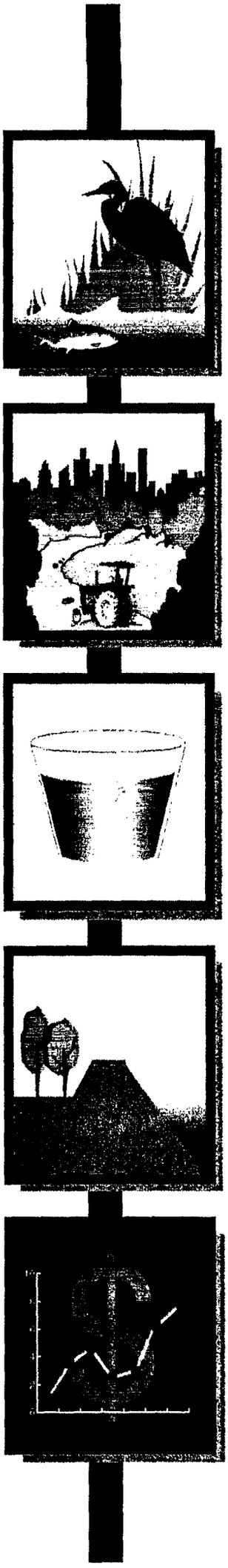

CALFED
BAY-DELTA
PROGRAM

Affected Environment and Environmental Impacts

Public Health & Environmental Hazards

Draft Technical Report
September 1997

CALFED/706

Introduction

The purpose of this report is to describe the affected environment associated with selected public health concerns in support of the continuing CALFED Bay-Delta Program planning efforts and environmental documentation process. This report will be used with other information to develop the affected environment portion of the CALFED Programmatic Environmental Impact Report/Environmental Impact Statement (EIR/EIS).

The geographical focus of this report is the CALFED study area, which consists of five separate regions: the Delta Region, the Bay Region, the Sacramento River Region, the San Joaquin Region, and the State Water Project and Central Valley Project Service Areas Outside the Central Valley Delta region. This document is consistent with the goals of CALFED, the California Environmental Quality Act (CEQA), and the National Environmental Policy Act (NEPA) and reflects a level of detail appropriate for a programmatic approach to environmental review.

This report describes current disease-vector production levels; disease transmission by mosquito, tick, and wildlife vectors; and mosquito abatement efforts in the Bay-Delta region (Delta region). It also addresses known hazardous waste sites. This information will be used to assess impacts in the Delta region associated with implementation of CALFED. Implementation of CALFED actions could affect mosquito production levels by changing the area of available breeding habitat (e.g., land use changes, restoration of wetland habitats) or could affect people's exposure to hazardous wastes through construction activities in known hazardous waste locations.

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II. Summary of Affected Environment

The emphasis of this technical report is on mosquito habitats that support the mosquito species that carry human diseases, specifically encephalitis and malaria, because these species have the greatest potential impact on public health in the study area.

The information presented in this section is common to all CALFED regions.

2.1 Regulatory Context

Mosquito abatement districts (MADs) are legal governmental organizations formed at the local level that are responsible for controlling specific disease vectors within their jurisdiction. MADs receive most of their revenue from property taxes. MADs were originally formed to and are primarily responsible for controlling mosquitoes as pest species and as disease vectors (Kramer and Lucchesi pers. comms.).

California law requires that if a problem source of mosquito production exists as a result of human-made conditions, the party responsible for those conditions is liable for the cost of abatement. The law is enforced at the discretion of the responsible MAD (CAL Health & Safety Sec. 2200 et seq.).

MADs do not have jurisdiction on state and federal lands; however, on state and federal wildlife refuges, MADs work with refuge managers through water and habitat management to eliminate potential disease and annoyance threats before they occur. DHS provides disease vector monitoring and control for those areas that are not incorporated into MADs or where the MAD does not have the capabilities to control a specific disease vector.

2.2 Mosquito-borne Diseases

Diseases carried by mosquitoes that are of particular concern to humans are known as arboviruses. At least 18 arboviruses of particular concern to humans exist in California (Reeves, 1990). Western Equine Encephalomyelitis and St. Louis Encephalomyelitis are mosquito-borne arboviruses of historical concern. Neither virus is usually reported unless patients develop acute symptoms; therefore, the prevalence of both viruses is significantly under-reported. These two arboviruses are described in the following paragraphs.

Malaria is caused by a parasite and may be transmitted by mosquitoes; it is discussed below. A short discussion of Dog Heartworm, which is transmitted by mosquitoes, is also provided.

Western Equine Encephalomyelitis

Since the 1960s, epidemics of Western Equine Encephalomyelitis in California have been rare (SYMVCD, 1992a). The number of reported encephalitis cases (Western Equine and St. Louis) has generally trended downward between 1970 and 1992; in 1970 there were 380 cases, and in 1992 there were 116 cases (DHS, 1994). Exceptions to this downward trend occurred in 1973, 1976, 1980, 1982, 1984, and 1990. No deaths in California have been attributed to encephalitis since 1962.

The number of cases of the disease varies by season. Illnesses associated with the virus usually begin in May, peak in July or August, and cease in November.

Western Equine Encephalomyelitis in

humans is a combination of inflammation of the brain (encephalitis) and the spinal cord (myelitis). It is commonly called sleeping sickness. In California, transmission of the virus primarily involves two mosquito species (*Culex tarsalis* and *Aedes melanimon*); wild birds such as house finches, sparrows, Brewer's blackbird, red-winged blackbird, mourning doves, and ring-necked pheasants; domestic birds such as chickens; jackrabbits; and occasionally rodents, horses, and humans. These birds and animals (including humans) act as hosts of Western Equine Encephalomyelitis. Mosquitoes can transmit the disease from these hosts to other birds, animals, and humans.

The infection can be mild, acute, or fatal (SYMVCD, 1989b). Most of the infections are mild, with less than 1 percent of those individuals infected becoming ill, and an even smaller percentage developing acute symptoms or dying from the disease. Although all age groups are susceptible to this disease, children under 10 are most likely to become ill. About 20 to 30 percent of the Western Equine Encephalomyelitis cases are found in children under one year of age, with infants under three months the most severely affected.

If the infection develops into encephalitis, the disease can result in recovery, permanent abnormalities, or death. Most patients recover; however, depending on age, some may suffer abnormalities such as recurring headache, memory impairment, tremors, sleeplessness, and sensory-motor or speech disturbances. Approximately 2.5 to 10 percent of the cases that produce encephalitis are fatal (SYMVCD, 1992a).

St. Louis Encephalomyelitis

As discussed above, the number of reported encephalitis cases has generally trended downward since 1970. However, a resurgance in St. Louise Encephaolomyelitis occurred in the middle and late 1980s. The seasonality of the St. Louis Encephalomyelitis virus in California is May through November, with 80 percent of the cases reported between August and September (SYMVCD, 1992b).

St. Louis Encephalomyelitis in humans is caused by another mosquito-borne arbovirus that attacks brain tissue (SYMVCD, 1992b). It can be transmitted by several mosquito species: *Culex tarsalis, Culex pipiens, and Culex quinquefasciatus*. The mosquito transmits the disease to birds, humans, and wild or domestic animals. The amount of the virus in humans and other large animals is too low to infect uninfected mosquitoes feeding on them; therefore, they are considered as deadened hosts (SYMVCD, 1993a and 1993b). St. Louis Encephalomyelitis is the most prevalent mosquito-borne encephalomyelitis in the United States, and is the second most prevalent mosquito-borne encephalomyelitis in California.

The infection can be mild, acute, or fatal (SYMVCD, 1992b). Most infections are mild, with only 1 to 6 percent of those individuals infected becoming ill and an even smaller percentage developing acute symptoms or dying from the disease. Although all age groups are susceptible to this disease, children under the age of nine are less likely to become ill than persons age 60 and over. The severity of the disease appears to be age-dependent, with a fatality rate for individuals under 40 of 1 to 5 percent, but increasing to between 15 and 23 percent for persons 60 and over. All St. Louis Encephalomyelitis infections are

followed by immunity, and permanent abnormalities, such as recurring headache, memory impairment, tremors, sleeplessness, and sensory motor or speech impairment, can result.

In temperate zones, the virus cycles between *Culex* mosquitoes and birds throughout the summer months, but apparently disappears from both during winter months (Des Rochers and Hardy, 1987). Scientists speculate that, during the winter period, the virus is maintained in the environment through transmission between the two mosquito species *Aedes taeniorynchus* and *Psoraphora confinnis*.

Rearing of female *Culex tarsalis* larvae under water conditions of high alkalinity or salinity may reduce their susceptibility to becoming infected with the St. Louis Encephalomyelitis virus (Hardy, et al., 1991).

Malaria

Malaria is no longer endemic to California. In 1986, two cases were reported in Yolo County near Courtland (SYMVCD, 1992c). An outbreak of 22 cases also occurred in San Diego County.

More recently, cases of malaria have been contracted in Asia and transported to California. As of December 31, 1993, no more introduced cases of malaria have been reported in the state (Bissell, pers. comm.). From 1970 to 1992, the number of case reported in California ranged from a low of 53 in 1973 to a high of 741 in 1980; 219 cases were reported in 1992 (DHS, 1994). Most of these cases were contracted outside the United States.

Malaria is caused by protozoans that attack red blood cells (SYMVCD, 1992c). Two species of mosquitoes, *Anopheles freeborni* and *Anopheles punctipennis*, can transmit malaria parasites in California. Other modes of transmission in humans include use of shared needles, blood transfusions, and congenital transmission. Other common names for malaria include jungle fever, blackwater fever, or intermittent fever (SYMVCD, 1992c).

Untreated malaria may cause enlargement of the spleen and liver or kidney failure, suppression of the immune system, and changes in body physiology (SYMVCD, 1992c). Some cases of untreated cerebral malaria can be fatal (SYMVCD, 1992c).

Dog Heartworm

Dog Heartworm *(Dirofilaria immitis)* is a parasite that lives in the heart, arteries in the lungs, veins of the liver, and veins entering the hearts of dogs. Fifteen mosquito species are believed to transmit the parasite.

Heartworms grow up to 12 inches long, and need at least two hosts to complete their cycle. The mosquito serves as the host for the larval stage of the worm. The mosquito ingests the worm larva when it bites an infected dog, and deposits the larva in an uninfected dog when it is seeking another blood meal. The larva burrow into the dog, and undergo several changes over a 3 to 4 month period to reach adult form. They then travel to the right side of the heart through a vein and reproduce. They can remain in the dog's heart for several years. Female heartworms bear thousands of live young in a day, which circulate in the bloodstream for up to 3 years, waiting to be ingested by a mosquito.

Symptoms of dog heartworm presence

include coughing, fainting, weakness and listlessness, loss of weight, possibly coughing up blood, and difficulty in breathing. If a blood test or symptoms indicate the presence of dog heartworm, treatment is possible if the disease has not progressed too far. Preventive medicine is available to avoid infection by heartworm.

III. Sources of Information

Information on mosquito ecology, control methods, mosquito-borne disease incidences, existing level of abatement, and midge production was collected from mosquito ecology and abatement literature and information provided by mosquito abatement districts, including the San Joaquin County Mosquito Abatement District (SJCMAD), Contra Costa Mosquito Abatement District (CCMAD), Sacramento-Yolo County Mosquito Abatement and Vector Control District (SYCMVCD), and Solano County Mosquito Abatement District (SCMAD). The California Department of Health Services (DHS) and the U.C. Berkeley School of Public Health (Kern County Arbovirus Research Station) provided information on incidence of malaria and encephalitis and the status of Lyme disease, bubonic plague, and rabies in the Delta region.

The Delta Wetlands Draft EIR/EIS (Jones & Stokes Associates 1995) and the Stone Lakes National Wildlife Refuge EIS (Jones & Stokes Associates 1992) provided supporting information.

IV. Environmental Setting

4.1 Study Area

The study area for this document includes both the "problem area" and the "solution area" as defined by the CALFED project. The "problem area" is the geographical area containing the problems and issues CALFED actions are intended to address. This area includes the legally defined Delta, Suisun Bay to Carquinez Strait, and Suisun Marsh and is defined by CALFED as the Delta Region.

The CALFED solution area, which includes areas in California that may affect or be affected by potential CALFED actions, includes the Delta Region and the four additional regions. These five regions include:

- Delta Region
- Bay Region
- Sacramento River Region
- San Joaquin River Region
- SWP and CVP Service Areas Outside Central Valley

The affected environment related to selected public health concerns, especially mosquitoes, is described below for each of these five regions.

4.2 Delta Region

The Delta study area includes the legal Sacramento-San Joaquin Delta, Suisun Resource Conservation District, Suisun Bay, and the area south of Suisun Bay bounded by State Routes 680 and 4.

4.2.1 Historical Perspective

As the population of California has increased, urban development has encroached upon wetlands, watercourses, and irrigated agricultural lands. This encroachment has resulted in more frequent human exposure to mosquitoes and has increased likelihood of transmission of

mosquito-borne diseases. The area of mosquito breeding habitat and, consequently, mosquito populations, has been affected by land use changes in the Delta region.

Although most prehistoric marshes in the Delta have been converted to agricultural land, suggesting a reduction in mosquito breeding habitat, agricultural infrastructure and practices, such as irrigation ditches and flooding fields to provide habitat for wintering waterfowl and other wildlife, also create suitable mosquito breeding conditions.

The California State legislature enacted the Mosquito Abatement Act in 1915. The act allows local mosquito abatement organizations to form into specific special districts that could levy a parcel tax on properties within their districts to support abatement programs. By 1973, 64 mosquito abatement districts (MADs) were established in California.

The Delta region has four abatement districts: SJCMAD, CCMAD, SYCMVCD, and SCMAD.

4.2.2 Current Resource Conditions

Mosquito Species of Concern

In the Delta region, mosquito control efforts are primarily focused on seven species of mosquitoes that can transmit malaria and several types of encephalitis or cause a substantial nuisance in surrounding communities. The seven species of concern are described below.

- The floodwater mosquito (*Aedes melanimon*) and the pasture mosquito (*Aedes nigromaculis*) are the primary nuisance species to humans. These species typically breed in intermittently flooded agricultural areas and are potential vectors of western equine encephalitis and St. Louis encephalitis (Bohart and Washino 1978, Meyer and Durso 1993).

- The encephalitis mosquito (*Culex tarsalis*) breeds in almost any area that ponds fresh water. This species is the primary carrier in California of western equine encephalitis, St. Louis encephalitis, and California encephalitis and is considered the most important disease vector in the State (Sacramento-Yolo County Mosquito Abatement and Vector Control District 1990).

- The western malaria mosquito (*Anopheles freeborni*) is the primary vector of malaria in the western United States. Algal mats that form in stagnant water are the preferred egg-laying habitat for this species (Stroh pers. comm.).

- The mosquito *Aedes dorsalis* breeds in intertidal marshes and is a suspected vector of California encephalitis (Bohart and Washino 1978).

- The cool-weather mosquito (*Culiseta inornata*) is most abundant in fall and spring. This species feeds primarily on domestic animals and has been identified as a vector of western equine encephalitis. It is not considered an important public health vector, however, because humans are not preferred hosts and the species has not been found to

carry western equine encephalitis in California (Bohart and Washino 1978).

- House mosquitoes (*Culex pipiens*) usually breed in water bodies that have a high content of organic material (Bohart and Washino 1978, Sacramento-Yolo County Mosquito Abatement and Vector Control District 1990). House mosquitoes are the primary vector of St. Louis encephalitis outside the western United States but are not considered a problem vector of St. Louis encephalitis in California (Bohart and Washino 1978).

Table 1 contains information such as habitat for all the species of concern in the CALFED study area. Table 2 lists recent historic disease incidence for the Delta region.

Mosquito Breeding Conditions/Habitat

All species of mosquitoes require standing water to complete their growth cycles; therefore, any body of standing water represents a potential mosquito breeding site. Mosquitoes are produced year round on Delta islands, but mosquito production diminishes substantially during the cool season, typically late October through April. (Kramer and Lucchesi pers. comms.)

Water quality affects the productivity of a potential mosquito breeding site. Typically, water bodies with poor circulation, higher temperatures, and higher organic content produce greater numbers of mosquitoes than do water bodies having good circulation, lower temperatures, and lower organic content (Collins and Resh 1989). Additionally, irrigation and flooding practices may influence the level of mosquito production associated with a water body. Typically, water bodies with water levels that slowly increase or recede produce greater numbers of mosquitoes than do water bodies with water levels that are stable or that rapidly fluctuate.

Among the habitat types in the study area, two general classes of habitats, open-water and flooded, provide suitable conditions for mosquito production. Open-water habitats in the study area include permanently inundated wetlands, ditches, sloughs, and ponds. Flooded habitats include managed wetlands and agricultural lands that may seasonally retain surface water.

Table 3 lists primary types of mosquito habitat, the species of mosquito found in that habitat, common abatement measures, and mosquito management issues for the CALFED study area.

Mosquito Control Methods

Compared with the historic prevalence of mosquito-borne diseases in humans, mosquito-borne diseases in California are under control. These diseases, however, are still present or could be readily reintroduced. Encephalitis naturally occurs in migratory bird populations and is easily transferred by mosquitoes. Malaria is occasionally brought back into the country by travelers from tropical climes. (Bohart and Washino 1978, Sacramento-Yolo County Mosquito Abatement and Vector Control District 1990.)

To reduce mosquito populations and, consequently, the likelihood of disease transmission to humans, MADs use a combination of various abatement procedures to control mosquitoes, each of

which may have maximum effectiveness under specific habitat conditions or periods of the mosquito life cycle (Kramer and Lucchesi pers. comms.). Mosquito control has shifted away from application of pesticides, kerosene, and diesel fuel since the late 1970s as a result of concern for the cumulative effects of pesticides on the environment. Mosquito control methods currently used by MADs in the Delta region include:

- Biological agents (e.g., establishing mosquitofish, which are predators on mosquito larvae) in mosquito breeding areas
- source reductions (e.g., draining water bodies that produce mosquitoes)
- pesticides
- ecological manipulations of mosquito breeding habitat

Actions such as better irrigation planning and monitoring of vector populations have also reduced the need for applications of traditional pesticides. Table 4 lists more information on mosquito control measures used in the CALFED study area. Table 5 lists control issues and measures by abatement district, for the Delta region and other regions.

Approximately 103,700 acres of land in the study area are currently treated annually by Delta MADs.

Other Vectors and Host Populations

Other public health concerns related to animal-vectored disease in California include the transmission of Lyme disease by ticks, bubonic plague by fleas, and rabies by wildlife; however, none of these issues are considered a high risk to public health in the Delta region. (Reilly pers. comm.)

Known Hazardous Waste Sites

Known hazardous waste sites include known disposal sites, gas stations, or other facilities using or handling hazardous or toxic materials. When proposed CALFED actions and alternatives are refined in more detail at the project level, relevant known hazardous waste sites can be identified for the affected environment description.

4.3 Bay Region

4.3.1 Historical Perspective

The historical perspective for public health concerns related to mosquitoes and mosquito-borne diseases is similar to that described for the Delta Region.

4.3.2 Current Resource Conditions

Mosquito Species of Concern

Mosquito species of concern are listed in Table 2.

Mosquito Breeding Conditions

Mosquito breeding conditions in the Bay region are similar to the conditions discussed for the Delta region. The Bay region, however, does not have as much habitat from agricultural land uses as the Delta region.

Mosquito Control Methods

Mosquito control methods in the Bay region are similar to the control methods discussed

for the Delta region. Control measures are described in more detail in Table 4.

Other Vectors and Host Populations

Other public health concerns related to animal-vectored disease in California include the transmission of Lyme disease by ticks, bubonic plague by fleas, and rabies by wildlife; however, none of these issues are considered a high risk to public health.

Known Hazardous Waste Sites

Known hazardous waste sites include known disposal sites, gas stations, or other facilities using or handling hazardous or toxic materials. When proposed CALFED actions and alternatives are refined in more detail at the project level, relevant known hazardous waste sites can be identified for the affected environment description.

4.4 Sacramento River Region

4.4.1 Historical Perspective

The historical perspective for public health concerns related to mosquitoes and mosquito-borne diseases is similar to that described for the Delta Region. Table 6 presents recent historic disease incidence in the Sacramento River region.

The Sacramento River Region has a relatively high rate of encephalitis among the regions in the study area. Reported cases of encephalitis between 1969 and 1992 peaked in 1974 with 41. Since 1975, fewer than 10 cases per year have been reported, except in 1983 when 10 cases were reported.

Historically, the Sacramento River Region has also had the highest rate of malaria of any of the regions under investigation. During a major malaria epidemic in 1979 and 1980, 90 cases of encephalitis and 8 cases of malaria were reported in the Sacramento River Region. Only a few cases have been identified as mosquito-borne, most of them in Sutter and Yuba counties.

4.4.2 Current Resource Conditions

Mosquito Species of Concern

Three species make up the primary disease vector mosquitoes in the Sacramento River region:

- *Aedes melanimon*
- *Culex tarsalis*
- *Anopheles freeborni*

These species are discussed briefly in the Delta region section, and more detail is provided in Table 2.

Mosquito Breeding Conditions

Mosquito breeding conditions in the Sacramento River region are similar to the conditions discussed for the Delta region.

Mosquito Control Methods

Mosquito control methods in the Sacramento River region are similar to the control methods discussed for the Delta region. Control measures are described in more detail in Table 4.

Other Vectors and Host Populations

Other public health concerns related to animal-vectored disease in California include the transmission of Lyme disease by ticks, bubonic plague by fleas, and rabies by wildlife; however, none of these issues are considered a high risk to public health.

Known Hazardous Waste Sites

Known hazardous waste sites include known disposal sites, gas stations, or other facilities using or handling hazardous or toxic materials. When proposed CALFED actions and alternatives are refined in more detail at the project level, relevant known hazardous waste sites can be identified for the affected environment description.

4.5 San Joaquin River Region

4.5.1 Historical Perspective

The historical perspective for public health concerns related to mosquitoes and mosquito-borne diseases is similar to that described for the Delta Region. Table 7 presents recent historic disease incidence in the San Joaquin River region.

The San Joaquin River Region has a moderate rate of encephalitis compared to other regions in this study. Cases between 1970 and 1992 were most numerous in 1970 with 35 cases reported. Very few of the cases are known to have been mosquito-borne.

Historically, the San Joaquin River Region has had a lower rate of malaria than the Sacramento River Region. During the 1979-1980 outbreak, 36 and 37 cases of malaria, respectively, were diagnosed in the San Joaquin River Region, most of them in Fresno County. In 1986, during a second epidemic, 57 cases were reported; 27 of these were identified as mosquito-borne.

4.5.2 Current Resource Conditions

Mosquito Species of Concern

Three species make up the primary disease vector mosquitoes in the Sacramento River region:

- *Aedes melanimon*
- *Culex tarsalis*
- *Anopheles freeborni*

These species are discussed briefly in the Delta region section, and more detail is provided in Table 2.

Mosquito Breeding Conditions

Mosquito breeding conditions in the San Joaquin River region are similar to the conditions discussed for the Delta region.

Mosquito Control Methods

Mosquito control methods in the San Joaquin River region are similar to the control methods discussed for the Delta region. Control measures are described in more detail in Table 4.

Other Vectors and Host Populations

Other public health concerns related to animal-vectored disease in California include the transmission of Lyme disease by ticks, bubonic plague by fleas, and rabies by wildlife; however, none of these issues are considered a high risk to public health.

Known Hazardous Waste Sites

Known hazardous waste sites include known disposal sites, gas stations, or other facilities using or handling hazardous or toxic materials. When proposed CALFED actions and alternatives are refined in more detail at the project level, relevant known hazardous waste sites can be identified for the affected environment description.

4.6 SWP and CVP Service Areas Outside Central Valley

4.6.1 Historical Perspective

The historical perspective for public health concerns related to mosquitoes and mosquito-borne diseases is similar to that described for the Delta Region. The St. Louis Encephalomyelitis arbovirus has become especially active in southern California in recent years. In the late 1980s, the virus occurred in the urban southern California areas of Los Angeles, Orange, Riverside, and San Diego counties (SYMVCD, 1992b). During 1989, a total of 27 cases in humans were reported in Kern, Tulare, Kings, and Los Angeles counties. Although only one case of St. Louis Encephalomyelitis in humans was reported in 1991, monitoring of sentinel chicken populations and isolations of the virus from pools of mosquitoes continue to indicate widespread viral activity in Southern California (Mosquito Control Research, 1991).

In recent years, cases of malaria have been contracted in Asia and transported to California, many of these to Los Angeles County. However, as of December 31, 1993, no more introduced cases of malaria have been reported in California.

4.6.2 Current Resource Conditions

Mosquito Species of Concern

Mosquito species of concern are listed in Table 2.

Mosquito Breeding Conditions

Mosquito breeding conditions in the SWP and CVP service areas outside Central Valley are similar to the conditions discussed for the Delta region.

Mosquito Control Methods

Mosquito control methods in the SWP and CVP service areas outside the Central Valley are similar to the control methods discussed for the Delta region. Control measures are described in more detail in Table 4.

Other Vectors and Host Populations

Other public health concerns related to animal-vectored disease in California include the transmission of Lyme disease by ticks, bubonic plague by fleas, and rabies by wildlife; however, none of these issues are considered a high risk to public health.

Known Hazardous Waste Sites

Known hazardous waste sites include known disposal sites, gas stations, or other facilities using or handling hazardous or toxic materials. When proposed CALFED actions and alternatives are refined in more detail at the project level, relevant known hazardous waste sites can be identified for the affected environment description.

TABLE 1 - DELTA REGION RECENT HISTORIC DISEASE INCIDENCE

District	Delta Region Disease Incidence
Sacramento-Yolo Mosquito and Vector Control District (MVCD)	1. Between 1945 and 1992, total combined cases of Western Equine Encephalomyelitis and St. Louis Encephalomyelitis ranged from a low of zero in many years to a high of 51 in 1952. 2. About twice as many cases of Western Equine Encephalomyelitis were reported as St. Louis Encephalomyelitis during the 1945-1992 period.
San Joaquin County MVCD	1. Since 1969, two cases of mosquito-borne St. Louis Encephalomyelitis have been identified (one in 1971 and one in 1973). 2. No cases of mosquito-borne malaria have been identified in San Joaquin County since 1969.
Contra Costa MVCD	1. No cases of mosquito-borne encephalitis or malaria were identified between 1970 and 1992.

TABLE 2 - PRIMARY AND SECONDARY DISEASE VECTOR MOSQUITOS

Species	Distribution	Habitat		Time Period	Disease
		Agriculture Areas	Natural Areas		
Culex tarsalis (1)	Found in western, central, and southern U.S., Canada, and all 58 counties in California from sea level to 9,900 feet elevation; can fly an average of 3 to 7 miles daily.	Pastures Rice fields Cotton fields Row crops Wetland habitat areas Non-row crops Orchards Seepage drains Canals Hoof prints Water troughs	Wetlands Lakes Ponds Rain pools Springs Freshwater marshes Snow pools Meadows	Population growth occurs spring to fall. June to September are the peak population months. During wet years, population peaks in spring and late-summer.	Primary vector of Western Equine Encephalomyelitis and St. Louis Encephalomyelitis in the Sacramento, San Joaquin, and Imperial valleys; feeds on birds and animals, including humans.
Aedes melanimon (1)	Found in western U.S. into southwestern Canada, and distributed throughout the interior valleys and the Sierra Nevada in California; can fly an average of 5 to 25 miles daily.	Pastures Rice fields Row crops Wetland habitat areas Orchards	Wetlands Rain pools Freshwater marshes	First generation hatches February to April. Each subsequent flooding of the eggs initiates a new generation from March to November. Adults disappear from December to February.	Secondary vector of Western Equine Encephalomyelitis; primary vector of California Encephalitis; feeds on blacktailed jackrabbits infected with Western Equine Encephalomyelitis, and humans.
Anopheles freeborni (1)	Found in western U.S. into southern British Columbia, and in all but seven of the southern counties in California; almost nonexistent in Tulare and Kern counties; can fly an average of 1 to 17.5 miles daily.	Rice fields Wetland habitat areas Seepage drains Canals	Wetlands Lakes Ponds Rain pools Springs Freshwater marshes Snow pools Meadows	In California, population growth occurs spring to fall; feed aggressively on humans during migratory phase in the spring and fall in the Sacramento and San Joaquin valleys; creates severe pest problems in Fresno County at that time.	Primary vector of human malaria in California; feeds on mammals, such as humans, cattle, and rabbits.
Culex pipiens (2)	Found in California in the northern and coastal regions and cooler portions of the Central Valley, such as the southern Sacramento Valley.	Not indicated	Not indicated	Not indicated	A vector of St. Louis Encephalomyelitis in the central and eastern U.S.; inefficient vector in California; feeds primarily on birds and occasionally on humans.
Culex quinquefasciatus (2)	Found in California in the warmer interior valleys, including the San Joaquin Valley and Tulare Lake Basin, and southern California; has been documented to migrate up to 3 miles; found concurrently with *Culex tarsalis*.	Not indicated	Riparian areas and residential areas in Kern County	Population increases during late summer and fall.	Has been documented as being infected with the St. Louis Encephalomyelitis, and may be a secondary transmitter, primarily between riparian and residential habitats; feeds primarily on birds and occasionally on humans.

TABLE 2 - PRIMARY AND SECONDARY DISEASE VECTOR MOSQUITOS

Species	Distribution	Habitat		Time Period	Disease
		Agriculture Areas	Natural Areas		
Culex erythrothorax (2)	Found widely distributed throughout California.	Not indicated	Marshes supporting dense tule and cattail stands	Population peaks in June in Butte and Glenn counties and in late July in Orange County.	Not likely an important vector of arboviruses in California; feeds on mammals.
Culex erythrothorax (2)	Found in California in the Sacramento Valley and Kern County.	Not indicated	Slow-moving streams in the foothills Rice fields	Population peaks in mid-summer.	Not likely a vector in human disease transmission; feeds primarily on small mammals such as rabbits and jackrabbits; few feed on birds or humans.
Anopheles hermsi (2)	Prevalent in southern California, but is established as far north as San Mateo County.	Not indicated	Not indicated	Not indicated.	Primary vector of malaria in Southern California, including San Diego County.
Anopheles punctipennis (2)	Found in California throughout the foothills of the Sierra Nevada in riverine areas of the Sacramento and San Joaquin valleys and the Tulare Lake Basin, often where *An. freeborni* is either absent or not abundant; was the suspected vector in the 1986 malaria outbreak in Fresno and Merritt Island, and in the 1988 outbreak in Chico.	Not indicated	Riparian areas with dense concentrations of trees or shrubs	One study of riverine areas of the San Joaquin Valley indicated that females peaked in August.	Possibly a vector of human malaria, especially where *An. freeborni* is absent.
Aedes nigromaculis (2)	Found in California widely distributed in the Central Valley; can migrate up to 36 miles.	Irrigated pastures Alfalfa fields	Not indicated	Hatches in the spring during flooding.	Does not transmit the encephalitis virus, but is a serious pest to cows, horses, and humans; rarely feeds on birds.
Aedes vexans (2)	Found in the central U.S. and in California in the Sacramento Valley; has disappeared from Kern County, where it was a major pest, because of construction of the Isabella Dam on the Kern River, which prevents spring flooding of the Kern River.	Irrigated pastures	Riparian areas	Hatches in the spring during flooding.	Few arboviruses have been transmitted by this species in California; feeds primarily on large domestic mammals and on humans, and rarely on birds.

TABLE 2 - PRIMARY AND SECONDARY DISEASE VECTOR MOSQUITOS

Species	Distribution	Habitat		Time Period	Disease
		Agriculture Areas	Natural Areas		
Aedes sierrensis (2)	Found widely distributed throughout California in treeholes; associated with mosquito population outbreaks in the San Joaquin Valley because of managed river surges to assist salmon populations in the spring of 1993; females can fly 100 miles in three days.	Wherever treeholes are available	Wherever treeholes are available	Adults emerge in the spring; in Butte County, peak emergence occurs in June and persists throughout the summer.	No arboviruses have been transmitted by this species in California.

TABLE 3 - MOSQUITO HABITAT, MOSQUITO SPECIES, AND ABATEMENT MEASURES

Habitat Description	Mosquito Species Found in Habitat	Abatement Measures Commonly Used	Mosquito Management Problems
Rice fields: found in many areas in the Central Valley; particularly prevalent in the Sacramento River Region, but also found in the San Joaquin River Region; very few in the Tulare Lake Region; flooded in spring and remain flooded all summer; produce a dense stand of emergent vegetation, which is excellent habitat for larvae; drainage channels may contain standing water, providing additional habitat.	*Aedes melanimon** *Anopheles freeborni* *Culex tarsalis*** *Large numbers are produced upon first flooding in the spring. **Abundance in the Sacramento Valley is variable ******Anopheles* and *Aedes* species bite humans aggressively and can cause severe nuisance problems.	Mosquitofish in conjunction with larviciding (applying a chemical to kill the larvae) with pyrethrins or BTI; natural predators, such as copepods and damselfly larvae, may also play a role in reducing the number of mosquito larvae.	1. Water management techniques are largely ineffective in rice fields; therefore, larviciding is usually required on a regular basis. 2. Rice fields have dense emergent vegetation that reduces the efficiency of mosquitofish. 3. If water in rice fields is drained and stored offsite, and fields are reflooded to enhance waterfowl habitat in fall, some mosquito populations could peak in the fall.
Wetland habitat areas: primarily flooded during hunting season; habitat is similar to habitats found in wildlife refuges; duck clubs are managed to provide waterfowl food as well as wetland acreage.	*Culex tarsalis* *Aedes melanimon** *Anopheles freeborni*** *A major pest produced from autumn flooding **Decreases in abundance further south	Ultra-low volume aerosol sprays of pyrethrins are commonly used to control adult emergence; this can be done only when there is an inversion layer and wind velocities are between 2 and 6 miles per hour.	1. Because duck clubs are managed for duck hunting, mosquito abatement districts may not be allowed access to wetland areas during hunting season for safety reasons. 2. In extensive areas of wetland, larval control (other than mosquitofish) in the interior of the wetland often may require spraying by aircraft.

TABLE 3 - MOSQUITO HABITAT, MOSQUITO SPECIES, AND ABATEMENT MEASURES

Habitat Description	Mosquito Species Found in Habitat	Abatement Measures Commonly Used	Mosquito Management Problems
Riparian areas: certain species breed in edges and backwaters in rivers and creeks; if stream flow rises and then falls quickly, leaving behind isolated water pockets, habitat for mosquitoes may be created; larger populations of mosquitoes may be produced in spring when river surges are high; because riparian habitats also support bird populations, they contribute to the amplification of mosquito-borne virus epidemics among animals.	*Culex tarsalis* *Culex quinquefasciatus** *Aedes melanimon* *Aedes sierrensis* *May be primarily responsible for transmitting Western Equine Encephalomyelitis and St. Louis Encephalomyelitis from riparian areas to residential areas	Natural predators, such as damselfly larvae, exist in riparian areas; spraying with adulticide, such as pyrethrins, is the only method to control mosquitoes in riparian areas.	1. Dense vegetation along channels may limit access to the river by district employees. 2. Spraying with adulticides has limited effectiveness on species that migrate long distances, such as *Aedes melanimon.*
Canals and drains: generally managed to be free of vegetation and to be steep-sided; as long as they are flowing, they do not tend to produce mosquitoes; if water is allowed to stand in canals or drains, mosquito larvae may develop; drains and areas of seepage surrounding agricultural lands are more likely areas for mosquito development.	*Culex tarsalis* *Anopheles freeborni*	Water management is most commonly used in canals; techniques include keeping the water flowing and reducing emergent vegetation in the canal; local mosquito control districts work with growers to manage water in seepage drains to preclude mosquito growth; if mosquito populations occur, larvicides, such as BTI and methoprene, and oils such as Golden Bear are used.	1. If properly managed, canals and drains do not produce significant mosquito populations.

TABLE 3 - MOSQUITO HABITAT, MOSQUITO SPECIES, AND ABATEMENT MEASURES

Habitat Description	Mosquito Species Found in Habitat	Abatement Measures Commonly Used	Mosquito Management Problems
Reservoirs: provide only a small amount of mosquito habitat concentrated around the reservoir edge; as reservoir levels decline, pockets of water may be left behind that can support the growth of mosquito larvae.	*Aedes sierrensis* Other species may develop at the water's edge and in emergent vegetation or algae growth.	Mosquitofish are commonly used in reservoirs; floating mats of algae and emergent vegetation around the edges of the reservoir are minimized; the edges of the reservoir are treated with spot applications of larvicide or adulticide.	1. Reservoirs, if managed properly, do not produce significant mosquito populations; if reservoir levels decline slowly, continual treatment of stagnant water pockets may be needed to control populations of treehole mosquitoes.
Pastures: often irrigated by flooding and allowing the water to sink in; often the water is allowed to stand long enough for mosquito larvae to develop into adults; in pastures, water often collects in hoofprints and other depressions.	*Culex tarsalis* *Aedes melanimon** *Aedes nigromaculis** *These two species are the species most commonly associated with pasture flood-irrigation	BTI, methoprene, and pyrethrins are the most commonly used chemical control measures; water management techniques are also used.	1. If pasture irrigation water is allowed to stand for more than three days, adult mosquitoes may emerge.
Wildlife refuges: generally located in areas of historical flooding, primarily near the Sacramento and San Joaquin rivers; they are primarily managed to provide seasonal or permanent wetland habitat for waterfowl.	*Culex tarsalis* *Aedes melanimon** *Anopheles freeborni** *A major pest produced from autumn flooding **Decreases in abundance further south	In National Wildlife Refuges, many of the biological or biorational controls, such as mosquitofish, BTI, methoprene, and some of the pyrethrins, are used In State Wildlife Management Areas, water management and mosquitofish are preferred over chemicals; BTI and methoprene may also be used.	1. Low water levels and plentiful emergent vegetation could make mosquitofish control difficult. 2. Biorational larvicides are often ineffective. 3. Aircraft for aerial spraying may not be within the budget of a local district.

TABLE 3 - MOSQUITO HABITAT, MOSQUITO SPECIES, AND ABATEMENT MEASURES

Habitat Description	Mosquito Species Found in Habitat	Abatement Measures Commonly Used	Mosquito Management Problems
Croplands: consist of row crops, non-row crops, and orchards; these do not provide significant mosquito habitat unless water is allowed to stand for more than three days.	*Culex tarsalis** *Culex quinquefasciatus** *Populations of both species peaked during the period of cotton irrigation in 1990, and declined rapidly after cotton irrigation was terminated.	Water management practices are most commonly used to control the emergence of mosquitoes from irrigated crops; if irrigation produces a significant mosquito population, the most common control methods are spraying fields with adulticides and treatment of drainages with larvicides including BTI, methoprene, and oil.	1. No serious problems unless water is mismanaged.
SOURCES: Batzer and Resh, 1992; Hofmann, pers. comm.; Inman, pers. comm.; McBride, pers. comm.; Norgaard, pers. comm.; Reisen et al., 1992; Reisen and Reeves, 1990.			

TABLE 4 - CONTROL MEASURES USED AGAINST MOSQUITOES

Type of Control Measure	Control Measure Description
WATER MANAGEMENT	Changing the hydrologic regime of wetlands may cause a change in seasonal water availability and thereby affect potential breeding habitat of mosquitoes in three ways: (1) attempting to reduce standing water for three or more days; (2) modifying the area covered by wetlands, which may vary and correspondingly increase or decrease habitat for waterfowl and invertebrates (this change in seasonal availability of waterfowl habitat reduces a mosquito transmission vector, as well as potential mosquito habitat); and (3) indirect plant consumption by animals and waterfowl, which reduces mosquito habitat.
BIOLOGICAL	
Herbivores	Herbivores feeding on wetland vegetation can indirectly affect mosquito populations by reducing their habitat; dabbling waterfowl (geese and ducks), muskrats, and crayfish can be important herbivore (plant-eating) agents in controlling mosquito populations.
Predators	A variety of fungi, parasitic protozoa, nematode worms, predaceous insects, and fish species have been considered mosquito control agents; predators include mosquitofish *(Gambusia)*, copepods *(Cyclops)*, flatworms *(Mesostoma)*, damselfly naiads *(Ichnura, Enallagma)*, hydrophylid beetle larvae *(Tropisternus, Hydrophilus)*, and dysticid beetles *(Laccophilis)*.
Mosquitofish	Feed mostly at the surface in areas of sparse vegetation where they encounter larvae; widely used by vector control districts to control populations in rice fields; dense vegetation and low water levels can inhibit movement of mosquitofish; mosquitofish also feed upon invertebrates that eat mosquitoes, potentially reducing the total effectiveness.
Invertebrates	Predaceous aquatic macroinvertebrates, especially insects, are generally regarded as important natural enemies of mosquitoes; the abundance of these predators is highly variable because they are affected by subtle changes in water chemistry, interactions between parasites, disease vectors, and predators for each host species.
Microbial	
BTI	Produces protein crystals that kill the larvae of mosquitoes, black flies, and midges; is ingested by mosquitoes; several factors can reduce its effectiveness; a second type of bacteria, *Bacillus sphaericus*, has also proven effective in controlling populations of *Culex* mosquito larvae.
Fungi	A fungal parasite *(Lagenidium giganteum)* of mosquito larvae has been effective in infecting and killing larvae of both *Culex tarsalis* and *Anopheles freeborni*; effectiveness of the fungus was similar to the Chemical effectiveness rate of BTI, described below in the Biorational Controls.

Type of Control Measure	Control Measure Description
CHEMICAL	
Biorational	Applied like pesticides; they include solutions or dust containing bacteria or fungi that are fairly selective in attacking mosquitoes (such as BTI), or chemicals that mimic insect hormones (such as methoprene); biorational controls only harm the mosquito (and sometimes related insects) but have no effect on other insects, birds, or animals.
Methoprene	A manmade chemical that mimics the biological activity of insect juvenile hormone; when present during critical development periods, the hormone interferes with the normal insect development process; methoprene is biodegradable; factors that may reduce the effectiveness of methoprene include removal by strong water flows, application is limited to certain larvae stages, it does not affect pupae, and only certain species are susceptible.
Pesticides	
Pyrethrins	A group of naturally occurring compounds with insecticidal properties; they are extracted from the flowers of a plant belonging to the Chrysanthemum family; pyrethrins disrupt insects' nerve actions within minutes; some mosquito species are resistant to pyrethrins; therefore, other materials are added to increase the effectiveness; pyrethrins have a low toxicity to mammals, are biodegradable, and are not detected within 12 to 24 hours after application.
Petroleum Oils	Oil, such as Golden Bear, is used as a larvacide in ditches and other isolated areas of standing water; the oil coats the surface of the water, suffocating the mosquito larvae when they come to the surface to breathe.
Malathion	Used as an adulticide; not usually used in sensitive wildlife areas because it is toxic to fish, shrimp, and beneficial insects; is much less toxic to mammals and birds than most other insecticides.
SOURCES: Collins and Resh, 1989; Kerwin and Washino, 1987; Reisen and Reeves, 1990; Spiller, 1968; SYMVCD, 1992d, 1992e, 1992f.	

TABLE 5 - MOSQUITO CONTROL BY DISTRICT

District	Mosquito Problem/ Abatement Activity	Mosquito Habitat	Problems/Concerns	Mosquito Population Data	Abatement Measures
Sacramento-Yolo MVCD (1)	Rice fields can provide mosquito habitat; district monitors for populations and disease; peak complaints occur in June through August.	Wetland habitat areas Rice fields Irrigated agriculture Sacramento River Wildlife refuges	1. If fields cannot be burned, but must be flooded in September instead, mosquito habitat may be available. 2. Management changes at duck clubs can affect habitat for *Aedes melanimon*. 3. Management changes at rice fields can affect habitat for *Culex tarsalis*. 4. District has limited funds.	1. At least 14 species of mosquitoes were present in this district from 1984 to 1993. The three most prevalent are listed below. • *Culex tarsalis* has a minor peak in April, a major peak in late June and early July, then tapers off. • *Aedes melanimon* peaks in late April, September, and October, then tapers off. • *Anopheles freeborni* increases starting in July, peaks in September, then tapers off.	1. BTI, methoprene, and pyrethrins in irrigated agricultural areas (row crops). 2. Mosquitofish and pyrethrins in rice fields. 3. Ultra-low volume aerosol sprays of pyrethrins in wetland habitat areas.
Sutter-Yuba MVCD	Rice fields, public and private refuges, and irrigated agriculture produce a large number of mosquitoes; most common mosquitoes are *Culiseta* species; peak complaints occur in July through September.	Rice fields Irrigated agriculture Public and private refuges Sacramento River Feather River	1. If rice fields are flooded after harvest, *Aedes* may migrate from pastures and refuges and colonize rice fields. 2. Fall and winter flooding of rice fields may produce large numbers of *Culiseta* species. 3. Riparian restoration projects that create new or enhanced riparian areas along the Sacramento or Feather rivers could affect spring and early summer mosquito production for *Aedes* species. 4. District has limited funds.	1. Information not provided.	1. Water management techniques that prevent water from standing for three or more days; BTI and mosquitofish; pyrethrins, pyrethroids, malathion, one organophosphate; and methoprene, Dimilin, chlorpyrifos granules, and Golden Bear-IIII on agricultural lands. 2. BTI, methoprene, and mosquitofish in wetlands. 3. Pyrethrins in refuges. 4. Adulticides such as pyrethrins, pyrethroids, malathion and one organophosphate in riparian areas.

TABLE 5 - MOSQUITO CONTROL BY DISTRICT

District	Mosquito Problem/ Abatement Activity	Mosquito Habitat	Problems/Concerns	Mosquito Population Data	Abatement Measures
Shasta MVCD	Major populations of *Aedes, anopheles,* and *Cules spp.* occur along the Sacramento River riparian coridor from March through October; peak complaints occur in April and June.	Sacramento River riparian corridor Irrigated agriculture Retired lands	1. Dense vegetation in the riparian habitat could make access for abatement difficult. 2. District has limited funds.	1. Information not provided.	1. Mosquitofish, modifying habitat by pond construction, applying biorational larvicides, and applying pyrethrins in wetlands.
Butte County MVCD	The main mosquito species present in the county include *Culex tarsalis, Anopheles freeborni, Anopheles punctipennis,* and many *Aedes* species including *Aedes melanimon, Aedes nigromaculis, Aedes sierrensis,* and *Aedes vexans.*	Rice fields Wildlife refuges Sacramento River Feather River	1. District has limited funds.	1. Information not provided.	1 Mosquitofish in permanent or semipermanent water bodies where there is not a large amount of debris or emergent vegetation. 2. BTI in areas where there is a large amount of debris or emergent vegetation; methoprene is used occasionally. 3. Pyrethrins and some malathion are used as adulticides. 4. Oils are used to kill mosquito pupae in areas where wildlife will not be harmed.
Colusa MAD (2)	Mosquito habitats and populations are similar to those in Sacramento-Yolo MVCD and Sutter-Yuba MVCD; Colusa NWR produces more *Aedes* when first flooded in fall if flooded before October 15.	Irrigated agriculture Rice fields Wetlands Wildlife refuges Wetland habitat areas	1. Colusa NWR is 1.5 miles from the City of Colusa, well within the range of *Anopheles* and *Aedes* migration. 2. Predation of mosquitofish by birds within a few days of planting the fish may be a problem.	1. Information not provided.	1. Water management techniques to ensure water does not stand for more than three days. 2. Pyrethrin, malathion, and mosquitofish in refuges, rice fields, and other wetland habitat areas.. 3. Adulticides around the edges of wetlands, which is not enough to control mosquito populations.

TABLE 5 - MOSQUITO CONTROL BY DISTRICT

District	Mosquito Problem/ Abatement Activity	Mosquito Habitat	Problems/Concerns	Mosquito Population Data	Abatement Measures
Tehama County MVCD	Most time is spent in surveillance and larval treatment of mosquitoes and the mosquitofish program; peak complaints occur July through September.	Rice fields Irrigated pasture Riparian areas Vernal pools	1. *Culex, Anopheles,* and *Aedes* species are vectors of dog heartworm, and a public nuisance in spring. 2. The number of vernal pools and resulting number of *Aedes sierrensis* are unique to this district. 3. District has limited funds.	1. Information not provided.	1. Water management and source reduction in irrigated agricultural areas, and chemical or biological controls when necessary. 2. Mosquitofish in rice fields, supplemented with adulticides.
San Joaquin County MVCD	Peak mosquito breeding season lasts from February to December, making mosquito control necessary year-round.	Rice fields Irrigated agriculture Wetland habitat areas Wildlife refuges San Joaquin River Stanislaus River Mokelumne River Canals Drains	1. Fluctuating river flows during warmer months may increase mosquito breeding along the river channels at increased cost. 2. An increase in flow could increase seepage and promote mosquito breeding in the low areas surrounding rivers. 3. If rice fields are used for off-stream storage of water, they may provide mosquito habitat; if the fields were drained, harvested, and reflooded, in fall there may be fewer mosquito predators.	1. Information not provided.	1. Mosquitofish in rice fields, refuges, wetland habitat areas, canals, drains, and water bodies associated with agriculture. 2. Water management, larvicides, and adulticides in irrigated agriculture. 3. Chemical controls in rice fields and refuges. 4. Chemical controls and water management in wetland habitat areas. 5. Weed control and vegetation removal in canals and drains.
East Side MAD	Provides mosquito abatement in northern Stanislaus County.	Rice fields Irrigated agriculture Irrigated pasture	1. Rice and riparian habitat produce mosquito control problems similar to those in San Joaquin County.	1. Information not provided.	1. Pyrethrins in riparian habitats in early spring. 2. Mosquitofish in rice fields, supplemented with larvicides and adulticides when necessary.

TABLE 5 - MOSQUITO CONTROL BY DISTRICT

	Mosquito Problem/ Abatement Activity	Mosquito Habitat	Problems/Concerns	Mosquito Population Data	Abatement Measures
Turlock MAD	Performs much abatement activity in wetland habitat areas and Grasslands Resource Conservation District; concentrates abatement activities within a 3-mile radius around populated areas, schools, and health facilities; other areas are treated as requested.	Rice fields Wildlife refuges Wetland habitat areas	1. Availability of pesticides for mosquito abatement may be limited.	1. Populations on the east side of the county peak during August and September, breeding mostly in agricultural areas. 2. Populations on the west side of the county peak in September and October, coinciding with the flooding of refuges and wetland habitat areas.	1. Water management in irrigated agricultural areas. 2. Larvicides or adulticides in tailwater areas as required. 3. Larvicides and mosquitofish in rice fields. 4. Water management, vegetation management, biorational controls, and mosquitofish in the Grasslands Resource Conservation District; effective, safe larvicides are needed.
Merced County MAD	Because of budget constraints, district concentrates abatement activities within a 3-mile radius around populated areas, schools, and health facilities.	Rice fields Wildlife refuges Wetland habitat areas	1. Availability of pesticides for mosquito abatement may be limited.	1. Populations on the east side of the county peak during August and September, breeding mostly in agricultural areas. 2. Populations on the west side of the county peak in September and October, coinciding with the flooding of refuges and wetland habitat areas.	1. Water management in irrigated agricultural areas. 2. Larvicides or adulticides in tailwater areas as required. 3. Larvicides and mosquitofish in rice fields. 4. Water management, vegetation management, biorational controls, and mosquitofish in the Grasslands Resource Conservation District; effective, safe larvicides are needed.
Madera County MVCD	About 5 percent of overall complaints come from CVP service area sources; provides mosquito abatement in Madera County.	Irrigated agriculture Riparian areas Private refuge lands	1. Has been substituting natural organic insecticides for synthetic organic insecticides; the substitutes are much more expensive. 2. District has limited funds.	1. Population data are not available from this district.	1. Water management and physical control of mosquito habitat, combined with biological control methods, primarily mosquitofish, followed by biological compounds such as BTI or chemical controls when necessary including Golden Bear-1111 or pyrethrin adulticides for agricultural areas, refuge lands, and canals and drains. 2. Peak abatement months are July, August, and September.

TABLE 5 - MOSQUITO CONTROL BY DISTRICT

District	Mosquito Problem/ Abatement Activity	Mosquito Habitat	Problems/Concerns	Mosquito Population Data	Abatement Measures
Fresno Westside MAD	Provides abatement in the western portion of the county.	Irrigated agriculture Rice fields Mendota WMA Wetland habitat areas San Joaquin River	1. Mosquitoes migrating from Grasslands Resource Conservation District in Merced County to populated areas around Firebaugh and Dos Palso are almost impossible to control. 2. During duck hunting season, mosquito control personnel are not allowed on duck club lands for safety reasons, which allows mosquitoes to breed unchecked. 3. District funds are limited.	1. The three most prevalent species are *Culex tarsalis*, *Aedes melanimon*, and *Anopheles freeborni*, the primary vector mosquitoes.	1. Biorational chemicals, such as BTI and methoprene. 2. Water management on agricultural lands and wetland habitat areas, supplemented with chemical controls as necessary. 3. Mosquitofish and chemical controls on rice fields, canals and drains, and riverine habitats. 4. Chemicals almost exclusively on refuges. 5. Peak abatement season is June through October in normal rainfall years.
Consolidated MAD	Mosquito species are similar to those found in Fresno Westside MAD.	Agricultural lands San Joaquin River Kings River	1. If riparian vegetation restoration occurs along the Kings River, larger mosquito populations will be produced near inhabited areas.	1. Information not provided.	1. Same measures as those listed for the Fresno Westside MAD.
Contra Costa MVCD	Information not provided.	Information not provided.	1. Information not provided.	1. Information not provided.	1. Information not provided.

NOTES:
(1) MVCD = Mosquito and Vector Control District
(2) MAD = Mosquito Abatement District

SOURCES:
Bissell, pers. comm.; Clement, pers. comm.; Cline, pers. comm.; Cox, pers. comm.; Dillahunty, pers. comm.; DHS, 1994.; DHS, no date; Inman, pers. comm.; McBride, pers. comm.; Seth, pers. comm.; Stroh, pers. comm.; SYMVCD, 1994 and no date; Whitesall, pers. comm.; Reisen et al, 1990.

TABLE 6 - SACRAMENTO RIVER REGION RECENT HISTORIC DISEASE INCIDENCE

District	Sacramento River Region Disease Incidence
Sutter-Yuba MVCD	1. Between 1970 and 1992, the number of encephalitis cases in Sutter County ranged from zero to 75; peaks occurred in 1975 through 1982. 2. Positive tests of Western Equine Encephalomyelitis in mosquitoes and chicken blood peaked in 1987, and no positive tests occurred between 1988 and 1992. 3. There were three cases of malaria in 1974, and one case each in 1981, 1985, and 1986.
Shasta MVCD	1. There were positive tests for encephalitis in mosquitoes and chickens in 1969 (number unknown), 1972 (three St. Louis Encephalomyelitis), 1979 (seven Western Equine Encephalomyelitis), and 1987 (four Western Equine Encephalomyelitis). 2. Since 1970, no cases of malaria have been reported in Shasta County.
Butte County MVCD	1. Western Equine Encephalomyelitis is fairly prevalent in chickens and mosquitoes in Butte County; in 1993, Western Equine Encephalomyelitis was more widespread than ever before. 2. The only diagnosed case of mosquito-borne Western Equine Encephalomyelitis occurred in 1971. 3. Between 1970 and 1992, one case of mosquito-borne malaria was diagnosed in Butte County in 1988.
Colusa Mosquito Abatement District (MAD)	1. In 1993, there was an outbreak of Western Equine Encephalitis in mosquitoes and chickens. 2. A Western Equine Encephalomyelitis outbreak occurred in mosquitoes between 1971 and 1973, and there were outbreaks in mosquitoes and chickens in 1979 through 1981; no occurrences between 1982 and 1992. 3. No cases of mosquito-borne malaria in humans have been diagnosed since 1970.
Tehama County MVCD	1. No cases of mosquito-borne encephalitis have been diagnosed in Tehama County. 2. Tehama County has had periodic outbreaks of Western Equine Encephalomyelitis in chickens and mosquitoes, and St. Louis Encephalomyelitis in mosquitoes. 3. Six cases of malaria have been diagnosed in Tehama County since 1970; none were diagnosed as mosquito-borne.

TABLE 7 - SAN JOAQUIN RIVER REGION RECENT HISTORIC DISEASE INCIDENCE

District	San Joaquin River Region Disease Incidence
East Side Mosquito Abatement District (MAD)	1. No cases of mosquito-borne encephalitis or malaria have been identified since 1969. 2. In 1993, 6 of 16 chickens tested positive for serum conversion to Western Equine Encephalomyelitis and St. Louis Encephalomyelitis. There were no positive tests for several years preceding 1993.
Turlock MAD	1. Trends are similar to those listed for East Side MAD.
Merced County MAD	1. No cases of mosquito-borne encephalitis have been diagnosed in Merced County. 2. Between 1970 and 1992, there have been between zero and six cases of malaria per year; no cases have been diagnosed as mosquito-borne.
Madera County MVCD	1. Madera County had one case of mosquito-borne St. Louis Encephalomyelitis in 1972 and one in 1976. 2. Between 1969 and 1992 (during 1972, 1987, and 1992), tests of mosquito pools and sentinel chicken blood were positive for encephalitis.
Fresno Westside MAD	1. Fresno County reported two mosquito-borne cases of Western Equine Encephalomyelitis in 1972. 2. In 1992, six cases of encephalitis were reported. 3. Between 1969 and 1992, the only positive tests of mosquitoes for Western Equine Encephalomyelitis occurred in 1972; serum conversion to Western Equine Encephalomyelitis and St. Louis Encephalomyelitis in sentinel chickens occurred as recently as 1992. 4. In 1986, Fresno County had two cases of mosquito-borne malaria.
Consolidated MAD	1. Trends are similar to those listed for Fresno Westside MAD.

DRAFT REPORT

Environmental Impacts/Consequences
Draft Technical Report
Public Health and Environmental Hazards

August 28, 1997

C-002782

Introduction

The purpose of this report is to analyze and describe the qualitative changes that could result from implementing each of the three CALFED alternatives. This report will be used with other information to develop the impact portion of the CALFED Programmatic Environmental Impact Report/Environmental Impact Statement (EIR/EIS).

In general, CALFED is intended to improve natural conditions in the Delta, which include a greater amount of water left in the Delta, the restoration of wetland habitats, and other land use changes. These could lead to an increase in suitable mosquito breeding habitat, which in turn could expose people to greater potential for transmission of certain diseases. Potential impacts may also occur resulting from changes in water quality or construction activities that may expose people to hazardous materials.

Other public health concerns related to animal-vectored disease include the transmission of Lyme disease by ticks, bubonic plague by fleas, and rabies by wildlife. However, none of these issues are considered a high risk to public health, and have not been addressed in this technical report. CALFED actions that increase the risk of flooding are discussed in detail in the Flood Control Economics technical report. Impacts that would create an interference with emergency response plans or emergency evacuation plans are addressed in the Socioeconomics technical report.

The potential impacts are described for five separate regions including the Delta Region, the Bay Region, the Sacramento River Region, the San Joaquin Region, and the State Water Project and Central Valley Project Service Areas Outside the Central Valley. Impacts are described by region and in comparison to both existing conditions and the No Action alternative.

2.0 EXECUTIVE SUMMARY

For all alternatives, most public health and environmental hazard effects result from changing the area of available mosquito breeding habitat. Additional effects include changes in water quality and construction activities that could expose people to hazardous substances. Mitigation is available for these impacts.

Other potential public health concerns include the transmission of Lyme disease by ticks, bubonic plague by fleas, and rabies by wildlife. However, none of these issues are considered a high risk to public health, and have not been addressed in this technical report. If deemed appropriate, these issues can be addressed in the project level EIR/EIS when more detailed project descriptions are available.

2.1 Summary of Potential Significant Impacts

Alternatives that include a substantial amount of land to be flooded or converted to wetlands habitat have potentially significant impacts to public health. These actions can significantly increase the area of available mosquito breeding habitat. Mosquitos can transmit several diseases, including malaria and encephalitis, and can be a nuisance. Construction activities that occur near known hazardous materials or waste sites also have potentially significant impacts. Table 1 summarizes all potentially significant impacts to public health in each of the five regions for each of the alternatives.

2.2 Summary of Mitigation Strategies

Several mosquito control methods can be used to mitigate increases in mosquito habitat resulting from CALFED actions. Mosquito control methods already in use throughout the CALFED study area include the following:

- Biological agents (e.g. establishing mosquitofish, which are predators on mosquito larvae)
- Chemical agents (e.g. hormone disrupters, pesticides)
- Ecological manipulations of mosquito breeding habitat (e.g. reducing amount of standing water including during construction, introducing plant-consuming animals)

Each method works best under specific habitat conditions and periods of the mosquito's life cycle. A combination of different control methods should be used for maximum effectiveness. Control methods should be selected when possible that do not create additional stressors on ecosystems.

Potential exposure to hazardous materials and waste sites would be mitigated with the following mitigations:

- Avoidance of known existing hazardous materials and waste sites during construction
- Proper management of hazardous construction materials, such as fuels
- Proper handling of unknown existing hazardous materials and waste sites encountered during construction
- Limiting construction activities in areas with potential mosquito habitat to the cooler season, when mosquito production is at a low level

2.3 Summary of Potential Significant Unavoidable Impacts

Potential significant impacts would be mitigated to less than significant with the mitigation measures described above. No potential significant unavoidable impacts to public health and environmental hazards are expected.

3.0 ASSESSMENT METHODS

Impacts to public health and environmental hazards are assessed qualitatively by evaluating changes to the following variables:

- area of mosquito breeding habitat
- area of habitat that supports other disease vector populations
- risk of contact between humans and vector populations
- risk of hazardous material and waste upset

CALFED actions could affect public health by creating conditions favorable to an increase in vector and host populations. Vector and host populations include insects and animals that can carry or transmit diseases, so an increase in vector populations can increase the possibility of disease transmission. For example, mosquitos can transmit malaria and several types of encephalitis as well as cause a substantial nuisance. Other vectors include ticks, which can transmit Lyme disease and wildlife or other animals which can transmit rabies.

In addition, CALFED actions could change the exposure of people and the environment to hazardous materials. Hazardous materials could include both raw materials and products such as fuels and oils that are commonly used in commercial activities and during construction. Hazardous materials could also include hazardous wastes from known and unknown sources. Exposure to

hazardous materials could result from construction actions or flooding in areas where hazardous materials could be present.

4.0 SIGNIFICANCE CRITERIA

Whether or not an impact is significant is determined by applying the significance criteria described in Section 4 below. Potential impacts from the different alternatives are evaluated and compared to the significance criteria. If the actions included in an alternative appear to meet one or more of the criteria, then the potential impact is described to the extent possible. At the programmatic level, it is often not possible to make an accurate determination of the significance of an impact. In these cases, potential impacts are described to the extent possible and it is noted that further analysis will be required in subsequent environmental review at the project level.

Several different criteria are used to determine if each of the proposed alternatives could have a potentially significant impact on public health and environmental hazards in the project area at the programmatic level. The significance criteria used for a qualitative or programmatic evaluation are substantially broader than those used for a quantitative or project level analysis. The significance criteria used for this study are the following:

- An increase in mosquito habitat acreage that may result in increased mosquito populations
- An increase in populations of, or exposure to, other disease vectors
- Increases in exposures to pathogens, carcinogens, or toxins

5.0 ENVIRONMENTAL IMPACTS/CONSEQUENCES

5.1 No Action Alternative

The impacts of the No Action Alternative on public health and environmental hazards are described qualitatively in this section. Impacts are described for actions defined as part of the CALFED No Action Alternative.

5.1.1 Summary of No Action Effects

The No Action Alternative would have potential impacts to public health and environmental hazards. New reservoirs, additional water for refuge needs, and potentially fluctuating water levels that could leave behind pools of trapped water could increase mosquito breeding habitat. Increased population and development could expose more people to mosquitos. Construction activities could expose people to hazardous materials, including known and unknown waste sites and hazardous products, such as fuels and oils, commonly used during construction.

With appropriate mitigation measures, these impacts would be reduced to less than significant.

5.1.2 Delta Region

Continued development in the Delta region would result in a larger population with potential exposure to mosquitos. This potential impact to public health in the Delta Region could be mitigated to less than significant using existing mosquito control practices.

The Stone Lakes National Wildlife Refuge Project would also result in potential impacts to public health. Refuge plans include restoration of wetlands, which could increase the amount of mosquito breeding habitat. These impacts could be mitigated to less than significant using existing mosquito control practices.

The Los Vaqueros Reservoir Project would also result in potential impacts to public health. The shallow water at the edge of the Reservoir and pockets of standing water left

as the Reservoir level decreases would create potential mosquito breeding habitat. These impacts could be mitigated to less than significant using existing mosquito control practices.

Construction activities for Los Vaqueros Reservoir Project would have potential public health and environmental hazard impacts. During construction, water could be temporarily ponded or isolated. If ponded or isolated water is allowed to stand for more than three days, mosquitos could use the water for larvae and adult mosquitos may emerge. This potential could be mitigated, where possible, by limiting construction to cooler seasons when mosquito reproduction is at its lowest.

Construction activities for the Los Vaqueros Reservoir Project could expose both people and the environment to hazardous materials. Hazardous materials, including hazardous wastes from known and unknown sources could be encountered during construction. Other hazardous products, su :h as fuels and oils, are commonly used during construction.

The potential impacts from hazardous materials associated with construction activities could be mitigated. Mitigation measures include avoidance of known existing hazardous materials and waste sites during construction, proper management of hazardous construction materials, and proper handling of unknown waste sites encountered during construction.

5.1.3 Bay Region

Potential impacts from possible fluctuating water levels trapping pools of stagnant water and increased development would be similar to those for the Delta Region.

5.1.4 Sacramento River Region

More water for refuge needs may lead to an increase in potential mosquito breeding habitat by increasing the area of wetland habitat. Changes in timing of water deliveries to refuges could increase pockets of water left behind on the shoreline that can support the growth of mosquito larvae. Continued development in the Sacramento River Region would result in a larger population with potential exposure to mosquitos.

5.1.5 San Joaquin River Region

Potential impacts due to additional water for refuge needs, changes in timing of water deliveries, or increased development would be similar to those for the Delta Region.

Agricultural land would be retired in the San Joaquin River Region as part of the No Action Alternative. This land would probably be reseeded with grasses and grazed by livestock or occasionally dryland farmed. These measures are similar to methods used on lands which have been fallowed historically due to crop rotation or periodic cropping pattern changes.

Because the cultivated and fallowed acreage patterns are similar to historical patterns, mosquito habitat distribution would be similar to historical conditions. No significant change in mosquito production is anticipated. However, some minor beneficial impacts may occur if irrigation canals and other facilities are eliminated when the land is fallowed.

5.1.6 SWP and CVP Service Areas Outside Central Valley

The Metropolitan Water District Eastside Reservoir Project would result in potential impacts to public health. The impacts and mitigation would be the same as discussed for the Los Vaqueros Reservoir in the Delta Region with the No Action Alternative.

Impacts from construction activities for the

Eastside Reservoir Project and the MWD Inland Feeder Project and mitigation measures would also be the same as discussed for the Los Vaqueros Reservoir in the Delta Region with the No Action Alternative.

5.2 Delta Region

5.2.1 Summary of Regional Effects by Alternative

Summary of Potential Significant Impacts

Alternatives that include a substantial amount of land to be flooded or converted to wetlands habitat have potentially significant impacts to public health. These actions can significantly increase the area of available mosquito breeding habitat. Mosquitos can transmit several diseases, including malaria and encephalitis, and can be a nuisance. Construction activities that occur near known hazardous materials or waste sites also have potentially significant impacts.

Summary of Mitigation Strategies

Mitigation strategies for impacts from mosquito habitat creation and from exposure to hazardous materials during construction are discussed in Section 2.1.

Summary of Potential Significant Unavoidable Impacts

Potential significant impacts would be mitigated to less than significant with the mitigation measures described in Section 2.1. No potential significant unavoidable impacts to public health and environmental hazards are expected.

5.2.2 Comparison of Program Actions to No Action Alternative

A summary of potential impacts to public health in the Delta Region for each alternative is shown on Table 2.

Alternative 1

Alternative 1 consists of three subalternatives, 1a, 1b, and 1c. For each of these subalternatives, the impacts to public health and environmental hazards are the same for the common components: the Ecosystem Restoration Program Plan (ERPP), Water Quality, Water Use Efficiency, and Levee System Integrity. The impacts to public health and environmental hazards vary among subalternatives only with respect to the storage and conveyance components proposed.

Ecosystem Restoration Program Plan (ERPP)

Objectives addressing ecosystem processes may lead to impacts to mosquito breeding habitat. The floodplain area in the Delta may be expanded to improve floodplain function. In addition, increases in Central Valley spring streamflow may lead to increases in flow through the Delta Region. These actions could result in higher winter or spring flows that leave areas of shallow standing water when the water goes down. The standing water would provide potential mosquito breeding habitat.

A large amount of agricultural acreage would be converted to wetland habitat or other habitat that may contain standing water. The habitat may provide an increase in available mosquito breeding area. In addition, some agricultural land would be managed to provide habitat for wintering and migrating water fowl and other birds and associated wildlife. The management practices may include seasonal flooding of agriculture lands that were not previously flooded. This could increase the area of mosquito breeding habitat in the Delta.

Increases in the area of mosquito breeding habitat would require additional mosquito

abatement measures for mitigation. These measures include the introduction of biological or chemical agents or the ecological manipulation of the habitat.

Water Quality Program

Improved water quality in the Delta could have direct beneficial impacts for users of water in the Delta. Source control actions and treatment actions will reduce the amount of pathogens and other contaminants in the water that could negatively affect public health. Actions to relocate water supply intakes to avoid salts and organic carbon may also provide benefits to public health. Salts and organic carbons can complicate disinfection and are sources of disinfection by-products.

Improved water quality could also have indirect beneficial impacts in regards to potential mosquito production. Any water quality program actions that reduce the amount of organic material in the water may decrease the likelihood of mosquitos breeding in that water. However, this may not lead to a significant change in the level of mosquito production.

Selenium, arsenic, mercury, pesticides, and other contaminants can occur in elevated levels in irrigation water runoff. These contaminants can have negative consequences for waterfowl and other wildlife. Water Quality Program actions that reduce the concentration of pollutants in irrigation water runoff may have beneficial impacts for waterfowl and other wildlife.

Water Use Efficiency Program

There may be an impact to the level of mosquito production as a result of Water Use Efficiency actions. More efficient irrigation may result in less water left standing on cropland. This could provide a benefit by reducing potential mosquito breeding habitat.

The Water Use Efficiency Program may modify the timing of wetland dewatering or reduce the amount of applied water. This could potentially affect the amount of mosquito habitat in the wetland areas and refuges.

Levee System Integrity Program

The Levee System Integrity Program would provide direct benefits to public health and environmental hazards by reducing the potential for destructive flooding.

Some levee reconstruction would include landside fill that creates riparian habitat on the waterside of the levee. Reconstruction may also create dikes that restrict ponded water on the islands. These levee components may lead to a small increase in potential mosquito habitat due to pockets of standing water in the riparian habitat and in the ponded water on the island. Other levees would be setback in a manner that may increase the amount of wetland habitat on the waterside of the levee. The wetlands could provide new mosquito breeding habitat.

During construction of levee repairs and strengthening measures, water could be temporarily ponded or isolated. If ponded or isolated water is allowed to stand for more than three days, mosquitos could use the water for larvae and adult mosquitos may emerge. This potential could be mitigated, where possible, by limiting construction to cooler seasons when mosquito reproduction is at its lowest.

Levee reconstruction activities could also expose both people and the environment to hazardous materials. Hazardous materials, including hazardous wastes from known and unknown sources, could be encountered during construction. Other hazardous products, such as fuels and oils, are commonly used during construction.

The potential impacts from hazardous materials associated with construction activities could be mitigated. Mitigation measures include avoidance of known existing hazardous materials and waste sites during construction, proper management of hazardous construction materials, and proper handling of unknown waste sites encountered during construction.

As part of the Levee System Integrity Program, some shallow islands would be flooded to control subsidence. This would create flooded wetlands which may be potential mosquito breeding habitat.

Storage Facilities

All three subalternatives for Alternative 1 would have some reoperation of system facilities. Changes in timing or volume of reservoir releases could increase pockets of water left behind on shoreline that can support the growth of mosquito larvae. Similarly, if river levels rise to a higher level than normal as a result of extra flow, and then recede, habitat for mosquitos may be created in isolated water pockets left in river riparian corridors.

Conveyance Facilities

No new conveyance facilities are associated with Alternative 1a. Conveyance modifications and operations proposed for Alternatives 1b and 1c may change timing or volume of flow in rivers. If river levels rise to a higher level than normal as a result of extra flow, and then recede, habitat for mosquitos may be created in isolated water pockets left in river riparian corridors.

Construction activities for river channel enlargement in Alternative 1c could have potential public health and environmental hazard impacts. During construction, water could be temporarily ponded or isolated. If ponded or isolated water is allowed to stand for more than three days, mosquitos could use the water for larvae and adult mosquitos may emerge. This potential could be mitigated, where possible, by limiting construction to cooler seasons when mosquito reproduction is at its lowest.

Construction activities could also expose both people and the environment to hazardous materials. Hazardous materials, including hazardous wastes from known and unknown sources, could be encountered during construction. Other hazardous products, such as fuels and oils, are commonly used during construction.

The potential impacts from hazardous materials associated with construction activities could be mitigated. Mitigation measures include avoidance of known existing hazardous materials and waste sites during construction, proper management of hazardous construction materials, and proper handling of unknown waste sites encountered during construction.

The enlarged river channel may also result in increased mosquito breeding habitat. High flows could cover a greater surface area of the channel than previously. When flows recede, water could be left standing in pockets in the enlarged channel, creating suitable mosquito breeding habitat.

Alternative 2

Alternative 2 consists of five alternatives, 2a, 2b, 2c, 2d, and 2e. For each of these subalternatives, the impacts to public health and environmental hazards are similar to the impacts for Alternative 1 for the common program components: the Ecosystem Restoration Program Plan, Water Quality, Water Use Efficiency, and Levee System Integrity. Differences in impacts from Alternative 1 are noted below. Differences among the subalternatives for common components are also noted.

The impacts to public health and

environmental hazards vary among the subalternatives with respect to the proposed storage and conveyance components.

Ecosystem Restoration Program Plan (ERPP)

The potential impacts of the ERPP are similar to Alternative 1 for Alternative 2. The subalternatives of Alternative 2 have only minor changes in amount and location of habitat. The potential impacts from an increase in available mosquito breeding habitat are expected to be similar to that for Alternative 1.

Water Quality Program

Potential Water Quality Program impacts from all five subalternatives of Alternative 2 are the same as for Alternative 1.

Water Use Efficiency Program

Potential Water Use Efficiency Program impacts from all five subalternatives of Alternative 2 are the same as for Alternative 1.

Levee System Integrity Program

Potential impacts from the Levee System Integrity Program for all five subalternatives would be similar to the potential impacts from Alternative 1, with minor increases in the level of levee reconstruction.

The minor increases for Alternatives 2a, 2b, 2d, and 2e include levee modification for flooding tracts for conveyance. The impacts from flooding the tracts are included in the Conveyance section.

Storage Facilities

Alternative 2c includes flooding of a Delta tract for storage. The flooded area may provide an increase in available mosquito breeding area, especially along the edges of the flooded tract where the water may be shallower and warmer. This could be a significant increase in potential mosquito breeding habitat compared to Alternative 1. The potential impacts from an increase in mosquito habitat due to storage facilities are expected to be greater for Alternative 2c than for Alternative 1 or the other subalternatives for Alternative 2.

Conveyance Facilities

As with Alternative 1, proposed conveyance modifications and operations may change timing or volume of flow in rivers. If river levels rise to a higher level than normal as a result of extra flow, and then recede, habitat for mosquitos may be created in isolated water pockets left in river riparian corridors.

Alternative 2c includes construction of isolated conveyance channels. Channel construction activities could expose both people and the environment to hazardous materials. Hazardous materials, including hazardous wastes fr)m known and unknown sources, could be encountered during construction. Other hazardous products, such as fuels and oils, are commonly used during construction.

During construction, water could be temporarily ponded or isolated. If ponded or isolated water is allowed to stand for more than three days, mosquitos could use the water for larvae and adult mosquitos may emerge.

The construction impacts may result in minor to moderately greater potential impacts from Alternative 2c compared to Alternative 1.

Alternatives 2a, 2b, 2d, and 2e include channel widening and Delta tract flooding as part of the conveyance facilities. The types of potential impacts from channel widening are similar to the impacts discussed in Conveyance Facilities for Alternative 1.

Delta tract flooding may provide an increase in available mosquito breeding area by creating wetland habitat along the edges of the flooded tract where the water may be shallower and warmer.

As a result of these actions, these four subalternatives would have significantly greater impacts from conveyance facilities compared to Alternative 1 or Alternative 2c. Alternative 2e would have the greatest increase in wetlands acreage and potential mosquito habitat and as a result would have the greatest potential impacts from conveyance facilities of these four subalternatives. Alternative 2d would have the next greatest potential impacts, followed by Alternatives 2a and 2b, which would have the same potential impacts.

Potential construction impacts from reconstruction of levees for conveyance purposes are discussed in the Levee System Integrity Program section.

Alternative 3

Alternative 3 consists of nine alternatives, 3a through 3i. For each of these subalternatives, the impacts to public health and environmental hazards are similar to the impacts for Alternative 1 for the common program components: the Ecosystem Restoration Program Plan, Water Quality, Water Use Efficiency, and Levee System Integrity. Differences in impacts from Alternative 1 are noted below. Differences among the subalternatives for common components are also noted.

With respect to the proposed storage and conveyance components, the impacts to public health and environmental hazards vary among the subalternatives

Ecosystem Restoration Program Plan (ERPP)

The potential impacts of the ERPP are similar to Alternative 1 for all subalternatives except 3h. These subalternatives have only minor changes in amount and location of habitat. The potential impacts from an increase in available mosquito breeding habitat are expected to be similar to that for Alternative 1.

Alternative 3h adds more acres of wetlands habitat under the ERPP than Alternative 1. This additional habitat would be available mosquito breeding habitat. The potential impacts from an increase in mosquito breeding habitat are expected to be greater than for the other subalternatives in Alternative 3 .

Water Quality Program

All subalternatives in Alternative 3 include actions to relocate water supply intakes to avoid salts and organic carbon. Salts and organic carbons can complicate disinfection and are sources of disinfection by-products. These actions may result in greater beneficial impacts to water quality from Alternative 3 compared to Alternative 1.

Water Use Efficiency Program

Potential Water Use Efficiency Program impacts from all nine subalternatives of Alternative 3 are the same as for Alternative 1.

Levee System Integrity Program

Potential impacts from the Levee System Integrity Program for subalternatives 3a through 3i would be similar to the potential impacts from Alternative 1, with minor increases in the level of levee reconstruction. These subalternatives include levee modification for flooding tracts for conveyance. The impacts from flooding the tracts are included in the Conveyance section.

Storage Facilities

Alternatives 3a, 3c, 3d, and 3h do not include storage facilities in the Delta region, so the potential impacts are expected to be the same as for Alternative 1a.

Alternatives 3b, 3e, and 3g include in-Delta storage. These storage facilities, especially if they include new reservoirs, would result in new available mosquito breeding habitat. They may also have significant effects on public health from construction impacts, similar to the construction impacts described for levee and conveyance facility construction for Alternative 1. This actions would result in greater potential impacts to public health for these alternatives compared to Alternative 1 or Alternatives 3a, 3c, or 3d.

Alternative 3i would include storage by flooding a Delta island. Although this would result in greater potential impacts from the Storage program compared to Alternative 1, the potential impacts would be less than for Alternatives 3b, 3e, and 3g.

Alternative 3f would have the greatest potential storage program impacts in the Delta region compared to all other alternatives. This is due to the Delta islands that would be flooded for storage with this subalternative.

Conveyance Facilities

The subalternatives in Alternative 3 include channel widening through levee setback and construction of new conveyance channels. The potential impacts from the channel widening would be similar to those described for Alternative 2. The construction of the conveyance channels would result in additional potential impacts from construction activities, of the same type discussed for levee construction. As a result, Alternative 3 is expected to have greater potential impacts to public health from conveyance facilities compared Alternative 1 or 2. The subalternatives 3f and 3h have significantly higher impacts due to extra setback levees and widened channels that increase potential mosquito habitat. Subalternative 3h also adds many new acres of wetlands due to channel modifications.

5.3 Bay Region

5.3.1 Summary of Regional effects by Alternative

Summary of Potential Significant Impacts

Potential significant impacts would occur primarily as a result of habitat restoration activities that are part of the ERPP. These activities can significantly increase the area of available mosquito breeding habitat. Mosquitos can transmit several diseases, including malaria and encephalitis, and can be a nuisance. Potential impacts are expected to be similar for the three main alternatives.

Summary of Mitigation Strategies

Mitigation strategies for impacts from mosquito habitat creation are discussed in Section 2.1.

Summary of Potential Significant Unavoidable Impacts

Potential significant impacts would be mitigated to less than significant with the mitigation measures described in Section 2.1. No potential significant unavoidable impacts to public health and environmental hazards are expected.

5.3.2 Comparison of Program Actions to No Action Alternative

A summary of potential impacts to public health in the Bay Region for each alternative is shown on Table 3.

Alternative 1

For each of these subalternatives 1a, 1b, and 1c, the impacts to public health and environmental hazards are the same for the following common components: the Ecosystem Restoration Program Plan (ERPP), Water Quality, and Water Use Efficiency. The Levee System Integrity Program and Storage Facilities Programs are not applicable in the Bay Region. There are minor variations in impacts to public health and environmental hazards among the subalternatives for the conveyance components proposed.

Ecosystem Restoration Program Plan (ERPP)

The ERPP includes several actions involving restoration in the Bay Region. In general, these actions are similar to those proposed for the Delta Region for Alternative 1 described above. These actions are anticipated to have similar impacts on public health and environmental hazards in the Bay Region.

Water Quality Program

The anticipated benefits of the Water Quality Program to public health and environmental hazards in the Bay Region are similar to those in the Delta Region for Alternative 1. See discussion in Section 5.2.2.

Water Use Efficiency Program

The potential impacts of the Water Use Efficiency Program on public health and environmental hazards in the Bay Region are similar to those in the Delta Region. See discussion in Section 5.2.2.

Levee System Integrity Program

Not applicable.

Storage Facilities

Not applicable.

Conveyance Facilities

As with Alternative 1 for the Delta region, proposed conveyance modifications and operations may change timing or volume of flow in rivers. If river levels rise to a higher level than normal as a result of extra flow, and then recede, habitat for mosquitos may be created in isolated water pockets left in river riparian corridors.

Alternative 2

For each of the five subalternatives in Alternative 2, the impacts to public health and environmental hazards are similar to the impacts for Alternative 1 for the common program components: the Ecosystem Restoration Program Plan, Water Quality, and Water Use Efficiency. The Levee System Integrity Program and Storage Facilities Programs are not applicable in the Bay Region. There are minor variations in impacts to public health and environmental hazards among the subalternatives for the conveyance components proposed.

Ecosystem Restoration Program Plan (ERPP)

The ERPP includes several actions involving restoration in the Bay Region. In general, these actions are similar to those proposed for Alternative 1 described above. These actions are anticipated to have similar impacts on public health and environmental hazards compared to Alternative 1.

Water Quality Program

The anticipated benefits of the Water Quality Program to public health and environmental hazards in the Bay Region are similar to those for Alternative 1.

Water Use Efficiency Program

The potential impacts of the Water Use Efficiency Program on public health and environmental hazards in the Bay Region are similar to those for Alternative 1.

Levee System Integrity Program

Not applicable.

Storage Facilities

Not applicable.

Conveyance Facilities

As with Alternative 1, proposed conveyance modifications and operations may change timing or volume of flow in rivers. If river levels rise to a higher level than normal as a result of extra flow, and then recede, habitat for mosquitos may be created in isolated water pockets left in river riparian corridors.

Alternative 3

For each of these nine subalternatives in Alternative 3, the impacts to public health and environmental hazards are similar to the impacts for Alternative 1 for the common program components: the Ecosystem Restoration Program Plan, Water Quality, and Water Use Efficiency. The Levee System Integrity Program and Storage Facilities Programs are not applicable in the Bay Region. There are minor variations in impacts to public health and environmental hazards among the subalternatives for the conveyance components proposed.

Ecosystem Restoration Program Plan (ERPP)

The ERPP includes several actions involving restoration in the Bay Region. In general, these actions are similar to those proposed for Alternative 1 described above. These actions are anticipated to have similar impacts on public health and environmental hazards compared to Alternative 1.

Water Quality Program

The anticipated benefits of the Water Quality Program to public health and environmental hazards in the Bay Region are similar to those for Alternative 1.

Water Use Efficiency Program

The potential impacts of the Water Use Efficiency Program on public health and environmental hazards in the Bay Region are similar to those for Alternative 1.

Levee System Integrity Program

Not applicable.

Storage Facilities

Not applicable.

Conveyance Facilities

As with Alternative 1, proposed conveyance modifications and operations may change timing or volume of flow in rivers. If river levels rise to a higher level than normal as a result of extra flow, and then recede, habitat for mosquitos may be created in isolated water pockets left in river riparian corridors.

5.4 Sacramento River Region

5.4.1 Summary of Regional effects by Alternative

Summary of Potential Significant Impacts

Potential significant impacts would occur primarily as a result of new storage facilities and habitat restoration activities. These activities can significantly increase the area of available mosquito breeding habitat, which can lead to an increase in the transmission of several diseases, and can lead to exposure to hazardous materials through construction activities. Potential impacts vary for the subalternatives within

each alternative.

Summary of Mitigation Strategies

Mitigation strategies for impacts from mosquito habitat creation and from exposure to hazardous materials during construction are discussed in Section 2.1.

Summary of Potential Significant Unavoidable Impacts

Potential significant impacts would be mitigated to less than significant with the mitigation measures described in Section 2.1. No potential significant unavoidable impacts to public health and environmental hazards are expected.

5.4.2 Comparison of Program Actions to No Action Alternative

A summary of potential impacts to public health in the Sacramento River Region for each alternative is shown on Table 4.

Alternative 1

For each of these subalternatives 1a, 1b, and 1c, the impacts to public health and environmental hazards are the same for the following common components: the Ecosystem Restoration Program Plan (ERPP), Water Quality, and Water Use Efficiency. The Levee System Integrity Program is not applicable in the Sacramento River Region. There are minor variations in impacts to public health and environmental hazards among the subalternatives for the conveyance components proposed. Significant variations in potential impacts occur only with the storage components.

Ecosystem Restoration Program Plan (ERPP)

The restoration activities included in the ERPP for the Sacramento River Region are primarily focused on the protection of fish. Some actions to restore and protect riparian habitat are also included. The restoration actions do not include the creation of wetlands habitats, which may provide the most significant new mosquito breeding habitat. As a result, actions in the Sacramento River Region are anticipated to have less potential negative impact on public health and environmental hazards as compared to the Delta or Bay Region.

The increase in riparian habitat may result in an increase in mosquito breeding habitat, if the habitat creation results in more potential for leaving isolated pockets of water when streams recede.

Water Quality Program

The anticipated benefits of the Water Quality Program to public health and environmental hazards in the Sacramento River Region are similar to those discussed in the Delta Region for Alternative 1.

Water Use Efficiency Program

The potential impacts of the Water Use Efficiency Program on public health and environmental hazards in the Sacramento River Region are similar to those in the Delta Region for Alternative 1.

Levee System Integrity Program

Not applicable.

Storage Facilities

Alternative 1c includes additional surface storage that could create new mosquito breeding habitat or lead to exposure to hazardous materials during construction. As a result, Alternative 1c would have greater potential impacts to public health from storage facilities compared to Alternatives 1a or 1b.

Conveyance Facilities

As with Alternative 1 for the Delta region, proposed conveyance modifications and operations may change timing or volume of flow in rivers. If river levels rise to a higher level than normal as a result of extra flow, and then recede, habitat for mosquitos may be created in isolated water pockets left in river riparian corridors.

Alternative 2

For each of the five subalternatives in Alternative 2, the impacts to public health and environmental hazards are similar to the impacts for Alternative 1 for the common program components: the Ecosystem Restoration Program Plan, Water Quality, and Water Use Efficiency. The Levee System Integrity Program is not applicable in the Sacramento River Region. There are minor variations in impacts to public health and environmental hazards among the subalternatives for the conveyance components proposed. Significant variations in potential impacts occur only with the storage components.

Ecosystem Restoration Program Plan (ERPP)

The ERPP includes several actions involving restoration in the Sacramento River Region. In general, these actions are similar to those proposed for Alternative 1 described above. These actions are anticipated to have similar impacts on public health and environmental hazards compared to Alternative 1.

Water Quality Program

The anticipated benefits of the Water Quality Program to public health and environmental hazards in the Sacramento River Region are similar to those for Alternative 1.

Water Use Efficiency Program

The potential impacts of the Water Use Efficiency Program on public health and environmental hazards in the Sacramento River Region are similar to those for Alternative 1.

Levee System Integrity Program

Not applicable.

Storage Facilities

Alternatives 2b and 2e include additional surface storage that could create new mosquito breeding habitat or lead to exposure to hazardous materials during construction. As a result, Alternatives 2b and 2e would have greater potential impacts to public health from storage facilities compared to Alternatives 2a, 2c, or 2d.

Conveyance Facilities

As with Alternative 1, proposed conveyance modifications and operations may change timing or volume of flow in rivers. If river levels rise to a higher level than normal as a result of extra flow, and then recede, habitat for mosquitos may be created in isolated water pockets left in river riparian corridors.

Alternative 3

For each of the nine subalternatives in Alternative 3, the impacts to public health and environmental hazards are similar to the impacts for Alternative 1 for the following common program components: the Ecosystem Restoration Program Plan, Water Quality, and Water Use Efficiency. The Levee System Integrity Program is not applicable in the Sacramento River Region. There are minor variations in impacts to public health and environmental hazards among the subalternatives for the conveyance components proposed. Significant variations in potential impacts occur only with the storage components.

Ecosystem Restoration Program Plan (ERPP)

The ERPP includes several actions involving restoration in the Sacramento River Region. In general, these actions are similar to those proposed for Alternative 1 described above. These actions are anticipated to have similar impacts on public health and environmental hazards compared to Alternative 1.

Water Quality Program

The anticipated benefits of the Water Quality Program to public health and environmental hazards in the Sacramento River Region are similar to those for Alternative 1.

Water Use Efficiency Program

The potential impacts of the Water Use Efficiency Program on public health and environmental hazards in the Sacramento River Region are similar to those for Alternative 1.

Levee System Integrity Program

Not applicable.

Storage Facilities

Alternatives 3b, 3d, 3e, 3f, 3g, 3h, and 3i include additional surface storage that could create new mosquito breeding habitat or lead to exposure to hazardous materials during construction. As a result, these alternatives would have greater potential impacts to public health from storage facilities compared to Alternatives 3a or 3c.

Conveyance Facilities

As with Alternative 1, proposed conveyance modifications and operations may change timing or volume of flow in rivers. If river levels rise to a higher level than normal as a result of extra flow, and then recede, habitat for mosquitos may be created in isolated water pockets left in river riparian corridors.

5.5 San Joaquin River Region

5.5.1 Summary of Regional effects by Alternative

Summary of Potential Significant Impacts

Potential significant impacts would occur primarily as a result of new storage facilities and habitat restoration activities. These activities can significantly increase the area of available mosquito breeding habitat, which can lead to an increase in the transmission of several diseases, and can lead to exposure to hazardous materials through construction activities. Potential impacts vary for the subalternatives within each alternative.

Summary of Mitigation Strategies

Mitigation strategies for impacts from mosquito habitat creation and from exposure to hazardous materials during construction are discussed in Section 2.1.

Summary of Potential Significant Unavoidable Impacts

Potential significant impacts would be mitigated to less than significant with the mitigation measures described in Section 2.1. No potential significant unavoidable impacts to public health and environmental hazards are expected.

5.5.2 Comparison of Program Actions to No Action Alternative

A summary of potential impacts to public health in the San Joaquin River Region for each alternative is shown on Table 5.

Alternative 1

For each of these subalternatives 1a, 1b, and 1c, the impacts to public health and environmental hazards are the same for the following common components: the Ecosystem Restoration Program Plan (ERPP), Water Quality, and Water Use

Efficiency. The Levee System Integrity Program is not applicable in the San Joaquin River Region. There are minor variations in impacts to public health and environmental hazards among the subalternatives for the conveyance components proposed. Significant variations in potential impacts occur only with the storage components.

Ecosystem Restoration Program Plan

The restoration program is generally the same as for the Sacramento River Region for Alternative 1, except that restoration actions include a small amount of wetlands habitat creation, which tends to provide the most significant new mosquito breeding habitat. As a result, actions in the San Joaquin River Region are anticipated to have less potential negative impact on public health and environmental hazards as compared to the Delta or Bay Region for Alternative 1.

Water Quality Program

The anticipated benefits of the Water Quality Program to public health and environmental hazards in the San Joaquin River Region are similar to those in the Delta Region for Alternative 1, with the exceptions noted below.

In addition agricultural land would be retired to improve water quality. If the retired land includes irrigated land, several sources of mosquito breeding habitat may be eliminated. These sources include irrigation canals and ponding in fields during irrigation.

Agricultural drainage ponds (each covering approximately 30 acres) would be created to reduce pollutant concentrations. The stored water may become mosquito breeding habitat. The more slowly the ponds are drained, the more likely the ponds are to become mosquito breeding habitat. Since these ponds are located on agricultural lands, the potential for contact between mosquitos from this habitat with large populations is quite small. However, there may be contact with agricultural workers and livestock.

Water Use Efficiency Program

The potential impacts of the Water Use Efficiency Program on public health and environmental hazards in the San Joaquin River Region are similar to those in the Delta Region for Alternative 1.

Levee System Integrity Program

Not applicable.

Storage Facilities

Alternative 1c includes additional surface storage that could create new mosquito breeding habitat or lead to exposure to hazardous materials during construction. As a result, Alternative 1c would have greater potential impacts to public health from storage facilities compared to Alternatives 1a or 1b.

Conveyance Facilities

As with Alternative 1 for the Delta region, proposed conveyance modifications and operations may change timing or volume of flow in rivers. If river levels rise to a higher level than normal as a result of extra flow, and then recede, habitat for mosquitos may be created in isolated water pockets left in river riparian corridors.

Alternative 2

For each of the five subalternatives in Alternative 2, the impacts to public health and environmental hazards are similar to the impacts for Alternative 1 for the common program components: the Ecosystem Restoration Program Plan, Water Quality, and Water Use Efficiency. The Levee System Integrity Program is not applicable in the

San Joaquin River Region. There are minor variations in impacts to public health and environmental hazards among the subalternatives for the conveyance components proposed. Significant variations in potential impacts occur only with the storage components.

Ecosystem Restoration Program Plan (ERPP)

The ERPP includes several actions involving restoration in the San Joaquin River Region. In general, these actions are similar to those proposed for Alternative 1 described above. These actions are anticipated to have similar impacts on public health and environmental hazards compared to Alternative 1.

Water Quality Program

The anticipated benefits of the Water Quality Program to public health and environmental hazards in the San Joaquin River Region are similar to those for Alternative 1.

Water Use Efficiency Program

The potential impacts of the Water Use Efficiency Program on public health and environmental hazards in the San Joaquin River Region are similar to those for Alternative 1.

Levee System Integrity Program

Not applicable.

Storage Facilities

Alternatives 2b and 2e include additional surface storage that could create new mosquito breeding habitat or lead to exposure to hazardous materials during construction. As a result, Alternatives 2b and 2e would have greater potential impacts to public health from storage facilities compared to Alternatives 2a, 2c, or 2d.

Conveyance Facilities

As with Alternative 1, proposed conveyance modifications and operations may change timing or volume of flow in rivers. If river levels rise to a higher level than normal as a result of extra flow, and then recede, habitat for mosquitos may be created in isolated water pockets left in river riparian corridors.

Alternative 3

For each of the nine subalternatives in Alternative 3, the impacts to public health and environmental hazards are similar to the impacts for Alternative 1 for the following common program components: the Ecosystem Restoration Program Plan, Water Quality, and Water Use Efficiency. The Levee System Integrity Program is not applicable in the San Joaquin River Region. There are minor variations in impacts to public health and environmental hazards among the subalternatives for the conveyance components proposed. Significant variations in potential impacts occur only with the storage components.

Ecosystem Restoration Program Plan (ERPP)

The ERPP includes several actions involving restoration in the San Joaquin River Region. In general, these actions are similar to those proposed for Alternative 1 described above. These actions are anticipated to have similar impacts on public health and environmental hazards compared to Alternative 1.

Water Quality Program

The anticipated benefits of the Water Quality Program to public health and environmental hazards in the San Joaquin River Region are similar to those for Alternative 1.

Water Use Efficiency Program

The potential impacts of the Water Use Efficiency Program on public health and environmental hazards in the San Joaquin River Region are similar to those for Alternative 1.

Levee System Integrity Program

Not applicable.

Storage Facilities

Alternatives 3b, 3d, 3e, 3f, 3g, 3h, and 3i include additional surface storage that could create new mosquito breeding habitat or lead to exposure to hazardous materials during construction. As a result, these alternatives would have greater potential impacts to public health from storage facilities compared to Alternatives 3a or 3c.

Conveyance Facilities

As with Alternative 1, proposed conveyance modifications and operations may change timing or volume of flow in rivers. If river levels rise to a higher level than normal as a result of extra flow, and then recede, habitat for mosquitos may be created in isolated water pockets left in river riparian corridors.

5.6 SWP and CVP Service Areas Outside Central Valley

5.6.1 Summary of Regional effects by Alternative

Summary of Potential Significant Impacts

Potential significant impacts would occur primarily as a result of new storage facilities. These activities can significantly increase the area of available mosquito breeding habitat, which can lead to an increase in the transmission of several diseases, and can lead to exposure to hazardous materials through construction activities. Potential impacts vary for the subalternatives within each alternative.

Summary of Mitigation Strategies

Mitigation strategies for impacts from mosquito habitat creation and from exposure to hazardous materials during construction are discussed in Section 2.1.

Summary of Potential Significant Unavoidable Impacts

Potential significant impacts would be mitigated to less than significant with the mitigation measures described in Section 2.1. No potential significant unavoidable impacts to public health and environmental hazards are expected.

5.6.2 Comparison of Program Actions to No Action Alternative

A summary of potential impacts to public health in the SWP and CVP Service Areas Outside the Central Valley for each alternative is shown on Table 6.

Alternative 1

For each of these subalternatives 1a, 1b, and 1c, the impacts to public health and environmental hazards are the same for the following common components: Water Quality and Water Use Efficiency. The Levee System Integrity Program, Conveyance Facilities, and ERPP are not applicable in the SWP and CVP Service Areas Outside Central Valley Region. Significant variations in potential impacts occur only with the storage components.

Ecosystem Restoration Program Plan

Not applicable.

Water Quality Program

The anticipated benefits of the Water Quality Program to public health and environmental hazards in the SWP and CVP Service Areas Outside Central Valley Region are similar to

those in the Delta Region for Alternative 1.

Water Use Efficiency Program

The potential impacts of the Water Use Efficiency Program on public health and environmental hazards in the SWP and CVP Service Areas Outside Central Valley Region are similar to those in the Delta Region for Alternative 1.

Levee System Integrity Program

Not applicable.

Storage Facilities

Alternative 1c includes additional surface storage off-aqueduct that could create new mosquito breeding habitat or lead to exposure to hazardous materials during construction. As a result, Alternative 1c would have greater potential impacts to public health from storage facilities compared to Alternatives 1a or 1b.

Conveyance Facilities

Not applicable.

Alternative 2

For each of the five subalternatives in Alternative 2, the impacts to public health and environmental hazards are the same for the following common components: Water Quality and Water Use Efficiency. The Levee System Integrity Program, Conveyance Facilities, and ERPP are not applicable in the SWP and CVP Service Areas Outside Central Valley Region. Significant variations in potential impacts occur only with the storage components.

Ecosystem Restoration Program Plan (ERPP)

Not applicable.

Water Quality Program

The anticipated benefits of the Water Quality Program to public health and environmental hazards in the SWP and CVP Service Areas Outside Central Valley Region are similar to those for Alternative 1.

Water Use Efficiency Program

The potential impacts of the Water Use Efficiency Program on public health and environmental hazards in the SWP and CVP Service Areas Outside Central Valley Region are similar to those for Alternative 1.

Levee System Integrity Program

Not applicable.

Storage Facilities

Alternatives 2b, 2d, and 2e include additional off-aqueduct, South of Delta surface storage that could create new mosquito breeding habitat or lead to exposure to hazardous materials during construction. As a result, Alternatives 2b, 2d and 2e would have greater potential impacts to public health from storage facilities compared to Alternatives 2a or 2c.

Conveyance Facilities

Not applicable.

Alternative 3

For each of the nine subalternatives in Alternative 3, the impacts to public health and environmental hazards are the same for the following common components: Water Quality and Water Use Efficiency. The Levee System Integrity Program, Conveyance Facilities, and ERPP are not applicable in the SWP and CVP Service Areas Outside Central Valley Region. Significant variations in potential impacts occur only with the storage components.

Ecosystem Restoration Program Plan (ERPP)

Not applicable.

Water Quality Program

The anticipated benefits of the Water Quality Program to public health and environmental hazards in the SWP and CVP Service Areas Outside Central Valley Region are similar to those for Alternative 1.

Water Use Efficiency Program

The potential impacts of the Water Use Efficiency Program on public health and environmental hazards in the SWP and CVP Service Areas Outside Central Valley Region are similar to those for Alternative 1.

Levee System Integrity Program

Not applicable.

Storage Facilities

Alternatives 3b, 3d, 3e, 3f, 3g, 3h, and 3i include additional surface storage that could create new mosquito breeding habitat or lead to exposure to hazardous materials during construction. As a result, these alternatives would have greater potential impacts to public health from storage facilities compared to Alternatives 3a or 3c.

Conveyance Facilities

Not applicable.

6.0 REFERENCES

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Facility Descriptions and Updated Cost Estimates for Shasta Lake Enlargement, prepared by the CALFED Storage and Conveyance Refinement Team, February 12, 1997.

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Project Descriptions and Updated Cost Estimates for Sites/Colusa Reservoir Project, prepared by the CALFED Storage and Conveyance Refinement Team, March 25, 1997.

Selected Public Health Concerns in the Delta Regions, CALFED Bay-Delta Program, DRAFT Affected Environment Technical Report, September 23, 1996.

Summary of Common Programs -- DRAFT, Appendix B, CALFED Bay-Delta Program, April 22, 1997.

Table 1
Public Health and Environmental Hazards Compared to the No-Action Alternative

Region	Alternatives																		
	Existing Conditions	No Action	1a	1b	1c	2a	2b	2c	2d	2e	3a	3b	3c	3d	3e	3f	3g	3h	3i
Delta		similar/ slightly worsened	less than significant																
Bay			less than significant																
Sacramento River			less than significant																
San Joaquin River			less than significant																
SWP_CVP Service Areas			less than significant																

Table 2a
Delta Region
Public Health and Environmental Hazards

Parameter/ Constituent	Existing Conditions	No Action	Alternatives							
			1a	1b	1c	2a	2b	2c	2d	2e
Ecosystem Restoration Program Plan (ERPP)		Continued development in the Delta Region could result in a larger population with potential exposure to mosquitos and hazardous substances. The Los Vaqueros Reservoir Project could result in increases in mosquito habitat due to standing water and increases in exposure to hazardous substances encountered or used during construction.	Restoration activities include: increased floodplain area, increased flows through the Delta Region, and conversion of agricultural drainage area to wetland habitat. All of these activities may increase mosquito habitat.							
Water Quality Program			Water quality may improve due to source control and treatment actions but mosquito production may not significantly change.							
Water Use Efficiency Program			Mosquito habitat may decrease due to more efficient irrigation and less standing water on cropland.							
Levee System Integrity Program			The Program provides direct benefits in public health by reducing the potential for destructive flooding. Mosquito habitat may increase due to increased riparian habitat and pockets of standing water. Exposure to hazardous materials may increase during the reconstruction of the levees. Hazardous materials include those used in construction and those from unknown sources encountered during construction.							
Storage Facilities			Mosquito habitat may increase due to isolated pockets of water created by changing in timing or flow of rivers.					Greater impacts that Alternative 1 due to the flooding of a Delta tract.	Same impacts as Alternative 1.	
Conveyance Facilities			No change in conveyance facilities.	Mosquito habitat may increase due to isolated pockets of water created by changing in timing or flow of rivers.	Same as Alternative 1b with the additional potential exposure to hazardous materials during the river channel enlargement construction.	Greater impacts than 2c due to channel widening and Delta tract flooding.		Greater or equivalent impacts than 1c due to the construction of conveyance channels.	Greater impacts than 2a due to Delta tract flooding.	Greatest impacts of all Alternatives 1 and 2 due to largest amount of Delta tract flooding.

Table 2b
Delta Region
Public Health and Environmental Hazards

Parameter/ Constituent	Existing Conditions	No Action	Alternatives								
			3a	3b	3c	3d	3e	3f	3g	3h	3i
Ecosystem Restoration Program Plan		Continued development in the Delta Region could result in a larger population with potential exposure to mosquitos and hazardous substances. The Los Vaqueros Reservoir Project could result in increases in mosquito habitat due to standing water and increases in exposure to hazardous substances encountered or used during construction.	Restoration activities include: increased floodplain area, increased flows through the Delta Region, and conversion of agricultural drainage area to wetland habitat. All of these activities may increase mosquito habitat.								
Water Quality Program			More beneficial impacts on water quality than from Alternative 1 or 2 due to the relocation of water intakes to avoid salts and organic carbon. Mosquito production may not significantly change								
Water Use Efficiency Program			Mosquito habitat may decrease due to more efficient irrigation and less standing water on cropland.								
Levee System Integrity Program			Mosquito habitat may increase due to increased standing water in the riparian habitat. Exposure to hazardous materials may increase during levee reconstruction.								
Storage Facilities			No storage facilities in the Delta region so no change expected.	Mosquito habitat may increase due to due to in-Delta storage. Exposure to hazardous materials may increase during construction of new storage facilities.	Same as 3a.		Same as 3b.	Greater impacts than 3b due to flooding of Delta islands for storage.	Same as 3b.	Same as 3a.	Fewer impacts than 3b due to flooding of a smaller Delta island.
Conveyance Facilities			Impacts from channel widening through setback levees and the construction of new conveyance channels may potentially increase mosquito habitat and exposure to hazardous materials greater than either Alternative 1 or 2.					Significantly greater impacts than 3a due to more setback levees.	Same as 3a.	Significantly greater impacts than 3a due to more setback levees and channel modifications that add wetland habitat.	Same as 3a.

Table 3
Bay Region
Public Health and Environmental Hazards

Parameter/ Constituent	Existing Conditions	No Action	Alternatives															
			1a	1b	1c	2a	2b	2c	2d	2e	3a	3b	3c	3d	3e	3f	3g	3h	3i
Ecosystem Restoration Program Plan (ERPP)		Continued development in the Bay Region could result in a larger population with potential exposure to mosquitos and hazardous substances.	Restoration activities include: increased floodplain area, increased flows through the Bay Region, and conversion of agricultural drainage area to wetland habitat. All of these activities may increase mosquito habitat.															
Water Quality Program			Water quality may improve due to source control and treatment actions but mosquito production may not significantly change.															
Water Use Efficiency Program			Mosquito habitat may decrease due to more efficient irrigation and less standing water on cropland.															
Conveyance Facilities			Mosquito habitat may increase due to isolated pockets of water created by changing in timing or flow of rivers.															

Table 4
Sacramento River Region
Public Health and Environmental Hazards

Parameter/ Constituent	Existing Conditions	No Action	Alternatives															
			1a	1b	1c	2a	2b	2c	2d	2e	3a	3b	3c	3d	3e	3f	3g	3h	3i
Ecosystem Restoration Program Plan (ERPP)		Continued development in theSacramento River Region could result in a larger population with potential exposure to mosquitos and hazardous substances. Exposure to hazardous substances could be from unknown sources encountered during construction or from materials used during construction. Increased water demand for refuge needs as well as potentially fluctuating water levels could potentially increase mosquito habitat.	Negative impacts on public health are low as restoration activities focus on the protection of fish and do not include the creation of wetlands or other potential mosquito breeding habitat.															
Water Quality Program			Water quality may improve due to source control and treatment actions but mosquito production may not significantly change.															
Water Use Efficiency Program			Mosquito habitat may decrease due to more efficient irrigation and less standing water on cropland.															
Storage Facilities			Mosquito habitat may increase due to changes in timing or volume of water releases. These changes could leave pockets of water behind and enhance mosquito habitat		Same as 3d.	Same as 1a.	Same as 3d.	Same as 1a.	Same as 3d.	Same as 1a.	Same as 3d.	Same as 1a.	Same as 3d.	Same as 1a.				Greater impacts than 1a due to increased surface storage.
Conveyance Facilities			Mosquito habitat may increase due to isolated pockets of water created by changing in timing or flow of rivers.															

Table 5
San Joaquin River Region
Public Health and Environmental Hazards

Parameter/ Constituent	Existing Conditions	No Action	Alternatives															
			1a	1b	1c	2a	2b	2c	2d	2e	3a	3b	3c	3d	3e	3f	3g	3h	3i
Ecosystem Restoration Program Plan (ERPP)		Continued development in the San Joaquin River Region could result in a larger population with potential exposure to mosquitos and hazardous substances. Exposure to hazardous substances could be from unknown sources encountered during construction or from materials used during construction. Increased water demand for refuge needs as well as potentially fluctuating water levels could potentially increase mosquito habitat. Agricultural land would be retired. Mosquito habitat could be reduced if irrigation canals are eliminated when the land is fallowed.	Restoration activities focus on the protection of fish and the creation of wetlands habitat. The wetlands could introduce some potential mosquito breeding habitat but negative impacts on public health are expected to be minimal.																
Water Quality Program			Water quality may improve due to source control, treatment actions, and the retirement of agricultural land. While improved water quality alone will not eliminate mosquito breeding, retired land would reduce the amount of irrigation canals and ponding in irrigated fields thus reducing potential mosquito habitat. In addition, agricultural drainage ponds would be created to reduce pollutant concentrations. These ponds may increase the potential mosquito habitat depending on the rate of drainage.																
Water Use Efficiency Program			Mosquito habitat may decrease due to more efficient irrigation and less standing water on cropland.																
Storage Facilities			Mosquito habitat may increase due to changes in timing or volume of releases. These changes could leave pockets of water behind and enhance mosquito habitat		Greater impacts than 1a due to increased surface storage.	Same as 1a.	Same as 1c.	Same as 1a.	Same as 1c.	Same as 1c.	Same as 1a.	Same as 1c.	Same as 1a.	Same as 1c.					
Conveyance Facilities			Mosquito habitat may increase due to isolated pockets of water created by changing in timing or flow of rivers.																

Table 6
SWP and CVP Service Areas Outside Central Valley
Public Health and Environmental Hazards

Parameter/ Constituent	Existing Conditions	No Action	Alternatives															
			1a	1b	1c	2a	2b	2c	2d	2e	3a	3b	3c	3d	3e	3f	3g	3h	3i
Water Quality Program		The Metropolitan Water District Eastside Reservoir Project could result in an increase in mosquito breeding ground due to the pockets of standing water left as the Reservoir recedes. Exposure to hazardous substances could occur from unknown sources encountered during construction or from materials used during construction.	Water quality may improve due to source control and treatment actions but mosquito production may not significantly change.															
Water Use Efficiency Program			Mosquito habitat may decrease due to more efficient irrigation and less standing water on cropland.															
Storage Facilities			Mosquito habitat may increase due to changes in timing or volume of releases. These changes could leave pockets of water behind and enhance mosquito habitat		Greater impacts than 1a due to increased surface storage.	Same as 1a.	Same as 1c.	Same as 1a.	Same as 1c.		Same as 1a.	Same as 1c.	Same as 1a.	Same as 1c.				

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