3.11 Groundwater Resources

This section addresses groundwater resources that could be affected by implementation of the proposed program in the study area. Specifically, it addresses groundwater storage and production, groundwater levels, groundwater quality, and subsidence. This section is composed of the following subsections:

- Section 3.11.1, "Environmental Setting," describes the physical conditions in the study area as they apply to groundwater resources.
- Section 3.11.2, "Regulatory Setting," summarizes federal, State, regional, and local laws and regulations pertinent to evaluation of the proposed program's impacts on groundwater resources.
- Section 3.11.3, "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 3.11.4, "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 3.11.5, "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."

See Section 3.10, "Geology, Soils, and Seismicity (Including Mineral and Paleontological Resources)," for a discussion of subsidence related to seismicity and oxidation of peat soils.

3.11.1 Environmental Setting

Information Sources Consulted

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

- *California's Groundwater* (DWR 2003)
- *California Water Plan Update 2005* (DWR 2005)
- *California Water Plan Update* (DWR 2009)
- *Groundwater Availability of the Central Valley Aquifer, California* (Faunt 2009)
- *Central Valley Project Improvement Act Draft Programmatic Environmental Impact Statement* (Reclamation 1997)
- *San Joaquin River Restoration Program Draft Environmental Impact Statement/Environmental Impact Report* (Reclamation 2011)

Geographic Areas Discussed

Groundwater resources are dominated by hydrologic characteristics and processes that define hydrologic regions, such as storage, production levels, quality, and subsidence. Because hydrologic regions cross the boundaries of the geographic areas in the study area, this discussion is organized by hydrologic region rather than by geographic area. The discussion focuses on groundwater basins within the Sacramento River and San Joaquin River hydrologic regions, and on the Suisun-Fairfield Valley Groundwater Basin located in the San Francisco Bay hydrologic region (Figure 3.11-1). The groundwater resources of these hydrologic regions are described below. None of the management activities included in the proposed program would be implemented in the SoCal/coastal Central Valley Project/State Water Project (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"). Thus, groundwater resources of the SoCal/coastal CVP/SWP service areas are described in this section because they lie within the PEIR Study Area, but at a lower level of detail than the Extended SPA and the Sacramento and San Joaquin Valley Watersheds.

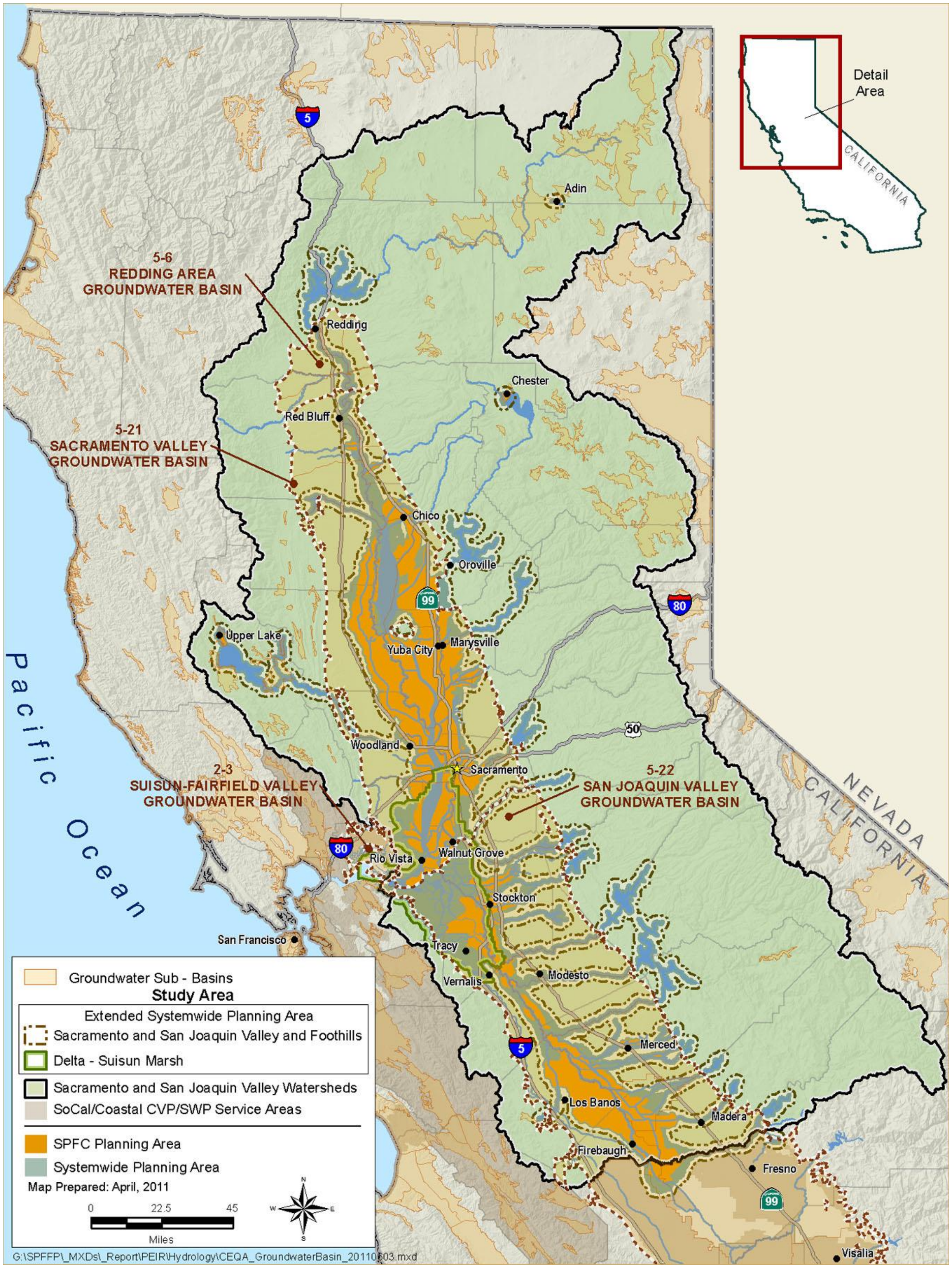

Figure 3.11-1. Groundwater Basins and Subbasins of the Sacramento River, San Francisco Bay, and San Joaquin River Hydrologic Regions

Sacramento River Hydrologic Region

The Sacramento River Hydrologic Region consists of the Sacramento River watershed (DWR 2010), and 63 groundwater basins are located within its boundaries (DWR 2003). It is located in the northern portion of the Sacramento and San Joaquin Valley watersheds (Figure 3.11-1). The Sacramento Valley Groundwater Basin, which is divided into 18 groundwater subbasins (DWR 2003), and the Redding Area Groundwater Basin, divided into six subbasins, are the primary groundwater basins in this hydrologic region. The remaining groundwater basins in the Sacramento River Hydrologic Region are not substantial groundwater resources and therefore are not discussed further. The hydrogeology, groundwater storage, groundwater production, groundwater levels, groundwater quality, and subsidence (as it relates to groundwater resources) are described below for the Sacramento Valley and Redding Area groundwater basins.

Hydrogeology This section describes the hydrogeology of the Sacramento Valley and Redding Area groundwater basins.

Sacramento Valley Groundwater Basin The Sacramento Valley Groundwater Basin consists of 18 subbasins: Antelope (groundwater subbasin number 5-21.54), Bend (5-21.53), Capay Valley (5-21.68), Colusa (5-21.52), Corning (5-21.51), Dye Creek (5-21.55), East Butte (5-21.59), Los Molinos (5-21.56), North American (5-21.64), North Yuba (5-21.60), Red Bluff (5-21.50), Solano (5-21.66), South American (5-21.65), South Yuba (5-21.61), Sutter (5-21.62), Vina (5-21.57), West Butte (5-21.58), and Yolo (5-21.67). The Sacramento Valley Groundwater Basin (Figure 3.11-1) makes up the northern one-third of the 400-mile-long, northwest-trending asymmetric trough of the Central Valley regional aquifer system in the northern extent of the Great Valley Geomorphic Province (Page 1986). The Sacramento Valley Groundwater Basin is bounded to the west by the Coast Ranges, to the south by the Sacramento–San Joaquin Delta (Delta) and San Joaquin Valley Groundwater Basin, to the east by the Sierra Nevada, and to the north by the Cascade Range and Klamath Mountains.

Groundwater in the Central Valley, including the Sacramento Valley and San Joaquin Valley groundwater basins, historically flowed from the Central Valley flanks to the axis of the valley during predevelopment conditions, then south from the Sacramento Valley and north from the San Joaquin Valley toward the Delta (Page 1986). The alluvial aquifer system in the Sacramento Valley Groundwater Basin typically extends to 80 feet below ground surface (bgs), but has been recorded to extend to as much as 200 feet bgs (DWR 2003; Fulton et al. n.d.). Alluvial deposits generally do not yield substantial quantities of groundwater and are largely unconfined except when overlain by flood basin deposits (DWR 1978).

The Tuscan Formation, found in the northeastern Sacramento Valley, is an important source of groundwater in the Sacramento Valley Groundwater Basin. However, the subsurface extent of the Tuscan Formation is limited in the northeast portion of the groundwater basin. The Upper Tuscan Formation is exposed on the east side of the Sacramento Valley Groundwater Basin and can be found to extend to approximately 800 feet bgs in the central portion of the basin (Fulton et al. n.d.). The upper portion of this formation underlies the alluvial aquifer system in the western portion of the groundwater basin, and interfingers with the Tehama Formation (DWR 1978). The Upper Tuscan Formation consists of consolidated and finer grained silts and clays and yields variable quantities of groundwater. The Lower Tuscan Formation is exposed on the east side of the Sacramento Valley Groundwater Basin and can be found from 800 feet bgs to approximately 1,000 feet bgs in the central portion of the basin. The Lower Tuscan Formation varies in texture from the Upper Tuscan Formation and consists of gravels, sands, and silts, which yield greater quantities of groundwater (Fulton et al. n.d.).

The Tehama Formation underlies the alluvial aquifer system on the west side of the Sacramento Valley Groundwater Basin and interfingers with the Tuscan Formation. The Tehama Formation aquifer system is intersected by two faults—the Willows-Corning Fault and the Black Butte Thrust Fault. Formed by uplift and erosion of the Coast Ranges, the Tehama Formation consists of clay, sand, and gravel. This formation is the principal water-bearing formation in the Sacramento Valley (DWR 1978).

The Mehrten Formation is also an important source of large quantities of groundwater in the Sacramento Valley Groundwater Basin. This formation crops out discontinuously along the eastern flank of the valley just south of the Bear River to just south of the Chowchilla River (Page 1986). The Mehrten Formation dips gently southwestward beneath the valley and interfingers with marine and nonmarine facies (Page 1986). The Mehrten Formation is made up of two units in the Sacramento Valley: (1) an overlying unit consisting of unconsolidated black sands interbedded with blue-to-brown clay, and (2) an underlying unit of hard, very dense tuff breccia (DWR 1978).

Groundwater in the Sacramento River Hydrologic Region has historically been used to supplement surface water supplies. Changing environmental laws and requirements and the effects of droughts have resulted in greater reliance on groundwater supplies and conjunctive management practices (DWR 2003). Groundwater provides 27 percent of the water supplies for agricultural and urban uses in the Sacramento River Hydrologic Region. The reliability of groundwater resources in the region varies but, in general, well yields range from 100 to several thousand gallons per minute (gpm) (DWR 2009).

Redding Area Groundwater Basin The Redding Area Groundwater Basin consists of six subbasins: Anderson (5-6.03), Bowman (5-6.01), Enterprise (5-6.04), South Battle Creek (5-6.06), Millville (5-6.05), and Rosewood (5-6.02). The Redding Area Groundwater Basin is located in the northwest portion of the Sacramento River Hydrologic Region, as designated by DWR and illustrated in Figure 3.11-1. The groundwater basin consists of water-bearing formations, including alluvium, and the Modesto, Riverbank, Tehama, and Tuscan formations. Water-bearing alluvium generally is up to 30 feet thick, with the exception of the Enterprise Subbasin, within which alluvium is up to 50 feet thick. The alluvium generally represents the perched water table and the unconfined aquifer zone, consisting of unconsolidated gravel, sand, silt, and clay from stream channel and floodplain deposits. The alluvium is not an important source of water supply (DWR 2003).

The Modesto and Riverbank formations typically are found as terrace deposits near the surface along the Sacramento River and its tributaries. These formations consist of poorly consolidated gravel with some sand and silt. The Modesto and Riverbank formations generally are up to 50 feet thick, are moderately to highly permeable, and are not an important source of domestic water supply (DWR 2003).

The Tehama Formation is the primary water supply source within the Redding Area Groundwater Basin, yielding 100–1,000 gpm, except within the South Battle Creek Subbasin, where the Tehama Formation is not present (DWR 2003). The Tehama Formation consists of silts, sand, gravel, and clay from the Klamath Mountains and Coast Ranges. In the description of subbasins in the Redding Area Groundwater Basin in DWR's Bulletin 118-03, the Tehama Formation was reported to vary in thickness between 300 feet and 4,000 feet across the groundwater basin (DWR 2003).

The Tuscan Formation is present across the majority of the groundwater basin, except within the Rosewood Subbasin. The Tuscan Formation generally yields 100–1,000 gpm, and is found interfingered with the Tehama Formation in some localized areas. The Tuscan Formation consists of volcanic gravel and tuff-breccia, fine- to coarse-grained volcanic sandstone, conglomerate, tuff, tuffaceous silt, and clay. The Tuscan Formation is the primary aquifer of the South Battle Creek Subbasin (DWR 2003).

Groundwater Storage The net changes in groundwater storage in the Sacramento River Hydrologic Region (which includes both the Redding Area and Sacramento Valley groundwater basins) that occurred in water years 1998–2005 are presented in Table 3.11-1. The table generally shows the relationship between the region's variable hydrologic conditions and groundwater storage in this hydrologic region. In general, groundwater storage decreased during dry years, when precipitation was less than 100 percent of normal. However, storage also decreased in 1999 and 2000, two normal (or slightly above-normal) water years. The negative change in groundwater storage in a normal or slightly above-normal water year could have resulted from various factors, such as increased groundwater pumping in the region or high-intensity storms that resulted in more runoff than recharge to the aquifer. The decrease in groundwater storage in 2005 (another above-normal water year) could have been caused by declining groundwater levels that had not yet responded to the shift in hydrologic conditions at the surface.

Table 3.11-1. Net Changes in Groundwater Storage in the Sacramento River Hydrologic Region, 1998–2005

	Water Year (percent of normal precipitation)							
	1998 (168)	1999 (101)	2000 (105)	2001 (67)	2002 (91)	2003 (99)	2004 (90)	2005 (127)
Change in Groundwater Storage (thousand acre-feet)	740	-1,731	-151	-1,148	-1,418	-1,470	-1,640	-1,211

Source: DWR 2009

The U.S. Geological Survey (USGS) simulated cumulative change in groundwater storage in the Central Valley as a whole, using the Central Valley Hydrologic Model (CVHM) (Faunt 2009). This cumulative change includes changes in groundwater storage within the Sacramento River, San Joaquin River, and Tulare Lake hydrologic regions. (The Sacramento River and San Joaquin River hydrologic regions are the two regions considered in this analysis of the proposed program.) The USGS study estimated a net loss of 57,700 thousand acre-feet (TAF) from aquifer storage in the Central Valley between 1962 and 2003, based on simulated annual recharge and discharge (Faunt 2009).

Sacramento Valley Groundwater Basin Total groundwater storage capacity of the alluvial unconfined aquifer in the Sacramento Valley Groundwater Basin is estimated to be 46,000 TAF, extending to a depth of 200 feet, or assuming a 200-foot-thick aquifer (DWR 2003). (The total groundwater storage capacity published in DWR Bulletin 118-03 for the Sacramento Valley Groundwater Basin's different subbasins was estimated to extend from the ground surface to a depth of 200 feet, except in the South American, Yolo, and Capay Valley subbasins. Total groundwater storage capacity in these subbasins was estimated to extend 20–310 feet, 20–420 feet, and 20–200 feet bgs, respectively.)

Redding Area Groundwater Basin Total groundwater storage capacity in the Redding Area Groundwater Basin, distributed among six subbasins, is estimated to be approximately 5,500 TAF (DWR 2003).

Groundwater Production USGS reported simulated groundwater pumping for the entire Central Valley using the CVHM for 1962–2003. Pumping for urban uses ranged between 600 and 2,000 TAF, making up less than 5 percent of total pumping in 1962 but increasing to about 30 percent of pumping in the late 1990s to early 2000s (Faunt 2009). Based on average annual data between 1998 and 2005, groundwater production in the Sacramento River Hydrologic Region (which consists of both the Redding Area and Sacramento Valley groundwater basins) makes up 27 percent of the water supply, or 2.6 million acre-feet (MAF) (DWR 2009).

Sacramento Valley Groundwater Basin The cities of Red Bluff, Corning, Woodland, Davis, and Dixon are completely reliant on groundwater production in the Sacramento Valley Groundwater Basin for their sole source of water (DWR 2003). Production rates in the groundwater subbasins beneath the cities of Red Bluff, Corning, and Colusa range from 81 to 310 TAF per year for agricultural uses and from 6.6 to 14 TAF per year for municipal and industrial (M&I) uses. Groundwater is also pumped in the Colusa Subbasin to support environmental wetlands. Nearly 90 TAF per year (81 TAF for agricultural uses and 8.9 TAF for M&I uses) is extracted in the Red Bluff Subbasin, which is much more pumping than occurs in neighboring subbasins to the east (approximately 19 TAF in the Antelope Subbasin and 340 acre-feet in the Bend Subbasin).

Redding Area Groundwater Basin As of 1995, approximately 12.5 percent of all water used in the Redding Area Groundwater Basin was derived from groundwater, the vast majority of which was used to meet M&I demands (Shasta County Water Agency 2007). Total annual groundwater pumping in this groundwater basin is approximately 37 TAF (DWR 1998). This is a minor amount compared with the basin's groundwater discharge to surface water of 266 TAF (Shasta County Water Agency 1998). Groundwater production is greatest in the Anderson Subbasin of the Redding Area Groundwater Basin, with approximately 3 TAF of groundwater extracted for agricultural uses and 20 TAF for M&I uses (DWR 2003).

Groundwater Levels This section describes groundwater levels in the Sacramento Valley and Redding Area groundwater basins.

Sacramento Valley Groundwater Basin In general, groundwater levels in the Sacramento Valley Groundwater Basin declined during the 1976–1977 and 1987–1994 droughts, before generally recovering in the 1990s to the predrought conditions of the early 1970s and 1980s (DWR 2003). The groundwater elevation contours developed by DWR in 1997 for the Sacramento Valley Groundwater Basin are presented in Figure 3.11-2.

Groundwater levels in composite wells (wells that combine the confined and unconfined portions of the aquifer) in the northern part of the East Butte Subbasin experienced the greatest declines during the drought periods, decreasing by 30–40 feet. Groundwater levels have also declined in the South Yuba Subbasin, causing a cone of depression to develop in the subbasin as early as the 1960s. However, by the 1990s, groundwater levels in the South Yuba Subbasin had increased by 10 feet because of increased deliveries of surface water and groundwater recharge; as noted by DWR monitoring records, these groundwater levels appear to be continuing to increase (DWR 2003). Long-term trends of substantial groundwater decline are prevalent in localized areas within the Yolo Subbasin near the cities of Davis, Woodland, and Dunnigan/Zamora, where pumping has created a cone of depression (DWR 2003).

In general, groundwater in the Sacramento Valley Groundwater Basin flows toward the Sacramento River, and then parallel to the river. Under localized conditions, it may be possible for groundwater levels to rise in recharge areas after precipitation events and come within a few feet of the ground surface; or in some areas, groundwater could flow in an artesian manner from wells. Under those conditions, the ground could become completely saturated, resulting in ponding on the ground surface. Overland flow could also result from high-intensity precipitation events that exceed the infiltration capacity of the soils; however, such overland flow would be a result of soil conditions, not a result of high groundwater levels. Thus, this topic is discussed in Section 3.10, “Geology, Soils, and Seismicity (Including Mineral and Paleontological Resources).”

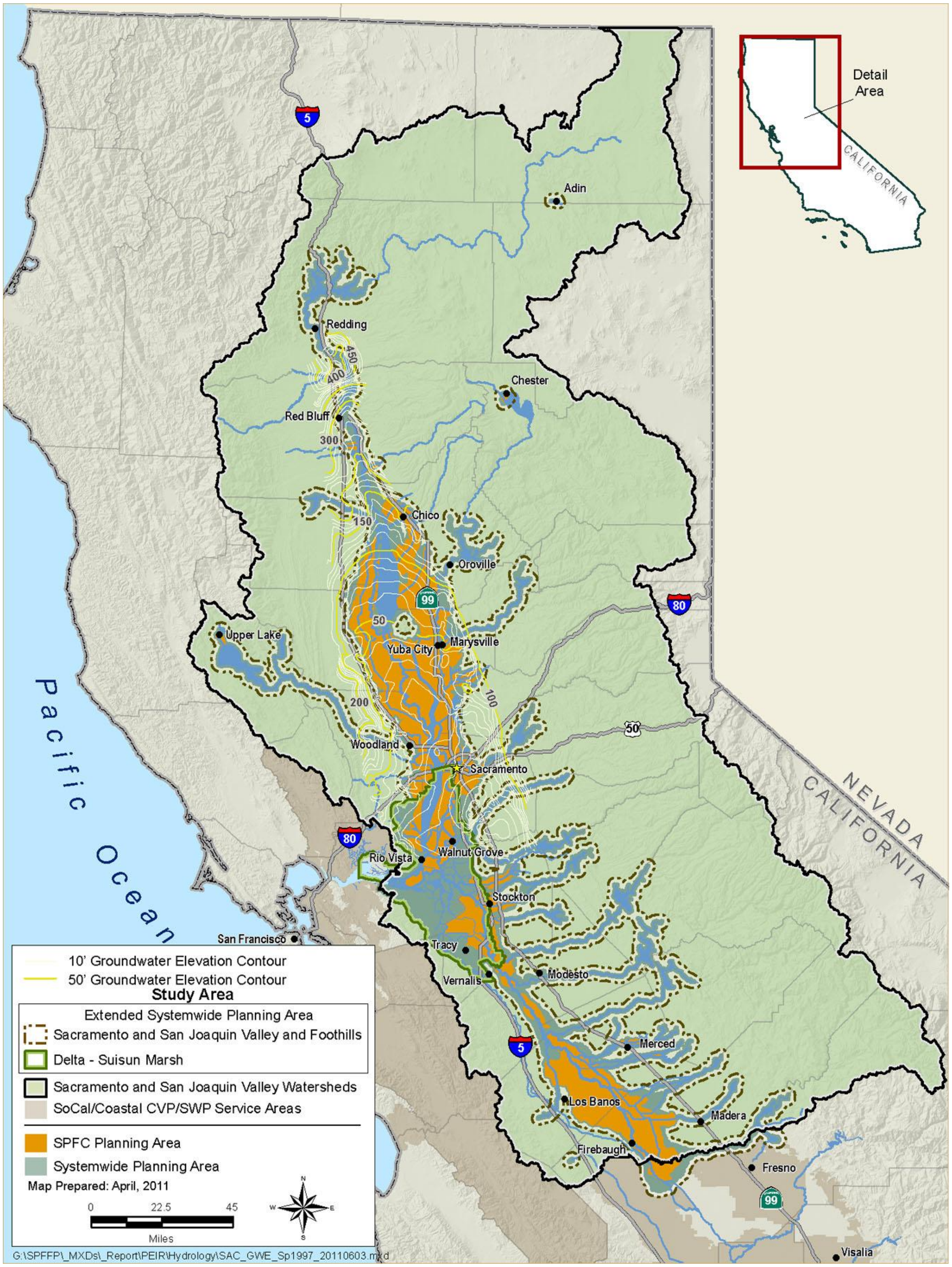

Figure 3.11-2. Groundwater Elevations in the Sacramento Valley Groundwater Basin (Spring 1997)

Localized cones of depression exist within the Sacramento Valley Groundwater Basin, but large-scale groundwater recharge projects have not been implemented to replenish the aquifer.

Redding Area Groundwater Basin Groundwater levels in the Redding Area Groundwater Basin declined during the 1976–1977 and 1987–1994 droughts, and generally recovered to predrought conditions of the early 1970s and 1980s (DWR 2003). Overall, groundwater levels in this groundwater basin have remained relatively stable, fluctuating seasonally by approximately 2–15 feet (DWR 2003).

Groundwater Quality This section describes groundwater quality in the Sacramento Valley and Redding Area groundwater basins.

Sacramento Valley Groundwater Basin The concentration of total dissolved solids (TDS) in groundwater in the Sacramento Valley Groundwater Basin is typically sufficient for M&I and agricultural uses, averaging less than 500 milligrams per liter (mg/L) (Table 3.11-2). This average value is below both the California and U.S. Environmental Protection Agency (EPA) secondary drinking-water standard of 500 mg/L and the agricultural water-quality goal of 450 mg/L stated in the *Water Quality Control Plan for the Sacramento River and San Joaquin River Basins* (Basin Plan) (Central Valley RWQCB 2009). Localized groundwater quality issues have been associated with natural impairments of water quality at the north end of the Sacramento Valley, where marine sedimentary rocks containing brackish to saline water are near the surface (DWR 2003). However, some groundwater quality issues in the Central Valley, including the Sacramento Valley Groundwater Basin, have been attributed to agricultural practices.

Redding Area Groundwater Basin Groundwater in the Redding Area Groundwater Basin is typically sufficient for M&I and agricultural uses, averaging less than 400 mg/L TDS (Table 3.11-2). This range is below both the California and EPA secondary drinking-water standard of 500 mg/L and the agricultural water quality limit of 450 mg/L. Groundwater impairments in the Redding Area Groundwater Basin are typically associated with localized areas of boron, iron, manganese, chloride, and TDS (DWR 2003).

Table 3.11-2. Groundwater Quality Data for the Sacramento Valley and Redding Area Groundwater Basins in the Sacramento River Hydrologic Region

DWR Groundwater Subbasin Name (number)	TDS (mg/L)	
	Average	Range
Sacramento Valley Groundwater Basin		
Antelope Subbasin (5-21.54)	296	–
Bend Subbasin (5-21.53)	–	334–360
Capay Valley Subbasin (5-21.68)	–	–
Colusa Subbasin (5-21.52)	391	120–1,220
Corning Subbasin (5-21.51)	286	130–490
Dye Creek Subbasin (5-21.55)	240	159–396
Los Molinos Subbasin (5-21.56)	217	–
North American Subbasin (5-21.64)	–	–
North Yuba Subbasin (5-21.60)	–	–
Red Bluff Subbasin (5-21.50)	207	120–500
Solano Subbasin (5-21.66)	427	150–880
South American Subbasin (5-21.65)	221	24–581
South Yuba Subbasin (5-21.61)	–	–
Sutter Subbasin (5-21.62)	–	–
Vina Subbasin (5-21.57)	285	48–543
West Butte Subbasin (5-21.58)	293	130–676
Yolo Subbasin (5-21.67)	880	480–2,060

Table 3.11-2. Groundwater Quality Data for the Sacramento Valley and Redding Area Groundwater Basins in the Sacramento River Hydrologic Region (contd.)

DWR Groundwater Subbasin Name (number)	TDS (mg/L)	
	Average	Range
Redding Area Groundwater Basin		
Anderson Subbasin (5-6.03)	194	109–320
Bowman Subbasin (5-6.01)	–	70–247
Enterprise Subbasin (5-6.04)	–	160–210
Millville Subbasin (5-6.05)	140	–
Rosewood Subbasin (5-6.02)	–	118–218
South Battle Creek Subbasin (5-6.06)	360	–

Source: DWR 2003

Key:
– = Not available
DWR = California Department of Water Resources
mg/L = milligrams per liter
TDS = total dissolved solids

Subsidence Subsidence resulting from aquifer compaction (caused by declines in groundwater levels) has been an issue in the Sacramento Valley Groundwater Basin, but no subsidence has been reported in the Redding Area Groundwater Basin.

Subsidence has occurred in the Sacramento Valley Groundwater Basin in areas where the underlying aquifer is overdrafted, causing compaction of the aquifer system. (Groundwater overdraft is the condition in which the amount of water withdrawn by pumping in a basin exceeds the amount of water that recharges the basin over a period of years, during which water supply conditions are approximately average (DWR 2005).) By 1973, compaction of the aquifer system had resulted in 2 feet of subsidence in two localized areas east of the town of Zamora and west of the town of Arbuckle in the Sacramento Valley (Williamson et al. 1989; Lofgren and Ireland 1973). Lofgren and Ireland (1973) identified six general areas with probable subsidence: northwest of Sacramento, northeast of Sacramento, southeast of Yuba City, 10 miles north of Willows, 20 miles north of Willows, and in the Arbuckle area.

A program studying subsidence between 1986 and 1989, led by USGS, documented the extent and magnitude of land subsidence in the Sacramento Valley Groundwater Basin. The maximum average rate of land subsidence in the southern Sacramento Valley Groundwater Basin was estimated to be 0.17 foot per year, or approximately 2.9 feet in the 17 years since the previous evaluations were completed using leveling data (Ikehara 1994). According to this study, land subsidence occurred along a north-south trending area between Zamora and Davis in the southern Sacramento Valley Groundwater Basin (Ikehara 1994).

DWR is conducting several surveys to improve data collection and its understanding of aquifer system compaction in the Sacramento Valley Groundwater Basin (DWR 2010). In addition, DWR is monitoring land subsidence with extensometers installed in the Sacramento Valley, from which the location and data are available in DWR's Water Data Library (DWR 2010).

San Joaquin River Hydrologic Region

The San Joaquin River Hydrologic Region consists of surface water basins that drain into the San Joaquin River system, from the Cosumnes River Basin to the north through the southern boundary of the San Joaquin River watershed (DWR 1998). This hydrologic region contains the Yosemite Valley and Los Banos Creek Valley groundwater basins and the northern portion of the San Joaquin Valley Groundwater Basin. The San Joaquin Valley Groundwater Basin is the primary basin in this hydrologic region and is discussed further below. The Yosemite Valley and Los Banos Creek Valley groundwater basins do not provide substantial groundwater resources to the San Joaquin River Hydrologic Region and thus are not described further.

Hydrogeology The northern portion of the San Joaquin Valley Groundwater Basin is located within the San Joaquin River watershed portion of the study area. This groundwater basin comprises nine subbasins, including the northern portion of the Delta-Mendota Groundwater Subbasin. The nine subbasins are Chowchilla (5-22.05), Cosumnes (5-22.16), Delta-Mendota (5-22.07), Eastern San Joaquin (5-22.01), Madera (5-22.06), Merced (5-22.04), Modesto (5-22.02), Tracy (5-22.15), and Turlock (5-22.03). In addition, the Kings (5-22.08) and Westside (5-22.09) groundwater subbasins, as well as the southern portion of the Delta-Mendota Groundwater Subbasin, all within the Tulare Lake Hydrologic Region, intersect the study area and are included in the analysis.

The San Joaquin Valley (Figure 3.11-1) makes up the southern two-thirds of the 400-mile-long, northwest-trending asymmetric trough of the Central Valley regional aquifer system in the southern extent of the Great Valley Geomorphic Province (Williamson et al. 1989). The San Joaquin Valley Groundwater Basin is bounded to the west by the Coast Ranges, to the south by the San Emigdio and Tehachapi mountains, to the east by the Sierra Nevada, and to the north by the Delta and the Sacramento Valley

Groundwater Basin (DWR 2003). However, the portion of the San Joaquin Valley Groundwater Basin within the study area is generally bounded to the south by the Tulare Lake Hydrologic Region's boundary with the San Joaquin River Hydrologic Region.

Aquifers in the San Joaquin Valley Groundwater Basin are thick, typically extending to depths of up to 800 feet. Groundwater subbasins in the northern half of this groundwater basin (which, as stated previously, is the primary basin of the San Joaquin River Hydrologic Region) include the Tracy, Delta-Mendota, Cosumnes, Eastern San Joaquin, Modesto, Turlock, Merced, Chowchilla, and Madera subbasins. Groundwater pumping in the San Joaquin Valley Groundwater Basin accounts for 5 percent of California's total agricultural and urban water use (DWR 1998).

Groundwater pumping and recharge from imported irrigation water have changed regional flow patterns. Groundwater largely flows from areas of recharge toward areas where groundwater levels are lower as a result of pumping (Bertoldi et al. 1991). The vertical movement of water in the aquifer has been increased in this region by operation of thousands of wells that were constructed with perforations above and below the confining unit (Corcoran Clay Member or E-clay), where present, thus providing a direct hydraulic connection (Bertoldi et al. 1991). However, vertical flow through the confining unit has decreased, possibly because of the inelastic compaction of fine-grained materials in the aquifer system (Bertoldi et al. 1991).

The San Joaquin Valley Groundwater Basin is divided into two major aquifers: a confined aquifer beneath the Corcoran Clay Member of the Tulare Formation and an unconfined to semiconfined aquifer above the Corcoran Clay (Mitten et al. 1970; Williamson et al. 1989). Corcoran Clay is a thick zone of clay deposited as part of the sequence of lacustrine and marsh deposits underlying Tulare Lake. On a regional scale, the Corcoran Clay divides the groundwater system. Corcoran Clay is considered equivalent to E-clay, ranges from 0 to 160 feet thick, and is found at depths between 80 feet (near Chowchilla) and 400 feet (in areas to the southwest) (Mitten et al. 1970).

The confined aquifer is overlain by the Corcoran Clay Member of the Tulare Formation and consists of mixed-origin sediments. The unconfined to semiconfined aquifer can be divided into three hydrogeologic units based on the source of the sediment:

- *Coast Ranges alluvial deposits* are derived largely from the erosion of marine rocks from the Coast Ranges. These deposits are up to 850 feet thick along the western edge of the San Joaquin Valley and taper off to the east as they approach the center of the valley floor (Belitz and Heimes 1990). These sediments contain a large proportion of silt and clay, are high in salts, and contain elevated concentrations of selenium and other trace elements.

- *Sierra Nevada sediments* on the east side of the San Joaquin Valley are derived primarily from granitic rock and consist primarily of well-sorted micaceous sand (Miller et al. 1971). These deposits make up most of the total thickness of sediments along the valley axis and gradually thin to the west until they pinch out near the western boundary. These sediments are relatively permeable, with hydraulic conductivities three times those of the Coast Ranges deposits (Belitz and Heimes 1990).

- *Flood basin deposits* are relatively thin. These deposits have been derived in recent time, in geologic terms, from sediments of the Coast Ranges to the west and the Sierra Nevada to the east. Flood basin deposits occur along the center of the valley floor and consist primarily of moderately to densely compacted clays ranging between 5 and 35 feet thick (Belitz and Heimes 1990).

Groundwater Storage As reported above, USGS simulated cumulative change in groundwater storage in the Central Valley as a whole, using the CVHM (Faunt 2009). This cumulative change includes changes in groundwater storage within the Sacramento River, San Joaquin River, and Tulare Lake hydrologic regions. (The Sacramento River and San Joaquin River hydrologic regions are the two regions considered in this analysis of the proposed program.) The USGS study estimated a net loss of 57,700 TAF from aquifer storage in the Central Valley between 1962 and 2003, based on simulated annual recharge and discharge (Faunt 2009).

Total groundwater storage capacity in the northern portion of the San Joaquin Valley Groundwater Basin (located within the San Joaquin River watershed portion of the study area) is estimated to be more than approximately 106,000 TAF to a depth of 300 feet, and approximately 263,000 TAF to the base of fresh groundwater (DWR 2003). These two estimates differ in part because the same subbasins are not included in both estimates:

- Both estimates exclude the Kings and Westside subbasins, which are only partially within the San Joaquin River watershed portion of the study area, and the Tracy Subbasin, which was estimated to have groundwater storage capacity of 4,000 TAF in its southern portion (DWR 2003).

- The estimate of total groundwater storage capacity to 300 feet bgs also excludes the Eastern San Joaquin Subbasin, with an estimated storage capacity of 42,000 TAF from 20 feet bgs to the base of fresh groundwater (DWR 2003).

- The estimate of total groundwater storage capacity to the base of fresh groundwater includes the estimate of storage capacity from the Cosumnes Subbasin: 6,000 TAF from 20 to 310 feet bgs.

Usable storage capacity for the entire San Joaquin River Hydrologic Region, which includes the San Joaquin Valley Groundwater Basin, has been estimated by DWR Bulletin 160-93 to be 24,000 TAF (DWR 1994). (DWR's definition of usable storage capacity is based on aquifer properties (i.e., permeability), groundwater quality, and economic considerations, such as the costs of well drilling and energy (DWR 1994).) The net change in groundwater storage in the San Joaquin River Hydrologic Region that occurred in water years 1998–2005 are presented in Table 3.11-3. The table generally shows the relationship between the region's variable hydrologic conditions and groundwater storage in this hydrologic region. In general, groundwater storage decreased during dry years, when precipitation was less than 100 percent of normal. However, storage also decreased in 1998 and 1999, normal (or above-normal) water years. The negative change in groundwater storage in a normal or slightly above-normal water year could have resulted from various factors, such as increased groundwater pumping in the region or high-intensity storms that resulted in more runoff than recharge to the aquifer. The decrease in groundwater storage in 2005 (another above-normal water year) could have been caused by declining groundwater levels that had not yet responded to the shift in hydrologic conditions at the surface.

Table 3.11-3. Net Changes in Groundwater Storage in the San Joaquin River Hydrologic Region, 1998–2005

	Water Year (percent of normal precipitation)							
	1998 (174)	**1999 (109)**	**2000 (79)**	**2001 (79)**	**2002 (82)**	**2003 (84)**	**2004 (85)**	**2005 (126)**
Change in Groundwater Storage (thousand acre-feet)	-444	-1,858	-96	-1,260	-1,673	-1,752	-1,999	-1,251

Source: DWR 2009

Groundwater Production Reduced deliveries of surface water and critically dry hydrologic conditions in the San Joaquin River Hydrologic Region during the 1987–1992 drought period resulted in increased pumping in the 1990s (DWR 1994). In 1990, an estimated 3,500 TAF of groundwater was pumped from this hydrologic region. The groundwater pumped from the region in 1990 exceeded the estimated perennial yield by approximately 200 TAF (DWR 1994). Groundwater extractions in the San Joaquin Valley during the first 5 years of the 1987–1992 drought exceeded recharge by 11,000 TAF, causing land subsidence in some areas (DWR 2005). All subbasins in the San Joaquin River Hydrologic Region experienced overdraft during the 1980s and the early 1990s (DWR 1994). At a 1995 level of development, annual average groundwater overdraft in this hydrologic region was estimated at about 240 TAF (DWR 1998). A comprehensive assessment of overdraft in California's subbasins has not been completed since 1980; however, the *California Water Plan Update* reports that three of the subbasins in the San Joaquin River Hydrologic Region—Chowchilla, Eastern San Joaquin, and Madera—are in a critical condition of overdraft (DWR 2009).

The San Joaquin River Hydrologic Region is heavily groundwater reliant, with groundwater making up approximately 33 percent, or 2,661 TAF, of the annual supply for agricultural and urban uses (DWR 2009). Production rates for individual subbasins within the San Joaquin Valley Groundwater Basin were last reported by DWR in 2003. The production rates for the subbasins of the San Joaquin Valley Groundwater Basin ranged from 94 to 551 TAF per year for agricultural uses and 15–81 TAF for urban uses (DWR 2003). In addition to agricultural and urban uses, groundwater extraction for "other" uses is included for two subbasins, Delta-Mendota and Merced, and ranges from 3 to 9 TAF (DWR 2003).

Groundwater Levels Between 1920 and 1950, expansion of agricultural practices caused groundwater levels to decline in many areas of the San Joaquin River Hydrologic Region. Groundwater levels declined substantially in the Chowchilla, Madera, western Kings County, Pleasant Valley, Tule, and Kern County areas, which depended heavily on groundwater for irrigation (Williamson et al. 1989). However, in 1950, the Friant-Kern Canal started delivering surface water to part of the east side of the San Joaquin Valley, and the deliveries reversed water-level declines because groundwater pumping was reduced (Williamson et al. 1989). Also, beginning in 1967, surface water from the California Aqueduct replaced groundwater as the primary source of irrigation supply to the area south of Mendota (Belitz and Heimes 1990).

The decrease in groundwater pumping allowed time for the confined aquifer to recover from extensive pumping. Between 1967 and 1984, the hydraulic head in the confined aquifer rose between 200 and 300 feet along the western part of the San Joaquin River Hydrologic Region in Fresno County (Belitz and Heimes 1990). Groundwater levels in the confined aquifer in northwestern Fresno County and western Merced County increased up to 100 feet by spring 1980. Groundwater levels in the semiconfined aquifer were affected by the 1976–1977 drought and were lower between spring 1970 and spring 1980 but had recovered to near predrought levels by the end of 1980 (Reclamation 1997).

Groundwater levels declined by 20–30 feet in the central and eastern parts of the San Joaquin Valley Groundwater Basin between 1987 and 1992 (DWR 2003). After the drought, groundwater depressions were present on the east side of the San Joaquin River Hydrologic Region in Merced and Madera counties, where groundwater was less than 50 feet above mean sea level. Groundwater levels declined on the eastern side of the San Joaquin River Hydrologic Region until 1995 (DWR 2003). In general, groundwater levels began to recover in some of the subbasins of this hydrologic region in 1994 and continued to increase through 2000, nearly reaching 1970 predrought levels (DWR 2003).

Figure 3.11-3 presents contours showing spring 2007 groundwater elevations in the San Joaquin River and Tulare Lake hydrologic regions, as developed by DWR (2010). These contours illustrate groundwater elevations in the unconfined and semiconfined aquifers of the San Joaquin Valley. The elevations indicate that the San Joaquin Valley Groundwater Basin had approximately recovered from the 1987–1992 drought. Groundwater elevations for spring 2007 conditions are presented in a series of DWR groundwater basin contour maps (DWR 2010).

Groundwater levels in the San Joaquin Valley Groundwater Basin are typically not shallow enough to result in flooding after a precipitation event; however, some localized areas exhibit shallow groundwater levels (Figure 3.11-3). Groundwater levels in these areas may rise in response to precipitation events, saturating the unconfined to semiconfined aquifer to the ground surface. These conditions could result in ponding.

In areas where groundwater levels have declined substantially, the potential exists for artificial recharge through conjunctive-use programs. Several artificial recharge programs are in operation or are planned for future operation in the San Joaquin Valley Groundwater Basin: the Farmington Groundwater Recharge Program, the City of Tracy’s Proposed Demonstration Phase Aquifer Storage and Recovery Project, the Mariposa Lakes Planned Community (City of Stockton 2007), and the City of Lodi’s proposed groundwater recharge opportunities. Additional projects may have been identified or are under way to support the recovery of the cone of depression in this basin.

Groundwater Quality Groundwater quality in the San Joaquin Valley Groundwater Basin varies considerably (Table 3.11-4). In general, groundwater quality is suitable for most agricultural and M&I uses. However, TDS above the secondary maximum contaminant levels of 500 mg/L, as identified by the California Environmental Protection Agency, have been reported in the Tracy, Merced, Modesto, and Turlock subbasins (Bennett et al. 2006; Landon and Belitz 2008). Bertoldi et al. (1991) report that TDS concentrations generally exceed 500 mg/L and are in excess of 2,000 mg/L along portions of the western margin of the San Joaquin Valley. Primary constituents of concern for groundwater quality within the San Joaquin Valley Groundwater Basin are boron, chloride, nitrates, arsenic, selenium, dibromocholorpropane, and radon (DWR 2003).

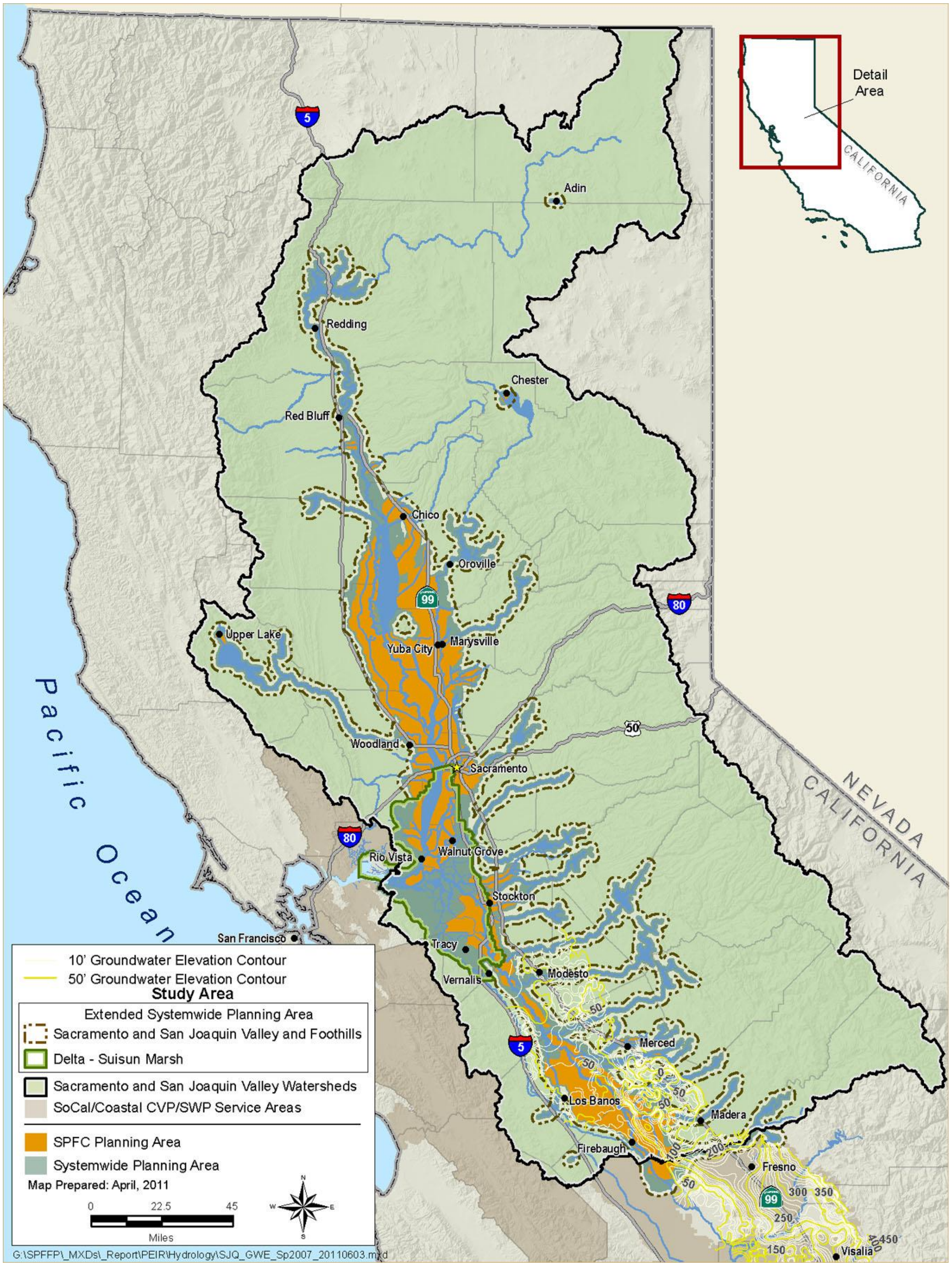

Figure 3.11-3. Groundwater Elevations in the San Joaquin Valley Groundwater Basin (Spring 2007)

Table 3.11-4. Groundwater Quality Data for the San Joaquin Valley Groundwater Basin in the San Joaquin River Hydrologic Region[1]

DWR Groundwater Subbasin Name (number)	TDS (mg/L)	
	Average	Range
Chowchilla Subbasin (5-22.05)	200–500	120–6,400
Cosumnes Subbasin (5-22.16)	218	140–438
Delta-Mendota Subbasin (5-22.07)	770	210–86,000
Eastern San Joaquin Subbasin (5-22.01)	310	30–1,632
Kings Subbasin (5-22.08)	200–700	40–2,000
Madera Subbasin (5-22.06)	200–400	100–6,400
Merced Subbasin (5-22.04)	200–400	100–3,600
Modesto Subbasin (5-22.02)	60–500	200–8,300
Tracy Subbasin (5-22.15)	1,190	210–7,800
Turlock Subbasin (5-22.03)	200–500	100–8,300
Westside Subbasin (5-22.09)	520	220–35,000

Source: DWR 2003

Note:
[1] Also includes two subbasins within the Tulare Lake Hydrologic Region that are in the study area.

Key:
DWR = California Department of Water Resources
mg/L = milligrams per liter
TDS = total dissolved solids

Groundwater quality in the Yosemite Valley Groundwater Basin is good, with TDS ranging from 43 to 73 mg/L (DWR 2003). No information is available about the quality of groundwater within the Los Banos Creek Valley Groundwater Basin (DWR 2003).

Subsidence In the San Joaquin Valley, aquifer system compaction resulting from declines in groundwater levels and near-surface hydrocompaction are the primary causes of subsidence (Ireland 1986). However, hydrocompaction does not occur within the study area and thus is not discussed further.

Declines in groundwater levels have been among the primary causes of land subsidence in the San Joaquin Valley Groundwater Basin because they have resulted in compaction of aquifer sediments. In the mid-1920s, land in the San Joaquin Valley began to subside as a result of increased groundwater pumping to irrigate crops (Ireland 1986). By the mid-1970s, maximum land subsidence in the San Joaquin Valley Groundwater Basin exceeded 28 feet (Poland et al. 1975). By 1977, the decline in groundwater levels in the valley caused at least 1 foot of land subsidence across more than 5,200 square miles, or nearly half of the irrigated land in the San Joaquin River and Tulare Lake hydrologic regions (Ireland 1986). The most seriously affected areas were located south of the study area and partially within the study area in the western parts of the valley, near Los Banos.

In the late 1960s and early 1970s, surface water was imported via canals, and the California Aqueduct began importing supplies into the subsiding areas, reducing the need for groundwater pumping and eliminating new land subsidence in the southern and western portions of the San Joaquin Valley Groundwater Basin (Ireland 1986). Drought conditions in 1976–1977 resulted in high groundwater pumping rates, inducing land subsidence in areas where it had been observed previously. Substantial subsidence was detected again in the San Joaquin Valley Groundwater Basin because of increased groundwater pumping during the 1987–1992 drought. Land subsidence was also reported along the Delta-Mendota Canal between 1984 and 1996.

San Francisco Bay Hydrologic Region

The San Francisco Bay Hydrologic Region is bounded to the north by the North Coast Hydrologic Region, to the east by the Sacramento River and San Joaquin River hydrologic regions, to the south by the Central Coast Hydrologic Region, and to the west by the Pacific Ocean. The San Francisco Bay Hydrologic Region contains 28 identified groundwater basins composed of Coast Ranges sediments. The groundwater basins in the San Francisco Bay Hydrologic Region underlie approximately 30 percent of the entire hydrologic region. Groundwater makes up approximately 16 percent of the region’s average water supply (DWR 2009).

The study area is partially underlain by two groundwater basins within the San Francisco Bay Hydrologic Region: the Suisun–Fairfield Valley Groundwater Basin and a small portion of the Pittsburg Plain Groundwater Basin. However, the small portion of the Pittsburg Plain Groundwater Basin located within the study area is not an important water supply source; therefore, it will not be described further. DWR’s description of the groundwater resources within the Suisun–Fairfield Valley Groundwater Basin is not complete (WRIME 2010). However, a report published by USGS in 1960 describes historical groundwater conditions in the basin (Thomasson et al. 1960).

Hydrogeology The Suisun–Fairfield Valley Groundwater Basin is bounded by the Coast Ranges to the north, the Sacramento Valley Groundwater Basin to the east, the Pittsburg Plain Groundwater Basin to the south, and the Napa-Sonoma Volcanic Highlands to the west. Aquifer units in the Suisun–Fairfield Valley Groundwater Basin consist of alluvial deposits in the west, overlying volcanics with a maximum thickness of 260 feet (Thomasson et al. 1960). The direction of groundwater flow was reported to follow the topography of the land surface (Thomasson et al. 1960).

Groundwater Storage Total groundwater storage capacity of the Suisun–Fairfield Valley Groundwater Basin was estimated to be 226 TAF in 1960 (Thomasson et al. 1960). No recent information has been published to revise this estimate.

Groundwater Production No current information is available on groundwater production for the Suisun–Fairfield Valley Groundwater Basin.

Groundwater Levels Groundwater levels in the Suisun–Fairfield Valley Groundwater Basin were reported to fluctuate seasonally, with declines throughout summer and recovery during the rainy season in fall and winter (Thomasson et al. 1960). Although DWR's description of the groundwater resources within the Suisun–Fairfield Valley Groundwater Basin is incomplete, historical groundwater level information for numerous wells within the groundwater basin is available in DWR's water data library (DWR 2010).

Groundwater Quality Historical information about groundwater quality indicated that boron, TDS, and volatile organic compounds were the primary constituents of concern (Thomasson et al. 1960). Boron concentrations were measured at 62 wells and ranged between nondetect and 28 mg/L in 1960 (Thomasson et al. 1960). Results from the USGS Ground-Water Ambient Monitoring and Assessment (GAMA) Program study also reported elevated boron concentrations of 5.4 mg/L at one well location (Dawson et al. 2008). Although TDS was not directly measured as part of the 1960 study, specific conductance was measured in 70 wells and was found to range between 158 and 3,260 micromhos (Thomasson et al. 1960). The USGS GAMA Program study results reported specific conductance values ranging from 859 to 1,300 microSiemens per centimeter in five wells (Dawson et al. 2008). (Note: 1 micromhos = 1 microSiemens.)

Subsidence Subsidence in the Delta and Suisun Marsh areas is described in Section 3.10, "Geology, Soils, and Seismicity (Including Mineral and Paleontological Resources)," under "Geomorphology."

SoCal/Coastal CVP/SWP Service Areas

The SoCal/coastal CVP/SWP service areas outside of the Extended SPA and the Sacramento and San Joaquin Valley watersheds include portions of the San Francisco Bay, Tulare Lake, Central Coast, South Coast, South Lahontan, and Colorado River hydrologic regions. Groundwater resources in each of these hydrologic regions are described briefly below.

San Francisco Bay Hydrologic Region As noted above, the San Francisco Bay Hydrologic Region contains 28 identified groundwater basins. Of those, 11 are at least partially within the boundary of the SoCal/coastal CVP/SWP service areas. Groundwater accounts for 16 percent of water use in the San Francisco Bay Hydrologic Region. The most heavily used basins within the CVP/SWP service areas are the Santa Clara Valley, Livermore Valley, and Napa-Sonoma Valley groundwater basins (DWR 2009).

Tulare Lake Hydrologic Region The Tulare Lake Hydrologic Region is located south of the San Joaquin River Hydrologic Region, described above. This region contains 12 distinct groundwater basins plus a portion of the San Joaquin Valley Groundwater Basin (the remainder of which is located in the San Joaquin River Hydrologic Region). All of the groundwater basins within the Tulare Lake Hydrologic Region are located within the SoCal/coastal CVP/SWP service areas. The San Joaquin Valley Groundwater Basin is the major contributor to groundwater resources in this hydrologic region. The portion of the San Joaquin Valley Groundwater Basin located in the Tulare Lake Hydrologic Region includes the southern half of the Delta-Mendota Groundwater Subbasin and the Kaweah, Kern County, Kings, Pleasant Valley, Tulare Lake, Tule, and Westside groundwater subbasins. Of those, the Delta-Mendota, Kings, and Westside groundwater subbasins were discussed above because they are located in the Extended SPA.

Groundwater accounts for 49 percent of the average historical water use in the region and 36 percent of all groundwater use in California (DWR 2009). Groundwater supplies in the Tulare Lake Hydrologic Region have been strongly linked historically to surface water deliveries. During times when surface water deliveries were historically uncertain or reduced, users relied on groundwater to make up for the shortfall. This led to overdraft of the groundwater basin and groundwater-related land surface subsidence (DWR 2009).

Historical overdraft has created a need for the conjunctive use of groundwater and surface water. Numerous existing groundwater recharge projects in the area are being used to recharge aquifers by direct methods, such as percolation ponds, and by in-lieu methods. These managed aquifer recharge projects help to improve groundwater storage, improve or maintain water quality, and halt land surface subsidence.

Central Coast Hydrologic Region The Central Coast Hydrologic Region is bounded to the west and south by the California coast; to the north by the San Francisco Bay Hydrologic Region; and to the east by the San Joaquin River, Tulare Lake, and South Coast hydrologic regions. The region contains 50 identified groundwater basins, and 41 of those are within the boundary of the SoCal/coastal CVP/SWP service areas.

Groundwater in the region is used to support both agricultural and urban uses and provides 84 percent of the water for overall water use (DWR 2009). Historical reliance on groundwater in coastal and inland basins has resulted in some occurrences of groundwater overdraft and seawater intrusion. Although several basins have enacted measures to slow or reverse seawater intrusion, it remains a problem for some groundwater basins (DWR 2009).

South Coast Hydrologic Region The South Coast Hydrologic Region is bounded to the west by the California coast and the Central Coast Hydrologic Region, to the north by the Tulare Lake and South Lahontan hydrologic regions, and to the east by the Colorado River Hydrologic Region. This region contains 56 identified groundwater basins, and 47 of those are within the boundary of the SoCal/coastal CVP/SWP service areas.

Groundwater has historically supported agricultural and urban growth in the South Coast Hydrologic Region, and it provides 33 percent of the water for overall water use (DWR 2009). Because many areas in this hydrologic region receive imported water, groundwater resources are vulnerable to overdraft when they are extracted to make up for shortfalls in deliveries. Urbanization in the region, and the associated loss of permeable surfaces, has contributed to a situation in which natural recharge is not sufficient to maintain groundwater levels, at least at current rates of groundwater withdrawal. Several actions, including adjudication of groundwater basins and managed groundwater recharge, are being used in the South Coast Hydrologic Region to maintain groundwater supplies and prevent seawater intrusion and other water quality problems associated with overdraft (DWR 2009).

South Lahontan Hydrologic Region The South Lahontan Hydrologic Region is located in the eastern part of California and is bounded to the west by the San Joaquin River and Tulare Lake hydrologic regions, to the north by the North Lahontan Hydrologic Region, and to the south by the Colorado River and South Coast hydrologic regions. The region contains

76 identified groundwater basins, and 22 of those are within the boundary of the SoCal/coastal CVP/SWP service areas.

Groundwater is used for approximately 70 percent of urban, agricultural, and environmental water demand in the South Lahontan Hydrologic Region (DWR 2009). Overdraft of groundwater basins, particularly the Mojave River Valley groundwater basins, is a concern. SWP water deliveries to the region are being used to recharge groundwater supplies, and those deliveries are important for other planned groundwater banking and storage projects (DWR 2009).

Colorado River Hydrologic Region The Colorado River Hydrologic Region is located in the southeast corner of California and is bounded to the north by the South Lahontan Hydrologic Region and to the west by the South Coast Hydrologic Region. This region contains 59 identified groundwater basins, and 20 of those are within the boundary of the SoCal/coastal CVP/SWP service areas.

In the Colorado River Hydrologic Region, groundwater accounts for 9 percent of the overall water supply. SWP water is used for mitigation of groundwater overdraft conditions in the Coachella Valley (DWR 2009).

3.11.2 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 groundwater resources.

Federal

Clean Water Act The Clean Water Act (CWA) is the major federal legislation governing the water quality aspects of the proposed program, which also affect groundwater resources. Regulations provided in Section 404 of the CWA are described in Subsection 3.5.2, "Regulatory Setting," in Section 3.5, "Biological Resources—Aquatic."

Comprehensive Environmental Response Compensation and Liability Act The Comprehensive Environmental Response Compensation and Liability Act (CERCLA), also known as the Superfund act (42 U.S. Code 9601 et seq.; 27, 40 Code of Federal Regulations), provides for the liability, compensation, cleanup, and emergency response for hazardous substances released into the environment and the cleanup of inactive hazardous-waste disposal sites. The mission of the CERCLA Superfund program is to protect human health and the environment, as implemented by the National Oil and Hazardous Substance Pollution Contingency Plan, in part by restoring contaminated groundwater to beneficial use. See Subsection 3.21.2, "Regulatory Setting," in Section 3.21, "Water Quality."

Safe Drinking Water Act The Safe Drinking Water Act was passed by Congress in 1974, then amended in 1986 and 1996, to protect public health by regulating the nation's public drinking-water supply. See Subsection 3.21.2, "Regulatory Setting," in Section 3.21, "Water Quality."

State

Porter-Cologne Water Quality Control Act Regulations included in the Porter-Cologne Water Quality Control Act (Porter-Cologne Act) (California Water Code, Section 13000 et seq.) are described in Subsection 3.5.2, "Regulatory Setting," in Section 3.5, "Biological Resources—Aquatic." Implementing the proposed program activities would not likely result in discharges of wastewater that could affect waters of the State, including groundwater. However, as a State regulation, the proposed program would comply with the Porter-Cologne Act, and DWR would file a report of discharge, if necessary.

Groundwater Management Act and Senate Bill 1938 Assembly Bill 3030 (1992), known as the Groundwater Management Act (California Water Code, Section 10750 et seq.), provides a systematic procedure for local agencies to develop a groundwater management plan for groundwater basins defined in DWR Bulletin 118. Senate Bill 1938, signed into law in 2002, amended the Water Code and the provisions of Assembly Bill 3030. This law requires any public agency seeking State funds administered through DWR for construction of groundwater or groundwater quality projects to prepare and implement a groundwater management plan with certain specified components. The public agency must establish basin management objectives, prepare a plan to involve other local agencies in a cooperative planning effort, and adopt monitoring protocols that promote efficient and effective groundwater management. These requirements still apply if the agency has already adopted a groundwater management plan or if its service area does not overlie groundwater basins identified in Bulletin 118 and its updates.

A groundwater management plan may provide details about the following components (California Water Code, Section 10753.8 et seq.):

- Controlling intrusion by saline water
- Identifying and managing wellhead protection areas and recharge areas
- Regulating the migration of contaminated groundwater
- Administering a well abandonment and well destruction program
- Mitigating overdraft conditions

- Replenishing groundwater extracted by water producers
- Monitoring groundwater levels and storage
- Facilitating conjunctive-use operations
- Identifying well construction policies
- Cleaning up local groundwater contamination
- Implementing recharge, storage, conservation, water recycling, and extraction projects
- Developing relationships with State and federal regulatory agencies
- Reviewing land use plans and coordinating with land use planning agencies to assess activities that create a reasonable risk of groundwater contamination

Once a groundwater management plan is adopted, rules and regulations must be adopted to implement the program called for in the plan. Groundwater management plans can be found online through DWR's Integrated Water Resources Information System Web site (DWR 2011).

Area-of-Origin Statute Limitations Section 1220 of the California Water Code prohibits pumping groundwater for export from within the combined Sacramento and Delta–Central Sierra basins, as defined in DWR Bulletin 160-74, unless the pumping complies with a groundwater management plan that is adopted by the ordinance.

Water Rights 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. 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.

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.

Other Existing Management Policies Existing law regarding groundwater is controlled by jurisdictional decisions. The California Water Code provides limited authority over groundwater use by allowing the formation of special districts (or water agencies) through general or special legislation. DWR identifies nine groundwater management agencies formed by special legislation (DWR 1994), none of which are located in the Central Valley.

Local Identification of Potential Groundwater Recharge Areas The 2007 flood legislation, in Government Code Section 65302 as amended by AB 162, directs cities and counties to identify in the conservation elements of their general plans those rivers, creeks, streams, flood corridors, riparian habitats and land that may accommodate floodwater for purposes of groundwater recharge and stormwater management, upon the next revision of their general plan housing element.

Regional and Local

Section 65302(d)(3) of the California Government Code requires that county general plans include a conservation element that identifies rivers, creeks, streams, flood corridors, riparian habitats, and land that may accommodate floodwater for purposes of groundwater recharge and stormwater management.

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.

3.11.3 Analysis Methodology and Thresholds of Significance

This section provides a program-level evaluation of the direct and indirect effects on groundwater resources of implementing management actions included in the proposed program. These proposed management actions are expressed as NTMAs and LTMAs. The mechanisms by which different categories of NTMAs and LTMAs could affect groundwater resources 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 3.11.4, “Environmental Impacts and Mitigation Measures for NTMAs,” and Section 3.11.5, “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 groundwater resources. 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 operations 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 the LTMAs, with modifications or expansions as needed.

Implementation of the proposed program would result in construction-related, operational, and maintenance-related impacts on groundwater resources in the study area. Impacts on groundwater could also result from altered hydrology or land use and induced growth caused by proposed management actions.

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 CEQA Guidelines, as amended, with slight modifications. An impact on groundwater quality, groundwater flow, or groundwater recharge and discharge (e.g., pumping) is considered significant if implementation of the proposed program would do any of the following when compared against existing conditions:

- Substantially degrade groundwater quality such that its use would be impaired
- Substantially deplete groundwater supplies or interfere substantially with groundwater recharge such that there would be a net deficit in aquifer volume or lowering of the local groundwater table level (e.g., the production rate of preexisting nearby wells would drop to a level which would not support existing land uses or planned uses for which permits have been granted)
- Substantially increase groundwater elevations such that overlying land use is impaired (e.g., groundwater levels would rise into the root zone of a crop and reduce yield substantially)

3.11.4 Environmental Impacts and Mitigation Measures for NTMAs

This section describes the physical effects of NTMAs on groundwater 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 GRW-1 (NTMA): ***Potential Localized Degradation of Groundwater Quality Related to Construction, Operation, and Maintenance Activities***

NTMAs could involve modifying, constructing, or removing facilities, which could result in temporary and short-term construction-related disturbance of hydrology and soil and associated human-caused effects on the quality of the water encountered during construction activities. These types of disturbances could potentially degrade the quality of waters recharging the groundwater aquifer of affected and adjacent areas. These effects would occur at facility sites and could include both infrequent events and activities that would be repeated at regular intervals, resulting in short- and long-term effects on the quality of the surface water recharging the underlying aquifer. Localized degradation of groundwater quality could result from NTMAs related to temporary and short-term construction activities, such as construction of access roads and temporary construction-related facilities, or related to operations and maintenance activities, such as vegetation control. If hazardous materials were to be discharged to the land surface or surface waters during these activities, they could travel to underlying aquifers; if the volume of discharge were sufficient, such hazardous materials could degrade local groundwater quality sufficiently to impair its continued use.

In compliance with existing regulations, storm water pollution prevention plans (SWPPPs) would be prepared for NTMAs, identifying best management practices (BMPs) to prevent or minimize the introduction of contaminants into surface and groundwater. BMPs for the project could include but would not be limited to silt fencing, straw bale barriers, fiber rolls, storm drain inlet protection, hydraulic mulch, and a stabilized construction entrance. Each SWPPP would include site-specific structural and operational BMPs to prevent and control effects on runoff quality, along with measures to be implemented before each storm event. The SWPPPs would require that BMPs be inspected and maintained, and that the quality of runoff be monitored by visual and/or analytical means. Among the BMPs that could be applied are appropriate spill prevention measures to minimize the risk of groundwater quality degradation. Because the activities would comply with existing regulations, including the requirement to prepare and implement a SWPPP, this impact would be **less than significant**. No mitigation is required.

Impact GRW-2 (NTMA): ***Degradation of Groundwater Quality Resulting from Decreased Natural Recharge or Increased Pumping due to Reduced Water Supplies from Changes to Reservoir Operational Criteria***

Changing the operation of the water supply system, including the magnitude and timing of flood releases and reservoir allocations, might result in changes in the timing, duration, and magnitude of river flows. Sufficient changes in river flow and subsequent alterations in surface water deliveries could require that groundwater pumping be increased to meet water supply needs. Groundwater quality could be affected by increased pumping if it were of sufficient volume to induce intrusion of saline water or upwelling of poor-quality water into aquifers used for water supply. Changes in downstream flow could also reduce natural groundwater recharge.

However, as described in Impact HYD-6 (NTMA), "Reduced Water Supplies from Reservoir Operational Criteria Changes," in Section 3.13, "Hydrology," changes to the operational criteria for reservoirs under NTMAs would include the use of coordinated operations and weather forecasting. Specifically, operational criteria would be changed to combine improved weather forecasts with real-time coordination of reservoir operations. When a reservoir operator consults weather forecasts, water can be stored in the reservoir until a large storm is predicted. If a large storm is predicted, forecast-based operations prompt increases in water releases, which increases available reservoir storage space that can be used to contain a larger volume of inflow, thus improving flood protection. If a small storm is predicted, reservoir releases are minimized, thus preventing unnecessary drawdown in the reservoir and allowing storage of water for other uses, such as water supply. This is in contrast to existing operations, in which reservoirs must set aside a certain storage volume for flood management at specific times of the year, regardless of actual weather patterns.

With the use of weather forecasting in conjunction with NTMAs, reservoirs may not need to set aside as much storage for flood management until large inflows are forecasted. In years where only smaller storms are forecasted, reservoirs would retain more water, thus increasing the availability of needed water supply.

Similarly, coordinated operations would improve the reliability and efficiency of reservoir operations. It would enable reservoir operators to increase or decrease releases to maximize the availability of water supply while still improving management of flood risks. Implementing these NTMAs would not affect the capacity of reservoirs, the volume of water in the reservoirs, or carryover storage in a way that would increase the demand on groundwater supplies such that groundwater quality would be degraded. Even if water deliveries are reduced in certain critically dry years, there are several mechanisms in the water supply system to alleviate the shortfalls. Among those mechanisms is the use of groundwater from water banks that would prevent excess pumpage from overdrafted aquifers that could substantially degrade groundwater quality. Therefore, this impact would be **less than significant**. No mitigation is required.

Impact GRW-3 (NTMA): ***Depletion of Groundwater Levels Resulting from Decreased Natural Recharge or Increased Pumping due to Reduced Water Supplies from Changes to Reservoir Operational Criteria***

Changing the operation of the water supply system, including the magnitude and timing of flood releases and reservoir allocations, may result in changes in the timing, duration, and magnitude of river flows. As described above, changing water supply operations to a sufficient degree could result in decreased natural recharge and increased groundwater pumping. If recharge were to decrease or if pumping were to increase to supplement changes in surface water flows, groundwater elevation could decline. A decline in groundwater storage or elevation could decrease the reliability of the water supply, increase pumping costs, and trigger subsidence of the land surface. However, as described for Impact GRW-2 (NTMA), implementing the NTMAs would not affect the capacity of the reservoirs, the volume of water in the reservoirs, or carryover storage in a way that would reduce natural groundwater recharge or require additional groundwater pumping. In addition, there are mechanisms to deal with reduced deliveries, including use of groundwater from water banks that can be used to prevent depletion of groundwater resources in sensitive areas. Therefore, this impact would be **less than significant**. No mitigation is required.

Impact GRW-4 (NTMA): ***Modification of Groundwater Flows Resulting in Decreased Natural Recharge to Regional or Local Groundwater Supplies or Reduced or Delayed Local Drainage***

Activities that could be implemented under the proposed program include improvement, remediation, repair, and reconstruction of existing levees. Depending on site conditions, slurry walls may be included in the improvement, remediation, repair, or reconstruction. Under certain conditions, installing slurry cutoff walls could potentially modify groundwater flow patterns and affect connectivity between streams and groundwater on a regional or localized basis. In cases when water flows out of the river and into groundwater aquifers, a slurry wall could reduce natural recharge into the groundwater on the landside of the levee. In the opposite scenario, when the aquifer discharges to the river, groundwater levels on the landside of slurry cutoff walls could increase and potentially remain elevated for an extended time period. The degree to which these impacts could be realized depends on many factors: the local geology and depth of the slurry wall in relation to saturated aquifer units, the length of the slurry wall, the interconnectedness of aquifer units, the local interactions between surface and groundwater flows, soil types, and surface water conditions.

In the case where a slurry wall could reduce recharge to nearby shallow aquifers, any impact in the form of decreased water-table elevation would likely only affect the shallow aquifer as deep as the bottom of the wall. Furthermore, it is not anticipated that these potential effects would propagate beyond the vicinity of the slurry wall; rather, they would be localized. Thus, the proposed program would not substantially deplete groundwater supplies, nor would it interfere substantially with groundwater recharge such that there would be a net deficit in aquifer volume or lowering of the local groundwater table level (e.g., drop in the production rate of preexisting nearby wells to a level that would not support existing land uses or planned uses for which permits have been granted). This impact would be **less than significant**. No mitigation is required.

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

This section describes the physical effects of LTMAs on groundwater 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 the 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.

LTMA Impacts and Mitigation Measures

Impact GRW-1 (LTMA): ***Potential Localized Degradation of Groundwater Quality Related to Construction, Operation, and Maintenance Activities***

This impact would be similar to Impact GRW-1 (NTMA) because the same impact mechanisms would occur; in particular, construction-related LTMAs would be similar to construction-related NTMAs. Because LTMAs have a greater potential extent than NTMAs, including the potential to occur throughout the study area and to be larger in scale than NTMAs, this impact has a greater potential to occur than Impact GRW-1 (NTMA). Impacts could include disturbance of hydrology and soil as a result of LTMAs related to temporary and short-term construction activities and long-term operation and maintenance activities. As described above, the activities would comply with existing regulations, including the requirement to prepare and implement a SWPPP for construction, operation, and maintenance activities. Thus, this impact would be **less than significant**. No mitigation is required.

Impact GRW-2 (LTMA): ***Degradation of Groundwater Quality Resulting from Decreased Natural Recharge or Increased Pumping due to Reduced Water Supplies from Changes to Reservoir Operational Criteria***

The LTMAs would continue the same reservoir operation changes included in the NTMAs. However, the full extent of potential, future operational changes, locations, extent, and the possible interactions of those changes in multiple reservoirs are unknown. In addition, construction and use of new bypasses and floodways may provide an opportunity for increased groundwater recharge and enhanced quality.

Although the extent of future reservoir operation changes is unknown, this impact would be the same as Impact GRW-2 (NTMA). This impact would be **less than significant**. No mitigation is required.

Impact GRW-3 (LTMA): ***Depletion of Groundwater Levels Resulting from Decreased Natural Recharge or Increased Pumping due to Reduced Water Supplies from Changes to Reservoir Operational Criteria***

Where the LTMAs would continue activities included in the NTMAs, this impact would be the same as Impact GRW-3 (NTMA). However, the full extent of potential, future operational changes, locations, extent, and the possible interactions of those changes in multiple reservoirs are unknown. In addition, construction and use of new bypasses and floodways may provide an opportunity for increased groundwater recharge and enhanced quality. Although the extent of future reservoir operation changes is unknown, this impact would be **less than significant**. No mitigation is required.

Impact GRW-4 (LTMA): ***Modification of Groundwater Flows Resulting in Decreased Natural Recharge to Regional or Local Groundwater Supplies or Reduced or Delayed Local Drainage***

The LTMAs would continue the same types of construction activities included in the NTMAs, although LTMAs may include additional new levees. Where the LTMAs would continue the same types of activities included in the NTMAs, this impact would be the same as Impact GRW-4 (NTMA). This impact would be **less than significant**. No mitigation is required.

Impact GRW-5 (LTMA): ***Degradation of Water Quality or Adverse Rise in Groundwater Elevation as a Result of Groundwater Banking***

LTMAs could include enhancing groundwater recharge and banking to supplement surface water supplies in conjunction with reservoir operations. Benefits of groundwater recharge include improved water quality (e.g., because saline intrusion would stop or slow down), reduced potential for land-surface subsidence, and reduced pumping costs. Although groundwater banking is generally beneficial, potentially significant adverse effects could occur if groundwater banking were not properly planned before implementation or if banking operations were not sufficiently monitored. Specific effects include degradation of water quality caused by entrainment of chemicals currently in the unsaturated zone and encroachment of groundwater levels on the land surface. This impact would be **potentially significant**.

Mitigation Measure GRW-5a (LTMA): ***Develop and Implement Groundwater Management Plans or Expand Existing Groundwater Management Plans, Including Defining Basin Management Objectives, Groundwater Monitoring Plans, and Conditions under Which Corrective Actions Are Taken***

Formalized groundwater management plans will be developed or expanded by the project proponent to guide management of groundwater basins where managed groundwater recharge and/or groundwater banking projects are to occur. These plans will include quantifiable basin-management objectives and groundwater monitoring plans to allow for management of the basin in a manner that minimizes adverse effects on groundwater. The plans will identify conditions to be evaluated using groundwater monitoring data and will describe corrective actions that may be taken, such as modifications to groundwater banking operations.

Mitigation Measure GRW-5b (LTMA): ***Conduct Phase I Environmental Site Assessments***

Phase I Environmental Site Assessments will be conducted by the project proponent at all sites before groundwater banking activities begin to prevent the degradation of water quality associated with recharging water in a potentially contaminated aquifer or exposing rising groundwater to contaminated soils.

Implementing these mitigation measures would reduce Impact GRW-4 (LTMA) to a **less-than-significant** level. No mitigation is required.

LTMA Impact Discussions and Mitigation Strategies

Impacts of the proposed program's NTMAs and LTMAs related to groundwater 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 groundwater resources.

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