</sup>AS = Aqueous suspension; B = Briquets; EC = Emulsifiable concentrate; G = Granules; LC = Liquid concentrate; P = Pellets; ULV = Ultra low volume; WDG = Water-dispersible granule

**Annual Meeting/Training.** All alternatives require that an annual meeting be held to discuss mosquito activities for the past year and any proposed wetland and mosquito management changes or issues for the upcoming season. Annual meetings will also allow for any changes that may need to be adapted as a result of changing environmental conditions or new treatment methods and pesticides. The following is a list of topics that should be covered:

Service:

- Staff introduction/changes
- Pest management policy changes
- Summary of current wetland restoration and management program
- Proposed enhancement or restoration projects
- Current wildlife populations & status
- Techniques to minimize disturbance to wildlife

MADs:

- Staff introduction/changes
- Mosquito policy changes
- Summary of mosquito production areas
- Summary of mosquito management activities
- Updated Pesticide Use Proposals and labels
- Proposed changes to mosquito management program
- Current mosquito and disease information
- Listed species monitoring and surveillance
- Results of relevant mosquito research projects
- Proposed mosquito reduction projects
- Current mosquito production areas

### 2.2.3 Alternative B – Non-chemical Mosquito Control

Under this alternative, mosquito populations would be managed primarily through enhancement or restoration of hydrology where possible (Table 1, Phases 1-3). Use of the larvicide Bti (a biological agent) would be permitted in areas where hydrological improvements have not been conducted or are not biologically, physically or economically feasible (Table 1, Phase 4). Factors, thresholds, and regulatory requirements associated with the use of Bti on the Refuge presented under Alternative A apply here. Use of chemical pesticides to reduce mosquito populations would not be permitted on the Refuge under this alternative. Eliminating the use of chemical pesticides would require that mosquito populations are always controlled at the larval level, requiring intensified monitoring efforts by the MADs. The Refuge manager would review all larvicide treatment response proposed by the regional MADs. Monitoring and disease surveillance would be allowed in documented mosquito production areas of the Refuge (using standardized methods, Appendix I). Surveillance and access parameters follow

techniques presented under Alternative A.

Areas known to produce above average mosquito populations would be identified by each District at the annual meeting. All identified mosquito production areas would be analyzed for the ability to improve tidal circulation, manipulate water control structures or alter the environmental features that produce mosquito breeding sites. These improvement actions often benefit estuarine ecosystems through changes in soil characteristics and plant health. Each District would submit their proposals to the Refuge manager for consideration. The Refuge and MAD managers would work cooperatively to plan, permit and finance proposed changes that do not significantly detract from or interfere with the purposes for the Refuge.

### 2.2.4 Alternative C – No Mosquito Management

Under this alternative, mosquito population monitoring, disease surveillance or mosquito control using biological or chemical methods would not be permitted on Refuge lands. Efforts to enhance and restore wetlands would necessarily be increased with a focus on design, management and maintenance that reduces mosquito populations to below threshold treatment levels.

### 2.2.5 Alternative D – No Action

Under this alternative, the MADs would continue to operate in a manner similar to the past 10 years in which mosquito monitoring and disease surveillance is followed by control with larvicides (excluding surface oils) and alcohol-based surfactants (e.g., Agnique) when action thresholds have been exceeded and all other reasonable IPM actions, such as tidal marsh enhancement projects, have been explored. The MADs would coordinate with the Refuge manager prior to surveillance, control, and monitoring activities on the Refuge. The No Action alternative is a phased approach similar to the Proposed Action with the exception that adulticides are not permitted on the Refuge.

### 2.2.6 Alternatives Summary

The table below summarizes the activities that would be permitted on the Refuge under each of the mosquito management alternatives.

**Table 3. Summary of mosquito management activities permitted under each alternative.**

Alternative	Monitoring and Surveillance of Mosquito Populations <sup>1</sup>	Pesticides Permitted for Use <sup>2</sup>	Restore Tidal Circulation	Access
A	Yes	L, P, A <sup>3</sup>	Yes	Limited in sensitive species habitat and along tidal channels and sloughs. ARGOs should be limited to mosquito production areas >100-acres in size (unless coordinated with Refuge staff) and no mechanized access within 700' of known CLRA occurrence.
B	Yes	L(Bti only)	Yes	Same as A
C	No	Pesticides not permitted	Yes	No access for mosquito management
D	Yes	L, P	Yes	Same as A

<sup>1</sup>See Appendix I for methods

<sup>2</sup>L = larvicides (Bti), P = pupacides (monomolecular film), A = adulticides (pyrethrin)

<sup>3</sup>Phase 5 = High risk of mosquito-borne disease

## **Chapter 3    AFFECTED ENVIRONMENT**

### **3.1    Physical Environment**

#### **3.1.1    Climate**

San Francisco Bay falls within the humid temperate domain as defined by Bailey (1995). The abiotic and biotic factors located in this area combine to produce an ecoregion within the Mediterranean Division known as the California Coastal Chaparral Forest and Shrub Province (Bailey 1995). As determined by the Service, San Francisco Bay falls within the administrative boundary of the Central Valley/San Francisco Bay Ecoregion.

The climate for the California Coastal Chaparral Forest and Shrub province is characterized by hot, dry summers and rainy, mild winters. Annual temperatures range from 50 degrees to 65 degrees F. Annual precipitation ranges from 10 to 60 inches with an average of 14 to 35 inches. Almost 90% of rainfall occurs in a 55-day period annually between November and April (Dreisbach 1969). Fog produces moisture in the summer but lightning-caused fire is common during the summer dry season (Bailey 1995). Evaporation from wetlands is high during the summer months with an average annual evaporation rate of 48 inches per year.

#### **3.1.2    Topography**

Much of San Francisco Bay is shallow, with an average depth of only 20 feet. Only 15 percent of the bay is more than 30 feet deep, although a few deeper channels representing dredged drainage systems are present and provide access for ocean-going vessels. The North Bay, where the Refuge is located, is shallower, averaging less than 6 feet.

Historically, tidal marshlands interwoven with tidal sloughs, tidal ponds and uplands bordered the bay. With the influx of settlers during the Gold Rush of 1850, many of these marshes were drained and used for agriculture or filled for use in urban development (Chamberlain 1973). In the North Bay, 95% of San Pablo Bay tidal marshes have been levied or filled since 1860 (Sloan 1980). The levied areas include approximately 25,000 acres of seasonal and farmed wetlands.

#### **3.1.3    Soils and Geology**

San Francisco Bay is a late Pliocene structural depression inundated by rising seas in the inter-glacial stages of the Pleistocene. The Bay lies on the Franciscan formation between the San Andreas and Hayward faults (Dreisbach 1969).

Soils in the salt marshes around the Bay consist of poorly drained silty clays formed in mixed bay and stream alluvium. Slopes are 0 to 2 percent with elevation ranges from 2 feet below to 10 feet above sea level. The Alviso Association, Tidal Marsh Association, Reyes Series and bedrock are the predominant soils in the Refuge.

The Alviso soils include dark gray clay surface soils and gleyed, silty clay subsoils. They overlie gleyed alluvium mixed with layers of organic matter and are affected by high concentrations of salt. Subsurface soil averages 6 to 10 inches in thickness and the subsoil averages 30 to 40 inches in thickness (SCS 1968). The Tidal Marsh Association occurs in areas periodically covered by tidal water.

The Reyes Series soils consist of poorly drained silty clays that are formed in mixed bay and stream alluvium. The soils are in salt water marshes adjacent to bodies of sea water. Typically, the surface layer is light brownish-gray and grayish-brown, extremely acidic silty clay about 14 inches thick. The subsoil is light brownish-gray and light-gray, mottled very strongly acidic silty clay about 17 inches thick. At a depth of about 31 inches is gray, mottled, very strongly acidic silty clay about 20 inches thick. This is underlain by muck and plant remains mixed with gray and black silty clay. Permeability is slow, runoff is slow to pond, and the erosion is none to slight. Fertility is moderate and the available water capacity is 8 to 10 inches (SCS 1968). Two distinct units comprise the underlying bay geologic formations: an older bedrock unit and a younger, unconsolidated sedimentary sequence. The bedrock is generally composed of sandstone, siltstone, chert and greenstone of the Franciscan

formation and is deeper in the southern part of the bay where depths of 300 to 800 feet are common. The surface of the bedrock is very irregular.

### **3.1.4 Air Quality**

The prevailing flow of the San Francisco Bay area winds is largely determined by the position of the semi-permanent high pressure over the eastern Pacific Ocean (Dreisbach 1969). Throughout most of the year, the wind direction is predominantly from the west to north-northwest although southeast winds may prevail during winter months. Wind averages are less during the winter months, but peak winds occur during that time period as a result of low pressure frontal systems that affect the Bay area on an average of once every two weeks (Dreisbach 1969).

Although weather conditions in the Bay area favor temperature inversions that contribute to air contamination, air quality is fairly good for a metropolitan area of 7.1 million residents. A ten year summary by the Bay Area Air Quality Management District showed the Bay Area did not exceed the national standards for ozone concentrations in 2004. California Ozone level standards were exceeded on 7 calendar days in 2004, the lowest level observed over the last decade. The district did not exceed national standards for carbon monoxide, nitrogen dioxide, sulfur dioxide or particulate matter during that period.

### **3.1.5 Water and Water Quality**

The San Francisco Estuary is the largest estuary on the West Coast of North and South America. The Estuary is commonly divided into three bays: San Francisco Bay, San Pablo Bay, and Suisun Bay. Salinity increases as you move from Suisun Bay to San Francisco Bay. The volume and timing of freshwater inflow into the Estuary via Suisun Bay are among the most important factors affecting physical, chemical, and biological states of the Estuary. Freshwater flows via the Sacramento and San Joaquin Rivers peak during spring following melting of the Sierra and other high mountain snow packs.

The San Francisco Bay exhibits a mixed-diurnal tide cycle, with two high tides and two low tides every day. Tidal ranges are greatest around the new moon and full moon of each month (spring tides). Maximum tidal ranges occur from December thru January and in June. Mean tidal level is highest in the North Bay, but tidal range is greater in the South Bay (ABAG et al. 1991). Tidal data are collected by the National Oceanic and Atmospheric Administration (NOAA) in San Pablo Bay. These data shows a mean tide level of 3.05ft, mean higher water of 5.73ft and mean low water of 0.93ft.

Water salinity varies greatly throughout the Bay and represents a balance between saline ocean influence, freshwater influence, and evaporation. Seawater has an average salinity of 35 parts per thousand (ppt) while distilled freshwater is defined as having 0 ppt. Estuarine or brackish water exhibits salinity that lies between freshwater and seawater. In general, salinity is lower in the northern portions of the Estuary (Suisun, San Pablo) and greater in the South Bay (San Francisco). During periods of high river outflows, North Bay salinities may be less than 5 ppt while the South Bay may be closer to 20 ppt. Typically, the San Pablo Bay salinities average 15-17 ppt.

The Refuge is most closely affected by the water quality of San Pablo Bay and its tributaries. Table 5 lists waters in the San Pablo Bay region that have been designated as impaired and the pollutants for which they were so designated. The designations can be the result of pollutants, such as heavy metals or pesticides, or a physical property of the water, such as dissolved oxygen content or temperature. The Bay is impaired by persistent agricultural chemicals, such as DDT and Chlordane (USEPA 2010). Metals, PCBs, and mercury, remnants of past industrial and mining operations, also occur in the Bay (USEPA 2010). The tributaries, which include Sonoma Creek and the Petaluma and Napa Rivers, are impaired by sediment, nutrients, and pathogens that are all related to the abundant agricultural activities found within the greater watershed.

**Table 4. Impaired water bodies in the vicinity of San Pablo Bay.**

Water Body/Waterways	Listed Impairment/Pollutant
San Pablo Bay	Chlordane, DDT, Diazinon, Dieldrin, Dioxin Compounds, Exotic Species, Furan Compounds, Mercury, Nickel, PCBs, Selenium
Napa River	Nutrients, Pathogens, Sedimentation/Siltation
Sonoma Creek	Nutrients, Pathogens, Sedimentation/Siltation
San Francisco Bay, Central	Chlordane, DDT, Diazinon, Dieldrin, Dioxin Compounds, Exotic Species, Furan Compounds, Mercury, PCBs, Selenium

Source: San Francisco Bay Regional Water Quality Control Board, Section 303(d) of the Clean Water Act, 2003.

## 3.2 Biological Considerations

The Refuge provides a variety of environments, each with its own characteristic set of flora and fauna. Environments throughout San Pablo Bay have been altered by past and current human actions including mining, salt production, agriculture and contamination. Today, land managers of remaining open spaces and interested partners are working towards enhancement and restoration of historic upland and wetland environments of San Pablo Bay. These efforts provide opportunities to enhance or expand existing habitats for the benefit of wildlife, plants, and people. An important consideration as we move forward is to ensure that our actions do not enhance or create conditions in which mosquito populations increase above levels that are naturally found in these wetland environments.

### 3.2.1 Environments, Vegetation, and Associated Resources

Environments of the Refuge may be grouped into four wetland types based on the U.S. Fish and Wildlife Service NWI maps: sub tidal shallow open water, intertidal mudflats, tidal marsh, and seasonal wetlands. Each of these wetland types supports a unique and diverse set of plant assemblages.

Open water. The dominant vegetation of the open water environments of the Refuge are phytoplankton, including diatoms, dinoflagellates, green algae, and blue-green algae.

Mudflats. Also known as tidal flats, mudflats are defined by their elevation in relation to tidal height. The tidal flats of San Pablo Bay generally occur between mean tidal level (MTL) to approximately 2.5 feet below Mean Lower Low Water (MLLW). Daily tides submerge and expose the mudflats twice daily. As the tide inundates shallow portions of the bay deposited sediments are exposed during low tides, leaving mudflats.

Tidal marsh. Tidal marshlands generally occur between MTL and extreme high tides (EHT). Within the tidal marsh environment are varying conditions of many physical factors such as tidal submergence, soil conditions, nutrient conditions, and drainage patterns (e.g., channel complexity). Tidal marshlands of the Refuge are high in productivity and biomass but generally are characterized by low plant species diversity. Characteristic species of Refuge tidal marsh are cordgrass (*Spartina foliosa*) and pickleweed (*Sarcocornia pacifica*). Other common species include salt grass (*Distichlis spicata*), gum plant (*Grindelia* spp.), jaumea (*Jaumea carnosa*), alkali heath (*Frankenia salina*), marsh rosemary (*Limonium californicum*), yarrow (*Achillea millefolium*), and bulrush (*Scirpus* spp.). Non-native species common in this zone include fennel (*Foeniculum vulgare*), perennial pepperweed (*Lepidium latifolium*), rye grass (*Lolium* spp.), and curly dock (*Rumex crispus*). Historically, tidal marshlands of San Pablo Bay were bordered by a large expanse of uplands and seasonal wetlands. The area where uplands and marshlands meet is commonly referred to as the “transition zone” or the “marsh-upland ecotone”. Tidal marsh that gradually slopes into native grasslands, oak woodlands, or other native communities is now uncommon in the Estuary. China Camp State Park and some areas along the Petaluma River contain the largest contiguous marsh with a “native” marsh-upland ecotone in San Pablo Bay. Today, the transition zone of most other North Bay marshlands, including those of the Refuge, consists of levees.

Diked baylands/Seasonal wetlands. Diked Baylands were historically tidal but are now isolated from the tides but which maintain wetland features (Goals Project 2000). The Cullinan Ranch unit (Cullinan) was diked and drained for agricultural in the late 1800s. Following the cessation of water pumping in the early 1990s, the 1,500 acre site

quickly reverted to seasonal wetlands. The dominant wetland plant found at Cullinan is *Typha latifolia*. In addition to shallow ponding following the rainy season, Cullinan also contains remnant drainage canals that hold water throughout the year.

### 3.2.2 Special Biological Communities/Critical Wildlife Habitat

The Refuge was established, in part, to conserve habitats of migratory birds and federally endangered species such as the salt marsh harvest mouse (*Reithrodontomys raviventris*) (SMHM) and California clapper rail (CLRA). The Refuge also provides breeding or wintering habitat for many state-listed species.

Human development within and adjacent to the San Francisco Bay Estuary has drastically altered biological communities. As a result, many species that depend on the estuarine environment are designated as needing special attention by federal and state agencies. The following federal or state listed species occur or have the potential to occur on the Refuge.

**Table 5. Federal and State listed wildlife and plant species that occur or have the potential to occur on the San Pablo Bay National Wildlife Refuge.**

Species	Status
California clapper rail ( <i>Rallus longirostris</i> )	FE, SE
California black rail ( <i>Laterallus jamaicensis</i> )	ST
Salt marsh harvest mouse ( <i>Reithrodontomys raviventris</i> )	FE, SE
Steelhead trout ( <i>Oncorhynchus mykiss</i> ) Central CA coast	FT
Sacramento River Chinook salmon ( <i>Oncorhynchus tshawytscha</i> ) (spring run)	FT, ST
Sacramento River Chinook salmon ( <i>Oncorhynchus tshawytscha</i> ) (winter run)	FE, SE
Green sturgeon ( <i>Acipenser medirostris</i> )	FT
Delta smelt ( <i>Hypomesus transpacificus</i> )	FT, ST
Soft bird's beak ( <i>Cordylanthus mollis</i> spp. <i>mollis</i> )	FE

<sup>1</sup>FE - Federal Endangered, SE - State Endangered, FT - Federal Threatened, ST - State Threatened

### 3.2.3 Noxious Weeds/Exotic Plants

Non-native and exotic plants exist in virtually every habitat type around the Bay. Special attention must be paid to any mechanical manipulation of wetlands for mosquito control to prevent the development of conditions that encourage colonization and spread of invasive plants. In some instances, the use of mechanical means to control mosquito populations may help reduce and/or eliminate invasive weeds by improving tidal inundation cycles. Dominant invasive plants of the San Francisco Estuary include non-native *Spartina* species and perennial pepperweed (*Lepidium latifolium*) (pepperweed). Pepperweed characteristically occurs in mid- to high- marsh elevations where the native pickleweed dominates. Assessments of pepperweed populations on the Refuge in 2005 and 2006 show positive associations with the marsh-levee interface (marsh-upland ecotone) and waterways (e.g., including natural channels and man-made mosquito ditches).

### 3.2.4 Wildlife

San Pablo Bay National Wildlife Refuge (The Refuge) provides habitat for a wide range of wildlife species. Refuge environments include mudflats, shallow open bay, tidal marsh, and seasonal wetlands. These environments provide feeding, resting, or reproductive habitat for both resident and migratory species. The most visible expression of biodiversity and abundance on the Refuge is seen among waterfowl and shorebird populations. Estuarine environments of the Refuge are used by a significant proportion of Pacific Flyway shorebird and waterfowl populations. San Pablo Bay, as part of the San Francisco Estuary, is designated as a site of “hemispheric importance” by the Western Hemisphere Shorebird Reserve Network and is considered an “Important Bird Area” by the Audubon Society. These designations recognize the importance that particular areas provide for long-term viability of migratory bird populations. The Refuge also supports a number of species endemic to tidal marsh of this region, including the endangered salt marsh harvest mouse and the endangered

California clapper rail.

### **3.2.4.1 Birds**

#### Waterfowl

The Refuge provides roosting, feeding, or nesting habitat for a significant portion of the Pacific Flyway wintering population of diving ducks (e.g., canvasback and scaup). At least 18 waterfowl species regularly occur on the Refuge during migratory and winter periods each year. These species have a long history in the San Francisco Bay and use a variety of environments in the region including seasonal wetlands, tidal marsh, open bay, and salt ponds. Annual waterfowl surveys conducted by the San Francisco Bay National Wildlife Refuge Complex allow a year-to-year comparison of waterfowl populations in the Estuary. A significant proportion of migrating and wintering West Coast waterfowl, particularly canvasback and sea ducks, winter in the San Francisco Estuary. For example, mid-winter waterfowl surveys conducted throughout the Pacific Flyway show the San Francisco Estuary supports on average, 34% of the canvasback population and 49% of the scaup population for the period spanning 1990 to 1999 (SFBJV 2000). Resident waterfowl species of the Refuge include mallard, gadwall, and Canada goose.

#### Shorebirds

San Francisco Bay is a designated Hemispheric Site by the Western Hemisphere Shorebird Reserve Network giving the San Francisco Bay international recognition as a critically important shorebird area. Shorebirds represent one of the most diverse groups of wildlife observed on the Refuge. Stenzel et al. (2002) stated that “on the conterminous U. S. Pacific coast, the bay holds more total shorebirds than any other wetland in all seasons, and it holds the majority of individuals of the 13 most abundant shorebirds in one or more seasons”. It is estimated that more than one million shorebirds are known to move through the San Francisco Estuary each year. Common species include western and least sandpipers, dowitchers, marbled godwits, dunlin, long-billed curlew, black-bellied plover, American avocet, black-necked stilts, willet, semi-palmated plover, red knot, yellowlegs, sanderling, black turnstone, and red-necked phalarope. The extensive mudflats of the Refuge provide key foraging areas for shorebirds at low tide. Tidal channels, marsh lagoons and ponds, and seasonal wetlands of the Refuge also provide high tide refuge, resting and foraging areas. During migratory and winter periods, the mudflats are often dense with foraging shorebirds as far as the eye can see.

### **3.2.4.2 Mammals**

A variety of mammal species inhabit environment of the Refuge. The most numerous group of mammal species of San Pablo Bay are rodents. Native rodent species include the endangered salt marsh harvest mouse and California vole (*Microtus californicus*) and ornate shrews (*Sorex ornatus*). Non-native rodent species include the house mouse (*Mus musculus*), deer mouse (*Peromyscus maniculatus*), and Norway rat (*Rattus norvegicus*). Other native mammal species known to occur on the Refuge include raccoons, gray fox, muskrat, beaver, deer, coyote, and harbor seals. Other non-native mammals that occur or have the potential to occur include feral cats, red fox, and opossum (*Didelphis virginiana*).

### **3.2.4.3 Reptiles and Amphibians**

Several species of reptiles and amphibians are known to inhabit the marshlands of San Pablo Bay. Surveys for reptiles and amphibians have not been conducted on the Refuge although surveys conducted in the Napa-Sonoma marshes in the 1970s found 18 species of reptiles and amphibians (Madrone Assoc. 1977). Species known to occur on the Refuge include the gopher snake, garter snake, and Pacific tree frog.

### **3.2.4.4 Fisheries**

The recovery plan for the Sacramento-San Joaquin Delta native fishes (USFWS 1994) identifies several fish species of concern within the Refuge boundaries. Adult long fin smelt (*Spirinchus thaleichthys*) concentrate in San Pablo and Suisun Bays. Larval and juvenile smelt utilize the food-rich nursery areas of San Pablo Bay. Sacramento splittail (*Pogonichthys macrolepidotus*) are found in the Petaluma and Napa River drainages of San Pablo Bay and spawning may occur in sloughs adjacent to the Refuge. The green sturgeon (*Acipenser medirostris*) and various runs of Chinook salmon (*Oncorhynchus* spp.) may also use and travel through the tidal

waters of the Refuge.

Other fish species such as the shiner perch (*Cymatogaster aggregata*), top smelt (*Atherinops affinis*), halibut (*Paralichthys californicus*), striped bass (*Morone saxatilis*), starry flounder (*Platichthys stellatus*), northern anchovy (*Anchoa* spp.) and American shad (*Alosa sapidissima*) use the salt marshes and shallow water areas throughout various stages of their life cycles (USFWS 1989).

One introduced species, the mosquito fish (*Gambusia affinis*), is a common biological control for mosquitoes in the Bay area. Historically, mosquito fish occurred in Coyote Creek as early as 1941. Since then, the species has spread into streams throughout the San Francisco Bay drainage. Due to the saline conditions found on the Refuge the species is unlikely to occur here.

### 3.2.4.5 Invertebrates

Invertebrates are considered an important component of any habitat, including tidal ecosystems. Despite their importance to ecosystems as a whole, little is known about the ecology and biology of invertebrates (excepting mosquitoes) within the San Francisco Estuary (Goals Project 2000). A more detailed understanding of how terrestrial and aquatic invertebrates contribute to the success of other estuarine organisms (e.g., plants, wildlife) is lacking (Goals project 2000). We do know that tidal marsh provides habitat for a wide variety of invertebrates including crab, shrimp, mussels, clams, snails, amphipods, worms, spiders, and insects (Goals project 2000). The trophic or feeding relationships between higher trophic levels (e.g., birds, fish) and lower trophic level organisms in tidal marsh of the Estuary is not well known (Grenier 2002). A study examining the pathways that contaminants take in tidal marsh food webs was conducted in tidal marshlands of San Pablo Bay (China Camp) (Grenier 2001). The study showed the tidal marsh food web has distinct segments within tidal channels, high marsh, low marsh, etc. and that these segments are connected by particular biotic pathways. Each segment has a distinct set of primary producers (plants) and associated primary (e.g., invertebrates) and higher order consumers (e.g., birds, fish). For example, pickleweed is the primary producer in the high marsh. This species is fed upon by invertebrates (e.g., amphipods) that are fed upon by higher order consumers such as song sparrows and fish. A large unknown is how alteration of lower order invertebrate consumers impacts higher order consumers.

#### Mosquitoes

Mosquitoes are typical nematoceran dipterans with aquatic immature stages and aerial adult stages. Eggs must come in contact with water in order to survive. Mosquitoes have four larval stages (instars) and one aquatic pupal stage. The aerial adult emerges from the pupal stage onto the surface of the water, expands its wings, hardens its exoskeleton, and flies off. In Northern California, it takes a mosquito from three to 12 days to complete a life cycle, depending on seasonal and environmental factors and the species of mosquito. The biology, diseases and pest ability of each mosquito species is different and influences decisions concerning control strategies.

A brief summary of the most common mosquito species detected on the Refuge are presented below. A more detailed account of mosquito biology and vector capabilities within the region is presented in Appendix N.

*Culiseta inornata* - Winter marsh mosquito. Monitored and treated from October through May. As temperatures cool, females emerge and seek water sources on which to lay eggs. The immature mosquito can be found in a wide variety of habitats ranging from duck club ponds, ditches, seepages, rainwater pools, salt marshes and manmade containers (Goals Project 2000). Adults are usually found resting near their larval habitats during their breeding season while summer aestivating adults are presumed to utilize animal burrows in upper marshes and adjacent uplands (Barnard and Mulla 1977, Shemanchuk 1965). *C. inornata* is a possible carrier of arboviruses. This species has been confirmed in laboratory tests and in the field to be a vector for West Nile Virus.

*Aedes dorsalis* - Summer salt marsh mosquito. Monitored and treated from January through November. *A. dorsalis* uses many of the same marsh habitats as *A. squamiger* in addition to using intertidal marshes. A multivoltine species, *A. dorsalis* can produce numerous generations from flooding tides between April and October. Dispersal paths are random, but the adult mosquitoes favor resting areas with large grassy regions. Known to harbor western equine encephalitis, St. Louis encephalitis, and California encephalitis, these aggressive

biters are capable of flying 15 or more miles from marsh. Laboratory tests have demonstrated that the species has a potential to vector West Nile Virus.

*Culex tarsalis* - Encephalitis mosquito. Monitored and treated from February through November. This multivoltine species can be found in almost any flooded pools including tidal marsh areas if salt content does not exceed 1.0 percent. Water temperature between 21 and 30 degrees Centigrade appears to be optimum for larval development. *C. tarsalis* is the primary vector of West Nile Virus, Western Equine Encephalitis and a carrier of St. Louis Encephalitis.

*Aedes squamiger* – Winter salt marsh mosquito. Monitored and treated from January through March for larval control. Larvae are found in salt marsh pools diluted by rainwater. Hatching usually occurs as a result of flooding the upper reaches of marshes with freshwater. Larvae develop in the marsh from January through March, depending on rainfall, with adults emerging around mid-March. The species is relatively long-lived, lasting through May or June in favorable conditions. Females disperse inland from the salt marsh along freshwater streams and are capable of flying 15 or more miles from the source. These are aggressive biters that are known carriers of California encephalitis. A 2004 pool of *A. squamiger* tested positive for West Nile Virus in San Luis Obispo County.

### **3.3 Socioeconomic Considerations**

#### **3.3.1 Cultural Resources**

Native Americans lived along the Bay shoreline for over 3,000 years prior to European settlement (ABAG et al 1991). At least eight Indian tribes occupied the twelve-county Bay area at the time of Spanish settlement. In the North Bay, the Coastal Miwok and Wintun Indian tribes inhabited the area that is now within the boundary of the Refuge (Dreisbach 1969).

Spanish settlers during the 1700s and American settlers during the 1800s brought drastic changes to the Bay area. A tremendous “influx” of immigrants assembled and the farming, ranching, industry and shipping trades flourished. Most of the wetlands of the North Bay were converted to agricultural lands during the late 1800s. World War II brought a great increase in the economy and land conversions throughout the Bay accelerated (USFWS 1990).

Preserving the culture and history of the nation’s past are the goals of regulations that include the National Historic Preservation Act (NHPA), Antiquities Act of 1906, Archeological Resource Protection Act of 1979, and Historic Sites Act of 1935. The NHPA regulations require that Federal agencies seek information, as appropriate from the State Historic Preservation Officer (SHPO), the Advisory Council on Historic Preservation (ACHP), Indian tribes and other individuals and organizations likely to have knowledge of, or concerns with, historic properties in the potentially affected area. Cultural resources defined within the framework of these regulations include archeological sites, historic sites, and traditional cultural properties associated with the values of Native Americans and other cultural groups.

Actions that physically disturb a site, alter its setting, or introduce elements out of character with the site may constitute an adverse effect. If a site is eligible for inclusion in the National Register of Historic Places, any type of physical damage results in a permanent loss of information that reduces the understanding of the site’s contribution to the past.

Monitoring, surveillance, and treatment of mosquitoes are not expected to impact cultural resources because they do not result in ground disturbing activities. As future restoration and enhancement projects are developed, site specific review would then be conducted.

#### **3.3.2 Socioeconomics and Environmental Justice**

A NEPA document includes a discussion of a proposed action’s economic and social effects when these effects are related to effects on the natural or physical environments. Executive Order 12898 “Federal Actions to

Address Environmental Justice in Minority Populations and Low-Income Populations,” required federal agencies to “identify and address, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations.”

The Refuge does not contain any urban development, the closest urban areas to the Refuge are Mare Island and the City of Vallejo located approximately one mile to the east. The Refuge is an approximately 16,500-acre area comprised of seasonal wetlands, open water, mudflats, tidal marsh, and upland habitats. There are no businesses, permanent or temporary residents or community centers located on the Refuge. However, there are several homes, farms and businesses immediately adjacent to the Refuge. No minority or low income populations inhabit the Refuge or are located directly adjacent. The anticipated effects of each of the alternatives would occur within the boundaries of the Refuge and do not involve loss or acquisition of businesses, residential homes or community facilities.

### **3.3.3 Land Use**

The Refuge was established to serve as a sanctuary for migratory waterfowl. The Refuge consists of about 16,500 acres of lands managed to provide habitat for a variety of species. The Service manages the Refuge consistent with the purposes for which the Refuge was established and the mission of the National Wildlife Refuge System. Significant public laws, regulations and policies that assist in Refuge management are described in section 1.5.3. Other than Refuge approved recreational activities and operation and maintenance activities, no other land use exists on the Refuge. Management of this Refuge has centered on protecting, improving and increasing the amount of wetland habitat available for resident wildlife species as well as the hundreds of thousands of waterfowl and approximately one million shorebirds that migrate and winter in the San Francisco Bay estuary. Because the Refuge is managed for wildlife habitat, the land represents a large section of open space along the San Pablo Bay. Lands immediately adjacent to the Refuge are predominantly open spaces and farmlands. A single transportation route, Highway 37, and two Pacific Gas and Electric power lines cross or parallel Refuge property.

#### Public Use of the Refuge

Several levels of public use occur on the Refuge from no activity in closed areas to seasonal high use areas around the headquarters office and nursery facilities at Sears Point.

Approximately 7,500 people visit the Refuge annually for the purposes of the San Francisco Bay Flyway Festival, environmental education, waterfowl hunting, and bird watching and to hike the trail at Tolay Creek/Lower Tubbs Island. Most of the Refuge is open to public access by boat with exception to the pickleweed tidal marshes. Access is provided through SUPs for certain types of research which is conducted throughout most of the year. Mosquito control activities must be adequately coordinated with the Refuge manager to avoid applying mosquito control products, such as pesticides, when visitors, partners, and staff are present.

#### Surrounding Land Uses

There are over seven million people who live along the shores of the San Francisco Bay Estuary making this the fourth-most populated area in the United States (ABAG 1994). Over 6.9 million people were estimated to populate the nine-county Bay Area in 2000 (ABAG 2000). The City of Vallejo with a population of 120,000 people is within one mile of the eastern Refuge boundary of the Cullinan Ranch Unit and on Mare Island, the Refuge is within the city limits adjacent to new residential housing sites. The City of Novato is located approximately five miles from the western boundary of the Refuge and has a population of over 47,000 people.

In this century, urbanization has been the major influence on the lands around the San Francisco Bay estuary. During the past 140 years, most of the wetland habitat has been drastically diminished. Of the 545,375 acres of historical tidal wetlands, only 44,371 (8 percent) remain (ABAG 1994). The Bay’s open water has been reduced by one-third and more than one-half of native upland habitats have been converted to urban land (ABAG 1994). Much of this development occurred prior to the presence of national wildlife refuges in the Bay area and is a predominant reason that the Refuge was established.

### 3.3.4 Human Health and Safety Concerns

The mosquito abatement districts of the Bay area are funded through taxes and fees to provide a service to the residents of the Bay area. The control of nuisance mosquitoes has been the main thrust of their efforts as diseases have not been a major factor in this area.

The Districts often receive and respond to public complaints and service requests. The Solano County MAD receives approximately 500 service requests each year. The Marin/Sonoma MAD averages 2,000 requests per year with numbers increasing annually. This section provides a discussion of the types of mosquito-borne diseases that have occurred in the past and have the potential to occur in the future.

*Western equine encephalomyelitis (WEE), St. Louis encephalitis (SLE), California encephalitis (CE), Jamestown Canyon Virus, Northway Virus, West Nile Virus (WNV) and malaria* are the primary mosquito-borne diseases known to occur in northern California (Eldridge 1993). In addition to the monitoring of mosquito abundance and occurrence, statewide surveys are conducted in order to detect the presence of encephalitis in mosquito and bird populations. In recent years, other mosquito-borne diseases have become more prevalent within the state of California. As California moves to a more global economy and lifestyle, the potential for outbreaks of mosquito-borne diseases imported from other countries is likely to increase.

*Encephalitis.* Encephalitis is caused by one or more viruses. The effects of the disease are often serious in humans, resulting in mental or physical impairment or death. *Culex tarsalis* is the primary carrier of encephalitis in northern California. Encephalitis can be monitored by examining adult female mosquitoes or blood samples from live birds. To evaluate mosquito populations, pools of 50 adult female mosquitoes are collected and analyzed for the presence of SLE, WEE, CE and WNV viruses. Sentinel chicken flocks are out-placed throughout the Bay area by the MADs. Blood samples from these chickens are then analyzed for the presence of viral antibodies. There are no flocks located on or adjacent to the Refuge. However, several flocks are located within mosquito flight distance. Sentinel flocks in San Mateo County, Santa Clara County and Alameda County have not developed antibodies (seroconverted) for the presence of encephalitis. However, one chicken flock in Sonoma County tested positive for encephalitis in 1993 and flocks in Solano County at Cordelia and Grizzly Island tested positive from 1993 through 1998.

*Malaria.* Malaria was first recorded in California around 1830 (Gray and Fontaine 1957). Major outbreaks in the Central Valley and Shasta lake regions occurred with reports of approximately 3/4 of the Central Valley Indian population dying in the malaria epidemic of 1833. Malaria was never a major issue along the coastal areas probably because the climate was not sufficiently warm for a continuous period of time. Gray and Fontaine (1957) consider the possibility that malaria would have declined in California after 1900 even without the mosquito control operations that began in 1910.

Malaria is caused by a blood parasite (*Plasmodium*) that is transmitted by mosquitoes. The disease is reservoired in infected humans, usually immigrants from countries where malaria is endemic. In the Bay area, mosquitoes are not monitored for the presence of malaria. Instead, the Districts rely on local health departments to notify them of apparent malaria cases.

*West Nile Virus.* Despite the number of human infections, WNV is primarily a wildlife disease. The virus is spread by mosquitoes from bird to bird. Mammals, including humans, are only incidentally infected. This may change as new mosquito vectors are identified. The transmission cycle initially involves only birds and is infectious for only 3 to 5 days. WNV is especially virulent in elderly and those with a compromised immune system. WNV was detected in northern California during the summer of 2004 with its first human case in Santa Clara (CDC 2010). WNV seropositives were discovered in 2005 (Huichica Creek and American Canyon) and 2009 (St. Helena) in Napa County (pers. Comm., Napa County MAD). Although new species of mosquitoes are being tested for potential to carry WNV, *C. tarsalis* is still the primary transmission vector.

*Dengue.* In mid-August, 1994, a resident of Santa Cruz County tested positive for Dengue fever that he apparently contracted on a trip to Puerto Rico (Hellbom 1994). This is the only recently documented case within

the state.

### **3.3.5 Aesthetics**

#### **3.3.5.1 Scenery**

Numerous studies have attempted to assign economic benefits to wetlands and open space, but quantifying the value of scenery for aesthetic purposes is extremely difficult. The draw and attachment that residents and visitors have for the San Francisco Bay area is largely due to the beauty of the Bay itself. The Refuge contributes to the aesthetic value of the San Francisco Bay with its large tracts of wetlands and undeveloped open space. Refuge wetlands support sport and commercial fisheries, improve water and air quality, help control floods, support wildlife and provide outdoor recreation opportunities. In addition, people enjoy wetlands for their beauty, wildness and solitude.

#### **3.3.5.2 Noise**

Noise levels vary throughout the Refuge depending on proximity to highways and adjacent land uses. Highway 37 bisects the Refuge, producing consistent background noise while auto races at the Sears Point Raceway in Sonoma County produces intermittent noise on the west side of the San Pablo Bay.

## Chapter 4 ENVIRONMENTAL CONSEQUENCES

This chapter provides an analysis of the effects of each of the alternatives on the physical, biological, and social environments discussed in Chapter 3. This analysis focuses on three aspects of each alternative – impacts associated with monitoring and surveillance activities, impacts associated with pesticide application, and impacts associated with wetland restoration projects. The impact analysis focuses on a programmatic-level approach to evaluate the effects of each alternative. The analysis of monitoring, surveillance, and pesticide use is presented at a project-specific level, while the analysis of wetland restoration projects is presented at a more general level because specific wetland restoration projects have not been developed at a site specific level. Further analyses of environmental consequences may occur when site-specific wetland restoration planning has been done. Where appropriate we have identified best management practices (BMPs) that should be implemented to avoid and minimize any potential environmental impacts.

The following resources would not be affected by any of the alternatives:

- Climate – None of the alternatives would change the climate in the San Francisco Bay area.
- Soils/Geology – None of the alternatives would have any effect on the soils or geology of the Refuge. None of the alternatives would alter the soils or geology on the Refuge.
- Environments – open water, mudflats, tidal marsh, and seasonal wetlands – None of the alternatives would change the abundance or distribution of the general environments found on the Refuge. While wetland restoration projects to improve tidal circulation may result in a different vegetative composition, they would not change the overall amount or location of environment.
- Noxious Weeds/Exotic Plants – Noxious weeds and exotic plants will continue to be plant community on the Refuge. None of the alternatives are focused on eradicating noxious weeds or exotic plants.
- Land Use – None of the alternatives would change the purposes for which the Refuge is managed. No public uses would be restricted on the Refuge as a result of any of the alternatives. The Refuge would remain a major section of open space along the San Francisco Bay shoreline.
- Socioeconomics and Environmental Justice – All of the alternatives would occur within the boundary of the Refuge and do not involve the loss or acquisition of businesses, residential homes or community facilities. Therefore, there are no adverse social or economic effects, and no minority or low-income populations or communities would be disproportionately affected under any of the alternatives.

These resources are not discussed further in this chapter.

**Pesticide Effects Measures.** The following is a description of some of the measures used to assess effects of pesticides to plants and wildlife by the U. S. Environmental Protection Agency (EPA). These measures are used to describe potential pesticide effects to wildlife and plants as a result of mosquito management on the Refuge. “Measures of effect are obtained from a suite of registrant-submitted guideline studies conducted with a limited number of surrogate species and/or from acceptable open literature studies” (EPA 2004, USFWS/NMFS 2004). The acute measures of effect routinely used for listed and non-listed animals in screening level assessments are the LD50, LC50 or EC50, depending on taxa. LD stands for “Lethal Dose”, and LD50 is the amount of a material, given all at once, that is estimated to cause the death of 50% of a group of test organisms. LC stands for “Lethal Concentration” and LC50 is the concentration of a chemical that is estimated to kill 50% of a sample population. EC stands for “Effective Concentration” and the EC50 is the concentration of a chemical that is estimated to produce some measured effect in 50% of the test population. Endpoints for chronic measures of exposure for listed and non-listed animals are the NOAEL or NOAEC. NOAEL stands for “No Observed-Adverse-Effect-Level” and refers to the highest tested dose of a substance that has been reported to have no harmful (adverse) effects on a test population. The NOAEC (*i.e.*, “No-Observed-Adverse-Effect-Concentration”) is the highest test concentration at which none of the observed results were statistically different from the control.”

## 4.1 Effects on the Physical Environment

### 4.1.1 Air Quality

Alternative A – Proposed Action. Regular mosquito monitoring and surveillance activities would not have any adverse effects on air quality. Mosquito monitoring and surveillance activities are limited to checking New Jersey light traps and sentinel chicken flocks located offsite of the Refuge. Monitoring and surveillance activities on the Refuge can occur by truck, foot, or kayak. This work is currently conducted by each MAD and the proposed action would not increase the number of monitoring trips needed, therefore, there would be no effect to air quality.

The aerial application of pesticides (larvicide or pupacide) where large areas of control are needed (e.g., greater than 250 acres) could result in aerial drift of pesticides. To minimize potential effects, wind speed restrictions on spraying will be employed.

Constructing wetland restoration projects with a focus of improving tidal circulation in order to reduce mosquito production could affect air quality by temporarily increasing vehicle related emissions. Depending on the size of the restoration project this temporary increase in emissions could range from one month to several months. Temporary, localized dust may also occur as a result of restoration or enhancement projects. As site-specific projects are identified, potential air quality effects would be further analyzed. Best management practices to minimize any effects to air quality would be identified in a project-specific document.

Alternative B - Non-chemical Mosquito Control. The effects of Alternative B on air quality would be the same as described under Alternative A.

Alternative C - No Mosquito Management. Under this alternative there would be no monitoring or surveillance of mosquitoes on the Refuge which would eliminate some vehicle emissions from trucks normally used during this activity. The MADs would continue monitoring and surveillance activity at locations off of the Refuge. Under this alternative no pesticides would be used to control mosquitoes. This would eliminate emissions associated with aircraft and heavy equipment used to apply pesticides. This alternative does include the construction of wetland restoration projects aimed at reducing mosquito production. As described under Alternative A, increases in vehicle related emissions and localized dust would be temporary in nature. As site-specific restoration projects are identified, potential air quality effects would be further analyzed.

Alternative D-No Action. Impacts under this Alternative are the same as described under Alternative A.

### 4.1.2 Topography

Alternative A - Proposed Action. Regular mosquito monitoring and surveillance, and the application of pesticides for mosquito control proposed in this alternative would have no effect on topography. None of the monitoring and control work would result in any physical changes to the existing topography.

Under this alternative we would construct wetland restoration projects to improve tidal circulation and reduce the production of mosquitoes. Restoration projects are likely to change site topography. As restoration projects are developed we will analyze changes in topography in project-specific documents. These changes would be beneficial because they would result in increased tidal circulation that promotes native tidal marsh regeneration and a reduction in mosquito production.

Alternative B - Non-chemical Mosquito Control. Impacts under this Alternative would be the same as described under Alternative A.

Alternative C - No Mosquito Management. This alternative does not include mosquito monitoring and control on the Refuge. Potential impacts from wetland restoration projects would be the same as described under Alternative A.

Alternative D – No Action. Impacts under this Alternative are the same as described under Alternative A.

### 4.1.3 Water

Alternative A - Proposed Action. Under this alternative, the regular mosquito monitoring and surveillance activities conducted by the MADs would continue. Monitoring and surveillance activities would not affect water resources because on the Refuge this work consists of walking, driving, or kayaking to the sample sites. No contaminants are introduced to the Refuge's water resources.

The application of pesticides on the Refuge could affect water resources because pesticide application is occurring in an aquatic environment. We do not expect application of pesticides to result in any adverse effects to water quality on the Refuge. The following information was gathered from a report supporting a statewide general pollutant discharge elimination system (NPDES) permit for discharges of aquatic pesticides to waters of the United States by the Coastal Region MAD (general permit No. CAG990003).

- Bti. Bti is not expected to have any measurable effect on water quality and occurs naturally in most aquatic environments. There are no established standards, tolerances or EPA approved tests for Bs.
- Methoprene. Methoprene is not expected to have a significant impact on water quality. Methoprene has shown to be effective against mosquitoes at levels below those that can be detected by any currently available test approved by the EPA.
- Surfactant (Agnique). This surfactant is considered "practically nontoxic" by the EPA.

Pyrethrin is extremely toxic to aquatic life, especially fish (Ecotoxnet 1994, USEPA 2006). Pyrethrum compounds are broken down in water to nontoxic products (Ecotoxnet 1994). Pyrethrins are inactivated and decomposed by exposure to light and air. Pyrethrins are also rapidly decomposed by mild acids and alkalis.

Best management practices for the application of pesticides would include:

- Where mosquito control is needed, use the most effective means that pose the lowest risk to abiotic and biotic resources.
- Apply pesticides where monitoring and surveillance data justify its use.
- Employ wind speed restrictions on spraying.
- The application of pyrethrins will only occur in rare instances when a risk of serious human disease or death, or high risk to public health has been documented by a public health agency whose jurisdiction includes the Refuge.
- The application of pyrethrins should occur at an ultra-low volume (according to pesticide label instructions and per habitat type).
- In a season when a risk of serious human disease or death, or high risk to public health is documented, the application of pyrethrins must be limited to reduce impacts to habitat and wildlife, but sufficient to ensure effective mosquito control.
- Avoid application of pesticides during high tides and avoid open water areas of the Refuge (e.g., sloughs, channels, open bay).

Construction of wetland restoration projects is likely to change the amount and location of surface water on the Refuge. Because these restoration projects would be constructed to improve tidal circulation this change would be beneficial to water resources on the Refuge by decreasing anaerobic conditions and improving conditions for aquatic vertebrate and invertebrate communities. Implementing wetland restoration projects could also provide an increase of the floodwater capacity of the Refuge which would reduce local flood risk. Restoration projects would also have some short term, localized impacts to water quality from construction activities. Best management practices would be developed as these projects proceed to avoid or minimize impacts to water resources on the Refuge. Additional analysis of the potential effects of restoration projects on water resources of the Refuge would be analyzed in project-specific documents.

Alternative B - Non-chemical Mosquito Control. The impacts of this alternative would be the same as described under Alternative A as applicable to the use of Bti.

Alternative C - No Mosquito Management. Under this alternative no mosquito monitoring, surveillance, or control would be allowed on the Refuge. Therefore there would be no effect to water resources on the Refuge from either monitoring or control. Potential effects from restoration projects would be the same as Alternative A.

Alternative D – No Action. The impacts of this alternative would be the same as described under Alternative A with the exception that impacts from adulticides would not be assessed because they are not permitted under this alternative.

#### **4.2 Effects on Biological Resources**

Table 6 summarizes the fate and biological effects of pesticides that would be used under Alternatives A, B, and D.

**Table 6. Summary of fate and biological effects of common pesticides used for mosquito control in wetlands by the Marin/Sonoma and Solano Mosquito Abatement Districts.**

Name	Degradation	Effects on Wildlife	Effects on humans
<i>Bacillus thuringiensis israelensis</i> (Bti) <sup>1, 2, 4, 5, 6</sup>	Foliar HL 1-4d, soil HL mean 4mo.	Nontoxic to birds and fish, minimal toxicity to bees and other non-target insects; indirect food web effects may occur, especially among higher order vertebrates (e.g., birds).	Adverse effects not likely from label applications of Bti on the Refuge.
Methoprene <sup>3, 5, 6</sup>	Degrades rapidly in water; HL <2d in alfalfa; low persistence in soil w/ HL up to 10d; aquatic HL 30-40hr.	Slightly to moderately toxic to fish, highly toxic to some species of estuarine invertebrates; slightly toxic to birds (5-8d LC <sub>50</sub> >10,000 ppm for mallard and quail) (amount needed for mosquito control is < 1ppb).	Methoprene is practically non-toxic when ingested or inhaled and slightly toxic by dermal absorption.
Monomolecular film <sup>9</sup>	Environmental fate not determined	Films are potentially lethal to any aquatic insect that lives on the water surface or requires periodic contact with the air-water interface to obtain oxygen; other ecotoxicological effects are unknown (e.g., birds, fish).	May cause eye irritation; otherwise acute and chronic effects are unknown.
Pyrethrins <sup>7, 8, 10</sup>	Soil HL 12d, rapidly degrades in sunlight and water.	Toxic to aquatic life including fish, insects, and aquatic invertebrates, slightly toxic to vertebrates.	Slight acute oral toxicity to mammals, allergic reaction possible.

<sup>1</sup>Data taken from National Pesticide Telecommunications Network for Bt (2000), <sup>2</sup>Poulin et al. 2010, <sup>3</sup>Ecotoxnet for methoprene (1996),

<sup>4</sup>Siegel and Shaddock 1992 (for Bti),

<sup>5</sup>Appendix K (2003), <sup>6</sup>Appendix J, <sup>7</sup>National Pesticide Information Center (1998), <sup>8</sup>Extension Toxicology Network (1994), <sup>9</sup>Agnique Material Safety Data Sheet (2006), USEPA 2006.

#### 4.2.1 Vegetation

Alternative A - Proposed Action. Impacts to vegetation could occur during access (on-foot, ARGOs) within tidal marsh to conduct mosquito management. The use of mechanized vehicles that traverse wetland areas such as ARGOs have a much greater impact on vegetation than foot access. Aerial photos of the Refuge show distinct ARGO tire tracks that occurred in the past. Depressions created by persistent use of particular tracks also result in additional shallow water pooling and may create mosquito breeding habitat. Use of mechanized vehicles or walking in the tidal marsh can also introduce and spread invasive weeds. The following best management practices would be implemented under the Proposed Action to reduce negative impacts to vegetation:

- Use techniques for ARGO operation that limit impact including: slow speeds; slow, several point turns; and using existing levees or upland to travel through sites when possible.
- ARGO access along tidal channels and sloughs will be prohibited within 30-meters of occupied rail habitat in order to reduce impacts to vegetation used by wildlife (e.g., nesting and escape habitat).
- Limit use of mechanized vehicles within wetlands to contiguous active production areas greater than 100-acres in size, unless coordinated with Refuge staff.
- Use existing pathways or limit the number of travel pathways used by mechanized vehicles within the marsh.
- Encourage application of pesticide (larvicide or pupacide) aerially or by foot over ARGO-based

application methods.

- Refuge staff and the MADs will develop and implement measures to reduce the introduction and spread of invasive weeds by mosquito management activities.
- Invasive weeds will be controlled through manual removal and chemical control.

The application of pesticides, including adulticides, are not likely to adversely affect vegetation directly because the pesticides used for mosquito control are not known to harm plants (Table 7). How reductions in certain invertebrate populations as a result of repeated pesticide applications would impact specific invertebrate-plant interactions (e.g., pollination) within tidal marsh of the Refuge are not known.

Best management practices will also include control of invasive weeds including manual removal and chemical control where possible, as well as annual meetings between the Refuge staff and the MADs to discuss how to reduce spread of invasive weeds by mosquito management activities.

Tidal circulation is a critical component in restoring native vegetation. Areas of the Refuge that sustain persistent shallow water result in poor vegetative health relative to other tidal areas (reduced species richness, cover, height). This condition is exacerbated by mosquito management activities described above. Therefore, projects designed to restore or enhance tidal circulation and reduce mosquito production will also improve habitat conditions for native vegetation. Reducing mosquito production through restoration of hydrology will have the added benefit of reducing direct impacts to vegetation from accessing the marsh. Wetland restoration projects may have some temporary, short-term impacts to vegetation during project implementation (e.g., use of construction equipment in the marsh). A detailed evaluation of vegetation impacts from restoration projects will be completed as site-specific projects are identified.

Alternative B - Non-chemical Mosquito Control. Same as described under Alternative A.

Alternative C - No Mosquito Management. Under this alternative no mosquito monitoring or control would be allowed on the Refuge. Vegetation would not be trampled by vehicles used for mosquito management. There would be no impacts to special status plant species of the Refuge. The effects of wetland restoration projects are the same as described under Alternative A.

Alternative D – No Action. Same as described under Alternative A.

#### **4.2.2 Effects on Mammals**

Alternative A - Proposed Action. The Proposed Action has the potential to impact mammals in two ways – first, through physically accessing the site with mechanized vehicles, and second through the application of pesticides. The federally endangered salt marsh harvest mouse (SMHM) occurs throughout tidal marsh of the Refuge. Adverse impacts to SMHM and other wetland mammals may occur as a result of marsh access via foot or mechanized vehicles for mosquito management activities. In a report on SMHM of the Mare Island Naval Shipyard, Bias and Morrison (1993) reported direct and indirect adverse effects on SMHM and populations caused by the use of mechanized vehicles in the tidal marsh. According to their personal observations, vehicle effects on habitat include compacted soil, destroyed vegetation, and documented the destruction of one salt marsh harvest mouse nest (Bias and Morrison 1993). In addition, repeated vehicle travel over the same areas creates paths through the pickleweed that increase access for predators. Lastly, they reported that vehicle travel can disrupt daily activity (e.g. movements) and has the potential to cause mortality of individual SMHM. Past and current aerial imagery from a variety of sources show visible paths where mechanized vehicles have traversed the marsh. Under the Proposed Action we would implement the following best management practices to reduce potential impacts:

- Use techniques for ARGO operation that limit impact including: slow speeds; slow, several point turns; and using existing levees or upland to travel through sites when possible.
- ARGO access along tidal channels and sloughs will be prohibited within 30-meters of occupied rail habitat in order to reduce impacts to vegetation used by wildlife (e.g., nesting and escape habitat).

- Limit use of mechanized vehicles within wetlands to contiguous active production areas greater than 100-acres in size, unless coordinated with Refuge staff.
- Use existing pathways or limit the number of travel pathways used by mechanized vehicles within the marsh.
- Encourage use of aerial pesticide.

The use of larvicides and pupacides for the purpose of mosquito management are not likely to directly affect native mammal populations of the Refuge. Larvicides and pupacides allowed under this alternative include Bti, methoprene, and monomolecular films (Agnique). New products will not be applied without prior Refuge approval. MADs and the Refuge will communicate regarding existing and new mosquito larvicides and adulticides that minimize non-target effects. Adverse effects on mammals from Bti, methoprene, and Agnique (monomolecular film) are not expected (Appendix J, K) when applied according to the label instructions. Furthermore, label rate application of pesticides is far below LD and LC50 toxicity data (pers. comm., E. Hawk). Bti has practically no acute or chronic toxicity to mammals, birds, fish, or vascular plants (U.S. EQP 1998). Extensive acute toxicity studies indicated that Bti is virtually innocuous to mammals (Siegel and Shaddock 1992). These studies exposed a variety of mammalian species to Bti at moderate to high doses and no pathological symptoms, disease, or mortality were observed. Methoprene is not considered toxic to mammals (Appendix J, K). Impacts to the mammalian community as a result of reduced invertebrate populations are not expected because most mammal species that inhabit wetlands of the Refuge are herbivorous (invertebrates are not a primary component of their diet). Insectivorous species such as shrews (e.g., *Sorex ornatus*) do occur in wetlands of the Refuge and reduced arthropod populations may impact food availability for these species.

Under the Proposed Action we would also allow the use of pyrethrin pesticides on the Refuge under certain conditions. Oral exposure of pyrethrins could occur through consumption of plants or plant parts that have been sprayed (ground-based application). A terrestrial exposure model showed no acute or chronic risks to mammal or bird species (USEPA 2006). To reduce any potential negative effects on mammals the Refuge will require the following best management practices by the MADs when applying adulticides:

- The application of pyrethrins occurs in rare instances when a mosquito-borne disease incidence has been documented on the Refuge or within flight range of vector mosquito species present on the Refuge; adult vector mosquito thresholds (Appendix M) are exceeded on the Refuge; and when there are no practical and effective alternatives to reduce a mosquito-borne, disease-based health threat.
- The application of pyrethrins must occur at an ultra-low volume (according to pesticide label instructions and per habitat type).
- The application of pyrethrins must occur where monitoring and surveillance data justify its use.
- In a season when a risk of serious human disease or death, or high risk to public health is documented, the application of pyrethrins must be limited to reduce impacts to habitat and wildlife, but sufficient to ensure effective mosquito control.

Wetland restoration projects that improve tidal circulation and reduce shallow ponding are likely to improve mammalian habitats by improving vegetation health and reduced need for mosquito management and associated disturbance. Mike Bias and Michael Morrison (1993) reported benefits to salt marsh harvest mouse populations as a result of improved water circulation and accompanying pickleweed health created by a tidal marsh restoration project (Strip Marsh unit, Caltrans mitigation, 1980s). Significant adverse effects to mammalian species are not likely to occur during restoration or enhancement projects because areas with poor hydrology typically exhibit low habitat quality for mammals, especially small mammals. Refuge data show absence of SMHM in areas that exhibit poor tidal hydrology, poor vegetation health, and produce high levels of mosquitoes. Best management practices to reduce effects (e.g., pickleweed removal) would be implemented to reduce direct effects during project construction. As restoration projects progress, additional site-specific analysis will be completed and methods to avoid and minimize any potential direct effects to the SMHM and other mammals will be identified.

Alternative B - Non-chemical Mosquito Control. Under this alternative, impacts related to access for mosquito management and impacts related to wetland restoration or enhancement projects are the same as described under

Alternative A. This alternative would include the application of Bti for mosquito control. Bti is not known to directly affect vertebrate species (Appendix J, K).

Alternative C - No Mosquito Management. This alternative does not include mosquito monitoring, surveillance, or control activities; therefore there would be no effect to mammals from mosquito management activities under this alternative. This alternative does include wetland restoration projects and effects to mammals from these activities would be the same as described in Alternative A.

Alternative D –No Action. The impacts of all mosquito management and restoration activities are the same as described under Alternative A with the exception of adulticide application. Adulticide are not currently permitted on the Refuge.

### **4.2.3 Effects on Birds**

Alternative A - Proposed Action. Impact to birds that use the Refuge may occur during refuge access for mosquito monitoring, surveillance and control, as well as the application of pesticides. There are two federal or state listed species that inhabit the Refuge, the California black rail and the California clapper rail. There are many other bird species listed as Species of Special Concern by the California Department of Fish and Game that occur on the Refuge.

Impacts to birds may occur; birds may be temporarily flushed as a result of ground access via foot or mechanized vehicle (ARGO). Birds will be able to return to roosting and nesting sites once operations have ceased in the area. It is anticipated that disturbance to birds is likely to be low as a result of regular communication between the Refuge and the MADs on known nest sites and other sensitive habitat locations. Use of mechanized vehicles can trample vegetation where these species may occur. Moreover, impacts from ARGOS should be reduced as a result of slow speeds, call identification by MAD staff, and use of levees and other established entry points when possible. However, impacts are considered limited because areas that need mosquito management typically provide poor habitat quality.

The use of pesticides for the purpose of mosquito management may directly or indirectly affect resident and migratory bird populations of the Refuge. Pesticides allowed under this alternative include Bti, methoprene, monomolecular films (Agnique) and pyrethrins.

Bti has practically no acute or chronic toxicity to mammals, birds, fish, or vascular plants (U.S.EPA 1998) (Appendix J, K). There is the potential for Bti to kill midge larvae (family *chironomidae*). Chironomid (non-biting midge) larvae can be abundant in wetlands and form a significant portion of the food base for other wildlife, including birds (Batzer et al. 1993; Cooper and Anderson 1996; Cox et al. 1998). As with Bti, there is concern regarding potential negative impacts to chironomid larvae from methoprene. Some studies have suggested methoprene impacts to other organisms that may form part of the food base for birds. McKenney and Celestial (1996) noted significant reductions in number of young produced in mysid shrimp at 2 ppb. Sub-lethal effects on the cladoceran, *Daphnia magna*, in the form of reduced fecundity, increased time to first brood, and reduced molt frequency have also been observed at lower concentrations of methoprene (Olmstead and LeBlanc 2001). Methoprene is considered practically non-toxic to birds (Appendix J, Extoxnet 1995, USEPA 2001). Monomolecular film is not known to cause direct chronic or acute avian toxicological effects to birds (Appendix K).

Pyrethrin pesticides would be the only adulticide chemicals permitted for use on the Refuge. Pyrethrins are not considered toxic to birds (Milam et al. 2000, USEPA 2006) when applied at labeled rates. See Appendices K and O for non-target effects of pyrethrins on vertebrates and invertebrates.

However, non-target effects to birds from pesticide application may occur as a result of reduced food base (e.g., Chironomid invertebrates). For example, monomolecular films are potentially lethal to any aquatic insect that lives on the water surface or requires periodic contact with the air-water interface to obtain oxygen (Appendix J, K). There is uncertainty with regard to pyrethrins, which have been shown to have no impact on large-bodied

arthropods, but have been shown to reduce invertebrate populations, especially among small-bodied arthropods (Boyce et al. 2007). Areas of the Refuge that require pesticide application for the purpose of mosquito management typically support poor habitat for native wildlife and plants. These areas have a number of characteristics in common. These include rapid marsh expansion over the last century (“centennial marsh”), shallow swales within the marsh plain (4-6’ NGVD29) that hold water for extended periods (e.g., following high tides) and a lack of tidal channels that permit drainage. These characteristics result in poor tidal hydrology and in turn, affect habitat quality for a variety of plant and wildlife species relative to other areas of the Refuge that exhibit adequate tidal flushing. Therefore, potential indirect effects to the food chain as a result of pesticide application within these areas is likely to be limited because of existing low quality habitat conditions for many estuarine-dependent species.

The reduction of mosquito production through improvement of tidal circulation and wetland quality will benefit both resident and migratory bird populations. Benefits will include improved water quality (reduced pesticide application), reduced human and vehicular disturbance, and improved primary productivity and food resources (e.g., invertebrates, fish). Short-term negative effects to birds during restoration or enhancement projects (aimed at reducing mosquito production) may occur as a result of construction activities. Techniques to reduce effects (e.g., exclusionary fencing, timing, equipment types) would be used to reduce effects during project construction. As restoration projects are identified a project specific document would be prepared that addresses any project-specific potential impacts.

Significant mosquito production and absence of control may negatively affect bird populations. Although mosquitoes themselves are a part of estuarine ecosystems they are known vectors of disease, including diseases that cause harm to humans and wildlife (e.g., West Nile Virus). Mosquito-borne diseases such as West Nile Virus (WNV) have shown to be lethal to wildlife. As of 2011, 326 bird species have been listed in the Center for Disease Control WNV avian mortality database (<http://www.cdc.gov/ncidod/dybid/westnile/birdspecies.htm>, accessed May 2, 2011). The list includes wildlife that inhabit tidal marsh such as waterfowl, grebes, heron, egrets, cormorants, songbirds (wrens, yellowthroats, song sparrows), and rails (clapper rail, Virginia rail, common moorhen, American coot). Other vertebrates known to be infected by WNV include horses, bats, chipmunks, skunks, rabbits, and squirrels.

To reduce the potential for negative impacts to bird populations the following best management practice would be implemented under this alternative:

- Access (via foot or mechanized vehicle) to tidal marsh for the purpose of mosquito management would be seasonally limited (e.g., reduced access during high tide events, use of biological monitor, use of ARGO only as a nurse rig) from January 15 to September 1 in areas that are known to be occupied by California clapper rails.
- ARGO access along tidal channels and sloughs will be prohibited within 30-meters of occupied rail habitat in order to reduce impacts to vegetation used by wildlife (e.g., nesting and escape habitat).
- Limit use of mechanized vehicles within wetlands to contiguous mosquito production areas greater than 100-acres in size, unless coordinated with Refuge staff.
- Limit the number of travel pathways used by mechanized vehicles within the marsh.
- Encourage use of aerial pesticide (larvicide or pupacide) application over ground-based application methods.
- Provide MADs with training on measures to avoid impacts to wetland wildlife.
- Application of pyrethrins would be informed by monitoring of mosquito vector populations and surveillance indicating location of disease prevalence.
- Application of pyrethrins would be limited to reduce impacts to wildlife and habitat but sufficient to prevent a second adult emergence.

Refuge data show absence or low density of sensitive bird species in areas that exhibit poor tidal hydrology, poor vegetation health, and produce high levels of mosquitoes. The potential also exists for transmission of mosquito-borne disease that has been shown to cause mortality in birds (e.g., West Nile virus). Impacts to birds as a result of physical access (trampling of vegetation, nests) and application of pesticides (food chain effects) as a result of

mosquito management could occur but it is unlikely that these actions would significantly affect bird populations of the Refuge given poor habitat conditions that exist in areas that require mosquito management.

Alternative B - Non-chemical Mosquito Control. See Alternative A for effects related to access and wetland restoration or enhancement projects. Only Bti is considered for mosquito control under this alternative. Bti is not known to directly affect vertebrate species although indirect effects may occur as a result of reduced invertebrate populations (See Appendix J, K).

Under this alternative chemical pesticides are not permitted for use on the Refuge. Effects related to chemical pesticides would not be realized. If mosquitoes are not adequately controlled at the larval stage, adult populations will develop and short-term control measures will not be available (e.g., adulticides). Significant adult mosquito production may produce negative effects on some bird populations. Although mosquitoes themselves are a part of estuarine ecosystems they are known vectors of disease, including diseases that cause harm to humans and wildlife (e.g., West Nile Virus). Mosquito-borne diseases such as West Nile Virus (WNV) have shown to be lethal to wildlife.

This alternative would also include wetland restoration projects. The effects of wetland restoration projects are described under Alternative A.

Alternative C - No Mosquito Management. Effects on birds will not occur as a result of mosquito management activities under this alternative although lack of mosquito management may have a negative effect on bird populations of the Refuge (See Alternative B). See Alternative A for effects related to wetland restoration or enhancement projects.

Alternative D –No Action. Under this alternative the Refuge would continue to allow the MADs access to the Refuge in order to conduct mosquito management. Impacts to birds (excepting use of adulticides) is described under Alternative A.

This alternative would also include wetland restoration projects. The effects of wetland restoration projects are described under Alternative A.

#### **4.2.4 Effects on Reptiles and Amphibians**

Alternative A - Proposed Action. Under this alternative the MADs would conduct mosquito monitoring and surveillance, mosquito control through application of pesticides, and tidal wetland restoration. Reptiles are known to occur within both tidal and seasonal wetland areas of the Refuge. Amphibians have been documented in seasonal wetlands of Cullinan Ranch and likely occur in seasonal wetland areas of Skaggs Island. Pesticide effects on reptiles and amphibians may occur through reductions in insects that serve as food source (Hoffman et al. 2008), and through direct individual effects from pesticide application or from trampling of individuals or habitat (e.g., access via ARGOs). Birds are often used as a surrogate for effects on reptiles and fish as a surrogate for amphibians (Hoffman et al. 2008). Direct chronic effects have been found for the San Francisco garter snake from application of labeled rates of permethrin (synthetic pyrethroid, Hoffman et al. 2008). This species does not occur on the Refuge and but these finding suggest other reptiles may incur direct chronic effects. Adulticides (pyrethrins) may adversely affect amphibians (e.g., tadpoles) that occur within seasonal freshwater wetlands of the Refuge (e.g., Cullinan Ranch) (Gunasekara 2005). Best management practices to reduce potential adverse effects of pyrethrin use will include:

- The application of pyrethrins would only occur in rare instances when a risk of serious human disease or death, or high risk to public health has been documented by a public health agency whose jurisdiction includes the Refuge.
- The application of pyrethrins should occur at an ultra-low volume (according to pesticide label instructions and per habitat type).
- The application of pyrethrins should occur where monitoring and surveillance data justify its use (e.g.,

incidence of mosquito-borne disease, exceedance of tolerance limits for adult mosquitoes).

- In a season when a risk of serious human disease or death, or high risk to public health is documented, the application of pyrethrins must be limited to reduce impacts to habitat and wildlife, but sufficient to ensure effective mosquito control.

Alternative B - Non-chemical Mosquito Control. The impacts to reptiles and amphibians of this alternative are the same as those described under Alternative A.

Alternative C - No Mosquito Management. Under this alternative the MADs would not conduct any mosquito monitoring or control on the Refuge. This alternative also includes wetland restoration projects. See Alternative A for a description of potential impacts from wetland restoration projects.

Alternative D – No Action. The impacts to reptiles and amphibians of this alternative are the same as those described under Alternative A, except that this alternative excludes the use of adulticides.

#### **4.2.5 Effects on Fisheries**

Alternative A – Proposed Action. Mosquito monitoring and surveillance activities are not expected to adversely affect fish because these activities do not occur within open sub tidal waters of the Refuge (e.g., sloughs, channels, open bay) and are not expected to adversely affect water quality (e.g., turbidity, dissolved oxygen). The Proposed Action does include the application of larvicides, pupacides and adulticides under certain conditions. Direct effects on fish populations are not expected from proposed larvicides and pupacides (Appendices J, K). However, the application of adulticides has the potential to adversely affect fish populations (Gunasekara 2005). Pyrethroids are considered highly toxic to fish and invertebrates (Appendices K and O).

Pesticide application may result in indirect effects to fish species by reducing their invertebrate prey base. Adverse impacts to invertebrates are expected from pesticide application. However, the application of pesticides on discrete areas of the Refuge is meant to lower mosquito numbers, but not eliminate mosquito populations entirely (or other invertebrate species), ensuring food availability for fish. Also, application of pesticides will occur in site specific locations and will not be applied indiscriminately across the entire Refuge.

Delta smelt, Central California coast steelhead, Chinook salmon, and green sturgeon are special status fish that have the potential to occur on the Refuge. To avoid adverse impacts to these and other fish species the following best management practices would be used:

- Application will be restricted to those specific areas where a pathogen is present and mosquito population thresholds have been exceeded on the Refuge, and where application can be effectively treated while minimizing non-target effects, especially to endangered species.
- If beneficial, the MAD should conduct simultaneous application of larvicides with the adulticide application to prevent future adult outbreaks
- When applying adulticides, the pesticide would be applied according to pesticide label instructions and per habitat type.

This alternative also includes construction of wetland restoration projects to improve tidal circulation. Areas of the Refuge where above average mosquito production occurs also contain swales where water impounds following high tides. These swales do not drain into tidal channels and can entrap fish that forage within tidal marsh during higher tides. We expect that wetland restoration projects aimed at reducing mosquito production will reduce effects related to entrapment and will improve foraging and nursery habitat. Reduced mosquito production would also reduce the need for pesticide application which would also benefit fisheries. As restoration projects are developed, additional project-specific analysis will be completed on the short-term impacts and long-term benefits to fish.

The frequency of conditions that would require use of adulticides on the Refuge has been rare over the past few decades. No requests have been made in over 10 years even with the presence of West Nile virus in the region.

This pattern suggests that future use of adulticides in discrete areas of the Refuge is unlikely, but if occurred, the frequency and scope of application is not likely to cause significant adverse effects to fish and invertebrate populations. Application would only occur in swales and would not be applied to channels, sloughs, or other open water areas. Application would only occur during low tides to avoid potential impacts to fish that may move into the tidal marsh plain during higher high or extreme tides.

Alternative B - Non-chemical Mosquito Control. Mosquito monitoring and surveillance would have no effects on fish as described under Alternative D. Because chemical pesticides are not permitted under this alternative, effects on fish from chemical mosquito control would not occur. Effects on fish populations, including special status species are not expected from approved larvicides (Appendices J, K). This alternative includes wetland restoration projects. Potential impacts of wetland restoration projects are described under Alternative A.

Alternative C - No Mosquito Management. No mosquito monitoring, surveillance, or control would be permitted under this alternative; therefore, there would be no impacts to fish. Wetland restoration projects are part of this alternative and potential impacts are described in Alternative D.

Alternative D – No Action. Mosquito monitoring and surveillance activities would have no effect on fisheries because none of this work would be conducted in the water. No adverse effects on fish, including special status species are expected from the application of approved larvicides and pupicides for mosquito control (Appendices J, K).

#### **4.2.6 Effects on Invertebrates**

Alternative A – Proposed Action. Monitoring and surveillance activities are not expected to adversely affect invertebrate populations. Chemical treatment of mosquito populations on the Refuge has the potential to adversely affect invertebrates and these are described below.

##### Bti (larvicide)

The effect on local populations of invertebrate species over time with periodic and continued use of Bti is unknown but potential for negative effects is a possibility (Appendices J, K). Host range and effect on non-target organisms indicates that Bti is relatively specific to the Nematocera suborder of *Deptera*, in particular filter-feed mosquitoes (*Culicidae*) and blackflies (*Simuliidae*) (Glare and O'Callaghan 1998). Bti is pathogenic to some species of midges (*Chironomidae*) and *Tipulidae*, although to a lesser extent than mosquitoes and biting flies and is not reported to affect a large number of other invertebrate species (Glare and O'Callaghan 1998). Bti concentration is important with regard to effects on non-target organisms. Of particular concern is the potential for Bti to kill midge larvae (family Chironomidae). Chironomid (non-biting midge) larvae are often the most abundant aquatic insect in wetland environments and form a significant portion of the food base for other wildlife (Batzer et al. 1993; Cooper and Anderson 1996; Cox et al. 1998). Reduced invertebrate populations as a result of food web effects (e.g., reduction of nematoceran Diptera) have been shown in studies of Bti (Hershey et al. 1998).

##### Methoprene (larvicide)

Because methoprene is a juvenile hormone (JH) mimic and all insects produce JH, there is concern about potential adverse effects on non-target aquatic insects when this pesticide is used for mosquito control (Appendices K). As with Bti, there is concern regarding potential negative on chironomid larvae due to their importance in food webs. As with any pesticide, toxicity is a factor of dose plus exposure. At mosquito control application rates, methoprene is present in the water at very small concentrations (4-10 ppb, initially). With regard to exposure, chironomid larvae occur primarily in the benthos, either within the sediments and/or within cases constructed of silk and detritus. Thus, there may be differences with regard to exposure to methoprene between chironomid and mosquito larvae, the latter occurring primarily in the water column. The published literature on the effects of methoprene to chironomids is not as extensive as that for Bti. However, there is evidence for potential toxicity to chironomid and other aquatic invertebrates from methoprene treatments. In summary, there is evidence for significant adverse non-target effects from methoprene even when applied at mosquito control rates.

### Monomolecular film (Agnique)

Monomolecular films are potentially lethal to any aquatic insect that lives on the water surface and requires periodic contact with the air-water interface to obtain oxygen (USFWS 2004). The film interferes with larval orientation at the air-water interface and/or increases wetting tracheal structures, thus suffocating the organism. As the film spreads over the water surface, the treatment tends to concentrate the larvae, which may increase mortality from crowding stress (Dale and Hulsman 1990).

### Pyrethrin (adulticide)

Under the Proposed Action, pyrethrin pesticides could be applied when there is high risk of mosquito-borne disease (Section 2.2.1, Phase 5). Pyrethrins are known to cause acute toxicological effects to benthic invertebrates at rates used for mosquito abatement (USEPA 2006). Because pyrethrins are broad-spectrum insecticides, they are potentially lethal to most insects, including both terrestrial and benthic forms. All adulticides are very highly toxic to aquatic invertebrates in low concentrations (e.g., 1 ppb) (Milam et al. 2000). Because most adulticides can be applied over or near water when used for mosquito control, there are risks to aquatic invertebrates from direct deposition and runoff of the pesticides.

In order to minimize adverse effect to invertebrate populations the following will be required.

- The MADs will be required to minimize the use of pesticides and continually investigate formulations and compounds that are least damaging to fish and wildlife populations.
- Each MAD will be required to review the past year's pesticide proposals and submit any changes in the pesticides or formulations of pesticides that they expect to use in the upcoming year. This information should be made available at or before the time of the annual meeting.
- Pesticide will be applied according to pesticide label instructions and per habitat type.
- Application of pesticides will be informed by monitoring of mosquito vector populations and surveillance indicating location of disease prevalence.
- MADs will adapt methods to reduce ecological risk to the environment (e.g., boom height, droplet size, application rate) as new information on ecological risk and avoidance measures are identified by appropriate regulatory agencies.

Under this alternative, we would also plan and implement wetland restoration or enhancement projects to reintroduce or improve tidal circulation. Improved tidal circulation is likely to improve invertebrate communities while reducing above-average mosquito production. Where tidal marsh restoration or enhancement has occurred on the Refuge, the need for mosquito management has been significantly reduced or eliminated.

Studies of invertebrate populations in tidal marsh with poor hydrology (e.g., shallow water impoundments) that require mosquito management have not been conducted. Available data on wildlife suggest these areas of the Refuge provide poor habitat for a variety of species. Poor habitat conditions could also exist for invertebrate communities, leading to depressed or absent higher order predators (e.g., birds, small mammals). Although some studies have shown direct and indirect effects of pesticides little is unknown which of two conditions, poor hydrological conditions or repeated pesticide applications, would contribute to depressed invertebrate populations.

Alternative B - Non-chemical Mosquito Control. There would be no adverse impacts to invertebrates from continued mosquito monitoring and surveillance activities. Under this alternative we would allow the application of Bti which is a non-chemical pesticide. Use of Bti may have a negative effect on invertebrate population as described under Alternative A. This alternative also includes the construction of wetland restoration projects aimed at restoring tidal circulation. Restoring tidal circulation would reduce the need to apply non-chemical pesticides and may have a positive effect on vertebrate populations

Alternative C - No Mosquito Management. Under this alternative no effects to invertebrates are expected because no pesticides would be applied at the Refuge. Restoration of tidal marsh to reduce mosquito production is likely to benefit other invertebrate populations.

Alternative D –No Action. See Alternative A for mosquito monitoring, surveillance, and application of larvicides and pupacides.

### **4.3 Effects on the Social Environment**

#### **4.3.1 Effects on Cultural and Historic Resources**

Alternative A – Proposed Action. Mosquito monitoring and surveillance activities are not likely to have any adverse effects to cultural resources because these activities are limited to walking and driving on the Refuge and sampling various mosquito production areas. The application of pesticides is also unlikely to have any adverse effect to cultural resources because they target mosquito populations and are applied through targeted spraying.

Wetland restoration projects identified to restore tidal circulation could affect cultural resources. As individual restoration projects are identified, the Service will exercise Section 106 of the NHPA including consultation with the State Historic Preservation Officer (SHPO), in accordance with the programmatic agreement between the SHPO and the Service.

Alternative B - Non-chemical Mosquito Control. See Alternative A.

Alternative C - No Mosquito Management. See Alternative A.

Alternative D - No Action. See Alternative A.

#### **4.3.2 Effects on Human Health and Safety Concerns**

Alternative A –Proposed Action. The primary purpose of mosquito control on the Refuge is to protect human health and safety. There would be no adverse effects on human health and safety from mosquito monitoring and surveillance. Under this alternative, the potential exists for human exposure (i.e., MAD staff, refuge visitors, and refuge staff) to pesticides including adulticides. The need to adjust mosquito control techniques and monitor mosquito populations is expected to progress according to future influxes of mosquito-borne disease and mosquito breeding sites. To minimize the potential effects of human exposure to pesticides on the Refuge, the following best management practices will be implemented:

- Prior to the application of any pesticide, the MAD must identify the treatment locations, treatment schedule, and identify the pesticide to be used. The MAD must provide this information to the Refuge Manager at least 48 hours prior to proposed application.
- The Refuge Manager will post a notice at the Refuge Office and at all visitor parking areas with information on the dates of adulticide application.
- During application of adulticides, the Refuge will be closed to all visitors and Refuge staff in areas where application will occur.

Construction of wetland restoration projects to improve tidal circulation would have no adverse impacts to human health and safety. During construction, public access would not be allowed in the project area. Improving tidal circulation should reduce mosquito populations and improve human health and safety.

Alternative B - Non-chemical Mosquito Control While the control of mosquito larvae and reduction in mosquito breeding sites should reduce the potential for disease outbreaks, the inability to use chemical larvicides and adulticides in the event of a disease outbreak could have an effect on human health and safety. The use of biological/biorational controls and habitat manipulation is designed to prevent the establishment of disease-carrying adult mosquito populations; however, tide and topographic features could combine to create unanticipated conditions that allow the emergence of adult mosquitoes at population levels higher than average. There would be no adverse effects to human health and safety from mosquito monitoring and surveillance activities.

Alternative C - No Mosquito Management. The lack of mosquito control may negatively affect human health and safety of Refuge visitors or surrounding communities. Seasonal wetlands, tidal marsh and dredge pond areas that do not have full tidal exchange may harbor disease vectors that spread to adjacent urban areas.

Alternative D – No Action. The primary purpose of mosquito control on the Refuge is to protect human health and safety. There may be an increased risk to human health and safety concerns as a result of maintaining the current program. Under this alternative, the potential exists for human exposure (MAD staff, Refuge visitors, Refuge staff) to pesticides. Adulticides are not permitted under this alternative. Therefore, human health risks from mosquitoes produced on Refuge lands may increase when mosquito-borne diseases are prevalent and control efforts (larvicides, pupicides) have not effectively reduced mosquito populations. Control of mosquitoes that carry vector borne diseases may benefit human health by reducing the risk of exposure. No adverse effects on human health and safety would result from the continued mosquito monitoring and surveillance program.

### **4.3.3 Effects on Aesthetics**

Alternative A –Proposed Action. Mosquito management activities are not expected to affect the scenery of the Refuge or noise levels at the Refuge. Wetland restoration projects to improve tidal circulation would improve the aesthetic value of the Refuge. There would be no change to the noise environment.

Alternative B - Non-chemical Mosquito Control. See Alternative A.

Alternative C - No Mosquito Management. See Alternative A.

Alternative D – No Action. See Alternative A.

## **4.4 Cumulative Effects**

Alternative A – Proposed Action. This action is likely to have cumulative effects due to the long-term use of ATVs and pesticides. Persistent use of mechanized vehicles such as ARGOS reduces vegetation health and creates shallow ponded areas along access routes. Persistent use of pesticides may depress invertebrate populations and alter food webs. The ultimate land management practice to reduce cumulative effects of mosquito management is to enhance or restore tidal hydrology. These types of actions would reduce mosquito production to “natural” levels and promote a healthy tidal marsh ecosystem. Other best management practices to reduce cumulative effects include:

- ARGO access along tidal channels and sloughs will be prohibited within 30-meters of occupied rail habitat in order to reduce impacts to vegetation used by wildlife (e.g., nesting and escape habitat).
- Limit use of mechanized vehicles within wetlands to contiguous active production areas greater than 100-acres in size, unless coordinated with Refuge staff.
- Limit the number of travel pathways used by mechanized vehicles within wetlands
- Encourage use of aerial pesticide (larvicide and pupicide) application over ground-based application methods.
- To the extent feasible, minimize the use of pesticides and continually investigate formulations and compounds that are least damaging to fish and wildlife populations.
- Apply pesticides according to pesticide label instructions and per habitat type.
- Apply pesticides only to discrete, mosquito producing areas of the Refuge.
- Refuge staff and the MADs will develop and implement measures to reduce the introduction and spread of invasive weeds by mosquito management activities.
- Invasive weeds will be controlled through manual removal and chemical control.

Alternative B - Non-chemical Mosquito Control. See Alternative A.

Alternative C - No Mosquito Management. The cessation of mosquito control on the Refuge may result in an increase the level of mosquito management in areas adjacent to the Refuge.

Alternative D –No Action. See Alternative A.

## **Chapter 5 COMPLIANCE, CONSULTATION, AND COORDINATION WITH OTHERS**

### **Agency Coordination and Public Involvement**

The Plan and EA was prepared with the involvement of local mosquito abatement districts and other agencies including:

- Alameda County Mosquito Abatement District
- Contra Costa Vector Control District
- Marin/Sonoma Mosquito Abatement District
- Napa Mosquito Abatement District
- San Mateo County Mosquito Abatement District
- Santa Clara County Vector Control District
- Solano County Mosquito Abatement District
- California Department of Health Services
- California Mosquito and Vector Control Association
- California Department of Fish and Game
- National Marine Fisheries Service
- California State Lands Commission
- California Coastal Commission
- San Francisco Regional Water Quality Control Board
- San Francisco Bay Conservation and Development Commission

### **Environmental Review and Consultation**

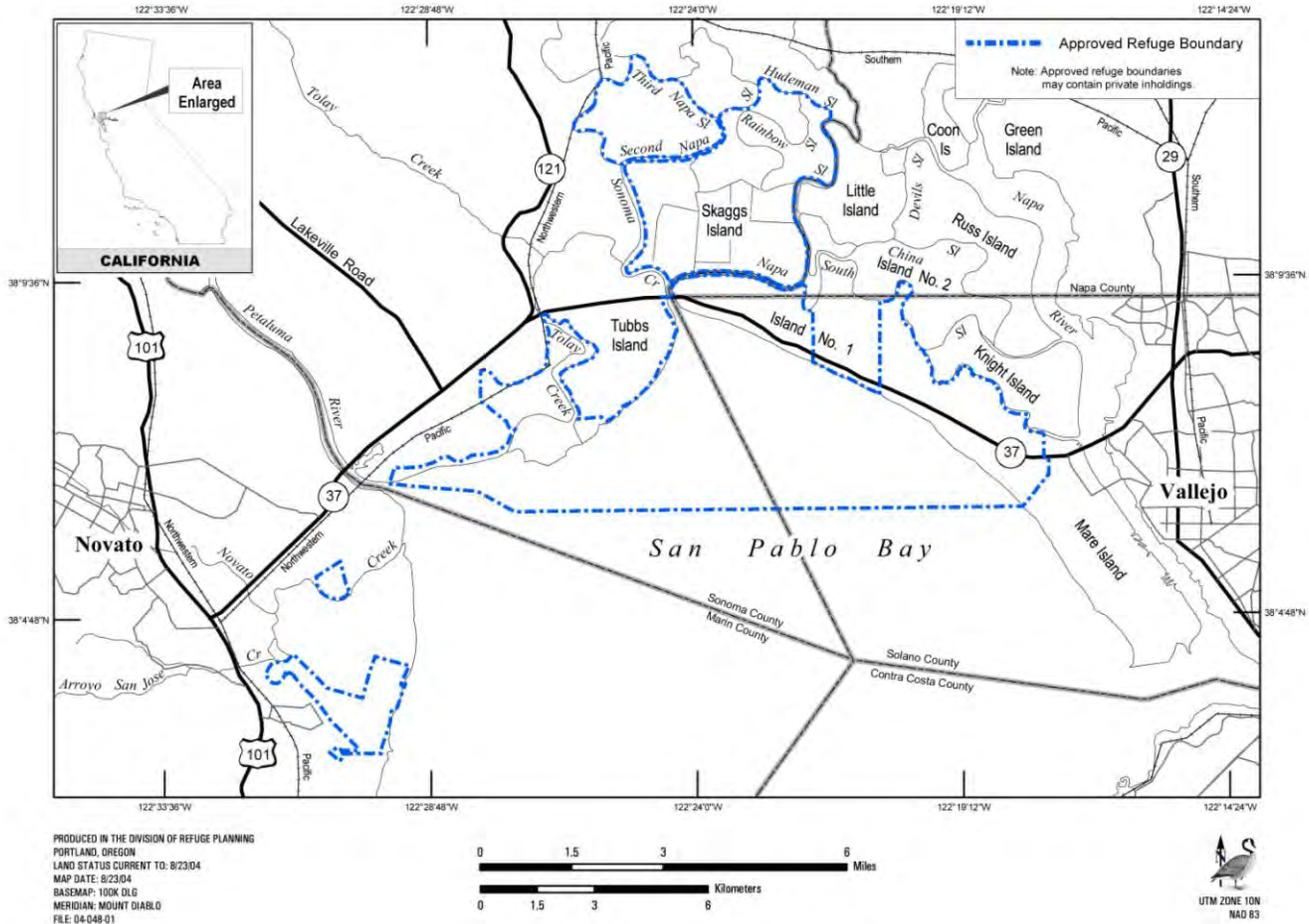
As a federal agency, the Service must comply with provisions of NEPA. An EA was developed to evaluate reasonable alternatives that would meet stated goals and assess the possible environmental, social, and economic impacts on the human environment. This EA serves as the basis for determining whether implementation of the preferred alternative would result in a federal action significantly affecting the quality of the environment. The EA also acts as a vehicle for consultation with other government agencies and interface with the public in the decision-making process.

### **Other Federal Laws, Regulations, and Executive Orders**

In undertaking the preferred alternative, the Service would comply with the following federal laws, Executive Orders (EOs), and legislative acts: Intergovernmental Review of Federal Programs (EO 12372); Archaeological Resources Protection Act of 1979, as amended; Fish and Wildlife Act of 1956; Fish and Wildlife Conservation Act of 1980 (16 USC 661-667e); Fish and Wildlife Improvement Act of 1978; Endangered Species Act of 1973 (16 USC 1531 et seq.); National Environmental Policy Act of 1969; Federal Noxious Weed Act of 1990; Floodplain Management (EO 11988); Protection of Wetlands (11990); National Historic Preservation Act of 1966, as amended; National Wildlife Refuge System Improvement Act of 1997; Antiquities Act of 1906; Protection and Enhancement of the Cultural Environment (EO 11593); Archaeological and Historic Preservation Act of 1974 (PL 93-291; 88 STAT 174; 16 USC 469); Environmental Justice (EO 12898); Management and General Public Use of the National Wildlife Refuge System (EO 12996); Refuge Recreation Act of 1962, as amended; Invasive Species (EO 13112); Migratory Bird Treaty Act of 1918, as amended (MBTA); and Responsibilities of Federal Agencies to Protect Migratory Birds (EO 13186).

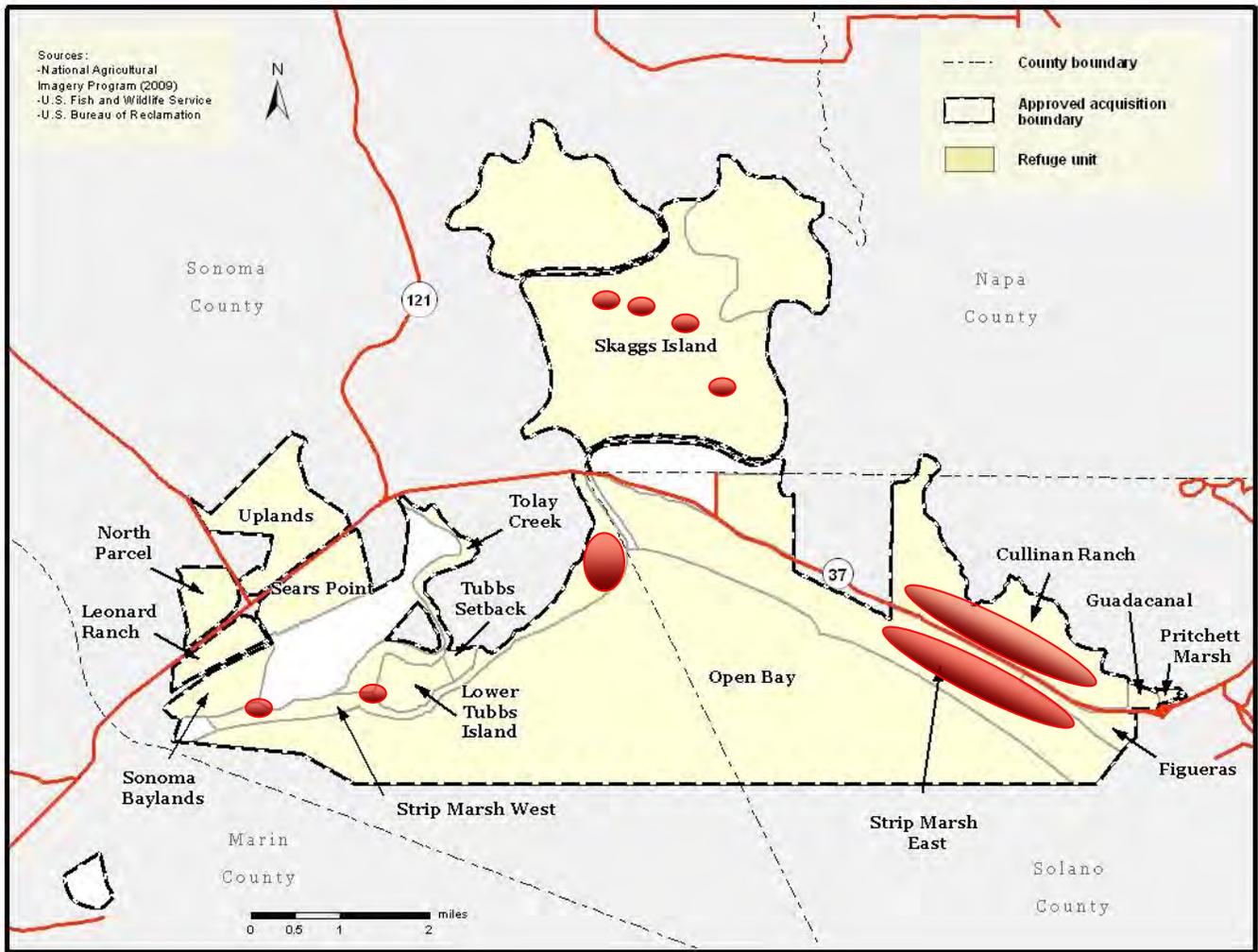
### **Distribution and Availability**

The draft Plan and EA was made available for comment to various agencies, organizations, community groups, and individuals for review and comment. Copies of this EA are available from the San Pablo Bay NWR, 7715 Lakeville Highway, Petaluma, CA, 94954 (phone 707/769 4200), and San Francisco Bay National Wildlife Refuge Complex, 1 Marshlands Road, Fremont, CA, 94536 (phone 510/792 0222).



**Figure 1. Approved Acquisition Boundary<sup>1</sup> of the San Pablo Bay National Wildlife Refuge.**

<sup>1</sup> The approved acquisition boundary for the Refuge is the area within which the Service is authorized to work with willing landowners to acquire and/or manage land. An approved acquisition boundary only designates those lands which the Service has authority to acquire and/or manage through various agreements, based upon planning and environmental compliance processes. Approval of an acquisition boundary does not grant the Service jurisdiction or control over lands within the boundary, and it does not make lands within the acquisition boundary part of the National Wildlife Refuge System. Lands do not become part of the National Wildlife Refuge System unless they are purchased or are placed under an agreement that provides for management as part of the Refuge System.



**Figure 2. Map of San Pablo Bay National Wildlife Refuge showing areas that trigger management by local mosquito abatement districts. Current mosquito production areas of the Refuge are shown as red ellipses. Tidal marsh along the perimeter of Skaggs Island also includes areas that consistently produce mosquito larvae according to the MSMAD.**

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## GLOSSARY

**Action Threshold.** Mosquito population levels that trigger integrated pest management (IPM) actions to manipulate mosquito populations.

**Adulticide.** Killing adult mosquitoes or a pesticide that kills adult mosquitoes.

**Approved Acquisition Boundary.** Area within which the Service is authorized to work with willing landowners to acquire and/or manage land. An approved acquisition boundary only designates those lands which the Service has authority to acquire and/or manage through various agreements, based upon planning and environmental compliance processes. Approval of an acquisition boundary does not grant the Service jurisdiction or control over lands within the boundary, and it does not make lands within the acquisition boundary part of the National Wildlife Refuge System. Lands do not become part of the National Wildlife Refuge System unless they are purchased or are placed under an agreement that provides for management as part of the Refuge System.

**Arbovirus.** Arthropod-borne virus. A viral disease carried and transmitted by mosquitoes or other arthropods.

**Biological Diversity.** The variety of life and its processes, including the variety of living organisms, the genetic differences among them, and communities and ecosystems in which they occur. (See 601 FW 3 for more information on biological diversity.)

**Biological Integrity.** Biotic composition, structure, and functioning at genetic, organism, and community levels comparable with historic conditions, including the natural biological processes that shape genomes, organisms, and communities. (See 601 FW 3 for more information on biological integrity.)

**BMPs.** Best management practices

**CD.** Compatibility Determination

**Competence (mosquito).** The relative ability of a mosquito species to carry and transmit virus.

**CWA.** Clean Water Act (33 U.S.C. 1251-1387)

**CX.** Categorical exclusion.

**EA.** Environmental assessment.

**EAS.** Environmental action statement.

**EIS.** Environmental impact statement.

**Environmental Health.** Composition, structure, and functioning of soil, water, air, and other abiotic features comparable with historic conditions, including the natural abiotic processes that shape the environment. (See 601 FW 3.)

**Enzootic.** A relatively consistent prevalence of disease in animals. The term is comparable to endemic, but refers to animals.

**EPA.** Environmental Protection Agency.

**Epizootic.** An outbreak of disease affecting many animals of one kind at the same time; also, the disease itself

**ES.** Ecological Services Program.

**ESA.** Endangered Species Act (16 U.S.C. 1531-1544).

**Health Threat.** An adverse impact to the health of human, wildlife, or domestic animal populations from mosquito-borne disease identified and documented by Federal, State, and/or local public health authorities. Health threats are locally derived and are based on the presence of endemic or enzootic mosquito-borne diseases, including the historical incidence of disease, and the presence and abundance of vector mosquitoes. Health threat levels are based on current monitoring of vectors and mosquito-borne pathogens.

**Integrated Pest Management (IPM).** A sustainable approach to managing pests by combining biological, cultural, physical, and chemical tools in a way that minimizes economic, health, and environmental risks.

**Larvicide.** Killing mosquito larvae, or a pesticide that kills mosquito larvae.

**MAD:** Mosquito abatement district.

**MAD.** Mosquito Abatement District

**Monitoring (mosquito).** Activities associated with collecting quantitative data to determine mosquito species composition and to estimate relative changes in mosquito population sizes over time.

**Mosquito management.** Any activity designed to inhibit or reduce populations of mosquitoes in the family Culicidae. Activity includes physical, biological, cultural, and chemical means of population control directed against any life stage of mosquitoes.

**Mosquito-borne disease.** An illness produced by a pathogen that mosquitoes transmit to humans and other vertebrates. The major mosquito-borne pathogens presently known to occur in the United States that are capable of producing human illness are the viruses causing eastern equine encephalitis, western equine encephalitis, St. Louis encephalitis, West Nile encephalitis/fever, LaCrosse encephalitis, and dengue, as well as the protozoans causing malaria.

**NEPA.** National Environmental Policy Act (42 U.S.C. 4321-4347).

**NMFS.** National Marine Fisheries Service.

**NOI.** Notice of Intent.

**Nontarget Organisms.** Species or communities other than those designated for population control.

**NPDES.** National Pollutant Discharge Elimination System established by section 402 of the

**NWRS.** National Wildlife Refuge System.

**Public Health Authority.** A Federal, State, and/or local agency that has health experts with training and expertise in mosquitoes and mosquito-borne diseases and that has the official capacity to identify health threats and determine health emergencies.

**PUP.** Pesticide Use Proposal.

**Pupacide.** A pesticide that kills the pupal stage of mosquitoes.

**PUR.** Pesticide Use Proposal.

**Refuge-Based Mosquitoes.** Mosquitoes that are produced within, or occur on, a refuge.

**Reservoir Host.** A species in which a pathogen is maintained over time. Reservoir hosts are capable of transferring the pathogen to a vector.

**Service.** United States Fish and Wildlife Service

**Service-Authorized Agent.** A contractor, cooperating agency, cooperating association, refuge support group, volunteer, or other party working on a refuge on behalf of the Service to help achieve the refuge purpose(s) or NWRS mission.

**SLEV.** Saint Louis encephalitis virus

**Surveillance (mosquito-borne disease).** Activities associated with detecting pathogens causing mosquito-borne diseases, such as testing adult mosquitoes for pathogens or testing reservoir hosts for pathogens or antibodies.

**ULV.** Ultra-low volume.

**Vector.** An organism, such as an insect or tick, that is capable of acquiring and transmitting a disease-causing agent, or pathogen, from one vertebrate host to another, or the act of transmitting a pathogen in such a manner.

**Viremia.** Level of virus in the blood.

**WEEV.** Western equine encephalomyelitis virus

**WNV.** West Nile Virus.