3.10 Public Health and Vector Management

3.10.1 Physical Setting

Methodology

An extensive body of literature exists on the mosquitoes associated with the tidal and seasonal wetlands of the South San Francisco Bay region, as summarized by Bohart and Washino (1978), Durso (1996), and Maffei (2000d; 2000e; 2000f; 2000g; 2000h). These and other resources, including personal communications with vector control specialists in the South Bay, were reviewed to develop these sections.

Regional Setting

An extensive body of literature exists on the mosquitoes associated with the tidal and seasonal wetlands of the South San Francisco Bay region (which includes the SBSP Restoration Project Area), as summarized by Bohart and Washino (1978), Durso (1996), and Maffei (2000d; 2000e; 2000f; 2000g; 2000h). More than 20 species of mosquitoes occur in the San Francisco Bay Area, but five species, the summer salt marsh mosquito (*Aedes dorsalis*), winter salt marsh mosquito (*Aedes squamiger*), Washino's mosquito (*Aedes washinoi*), western encephalitis mosquito (*Culex tarsalis*), and winter marsh mosquito (*Culiseta inornata*), are routinely controlled by the mosquito and vector control agencies within each of the counties of South San Francisco Bay. Within the SBSP Restoration Project Area, the Alameda County Mosquito Abatement District, Santa Clara Vector Control District, and San Mateo County Mosquito Abatement District are responsible for managing the populations of mosquitoes for their respective communities.

The ecology of these mosquitoes, including preferred habitats, salinity tolerances, reproductive rates, flight characteristics, adult hosts and vector/nuisance potential were summarized in detail for the Goals Project's Baylands Ecosystem Species and Community Profiles (Maffei 2000d; 2000e; 2000f; 2000g; 2000h). Adult females feed on blood, the hosts varying depending on the species but include mammals, birds, reptiles, and amphibians. Adult males feed on plant juices, while larvae generally feed on particulate matter, unicellular algae, and other microorganisms. Larvae serve as prey for a variety of aquatic organisms, shorebirds, and waterfowl, and adults may be eaten by other insects and birds such as swallows. The rate of larval development is often a function of water temperature and food availability. Larval survivorship is typically low, with most losses attributable to predation.

Within the San Francisco Bay Area, the summer salt marsh mosquito occurs primarily in "temporarily flooded tidal marsh pannes, heavily vegetated ditches and brackish seasonal wetlands," while adults occur in open habitats such as grasslands, salt marsh, and woodland edges (Maffei 2000d). The summer salt marsh mosquito lays its eggs on mud at the edges of tidal pools or brackish seasonal wetlands, with larvae often occupying the same pools occupied by the tidal pool brine fly (*Ephydra millbrae*) and reticulate water boatman (*Trichocorixa reticulata*) (Maffei 2000d). Eggs may hatch in the spring, but they can remain viable for years, and subsequent hatching can occur when the larval habitat is re-flooded. Although survivorship may be highest in water having a salinity near seawater (Washino and Jensen 1990), larvae have successfully completed development at the Great Salt Lake in water with salinities as high as 120 ppt (Rees and Nielsen 1947). Adults are highly mobile, aggressive, day-biting mosquitoes that may be able to disperse more than 30 miles (Rees and Nielsen 1947).

The winter salt marsh mosquito occurs along the Pacific Coast from Sonoma County south to Baja California, including much of the area around the immediate South and North San Francisco Bays (Maffei 2000h). Tidal and diked pickleweed marshes with salt marsh pools diluted by rains provide the preferred habitat of this species. This species has not been found in freshwater marshes, instead occurring in brackish and salt marshes having salt concentrations from 1.2 to 35 ppt, with optimal conditions for larval development at salinities of 5 to 15 ppt. Egg-laying occurs in spring on plants and on mud close to the edges of marsh pools. The eggs lie dormant until fall rains inundate them, although hatching as early as late September has been noted due to water diversion into a marsh. Some eggs do not hatch until later re-floodings. Most adults emerge from salt marsh pools in late February and March and disperse widely into surrounding areas, sometimes dispersing as far as 15 miles or more from larval areas. Feeding occurs from March through June, with biting occurring during daytime and early dusk.

Washino's mosquito occurs from Oregon south to Santa Barbara, California, including the entire San Francisco Bay Area (Maffei 2000e). In the Bay Area, shallow pools and fresh to slightly brackish sites in uplands near salt marshes or in riparian areas, often dominated by willow, cottonwood, or blackberry, provide this species' preferred habitat. Females deposit eggs in mud along the receding water line of larval habitat. The eggs hatch when these pools are reflooded the following winter. Adults emerge from the larval depressions in late winter and early spring, and are present into June. Females are day-biting mosquitoes, and may travel up to 1.5 miles from their larval habitat along artificial canals (Maffei 2000e).

The western encephalitis mosquito is widespread in a variety of habitats and locations in western North America, with larvae occurring in most freshwater habitats (Maffei 2000f). Typical larval habitat includes poorly drained fields and pastures, rice fields, marshes, ponds, and seeps, although most artificial waterbodies in urban areas provide potential habitat for this species as well. The species has been found to occur in salt marsh pools with salt concentrations up to 10 ppt (Telford 1958). Adults may be present year-round but enter facultative diapause (period of physiological dormancy) in winter. Females lay eggs in groups directly into the water. Adult females usually feed at night. This species seems to be able to disperse readily with wind, and dispersal distances of 20 to 25 miles are suspected for some Sacramento Valley populations (Bailey and others 1965). The western encephalitis mosquito is the main vector of western equine encephalitis and St. Louis encephalitis in most of the western United States (Maffei 2000f), and is a vector of avian malaria.

The winter marsh mosquito occurs in a wide range of habitats throughout much of western North America. Larval habitat includes a variety of pools, ponds, marshes, and other water bodies, in salinities ranging from 8 to 26 ppt (Maffei 2000g; Telford 1958). Adults are present from fall through spring, entering facultative diapause in summer. Females lay groups of eggs directly on the water. San Francisco Bay populations tend to remain within two miles of their larval source, although dispersal up to 14 miles is known (Clarke 1943). Larvae of the summer salt marsh mosquito, winter salt marsh mosquito, and winter marsh mosquito are often found in the same locations (Maffei 2000h).

Project Setting

Mosquito species occurring in the major habitats in the SBSP Restoration Project Area are listed in Table 3.10-1.

Table 3.10-1 Mosquito Species Found in Marsh Habitats in the SBSP Restoration Project Area

HABITAT	MOSQUITO SPECIES
Open salt pond with vigorous wave action	none
Fully tidal salt marsh: Higher ground with pools or borrow channels that do not flush	*Aedes squamiger* (winter), *Aedes melanimon* (fall), *Aedes dorsalis* (summer), *Aedes taeniorhynchus* (summer), *Culiseta inornata* (winter)
Muted tidal salt marsh: Pools and channels that do not flush vigorously	*Aedes squamiger* (winter), *Aedes melanimon* (fall), *Aedes dorsalis* (summer), *Aedes taeniorhynchus* (summer), *Culiseta inornata* (winter)
Seasonal wetland: Brackish to nearly fresh water pools with vegetated margins	*Aedes squamiger* (winter), *Aedes melanimon* (fall), *Aedes dorsalis* (summer), *Aedes taeniorhynchus* (summer), *Aedes washinoi* (winter fresh water), *Culex tarsalis* (spring, summer), *Culex erythrothorax* (summer in tules), *Culex pipiens* (foul fresh water), *Culiseta incidens* (spring, fall fresh water), *Culiseta inornata* (winter)
Vernal pools, upland fresh water marsh	*Aedes washinoi* (winter), *Culex tarsalis* (spring, summer), *Culex erythrothorax* (summer in tules), *Culex pipiens* (foul fresh water), *Culiseta incidens* (spring, fall fresh water), *Culiseta inornata* (winter)

Marshes that lack vigorous tidal flow can provide suitable mosquito breeding habitat. Salt marshes at the southern end of San Francisco Bay produce a single seasonal brood of the winter salt marsh mosquito and multiple broods of the summer salt marsh mosquito each season. Because both of these mosquito species can fly considerable distances and are aggressive biters, control of mosquitoes at the source (*i.e.*, in salt marshes) is necessary to reduce the inconvenience to humans in the South Bay.

Detailed records are maintained by the local mosquito and vector control districts concerning major mosquito breeding areas, population densities, and control techniques and materials. In Santa Clara County, areas with known or potential mosquito problems include Coyote Reach 1A, New Chicago Marsh, Sunnyvale Baylands Park, the Moffett Federal Airfield Flood Control Basin, Mountain View Demonstration Marsh, the Palo Alto Flood Basin (Palo Alto Baylands Park), the Zanker Landfill Marsh, Dow-Corning Marsh, Alviso Marshes, ITT Marsh (near the Palo Alto Water Quality Control Plant), the Palo Alto Municipal Airport, and the Palo Alto Municipal Golf Course (Strickman 2005). In San Mateo County, Bair Island produces large numbers of mosquitoes. In the Alameda County portion of the SBSP Restoration Project Area, south of the San Mateo Bridge, sites that can produce large numbers of mosquitoes if not treated include the Perry Duck Club, Alameda Creek Marshes, Union City Marshes, Coyote Hills Marshes, Mayhew's Landing, and the upper ends of major sloughs (Mowry, Newark, Plummer, Albrae, and Mud Sloughs). Fully tidal marshes such as Hook Island (Palo Alto), Triangle Marsh (Coyote Creek), and Greco Island, do not produce significant numbers of mosquitoes.

Mosquito control techniques employed by these agencies emphasize minimization and disruption of suitable habitat, and control of larvae through chemical and biological means, as opposed to spraying of adults. Control techniques most often include source reduction, source prevention, larviciding, use of mosquito fish (*Gambusia affinis*) as larval predators, and monitoring of mosquito populations and vector-borne diseases (Alameda County Mosquito Abatement District 1999). Larvicides employed by the San Mateo County Mosquito Abatement District include "Golden Bear 11 11" (a short-lived petroleum distillate that is applied to the surface of the water and causes mosquito larvae to drown), methoprene (a juvenile growth hormone that specifically targets mosquito larvae and prevents their maturation), *Bacillus thuringensis israelis* (a bacteria that is toxic to mosquito larvae), and *Bacillus sphaericus* spores and toxin (for *Culex* species) (http://www.smcmad.org/preventative_approach.htm).

In salt marshes, attempts to control mosquito populations by ditching have resulted in marsh degradation. Ditching is not necessary to reduce mosquito populations in tidal marshes. Rather, functional tidal marshes do not provide high-quality habitat for the most troublesome mosquito species in the Bay Area, and maintenance and restoration of natural tidal flushing in these marshes is effective at limiting mosquito populations while sustaining the natural hydrology of the marsh (San Francisco Bay Joint Venture 2004).

Mosquitoes serve as vectors for several diseases that pose health concerns for humans and domestic animals. The western encephalitis mosquito is a vector of avian malaria and the main vector of western equine encephalitis and St. Louis encephalitis in the western United States (Maffei 2000f). Anopheles mosquitoes carry the organism that causes malaria. The West Nile virus is a mosquito-borne disease that has been found in parts of Asia, Eastern Europe, Africa and the Middle East. First detected in the US in 1999 in New York City, West Nile virus has since spread through most of the US. West Nile Virus is typically spread from an infected mosquito, usually in the genus *Culex*, to a bird that then disperses or migrates, spreading the virus after being bitten by other mosquitoes. Most people and domestic animals that become infected with the virus have few or no symptoms, but in rare cases they can become seriously ill. As of December 22, 2004, 819 human infections from 23 counties in California had been detected in 2004, with 25 West Nile virus-related fatalities to date in California, in Los Angeles, Riverside, Kern, Orange, San Bernardino and Tehama counties (http://westnile.ca.gov/latest_activity.htm). In 2004, 536 infections of horses from 32 counties in California were reported, along with 3,218 dead birds that tested positive for the virus (most of which were corvids).

Please refer to Section 3.6.1 in Section 3.6, Biological Resources, for a detailed description of the habitats present in the specific SBSP Restoration Project Area.

3.10.2 Regulatory Setting

The Project would coordinate closely with the local municipalities and vector management districts, including the Santa Clara County Vector Control District, Alameda County Mosquito Abatement District, and San Mateo County Mosquito Abatement District. Any mosquito management that occurs within the Refuge will be consistent with the Refuge Mosquito and Mosquito-Borne Disease Management Policy (draft October 2007).

3.10.3 Environmental Impacts and Mitigation Measures

Overview

Thresholds of significance for potential Project impacts to public health and vector management follow. The rationale for all of the potential impacts as they relate to the significance criteria can be found in the Program-Level Evaluation section.

Significance Criteria

The threshold of significance is defined as a substantial increase in the need for vector management activities in the SBSP Restoration Project Area, as a result of Project activities.

As explained in Section 3.1.2, while both CEQ Regulations for Implementing NEPA and the CEQA Guidelines were considered during the impact analysis, impacts identified in this EIS/R are characterized using CEQA terminology. Please refer to Section 3.1.2 for a description of the terminology used to explain the severity of the impacts.

Program-Level Evaluation

SBSP Long-Term Alternatives

SBSP Impact 3.10-1: **Potential increase in mosquito populations.**

An increase in vegetated wetlands could potentially result in increased mosquito populations, if these wetlands do not drain properly. However, well drained tidal wetlands are not expected to host large mosquito populations, and restoration of tidal wetlands possessing extensive channel networks may not increase mosquito numbers substantially. The tidal restoration that would occur under Alternatives B and C would target the restoration of large, well-drained marshes. Restoration techniques such as breaching pond levees in the locations of remnant sloughs and blocking borrow ditches would be implemented to facilitate the development of well-drained marshes.

In contrast, diked, vegetated seasonal wetlands, such as those expected to develop in some of the ponds under the No Project alternative, typically support high mosquito densities in the South Bay, requiring intensive vector control efforts. Such seasonal wetlands are expected to develop within ponds that are no longer managed, under Alternative A, the No Action Alternative.

Although well drained tidal marshes are not expected to increase mosquito production, marsh ponds and pannes that are vegetated may support mosquitoes. In addition, upland transition zones that would be created along the upper edges of restored marshes under Alternatives B and C could potentially provide pools that may support mosquitoes. As a result, there is some uncertainty regarding potential effects of the SBSP Restoration Project on the need for vector control. Monitoring and adaptive management would be implemented to detect increases in mosquito numbers, and address any deficiencies in Project design resulting in increases in numbers before this impact reaches the threshold of significance.

Alternative A No Action. Under the No Action Alternative, Ponds E1C, E2C, E4C, and E5C in the Eden Landing pond complex would likely be managed as seasonal wetlands. These ponds would eventually become vegetated, providing suitable conditions for mosquito breeding. Ponds E10, E11, E8, E6A, and E6B are expected to remain as managed ponds for the 50-year planning horizon, but the remaining ponds at Eden Landing would not be managed, and eventually most of these ponds are likely to become tidal due to the expected failure of unmaintained levees. Most ponds within the Ravenswood and Alviso pond complexes are likely to be maintained under the No Action Alternative, although in the Alviso pond complex, the levees around Ponds A5, A6, and A7 would likely not be maintained, eventually resulting in the breaching of levees and development of tidal marsh. The wetlands that would develop within these unintentionally breached ponds may not drain as well as those that would be restored intentionally under Alternatives B and C, as borrow ditches may capture tidal flow, and remnant sloughs that do not drain well may form marsh ponds that provide suitable conditions for mosquito breeding. As a result, mosquito densities are expected to increase, relative to existing conditions, under the No Action Alternative.

Alternative A Level of Significance: Potentially Significant

Alternative B Managed Pond Emphasis. Under Alternative B, approximately 50 percent of the SBSP Restoration Project Area would be managed as shallow pond habitat for birds, with 50 percent restored to tidal habitats. Shallow pond habitat would decline from existing conditions under this alternative, but the magnitude of this decline would be less than that under the No Action Alternative. Alternative B would not result in any vegetated seasonal wetlands such as those likely to develop under Alternative A. In addition, planned tidal restoration would likely result in more extensive channel networks and better-drained tidal marsh than would develop in ponds breached unintentionally under the No Action Alternative. Although upland transition zones created along the upper edges of restored marshes under Alternative B could potentially provide pools that may support mosquitoes, these pools would be in locations along the upland edge where mosquito control can be easily conducted if necessary. Therefore, Alternative B is far superior to Alternative A in terms of potential increases in mosquito abundance.

There is some uncertainty as to whether the marsh ponds that are expected to develop in some restored marshes and pools in upland transition habitat under Alternative B would provide mosquito breeding habitat, thereby increasing mosquito abundance. Therefore, the Adaptive Management Plan would be used to monitor changes in mosquito abundance to ensure that impacts do not exceed the threshold of significance.

Alternative B Level of Significance: Less than Significant

Alternative C Tidal Habitat Emphasis. Under Alternative C, less shallow water pond habitat would be maintained than under Alternative B, as 90 percent of the SBSP Restoration Project Area would be restored to tidal inundation. Well drained tidal wetlands are not expected to host large mosquito populations. Broad upland transition zones may provide shallow depressions for breeding and could make access difficult for management. However, Alternative C would not result in any vegetated seasonal wetlands such as those likely to develop under Alternative A, and would provide more tidal areas than Alternative B. Local vector control agencies have indicated that they would prefer to see more tidal restoration to any sort of pond management.

Alternative C Level of Significance: Less than Significant

Adaptive Management Plan. Monitoring of vector issues as part of the Adaptive Management Plan provide a mechanism by which the Project can offset any potential long-term impacts.

Determination of Baseline and Monitoring. Local vector control agencies have monitoring protocols in place to pinpoint problem areas for vector management. Additional monitoring would also be employed. The combined monitoring program would consist of the following elements:

- Presence/absence of mosquitoes in former salt ponds;
- Number of acres of potential breeding habitat for mosquitoes;
- Number larvae/dip in potential breeding habitat;
- Number of acres treated for mosquitoes; and
- Costs/level of effort (*e.g.*, hours spent in treatment, amount of material applied and helicopter cost) to control mosquitoes.

Adaptive Management Triggers. Once a baseline is established and restoration activities commence, ongoing monitoring of vector management activities would be used to detect changes in numbers of mosquito complaints and level of effort to treat any new habitat areas. “Triggers” would be established to signal Project impacts that are approaching the threshold of significance, well before they reach that threshold. Three “triggers” would be used to determine whether the SBSP Restoration Project is having, or could have, potentially adverse effects:

- Detection of breeding mosquitoes in a former salt pond;
- Detectable increase in monitoring parameters (relative to the baseline), particularly in areas with human activity/exposure; and
- Detection of mosquitoes that are known disease vectors and/or are of particular concern (*i.e.*, *Aedes squamiger*, *A. dorsalis*) in the Project Area.

Adaptive Management. If monitoring results signal a “trigger,” the first step in adaptive management would be to determine whether a change in numbers has truly occurred, and whether this change is likely a result of the SBSP Restoration Project. If the change is attributable to the SBSP Restoration Project, design adjustments would be recommended. These could include construction activities to enhance drainage or tidal flushing, active vegetation control in ponded areas, or improving access into problem areas to facilitate control activities. An increase in the level of vector control activities would only be implemented as an interim measure to avoid significant impacts while design modifications are being implemented to reduce mosquito breeding habitat. As mentioned previously, any mosquito management that occurs within the Refuge will be consistent with the Refuge Mosquito and Mosquito-Borne Disease Management Policy (draft October 2007).

Project-Level Evaluation

Phase 1 Impact 3.10-1: **Potential increase in mosquito populations.**

Potential impacts to Vector Management are addressed in detail above. Here, project-level impacts of the implementation of Phase 1 of the SBSP Restoration Project as well as the No Action are assessed. Phase 1 actions are described in Section 2.5 of this EIS/R. Project-level effects are addressed for each of the three major restoration areas: Eden Landing, Alviso, and Ravenswood.

Phase 1 No Action

The following discussion addresses the No Action Alternative (Alternative A) at the project level.

Eden Landing. Under the No Action Alternative, Eden Landing Ponds E8A, E8X, E9, E12, and E13 would not be managed, and eventually most or all of these ponds are likely to become tidal due to the expected failure over time of unmaintained levees. These ponds would become seasonal wetlands, and at least in the short term, would likely become vegetated. Such vegetated seasonal wetlands would provide potentially high-quality mosquito breeding habitat. In the long term, most or all of these ponds are likely to become tidal due to the expected failure of unmaintained levees. The wetlands that would develop within these unintentionally breached ponds under the No Action Alternative may not drain as well as those that would be restored intentionally under the proposed Phase 1 actions, as borrow ditches may capture tidal flow, and remnant sloughs that do not drain well may form marsh ponds that provide suitable conditions for mosquito breeding. As a result, mosquito densities in these ponds are expected to increase, relative to existing conditions, under the No Action Alternative.

Eden Landing Phase 1 No Action Level of Significance: Potentially Significant

Alviso. Under the No Action Alternative, Pond A6 would continue to be operated as a seasonal pond in the short term, and would likely become vegetated. Vegetated seasonal wetlands would provide potentially high-quality mosquito breeding habitat. The bayfront levee around Pond A6 is actively eroding and would likely not be maintained, eventually resulting in the unplanned breaching of levees and development of open Bay and intertidal mudflat habitat in A6; such habitat would not be expected to provide mosquito breeding habitat. Continued management of Ponds A8 and A16 would likely not change the quality of mosquito breeding habitat (which is negligible) appreciably, compared to existing conditions.

Alviso Phase 1 No Action Level of Significance: Less than Significant

Ravenswood. Under the No Action Alternative, SF2 would continue to be managed much as it is currently. Continued management of Pond SF2 would likely not change the quality of mosquito breeding habitat (which is negligible) appreciably, compared to existing conditions.

Ravenswood Phase 1 No Action Level of Significance: Less than Significant

Phase 1 Actions

The following discussion addresses the Phase 1 actions (the first phase of Alternatives B and C) at the project level.

Eden Landing. Phase 1 actions at Eden Landing would include the conversion of Ponds E8A, E8X, and E9 to full tidal action, and conversion of Ponds E12 and E13 to a series of ponds with a range of salinities.

Ponds E8A, E8X and E9. Currently, E8A and E8X are dry during summer, and contain shallow water during winter. Pond E9 has some shallow water habitat during summer and deep water habitat during winter. Phase 1 actions would result in an increase in tidal flushing for Ponds E8X, E8A, and E9 resulting in the development of tidal salt marsh. Although this new salt marsh could increase the potential for the presence of salt marsh mosquito species, as outlined in Table 3.10-1, well-drained tidal marshes typically do not provide high-quality habitat for the most troublesome mosquito species in the Bay Area, and maintenance and restoration of natural tidal flushing in these marshes is effective at limiting mosquito populations while sustaining the natural hydrology of the marsh."

Ponds E12 and 13. Ponds E12 and 13 would be managed as shallow-water habitat for foraging shorebirds. Vegetation management would occur and the existing large fetch would be maintained with the exception of low berms added to control water movement. Therefore, there would be no anticipated change in the amount of potential breeding habitat.

Alviso. Phase 1 actions at Alviso would include opening of Ponds A8 and A6 to tidal action, and management of Pond A16 as a shallow pond for shorebirds.

Pond A6. Currently, Pond A6 is managed as a seasonal pond, being allowed to dry during the summer, and contains shallow water during winter. Phase 1 actions would result in an increase in tidal flushing for Pond A6 resulting in the development of tidal salt marsh. This would likely result in an overall decrease in potential breeding habitat, but could increase the potential for the presence salt marsh mosquito species as outlined in Table 3.10-1.

Pond A8. Opening Pond A8 to muted tidal action would result in deeper water in this pond, as well as in Ponds A5 and A7, through which water would flow to reach Pond A8. Deeper water with more frequent tidal exchange would result in a net decrease in the amount of potential breeding habitat in these ponds.

Pond A16. Pond A16 would be managed as shallow-water habitat for foraging shorebirds. Vegetation management would occur on the created islands and a large fetch would be maintained with the exception of low berms added to control water movement and numerous nesting islands. However, there would be a slight increase in the amount potential breeding habitat.

Ravenswood. Currently, Pond SF2 is managed as a seasonal pond, being allowed to dry during the summer, and contains shallow water during winter. Under Phase 1, Pond SF2 would be managed as shallow-water habitat for foraging shorebirds with frequent water flow-through. A large fetch would be maintained with the exception of low berms added to control water movement and numerous nesting islands. Vegetation management would occur on the created islands. The change in water management would result a slight decrease in the amount potential breeding habitat.

Phase 1 Actions Level of Significance: Less than Significant