3.13 Hydrology

This section describes hydrologic resources (surface water, water supply, and flood management resources) that could be affected by implementation of the proposed program. Included in this description are surface water resources that affect both water supply and flood management—specifically, levees (both State Plan of Flood Control (SPFC) and non-SPFC levees), channels, dams, weirs, and other flood management infrastructure. This section is composed of the following subsections:

- Section 3.13.1, "Environmental Setting," describes the physical conditions in the study area as they apply to hydrologic resources.
- Section 3.13.2, "Regulatory Setting," summarizes federal, State, and regional and local laws and regulations pertinent to evaluation of the proposed program's impacts on hydrologic resources.
- Section 3.13.3, "Analysis Methodology and Thresholds of Significance," describes the methods used to assess the environmental effects of the proposed program and lists the thresholds used to determine the significance of those effects.
- Section 3.13.4, "Environmental Impacts and Mitigation Measures for NTMAs," discusses the environmental effects of near-term management activities (NTMAs) and identifies mitigation measures for significant environmental effects.
- Section 3.13.5, "Environmental Impacts, Mitigation Measures, and Mitigation Strategies for LTMAs," discusses the environmental effects of long-term management activities (LTMAs), identifies mitigation measures for significant environmental effects, and addresses conditions in which any impacts would be too speculative for evaluation (CEQA Guidelines, Section 15145).

NTMAs and LTMAs are described in detail in Section 2.4, "Proposed Management Activities."

For discussions of Federal Energy Regulatory Commission (FERC) licensing and hydropower, subsidence, and potential impacts on water quality, respectively, see Section 3.9, "Energy"; Section 3.10, "Geology, Soils, and Seismicity (Including Mineral and Paleontological Resources)"; and Section 3.21, "Water Quality."

3.13.1 Environmental Setting

Information Sources Consulted

Sources of information used to prepare this section include the following:

- *Flood Control System Status Report* (DWR 2011)
- *Post-Flood Assessment for 1983, 1986, 1995, and 1997, Central Valley, California* (USACE 1999)
- *Sacramento and San Joaquin River Basins Comprehensive Study* (Comprehensive Study) (USACE 2002a)
- *State Plan of Flood Control Descriptive Document* (DWR 2010a)
- *California Water Plan Update 2009* (DWR 2009a)

Geographic Areas Discussed

Hydrology is discussed separately for the following geographic areas within the study area because of differences in their hydrology and the potential effects of the program on this resource:

- Extended systemwide planning area (Extended SPA), divided into the Sacramento and San Joaquin Valley and foothills, and the Sacramento–San Joaquin Delta (Delta) and Suisun Marsh, including the geographic extent of the SPFC facilities
- Sacramento and San Joaquin Valley watersheds
- SoCal/coastal Central Valley Project/State Water Project (CVP/SWP) service areas

The Delta and Suisun Marsh are specifically discussed because of their unique hydrologic conditions and water supply roles. When appropriate, reservoirs and lakes are noted as being in or outside the Extended SPA to give context regarding parts of the system that may be most affected by the proposed program.

Water supply is discussed in this section because the proposed program could affect water supply reliability. Of the water districts in California, approximately 344 receive water from federal water systems such as the CVP, 38 receive water from State contracts and supply systems such as the SWP, and 693 rely on local and private water supplies. Many of these water districts are not exclusive to a single water contract source and rely instead on a combination of federal, State, and local contracts. Water supply resources related to water supply in the Sacramento and San Joaquin

Valley and foothills, Delta, and Suisun Marsh are discussed under "Extended Systemwide Planning Area." The water supply roles of reservoirs outside the Extended SPA and facilities central to CVP/SWP operations are discussed under "SoCal/Coastal CVP/SWP Service Areas."

Flood management resources are also included in this section because the proposed program could affect these resources. Flood management resources are discussed only for the geographic areas of the study area that are located within the Extended SPA. Only negligible effects on flood management resources are expected in the portion of the Sacramento and San Joaquin Valley watersheds located outside the Sacramento and San Joaquin Valley and foothills; therefore, that geographic area is not discussed in detail in this section. In addition, none of the management activities included in the proposed program would be implemented in the SoCal/coastal CVP/SWP service areas, and program implementation would not result in long-term reductions in water deliveries to these service areas (see Section 2.6, "No Near- or Long-Term Reduction in Water or Renewable Electricity Deliveries"). Further, SPFC facilities are not located in the SoCal/coastal CVP/SWP service areas, and flooding conditions or flood management resources in these service areas would not be affected by the proposed program. Given these conditions, the SoCal/coastal CVP/SWP service areas are not included in the discussion of flood management resources.

Historical Perspective on Flood Protection

In the past, under natural conditions, the Sacramento and San Joaquin rivers had insufficient capacity to carry the heavy winter and spring flows generated by wet-season precipitation and/or snowmelt. Once flow exceeded channel capacity, channels overflowed onto the surrounding countryside. Flow velocity was much less in overflow areas than in the channels. Thus, the water's sediment-carrying capacity was also less, allowing much of the material naturally eroded from the channel banks and mountain and foothill areas and carried in the streams to drop out of suspension in the overflow areas.

Over many years, the Sacramento and San Joaquin rivers built up their beds and formed natural levees composed of the heavier, coarser material carried by the seasonal flood flows. The finer material stayed in suspension much longer and tended to drop out when water ponded in the overflow basins that developed on both sides of the rivers. The higher land elevation of the natural levees adjacent to the rivers attracted the first settlements in the Central Valley (USACE 1999). Similarly, the fine, fertile soils of the overflow basins attracted early agricultural development.

The largest floods in the Sacramento River basin have been primarily rain-driven (including rain-on-snow) events occurring earlier in the season (November through February). By contrast, many of the largest floods in the San Joaquin River basin have been driven more by snowmelt and have occurred later in the season (February through April). This is a natural result of the higher elevation and drier conditions of the upper San Joaquin River basin relative to the upper Sacramento River basin.

Federal, State, local, and private entities have worked independently and interdependently over the years to shape the current flood management system in the Sacramento and San Joaquin valleys. The Sacramento River flood control system, which was developed primarily in the latter part of the 19th century and first part of the 20th century, reflected public values and attitudes at the time; it was based on managing and redirecting flood flows to maximize the amount of land put to economic use. The original levee system, primarily below Colusa on the Sacramento River system, was also intended to facilitate navigation and waterborne commerce by maximizing water depths and movement of sediment (hydraulic mining debris) within confined and straightened river channels. In the early 20th century a more systematic State/federal flood control system, recognizing the need to mimic the natural overflow basins to contain flows beyond the channel system's capacity, built or incorporated a system of overflow weirs, bypasses, and flood basins in the Sacramento River system. The San Joaquin River flood control system developed later in the 20th century with much consideration on irrigation. Current flood management philosophies are evolving to incorporate values that would conserve and protect natural floodplain processes while protecting public safety and economic values.

River channels below major dams provide substantial conveyance for water to meet increasing demands for high-quality surface water supply.

The existing State/federal flood management system in the Extended SPA influences flooding and flood management on more than 2.2 million acres (3,400 square miles) of land. The Central Valley Flood Management System includes SPFC facilities that are operated and maintained in conjunction with flood control facilities operated and maintained by federal, State, local, and private interests. This system includes approximately 1,600 miles of project levees and dams on nearly every major tributary. These facilities form the backbone of the flood management system in the Sacramento and San Joaquin Valley. Local and regional flood management facilities and projects reduce flooding to additional valley land in both urban and rural areas. The geographic area that includes land subject to flooding if current facilities fail, and is subject to operation of the Sacramento–San Joaquin River Flood Management System,[1] is included in the Extended SPA.

Despite improvements to the flood management system, damages from flooding have increased. Table 3.13-1 lists large flood events that have occurred in the Sacramento and San Joaquin river basins since 1850.

Extended Systemwide Planning Area

This section describes hydrologic conditions, water supply resources, and the flood management system of the Sacramento and San Joaquin Valley and foothills, Delta, and Suisun Marsh. The Delta and Suisun Marsh are discussed because of their unique surface water and water supply roles.

Table 3.13-1. Historic Flood Events by Basin (1850–2000)

Year	Sacramento River Basin	San Joaquin River Basin	Year	Sacramento River Basin	San Joaquin River Basin
1850	X		1893		X
1852	X	X	1904	X	
1853	X		1907	X	X
1861	X	X	1909	X	
1862	X		1911		X
1867	X	X	1928	X	
1868	X	X	1955	X	X
1869		X	1964	X	
1871		X	1967	X	X
1872		X	1969	X	
1878	X		1970	X	
1881	X	X	1974	X	
1884		X	1983	X	X
1886	X	X	1986	X	X
1889	X	X	1995	X	X
1890	X	X	1997	X	X
1891	X		1998	X	X
1892		X			

Source: Adapted from USACE 1999

[1] Section 9611 of the California Water Code defines the Sacramento–San Joaquin River Flood Management System as the system that includes "(a) the facilities of the State Plan of Flood Control as that plan may be amended pursuant to this part. (b) any existing dam, levee, or other flood management facility that is not part of the State Plan of Flood Control if the board [Central Valley Flood Protection Board] determines, upon recommendation of the department [DWR], that the facility does one or more of the following: (1) provides significant systemwide benefits for managing flood risks within the Sacramento–San Joaquin Valley. (2) protects urban areas within the Sacramento–San Joaquin Valley" (where urban area is defined as "any contiguous area in which more than 10,000 residents are protected by project levees").

From a flood management perspective, all areas within the Extended SPA fall into one of the following categories:

- Areas within the Comprehensive Study's 500-year floodplain, updated for the Central Valley Flood Protection Plan (CVFPP)
- Areas within the Comprehensive Study's 200-year floodplain along the Sacramento River from Redding to Red Bluff
- Areas that could be inundated should a project levee fail while flow is at maximum reasonable capacity (depicted in draft Levee Flood Protection Zone maps available at http://www.water.ca.gov/floodmgmt/lrafmo/fmb/fes/levee_protection_zones/LFPZ_maps.cfm)
- Areas between major reservoirs with flood management functions related to the Comprehensive Study's 500-year floodplain

An overview discussion of the current status of SPFC facilities is provided after the discussion of the San Joaquin Valley and foothills.

Sacramento Valley and Foothills The Sacramento Valley and foothills extends from Shasta Lake to the mouth of the Delta. From Shasta Lake, the Sacramento River flows southward to Colusa and continues southwesterly in a leveed channel bordered by overflow basins. The Colusa Basin to the west receives flow of several minor tributaries. The natural overflow basin to the east, Butte Basin, receives flow from several minor tributaries and the Sacramento River, and overflow from the Moulton and Colusa weirs.

Outflow from Butte Basin discharges through the Sutter Bypass; reentering the Sacramento River directly across and downstream from Fremont Weir. During high-flow events, the bulk of flows pass over the Fremont Weir to continue through the Yolo Bypass for approximately 72 miles south then ultimately discharge in the North Delta. Flow from the Coast Ranges to the west is captured by the Colusa Basin Drain, which discharges directly to the Sacramento River, and into the Knights Landing Ridge Cut which empties into the Yolo Bypass, and by Cache, Willow Slough Bypass and Putah creeks, which discharge into the Yolo Bypass.

Flow from the Yuba and Bear rivers combines with Feather River flow and enters the Sacramento River near the Fremont Weir. The Sacramento River is joined by the American River at the city of Sacramento. Large flows from the American River create backwater in the Sacramento River as far upstream as the confluence with the Sutter Bypass, reducing flow in the mainstream leveed channel between this point and flowing instead into the

Yolo Bypass through the Sacramento Weir and Bypass upstream of West Sacramento (CRFSC 1971).

On average, more than 22 million acre-feet (MAF) of water, approximately one-third of the total runoff in California, flows through the Sacramento Valley. The operation and capacity of reservoirs in the Sacramento Valley are affected by precipitation, agricultural diversions, water supply, hydroelectric power generation, and flood management (i.e., not exceeding downstream channel capacities).

Along with the major hydrologic features in the Sacramento Valley and foothills, Figure 3.13-1 shows the locations of multipurpose dams and reservoirs and the locations of SPFC facilities within the Sacramento Valley and foothills. Note that one location discussed in the Sacramento Valley and foothills geographic area is actually in the Cascade Range (North Fork Feather River Diversion Structure and Channel near Chester), one is in the Modoc Plateau (Ash Creek Channel in Adin), and one is in the Coast Ranges (Middle Creek Channel near Clear Lake).

A list of the major SPFC facilities in the Sacramento Valley and foothills is presented in Table 3.13-2.

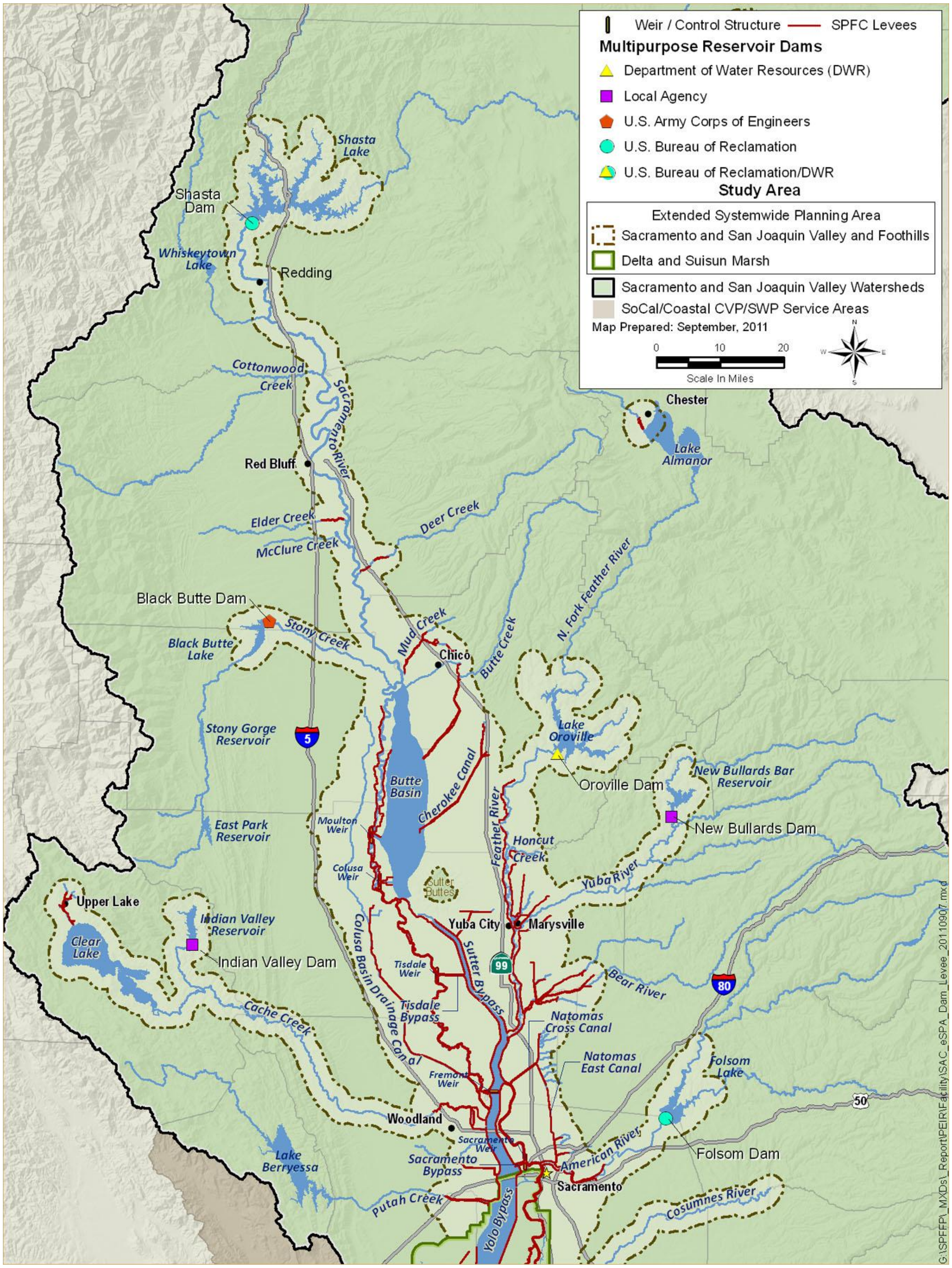


Figure 3.13-1. Locations of Multipurpose Dams and Reservoirs and State Plan of Flood Control Levees in the Sacramento Valley and Foothills

Table 3.13-2. State Plan of Flood Control Facilities in the Sacramento Valley and Foothills

State Plan of Flood Control Facility
Sacramento River bank protection, Red Bluff to Chico Landing
North Fork Feather River channel improvements, including a diversion structure, an excavated rock-lined diversion channel, seven drop structures, and levees
Feather River right-bank levee, high ground to Yuba City
Feather River right-bank levee, Yuba City to Sutter Bypass
Feather River left-bank levee, Honcut Creek to Jack Slough
Feather River left-bank levee, Yuba River to Bear River
Sutter-Butte Canal Headgate
Honcut Creek left bank levee, upstream from Feather River confluence
Back levee for RD 10, along Jack and Simmerly sloughs
Ring levee around City of Marysville
Yuba River right-bank levee, upstream from Marysville ring levee
Yuba River left-bank levee, upstream from Feather River confluence
Feather River left-bank levee
Feather River right-bank levee
Dry Creek left-bank levee, upstream from Bear River confluence
Dry Creek right-bank levee, upstream from Bear River confluence
Bear River right- and left-bank levees, upstream from Dry Creek confluence
Yankee Slough right- and left-bank levee, upstream from Bear River confluence
WPRR Intercepting Channel right-bank levee
WPRR Intercepting Canal Bridge (WI-1)
WPRR Intercepting Canal Bridge (WI-2)
WPRR Intercepting Canal Bridge (WL-1)
Bear River right-bank levee, downstream from Dry Creek confluence
Bear River left-bank levee, downstream from Dry Creek confluence
Feather River right-bank levee from Bear River to Sutter Bypass
Feather River left-bank levee from Bear River to Sutter Bypass
Nelson Bend Rock weir on Feather River at Sutter Bypass
Sutter Bypass channel
Sutter Bypass Toe Drain Bridge (EL-1A)
Sutter Bypass East Borrow Canal Bridge (EL-2)

Table 3.13-2. State Plan of Flood Control Facilities in the Sacramento Valley and Foothills (contd.)

State Plan of Flood Control Facility
Sutter Bypass East Borrow Canal Bridge (EL-3)
Sutter Bypass East Borrow Canal Bridge (EL-6)
East Interceptor Canal/Sand Creek Bridge (EI-2)
East Interceptor Canal Bridge (EI-5)
State Drain Bridge (CC-4)
Feather River/Sutter Bypass right-bank levee, upstream from Sacramento River confluence
Feather River/Sutter Bypass left-bank levee, upstream from Sacramento River confluence
American River right-bank levee, upstream from Natomas East Main Drainage Canal
Vegetation mitigation, five sites between H Street and Watt Avenue
Pumps along American River at H Street and Watt Avenue
American River left-bank levee, upstream from Natomas East Main Drainage Canal
American River channel
Natomas East Main Drainage Canal right-bank levee at Sankey Road
Dry (Linda) Creek left-bank levee, upstream from Natomas East Main Drainage Canal
Magpie Creek diversion channel
Natomas East Main Drainage Canal right- and left-bank levees, from Arcade Creek to American River
Arcade Creek right- and left-bank levees, upstream from Natomas East Main Drainage Canal
American River right-bank levee, from Natomas East Drainage Canal to Sacramento River
Lower Butte Creek channel improvements and Howard Slough diversion structure
Butte Slough Outfall Gates
Butte Slough Bypass channel
Right-bank levee from Butte Slough Outfall Gates to Sutter Bypass
Sutter Bypass channel
Sutter Bypass pumps and right- and left-bank levees from State Route 20 to Wadsworth Canal
Wadsworth Canal right- and left-bank levees and channel, West Intercepting Canal, and East Intercepting Canal right- and left-bank levees
Sutter Bypass right-bank levee from Wadsworth Canal to Tisdale Bypass
Sutter Bypass left-bank levee from Wadsworth Canal to Tisdale Bypass and Pumping Plant No. 2

Table 3.13-2. State Plan of Flood Control Facilities in the Sacramento Valley and Foothills (contd.)

State Plan of Flood Control Facility
Sutter Bypass right-bank levee downstream from Tisdale Bypass to Feather River confluence
Sutter Bypass left-bank levee downstream from Tisdale Bypass to Feather River confluence and Pumping Plant No. 1
Feather River/Sutter Bypass right-bank levee, upstream from Sacramento River confluence
Feather River/Sutter Bypass left-bank levee, upstream from Sacramento River confluence
Colusa Basin Drain left-bank levee
Knights Landing Outfall Gates
Knights Landing Ridge Cut channel and right- and left-bank levees
Knights Landing Ridge Cut channel
Middle Creek and Tributaries Project (levees, channels, diversion structures, and pumping plant)
Willow Slough Diversion Weir, right- and left-bank levees to confluence with Yolo Bypass, and channel downstream from Southern Pacific Railroad from Davis to Woodland
Putah Creek channel and levees from Interstate 505 highway bridge in Winters to Yolo Bypass
Cache Slough and Lindsey Slough levees
Yolo Bypass right-bank levee from Fremont Weir to Cache Creek Settling Basin
Yolo Bypass left-bank levee from Knights Landing Ridge Cut to Cache Creek Settling Basin
Cache Creek Settling Basin, east and west training levees
Yolo Bypass right-bank levee from Cache Creek to Sacramento Bypass
Yolo Bypass left-bank levee from Cache Creek to Sacramento Bypass
Yolo Bypass right-bank levee from Sacramento Bypass to Putah Creek
Yolo Bypass left-bank levee from Sacramento Bypass to Putah Creek
Yolo Bypass right-bank levee from Putah Creek to Sacramento River
Yolo Bypass left-bank levee from Putah Creek to Sacramento River
Yolo Bypass channel
Ash Creek and Dry Creek channel clearing
Salt Creek channel clearing, upstream from Sacramento River confluence
Elder Creek channel clearing and left-bank levee upstream from Sacramento River confluence
Elder Creek channel
McClure Creek channel clearing near U.S. Highway 99

Table 3.13-2. State Plan of Flood Control Facilities in the Sacramento Valley and Foothills (contd.)

State Plan of Flood Control Facility
Deer Creek channel clearing and right and left-bank levees upstream from Delany Slough to Sacramento River
Deer Creek channel
Cherokee Canal channel
Big Chico/Sandy Gulch (Lindo Channel) left-bank levee and Big Chico Creek Gates, Lindo Channel Gates, and Sycamore Weir diversion structures
Big Chico Creek, Sandy Gulch (Lindo Channel), Little Chico Creek channels
Sycamore, Sheep Hollow and Mud creeks right- and left-bank levees
Sacramento River channel, as included in the Sacramento River Flood Control Project
Sacramento River bank protection, Chico Landing to Goose Lake Flood Relief Structure
M&T and Goose Lake Flood Relief Structures
Sacramento River right-bank levee from Ord Ferry to Moulton Weir
Sacramento River left-bank levee from Ord Ferry to Moulton Weir
Moulton Weir
Sacramento River right-bank levee from Moulton Weir to Colusa Weir
Sacramento River left-bank levee from Moulton Weir to Colusa Weir
Colusa Weir, sediment basin, and training levees
Sacramento River left-bank levee from Colusa Weir to Tisdale Weir
Sacramento River right-bank levee from Colusa Weir to Tisdale Weir
Tisdale Weir and Tisdale Bypass, including right-bank, and left-bank levees
Sacramento River right-bank levee from Fremont Weir to Sacramento Weir
Sacramento River left-bank levee from Fremont Weir to Sacramento Weir
Sacramento Weir and Sacramento Bypass channel
East Side Canal and Natomas Cross Canal right-bank levee
Pleasant Grove Canal and Natomas Cross Canal left-bank levee
Sacramento River left-bank levee from Sacramento Weir to American River confluence
Sacramento River right-bank levee from Sacramento Weir to American River confluence
Sacramento River right-bank levee from American River to Elk Slough
Sacramento River left-bank levee from American River to Elk Slough

Table 3.13-2. State Plan of Flood Control Facilities in the Sacramento Valley and Foothills (contd.)

State Plan of Flood Control Facility
Sacramento River right-bank levee from Elk Slough to Collinsville
Sacramento River left-bank levee from Elk Slough to Collinsville
Elk Slough right- and left-bank levees
Sutter Slough right- and left-bank levees
Miner Slough right- and left-bank levees
Steamboat Slough right- and left-bank levees
Georgiana Slough right- and left-bank levees
Three Mile Slough right- and left-bank levees

Source: DWR 2010a

The Sacramento Valley and foothills can be divided into two geographic areas: upper and lower. The upper geographic area encompasses the Sacramento River before its confluence with the Feather River. The lower area extends from the Sacramento River confluence with the Feather River to the Delta.

Upper Sacramento River Geographic Area The upper Sacramento River geographic area is the reach of the Sacramento River between Shasta Lake, the northernmost reservoir in the Extended SPA, and just upstream from the Sacramento River/Feather River confluence. The Butte and Colusa basins, Sutter Bypass, and Feather River are also located in this area. The hydrology and major flood control facilities in the upper Sacramento River and its major tributaries are described below. Features are discussed in order of location, starting with Shasta Lake, the northernmost (most upstream) reservoir. This discussion ends with a description of the Butte Basin, Sutter Bypass, and Colusa Basin.

Shasta Lake, owned and operated by U.S. Department of the Interior, Bureau of Reclamation (Reclamation), is the largest reservoir in California. Shasta Lake provides flood management storage for the upper Sacramento River, and water supply as part of the CVP; about half of the total annual water supply developed by the CVP comes from Shasta Lake. Other main purposes of Shasta Lake are irrigation development, power generation, recreation, fish and wildlife conservation, and protection of the Delta from intrusion of saline ocean water. Shasta Lake has a capacity of 4,552.1 thousand acre-feet (TAF) and a flood management reservation of 1,300 TAF.

Shasta Lake provides flood protection for the nearby communities of Redding, Anderson, Red Bluff, and Tehama, and also for agricultural lands, industrial developments, and communities downstream along the Sacramento River. Shasta Lake is operated for an objective release of 79,000 cubic feet per second (cfs) at Bend Bridge in Red Bluff, subject to inflows from tributaries between Shasta Lake and Bend Bridge.

Downstream from Shasta Lake, flows are reregulated at Keswick Dam. Keswick Dam serves as an afterbay for the Shasta and Spring Creek power plants and serves to regulate downstream flows. Keswick Dam and Reservoir were completed in 1950 as part of the CVP. Downstream from Keswick Dam, the Anderson-Cottonwood Irrigation Dam and Red Bluff Diversion Dam divert agricultural flows into the Anderson-Cottonwood Irrigation District and Tehama-Colusa canals, respectively.

Between Shasta Lake and Chico Landing, Sacramento River flows are influenced by uncontrolled (i.e., without flood control dams and reservoirs) tributary inflow. Although Shasta Lake effectively manages flood flows from the upper watershed, uncontrolled tributaries can have a substantial influence on downstream flood flows in the Sacramento River. Major eastside tributaries include Churn, Cow, Bear, Battle, Paynes, Antelope, Mill, Deer, and Pine creeks. Mud Creek and its tributary, Sycamore Creek, and Rock Creek join into Big Chico Creek and contribute to Sacramento River flow. Major westside tributaries to the Sacramento River include Clear, Cottonwood, Reeds, Red Bank, Elder, and Thomes creeks. Of these creeks, those with SPFC levees are discussed below in order of location, starting with the most upstream creek.

Elder Creek has a levee on both banks beginning 1.25 miles upstream from the Sacramento River, with 8.2 levee miles on the right and left banks and a design capacity of 17,000 cfs. Deer Creek is leveed intermittently and has a design flow of 21,000 cfs. Diversion structures on Big Chico Creek and Lindo Channel send flows down Sycamore Creek Diversion Channel, which has a capacity of 8,000 cfs. Channel improvements and levees extend along both banks of Sycamore Creek and Mud Creek, with a total of about 20 miles of levees. Downstream from the confluence with the Sacramento River, Mud Creek has a design capacity of 15,000 cfs.

Between Chico Landing and Colusa, the Sacramento River meanders through alluvial deposits between widely spaced levees. The design capacity of the Sacramento River at Chico Landing is about 260,000 cfs. Stony Creek is the only major tributary in this segment of the river.

On Stony Creek, Black Butte Lake is owned and operated by the U.S. Army Corps of Engineers (USACE) to manage flood flows on the

Sacramento River, and to provide irrigation, water supply, and recreational opportunities. Black Butte Lake is not an SPFC facility. Water is stored and diverted from Black Butte Lake to the Orland Unit Water Users Association. Water is sometimes delivered to the Tehama-Colusa Canal Authority to mitigate supply restrictions from Red Bluff Diversion Dam. Black Butte Lake has a capacity of 136.2 TAF; the entire capacity is reserved for flood management space during winter. The project originally provided a minimum pool of 6 TAF for sediment and fishery values, but sediment has completely filled this reservation and now affects overall flood operations.

The specific flood management objectives of Black Butte Lake are to protect Hamilton City, the city of Orland, Interstate 5, and 64,000 acres of agricultural areas along Stony Creek from rain floods. Black Butte Lake is operated for an objective release of 15,000 cfs at the damsite and 130,000 cfs at Ord Ferry. Black Butte Lake is operated in conjunction with Stony Gorge and East Park storage reservoirs, located upstream. These reservoirs are owned and operated by local irrigation interests.

SPFC levees begin downstream from Ord Ferry on the right bank (west side) of the Sacramento River and above Butte City on the river’s left bank (east side). Total design capacity at the latitude of Ord Ferry (where the right-bank or west levee begins) is about 300,000 cfs. The design capacity of the river where the left-bank levee begins (7.5 river miles downstream from Ord Ferry, near the Butte/Glenn county line) is about 160,000 cfs. This reduction in river capacity requires that flows leave the river upstream from where the SPFC levees are in place on both banks. Historically, overflow over the left bank of the river has spilled into the Butte Basin.

The right-bank levee begins at Ord Ferry and extends downstream to the Colusa Bridge and beyond, and the left-bank levee begins about 7.5 river miles downstream from Ord Ferry and extends past Moulton Weir to the Butte Slough Outfall Gates. These levees are generally set back from the river and are about 0.5 mile to 1.5 miles apart. Downstream from Colusa, the levee corridor is comparatively narrow, with levees tightly spaced along the edge of the active channel.

Flow in the upper Sacramento River geographic area is also affected by floodwater spilled into bypass areas through historical overflow areas and weirs. Between Chico Landing and Colusa, high flows can overflow the left bank of the Sacramento River and pass into the Butte Basin, at three locations: M&T Flood Relief Structure, the Three Bs Overflow Area, and the Parrot Plug (Goose Lake) Flood Relief Structure. Floodwaters are also diverted over Moulton and Colusa weirs into the Butte Basin. Farther downstream, floodwaters flow over the Tisdale Weir into the Tisdale Bypass, which routes the water into the Sutter Bypass.

In 1932, USACE constructed the Moulton Weir, an ungated, fixed-crest weir on the left bank of the Sacramento River between the towns of Butte City and Colusa. The crest of the weir is 535 feet long, 13 feet high, and 49 feet wide. The weir routes excess flows from the Sacramento River into the Butte Basin when flows in the river at the weir exceed 70,000 cfs. DWR now maintains the weir. The design capacity of the Moulton Weir is 25,000 cfs to the Butte Basin.

Between the Moulton and Colusa weirs, the design capacity of the Sacramento River is 135,000 cfs. The levees are generally set back from the river and are about 0.5 mile to 1.5 miles apart.

The Colusa Weir, completed in 1933, is an ungated, fixed-crest weir with a crest measuring 1,650 feet long, 0.75 foot high, and 20 feet wide. The weir, located on the Sacramento River between the Moulton Weir and the city of Colusa, routes excess flows from the Sacramento River into the Butte Basin when flows in the river at the weir exceed 30,000 cfs. As with the Moulton Weir, USACE constructed the Colusa Weir, and DWR now maintains it. The design capacity of the Colusa Weir is 70,000 cfs to the Butte Basin.

The design capacity of the Sacramento River between the Colusa and Tisdale weirs ranges from 65,000 cfs to 66,000 cfs. Downstream from Tisdale Weir, the river's design capacity is 30,000 cfs. The levees along this reach are generally at the riverbank, about 300–400 feet apart.

The Tisdale Weir, south of Colusa and just downstream from Grimes, was built by USACE in 1932. This ungated, fixed-crest weir, with a crest measuring 1,150 feet long, 11 feet high, and 38 feet wide, routes excess flows from the Sacramento River into the leveed Tisdale Bypass, which in turn conveys the flows to the Sutter Bypass. The weir begins to operate when flows in the Sacramento River exceed 23,000 cfs. When flows are greater in the Sutter Bypass and the Sacramento River stage is sufficiently lower, flows may reverse and leave the Sutter Bypass and rejoin the river over the Tisdale Weir via the Tisdale Bypass. DWR maintains the weir and bypass, with maintenance tasks including vegetation and sediment removal. The design capacity of the Tisdale Weir is 38,000 cfs.

Butte Basin The Butte Basin is the northernmost of the natural overflow basins flanking the Sacramento River. Located east of the Sacramento River, it extends from northwest of Chico to the mouth of Butte Slough, north of Meridian. Its eastern boundary is an indefinite line along the gently sloping lands rising from the trough of the basin toward the Sierra Nevada foothills. The Glenn/Colusa county line divides the Butte Basin into an upper basin and a lower basin. The Butte Basin has a substantial attenuation effect on flows before it discharges them into the Sutter Bypass downstream from Colusa. The Butte Basin holds more than 1 MAF when it is flowing full, and flows have a travel time of about 2 days from the upper end of the basin to the Sutter Bypass. Outflows from the Butte Basin pass through Butte Slough into the Sutter Bypass when the Sacramento River is high, or through the Butte Slough Outfall Gates into the Sacramento River when the river is low. In addition to Sacramento River overflows near Ord Ferry, the basin receives inflow over the Moulton and Colusa weirs and from tributary streams draining from the northeast, principally Cherokee Canal and Butte Creek. Encroachments into the Butte Basin boundary are regulated by Title 23, Section 135 of the California Code of Regulations and must be approved by the Central Valley Flood Protection Board (Board) (formerly known as The Reclamation Board).

When Sacramento River flows exceed 100,000 cfs at Ord Ferry, floodwaters overflow the left bank through three flood relief structures and an emergency overflow roadway, in a reach referred to by the State as the Butte Basin Overflow Area. The relief structures are concentrated along 18 river miles between Big Chico Creek and the upstream end of the left (east) bank levee of the Sacramento River. The first two overflows, moving downstream, are upstream from Ord Ferry (M&T Flood Relief Structure and 3Bs Overflow Area), and the third (Parrot Plug Flood Relief Structure) is downstream.

Flow in the upper Sacramento River is reduced further by diversion through the Moulton and Colusa weirs to the lower Butte Basin downstream. Farther downstream, the Tisdale Weir diverts additional flows from the Sacramento River into the Tisdale Bypass, which routes the floodwater into the Sutter Bypass.

SPFC facilities—levees, channels, and diversion structures—can be found on Little Chico Creek, Butte Creek, and the Cherokee Canal. The Little Chico Diversion Structure sends up to 3,000 cfs down the diversion channel to Butte Creek. Downstream from the confluence, the design capacity of Butte Creek is 27,000 cfs in a 15-mile-long channel with levees on both banks. The Cherokee Canal collects flows from Dry, Gold Run, and Cottonwood creeks. Downstream from the confluence with Cottonwood Creek, the Cherokee Canal has a design capacity of 12,500 cfs.

Sutter Bypass The Sutter Bypass, which began operation in the 1930s, is a leveed portion of the natural floodway in the Sutter Basin. The bypass is south of the Sutter Buttes, from Colusa to Verona between the Sacramento and Feather rivers. Flows enter the Sutter Bypass from the Butte Basin at its upper end near Colusa at Butte Slough. Other flows, such as interior drainage from pumping plants or from the Wadsworth Canal, discharge to the Sutter Bypass, as do flows from the Sacramento River by way of the Tisdale Weir and Bypass. Flood flows in the Sutter Bypass and the Feather River combine about 7 miles upstream from their confluence with the Sacramento River at the Fremont Weir. The design capacity of the Sutter Bypass (including Feather River) upstream from the Fremont Weir is 380,000 cfs. During a flood, a majority of this flow crosses the Sacramento River and flows over the Fremont Weir into the Yolo Bypass. Downstream from the Fremont Weir, the Feather River and Sutter Bypass flow in a joint channel to the Sacramento River (see Figure 3.13-1). The design channel capacity of this reach is 416,500 cfs, based on operations and maintenance manuals (DWR 2010a).

Colusa Basin The Colusa Basin, a natural overflow basin on the west side of the Sacramento River, extends from south of Stony Creek to Knights Landing. Before the 1850s, when agricultural land reclamation began, the area within the basin was subjected to periodic flooding from the Sacramento River. Flows in the basin generally discharged southeast to the river through a series of sloughs ending at Knights Landing, above the Fremont Weir. Since the 1850s, much of the wetland area has been drained.

Inflow into the basin comes from approximately 11 streams. The Colusa Basin Drain (Colusa Trough Drainage Canal or Colusa Basin Drainage Canal), a channel leveed on only the left bank, was constructed before 1930 to intercept drainage on the west side of the Sacramento River between Colusa and Knights Landing, where the drain releases flows to the Sacramento River. Levees along the right bank of the Sacramento River contain water in the river. The Colusa Basin Drain has a design capacity of 20,000 cfs and is included in the SPFC facilities.

The Knights Landing Ridge Cut, at the southern end of the Colusa Basin Drain, provides an outlet for flood flows (up to 20,000 cfs) to the Yolo Bypass when the Sacramento River is high. The Knights Landing Ridge Cut also conveys irrigation supply and drainage during the agricultural season.

The Colusa Basin can also drain into the Sacramento River through the Knights Landing Outfall Gates, located along the Sacramento River's right-bank levee about 26 miles downstream from Tisdale Weir. The Knights Landing Outfall Gates, also known as the Sycamore Slough Outfall Gates, are intended to reduce flood risk to the lower Colusa Basin from Sacramento River backwater, but provide drainage to the Sacramento River during low flow. The structure was originally built by local interests, but flap gates were added by USACE and DWR (DWR 2010a).

Lower Sacramento River Geographic Area The lower Sacramento River geographic area begins at the confluence of the Feather and Sacramento rivers and ends where the Sacramento River enters the Delta. The Feather and American rivers are major tributaries that contribute flow to the Sacramento River in this area. Feather River flow is also affected significantly by the Yuba and Bear rivers.

Downstream from the Sacramento River/Feather River confluence, the Natomas Cross Canal and Natomas East Main Drainage Canal (also known as Steelhead Creek) drain water from the area between the Bear River and American River drainages into the Sacramento River, except during high-flow events when water flows into the American River. The Natomas Cross Canal collects flows from Coon, Curry, Markham, and Pleasant Grove creeks; Pierce Roberts Drain; and Auburn Ravine via the Pleasant Grove Creek and East Side canals, and routes the flows to the Sacramento River. Levees line both sides of the Natomas Cross Canal; at the canal's east end, the levees split north to protect areas to the north (lining the right side of the East Side Canal), and south to form the left levee of Pleasant Grove Creek. The design capacity of the Natomas Cross Canal is 22,000 cfs. The Natomas East Main Drainage Canal begins directly south of the Pleasant Grove Canal and flows south before eventually emptying into the American River, 2.2 miles upstream from the American River's confluence with the Sacramento River. It protects the Natomas area of Sacramento. Dry, Robla, Magpie, and Arcade creeks are tributaries to the Natomas East Main Drainage Canal. The design capacity of the Natomas East Main Drainage Canal near the confluence with the American River is 16,000 cfs.

Three miles upstream from the confluence of the Sacramento and American rivers, immediately west and across the Sacramento River from the city of Sacramento, flows are diverted over the Sacramento Weir and through the Sacramento Bypass into the Yolo Bypass (which is described in greater detail below). Between the Fremont Weir and the American River, the design capacity of the Sacramento River is 107,000 cfs. Downstream, between the American River confluence and Sutter Slough, the Sacramento River's design capacity is 110,000 cfs. Design capacity generally decreases farther downstream because of distributary channels, such as Georgiana Slough, as the river heads toward and enters the Delta.

From Sutter Slough to Steamboat Slough, the design capacity of the Sacramento River is 84,500 cfs. The Sacramento River's design capacity decreases to 56,900 cfs from Steamboat Slough to Georgiana Slough, and to 35,900 cfs from Georgiana Slough to the end of the Yolo Bypass.

Feather River The Feather River, the largest eastside tributary to the Sacramento River, enters the Sacramento River just above Verona. Flooding along the Feather River affects the cities of Oroville, Marysville, and Yuba City and agricultural lands.

Lake Oroville, located on the Feather River, is the largest SWP reservoir. Lake Oroville is operated in coordination with five associated dams: two saddle dams on Lake Oroville, and Thermalito Diversion Dam, Thermalito Forebay Dam, and Thermalito Afterbay Dam. The reservoir and associated facilities provide flood control, water supply, power generation, recreation, and fish and wildlife enhancement though the Low Flow Channel of the Feather River. The Low Flow Channel, on the Feather River between the Feather River Fish Hatchery and Thermalito Afterbay Outlet, usually conveys only the minimum required fishery flows for this reach. DWR also makes releases from Lake Oroville to control Delta salinities as part of the CVP and SWP Coordinated Operations Agreement described in the *Long-Term Central Valley Project and State Water Project Operations Criteria and Plan Biological Assessmen*t (Reclamation 2004). Lake Oroville's water is diverted by various SWP facilities for delivery to service areas in the Feather River basin, San Francisco Bay Area, Central Coast, San Joaquin Valley, Tulare basin, and Southern California. Completed in 1967, the earthfill Oroville Dam is the tallest dam in the United States, impounding nearly 3.54 TAF of water.

The flood management reservation of 750 TAF in Lake Oroville is used to reduce flows downstream from the dam to the objective release of 150,000 cfs, and to reduce flows below the confluence with the Yuba River to 300,000 cfs. Lake Oroville flood management operations provide flood protection to Marysville, Yuba City, Oroville, and many smaller communities. Flood protection is also provided to about 283,000 acres of highly developed agricultural lands and to important highway and railroad routes.

In addition to Lake Oroville, major features affecting flow in the Feather River are levees, which direct flood flows along the Feather River and its tributaries. The levee system includes a ring levee surrounding Marysville. The Feather River, upstream from its confluence with the Yuba River, has a channel design capacity of 210,000 cfs. Between the Feather River's confluences with the Yuba and Bear rivers, the design channel capacity is 300,000 cfs. Farther downstream, up to the Feather River/Sutter Bypass confluence, the design channel capacity increases to 320,000 cfs. Also, the Nelson Bend Control Structure, a rock weir, controls flow where the Feather River meets the Sutter Bypass.

From the Feather River/Sutter Bypass confluence, water flows in a joint channel to the Sacramento River. The design channel capacity of this reach of the Feather River is 416,500 cfs. SPFC facilities include right- and left-bank levees about 1.3 miles apart.

Yuba River The Yuba River flows into the Feather River near Marysville. The Yuba River has three major tributaries: the North, Middle, and South Yuba rivers. Most of the total flow in the Yuba River is unregulated. Yuba River flooding affects Marysville, Yuba City, and Olivehurst, as well as other small communities and agricultural lands.

New Bullards Bar Reservoir on the North Fork Yuba River is the only reservoir in the watershed with reserved flood management capacity; this reservoir regulates only one-third of the flow in the Yuba River watershed. The reservoir also serves water supply, power, fish and wildlife, and recreational purposes. Water supplies are delivered to the Yuba County Water Agency. New Bullards Bar Dam and Reservoir, completed in 1967, is owned, operated, and maintained by Yuba County Water Agency and has a capacity of 966 TAF, with flood management reservation of 170 TAF to reduce flows to the following objective releases:

- 50,000 cfs at the damsite
- 120,000 cfs at Marysville if the Feather River is high
- 180,000 cfs at Marysville if the Feather River is low

Downstream from New Bullards Bar Reservoir, Englebright Lake is impounded by Narrows Dam. This dam was constructed by the federal government in 1941 as part of the Sacramento River Debris Control Project. The reservoir has a capacity of 70 TAF, with no flood management reservation.

The channel capacity of the Yuba River upstream from its confluence with the Feather River is 120,000 cfs. SPFC facilities include right- and left-bank levees.

Bear River The Bear River enters the Feather River just north of the town of Nicolaus. No reservoirs are located on the Bear River within the Extended SPA.

Upstream from its confluence with Dry Creek, the Bear River has a design channel capacity of 30,000 cfs. Additional SPFC facilities in the Bear River watershed include levees along Dry Creek (7,000 cfs), Yankee Slough (2,500 cfs), and the Western Pacific Railroad Intercepting Channel (10,000 cfs). Downstream from the Dry Creek confluence, the Bear River's design capacity increases to 40,000 cfs in this reach.

American River The American River, the southernmost major Sacramento River tributary, enters the Sacramento River in the city of Sacramento. Most of the flood flows in the American River are regulated by Folsom Dam and come from rain or rain-on-snow floods.

The largest regulating reservoir on the American River is Folsom Lake. Folsom Lake's primary purpose is flood management, but water stored in the reservoir is also allocated to a variety of supply-related purposes throughout the year, including water supply, recreation, power generation, and fishery enhancement. Folsom Lake is also operated to help maintain water quality in the Delta, prevent saltwater intrusion, and maintain minimum flows on the American, Sacramento, and other rivers through coldwater releases (State Parks and Reclamation 2007). Folsom Lake provides water to four main water users: the City of Roseville, San Juan Water District, the City of Folsom, and Folsom Prison. Folsom Dam was completed in 1956 by USACE, but the dam and reservoir are operated and maintained by Reclamation, as a unit of the CVP. The reservoir has a capacity of 977 TAF, and is operated to meet the objective release of 115,000 cfs at the dam site. Folsom Lake provides flood protection to areas below the dam, including the cities of Folsom and Sacramento.

Folsom Dam is undergoing physical and operational modifications through the Folsom Dam Joint Federal Project (as part of the American River Watershed, Common Features Project). The Folsom Dam Joint Federal Project is a collaborative effort by Reclamation and USACE to address the hydrologic risk to dam safety at Folsom Lake, and to improve flood protection. The Board and the Sacramento Area Flood Control Agency are the local sponsors. Among other modifications, this project will include a new auxiliary spillway, a change in Folsom Lake's operational capabilities provided by the new auxiliary spillway, improved weather forecast predictions, alternative variable-storage options, and a new water control diagram.

The flood management reservation in the lake will be modified in accordance with a new water control diagram, which reduced the variable flood control space from the current operating range of 400–670 TAF to 400–600 TAF after completion of improvements to Folsom Dam. Operations at Folsom Lake were changed to reflect new design targets. These targets included limiting the discharge for the 1 percent annual-chance flood to 115,000 cfs and the 0.5 percent annual-chance flood to 160,000 cfs. For more information on changes to Folsom Dam and Lake operations, refer to the *Folsom Dam Auxiliary Spillway Control Structure*

Draft Design Documentation Report (USACE 2009) and the Reclamation Web site (Reclamation 2009).

Nimbus Dam is downstream from Folsom Lake, and forms Lake Natoma. This 8,760-acre-foot reservoir is owned by Reclamation and is used for hydroelectric power, irrigation, fish and wildlife protection, and recreation purposes.

Two minor tributaries, Dry and Arcade creeks, which drain approximately 239 square miles, are uncontrolled and flow into the Natomas East Main Drainage Canal and then into the American River. In addition to Folsom Lake, the flood management system includes levees along the American River from the confluence with the Sacramento River for approximately 11.5 miles on the left bank and 14.2 miles on the right bank. Upstream from the American River's confluence with the Natomas East Main Drainage Canal, design capacity is 115,000 cfs, and downstream from the confluence the design capacity is 152,000 cfs. Between the Natomas East Main Drainage Canal and the Sacramento River, the American River's design capacity is 180,000 cfs.

Yolo Bypass Flow in the lower Sacramento River geographic area is affected by floodwater spilled into the Yolo Bypass. The Yolo Bypass is a 59,000-acre, mostly leveed floodway through the natural-overflow Yolo Basin on the west side of the Sacramento River, between Verona at its confluence with the Sutter Bypass/Feather River and Rio Vista in the Delta, and immediately west of the Sacramento and West Sacramento metropolitan area. The bypass is lined by approximately 27 and 42 miles of right- and left-bank levees, respectively. The Sacramento Deep Water Ship Channel, completed in 1963, narrowed the channel of the Yolo Bypass. The west levee of the ship channel replaced the function of the left levee of the Yolo Bypass. The Deep Water Ship Channel levees are maintained by USACE and are not part of the SPFC.

The bypass extends generally north to south, and from the Fremont Weir downstream to Liberty Island. The bypass is an operative feature of the Sacramento River Flood Control Project, which began operation in the 1930s. The bypass carries floodwaters approximately once every 3 years, with flood flows generally occurring from November to April. The channel capacity of the Yolo Bypass increases downstream, from 343,000 cfs to 490,000 cfs. During high flows in the Sacramento River, water enters the Yolo Bypass over the Fremont and Sacramento weirs and through the Knights Landing Ridge Cut, and is conveyed south around the metropolitan area of Sacramento, paralleling the Sacramento River. Flows entering the bypass from the west at Cache Creek, Putah Creek, Cache Slough, Willow Slough, and the Willow Slough Bypass are often the greatest sources of inflow to the Yolo Bypass in spring, summer, and fall, and in dry years when Sacramento River water does not spill over the weirs (USGS 2002). Floodwaters from the Yolo Bypass reenter the Sacramento River upstream from Rio Vista through Cache Slough.

The mainstem of Cache Creek originates at Clear Lake and ultimately discharges into the Cache Creek Settling Basin and over a spillway into the Yolo Bypass. Clear Lake has an operated capacity of 320 TAF in addition to 835 TAF in the natural freshwater lake, and has hydropower, recreation, and water supply purposes. Clear Lake is not an SPFC facility. Yolo County Flood Control and Water Conservation District owns the water rights to Clear Lake.

On the North Fork Cache Creek, flow is regulated by Indian Valley Reservoir and has a total storage capacity of 300.6 TAF. The reservoir is owned and operated by Yolo County Flood Control and Water Conservation District for purposes of flood management, water supply, recreation, and downstream fishery releases. It is not an SPFC facility.

The Fremont Weir, completed by USACE in 1924, is an ungated, fixed-crest weir with a crest measuring 9,518 feet long, 6 feet high, and 35 feet wide. The Fremont Weir is on the right bank of the Sacramento River where the Sutter Bypass, Yolo Bypass, Feather River, and Sacramento River meet near Verona. Excess flows from the Sacramento River and Sutter Bypass flow over the weir into the Yolo Bypass when flows in the Sacramento River at Verona exceed 62,000 cfs. DWR maintains the weir. The design capacity of the Fremont Weir is 343,000 cfs.

The City of Sacramento built the Sacramento Weir in 1918, and DWR currently maintains and operates the weir. The Sacramento Weir is the only weir in the Sacramento system with gates that allow operation during flood events. This weir has a variable crest with 48 removable gates, each 38 feet wide. The gates are opened when the Sacramento River reaches or exceeds a stage of 27.5 feet National Geodetic Vertical Datum at the I Street Bridge. The design capacity of the Sacramento Weir and Bypass is 112,000 cfs. When flows from the American River are high enough, American River water flows upstream through the Sacramento River to the Sacramento Weir.

Cache Creek originates at the east end of Clear Lake and discharges into the Yolo Bypass over the Cache Creek Settling Basin Weir. Because of the large volume of sediment transported by Cache Creek in the lower basin, the Cache Creek Settling Basin, with a low-flow outlet, was constructed to prevent sediment from being carried into and deposited in the Yolo Bypass. The settling basin has been modified several times since its original construction in 1937. In 1991, the basin was enlarged to provide an estimated 50-year sediment storage capacity.

Upstream from Clear Lake is the Upper Lake Valley, which includes Middle, Scotts, and Clover creeks. This area has 14.4 miles of levees, two diversion structures, and a floodwater pumping station. Levees contain the flows of Middle and Scotts creeks within the channels, while a majority of the flows from Clover Creek are diverted around the northern side of the community of Upper Lake to Middle Creek. Upper Lake Valley is included in the SPFC facilities.

Indian Valley Dam and Reservoir are on the North Fork Cache Creek about 50 miles northwest of the city of Woodland, and about 11 miles upstream from the confluence with Cache Creek. Completed in 1976 by the Yolo County Flood Control and Water Conservation District, this facility is owned, operated, and maintained by the district. The capacity of Indian Valley Reservoir at gross pool is 300.6 TAF, which includes 40 TAF reserved for flood management. Indian Valley Reservoir uses these 40 TAF to reduce flows in Cache Creek at Rumsey to an objective release of 20,000 cfs. The Indian Valley Dam and Reservoir are not included in the SPFC facilities.

Lower Cache Creek has SPFC levees that begin at high ground about 1.5 miles west of Interstate 5 near Woodland on the left bank, extending approximately 8.2 miles to the Cache Creek Settling Basin, and immediately upstream from Interstate 5 on the right bank, extending 6.9 miles. The design capacity is 30,000 cfs as the creek flows to the Cache Creek Settling Basin. East and west training levees direct flows toward the southern end of the Cache Creek Settling Basin and then over a spillway into the Yolo Bypass.

The Willow Slough watershed drains most of the central part of Yolo County between Cache Creek and Putah Creek. East of State Route 113, the natural channel of Willow Slough has been blocked off and replaced with the Willow Slough Bypass, which flows directly east to the western edge of the Yolo Bypass. The Willow Slough Bypass has a design capacity of 6,000 cfs.

The Putah Creek watershed drains about 710 square miles of mostly mountainous area west of the city of Winters, includes Lake Berryessa, and eventually discharges into the Yolo Bypass. The south fork of Putah Creek is leveed for about 9 miles, from 1 mile upstream of the Interstate 80 crossing of the creek near the city of Davis to the Yolo Bypass. The channel conveys excess flows into the bypass and the levees protect adjacent agricultural lands from flooding because of the backwater from the Yolo Bypass. Putah Creek has a design capacity of 62,000 cfs.

Flows from Cache Slough, which is within the Delta, join the Yolo Bypass about 8 miles from its terminus near Rio Vista. SPFC facilities include levees along the sloughs, and around Peters Tract, Hastings Tract, and Egbert Tract. Cache Slough discharges into Lindsey Slough before the confluence of Lindsey Slough with the beginning of the Sacramento Deep Water Ship Channel. Lindsey Slough has a design capacity of 43,500 cfs.

San Joaquin Valley and Foothills Within the San Joaquin Valley and foothills, the San Joaquin River flows westward from Millerton Lake to the center of the valley floor, and then northwestward to the Delta. The southern portion of the San Joaquin River is affected by flow in three bypasses: Chowchilla, Eastside, and Mariposa. San Joaquin River flood flow is diverted into the Chowchilla Bypass 10 miles downstream from Gravelly Ford, the beginning of the SPFC levee system, through the Chowchilla Bifurcation Structure. Flows are then routed from the Chowchilla Bypass to the Eastside Bypass. The Eastside Bypass receives flows from the Fresno and Chowchilla rivers, Berenda and Ash sloughs, and the Merced County Streams Group, including Bear Creek, and carries the flows to the San Joaquin River. Flow from the Eastside Bypass is also delivered to the San Joaquin River via the Mariposa Bypass. This bypass system parallels a 45-mile reach of the San Joaquin River without project levees.

Farther downstream, the San Joaquin River, lined by intermittent levees, receives flow from three main tributaries to the east: the Merced, Tuolumne, and Stanislaus rivers. Streams on the west side of the basin, including Los Banos, Orestimba, and Del Puerto creeks, are intermittent, and their flows rarely reach the San Joaquin River. Near the Delta, flow from the eastside tributaries (the Calaveras, Mokelumne, and Cosumnes rivers) and Mormon and French Camp sloughs enters the San Joaquin River.

The basic flood management system for the San Joaquin River includes foothill reservoirs with reserved flood storage space to help regulate snowmelt, while conserving water supplies for multiple purposes. Although less frequent than snowmelt floods, rain floods do occur in the San Joaquin Valley and tend to have higher peak flows than the snowmelt floods. Reservoirs in the San Joaquin Valley provide some protection against rain floods, but available storage space for flood management can fill quickly during this type of event.

In some areas, the channel capacity of the San Joaquin River decreases as one moves downstream. The San Joaquin River's levee and diversion systems are not designed to contain the objective release from each of the project reservoirs simultaneously. Channel capacity has been affected because of the in-channel growth of trees, native and nonnative plants, sedimentation, and subsidence. Flows in the San Joaquin River that are less than the design flow may damage land inside the levee system, or may seep through the levees and damage adjacent areas.

Along with major hydrologic features in the San Joaquin Valley and foothills, Figure 3.13-2 shows the locations of multipurpose dams and reservoirs and the locations of SPFC facilities and Stanislaus Local Interest Project levees (described below in the discussion of the Stanislaus River) within the San Joaquin Valley and foothills.

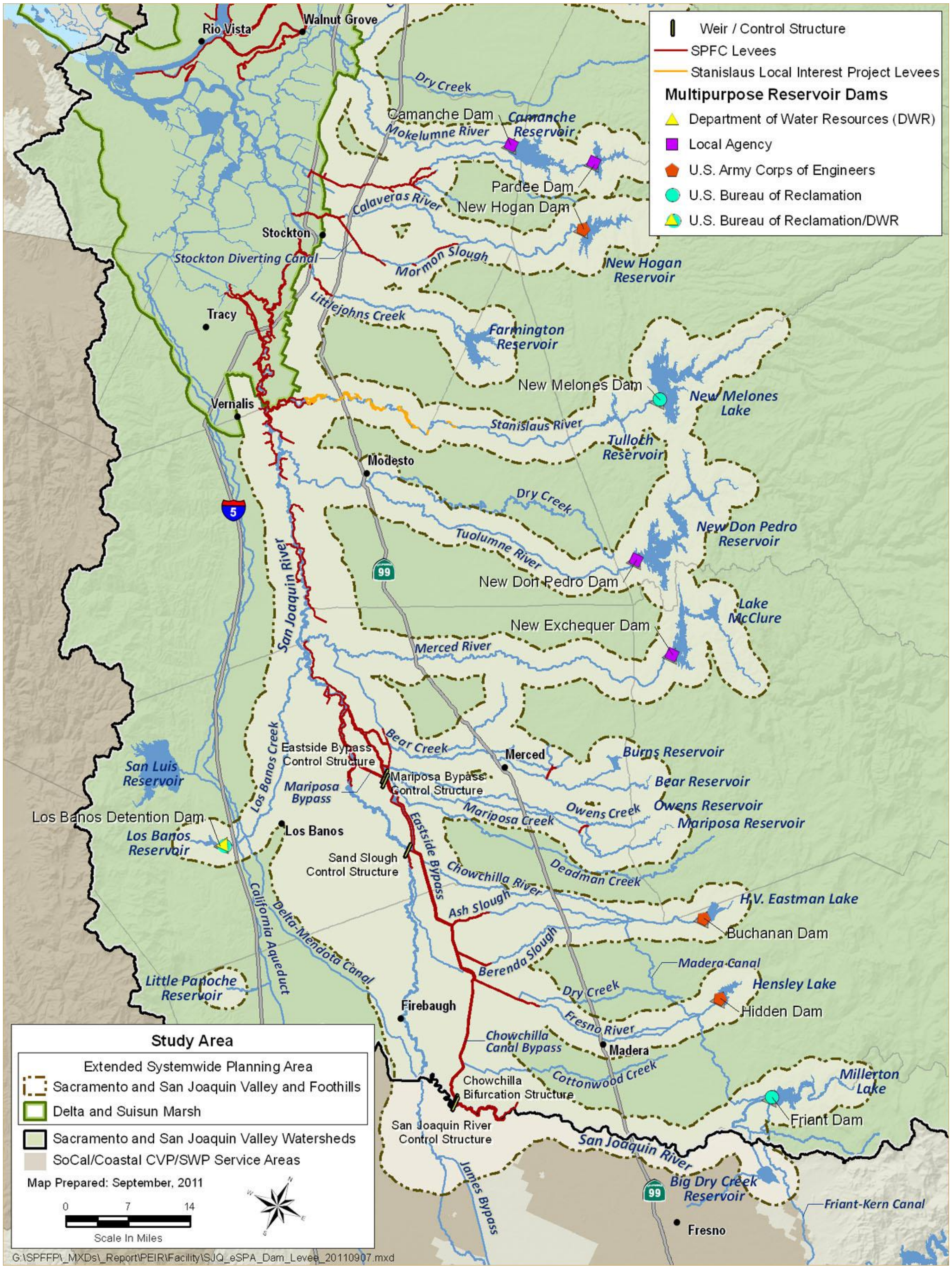


Figure 3.13-2. Locations of Multipurpose Dams and Reservoirs, and State Plan of Flood Control and Stanislaus Local Interest Project Levees in the San Joaquin Valley and Foothills

The San Joaquin River watershed contains considerably more non-SPFC levees than the Sacramento River watershed. In addition, levee segments are frequently discontinuous and are present on only one side in many reaches. A list of the major SPFC facilities is presented in Table 3.13-3.

Table 3.13-3. State Plan of Flood Control Facilities in the San Joaquin Valley and Foothills

State Plan of Flood Control Facility
Chowchilla Bypass right- and left-bank levees
Fresno River right- and left-bank levees
Berenda Slough right- and left-bank levees from levee mile 0 to levee mile 2.03
Berenda Slough right- and left-bank levees in Madera County Flood Control and Water Conservation Agency
Ash Slough right- and left-bank levees from levee mile 0 to levee mile 1.28
Ash Slough right- and left-bank levees in Madera County Flood Control and Water Conservation Agency
Eastside Bypass right- and left-bank levees
Mariposa Bypass right- and left-bank levees
San Joaquin River right- and left-bank levees in Lower San Joaquin LD
Owens Creek Diversion Channel right- and left-bank levees
Merced County Stream Group Project (Black Rascal Creek, Bear Creek Burns Creek, Mariposa Creek and Duck Slough, Miles Creek, Owens Creek) channels
Black Rascal Diversion Channel
Castle Dam
San Joaquin River left-bank levee in RD 1602
San Joaquin River right-bank levee in RD 2063 and Lower San Joaquin River (RD 2063) pumping plant
Mormon Slough Project (diversion, Pumping Plants No. 1, 2, and 3, right and left-bank levees, and channels)
San Joaquin River right-bank levee in RD 2091
San Joaquin River right-bank levee in RD 2092
San Joaquin River left-bank levee in RD 2102
San Joaquin River left-bank levee in RD 2100
San Joaquin River left-bank levee in RD 2099
San Joaquin River left-bank levee in RD 2101

Table 3.13-3. State Plan of Flood Control Facilities in the San Joaquin Valley and Foothills (contd.)

State Plan of Flood Control Facility
San Joaquin River right-bank levee in RD 2031
Stanislaus River left-bank levee from levee mile 0 to levee mile 7.15
Stanislaus River right-bank levee from levee mile 6.06 to San Joaquin River
San Joaquin River right-bank levee in RD 2064
San Joaquin River right-bank levee in RD 2075
San Joaquin River left-bank levee in RD 2085
San Joaquin River right-bank levee in RD 2094
Weatherbee Lake Pumping Plant and Navigation Gate and San Joaquin River right-bank levee in RD 2096
San Joaquin River left-bank levee in RD 2095
Paradise Cut left-bank levee in RD 2095
Paradise Cut left-bank levee in RD 2058
Paradise Cut right-bank levee in RD 2107
Paradise Cut right-bank levee in RD 2062
San Joaquin River left-bank levee in RD 2107
San Joaquin River left-bank levee in RD 2062
Old River left-bank levee from San Joaquin River to Paradise Cut
Old River right-bank levee from San Joaquin River to Middle River
Old River right-bank levee in RD 1
Old River and Salmon Slough right-bank levees in RD 2089
San Joaquin River left-bank levee from Old River to Howard Road
San Joaquin River right-bank levee from Walthall Slough to French Camp Slough
San Joaquin River left-bank levee from Howard Road to Burns Cutoff
French Camp Slough right-bank levee
French Camp Slough left-bank levee
San Joaquin River right-bank levee from French Camp Slough to Burns Cutoff
South Littlejohns Creek right- and left-bank levees
Duck Creek Diversion Channel
Potter Creek right- and left-bank levees

Table 3.13-3. State Plan of Flood Control Facilities in the San Joaquin Valley and Foothills (contd.)

State Plan of Flood Control Facility
North Paddy Creek right- and left-bank levees
Middle Paddy Creek right- and left-bank levees
Paddy Creek right- and left-bank levees
Bear Creek right- and left-bank levees

Source: DWR 2010a

The San Joaquin Valley and foothills is divided into two geographic areas: upper and lower. The upper geographic area includes the San Joaquin River to its confluence with the Merced River; the lower area extends from the confluence with the Merced River to the Delta.

Upper San Joaquin River Geographic Area As mentioned, the upper San Joaquin River geographic area extends from Millerton Lake on the San Joaquin River to just upstream from the confluence of the San Joaquin and Merced rivers. Flow in the upper San Joaquin River is also affected by flow in three bypasses: Chowchilla, Eastside, and Mariposa. Those bypasses are described following an overview discussion of upper San Joaquin River flows and the dams, tributaries, and levees in the upper San Joaquin River geographic area.

Friant Dam, which forms Millerton Lake, is the southernmost reservoir in the Extended SPA. It is owned and operated by Reclamation, and was a key unit in the development of water resources for the CVP. It is operated for flood management, irrigation storage, and recreational purposes. Additionally, under requirements of the San Joaquin River Restoration Program, Millerton Lake must make releases to restore and maintain fish populations in "good condition" (Reclamation 2011). Millerton Lake stores and diverts water to the Madera and Friant-Kern canals for irrigation, and for municipal and industrial (M&I) water supplies in the eastern portion of the San Joaquin Valley (SJRGA 1999). Friant Dam was completed in 1949; the dam and Millerton Lake are owned, operated, and maintained by Reclamation as part of the CVP. Millerton Lake, formed by Friant Dam, has a gross storage capacity of 520.5 TAF and a flood management reservation of 170 TAF.

The dam protects hundreds of square miles of leveed agricultural land, infrastructure, and some limited urbanized areas (Firebaugh and Mendota) along the San Joaquin River by regulating outflows to an objective release of 8,000 cfs.

Downstream from Millerton Lake, flows from Big Dry Creek Reservoir (not part of the SPFC facilities) enter the San Joaquin River. Big Dry Creek Reservoir, along with four other facilities, makes up the Redbank and Fancher Creeks Flood Control Project. This project was constructed from 1948 to 1991 for the single purpose of flood management for the Fresno-Clovis metropolitan area and nearby agricultural land. The project is owned and operated by the Fresno Metropolitan Flood Control District. The five features of the project are Big Dry Creek Dam and Reservoir, Alluvial Drain Detention Basin, Fancher Creek Dam and Reservoir, Pup Creek Detention Basin, and Redbank Creek Detention Basin. The only project feature subject to formal flood management regulation is Big Dry Creek Reservoir, built in 1948 by USACE. The flood management capacity of Big Dry Creek Reservoir is 30.2 TAF. Current flood operation procedures direct most floodwater (up to 700 cfs) to the San Joaquin River through the Little Dry Creek low-level release facility to the Little Dry Creek Flood Channel. Flows from Big Dry Creek Reservoir enter the San Joaquin River and must be accounted for in the operation of Millerton Lake.

The San Joaquin River, downstream from its confluence with Big Dry Creek, continues westward toward the Chowchilla Canal Bypass and Mendota Pool. In this reach, the SPFC levees begin near Gravelly Ford. Design capacity upstream from the Chowchilla Bifurcation Structure is 8,000 cfs. The design capacity of the river downstream from the control structure and through the Mendota Pool is 2,500 cfs.

The San Joaquin River flows north downstream from the Mendota Pool and receives flow from the east from the Fresno and Chowchilla rivers, Ash and Berenda sloughs, and the Merced County Stream Group (Bear, Burns, Owens, and Mariposa creeks) via the Eastside Bypass, and from Los Banos Creek from the west.

About 45 miles of the San Joaquin River, from the beginning of the bypass system downstream to near the Sand Slough Control Structure, have no SPFC levees or other facilities (with the exception of levees on the right and left banks just upstream from the structure); channel capacity ranges from 2,500 cfs to 4,500 cfs. The San Joaquin River Control Structure at Sand Slough and the Sand Slough Control Structure were designed to control the flow split between the bypass and the river, but the San Joaquin River Control Structure has remained closed for many years because of the river’s limited channel capacity. The design channel capacity of the San Joaquin River increases from 1,500 cfs (from the San Joaquin River Control Structure at Sand Slough to the Mariposa Bypass), to 10,000 cfs (from the Mariposa Bypass to the Eastside Bypass), and to 26,000 cfs (from the Eastside Bypass to the Merced River).

The Fresno River, a tributary to the San Joaquin River, discharges into the Chowchilla Canal Bypass. Because of the relatively low elevation of its watershed, most of the flow in the Fresno River results from rainfall. The Fresno River upstream from the bypass has a design capacity of 5,000 cfs.

Hidden Dam on the Fresno River forms Hensley Lake, which is owned and operated by USACE for the purposes of flood management, irrigation, and recreation. The CVP has rights to store and divert water from Hensley Lake, and Madera Irrigation District is proposing to store some of its water behind Hidden Dam (Reclamation 2010). The dam has a gross pool of 90 TAF and a flood management reservation of 65 TAF.

The dam and reservoir provide flood protection to the city of Madera and agricultural lands downstream. Hensley Lake is operated to reduce flows in the Fresno River at Madera to the objective flow of 5,000 cfs.

Slightly downstream from Hidden Dam, the John Franchi Diversion Dam, operated by Madera Irrigation District, diverts water to the Madera Canal, which then conveys water northwest to the Chowchilla River.

The Chowchilla River is another tributary to the San Joaquin River. Because of the low elevation of the watershed, most of the flow in the Chowchilla River results from rainfall runoff and is diverted through Ash and Berenda sloughs. The Chowchilla River ultimately discharges into the San Joaquin River via the Eastside Bypass.

On the Chowchilla River, Buchanan Dam, forming H. V. Eastman Lake, is operated for the purposes of flood management, irrigation, recreation, and fish and wildlife activities. Although H. V. Eastman Lake is owned by USACE, Reclamation markets the stored water on behalf of USACE. Chowchilla Water District and La Branza Water District receive water from the lake (Reclamation 2008). Releases for water supply from H. V. Eastman Lake are supplemented by supplies from the Madera Canal. The lake has a gross pool of 150 TAF and a 45-TAF flood management reservation.

H. V. Eastman Lake provides flood protection to the city of Chowchilla and highly developed agricultural areas below the dam. It has a combined downstream objective release of 7,000 cfs via Ash Slough (5,000 cfs) and Berenda Slough (2,000 cfs).

Los Banos Creek is a westside tributary to the San Joaquin River. Los Banos Detention Dam, located on Los Banos Creek, was completed in 1965. The dam is owned by Reclamation, but is operated by the State to provide flood protection to the San Luis and Delta-Mendota canals, the community of Los Banos, and agricultural lands downstream. Los Banos Reservoir has a storage capacity of 34.6 TAF, with a flood management reservation of 14 TAF used to control downstream releases to a maximum of 1,000 cfs at Los Banos.

The Merced County Stream Group Project consists of five dry dams (Bear, Burns, Owens, Mariposa, and Castle) and two diversion structures with a total flood storage capacity of 39.5 TAF. A dry dam allows the channel to flow freely during normal conditions without impoundment but temporarily stores floodwaters, releasing the flows downstream at a controlled rate. All of the dams are in the foothills east of the city of Merced on tributaries to the San Joaquin River, and provide flood protection to Merced. The Black Rascal Creek and Owens Creek diversion channels have design capacities of 3,000 cfs and 400 cfs, respectively.

The objective of the Merced County Stream Group Project is to restrict the flood flows of several streams in the Merced County Stream Group (Bear, Burns, Owens, and Mariposa creeks) to the nondamaging capacity of the valley floor channels, from the foothill line to the city of Merced.

Chowchilla, Eastside, and Mariposa Bypasses Flow in the upper San Joaquin River is also affected by flow in three bypasses: Chowchilla Canal, Eastside, and Mariposa. The southernmost bypass, the Chowchilla Canal Bypass, diverts excess San Joaquin River flow and routes it to the Eastside Bypass.

The Chowchilla Canal Bypass begins at the San Joaquin River 8 miles downstream from Gravelly Ford, where it picks up diverted San Joaquin River flood flows, runs northwest to the Fresno River, and ends at the Eastside Bypass. The bypass provides protection against flood damage for downstream agricultural lands. San Joaquin River flows that exceed 2,500 cfs are diverted to the canal through the Chowchilla Bifurcation Structure. The design capacity of the Chowchilla Canal Bypass is 5,500 cfs. When flows exceed the combined design capacity of the San Joaquin River and the Chowchilla Canal Bypass (8,000 cfs), the excess flows are to be split evenly between the two, at the discretion of the operator (Lower San Joaquin River Levee District).

The Eastside Bypass begins at the Fresno River, runs northwest, and ends at the San Joaquin River upstream from the Merced River between Fremont Ford and Bear Creek. The bypass receives flows from the Chowchilla Canal Bypass and intercepts flows from the Fresno and Chowchilla rivers; Berenda, Owens, and Ash sloughs; and the Merced County Stream Group, including Bear Creek, and carries the flows to the San Joaquin River.

The design capacity of the Eastside Bypass begins at 10,000 cfs at its bifurcation from the Fresno River, and increases in increments to a maximum of 17,500 cfs after crossing Ash Slough. However, actual capacities may be less because of subsidence under sections of the Eastside Bypass levees. Flows at the downstream end of the bypass are controlled by the Eastside and Mariposa bypass control structures, which split the flows to either continue down the Eastside Bypass or enter the San Joaquin River through the Mariposa Bypass.

The Mariposa Bypass delivers flow into the San Joaquin River from the Eastside Bypass. The bypass begins at the Mariposa Bypass Control Structure and extends to the Mariposa Bypass Drop. The Mariposa Bypass has a design capacity of 8,500 cfs.

Lower San Joaquin River Geographic Area The lower San Joaquin River geographic area is the area between the confluence of the San Joaquin River with the Merced River and the Delta at Vernalis. Major tributaries to the San Joaquin River in this area are the Merced, Tuolumne, and Stanislaus rivers and eastside tributaries in the Delta. These rivers and eastside tributaries are described below following the discussion of lower San Joaquin River flows.

Within the last decade, large-scale urban and commercial development has occurred at hubs near major east-west highways along the lower portion of the San Joaquin River, between the Stockton and Tracy urban areas. The flood management system in this area was originally designed to protect agricultural land uses; therefore, the levees were not constructed with the same engineering standards as those in urban areas. Consequently, the public may underestimate the risk of flooding in these areas.

The design channel capacity of the lower San Joaquin River is 45,000 cfs between the confluences with the Merced and Tuolumne rivers and 46,000 cfs between the confluences with the Tuolumne and Stanislaus rivers. In these two reaches, the right-bank levee has three discontinuous segments, and the left-bank levee has four. Downstream from the San Joaquin River's confluence with the Stanislaus River, the design channel capacity increases to 52,000 cfs.

Merced River The Merced River enters the San Joaquin River near Hills Ferry. New Exchequer Dam, forming Lake McClure, regulates releases to the lower Merced River. The dam is owned and operated by Merced Irrigation District, has a capacity of 1,024.6 TAF. Lake McClure is operated for flood management, power production, irrigation, recreation, and downstream fishery and wildlife purposes. Releases from Lake McClure pass through a series of power plants and smaller diversions, and are reregulated at McSwain Reservoir. Pacific Gas and Electric Company's Merced Falls Dam is below McSwain Dam. Farther downstream is Merced Irrigation District's Crocker Huffman Dam, which diverts water for irrigation purposes (SJRGA 1999).

The dam and lake provide flood protection to prime agricultural lands below the dam, and to the communities of Livingston, Snelling, Cressy, and Atwater. Lake McClure has a flood management reservation of 350 TAF, with a downstream objective release of 6,000 cfs in the Merced River at Stevinson.

Tuolumne River The Tuolumne River, the largest tributary to the San Joaquin River, enters the San Joaquin River near Modesto. New Don Pedro Dam, owned and operated jointly by Merced and Turlock irrigation districts, regulates flows on the lower portion of the Tuolumne River. New Don Pedro Reservoir stores water for flood management purposes, irrigation, hydroelectric generation, fish and wildlife enhancement, and recreation. The City and County of San Francisco, Modesto Irrigation District, and Turlock Irrigation District receive water supply from this reservoir. The dam impounds more than 2,030 TAF, with a maximum flood management reservation of 340 TAF.

This reservoir provides flood management for agricultural property, infrastructure, and some low areas in suburban Modesto by controlling rain and snowmelt floods to the downstream objective release of 9,000 cfs.

A short distance downstream from New Don Pedro Reservoir, at La Grange Dam, water is diverted to the Modesto Main Canal and Turlock Main Canal.

Stanislaus River The Stanislaus River enters the San Joaquin River just upstream from Vernalis. Although snowmelt contributes a large portion of the flows and the highest runoff is in May and June, rain floods do occur in this watershed. Ungauged tributaries contribute flow to the lower portion of the Stanislaus River, downstream from the Goodwin Diversion Dam.

New Melones Dam regulates flow on the Stanislaus River. New Melones Dam and Reservoir are operated for flood control, water supply, instream water quality, Delta water quality, irrigation, hydropower, fishery enhancement, and recreation. Reclamation operates New Melones Dam as part of the CVP. Stockton East Water District and Central San Joaquin County also receive water supply from New Melones Reservoir (SEWD 2011). New Melones Dam, which replaced the original Melones Dam, was completed by USACE in 1978 and was approved to begin operation in

1983. The lake has a capacity of 2,400 TAF, 450 TAF of which are reserved for flood management.

Flood management protects more than 35,000 acres of leveed agricultural land, infrastructure, and some limited urbanized areas in Oakdale, Riverbank, and Ripon along the Stanislaus and San Joaquin rivers. The flood management reservation of 450 TAF in New Melones Reservoir is used to regulate to a downstream objective release of 8,000 cfs.

Downstream from New Melones Dam, on the mainstem Stanislaus River, flow is reregulated by Tulloch Dam. Farther downstream along the Stanislaus River is Goodwin Dam, the river's main water diversion point. The Oakdale and South San Joaquin irrigation districts own and operate the downstream Goodwin Dam, which diverts Stanislaus River water into the districts' canals. Goodwin Dam is also used to divert water into the Goodwin Tunnel for deliveries to Stockton East Water District and Central San Joaquin Water Conservation District (SJRGA 1999).

The Stanislaus River upstream from the San Joaquin River has right- and left-bank levees extending up to high ground. The Stanislaus River is also protected by local-interest project levees between Goodwin Dam and the Stanislaus River confluence with the San Joaquin River. The local-interest project levees have been identified by USACE as adequate to contain the Stanislaus River's design capacity of 8,000 cfs.

The existing channel and local-interest project levees along the Stanislaus River between Goodwin Dam and the San Joaquin River confluence have together been named the "Stanislaus River Designated Floodway" by the Board. The Board exercises USACE's property rights in the designated floodway and project floodway, providing assurances to USACE that if the local-interest project levees are not satisfactorily maintained, the Board will extend the designated floodway's encroachment lines to include the area that would be flooded during a design flood if those levees did not exist.

Eastside Tributaries to the Delta Eastside tributaries to the Delta are in the northern portion of the San Joaquin River basin, primarily between the watersheds of the American and Stanislaus rivers. Among these are the Cosumnes, Mokelumne, and Calaveras rivers (described separately below). Other eastside tributaries are the Littlejohns Creek Stream Group, French Camp Slough, Mormon Slough (included with the Calaveras River), and Bear Creek.

The Littlejohns Creek Stream Group—Duck, Littlejohns, Temple, and Lone Tree creeks—is located southeast of Stockton in San Joaquin and Stanislaus counties. Most of the area associated with the Littlejohns Creek

Stream Group is devoted to farming and ranching. However, urban and commercial development has taken place in several areas near Stockton. The only flood management facility, Farmington Dam, is on Littlejohns Creek. Farmington Reservoir on Littlejohns Creek is owned and operated by USACE to restrict downstream flood flows to nondamaging levels throughout the network of channels along the lower reaches of Littlejohns and Rock creeks. The reservoir has the capacity to temporarily store up to 52 TAF of floodwater. The project also includes a diversion channel from Duck Creek to Littlejohns Creek, channel improvement work on selected streams, cutoff dikes, and a small diversion dam to confine flood flows to the main channel of Littlejohns Creek.

By reducing flows to the downstream objective release of 2,000 cfs, Farmington Dam provides flood protection to 58,000 acres of intensely developed agricultural lands below the dam, the city of Stockton, and the rural towns of Farmington and French Camp.

A dike across Duck Creek and a 5,000-foot-long diversion channel divert Duck Creek flow to Littlejohns Creek. The channel has a design capacity of 500 cfs. South Littlejohns Creek has a 2.3-mile-long right-bank levee in two segments and a 2.6-mile-long left-bank levee. The project is intended to reduce flood risk to Stockton and its surrounding urban area and is not technically included in the SPFC facilities.

French Camp Slough enters the river about 2.3 miles upstream from Burns Cutoff. SPFC facilities within the French Camp Slough drainage include a diversion, channel clearing and excavation, and levees. The SPFC left-bank levees on French Camp Slough extend about 1.8 miles upstream from the San Joaquin River while the right bank follows a 0.5 mile portion of Walker Slough, one mile upstream from the San Joaquin confluence. The levees' project design capacities are 3,000 cfs for the left-bank levee and 2,000 cfs for the right-bank levee.

Bear Creek is another tributary to the San Joaquin River that enters the river downstream from the Calaveras River. The design capacity of Bear Creek at its mouth is 5,500 cfs. SPFC facilities include 15.7 miles of channels and 30.1 miles of levees on Bear Creek and its tributaries—Paddy, Middle Paddy, and North Paddy creeks.

Cosumnes River The Cosumnes River enters the Mokelumne River within the Delta near the town of Thornton. Most of the flow in the Cosumnes River and its tributaries results from winter rain, and the annual hydrograph closely follows the pattern of precipitation. The river is generally considered to be undammed because it has no major hydroelectric dams. Extreme low flows (including dry bed) occur in the lower Cosumnes River in the late summer, after long periods without precipitation. Flooding on the Cosumnes River affects the towns of Thornton and Wilton, as well as adjacent agricultural communities. Because of the low elevation of its headwaters, the Cosumnes River receives most of its water from rainfall.

Mokelumne River The Mokelumne River enters the lower San Joaquin River northwest of Stockton, in the Delta at Bouldin Island. Two reservoirs on the Mokelumne River, Pardee and Camanche, are within the Extended SPA. Both are owned and operated by East Bay Municipal Utility District (EBMUD).

Pardee Reservoir has a storage capacity of 210 TAF and is operated for water supply, power, and recreation. Downstream, Camanche Reservoir has a total storage capacity of 430.9 TAF and a maximum flood management reservation of 200 TAF. Camanche Reservoir is operated for purposes of flood management, downstream fishery needs, irrigation, hydroelectric power generation, and recreation. It provides flood protection to the lower Mokelumne River basin—Lodi, Woodbridge, Thornton, and 69,000 acres of agricultural land—by reducing river flows to the downstream objective release of 5,000 cfs.

EBMUD receives water supply from both Pardee and Camanche reservoirs. The district receives water directly from Pardee Reservoir via the Mokelumne River Aqueduct (EBMUD 2009).

Camanche Dam is operated in conjunction with Pardee Dam and Reservoir (EBMUD), and Salt Springs and Lower Bear reservoirs (Pacific Gas and Electric Company), all located upstream from Camanche Dam. The required flood management reservation can be exchanged between Camanche and Pardee reservoirs.

Calaveras River and Mormon Slough The Calaveras River enters the San Joaquin River near the city of Stockton. With a design capacity of 13,500 cfs, the Calaveras River receives nearly all of its flow from rainfall.

The major water management facilities on the Calaveras River, New Hogan Dam and Reservoir, are operated for flood management and, if possible, for M&I water supply, irrigation, recreation, and power generation purposes. New Hogan Dam and Reservoir are owned and operated by USACE; the reservoir has a total storage capacity of 317.1 TAF and a flood management reservation of 165 TAF. Stockton East Water District and Calaveras County Water District receive more than half of the reservoir’s water supply yield (Fishery Foundation of California 2004).

Flood management operations at New Hogan Dam and Reservoir protect about 46,000 acres of agricultural land and 14,000 acres of urban and suburban land along the Calaveras River, Mormon Slough, and the Stockton Diverting Canal. The reservoir provides protection to Stockton and the smaller cities of Linden, Waterloo, and Bellota. New Hogan Reservoir is operated to meet an objective release of 12,500 cfs downstream in Mormon Slough.

SPFC facilities within the Calaveras River drainage include facilities of the Mormon Slough Project, which consist of a diversion from Mormon Slough, pumping plants, and levees and improved channels along Mormon Slough, Potter Creek, and the Calaveras River. The Mormon Slough Project is maintained by the San Joaquin County Flood Control and Water Conservation District. Mormon Slough diverts irrigation and higher flows from the Calaveras River at Bellota Weir and has a design capacity of 12,500 cfs. Intermittent spoil dikes and levees are located along approximately 11 miles of Mormon Slough.

Status of Flood Management Facilities in the Sacramento and San Joaquin Valley and Foothills This section describes the current status (physical condition) of flood management facilities at a systemwide level within the Sacramento and San Joaquin Valley and foothills. Information provided in this section is taken from the *Draft Flood Control System Studies Report* (DWR 2011). In some cases, the current condition of SPFC facilities presents unacceptable threats for potentially flooding certain land uses in protected areas.

Table 3.13-4 lists factors that influence facility performance, findings related to each factor, and the relative threat posed by the factor. The relative threats to SPFC facilities posed by each factor are generally defined as follows:

- **High relative threat—**The factors that either are the most prevalent or greatly contribute to the potential for facility failure, or both
- **Medium relative threat—**The factors that either are moderately prevalent or moderately contribute to the potential for facility failure, or both
- **Low relative threat—**The factors that either are the least prevalent or make less of a contribution to the potential for facility failure, or both

Table 3.13-4. Findings of the Flood Control System Status Report

	Factors	Findings	Relative Threat Posed by Factor[1]
Levees	**Overall Levee Condition (multiple factors)**	• Approximately half of SPFC urban levees do not meet current levee freeboard, stability, or seepage design criteria at the design water surface elevation. • Approximately three-fifths of SPFC nonurban levees have a high potential for levee failure from underseepage, through-seepage, structural instability, and/or erosion at the assessed water surface elevation.	See Figure 3.13-3
	Levee Geometry Check	• Approximately one-third of SPFC urban levees deviate from current standard levee design prism criteria. • Levee geometry deviates significantly from the standard levee design prism criteria for some nonurban SPFC levees.	Medium
	Seepage	• Approximately one-third of urban levees do not meet current seepage design criteria. • Almost half of SPFC nonurban levees have a high potential for levee failure from underseepage. • Approximately one-quarter of SPFC nonurban levees have a high potential for levee failure from through-seepage.	High
	Structural Instability	• Approximately one-fifth of SPFC urban levees do not meet current structural stability design criteria. • Approximately one-seventh of SPFC nonurban levees evaluated in the Sacramento River watershed and 1 percent in the San Joaquin River watershed have a high potential for levee failure from structural instability.	Medium
	Erosion	• Erosion assessments for urban levees are under way. Results are not available at this time. • Almost one-sixth of SPFC nonurban levees have a high potential for levee failure from erosion.	Medium

Table 3.13-4. Findings of the Flood Control System Status Report (contd.)

	Factors	Findings	Relative Threat Posed by Factor[1]
Levees	**Settlement**	• Four known localized levee locations have settlement (localized depressions) that endangers the integrity of SPFC levees.	Low
Levees	**Penetrations[2]**	• More than 6,000 penetration sites are documented in SPFC levees, and many more remain undocumented.	Medium
Levees	**Levee Vegetation**	• About 15 miles of SPFC levees are noncompliant with DWR 2007a *Interim Levee Vegetation Criteria.*[3,4]	Low
Levees	**Rodent Damage**	• More than one-third of the 1,459 miles of SPFC levees studied had at least eight reported occurrences of burrowing activity over a 21-year study span.	Medium
Levees	**Encroachments[5]**	• 1,223 encroachment sites were identified as partially or completely obstructing visibility and access to the levee and/or within 10 feet of the landside toe.[4]	Medium
Channels	**Inadequate Conveyance Capacity**	• Approximately half of the 1,016 miles of SPFC channels evaluated are potentially inadequate to convey design flows, and require additional evaluation to confirm conditions. • Approximately one-quarter of channel design capacities reported in O&M manuals do not agree with flows specified in the design profiles.	Medium
Channels	**Channel Vegetation**	• Of 186 miles of SPFC channels inspected by DWR, one location was rated Unacceptable and 54 locations were rated Minimally Acceptable because of vegetation and obstructions.[4]	Low
Channels	**Channel Sedimentation**	• Of 186 miles of SPFC channels inspected by DWR, one location was rated Unacceptable and 23 locations were rated Minimally Acceptable because of shoaling/sedimentation.[4]	Low

Table 3.13-4. Findings of the Flood Control System Status Report (contd.)

	Factors	Findings	Relative Threat Posed by Factor[1]
Structures	**Inadequate Hydraulic Structures**	• Of 32 SPFC hydraulic structures inspected by DWR, no structures were rated Unacceptable because of structural, vegetation/obstruction, encroachment, or erosion/sedimentation issues.[4]	Low
	Inadequate Pumping Plants	• Of 11 SPFC pumping plants inspected by DWR, none were rated Unacceptable.[4]	Low
	Inadequate Bridges	• Of 10 SPFC bridges inspected by DWR, 2 were in need of repairs.[4]	Low

Source: DWR 2011

Notes:

[1] The relative threats listed in this table were generated based on professional experience of technical staff of DWR and partner agencies.

[2] Penetrations include human-made objects that cross through or under a levee or floodwall and have the potential to provide a preferential seepage path or hydraulic connection with the waterside. Typically, a penetration is a pipe or transportation structure, such as a roadway or rail line.

[3] This finding is based on *Interim Levee Vegetation Criteria* (DWR 2007a), and not on the U.S. Army Corps of Engineers' (USACE) levee vegetation criteria. Comparison with USACE levee vegetation criteria would show more SPFC levees as noncompliant.

[4] Inspection results reported are from DWR's 2009 inspections.

[5] Encroachments are any obstruction or physical intrusion by construction of works or devices, planting or removal of vegetation, or caused by any other means, for any purpose, into a flood control project, waterway area of the flood control project, or area covered by an adopted plan of flood control (California Code of Regulations, Title 23, Chapter 1, Article 2, Section 4(m)). Encroachments include boat docks, ramps, bridges, sand and gravel mining, placement of fill, fences, retaining walls, pump stations, residential structures, and irrigation and landscaping materials/facilities.

Key:
DWR = California Department of Water Resources
FCSSR = Flood Control System Status Report
O&M = operations and maintenance
SPFC = State Plan of Flood Control

The relative threat posed by each factor is subjective and only serves to help identify and prioritize the factors most likely to contribute to the failure of SPFC facilities. These results do not reflect economic or loss-of-life consequences of flooding, which are key factors in planning system improvements.

The overall condition of urban levees, nonurban levees, and channels can be summarized as follows:

- **Urban levees—**Approximately half of about 300 miles[2] of SPFC urban levees evaluated do not meet current levee freeboard, stability, or seepage design criteria[3] at the design water surface elevation.

- **Nonurban levees**—Approximately three-fifths of about 1,200 miles of SPFC nonurban levees evaluated have a high potential for failure from underseepage, through-seepage, structural instability, and/or erosion at the assessment water surface elevation.[4] Nonurban levees were evaluated based on systematic, consistent, repeatable analyses that correlated geotechnical data with levee performance history, and not relative to any current design criteria.[5]

- **SPFC channels—**Approximately half of the 1,016 miles of channels evaluated in the SPFC have a potentially inadequate capacity to convey design flows, and require additional evaluation to confirm conditions.

The overall relative ratings of the condition of SPFC levees, considering most of the levee factors in Table 3.13-4, are summarized in Figure 3.13-3, which includes both SPFC and non-SPFC levees. To show a simplified representation of levee conditions, the figure includes results from urban and nonurban levee evaluations (ULE and NULE, respectively) that are not directly comparable to each other because different evaluation methodologies were used. The figure is intended to broadly show which levee reaches are of relatively higher, medium, and lower concern, based on the physical conditions of the levees. Levees shown in purple (higher concern) on the map generally display more performance problems than those shown in green (lower concern).

As mentioned, the results of these relative ratings are not meant to be used to determine how a levee or associated system may perform in a flood event. They also do not represent the level of effort that would be necessary to assess whether a levee could be certified under Federal Emergency Management Agency (FEMA) standards to provide base flood protection under the National Flood Insurance Program (NFIP). Furthermore, these

[2] Evaluations of an additional 10 miles of SPFC urban levees were under way at publication of the *Draft Flood Control System Studies Report* (DWR 2011) and the results of these evaluations will be included in future updates.

[3] The design criteria used were based on *Design and Construction of Levees* (Engineering Manual 1110-2-1913) (USACE 2000) and *Interim Levee Design Criteria for Urban and Urbanizing Areas in the Sacramento–San Joaquin Valley,* Version 4 (DWR 2010b).

[4] Where available, the 1955/57 design water surface elevations were used as the water surface elevation in the assessment. In the absence of 1955/57 design water surface elevations, the assessment of water surface elevation was based on freeboard requirements for each levee segment (i.e., generally 3 feet below the levee crest).

[5] This approach was selected because the extent of the NULE Project is substantially greater than that of the ULE Project, making it difficult to conduct the same level of field explorations and geotechnical data collection performed for ULE levees.

results do not reflect the consequences to economics or life safety of flooding, which are key factors in planning system repairs and improvements.

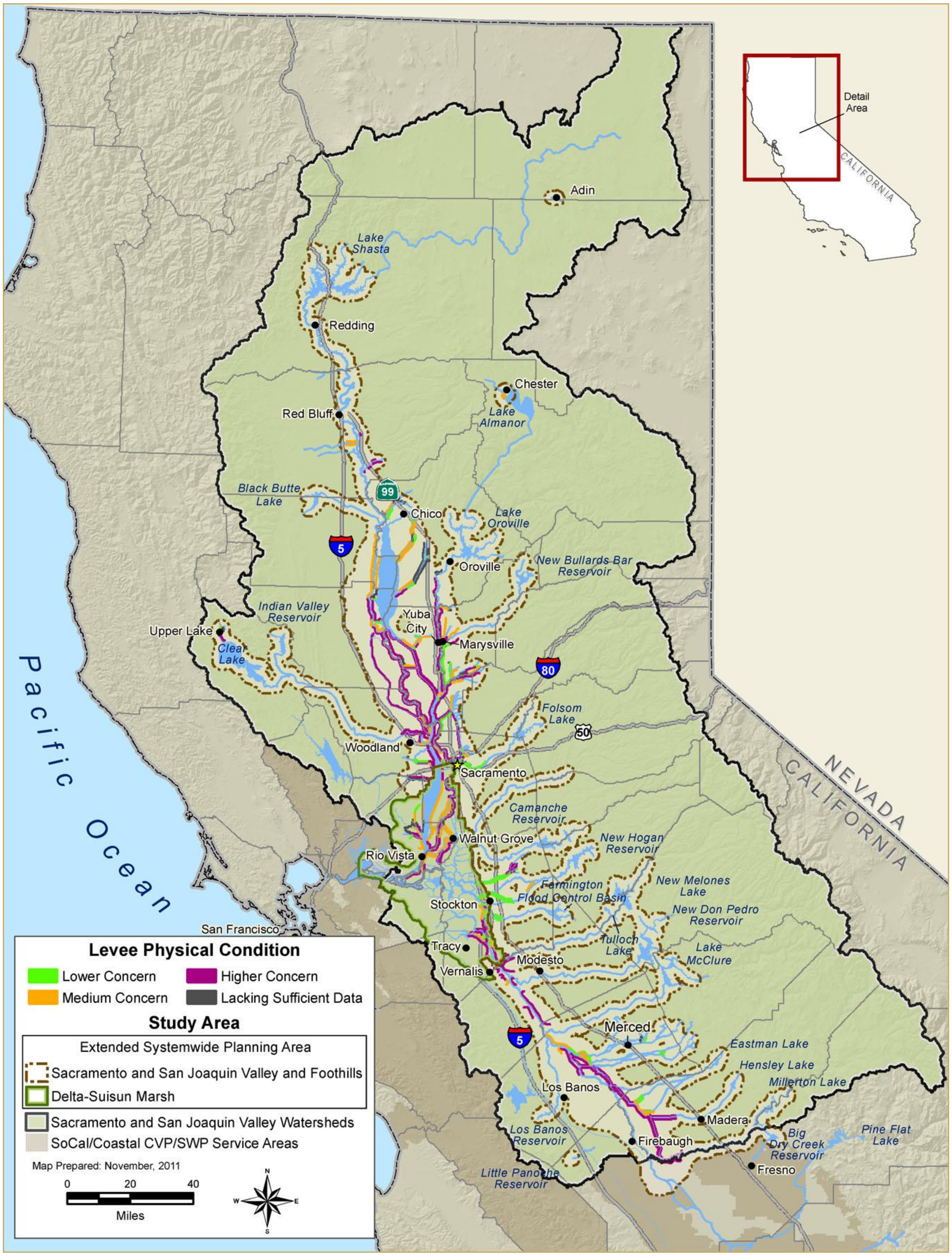


Figure 3.13-3. Relative Physical Condition of Levees in the Sacramento and San Joaquin River Watersheds

Delta The Delta is a network of islands, channels, and marshland at the confluence of the Sacramento and San Joaquin rivers. Major rivers entering the Delta are the Sacramento River flowing from the north, the San Joaquin River flowing from the south, and eastside tributaries flowing from the east (Figure 3.13-4). The Delta, together with Suisun Marsh and greater San Francisco Bay, make up the largest estuary on the west coast of North and South America (DWR 2009a).

Before 1850, the Delta was essentially a broad expanse of water-dependent habitat and natural channels. Large-scale widening and dredging of the main Sacramento River channel, especially near its mouth, occurred during the early 20th century to more rapidly drain floodwaters and facilitate navigation. In addition, reclamation of the Delta for agriculture has resulted in approximately 700 miles of meandering waterways, and 1,100 miles of levees protecting more than 538,000 acres of farmland, homes, and other structures. About 65 major islands and tracts in the Delta rely on a levee system to hold back river and tidal waters. A few small islands lack levees, and a series of open-water areas were formerly islands. Most original Delta levees were built with soils dredged from nearby channels during early reclamation efforts. Each levee system generally provides low levels of protection for adjoining lands. Most levees were never engineered and have been built and maintained locally. These levees have been improved in various locations using a variety of methods, resulting in a system of levees with variations in their ability to withstand natural forces.

Flooding is a near-annual event in the Delta and can cause overtopping and erosion of levees. Delta floods originate from levee failures, which can happen at any time throughout the year. Levee failures often result from the combination of high river inflows, high tide, and high winds. However, they also can occur in fair weather because of rodent damage (predominantly from ground squirrels and beavers), piping (a phenomenon whereby a pipe-like opening develops below the levee base), foundation movement, or other causes. The possibility of a seismic event also puts the integrity of Delta levees at risk. Because many Delta islands are below sea level, the potential exists for deep and prolonged flooding during a levee failure event. Levee failures in this geographic area can pull saltwater into the Delta, affecting water exports from the Delta; inundate transportation, energy, and water transmission infrastructure; and adversely affect agricultural and other local economic activities.

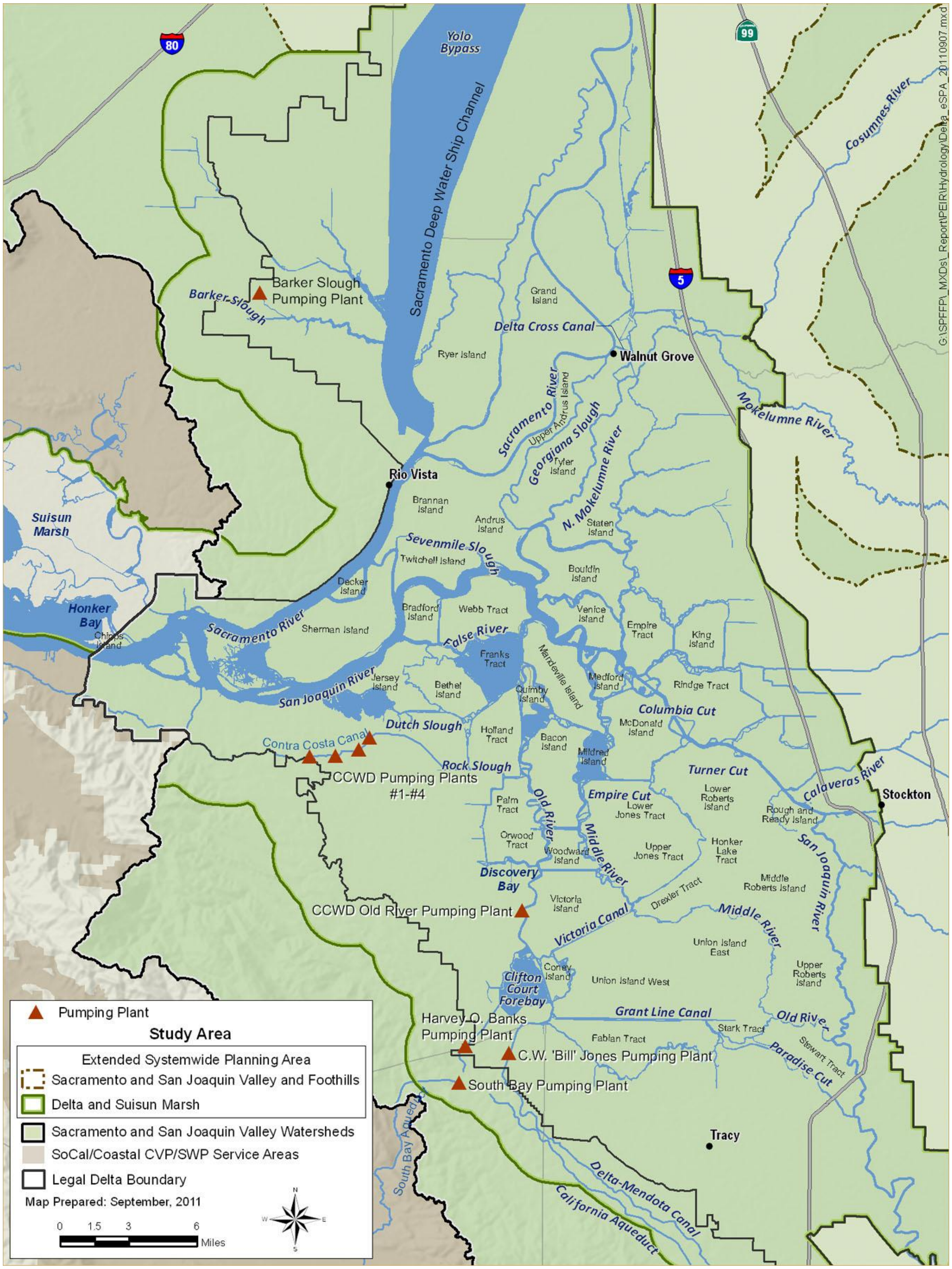


Figure 3.13-4. Delta Hydrologic Features

As stated above, the Delta is located at the confluence of the Sacramento and San Joaquin rivers. Most of the channels and islands of the Delta are protected by non-SPFC local levees. The limited SPFC levees are located primarily in the North Delta and along parts of the San Joaquin River below Stockton. The right bank of the Sacramento River is lined by about 20 miles of levees from the northern extent of the legal Delta boundary at Elk Slough to the confluence of the Sacramento River and Yolo Bypass. Downstream from the Sacramento River confluence with the Yolo Bypass there is no right-bank levee. The left-bank levee along the Sacramento River is about 38 miles long. Both levees were constructed by local interests and enlarged, set back, or repaired to project standards by USACE. The levees are intended to reduce flood risk to adjacent agricultural areas in the Delta.

The design capacity of the Sacramento River decreases as the river enters the Delta and distributary channels appear. Specifically, the design capacity declines from 110,000 cfs downstream from Elk Slough to 35,900 cfs downstream from Georgiana Slough. Capacity increases to 579,000 cfs after the river's confluence with the Yolo Bypass, then decreases back to 514,000 cfs downstream from Threemile Slough.

On the distributary channels to the Sacramento River, there are SPFC levees on both banks of Elk, Sutter, Miner (a distributary of Sutter Slough), Steamboat, Georgiana, and Threemile sloughs.

On the San Joaquin River within the Delta, SPFC facilities consist of levees on both banks and a pumping plant in the legal Delta. SPFC San Joaquin River levees end at Stockton. San Joaquin River levees are all local non-SPFC downstream of Stockton until the confluence with the Sacramento River. Between Paradise Cut and Old River upstream of Stockton, the design capacity of the San Joaquin River is 37,000 cfs. The right- and left-bank levees are about 5 miles long and are intended to reduce flood risk for the city of Lathrop. The Weatherbee Lake Pumping Plant and Navigation Gate are located where the right-bank levee crosses Walthall Slough, about 0.8 miles upstream from Mossdale. The pumping plant has a rated capacity of 22,500 gallons per minute.

The design capacity of the San Joaquin River decreases to 18,000 cfs between Old River and Burns Cutoff. The right- and left-bank levees are approximately 12 miles long. French Camp Slough (described earlier) enters the river about 2.3 miles upstream from Burns Cutoff.

SPFC facilities within the Delta also include levees on both sides of Paradise Cut from the San Joaquin River to the confluence with the Old River and surrounding Stewart Tract. The design channel capacity is

15,000 cfs. The right-bank levee is 5.9 miles long; this levee is intended to reduce flood risk to Stewart Tract and an urbanizing portion of Lathrop on Steward Tract. The left-bank levee is 6.2 miles long.

Old River has SPFC levees on both sides of the channel. The right- and left-bank levees extend about 7.1 miles from the San Joaquin River to the Grant Line Canal and about 5.6 miles from the San Joaquin River to the confluence with Paradise Cut, respectively. The design capacity for this reach is varied: 19,000 cfs from the San Joaquin River to Middle River, 15,000 cfs from Middle River to Paradise Cut, and 30,000 cfs from Paradise Cut to the Grant Line Canal. The left-bank levee is intended to reduce flood risk to Stewart Tract and an urbanizing portion of Lathrop on Stewart Tract.

The Delta is heavily driven by tidal influences. Pacific Ocean tides move into and out of the Delta, ranging from less than 1 foot in the eastern Delta to more than 5 feet in the western Delta (DWR 2009a). Tidal effects on river stage typically exhibit a frequency of approximately two cycles per day, and a larger tidal effect is observed roughly twice each month. The influence of Delta tidal flows extends up the Sacramento River for 80 miles to the Feather River at Verona at low river stages, inducing tidal backwater into the Yolo Bypass and the Sacramento Deep Water Ship Channel, which runs along the east levee of the bypass. On the San Joaquin River, the tidal influence extends nearly 72 miles to just upstream of Vernalis.

The Delta is also influenced by a combination of river and bypass inflows, agricultural and M&I diversions in the Delta, CVP and SWP operations and exports, and precipitation. In an average water year, the largest source of freshwater into the Delta is the Sacramento River. In 2000 (an above-normal water year in the Sacramento Valley), the Sacramento River transported approximately 18.3 MAF into the Delta, while flows from the San Joaquin River contributed 2.8 MAF. Flows from the Yolo Bypass and eastside tributaries contributed just over 3.9 MAF, with precipitation adding about another 1 MAF. In-Delta consumption and exports from the Delta accounted for 1.7 MAF and 6.3 MAF of use, respectively, in addition to 18.1 MAF of outflow to San Francisco Bay (DWR 2009a).

As described above, inflow to the Delta is from the Sacramento River, San Joaquin River, and eastside tributaries. Historical average monthly total Delta inflow is shown in Table 3.13-5 by year type.

Table 3.13-5. Historical Average Monthly Sacramento–San Joaquin Delta Inflow

Water Year Type[2]	Average Monthly Inflow (cfs)[1]											
	Oct	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
All Years	16,089	19,540	36,435	58,429	67,358	59,327	43,370	32,925	24,811	19,658	17,934	18,187
Wet	19,135	25,634	61,875	99,536	110,506	91,466	76,891	54,024	38,873	25,251	21,683	23,436
Above Normal	12,717	15,297	21,482	65,912	74,084	74,818	37,090	33,465	23,817	19,602	18,647	18,497
Below Normal	15,822	16,655	22,077	31,460	48,980	41,330	23,488	21,723	17,247	16,189	15,846	15,536
Dry	14,083	16,884	21,290	21,799	27,137	27,989	17,840	15,070	13,606	16,559	15,616	14,105
Critical	13,927	13,465	16,750	16,651	16,553	17,348	13,072	10,413	10,278	12,123	12,212	11,743

Source: DWR 2009a
Notes:
1 Period of record: water years 1956–2007.
2 Sacramento Valley water year types.
Key:
cfs = cubic feet per second

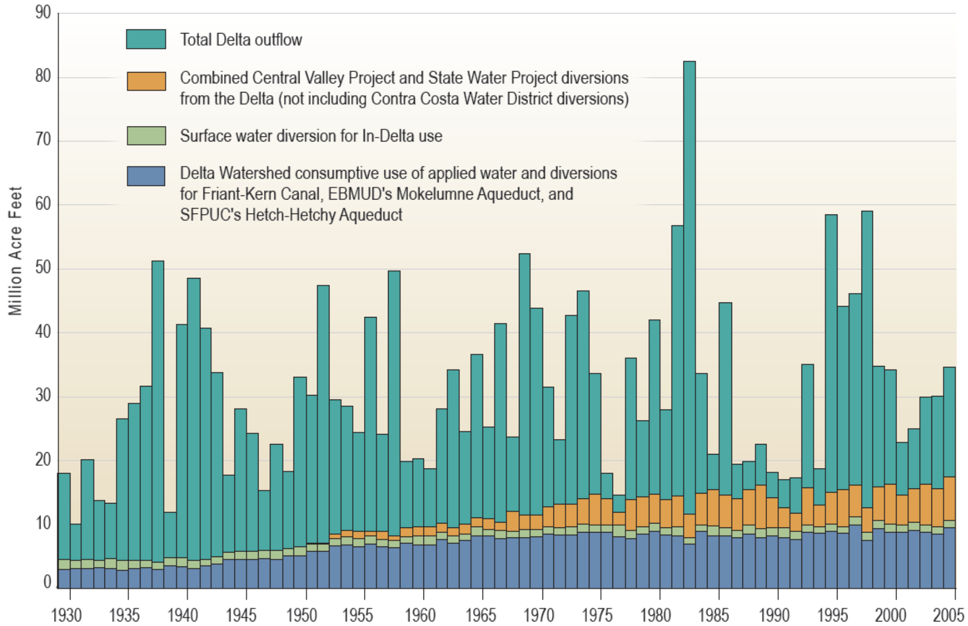
Because tidal inflows and outflows are approximately equivalent during each daily tidal cycle, tributary inflows and export pumping are the principal variables that define the range of hydrodynamic conditions in the Delta. Uncontrolled outflow occurs almost entirely during the winter and spring months. Outflow averages about 32,000 cfs during the winter and 6,000 cfs during the summer. Because of tidal factors and changing channel geometry, Delta outflow is typically calculated rather than directly measured. Table 3.13-6 shows calculated average monthly Delta outflow by water year type.

Table 3.13-6. Calculated Average Monthly Sacramento–San Joaquin Delta Outflow

Water Year Type[2]	Average Monthly Outflow (cfs)[1]											
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
All Years	9,726	15,063	32,049	54,724	64,021	54,942	38,282	27,133	16,071	8,451	6,698	9,402
Wet	12,939	22,120	59,197	97,478	108,005	88,897	73,229	48,241	30,115	14,024	10,424	15,123
Above Normal	6,758	10,939	17,087	61,807	69,421	70,408	32,290	27,874	13,450	7,164	5,990	7,866
Below Normal	10,684	13,066	18,778	28,662	47,909	36,353	17,719	15,488	7,433	5,045	5,121	7,296
Dry	7,260	11,265	14,837	16,982	22,595	22,784	11,114	9,183	5,449	4,273	3,469	4,936
Critical	5,942	6,731	9,198	9,189	11,292	9,649	6,737	5,038	3,614	3,675	3,180	3,376

Source: DWR 2009a
Notes:
[1] Period of record: water years 1956–2007.
[2] Sacramento Valley water year types.
Key:
cfs = cubic feet per second

Water control structures also affect Delta hydraulics. One such structure is the Delta Cross Channel (DCC), a federal facility constructed in 1951 to improve water conveyance through the Delta. The DCC is not a facility of the SPFC. Operation of the structure was adapted to address both fisheries and water conveyance issues. Located about 30 miles south of Sacramento, the DCC diverts water from the Sacramento River into eastern Delta channels at Snodgrass Slough, when the structure is open. The DCC operates on a schedule mandated by the State Water Resources Control Board (SWRCB). DCC gates are generally open only from mid-June to the end of October. Sacramento River flows do not typically pass through the DCC into the Mokelumne River system during flood events because the DCC is closed after Sacramento River flows reach 25,000 cfs (DWR 2007b). The Delta has been managed as a freshwater system to support many water agencies/contractors and their customers and for local Delta agricultural diversion since the construction of federal and State water project facilities, beginning in the 1940s. Water passing through the Delta supplies drinking water and other water uses for two-thirds of California's population, and provides irrigation water to about 3 million acres of agricultural lands (DWR 2009a). Figure 3.13-5 portrays historical diversions before water enters the Delta, in-Delta uses, and exports and outflows to the ocean.



Source: DWR 2009a

Figure 3.13-5. Historical Diversions, In-Delta Uses, and Exports and Outflows from the Delta Watershed

Water use in the Delta is mostly agricultural. Irrigation water is taken directly from the channels and sloughs through approximately 1,800 diversions, which together divert up to 5,000 cfs during peak summer months. Some formal institutions (e.g., North Delta Water Agency) have been established to manage aspects of Delta water, such as the quality of agricultural water to be maintained by the CVP and SWP at various locations in the Delta (DWR 2009a).

Most Delta farms use water under riparian and appropriative water rights, and agricultural drainage water from the islands is pumped back into Delta waterways. In 2000 about 1.3 MAF of water was used for Delta agriculture to irrigate about 476,000 acres of crops (Tully and Young 2007). In-Delta residential water generally comes from private wells or is provided through community public water systems. The remaining portion of water in the Delta is either lost by various forms of evapotranspiration or contributes to Delta outflow, through which it can provide wildlife habitat and salinity control benefits (DWR 2009a).

Suisun Marsh Suisun Marsh is a tidally influenced brackish marsh located about 35 miles northeast of San Francisco in southern Solano County, and is a critical part of the San Francisco Bay/Sacramento–San Joaquin Delta (Bay-Delta) estuary ecosystem. The marsh is bordered on the east by the Delta, on the south by Suisun Bay, on the west by Interstate 680, and on the north by State Route 12 and Suisun City and the city of

Fairfield (see Figure 3.13-6). The marsh contains approximately 52,000 acres of diked wetlands, 6,300 acres of unmanaged tidal wetlands, 30,000 acres of bays and sloughs, and 27,000 acres of upland grasslands (DWR 1999). The Suisun Marsh are non-SPFC and locally maintained levees.

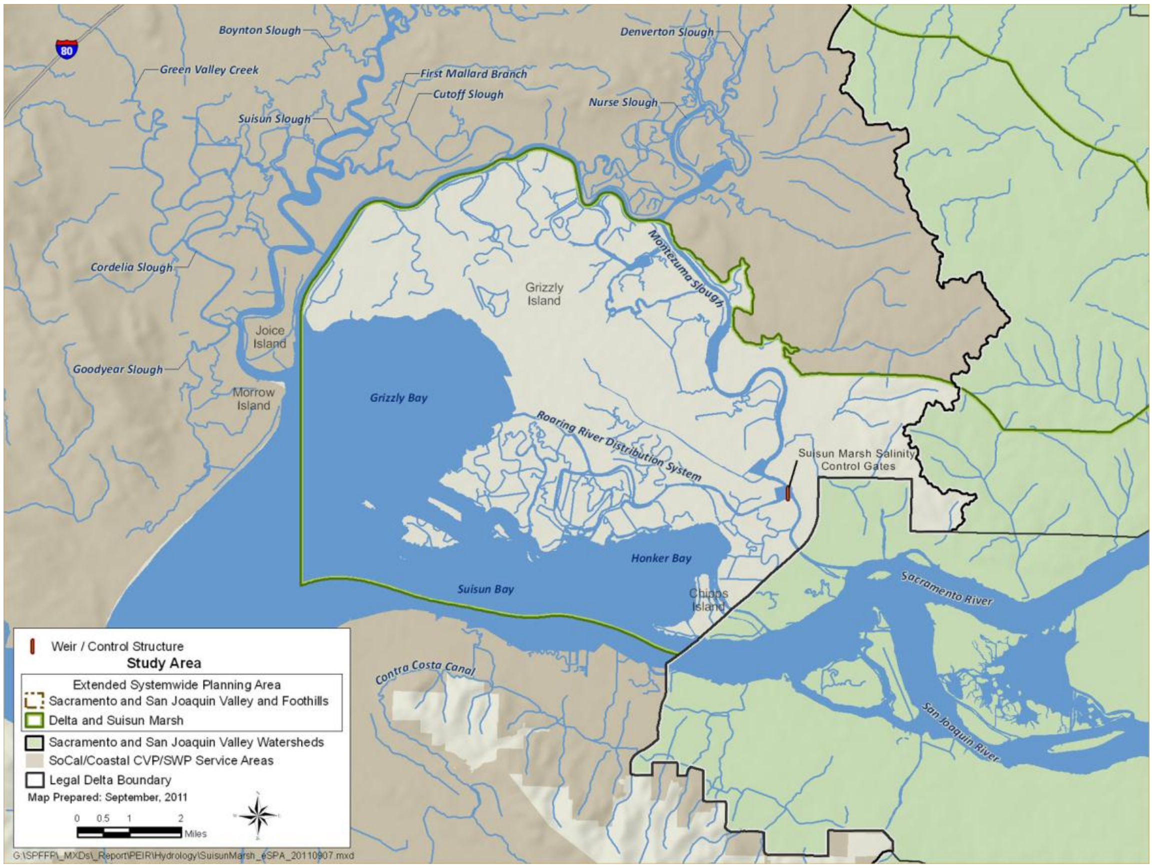


Figure 3.13-6. Suisun Marsh Hydrologic Features

The marsh is influenced by saline ocean water from Suisun Bay and freshwater from the Delta. Salinity in the marsh varies seasonally, with higher salinities in summer and fall, and lower salinities in winter and spring. Suisun Marsh's only outlet is the Sacramento River. American Canyon, Denverton, Green Valley, Jameson Canyon, Laural, Ledgewood, Suisun, and Union creeks provide freshwater inflow to the northern areas of the marsh, and are outside the Extended SPA (DWR 2009a).

Tidal flow enters Suisun Marsh through western Grizzly Bay, creating large tidal exchanges at the mouths of Montezuma and Suisun sloughs (peak flows of about 50,000 cfs and 15,000 cfs, respectively). Tides in the eastern marsh are smaller, and peak tidal flows in the eastern end of Montezuma Slough are about 10,000 cfs. Tidal exchange occurs from both ends of Montezuma Slough, although tidal flows are smaller—averaging about 5,000 cfs—at the upstream end (head), near Collinsville (Reclamation, USFWS, and DFG 2010).

Suisun Marsh is protected by a series of laws and regulations designed to stop urban encroachment, preserve Suisun Marsh habitat, maintain an adequate water supply with suitable water quality, and protect lands within the marsh (DWR 1999) (see Section 3.13.2, "Regulatory Setting," for more details). To meet salinity standards, DWR and Reclamation have constructed large facilities in lieu of requiring an estimated CVP/SWP storage release as high as 2 MAF during dry/critical water years in the Sacramento Valley. One of these facilities, the improved Roaring River Distribution System, was constructed to provide 5,000 acres of private wetlands and 3,000 acres of California Department of Fish and Game–managed wetlands on Grizzly, Hammond, Simmons, Van Sickle, and Wheeler islands with lower salinity water from Montezuma Slough. In addition, the Morrow Island Distribution System and Goodyear Slough outfall improve the supply of lower salinity water for the southwestern marsh (Reclamation 2010). Other facilities constructed include the Cygnus Drain, Lower Joice Island Diversion, and Suisun Marsh Salinity Control Gates. Approximately 200 miles of levees in the marsh also help manage salinity in the Delta. Salinity is also affected by the CVP and SWP, whose upstream reservoir storage and releases and Delta exports regulate Delta outflows.

Sacramento and San Joaquin Valley Watersheds

The Sacramento and San Joaquin Valley watersheds form a mountain-enclosed basin about 500 miles long and about 120 miles wide on average; these watersheds compose more than one-third of the total area of California. The two major river systems in the Sacramento and San Joaquin Valley watersheds—the Sacramento and San Joaquin rivers, respectively—convey more than 40 percent of the surface water in California and have a combined drainage area of more than 43,000 square miles. These two rivers join at their lowest elevations in the Delta. In the Sacramento and San Joaquin Valley watersheds, average annual precipitation can vary from 95 inches in the highest elevations of the Sierra Nevada and Cascade Range to 8 inches on the valley floor at Los Banos (USACE 1999).

Sacramento Valley Watershed The Sacramento Valley watershed covers approximately 27,246 square miles. The watershed is bounded by the Sierra Nevada on the east, the Coast Ranges on the west, the Cascade Range and Trinity Mountains on the north, and the Delta on the south.

Precipitation in the Sacramento Valley watershed occurs as both rain and snow, resulting in highly variable runoff patterns during late fall, winter, and spring (USACE and SAFCA 2009). Winter flows are affected by reservoir releases, storm runoff, and diversions to bypass channels used for flood management (Coalition 2004). Part of the runoff from winter rains and spring snowmelt is stored in reservoirs and released during the drier summer months. Temperatures on the valley floor normally range from winter lows near freezing to summer highs of about 100 degrees Fahrenheit (°F). In mountainous areas, winter temperatures average about 30°F, but occasionally fall below zero.

The largest runoff occurs in the upper watershed of the Sacramento River above Shasta Lake, and in rivers originating on the west slope of the Sierra Nevada, producing an average of 1–2 TAF of runoff per square mile annually (Coalition 2004).

The Sacramento Valley watershed can be divided into two geographic areas: upper and lower. The upper geographic area encompasses the Sacramento River before its confluence with the Feather River. The lower area extends from its confluence with the Feather River to the Delta.

Upper Sacramento River Watershed Geographic Area The Sacramento River headwaters are near Mount Shasta. The drainage area of the Sacramento River above Shasta Lake is 6,421 square miles (USACE 1999). In addition to the Sacramento River headwaters, the Pit and McCloud rivers contribute to flows.

Flows on two Sacramento River tributaries, Clear and Stony creeks, are regulated by reservoirs that are outside the Extended SPA. Whiskeytown Lake impounds water diverted from the Trinity River and affects flow on Clear Creek, and the dam is operated for irrigation supply and electricity generation. Upstream from Black Butte Lake on Stony Creek are East Park and Stony Gorge reservoirs, which store surplus water for irrigation purposes.

Lower Sacramento River Watershed Geographic Area Major tributaries to the Sacramento River in this area from the east include the Feather River system (Yuba and Bear rivers) and the American River.

Feather River The Feather River watershed drains an area of 5,921 square miles, with 75 percent of the area below 5,000 feet in elevation (USACE 1999). The river originates in the Sierra Nevada and Cascade Range and flows southwest to enter the Sacramento River after combining with the Sutter Bypass near Verona. Flows in the upper Feather River are affected by several reservoirs: Lake Almanor, Mountain Meadows Reservoir, Bucks Lake, Little Grass Valley Reservoir, Lake Davis, Frenchman Lake, Butt Valley Reservoir, Sly Creek Reservoir, Philbrook

Reservoir, and Antelope Lake. All of these reservoirs are outside the Extended SPA.

Yuba River The Yuba River originates in the Sierra Nevada, and drains approximately 1,339 square miles of its western slopes as well as a small portion of the eastern Sacramento Valley before entering the Feather River. Approximately 75 percent of the drainage area is below 5,000 feet in elevation (USACE 1999).

Other small to medium-sized reservoirs in the watershed but outside of the Extended SPA are Lake Spaulding, Bowman Lake, Jackson Meadows Reservoir, Englebright Lake, Lake Fordyce, and Scotts Flat Reservoir.

Bear River The Bear River also originates in the Sierra Nevada and drains an area of about 292 square miles. It flows southwest until it enters the Feather River. The basin receives inflow mainly from rain, because the entire watershed is below the 5,000-foot elevation (USACE 1999).

Several reservoirs on the Bear River outside the Extended SPA provide hydroelectric generation and regulate flow. The largest reservoir in the watershed is Camp Far West Reservoir. Other smaller impoundments, including Rollins Reservoir and Lake Combie, and 11 power plants and their associated forebays and afterbays also regulate Bear River flow.

American River The American River originates in the Sierra Nevada and drains a watershed of 2,100 square miles (USACE 1999) before entering the Sacramento River in the city of Sacramento. The watershed ranges in elevation from 10,000 feet to near sea level at the Sacramento River confluence. Sixty percent of the drainage area is below 5,000 feet in elevation (USACE 1999).

The American River is divided into three forks, which meet at Folsom Lake. The North and Middle forks begin near Lake Tahoe and the South Fork originates near Echo Lake, south of Lake Tahoe. On the North Fork, only a small debris dam outside the Extended SPA, Clementine, affects flow in the North Fork before its confluence with the Middle Fork at the city of Auburn. On the Middle and South forks, several reservoirs outside the Extended SPA are regulated to provide recreation, hydroelectric generation, and water supply. Although the upper portion of the basin has 54 reservoirs, approximately 90 percent of the storage capacity is provided by French Meadows, Hell Hole, and Loon Lake reservoirs on the North Fork and Union Valley, Ice House, and Chili Bar reservoirs on the South Fork.

San Joaquin Valley Watershed The San Joaquin Valley watershed has an area of approximately 16,700 square miles, including the drainage area of central Sierra Nevada rivers and streams, and central Delta islands (USACE 1999). The watershed encompasses the northern half of the San Joaquin Valley and lies between the crests of the Sierra Nevada in the east and the Coast Ranges in the west. The watershed extends from the northern boundary of the Tulare Lake basin, near Fresno, to the confluence of the San Joaquin River with the Sacramento River in the Delta. The San Joaquin River basin and the Tulare Lake basin are hydrologically connected during very wet years through the Kings River when part of the Kings River flow is diverted to the North Fork of the Kings River, then through the James Bypass, Fresno Slough, and Mendota Pool, and into the San Joaquin River.

Most of the San Joaquin River tributaries drain large areas of high elevation that supply snowmelt runoff during late spring and early summer, resulting in peak flows that generally occur in May and June.

The San Joaquin Valley watershed is divided into two geographic areas: upper and lower. The upper geographic area includes the San Joaquin River until its confluence with the Merced River; the lower area extends from the confluence with the Merced River until the San Joaquin River reaches the Delta at Stockton.

Upper San Joaquin River Watershed Geographic Area As mentioned, the upper San Joaquin River geographic area extends from the origin of the San Joaquin River in the Sierra Nevada, at an elevation of more than 10,000 feet, to just upstream from the confluence of the San Joaquin and Merced rivers.

Upstream from Millerton Lake, the San Joaquin River drains approximately 1,676 square miles, and has an annual average unimpaired runoff of 1.7 MAF (SJRGA 1999). Precipitation in the drainage area occurs primarily as snow because 70 percent of the area is above 5,000 feet. Several reservoirs outside the Extended SPA, in the upper portion of the San Joaquin Valley watershed—Edison, Florence, Huntington, Mammoth Pool, and Shaver Lake—are used mainly for hydroelectric power generation. Operation of these reservoirs affects inflow to Millerton Lake.

Near Mendota Pool, the San Joaquin River receives about half of the Kings River flows via the Fresno Slough and James Bypass during flood release events from Pine Flat Reservoir.

The Fresno River originates in the foothills of the Sierra Nevada and is below 5,000 feet in elevation. It drains a watershed of approximately 500 square miles, as measured at the Eastside Bypass. The Chowchilla River also originates in the Sierra Nevada and drains a watershed of approximately 600 square miles, with 95 percent of the basin below 5,000 feet in elevation (USACE 1999). Both rivers are at low elevations, and most runoff comes from rainfall.

Lower San Joaquin River Watershed Geographic Area The lower San Joaquin River geographic area is influenced by its major tributaries: the Merced, Tuolumne, and Stanislaus rivers and the eastside tributaries.

Merced River The Merced River originates in the Sierra Nevada and drains an area of approximately 1,273 square miles east of the San Joaquin River. More than 50 percent of the drainage area is below 5,000 feet in elevation (USACE 1999).

Tuolumne River The Tuolumne River originates in the Sierra Nevada in Yosemite National Park, and drains a watershed of approximately 1,540 square miles. About 60 percent of the watershed is below 5,000 feet in elevation (USACE 1999).

Several reservoirs in the upper Tuolumne River basin outside the Extended SPA provide hydroelectric generation and water supply: Hetch Hetchy Reservoir, Lake Eleanor, and Cherry Lake.

Stanislaus River The Stanislaus River originates in the Sierra Nevada and enters the San Joaquin River just upstream from Vernalis. This river drains a watershed of approximately 1,075 square miles. About 60 percent of the drainage area is below 5,000 feet in elevation (USACE 1999). Snowmelt runoff contributes the largest portion of the flows in the Stanislaus River, with the highest monthly flows in May and June.

On the Middle Fork Stanislaus River, upstream from New Melones Reservoir and outside the Extended SPA, are Donnells and Beardsley reservoirs.

Eastside Tributaries to the Delta The streams in the northern portion of the San Joaquin River Basin, generally between the American and Stanislaus rivers, are commonly referred to as the eastside tributaries to the Delta. These rivers flow into the San Joaquin River within the boundaries of the Delta. The three main eastside tributaries to the Delta are the Cosumnes, Mokelumne, and Calaveras rivers. Other eastside tributaries either partially in or outside the Extended SPA are Dry and Morrison creeks. Morrison Creek with within the Extended SPA except at the southern end near the confluence with the Sacramento River.

Cosumnes River The Cosumnes River watershed drains approximately 537 square miles, with 90 percent below 5,000 feet in elevation (USACE 1999). The Cosumnes River enters the Mokelumne River near Galt.

Mokelumne River The Mokelumne River originates at an elevation of approximately 10,000 feet in the Sierra Nevada, and enters the lower San Joaquin River northwest of Stockton. The Mokelumne River watershed drains a total area of 670 square miles, with 65 percent of the area below 5,000 feet in elevation. On the Mokelumne River are 11 reservoirs with a total storage around 1 MAF.

Calaveras River The Calaveras River originates in the Sierra Nevada, drains approximately 470 square miles, and enters the San Joaquin River near the city of Stockton. The Calaveras River watershed is entirely below 5,000 feet in elevation, and receives nearly all of its flow from rainfall (USACE 1999).

SoCal/Coastal CVP/SWP Service Areas

The CVP and SWP are water storage and delivery systems of reservoirs, aqueducts, power plants, and pumping plants. The main purpose of the CVP and SWP is to store water in Northern California and distribute water to urban and agricultural water suppliers in the Central Valley, Southern California, and coastal service areas. The projects generally are not able to deliver their full contract amounts because they are also operated for Delta water quality requirements and fish protection purposes. On average, the projects together export about 5 MAF annually from the Delta (DWR 2009a).

None of the management activities included in the proposed program would be implemented in the SoCal/coastal CVP/SWP service areas. In addition, implementation of the proposed program would not result in long-term reductions in water deliveries to the SoCal/coastal CVP/SWP service areas (see Section 2.6, “No Near- or Long-Term Reduction in Water or Renewable Electricity Deliveries”). Given these conditions, the program is not expected to result in adverse impacts on hydrology in the SoCal/coastal CVP/SWP service areas.

3.13.2 Regulatory Setting

The following text summarizes federal, State, and regional and local laws and regulations pertinent to evaluation of the proposed program’s impacts on hydrologic resources.

Federal

Central Valley Project Improvement Act See Subsection 3.5.2, “Regulatory Setting,” in Section 3.5, “Biological Resources—Aquatic.”

Clean Water Act (Sections 402 and 404) See Subsection 3.5.2, "Regulatory Setting," in Section 3.5, "Biological Resources—Aquatic."

Coordinated Operations Agreement With the goal of using coordinated management of reservoir releases and surplus flows in the Delta to improve Delta export and conveyance capability, the Coordinated Operations Agreement received congressional approval in 1986 and became Public Law 99-546. As modified by interim agreements, the Coordinated Operations Agreement coordinates operations between the CVP and SWP, and provides for equitable sharing of surplus water entering the Delta.

San Joaquin River Agreement The San Joaquin River Agreement, adopted in 2000, is a water supply program to provide increased instream flows in the San Joaquin River. The water helps protect fall-run Chinook salmon in the San Joaquin River under the Vernalis Adaptive Management Plan. Parties to the agreement include Reclamation, the U.S. Fish and Wildlife Service (USFWS), DWR, DFG, the San Joaquin River Group Authority, and the CVP and SWP Export Interest parties. The CVP and SWP Export Interest parties include the State Water Contractors, Kern County Water Agency, Tulare Lake Basin Water Supply District, Santa Clara Valley Water District, San Luis and Delta-Mendota Water Authority, Westlands Water District, and Metropolitan Water District of Southern California.

U.S. Army Corps of Engineers—Related Laws and Regulations
USACE has nationwide responsibility for flood management. In California, flood management is performed through a combination of projects operated by USACE, Reclamation, the State, local maintaining agencies, and private proponents, all under official USACE flood management plans. Laws and regulations related to USACE functions are described below.

Flood Control Act of 1917 The Flood Control Act of 1917 was enacted in response to costly floods in the lower Mississippi Valley, the Northeast, and the Ohio and Sacramento valleys between 1907 and 1913. It authorized the formation of the State/federal Sacramento River Flood Control Project which includes most of the levees, weirs, control structures, bypass channels, and river channels that make up the SPFC in accordance with initial plans contained in the 1910 California Debris Commission report as modified in 1913 and subsequently modified and extended by the Acts of 1928, 1937, and 1941.

Flood Control Act of 1936 The Flood Control Act of 1936 was enacted as part of the federal New Deal legislation to stimulate the national economy during the Great Depression. This act declared flooding to be a menace to the national welfare and directed the federal government (USACE and the

U.S. Department of Agriculture) to improve, or participate in improving, navigable waters or their tributaries if the benefits would exceed costs, and if the lives and social security of people would be adversely affected. The legislation also enabled the federal government to enter into compacts with states or other local agencies for flood management projects.

Flood Control Act of 1944 The Flood Control Act of 1944 was passed (and amended in 1950) to formally assign the duties of flood management and navigation to USACE, and for federal authorization of projects on the Sacramento and San Joaquin rivers and tributaries. The act authorized construction of Folsom Lake in the Sacramento River Flood Control System. In the San Joaquin watershed, the act authorized the Lower San Joaquin River and Tributaries Project, flood improvements to the San Joaquin River and tributaries upstream from the Merced River on the Tuolumne, Stanislaus, and Calaveras rivers, and Littlejohns Creek. Flood improvements in the Merced Streams Group project and the construction of reservoirs on the Kern, Kaweah, Tule, and Calaveras rivers and Littlejohns Creek were also included in this act.

U.S. Army Corps of Engineers Navigation Projects Federal interest in navigation is established by the Commerce Clause of the U.S. Constitution, and by court decisions that define the right to improve and protect navigable waterways in the public's interest. USACE navigation projects in the Delta include the Suisun Bay channel, the Sacramento River Deep Water Ship Channel, and the Stockton Deep Water Ship Channel. The Suisun Channel Operations and Maintenance Project is a USACE navigation project to maintain a navigable connection between the city of Suisun City and Grizzly Bay (USACE 2006, 2010a). Associated with navigation is the *Long-Term Management Strategy for Dredged Material in the Delta*, which is a plan to coordinate and manage dredging for navigation, flood risk management, water conveyance, and recreation; stabilize levees; and protect ecosystems (USACE 2010b). Technical work groups are engaged in pilot studies, preparing orders and permits for dredging and beneficial reuse and compliance with environmental laws.

Operations and Maintenance Controls, Flood Control Projects The maintenance and operation of federal project levees is discussed in Title 33, Section 208.10, of the Code of Federal Regulations (33 CFR 208.10), Local Flood Protection Works; Maintenance and Operation of Structure and Facilities, which states the following:

> *No improvement shall be passed over, under, or through the walls, levees, improved channels or floodways, nor shall any excavation or construction be permitted within the limits of the project right-of-way, nor shall any change be made in any feature of the works*

> *without prior determination by the District Engineer of the Department of the Army or his authorized representative that such improvement, excavation, construction, or alteration will not adversely affect the functioning of the protective facilities.*

This regulation outlines federal regulatory requirements for the maintenance and operation of structures and facilities that compose the State/federal flood protection system. It, along with Section 14 of the Rivers and Harbors Appropriation Act (Title 33, Section 408 of the U.S. Code), is the basis for requiring permission from USACE before any major change in maintenance and operations at federal project levees and other facilities such as pumping plants can occur. It also specifies the responsibilities of the maintaining superintendent, necessary inspections, operations and maintenance reporting requirements, maintenance requirements, and high-water/flood operations for local maintenance of federal structures and flood facilities.

Rivers and Harbors Appropriation Act (Sections 10 and 14) See Subsection 3.5.2, “Regulatory Setting,” in Section 3.5, “Biological Resources—Aquatic.”

Emergency Flood Control Funds Act (Public Law 84-99) The Emergency Flood Control Funds Act (Public Law 84-99) was enacted after major flooding occurred in the eastern United States and the Central Valley in 1955. The legislation included federal authorization of levees and bypasses on the San Joaquin River above the Merced River confluence. Under this act, USACE has emergency authority to fight any flood to protect life and property and to rehabilitate federal flood management facilities that are maintained by State and local entities.

Flood Control Act of 1960 The Flood Control Act of 1960 authorized the Sacramento River Bank Protection Project to preserve the integrity of the Sacramento River Flood Control Project levee system.

Flood Control Act of 1970 The Flood Control Act of 1970 authorized flood protection projects on Cottonwood Creek in the Sacramento River Basin, and Merced County Streams in the San Joaquin River Basin. It established written agreement requirements for cost sharing projects between USACE and nonfederal sponsors.

Water Resources Development Act of 1986 The Water Resources Development Act (WRDA) of 1986 was the first major “omnibus” projects authorization bill for USACE in 16 years and authorized more than 270 USACE projects for study or construction. It also contained environmental provisions addressing issues such as mitigation, enhancement and modification of USACE projects to improve the environment and authorized more than $500 million in fish and wildlife mitigation/enhancement features. The WRDA of 1986 directed the Secretary of the Army to issue new guidelines for crediting against the nonfederal share of project costs for flood work carried out by local interests. Prior cost-share provisions for a cash contribution of 5 percent of the cost of the project and the requirement for local provision of lands, easements, rights-of-way, relocations and disposals (LEERD) remained unchanged. The WRDA of 1986 set a 25 percent minimum to 50 percent maximum contribution with LEERD and the cash contribution credited toward this percentage cost share.

Water Resources Development Act of 1990 The WRDA of 1990 added environmental protection as a primary mission for USACE. The WRDA of 1990 amended the WRDA of 1986 to treat as construction the costs of planning and engineering for projects for which nonfederal interests contributed 50 percent or more of the cost of the feasibility study.

Water Resources Development Act of 1996 The WRDA of 1996 amended cost sharing requirements. Nonfederal sponsors are required to contribute a minimum of 35 percent to a maximum of 50 percent.

Water Resources Development Act of 1999 The WRDA of 1999 amended the Flood Control Act of 1936 to authorize funds contributed by states and other political subdivisions for environmental restoration work, in addition to flood management.

Federal Emergency Management Agency—Related Laws and Regulations FEMA is responsible for maintaining minimum federal standards for floodplain management within the United States and territories of the United States. As discussed below, FEMA plays a major role in managing and regulating floodplains, which are defined as lowland and relatively flat areas adjoining inland and coastal waters that are subject to a 1-percent or greater chance of flooding in any given year (100-year floodplain).

National Flood Insurance Program The NFIP is administered by FEMA. The NFIP has two main components: flood insurance assistance and floodplain management assistance. The purpose of flood insurance is to enable property owners to purchase insurance against losses from physical damage or the loss of buildings and their contents caused by floods, flood-related mudslides, or erosion. Insurance is available to property owners in NFIP-participating communities. The NFIP is administered by the Federal Insurance Administration under FEMA. Participation in the NFIP also makes communities eligible for federal flood disaster assistance.

To be eligible to participate in the NFIP, a community must adopt a local floodplain management ordinance that meets or exceeds the minimum federal standards defined in 44 CFR 60–65. Participating communities must adhere to all floodplain management requirements, with oversight from FEMA, for all activities that may affect floodplains within designated Special Flood Hazard Areas.

As part of the NFIP, FEMA provides one or more flood insurance rate maps. Each map contains flood zones that are used to determine a community's flood insurance rates and floodplain development restrictions. It identifies the communities that are federally required to carry flood insurance. (For example, communities can choose to participate or not participate in the NFIP. Homeowners with federally backed mortgages are generally required to carry flood insurance, but otherwise may not be required to carry insurance.) Flood zones are areas delineated to represent areas with similar flood risk, flood protection infrastructure, flood protection infrastructure certifications, and designated floodways. FEMA requires that the local government for a community covered by federal flood insurance pass and enforce a floodplain management ordinance that specifies minimum requirements for any construction within the 100-year floodplain.

Flood Zone Regulations Special Flood Hazard Areas are subject to State and federal requirements, which are defined primarily by federal regulations (44 CFR 60.3 and 44 CFR 65.12). These federal regulations are intended to address the need for effective floodplain management. Development is regulated to limit the cumulative effects of floodplain encroachment to no more than a 1-foot rise in water surface elevation after the floodplain has been identified on the flood insurance rate map. (Local flood ordinances can set a more stringent standard.) The absence of a detailed study or floodway delineation places the burden on the project proponent to perform an appropriate engineering analysis to prepare hydrologic and hydraulic analyses consistent with FEMA standards. These analyses would then be used to evaluate the project together "with all other existing and anticipated development" (44 CFR 60.3(c)(10)). Defining future anticipated development can be difficult; the purpose of this requirement is to avoid inequitable encroachments into the floodplain.

Provisions for projects that are discovered to cause any increase in water surface elevations are described in 44 CFR 65.12, Revision of Flood Insurance Rate Maps to Reflect Base Flood Elevations Caused by Proposed Encroachments. This regulation states that the project must cause no effect on the base flood elevations, or that the project must obtain a Conditional Letter of Map Revision before it can be permitted for construction. Also, as suggested, if the project would have no effect on the base flood elevations, it can be approved by the floodplain administrator for the community without obtaining any approvals by FEMA or submitting a Conditional Letter of Map Revision to FEMA. However, the floodplain administrator can require a Conditional Letter of Map Revision if it is felt that a project is of sufficient complexity to warrant FEMA's review.

The minimum federal regulatory requirement pertaining to encroachments into the floodway is defined by 44 CFR 60.3(d)(3). When there is such an encroachment, the FEMA effective hydraulic model should be used to evaluate FEMA impacts and mitigation options for the encroachment.

FEMA Levee Design and Maintenance Regulations

Code of Federal Regulations Guidance and criteria for levees included in the NFIP are provided in 44 CFR 65.10. Major design criteria include freeboard, closure structures, embankment protection, embankment and foundation stability, settlement, interior drainage, and other design criteria. Operations and maintenance requirements are also discussed. Each of these criteria includes specific design guidelines that must be met for a levee to remain in the NFIP. It should be noted that FEMA is not responsible for evaluating these levees; evaluations are performed by others, which leads to FEMA accreditation when FEMA adopts the certification.

Procedure Memorandum 34 Procedure Memoranda supplement and clarify the information in Appendix H of FEMA's *Guidelines and Specifications for Flood Hazard Mapping Partners* (FEMA 2003) regarding mapping the base flood in areas with levees. Procedure Memorandum 34, *Interim Guidance for Studies Including Levees*, provides FEMA staff, contractors, and mapping partners with guidance for evaluating and mapping levees and levee affected areas as part of the FEMA Flood Map Modernization Program (FEMA 2010).

Procedure Memorandum 43 Procedure Memorandum 43, *Guidelines for Identifying Provisionally Accredited Levees*, provides FEMA staff, contractors, and mapping partners with guidance for identifying provisionally accredited levees and mapping affected levee areas. A fact sheet, prepared in question-and-answer format, is included and provides detailed information about NFIP procedures for evaluating and mapping levee systems, with emphasis on Procedure Memorandum 43 and provisionally accredited levee systems. This fact sheet was designed for a more technical audience. Additional documents include flowcharts and sample letters for different levee scenarios (National Committee on Levee Safety 2009).

Hazard Mitigation Plan Criteria Guidance regarding hazard mitigation plans for both State and local agencies is provided in 44 CFR 201. Such plans are necessary for receiving grant funding under the Stafford Act for disaster prevention planning. States must demonstrate a commitment to reducing risks from natural hazards, including levee failure. Hazard mitigation plans act as guidance for State decision-makers in determining the appropriation of resources to reduce these risks.

Executive Order 11988 (Flood Hazard Policy) See Subsection 3.5.2, “Regulatory Setting,” in Section 3.5, “Biological Resources—Aquatic.”

CALFED Bay-Delta Program Levee System Integrity Program The Levee System Integrity Program of the CALFED Bay-Delta Program (CALFED) is intended to provide maintenance and improvement work to the Delta levee system. Goals and objectives of the program include the following:

- **Base Level Protection**—This program provides funding to help local reclamation districts reconstruct Delta levees to a base level of protection (Public Law 84-99).

- **Special Improvement Projects**—This program is intended to enhance levee stability for particularly important levees. Priorities include protecting life, personal property, water quality, the Delta ecosystem, and agricultural production.

- **Suisun Marsh Protection and Ecosystem Enhancement**—This program provides levee integrity, ecosystem restoration, and water quality benefits by supporting maintenance and improvement of the levee system in Suisun Marsh.

- **Levee Emergency Response Plan**—This program is intended to enhance agency and local efforts to respond to levee emergencies.

CALFED Bay-Delta Implementation Act In the CALFED Record of Decision (ROD) dated August 28, 2000, Reclamation and other federal and State agencies committed to implementing a long-term plan to restore the Bay-Delta. This plan consists of many programs: storage, conveyance, ecosystem restoration, levee integrity, watersheds, water supply reliability, water use efficiency, water quality, water transfers, and science. The Implementation Memorandum of Understanding, also signed August 28, 2000, continued the operations decision-making process that had evolved through CALFED. The ROD identified numerous programs, including the Environmental Water Account, to protect fish in the Bay-Delta estuary through environmentally beneficial changes in CVP and SWP operations at no loss of uncompensated water cost to CVP and SWP water users.

State of California

State Water Project The State Water Resources Development System is the project authorized and financed by the California Water Resources Development Bond Act, also known as the Burns-Porter Act (California Water Code, Section 12930 et seq.). The State Water Resources Development System includes the SWP, Davis-Grunsky Act Program, and the San Joaquin Drainage Implementation Program. The Burns-Porter Act was passed by the California Legislature in 1959 and approved by voters in 1960. The act expressly authorized the State of California to enter into contracts for the sale, delivery, or use of water made available by the SWP in return for payment of a major portion of the capital and operation costs of the SWP. The first of these contracts was signed with the Metropolitan Water District of Southern California on November 4, 1960, and served as a prototype for all subsequent SWP long-term water supply contracts. The Burns-Porter Act, Central Valley Project Act, and the long-term contracts provide the institutional structure supporting the operation and financing of the SWP (California Water Code, Section 11450 et seq. and Section 12930 et seq.). DWR currently has contracts with 29 water agencies. Collectively known as the SWP contractors, these 29 water agencies deliver water directly to agricultural and urban water users or to water wholesalers or retailers.

Section 1602 of the California Fish and Game Code—Streambed Alteration Agreement See Subsection 3.5.2, “Regulatory Setting,” in Section 3.5, “Biological Resources—Aquatic.”

Section 5937 of the California Fish and Game Code Section 5937 of the California Fish and Game Code requires that “[t]he owner of any dam shall allow sufficient water to pass over, around or through the dam, to keep in good condition any fish that may be planted or exist below the dam.”

California Water Rights A water right is a legally protected right, granted by law, to take possession of water and put it to beneficial use. Water rights within California generally consist of appropriative rights to divert surface water, riparian rights to use surface water, and groundwater rights:

- *Appropriative water rights* allow the user to divert surface water for beneficial use. Before 1914, appropriative water rights involved simply describing the intent and scope of water use, diversion, or construction of diversion activities. Since 1914, those seeking appropriative water rights have been required to file an application with the SWRCB. Before it can issue a water rights permit, the SWRCB must demonstrate the availability of unappropriated water. Appropriative water rights may be lost if the water has gone unused for 5 years.

- *Riparian water rights* to use surface water apply only to lands that are traversed by or border on a natural watercourse. Riparian owners each have a right to share in the beneficial use of the natural flow of water passing the owner's land. No permit is required to use this water. Riparian water must be used reasonably, beneficially, and solely on riparian (adjacent) land and cannot be stored for later use.

- Some *groundwater rights* in California have been settled by the courts after landowners or other parties have appealed to the courts to settle disputes over how much groundwater can rightfully be extracted. In these "adjudicated groundwater basins," the courts have determined an equitable distribution of water that will be available for extraction each year. In adjudicated groundwater basins, the courts typically appoint a watermaster to administer the court judgment. Counties have also enacted laws to prevent wells developed on one property from interfering with the use of adjacent wells.

- The *State Watermaster Program's* main purpose is to ensure that water is allocated according to established water rights (riparian, appropriative, or groundwater), as determined by court adjudications or agreements by an unbiased, qualified person, thereby reducing water rights court litigation, civil lawsuits, and law enforcement workload. It also helps prevent the waste or unreasonable use of water. The State established the Watermaster Program in 1924 to provide for general public welfare and safety after many injuries and some deaths resulted from disputes over adjudicated water rights. Watermaster service is administered by DWR in accordance with Part 4, Division 2 of the California Water Code. Watermaster service areas are created by DWR either at the request of water users or by order of the Superior Court. The first watermaster service area was formed in September 1929. DWR provides watermaster service for a number of stream systems in Northern California and also serves as watermaster for two groundwater basins in Southern California.

Surface Water Rights See the discussion of appropriative and riparian water rights in the "California Water Rights" section above. Section 1735 of the California Water Code provides the regulatory framework for long-term transfers of surface water rights, subject to CEQA requirements.

Groundwater Quality and Supply The State requires counties to enact regulations covering well design to protect groundwater quality from surface contamination, and to properly construct and develop wells for domestic use. The Groundwater Management Act (California Water Code, Part 2.75, starting with Section 10750) provides a systematic procedure for groundwater management planning at the county and city levels.

California Urban Water Management Planning Act The California Urban Water Management Planning Act of 1983 (California Water Code, Section 10610 et seq.) requires urban water suppliers to prepare, adopt, and update their urban water management plans at least once every 5 years. The law applies to agencies that provide water for municipal purposes to more than 3,000 customers, or supply more than 3,000 acre-feet of water annually.

State Lands Commission Land Use Lease The California State Lands Commission has the authority and responsibility to manage and protect important natural and cultural resources on certain public lands in California, and the public's rights to access these lands. Public lands under the commission's jurisdiction are of two distinct types: sovereign lands and school lands. Sovereign lands encompass approximately 4 million acres. These lands include the beds of California's naturally navigable rivers, lakes, and streams, and tidal and submerged lands along California's coastline, extending from the shoreline out to 3 miles offshore. School lands are lands that remain of the nearly 5.5 million acres throughout the State originally granted by Congress in 1853 to benefit public education. Many of the school land parcels have been sold; however, the State retains fee ownership of approximately 470,000 acres and also retains mineral rights to an additional 790,000 acres. A lease is required for projects on State-owned lands under the jurisdiction of the California State Lands Commission.

Central Valley Flood Protection Board The Board was authorized by Sections 8520–9110 of the California Water Code and established in 1911. Section 8590 of the Water Code describes the Board's powers:

> *To carry out the primary [S]tate interest described in Section 8532 [of the California Water Code], the [B]oard may do any of the following:*
>
> *(a) Acquire either within or outside the boundaries of the drainage district, by purchase, condemnation or by other lawful means in the name of the drainage district, all lands, rights-of-way, easements, property or material necessary or requisite for the purpose of bypasses, weirs, cuts, canals, sumps, levees,*

overflow channels and basins, reservoirs and other flood control works, and other necessary purposes, including drainage purposes.

(b) Construct, clear, and maintain bypasses, levees, canals, sumps, overflow channels and basins, reservoirs and other flood control works.

(c) Construct, maintain, and operate ditches, canals, pumping plants, and other drainage works.

(d) Make contracts in the name of the drainage district to indemnify or compensate any owner of land or other property for any injury or damage caused by the exercise of the powers conferred by this division, or arising out of the use, taking, or damage of any property for any of the purposes of this division.

(e) Collaborate with [S]tate and federal agencies, if appropriate, regarding multiobjective flood management strategies that incorporate agricultural conservation, ecosystem protection and restoration, or recreational components.

California Department of Water Resources DWR established the Division of Flood Management in November 1977, although flood forecasting and flood operations were integral functions of DWR and its predecessor agencies (e.g., Department of Public Works) for about a century. DWR itself was created after severe flooding occurred across Northern California in December 1955.

Today, the functions of statewide flood forecasting, flood operations, and other key flood emergency response activities are the primary missions of the Division's Hydrology and Flood Operations Office. Other components of this division include the Delta-Suisun Marsh Office, the Flood Projects Office, the Levee Repairs and Floodplain Management Office, and the Flood Maintenance Office.

As mandated by the California Water Code, DWR has responsibility for the supervision of dams and reservoirs, which is delegated to the Division of Safety of Dams.

DWR’s Division of Flood Management, through its Central Valley Flood Planning Office, and the FloodSAFE Program Management Office are carrying out the work of the agency’s FloodSAFE California Program, which partners with local, regional, State, Tribal, and federal officials in creating sustainable, integrated flood management and emergency response systems throughout California. Flood control legislation of 2007 and 2008 directed DWR to prepare a flood control system status report for the SPFC and CVFPP.

Board Authority to Adopt Alternative Plan Section 8621 of the California Water Code allows the Board, with the approval of the California Department of Finance, to execute a substitute plan for a flood management project in which the State will construct project works when, in lieu of acquiring all or any portion of the lands, easements, or rights-of-way in connection with the project, a saving to the State will result. The Board may adopt on the State’s behalf any necessary revision of a flood management project authorized under Chapter 2, Part 6, Division 6, of the California Water Code. However, the Board may not spend money to meet federal requirements for local cooperation in connection with such a project unless the federal government agrees to accept the substitute plan.

Assembly Bill 142 On February 24, 2006, after sustained heavy rainfall and runoff, Governor Arnold Schwarzenegger declared a State of Emergency for California’s levee system, commissioning up to $500 million of State funds (Assembly Bill (AB) 142—Flood Control: Levee Repair and Flood Control Systems) to repair and evaluate State/federal project levees. This declaration was a necessary step in preventing possible catastrophic failures of the flood protection system.

After the emergency declaration, Governor Schwarzenegger directed DWR to secure the necessary means to fast-track repairs of critical erosion sites. In addition, California’s lengthy environmental permitting process was streamlined without compromising the protection of the important aquatic and terrestrial species inhabiting the California’s river's ecosystem. The State repaired 77 critical erosion/seepage sites under this directive.

Disaster Preparedness and Flood Prevention Bond Act of 2006 (Proposition 1E) Proposition 1E authorizes $4.09 billion in general obligation bonds to rebuild and repair California’s most vulnerable flood control structures to protect homes and prevent loss of life from flood-related disasters, including levee failures, flash floods, and mudslides, and to protect California’s drinking water supply system by rebuilding Delta levees that are vulnerable to earthquakes and storms. As of 2010, of the allocated $4.09 billion, approximately $1.05 billion was still available for appropriation (State of California 2010).

Safe Drinking Water, Water Quality and Supply, Flood Control, River and Coastal Protection Bond Act of 2006 (Proposition 84) The $800 million specified for flood control in Proposition 84 included the following:

- State flood control projects (evaluation, system improvements, flood corridor program)
- Flood control projects in the Delta
- Local flood control subventions (outside the Central Valley flood control system)
- Floodplain mapping and assistance for local land use planning

Of the $800 million specified for flood control, approximately $26 million was still available for appropriation as of 2010 (State of California 2010).

Assembly Bill 1200 AB 1200 (Chapter 573, Statutes of 2005) highlighted the complex Delta water issues and directed DWR and the DFG to report to the Legislature and Governor on the following (DWR and DFG 2006):

- Potential impacts of levee failures on water supplies derived from the Delta because of future subsidence, earthquakes, floods, and effects of climate change
- Options to reduce the impacts of these factors
- Options to restore salmon and other fish that use the Delta estuary

This legislation amended Section 139.2 of the California Water Code to read: "The department shall evaluate the potential impacts on water supplies derived from the Delta based on 50-, 100-, and 200-year projections for each of the following possible impacts on the Delta: subsidence; earthquakes; floods; changes in precipitation, temperature, and ocean levels; and a combination of these impacts."

Assembly Bill 1147 AB 1147 changed the requirements for State participation in flood management projects, primarily nonproject levee projects, authorized or approved beginning January 2002. This legislation revised Section 12585.7 of the California Water Code. The revised Water Code section establishes requirements for flood management projects to qualify for State financial assistance, and requires that the recommended increase in State cost sharing be included in that report. The report must also include substantiating data to demonstrate whether the project meets the requirements set forth in Water Code Sections 12582.7(a) and 12585.9 regarding the mitigation of individual or cumulative hydraulic impacts. AB 1147 also requires DWR to develop regulations specifying the criteria to determine a project's contribution to habitat, open space, recreational opportunities, communities at or near poverty level, and State transportation and water supply facilities objectives.

State Regulations on Levee Standards Title 23 of the California Code of Regulations provides guidance to DWR and the Board on enforcing appropriate standards for flood control projects in the Central Valley. For projects included in the SPFC, the Board, as the nonfederal sponsor, coordinates reviews and submits project requests, project designs, and technical engineering documents to USACE for consideration under Title 33, Sections 408 and 208.10 of the U.S. Code.

California Water Code Sections 50000 and 70000 Section 50000 et seq. of the California Water Code enable reclamation districts to be formed as a way for areas to finance the reclamation of land that have been subject to overflow or flooding. Similarly, Section 70000 et seq. enable levee districts, through acquisitions, purchases, or construction or maintenance activities, to protect levee district lands from overflow.

Delta Levees Special Flood Control Projects Program The Delta Levees Special Flood Control Projects program provides authority to local levee-maintaining agencies to improve and rehabilitate levees in the Delta and a small portion of Suisun Marsh (DWR 2009b). The program was established by the California Legislature under SB 34 in 1988. Since the inception of the program, more than $200 million has been provided to local agencies in the Delta for flood control and related habitat projects. The Delta Levees Special Flood Control Projects program is authorized in Sections 12300–12314 of the California Water Code. Its purpose is to protect discrete identifiable State interests, such as the protection of public highways and roads, utility lines and conduits, and other public facilities, and the protection of urbanized areas, water quality, recreation, navigation, and fish and wildlife habitats, and other public benefits. The program also includes net long-term habitat improvement.

Delta Levees Maintenance Subventions Program Established in 1976, the Delta Levees Maintenance Subventions Program is a cost share program that provides financial assistance to local levee maintaining agencies in the Delta for maintenance and rehabilitation of nonproject and eligible project levees. The program is authorized by Sections 12980–12995 of the California Water Code and is managed by DWR. The Board reviews and approves DWR's recommendations and enters into agreements with local agencies to reimburse eligible costs of levee maintenance and rehabilitation.

Delta Protection Act of 1992 The Delta Protection Act of 1992 declares that the State's basic goals for the Delta are, among other findings, to improve flood protection by structural and nonstructural means to increase the level of public health and safety.

Delta Risk Management Strategy A major need for the State is to determine how to make the Delta sustainable in the future. The 2000 CALFED ROD presented, as part of the Preferred Program Alternative, the completion of a Delta Risk Management Strategy that would look at sustainability of the Delta and assess major risks to Delta resources from floods, seepage, subsidence, and earthquakes. This strategy would also evaluate consequences of, and develop recommendations to manage, the risks to Delta resources from floods, seepage, subsidence, and earthquakes. In addition, the Delta Risk Management Strategy would provide a majority of the information to meet the requirements of AB 1200 (DWR 2011).

Bay Delta Conservation Plan The preparation of the Bay Delta Conservation Plan (BDCP) is being led by a group of State and federal agencies. It is intended to address the increasingly significant and intensifying conflict between the ecological needs of a number of at-risk species adversely affected by a range of human activities and the need for adequate and reliable water supplies from the Delta for people, communities, agriculture, and industry. The BDCP will set out a comprehensive conservation strategy for the Delta designed to advance the coequal planning goals of restoring ecological functions of the Delta and improving water supply reliability to large portions of the State.

Under its Planning Agreement (2006, amended 2009), the BDCP is intended to establish a conservation strategy for the Delta infrastructure and operations of the SWP and CVP, as well as the powerplant operations of Mirant Corporation. It is specifically intended to assure that these and any other covered activities comply with the requirements of the federal and California Endangered Species Acts, Natural Community Conservation Planning Act, and other applicable laws, over a plan term up to 50 years. When complete, the BDCP will provide the basis for the issuance of endangered species permits for SWP and CVP operations. The plan would be implemented over the next 50 years (BDCP Steering Committee 2010). Completion of the final BDCP and its accompanying environmental impact statement/report is expected by the end of 2012.

Regional and Local

Local surface water regulations can include water supply master plans, general plans, integrated regional water management plans, habitat conservation plans, and land use ordinances. Many of these regulations include goals, objectives, and policies pertaining to the study area.

Integrated regional water management plans are statewide voluntary initiatives to foster regional water management. Such plans are intended to provide "sustainable water uses, reliable water supplies, better water quality, environmental stewardship, efficient urban development, protection of agriculture, and a strong economy" (DWR 2005).

Local habitat conservation plans can be countywide initiatives or can be implemented in response to proposed development. The main objectives of these plans are to protect natural resources, including species and habitat, and to enhance coordination and collaboration of development stakeholders.

Should a place-based project be defined and pursued as part of the proposed program, and should the CEQA lead agency be subject to the authority of local jurisdictions, the applicable county and city policies and ordinances would be addressed in a project-level CEQA document as necessary.

Suisun Marsh Preservation Agreement Since the early 1970s, the California Legislature, the SWRCB, Reclamation, DFG, Suisun Resource Conservation District, DWR, and other agencies have worked to preserve beneficial uses of Suisun Marsh as mitigation for potential impacts of reduced Delta outflow on Delta salinity. In 1987, the *Suisun Marsh Preservation Agreement* (SMPA) was signed by DWR, Reclamation, DFG, and Suisun Resource Conservation District. The agreement contains provisions for DWR and Reclamation to mitigate the effects of CVP and SWP operations and other upstream diversions on channel water salinity in Suisun Marsh. It also defines methods and obligations for DWR and Reclamation to meet water supply and salinity standards, sets a timeline for implementing a plan of protection, and delineates monitoring and mitigation requirements. In addition, the SMPA includes provisions to recognize water uses in Suisun Marsh and improve wildlife habitat within the marsh.

The requirements of the SMPA are recognized in SWRCB Water Right Decision 1641. The two primary physical mechanisms for meeting salinity standards set forth in Water Right Decision 1641 and the SMPA are the implementation and operation of physical facilities in the marsh, and management of Delta outflow. Physical facilities include the Suisun Marsh Salinity Control Gates on Montezuma Slough (initiated in 1988), which restricts flows of high-salinity water from Grizzly Bay into Montezuma Slough during incoming tides and retains low-salinity water; and the Roaring River Distribution System and Morrow Island Distribution System (constructed in 1979 and 1980), which provides low-salinity water to a portion of the Suisun Marsh wetlands.

The Suisun Resource Conservation District, Reclamation, USFWS, DWR, and DFG are preparing the *Habitat Management, Preservation, and Restoration Plan for the Suisun Marsh* and Programmatic EIS/EIR to develop, analyze, and evaluate the potential effects of various actions in Suisun Marsh. The actions are intended to preserve and enhance managed seasonal wetlands, implement a comprehensive levee protection/improvement program, and protect ecosystem and drinking water quality while restoring habitat for tidal marsh–dependent sensitive species. SWRCB is also coordinating with the lead agencies, and will consider appropriate changes in water right orders.

Lower San Joaquin Levee District The Lower San Joaquin Levee District was created in 1955 by a special act of the California Legislature to operate, maintain, and repair levees, bypasses, and other facilities built in connection with the Lower San Joaquin River Flood Control Project. The district encompasses approximately 468 square miles (300,000 acres) in Fresno, Madera, and Merced counties, of which 94 square miles are in Fresno County. Additional flood facilities within the Lower San Joaquin River Flood Control Project and several other San Joaquin Valley federal projects are operated, maintained and repaired by reclamation districts.

General Plans According to Section 65300 of the Government Code, each California city or county must prepare and adopt a “comprehensive, long-range general plan” to guide development of the community. Several bills were signed in 2007 that amended State flood and land use management laws. DWR has released a draft guide titled *Implementing California Flood Legislation into Local Land Use Planning: A Handbook for Local Communities* (DWR 2010c). This guide describes how the 2007 flood risk management legislation affects city and county planning responsibilities such as general plans, development agreements, zoning ordinances, and tentative maps. Among these changes, cities and counties in the Central Valley must update their general plans within 24 months, and local zoning ordinances within 36 months, of adoption of the CVFPP. The updates must depict the facilities identified in the SPFC, locations of other flood management facilities, maps of property protected by these facilities, and locations of flood hazard zones. Jurisdictions must use the data from the SPFC to create goals and policies that reduce the risk of flood damage (California Government Code, Section 65302.9).

By approximately 2015, cities and counties within the Sacramento–San Joaquin Valley will be required to make findings regarding an urban (200-year) level of flood protection when they consider whether to enter into a development agreement for a property, approve a discretionary permit or entitlement for any property development or use, approve a ministerial permit that would result in construction of a new residence, or approve a tentative map/parcel map for a subdivision (California Government Code, Sections 65865.5, 65962, and 66474.5). Improvements to urban levees or floodwalls would follow DWR's *Urban Levee Design Criteria* (anticipated 2012), at a minimum.

3.13.3 Analysis Methodology and Thresholds of Significance

This section provides a program-level evaluation of the direct and indirect effects on hydrologic resources (surface water, water supply, and flood management resources) of implementing management actions included in the proposed program. These proposed management actions are expressed as NTMAs and LTMAs. The methods used to assess how different categories of NTMAs and LTMAs could affect the hydrologic environment are summarized in "Analysis Methodology"; thresholds for evaluating the significance of potential impacts are listed in "Thresholds of Significance." Potential effects related to each significance threshold are discussed in Section 3.13.4, "Environmental Impacts and Mitigation Measures for NTMAs," and Section 3.13.5, "Environmental Impacts, Mitigation Measures, and Mitigation Strategies for LTMAs."

Analysis Methodology

Impact evaluations were based on a review of the management actions proposed under the CVFPP, expressed as NTMAs and LTMAs in this PEIR, to determine whether these actions could potentially result in impacts on the hydrologic environment. NTMAs and LTMAs are described in more detail in Section 2.4, "Proposed Management Activities." The overall approach to analyzing the impacts of NTMAs and LTMAs and providing mitigation is summarized below and described in detail in Section 3.1, "Approach to Environmental Analysis." NTMAs can consist of any of the following types of activities:

- Improvement, remediation, repair, reconstruction, and operation and maintenance of existing facilities
- Construction, operation, and maintenance of small setback levees
- Purchase of easements and/or other interests in land
- Operational criteria changes to existing reservoirs that stay within existing storage allocations
- Implementation of the vegetation management strategy included in the CVFPP
- Initiation of conservation elements included in the proposed program

- Implementation of various changes to DWR and Statewide policies that could result in alteration of the physical environment

All other types of CVFPP activities fall within the LTMA category. NTMAs are evaluated using a typical "impact/mitigation" approach. Where impact descriptions and mitigation measures identified for NTMAs also apply to LTMAs, they are also attributed to LTMAs, with modifications or expansions as needed.

Implementation of the proposed program would result in construction-related, operational, and maintenance-related impacts on hydrologic resources (surface water, water supply, and flood management resources). The UNET model was used to evaluate the potential effects of the proposed program on river stage, and the effects of modifications to reservoir operational criteria on surface water supplies, respectively. The following text describes the modeling and assumptions used to assess effects on hydrologic resources.

UNET UNET is a hydraulic model designed to simulate one-dimensional, unsteady (varying with time) flow through a full network of open channels, weirs, bypasses, and storage areas. It is a fixed-bed model and does not account for sediment movement, scour, deposition, or exchange with groundwater. UNET is capable of simulating levee breaks and breaches, and it can be used to determine river flow, stage, velocity, and depth, as well as breakout and return flows from overbank areas (USACE 2002b).

UNET models of the Sacramento and San Joaquin River basins previously developed for the *Sacramento and San Joaquin River Basins Comprehensive Study* (Comprehensive Study) (USACE 2002a) were the basis for the 2012 CVFPP technical riverine evaluations. UNET Version 4.0 (August 1998), with modifications made in April 2000, was used for the Comprehensive Study. For more information about the capabilities of this model, refer to the August 1997 UNET user's manual (USACE 1997) and Appendix D of the Comprehensive Study (USACE 2002b).

For the 2012 CVFPP technical analysis, cross sections for the Tisdale Bypass and Yolo Bypass downstream from Fremont Weir were updated in the model to reflect completed sediment removal and maintenance work (DWR 2006a, 2006b). Other modifications were made to the model to reflect potential management actions included in the proposed program. See Attachment 8C, "Riverine Channel Evaluations," in the 2012 CVFPP (Appendix A to this PEIR) for details regarding CVFPP UNET model selection and assumptions.

Thresholds of Significance

The following applicable thresholds of significance have been used to determine whether implementing the proposed program would result in a significant impact. These thresholds of significance are based on Appendix G of the State CEQA Guidelines, as amended, with slight modifications based on the types of activities that may be implemented under the proposed program. A hydrologic resources impact is considered significant if implementation of the proposed program would do any of the following when compared to existing conditions:

- Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, in a manner which would substantially increase deleterious erosion or siltation on- or off-site
- Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, or substantially increase the rate or amount of surface runoff in a manner which would result in flooding on or off site
- Place housing within a 100-year (1-percent annual exceedence probability (AEP)) flood hazard area as mapped on a federal Flood Hazard Boundary or Flood Insurance Rate Map or other flood hazard delineation map
- Place within a 100-year (1-percent AEP) flood hazard area structures, other than flood conveyance structures, which would impede or redirect flood flows, or modify the flood conveyance system such that it would redirect flood flows in a way that would substantially increase flood risk
- Substantially increase exposure of people or structures to a risk of loss, injury, or death involving flooding, including flooding as a result of the failure of a levee or dam
- Substantially increase the risk of inundation by seiche, tsunami, or mudflow

The following threshold of significance also is used to assess potential hydrologic effects of the proposed program on water supply reliability. Under this threshold, a hydrologic impact is considered significant if implementation of the proposed program would do the following:

- Substantially reduce existing water supplies in a manner that would require new or expanded supplies to meet existing demands

Significance Thresholds Not Evaluated Further

Tsunamis and mudflows are not a factor in the study area. Although areas immediately adjacent to San Francisco Bay could be inundated by a tsunami wave, studies have shown that the run-up would be negligible by the time the wave reached the Carquinez Strait, which is west of the study area (EBRPD 2010). Because the study area is generally flat, the risk of inundation associated with mudflow is minimal. For these reasons, the potential for tsunami and mudflow inundation is not evaluated further.

Only erosion and siltation effects associated with changes to hydrologic resources (e.g., changes to the timing and magnitude of flows) are discussed in this section. Erosion and siltation effects associated with constructing the proposed program are discussed in Section 3.10, "Geology, Soils, and Seismicity (Including Mineral and Paleontological Resources)."

Because one of the purposes of the proposed program is to improve flood management, thereby reducing the frequency of destructive flood flows and damage caused by flooding, increased development in the floodplain could result. This issue is addressed in Section 3.14, "Land Use and Planning," and Section 6.1, "Growth-Inducing Impacts."

3.13.4 Environmental Impacts and Mitigation Measures for NTMAs

This section describes the physical effects of NTMAs on hydrologic resources. For each impact discussion, the environmental effect is determined to be either less than significant, significant, potentially significant, or beneficial compared to existing conditions and relative to the thresholds of significance described above. These significance categories are described in more detail in Section 3.1, "Approach to Environmental Analysis."

Impact HYD-1 (NTMA): *Increased Erosion and Siltation from Modifying the Flood Conveyance System*

NTMAs could change the existing hydraulics of the system and increase erosion. Raising or strengthening existing levees, increasing upstream flows by changing water releases (e.g., making operational changes to reservoirs), or implementing other NTMAs could change the timing, magnitude, frequency, or velocities of flows downstream of reservoirs. These changes could increase waterside erosion. This would occur in areas between existing levees, where soil formation is limited by the intermittent reworking of channel banks that currently occurs during high flows. Because the hydraulic changes would occur in areas within the existing channel where soils are frequently reworked, and because complying with existing standards and requirements (e.g., developing a storm water pollution prevention plan, complying with the Surface Mining and Reclamation Act (refer to Section 3.10, "Geology, Soils, and Seismicity (Including Mineral and Paleontological Resources)," for details)) would minimize bank erosion near levee modifications, this effect would be minor. Therefore, this impact would be **less than significant**. No mitigation is required.

See also Impact GEO-2 (NTMA), "Potential Localized Soil Erosion and Inadvertent Permanent Soil Loss as a Result of Construction or Operation and Maintenance Activities," in Section 3.10, "Geology, Soils, and Seismicity (Including Mineral and Paleontological Resources)," for a discussion of the potential for changes in erosion or siltation as a result of construction activities.

Impact HYD-2 (NTMA): ***Increased Flooding from Modifying the Flood Conveyance System***

The primary purpose of the proposed program is to improve flood management, and thereby to reduce the frequency of destructive flood flows and the damage caused by flooding. Although implementing some individual NTMAs might cause the existing course of a stream or river to change, implementing the proposed program overall is not expected to increase flooding on or off site. Individual NTMAs would not be implemented or approved if the water surface elevation, and thus flooding potential, would increase above the maximum allowed rise set by USACE. The project proponent for any NTMA would need to obtain permits and approvals, such as Section 408 and 208.10 and Board encroachment permits, to be able to implement the project. These permits require that there be no increase in flooding. Hence, any flooding impacts associated with a specific activity would need to be mitigated and the project would need to be modified before implementation.

In addition, implementing NTMAs would not increase the rate or amount of surface runoff in a manner that would increase the risk of flooding. The rate and amount of surface runoff are determined by multiple factors: topography, amount and intensity of precipitation, amount of evaporation that occurs in the watershed, and amount of precipitation and imported water that infiltrates into groundwater. Implementing NTMAs would not appreciably alter precipitation amounts or intensities, evaporation rates, or the amount of precipitation that infiltrates into groundwater. Therefore, this impact would be **less than significant**. No mitigation is required.

Impact HYD-3 (NTMA): ***Placement of Housing within a 100-Year Flood Hazard Area***

No homes or businesses would be constructed as part of the NTMAs, so none would be placed in a 100-year flood hazard area by this portion of the proposed program. Implementing the NTMAs would provide a higher level of flood protection for some areas currently protected by facilities of the SPFC. In some areas, providing a higher level of flood protection could potentially cause the boundaries of flood hazard areas to change, and existing homes in those areas would no longer be within a flood hazard area. In addition, SB 5 triggers the requirements described in Sections 65865.5 and 65962 of the Government Code. The California Legislature has tied achieving those requirements to the Board's adoption of the CVFPP. Therefore, the adoption of the CVFPP will trigger the statutory requirements that local agencies amend their general plans and zoning ordinances, and make certain findings before approving projects, that could restrict construction of new homes in a flood hazard area. Further, opportunities to construct new homes within a 100-year flood hazard area would be removed where flood, conservation, or other easements are purchased. Therefore, this effect would be **beneficial**. No mitigation is required.

Impact HYD-4 (NTMA): ***Modification of the Flood Conveyance System in a Way that Would Redirect Flood Flows and Increase Flood Risk or Exposure of People or Structures to a Risk of Loss, Injury, or Death Involving Flooding***

The primary purpose of the proposed program is to improve flood management, thereby reducing the frequency of destructive flood flows and the damage caused by flooding. No NTMAs would be undertaken that would increase flood risk in the reaches where improvements are made. The project proponent for any NTMA would analyze the potential of the project to locally impede flow or transfer flood risk by causing changes in river velocity, stage, or cross section. The project proponent would also need to obtain permits, such as Section 408 and 208.10 and Board encroachment permits, to be able to implement the project. Should an NTMA be found to have the potential to locally impede flow or transfer flood risk to downstream or upstream areas, individual NTMAs would be designed to reduce the impacts of redirected flood flows to less-than-significant levels.

However, because the proposed program could not be entirely implemented in the short term, not all reaches would be improved; levees protecting high-risk communities would be considered for prioritization. Regardless, individual NTMAs would not be implemented nor approved if water surface elevations for a proposed project, any redirected flood risks, would increase above permitted allowances, which are typically extremely small such as 0.1 ft or less. Actions would be incorporated into project design to reduce the potential for redirected flood flow impacts, using known and accepted engineering design standards and features to less-than-significant levels.

See Attachment 8C, “Riverine Channel Evaluations,” in the 2012 CVFPP (Appendix A to this PEIR) for details regarding the effects of the various management activities on the system. This impact would be **less than significant**. No mitigation is required.

Impact HYD-5 (NTMA): ***Increased Risk of Inundation by Seiche***

Seiches are wind- or earthquake-generated waves or oscillations of the water surface elevations within restricted bodies of water. They are extremely rare in the study area. If additional flood flows were to enter into the Delta, levee instability or failure could occur, thereby increasing the surface area and potential for a seiche. However, simulations of NTMAs showed a nominal change in Delta flow. (See Attachment 8C, “Riverine Channel Evaluations,” in the 2012 CVFPP (Appendix A to this PEIR) for details regarding the potential hydraulic effects of the various management activities on the system.) Because the surface elevation or area of the Delta would not increase, the chance of inundation by seiche would not increase. Therefore, this impact would be **less than significant**. No mitigation is required.

Impact HYD-6 (NTMA): ***Reduced Long-Term Water Supplies from Reservoir Operational Criteria Changes***

The proposed program includes forecast-based operations, which would use more accurate long-term runoff forecasting to provide greater flexibility in reservoir operations. Proposed changes to reservoir operations under the proposed program include allowing flood releases to occur over a range of reservoir water surface elevations rather than requiring flood releases to start at a single, set water surface elevation, based on long-term forecast data. Under forecast-based operations, water may be released from reservoirs in anticipation of higher than normal precipitation, to provide additional room for flood storage. When drier conditions are anticipated, more water may be retained to enhance water supply. In most years, this is anticipated to be beneficial because improving reservoir operations could actually increase the availability of water supply while also improving flood protection. However, DWR’s current modeling has indicated that when the forecasts prove incorrect (particularly when an anticipated storm does not result in the expected precipitation), under some scenarios, the overall volume of water storage and releases available for water supply could potentially be reduced.

The water utilities receiving these water supplies are well adapted to responding to water supply fluctuations. The worst-case supply reductions that could result from the proposed program's changes to reservoir operations are orders of magnitude less than other supply uncertainties faced by these entities, and are well within the scope of the contingency planning undertaken by these entities.

Additionally, increased use of other water storage and banking options would compensate for any potential program-induced reductions in water deliveries during critically dry years. During wet years, the proposed program would make additional water available for water bank deposits (e.g., increased allocations of water to groundwater storage). This available banked water would be tapped during extreme dry years to ensure that deliveries would not be reduced. Therefore, this impact would be **less than significant**. No mitigation is required.

3.13.5 Environmental Impacts, Mitigation Measures, and Mitigation Strategies for LTMAs

This section describes the physical effects of LTMAs on hydrologic resources. LTMAs include a continuation of activities described as part of NTMAs and all other actions included in the proposed program, and consist of all of the following types of activities:

- Widening floodways (through setback levees and/or purchase of easements)
- Constructing weirs and bypasses
- Constructing new levees
- Changing operation of existing reservoirs
- Achieving protection of urban areas from a flood event with 0.5 percent risk of occurrence
- Changing policies, guidance, standards, and institutional structures
- Implementing additional and ongoing conservation elements

Actions included in LTMAs are described in more detail in Section 2.4, "Proposed Management Activities."

Impacts identified above for NTMAs would also be applicable to many LTMAs and are identified below. The NTMA impact discussions are modified or expanded where appropriate, or new impacts and mitigation measures are included if needed, to address conditions unique to LTMAs.

Feasible mitigation measures are identified to address significant or potentially significant impacts. Actual implementation, monitoring, and reporting of the PEIR mitigation measures would be the responsibility of the project proponent for each site-specific project. For those projects not undertaken by, or otherwise subject to the jurisdiction of, DWR or the Board, the project proponent generally can and should implement all applicable and appropriate mitigation measures. The project proponent is the entity with primary responsibility for implementing specific future projects and may include DWR; the Board; reclamation districts; local flood control agencies; and other federal, State, or local agencies. Because various agencies may ultimately be responsible for implementing (or ensuring implementation of) mitigation measures identified in this PEIR, the text describing mitigation measures below does not refer directly to DWR but instead refers to the "project proponent." This term is used to represent all potential future entities responsible for implementing, or ensuring implementation of, mitigation measures.

Impact HYD-1 (LTMA): ***Increased Erosion and Siltation from Modifying the Flood Conveyance System***

Where the LTMAs would continue activities included in the NTMAs, this impact would be the same as Impact HYD-1 (NTMA). Implementing some LTMAs could result in larger changes to the existing hydraulics of the system compared to NTMAs and increase erosion or siltation. Widening floodways by setting back levees, lowering weirs, creating new or widened bypasses, or implementing other LTMAs could change the timing and magnitude of flows. As a result of these hydraulic changes, the rivers and streams may be subject to changes in the duration, depth, and velocity of flows, which could increase deleterious waterside erosion or siltation. Flows that would result from implementing some LTMAs, would likely be lower in depth and velocity than flows without the proposed program, but may still be at a high enough velocity to allow some erosion to continue to occur. Because the same volume of water must pass through the system and the program-related flows would be slower, the duration that water is evacuated from the system would likely be longer; such program-related flows may offset any benefits associated with lower flow velocity and may result in a net increase erosion.

Floodplain contouring, terracing, and other design features can be incorporated when levees are set back or removed to widen a floodway.

These features allow natural geomorphic processes within the floodway (such as channel meander), or outside the leveed floodway on flowage easements, without compromising the system's overall flood-carrying capacity, while further lowering the movement (velocity) of water (e.g., by decreasing ground slope) and therefore erosive forces. However, in some areas, these design features may not be able to be implemented or be insufficient of offset the effects of these LTMAs and some rivers and streams still may be subject to increased deleterious erosion. Therefore, this impact would be **potentially significant**.

See also Impact GEO-2 (LTMA), "Potential Localized Soil Erosion and Inadvertent Permanent Soil Loss as a Result of Construction or Operation and Maintenance Activities," in Section 3.10, "Geology, Soils and Seismicity (Including Mineral and Paleontological Resources)," for a discussion of the potential for changes in erosion or siltation as a result of construction activities.

Mitigation Measure HYD-1 (LTMA): ***Identify and Implement Measures to Minimize Downstream Erosion and Siltation***

Before a project is approved and implemented, the project proponent will perform an analysis of the new facilities to determine whether the facility will experience or cause elsewhere an erosion or siltation problem. To the extent possible, the facility will be designed to avoid or minimize these effects. Where avoidance is not feasible, the project proponent will address any erosion or siltation impacts through bank protection measures on- or off-site depending on where the increase erosion or siltation may occur. Measures could include moving levee foundations landward away from the eroding bank, maintaining waterside vegetation, dredging to remove siltation, or installing rock revetments, riprap, or other engineered structures along the eroding banks to reduce further erosion and protect the foundation of the levee. These measures will be implemented or funded by the project proponent.

Implementing this mitigation measure would reduce Impact HYD-1 (LTMA) to a **less-than-significant** level.

Impact HYD-2 (LTMA): ***Increased Flooding from Modifying the Flood Conveyance System***

This impact would be similar to Impact HYD-2 (NTMA), described above. LTMAs would further improve the overall flood system, thereby lowering flood risk in the study area, including risk associated with redirected flood flows. Because the LTMAs would improve overall flood system conveyance, this effect would be **beneficial**. No mitigation is required.

Impact HYD-3 (LTMA): ***Placement of Housing within a 100-Year Flood Hazard Area***

As with the NTMAs, no new homes or businesses would be constructed as part of the LTMAs, so none would be placed in a 100-year flood hazard area by the proposed program. As described above for Impact HYD-3 (NTMA), implementing the proposed program would increase flood protection and limit opportunities for construction within a 100-year flood hazard area. Therefore, this effect would be **beneficial**. No mitigation is required.

Impact HYD-4 (LTMA): ***Modification of the Flood Conveyance System in a Way that Would Redirect Flood Flows and Increase Flood Risk or Exposure of People or Structures to a Risk of Loss, Injury, or Death Involving Flooding***

As described above for Impact HYD-4 (NTMA), the purpose of the proposed program is to improve flood management, thereby reducing the frequency of destructive flood flows and the damage caused by flooding. NTMAs focus on modifying only parts of the system; by contrast, many LTMAs would provide regional level flood system conveyance improvements, thereby lowering flood risk over larger geographic areas, including risk associated with redirected flood flows.

No LTMAs would be undertaken that would increase flood risk in the study area. The project proponent for any LTMA would need to obtain permits, such as Section 408 and 208.10 and Board encroachment permits, to be able to implement the project. The project proponent would be required to analyze the potential of the project to locally impede flow or transfer flood risk to downstream or upstream areas by causing changes in river velocity, stage, or cross section. Should an LTMA be found to have the potential to locally impede flow or transfer flood risk to downstream or upstream areas, the LTMA would be designed using known and accepted engineering design standards and features to reduce the impacts of redirected flood flows to a less-than-significant level. Actions could include but would not be limited to modifying project design, modifying existing levees, providing a larger floodplain between levees through acquisition of land (via purchasing easements) and construction of setback levees, and regrading land between levees. LTMAs that could not or would not reduce redirected flood impacts to less-than-significant levels would not be implemented as part of the proposed program.

Because implementing the proposed program would not place structures that would impede or redirect flood flows in a way that would increase flood risk, this impact would be **less than significant**. No mitigation is required.

Impact HYD-5 (LTMA): ***Increased Inundation by Seiche***

As described above in Impact HYD-5 (NTMA), implementing the proposed program would not substantially increase flows that enter the Delta where a seiche could potentially occur. Simulations of LTMAs showed there was no change in Delta flow (see Attachment 8C, "Riverine Channel Evaluations," in the 2012 CVFPP (Appendix A to this PEIR)). The potential for a seiche is related to the water surface elevation or area. The proposed program would not increase water volume, and thus, the Delta's water surface elevation or area; therefore, the proposed program would not increase the risk of inundation by seiches.

Other LTMAs that would be implemented in the Extended SPA, such as new flood bypasses and setback levees, involve creating or expanding large bodies of water. Large bodies of water susceptible to seiche would only be present during high-water events when bypasses and floodways are inundated. Actions would be incorporated into project design to reduce the potential risk of inundation by seiches, using known and accepted engineering design standards and features (e.g., increase freeboard), to less-than-significant levels. Therefore, this impact would be **less than significant**. No mitigation is required.

Impact HYD-6 (LTMA): ***Reduced Long-Term Water Supplies from Reservoir Operational Criteria Changes***

This impact would be similar to Impact HYD-6 (NTMA). As described above in Impact HYD-6 (NTMA), implementing the proposed program would not substantially affect water supply. Therefore, this impact would be **less than significant**. No mitigation is required.

LTMA Impact Discussions and Mitigation Strategies

The impacts of the proposed program's NTMAs and LTMAs related to hydrologic resources and the associated mitigation measures are thoroughly described and evaluated above. The general narrative descriptions of additional LTMA impacts and mitigation strategies for those impacts that are included in other sections of this draft PEIR are not required for hydrologic resources.

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