Chapter 7

Groundwater Resources and Groundwater Quality

7.1 Introduction

This chapter describes groundwater resources and groundwater quality in the Study Area, and potential changes that could occur as a result of implementing the alternatives evaluated in this Environmental Impact Statement (EIS). Implementation of the alternatives could affect groundwater resources through potential changes in operation of the Central Valley Project (CVP) and State Water Project (SWP) and ecosystem restoration.

7.2 Regulatory Environment and Compliance Requirements

Potential actions that could be implemented under the alternatives evaluated in this EIS could affect groundwater resources in the areas along the rivers impacted by changes in the operations of CVP or SWP reservoirs and in the vicinity of and lands served by CVP and SWP water supplies. Groundwater basins that may be affected by implementation of the alternatives are in the Trinity River Region, Central Valley Region, San Francisco Bay Area Region, Central Coast Region, and Southern California Region.

Actions located on public agency lands or implemented, funded, or approved by Federal and state agencies would need to be compliant with appropriate Federal and state agency policies and regulations, as summarized in Chapter 4, Approach to Environmental Analyses.

Several of the state policies and regulations described in Chapter 4 have resulted in specific institutional and operational conditions in California groundwater basins, including the basin adjudication process, California Statewide Groundwater Elevation Monitoring Program (CASGEM), California Sustainable Groundwater Management Act (SGMA), and local groundwater management ordinances, as summarized below.

7.2.1 Groundwater Basin Adjudication

Basin adjudications are determined through court decisions or pre-court mediation on litigation that determine the groundwater rights of all the groundwater users overlying the basins. The court identifies the extractors or well owners and the amount of groundwater those well owners are allowed to extract, and appoints a Watermaster whose role is to ensure that the basin is managed in accordance with the court's decree. The Watermaster must report periodically to the court. There are currently 23 adjudicated groundwater basins in California, most of which are located in Southern California. Table 7.1 lists the adjudicated groundwater basins located in the Study Area.

Table 7.1 Adjudicated Groundwater Basins in the Study Area

Basin Name	Date of Final Court Decision	County
Antelope Valley Groundwater Basin	Under way	Kern and Los Angeles
Beaumont – Upper Santa Ana Groundwater Basin	2004	Riverside
Brite Groundwater Basin	1970	Kern
Central Subbasin of the Coastal Plain of Los Angeles Basin	1965	Los Angeles
Chino Subbasin of the Upper Santa Ana Valley Basin	1978	Riverside and San Bernardino
Cucamonga Subbasin of the Upper Santa Ana Valley Basin	1978	San Bernardino
Cummings Valley Groundwater Basin	1972	Kern
Goleta Groundwater Basin	1989	Santa Barbara
San Jacinto Groundwater Basin	2013	Riverside
Los Osos Valley Groundwater Basin	Under way	San Luis Obispo
Mojave Basin Area (Lower Mojave River Valley, Middle Mojave River Valley, Upper Mojave River Valley, El Mirage Valley, and Lucerne Valley groundwater basins)	1996	San Bernardino
San Gabriel Valley Groundwater Basin – excluding Raymond Groundwater Basin	1973	Los Angeles
San Gabriel Valley Groundwater Basin – Puente Narrows	1985	Los Angeles
Raymond Groundwater Basin	1944	Los Angeles
Rialto-Colton Subbasin of the Upper Santa Ana Valley Basin	1961	San Bernardino
Santa Margarita River Watershed – Santa Margarita Valley, Temecula Valley, and Cahuilla Valley groundwater basins	1966[*]	Riverside and San Diego
Santa Maria Valley Groundwater Basin	2008	San Luis Obispo and Santa Barbara
Santa Paula Subbasin of the Santa Clara River Valley Groundwater Basin	1996	Ventura
Six Basins Area in upper Santa Ana Valley	1998	Los Angeles and San Bernardino
Tehachapi Valley West Basin and Tehachapi Valley East Basin	1973	Kern

Basin Name	Date of Final Court Decision	County
Upper Los Angeles River Area– San Fernando Valley Groundwater Basin	1979	Los Angeles
Warren Valley Groundwater Basin	1977	San Bernardino
West Coast Subbasin of the Coastal Plain of Los Angeles Basin	1961	Los Angeles
Western San Bernardino – Upper Santa Ana Groundwater Basin	1969	San Bernardino

Sources: DWR 2003a, 2014a; LOCSD 2013

Note:

* Santa Margarita Watershed Adjudication addresses both groundwater and surface water if water contributes to Santa Margarita River and its tributaries flows (SMRW 2014). The agreements include interlocutory judgements for Murrieta-Temecula Groundwater Basin that describes non-Indian water rights subject to court jurisdiction, land and water rights not subject to court jurisdiction, reserved water rights for the Pechanga Reservation, appropriative storage and diversion rights in conjunction with use of groundwater by the Vail Company.

7.2.2 California Statewide Groundwater Elevation Monitoring Program

Senate Bill X7-6, enacted in November 2009, mandates a statewide groundwater elevation monitoring program to track seasonal and long-term trends in groundwater elevations in California's groundwater basins defined in Bulletin 118. This amendment to Division 6 of the Water Code, specifically Part 2.11 Groundwater Monitoring, requires the collaboration between local monitoring entities and California Department of Water Resources (DWR) to collect groundwater elevation data. The law requires local agencies to monitor and report the groundwater elevation in the basins. To achieve this goal, DWR developed the CASGEM Program to establish a permanent, locally-managed program of regular and systematic monitoring in all of the state's alluvial groundwater basins.

DWR is required to establish a priority schedule for monitoring groundwater basins, and to report to the Legislature on the findings from these investigations (Water Code section 10920 et. seq). The 2012 CASGEM Status Report to the Legislature describes that more than 400 monitoring entities have been identified and water level data are being submitted to DWR (DWR 2012). The prioritization of basins is to identify, evaluate, and determine the need for additional groundwater level monitoring. The prioritization approach includes the following eight criteria.

- Overlying population in the groundwater basin
- Projected growth of the overlying population
- Number of public water supply wells

- Total number of water supply wells
- Irrigated acreage overlying the groundwater basin
- Reliance on groundwater as the primary source of water by the overlying land uses
- Impacts on groundwater, including overdraft, subsidence, saline intrusion, and other water quality degradation
- Any other information relevant to the groundwater conditions

Groundwater basins designations in the study area are described for each basin in the following subsection of this chapter (DWR 2014e).

7.2.3 Sustainable Groundwater Management Act

In September 2014, the SGMA was enacted. The SGMA establishes a new structure for locally managing California's groundwater in addition to existing groundwater management provisions established by Assembly Bill (AB) 3030 (1992), Senate Bill (SB) 1938 (2002), and AB 359 (2011), as well as SBX7-6 (2009).

The SGMA includes the following key elements:

- Provides for the establishment of a Groundwater Sustainability Agency (GSA) by one or more local agencies overlying a designated groundwater basin or subbasin identified in DWR Bulletin 118-03
- Requires all DWR Bulletin 118 groundwater basins found to be of "high" or "medium" priorities to prepare Groundwater Sustainability Plans (GSPs)
- Provides for the proposed revisions, by local agencies, to the boundaries of a DWR Bulletin 118 basin, including the establishment of new subbasins
- Provides authority for DWR to adopt regulations to evaluate GSPs, and review the GSPs for compliance every 5 years
- Requires DWR to establish best management practices and technical measures for GSAs to develop and implement GSPs
- Provides regulatory authority to the State Water Resources Control Board (SWRCB) for developing and implementing interim groundwater management plans under certain circumstances (such as lack of compliance with development of GSPs by GSAs)

The SGMA defines sustainable groundwater management as "the management and use of groundwater in a manner that can be maintained during the planning and implementation horizon without causing undesirable results." Undesirable results are defined as any of the following effects.

- Chronic lowering of groundwater levels (not including overdraft during a drought if a basin is otherwise managed)
- Significant and unreasonable reduction of groundwater storage

- Significant and unreasonable seawater intrusion
- Significant and unreasonable degraded water quality, including the migration of contaminant plumes that impair water supplies
- Significant and unreasonable land subsidence that substantially interferes with surface land uses
- Depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water

Based on basin priority definitions defined by DWR's CASGEM program in June 2014 and confirmed in January 2015, the SGMA requires the formation of GSPs by 2020 or 2022. GSPs for medium and high priority basins identified subject to critical conditions of overdraft are required by 2022. All other high and medium priority basins must complete a GSP by 2020. Updates to CASGEM-defined June 2014 designated priorities are possible and can affect GSP deadline requirements. Sustainable groundwater operations must be achieved within 20 years following completion of the GSPs.

7.2.4 Regional and Local Groundwater Ordinances

Many counties within the Study Area considered in this EIS have adopted or are considering groundwater ordinances. The ordinances primarily address well installation, groundwater extraction, and export of the groundwater to areas outside the basin of origin. Local county groundwater ordinances vary by authority, agency, or region but typically involve permitting for well installation, and provisions to limit or prevent groundwater overdraft, to regulate transfers, and to protect groundwater quality.

Table 7.2 provides a list of substantial county groundwater ordinances within the Study Area that could affect groundwater supply availability.

Table 7.2 County Groundwater Ordinances in the Study Area with a Summary of Regulations

County	Ordinance Number and Title	Description
Trinity	County Code Title 15: Buildings and Construction, Chapter 15.20: Water wells.	Well standards.
Trinity and Humboldt	Hoopa Valley Tribal Council Title 37: Pollution Discharge Prohibition Ordinance	Regulates surface water and groundwater operations.
Humboldt	County Code Title VI: Water and Sewage, Division 3: Wells.	Well standards.
	Hoopa Valley Tribe: Not identified at this time.	Not applicable.
Del Norte	County Code Title 7: Health and Welfare Chapter 32: Regulations of Wells and Preservation of Groundwater.	Well standards.

County	Ordinance Number and Title	Description
Shasta	County Code Title 18: Environment 18.08: Groundwater Management.	Requires permit for groundwater extraction for use outside county.
Shasta	County Code Title 8: Health and Safety, 8.56: Water Wells.	Well standards.
Plumas	County Code Title 6: Sanitation and Health, Chapter 8: Water Wells.	Well standards. Groundwater management plans have been adopted in Plumas County, but not in the vicinity of the Study Area.
Tehama	County Code Title 9: Health and Safety, Chapter 9.40: Aquifer Protection.	Prohibits groundwater from being exported out of county. Requires permit to use groundwater from wells on a parcel on other parcels of land.
Tehama	County Code Title 9: Health and Safety, Chapter 9.42: Well Construction, Rehabilitation, Repair and Destruction.	Well standards.
Glenn	County Code Title 20: Water 20.030: Groundwater Coordinated Resource Management Plan.	Basin Management Objectives and monitoring network to detect changes in groundwater level, quality, land subsidence; and defines acceptable ranges of groundwater levels.
	County Code Title 20: Water, 20.080: Water Well Drilling Permits and Standards.	Well standards.
Colusa	County Code Chapter 43: Groundwater Management.	Requires permit for groundwater extraction for use outside county.
	County Code Chapter 35: Well Standards.	Well standards.
Butte	County Code Chapter 33A: Basin Management.	Basin Management Objectives for: groundwater quality and groundwater levels, and other protections to reduce land subsidence.
	County Code Chapter 23B: Water Wells.	Well standards.
Yuba	County Code Title VII: Health and Sanitation, Chapter 7.03: Water wells.	Well standards.

County	Ordinance Number and Title	Description
Sutter	County Code Section 700: Health and Sanitation, Chapter 765: Water Wells.	Well standards.
Placer	County Code Chapter 13: Public Services, Article 13.08: Water Wells.	Well standards.
El Dorado	County Code Title 8: Health and Safety, Chapter 8.39: Well Standards.	Well standards. Groundwater management plans have been adopted in El Dorado County, but not in the vicinity of the Study Area.
Sacramento	County Code Title 6: Health and Sanitation, Chapter 6.28: Wells and Pumps.	Well standards.
Yolo	County Code Title 10: Environment Chapter 7: Groundwater.	Requires permit for groundwater extraction for use outside of the county.
	County Code Title 6: Sanitation and Health, Chapter 8: Water Quality, Article 10: Standards, Criteria, and Regulations of Wells.	Well standards.
Solano	County Code Chapter 13.6: Injection Wells.	Restricts operation of injection wells.
	County Code Chapter 13.10: Well Standards.	Well standards.
Napa	County Code Title 13: Waters, Sewers, and Public Services Chapter 13.15: Groundwater Conservation.	Regulates the use of groundwater.
	County Code Title 13: Waters, Sewers, and Public Services Chapter 13.12: Wells.	Well standards.
San Joaquin	County Code Title 5: Health and Sanitation, Division 4: Wells and Well Drilling.	Well standards.
	County Code Title 5: Health and Sanitation, Division 8: Groundwater.	Requires permit for groundwater use outside of the county.
Stanislaus	County Code Title 9: Health and Safety, Chapter 9.37: Groundwater Mining and Export Prevention.	Regulates groundwater use and prohibits export of water outside of the county (except as noted in the requirements).
	County Code Title 9: Health and Safety, Chapter 9.36: Water Wells.	Well standards.

County	Ordinance Number and Title	Description
Madera	County Code Title 13: Waters and Sewers, V Groundwater Exportation, Groundwater Banking, and Importation of Foreign Water, for Purposes of Groundwater Banking, to Areas of Madera County which are Outside of Local Water Agencies that Deliver Water to Lands Within their Boundaries. Chapter 13.1: Rules and Regulations Pertaining to Groundwater Banking—Importation of Foreign Water, for the Purpose of Groundwater Banking, to Areas of Madera County which are Outside of Local Water Agencies that Deliver Water to Lands within their Boundaries—Exportation of Groundwater Outside the County.	Regulates development of groundwater banking, including importation of groundwater to be stored in the groundwater bank, and exportation of groundwater for use outside of the county; and prohibits groundwater injection.
	County Code Title 13: Waters and Sewers, I: Water, Chapter 13.52: Well Standards.	Well standards.
Merced	County Code Title 9: General Health and Safety, Chapter 9.28: Wells.	Well standards.
Fresno	County Code Title 14: Waters and Sewers, Chapter 14.03: Groundwater Management.	Regulates groundwater use outside of the county.
	County Code Title 14: Waters and Sewers, Chapter 14.04: Well Regulations – General Provisions.	Well standards.
	County Code Title 14: Waters and Sewers Chapter 14.08: Well Construction, Pump Installation and Well Destruction Standards.	Well standards.
Tulare	County Code Part IV: Health, Safety, and Sanitation, Chapter 13: Well.	Well standards.
Kings	County Code Chapter 14A: Water Wells.	Well standards.
Kern	County Code Title 14: Utilities Chapter 14.08: Water Supply Systems, Article III: Well Standards.	Well standards.
Contra Costa	County Code Title 4: Health and Safety, Chapter 414: Waterways and Water Supply, Chapter 414-4: Water supply.	Well standards.
Alameda	County Code Title 6: Health and Safety, Chapter 6.88: Water Wells.	Well standards.

County	Ordinance Number and Title	Description
Santa Clara	Santa Clara Valley Water District Act (California Water Code Appendix, Chapter 60).	Santa Clara Valley Water District is the designated agency to manage water within Santa Clara County, including groundwater management to recharge the basin, conserve water, increase water supply, and prevent waste or diminution of the water supply.
	Santa Clara Valley Water District Well Ordinance 90-1.	Well standards.
San Benito	County Code Title 15: Public Works, Chapter 5.05: Water, Article I: Groundwater Aquifer Protections.	Regulates use of groundwater on non-contiguous parcels with separate owners than parcel with well, injection of groundwater, and operations that could adversely affect other groundwater users or the groundwater aquifer.
	County Code Title 15: Public Works, Chapter 5.05: Water, Article III: Well Standards.	Well standards.
San Luis Obispo	County Code Title 8: Health and Sanitation, Chapter 8.40: Construction, Repair, Modification and Destruction of Wells.	Well standards.
Santa Barbara	County Code Chapter 34A: Wells.	Well standards.
Ventura	County Code Division 4: Public Health, Chapter 8: Water, Article 1: Groundwater Conservation.	Well standards.
Los Angeles	County Code Title 11: Health and Safety, Chapter: 11.38 Water and Sewers, Part 2: Water and Water Wells.	Well standards.
Orange	County Code Title 4: Health and Sanitation and Animal Regulations, Division 5: Water Conservation, Article 3 Construction and Abandonment of Water Wells.	Well standards.

County	Ordinance Number and Title	Description
San Diego	County Code Title 6: Health and Sanitation, Division 7: Water and Water Supplies, Chapter 4: Wells.	Well standards.
	County Code Title 6: Health and Sanitation, Division 7: Water and Water Supplies, Chapter 7: Groundwater.	Regulates actions for the protection, preservation, and maintenance of groundwater resources.
Riverside	County Code Title 13: Public Services, Chapter 13.20: Water Wells.	Well standards.
San Bernardino	County Code Title 3: Health and Sanitation, Division 3: Environmental Health, Chapter 6: Domestic Water Sources and Systems, Article 3: Water Wells.	Well standards.
	County Code Title 3: Health and Sanitation, Division 3: Environmental Health, Chapter 6: Domestic Water Sources and Systems, Article 5: Desert Groundwater Management.	Regulates groundwater basins not adjudicated by judicial decree; and wells not within the boundaries of the Mojave Water Agency and public water agencies within the Morongo Basin, incorporated areas, or Federal lands. This section does not apply to wells used for existing mining operations, small agricultural operations, small wells, or replacement wells of similar size to abandoned wells. This section does not apply to areas with a groundwater management plan and a memorandum of understanding with the county.

Sources: Trinity County 2014; Hoopa Valley Tribe 2008; Humboldt County 2014; Del Norte County 2014; Shasta County 2014 a, b; Plumas County 2014; Tehama County 2014; Glenn County 2014; Colusa County 2014 a, b; Butte County 2014 a, b; Yuba County 2014; Sutter County 2014; Placer County 2014; El Dorado County 2014; Sacramento County 2014; Yolo County 2014; Solano County 2014; Napa County 2014; San Joaquin County 2014; Stanislaus County 2014; Madera County 2014; Merced County 2014; Fresno County 2014; Tulare County 2014; Kings County 2014; Kern County 2014; Contra Costa County 2014; Alameda County 2014; SCVWD 2014 a, b; San Benito County 2014; San Luis Obispo County 2014a; Santa Barbara County 2014; Ventura County 2014; Los Angeles County 2014a; Orange County 2014; San Diego County 2014; Riverside County 2014; San Bernardino County 2014

7.3 Affected Environment

This section describes groundwater resources that could be potentially affected by the implementation of the alternatives considered in this EIS. Changes in groundwater resources due to changes in CVP and SWP operations may occur in the Trinity River, Central Valley, San Francisco Bay Area, Central Coast, and Southern California regions.

Groundwater occurs throughout the Study Area. However, the groundwater resources that could be directly or indirectly affected through implementation of the alternatives analyzed in this EIS are related to groundwater basins which include users of CVP and SWP water supplies that also use groundwater, and areas along the rivers downstream of CVP or SWP reservoirs that use groundwater supplies. Therefore, the following description of the affected environment is limited to these areas and does not include groundwater basins or subbasins that area not directly or indirectly affected by changes in CVP and SWP operations.

7.3.1 Overview of California Groundwater Resources

As described in Chapter 5, Surface Water Resources and Water Supplies, groundwater is a vital resource in California. Groundwater supplied about 37 percent of the state's average agricultural, municipal, and industrial water needs between 1998 and 2010, and 40 percent or more during dry and critical water years in that period (DWR 2013i). About 20 percent of the nation's groundwater demand is supplied from the Central Valley aquifers, making it the second-most-pumped aquifer system in the United States (USGS 2009). The three Central Valley hydrologic regions (Tulare Lake, San Joaquin River, and Sacramento River) account for about 75 percent of the state's average annual groundwater use (DWR 2013i).

The DWR has delineated 515 distinct groundwater systems throughout the state, as described in Bulletin 118-03 (DWR 2003a), that are considered to be the most important groundwater basins. These basins and subbasins have various degrees of supply reliability considering yield, storage capacity, and water quality, and are typically alluvial, or non-consolidated (non-fractured rock) aquifers. Figure 7.1 shows the statewide occurrence of groundwater in the groundwater basins and subbasins identified by DWR as Bulletin 118 basins. A majority of the descriptions provided herein are summarized form DWR Bulletin 118 reports.

The importance of groundwater as a resource varies regionally. The Central Coast has the most reliance on groundwater to meet its local uses, with more than 80 percent of the agricultural, municipal, and industrial water supplies by groundwater in an average year. The central and southern San Joaquin Valley (described as the Tulare Lake Area of the San Joaquin Valley Groundwater Basin in this chapter) groundwater use, on average, meets about 50 percent of the total water supplies. The Sacramento Valley and northern portion of the San Joaquin Valley Groundwater Basin use groundwater to meet approximately 30 and 40 percent of the agricultural, municipal, and industrial water demand, respectively. In the coastal areas of Southern California, groundwater use varies from less than 10 percent in western San Diego County to between 35 and 50 percent of the agricultural, municipal, and industrial water supplies in counties along the coast western Ventura, Los Angeles, and Riverside counties and Orange County, on an annual average basis. In the inland areas of Southern California, groundwater use varies from approximately 45 to over 90 percent of the agricultural, municipal, and industrial water supplies (DWR 2013).

A comprehensive assessment of overdraft in all of the state's groundwater basins has not been conducted since Bulletin 118-80 was published in 1980, but overdraft is estimated at between 1 to 2 million acre-feet annually (DWR 2003a). In DWR's Bulletin 118-80 (DWR 1980), an assessment of critically overdrafted basins was conducted, as shown in Figure 7.2. In the past 20 years, specific groundwater studies have been conducted by regional water agencies or the U.S. Geological Survey (USGS) to update the statewide survey conducted by DWR in 1980 (USGS 2000a, 2006, 2008, 2009, 2012, 2014). The results of many of those studies are discussed in the following subsections of this chapter.

7.3.2 Trinity River Region

The Trinity River Region includes the area along the Trinity River from Trinity Lake to the confluence with the Klamath River; and along the Klamath River from the confluence with the Trinity River to the Pacific Ocean.

Most usable groundwater in the Trinity River Region occurs in widely scattered alluvium filled valleys, such as those immediately adjacent to the Trinity River. These valleys contain only small quantities of recoverable groundwater, and, therefore, are not considered a major source. A number of shallow wells adjacent to the river provide water for domestic purposes (Reclamation et al. 2006a; NCRWQCB et al. 2009). Groundwater present in these alluvial valleys is in close hydraulic connection with the Trinity River and its tributaries. Both groundwater discharge to surface streams as well as leakage of steam flow to underlying aquifers are expected to occur at various locations.

The Bulletin 118-03 (DWR 2003a, 2004do, 2004dp) identified only two groundwater basins underlying the Trinity River Region in the Study Area, Hoopa Valley and Lower Klamath River Valley groundwater basins, as shown in Figure 7.3. These groundwater basins are small, isolated, valley-fill aquifers that provide a very limited quantity of groundwater to satisfy local domestic, municipal, and agricultural needs. Groundwater pumped from these aquifer systems is used strictly for local supply.

As described in Chapter 5, Surface Water Resources and Water Supplies, several communities use infiltration galleries along the Trinity River and the tributaries to convey surface water to groundwater wells, including the Lewiston Community Services District, Lewiston Valley Water Company, and Lewiston Park Mutual Water Company (NCRWQCB et al. 2009).

Groundwater within the Hoopa Valley Indian Reservation occurs along alluvial terraces (Hoopa Valley Tribe 2008). The aquifers are approximately 10 to 80 feet deep. Some of the shallow wells are productive only during winter and early spring months.

The Lower Klamath River Valley Groundwater Basin extends over 7,030 acres in Del Norte and Humboldt counties, including areas along the Lower Klamath River (Reclamation 2010a). Groundwater along the Lower Klamath River occurs in alluvial fans near the confluences of major tributaries and along terrace and floodplain deposits adjacent to the river (Yurok Tribe 2012). The aquifers range in depth from 10 to 80 feet and are used by some members of the community.

The Hoopa Valley and Lower Klamath River Valley groundwater basins were designated by the CASGEM program as very low and low priorities, respectively.

Groundwater quality is suitable for many beneficial uses in the region. In other locations, the groundwater can include naturally occurring metals, including manganese, cadmium, zinc, and barium (Hoopa Valley Tribe 2008). Other groundwater quality issues include nitrate contamination (DWR 2013i). Groundwater and surface water contamination is suspected at several former and existing mill sites that historically used wood treatment chemicals. Discharges of pentachlorophenol, polychlorodibenzodioxins, and polychlorodibenzofurans have likely occurred due to the poor containment practices typically used in historical wood treatment applications. Additional investigation, sampling and monitoring, and enforcement actions have been limited by the insufficient resources that exist to address this historical toxic chemical problem (NCRWQCB 2005).

7.3.3 Central Valley Region

The Central Valley Region extends from above Shasta Lake to the Tehachapi Mountains, and includes the Sacramento Valley, San Joaquin Valley, Delta, and Suisun Marsh.

Groundwater for the Central Valley Region is described in relation to the basins described by DWR in Bulletin 118-03 (DWR 2003a). The overall area includes the Sacramento Valley Basin which extends through the Sacramento Valley, and the San Joaquin Valley Groundwater Basin (including the Tulare Lake Area, which extends through the San Joaquin Valley). The Delta and Suisun Marsh area are located partially in the Sacramento Valley Basin and partially in the San Joaquin Valley Groundwater Basin. The Delta and Suisun Marsh area is described separately because of its distinct characteristics as an estuary at the confluence of the Sacramento and the San Joaquin rivers.

7.3.3.1 Sacramento Valley

The Sacramento Valley includes the Redding Groundwater Basin and the Sacramento Valley Groundwater Basin. The Sacramento Valley Groundwater Basin is one of the largest groundwater basins in the state, and extends from Redding in the north to the Delta in the south (USGS 2009).

Approximately one-third of the Sacramento Valley's urban and agricultural water needs are met by groundwater (DWR 2003a). The portion of the water diverted for irrigation but not actually consumed by crops or other vegetation becomes recharge to the groundwater aquifer or flows back to surface waterways.

Overall, the Sacramento Groundwater Basin is approximately balanced with respect to annual recharge and pumping demand. However, there are several locations showing early signs of persistent drawdown, suggesting limitations due to increased groundwater use in dry years. Locations of persistent drawdown include: Glenn County, areas near Chico in Butte County, northern Sacramento County, and portions of Yolo County.

The water quality of groundwater in the Sacramento Valley is generally good, as described below for individual basins. Several areas have localized aquifers with high nitrate, total dissolved solids (TDS) or boron concentrations. High nitrate concentrations frequently occur due to residuals from agricultural operations or septic systems. High TDS, a measure of salinity, concentration can be an indicator of brackish or connate water when it occurs in high concentrations. High boron concentration usually is associated with naturally occurring deposits.

7.3.3.1.1 Overview of Groundwater Basins in the Sacramento Valley

The Sacramento Valley includes the Redding Groundwater Basin and the Sacramento Valley Groundwater Basin. The Redding Groundwater Basin is situated in the extreme northern end of the valley and is a separate, isolated groundwater basin, but due to similarities in geology and stratigraphy is discussed as part of the overall Sacramento Valley. It is bordered by the Coast Ranges on the west, and by the Cascade Range and Sierra Nevada mountains on the east.

The Sacramento Valley Groundwater Basin has been divided into 17 subbasins by DWR, as shown in Figure 7.4, based on groundwater characteristics, surface water features, and political boundaries (DWR 2003a). However, from a hydrologic standpoint, these individual groundwater subbasins have a high degree of hydraulic connection because the rivers do not always act as barriers to groundwater flow. Therefore, the Sacramento Valley Groundwater Basin functions primarily as a single laterally extensive alluvial aquifer, rather than numerous discrete, smaller groundwater subbasins.

For discussion purposes, and due to their common characteristics, the Sacramento Valley is further sub-divided into the Upper Sacramento Valley, the Lower Sacramento Valley West of the Sacramento River, and the Lower Sacramento Valley East of the Sacramento River.

General Hydrogeology of the Sacramento Valley

Freshwater in the Sacramento Valley Groundwater Basin occurs within the continental deposits. Hydrogeologic units containing freshwater along the eastern portion of the basin, primarily occur in the Tuscan and Mehrten formations, and are derived from the Sierra Nevada. Toward the southeastern portion of the Sacramento Valley, the Mehrten formation is overlain by sediments of the Laguna, Riverbank, and Modesto formations, which also originated in the

Sierra Nevada. The primary hydrogeologic unit in the western portion of the Sacramento Valley is the Tehama formation, which was derived from the Coast Ranges. In most of the Sacramento Valley, these deeper units are overlain by younger alluvial and floodplain deposits. Generally, groundwater flows inward from the edges of the basin toward the Sacramento River, then in a southerly direction parallel to the river. Depth to groundwater throughout most of the Sacramento Valley averages about 30 feet below the ground surface, with shallower depths along the Sacramento River and greater depths along the basin margins. Wells developed in the sediments of the valley provide excellent supply to irrigation, municipal, and domestic uses. The deepest elevation of the base of freshwater in the Sacramento Valley ranges between 400 feet and 3,350 feet below mean sea level (Berkstresser 1973). The location where the base of freshwater is the deepest occurs in the Delta near Rio Vista. Near the valley margins and the Sutter Buttes, the base of freshwater is relatively shallow; suggesting that the base of freshwater may coincide with bedrock or connate water trapped in shallower deposits close to the basin margins (Berkstresser 1973).

Today, groundwater levels are generally in balance valley-wide, with pumping matched by recharge from the various sources annually. Some locales show the early signs of persistent drawdown, especially in areas where water demands are met primarily, and in some locales exclusively, by groundwater. These areas include portions of the far west side of the Sacramento Valley in Glenn County, portions of Butte County near Chico, in portions of Yolo County, and in the northern Sacramento County area. The persistent areas of drawdown could be early signs that the limits of sustainable groundwater use have been reached in these areas. Due to the drought that started in 2011, surface water supplies have declined and new wells have been installed. Between January and October 2014, over 100 water supply wells were drilled in both Shasta and Butte counties (DWR 2014d).

Land subsidence in the Sacramento Valley has resulted from inelastic deformation (non-recoverable changes) of fine-grained sediments related to groundwater withdrawal. Areas of subsidence from groundwater level declines have been measured in the Sacramento Valley at several locations. Subsidence monitoring was established following several studies in the 1990s that indicated more than four feet of subsidence since 1954 in some areas, such as in Yolo County (Ikehara 1994). Initial data from the Yolo County extensometers indicated subsidence in the Zamora area, which has subsequently been confirmed with a countywide global positioning system network installed in 1999 and monitored in 2002 and 2005. Subsidence up to 0.4 feet occurred between 1999 and 2005 in the Zamora area (Frame Surveying and Mapping 2006). The Zamora area does not currently use CVP or SWP water supplies. However, this area was designated as part of the CVP Sacramento Valley Irrigation Canals service area in the Reclamation Act of 1950 and as amended in the Reclamation Act of 1980 and Central Valley Project Improvement Act.

7.3.3.1.2 Upper Sacramento Valley

The Upper Sacramento Valley includes the Redding Groundwater Basin and upper portions of the Sacramento Valley Groundwater Basin (DWR 2003a). The Redding Groundwater Basin extends from approximately Redding in Shasta County through the northern portions of Tehama County. The portions of the Sacramento Valley Groundwater Basin in the Upper Sacramento Valley are located primarily in Tehama County with small portions extending into Glenn County near Orland and Butte County near Chico in the south. The geology of this area is dominated by the Tuscan and Tehama Formations. The hydrology of this area is dominated by numerous smaller drainages that originate in the Sierra Nevada and Coast Ranges and drain to the Sacramento River (DWR 2003a).

Hydrogeology and Groundwater Conditions

The Redding Groundwater Basin comprises the northernmost part of the Sacramento Valley and is bordered by the Klamath Mountains to the north, the Coast Ranges to the west, the Cascade Mountains to the east, and the Red Bluff Arch to the south. This basin consists of a sediment-filled, symmetrical, southward-dipping trough formed by folding of the marine sedimentary basement rock. These deposits are overlain by a thick sequence of inter-bedded, continentally-derived, sedimentary, and volcanic deposits of Late Tertiary and Quaternary age. The primary fresh water-bearing deposits in the basin are the Pliocene age volcanic deposits of the Tuscan Formation and the Pliocene age continental deposits of the Tehama Formation (DWR 2003a, 2003b, 2004a, 2004b, 2004c, 2004d, 2004e, 2004f).

The Tehama Formation consists of unconsolidated to moderately consolidated coarse and fine-grained sediments derived from the Coast Ranges to the west. The Tehama Formation is up to 4,000 feet thick and varies in depth from a few feet to several hundred feet below the land surface, with depth generally increasing to the east towards the Sacramento River (DWR 2003a, 2004a, 2004b, 2004c, 2004d, 2004e, 2004f). The Tuscan formation is derived from the Cascade Range to the east and is primarily composed of volcaniclastic sediments.

The Redding Groundwater Basin includes six subbasins: Anderson, Rosewood, Bowman, Enterprise, Millville, and South Battle Creek (DWR 2003a, 2004a, 2004b, 2004c, 2004d, 2004e, 2004f). The Anderson subbasin is one of the main groundwater units in the Redding Basin. Groundwater levels in the unconfined and confined portions of the aquifer system fluctuate annually by 2 to 4 feet during normal precipitation years and up to 10 to 16 feet during drought years (DWR 2003b). Between spring 2010 and spring 2014 in the Redding Groundwater Basin, recent information indicates that groundwater levels declined at multiple wells by up to 10 feet. The groundwater levels in some areas declined up to 10 feet between Fall 2013 and Fall 2014 (DWR 2014c, 2014d).

Tehama County overlies three subbasins within the Redding Groundwater Basin and seven subbasins in the Sacramento Valley Groundwater Basin. The Rosewood, South Battle Creek, and Bowman subbasins in the Redding Groundwater Basin are located in Tehama County. The Red Bluff, Corning, Bend, Antelope, Dye Creek, Los Molinos, and Vina subbasins in the Sacramento Valley Groundwater Basin are located in Tehama County (DWR 2004b, 2004c, 2004f, 2004g, 2004h, 2004i, 2004j, 2004k, 2004l, 2006a). The Corning subbasin extends into northern Glenn County near Orland. The Vina subbasin extends into northern Butte County near Chico. Groundwater levels in these subbasins show a significant seasonal variation due to high groundwater use for irrigation during the summer months. Groundwater levels showed significant declines in some wells associated with the 1976 to 1977 and 1987 to 1992 drought periods. Groundwater levels appeared to recover quickly during subsequent wet years. Groundwater levels in the Corning area of Tehama County showed a general decline before 1965 due to increased groundwater pumping for agricultural uses. Following construction by the CVP of the Tehama-Colusa Canal and the Corning Canal, surface water was delivered to these areas and there was a subsequent upward trend in groundwater levels following initial operations (Tehama County Flood Control and Water Conservation District 1996). Between spring 2010 and spring 2014 in the Upper portion of the Sacramento Valley Groundwater Basin, recent information indicates that groundwater levels declined at multiple wells approximately 2.5 feet to 10 feet (DWR 2014c, 2014d). The groundwater levels in some areas declined up to 10 feet between fall 2013 and fall 2014, and in some areas more than 10 feet.

Groundwater quality in the Redding Groundwater Basin is generally good to excellent for most uses. Some areas of poor quality due to high salinity from marine sedimentary rock exist at the margins of the basin. Portions of the basin are characterized by high boron, iron, manganese, and nitrates in localized areas (DWR 2004a, 2004b, 2004c, 2004d, 2004e, 2004f). In general, groundwater in the Sacramento Valley Groundwater Basin within Tehama County is of excellent quality, with some localized areas with groundwater quality concerns related to boron, calcium, chloride, magnesium, nitrate, phosphorous, and TDS (DWR 2004g, 2004h, 2004i, 2004j, 2004k, 2004l, 2006a). In the vicinity of Antelope, east of Red Bluff, historical high nitrates in groundwater occur. Higher boron levels have been detected in wells located in the eastern portion of Tehama County. High salinity occurs near Salt Creek, which most likely originates from the Tuscan Springs, which is a source of high boron and sulfates.

The Vina subbasin was designated by the CASGEM program as high priority. The Anderson, Enterprise, Bowman, Red Bluff, Corning, Antelope, Dye Creek, and Los Molinos subbasins were designated medium priority. The Rosewood, Millville, South Battle Creek, and Bend subbasins were designated very low priority in the June 2014 CASGEM designation.

Groundwater Use and Management

Tehama County uses groundwater to meet approximately 65 percent of its total water needs (Tehama County Flood Control and Water Conservation District 2008). Groundwater in the county provides water supply for agricultural, domestic, environmental, and industrial uses.

One of the main users of groundwater in this area is the Anderson-Cottonwood Irrigation District. Approximately 5 percent of the irrigated acres rely upon groundwater (DWR 2003b). Groundwater also is the primary water supply for residences and small scale agricultural operations.

7.3.3.1.3 Lower Sacramento Valley (West of Sacramento River)

The Lower Sacramento Valley area west of the Sacramento River includes three main groundwater subbasins: Colusa, Yolo, and Solano (DWR 2003a, 2004m, 2004n, 2006b).

Hydrogeology and Groundwater Conditions

Colusa Subbasin

The Colusa subbasin is bordered by the Coast Ranges to the west, Stony Creek to the north, Sacramento River to the east, and Cache Creek to the south. The Colusa subbasin extends primarily in western Glenn and Colusa counties. This subbasin is composed of continental deposits of late Tertiary age, including the Tehama and the Tuscan Formations, to Quaternary age, including alluvial and floodplain deposits as well as Modesto and Riverbank Formations. The Tehama Formation represents the main water bearing formation for the Colusa subbasin (DWR 2003b, 2006b). Groundwater levels are fairly stable in this subbasin, except during droughts, such as in 1976 and 1977 and 1987 to 1992 (DWR 2013a). Groundwater levels in the Colusa subbasin declined in the 2008 drought, and increased during the wetter periods of 2010 and 2011 to the pre-drought 2008 levels (DWR 2014c, 2014d). Historically, groundwater levels fluctuate by approximately 5 feet seasonally during normal and dry years (DWR 2006b, 2013a). Recent information indicates that groundwater levels declined at multiple wells in the Colusa subbasin approximately 10 to 20 feet between spring 2010 and spring 2014 in southwestern Colusa subbasin (DWR 2014c, 2014d). The groundwater levels in some areas declined up to 10 feet between fall 2013 and fall 2014, and in some areas more than 10 feet.

Groundwater quality for the Colusa subbasin is characterized by moderate to high TDS; with localized areas of high nitrate and manganese concentrations near the town of Colusa (DWR 2013a, 2006b). High TDS and boron concentrations have been observed near Knights Landing. High nitrate levels have been observed near Arbuckle, Knights Landing, and Willows.

The Colusa subbasin was designated by the CASGEM program as medium priority.

Yolo Subbasin

The Yolo subbasin lies to the south of the Colusa subbasin primarily within Yolo County. The primary water bearing formations for the Yolo subbasin are the same as those for the Colusa subbasin. Younger alluvium from flood basin deposits and stream channel deposits lie above the saturated zone and tend to provide significant well yields. In general, groundwater levels are stable in this subbasin, except during periods of drought, and in certain localized pumping depressions in the vicinity of Davis, Woodland, and Dunnigan and Zamora areas

(DWR 2004m, 2013a). However, between spring 2010 and spring 2014 in the Yolo subbasin, recent information indicates that groundwater levels declined at multiple wells at least 10 feet and in some areas up to 20 feet (DWR 2014c, 2014d). The groundwater levels in some areas declined up to 10 feet between fall 2013 and fall 2014, and in some areas more than 10 feet.

Groundwater quality is generally good for beneficial uses except for localized impairments including elevated concentrations of boron in groundwater along Cache Creek and in the Cache Creek Settling Basin area, elevated levels of selenium present in the groundwater supplies for the City of Davis, and localized areas of nitrate contamination (DWR 2004m, 2013a). The cities of Davis and Woodland, which heavily rely on groundwater supply, lost nine municipal wells since 2011 due to high nitrate concentrations (YCFCWCD 2012). Sources of high nitrate concentrations near these cities have been determined to be primarily from agricultural and wastewater operations. High salinity levels have also been reported in some areas that may be related to groundwater use for irrigation which tends to increase salt concentrations in groundwater.

In Yolo County, as much as 4 feet of groundwater withdrawal-related subsidence has occurred since the 1950s. Groundwater withdrawal-related subsidence has damaged or reduced the integrity of highways, levees, irrigation canals, and wells in Yolo County, particularly in the vicinities of Zamora, Knights Landing, and Woodland (Water Resources Association of Yolo County 2007).

The Yolo subbasin was designated by the CASGEM program as high priority.

Solano Subbasin

The Solano subbasin includes most of Solano County, southeastern Yolo County, and southwestern Sacramento County. In the Solano subbasin, general groundwater flow directions are from the northwest to the southeast (DWR 2004n, 2013a). Increasing agricultural and urban development in the 1940s in the Solano subbasin has caused significant groundwater level declines. Today, groundwater levels are relatively stable but show significant declines during drought cycles. Groundwater level data also suggest that these declines tend to recover quickly during subsequent wet years. Between spring 2010 and spring 2014 in the Solano subbasin, recent information indicates that groundwater levels declined at multiple wells by at least 10 feet (DWR 2014c, 2014d).

Groundwater quality in the Solano subbasin is generally good and is deemed appropriate for domestic and agricultural use (DWR 2004n, 2013a). However, TDS concentrations are moderately high in the central and southern areas of the basin with localized areas of high calcium and magnesium.

The Solano subbasin was designated by the CASGEM program as medium priority.

Groundwater Use and Management

Many irrigators on the west side of the Sacramento Valley relied primarily on groundwater prior to completion of the CVP Tehama-Colusa Canal facilities which conveyed surface water to portions of Colusa County.

In the Colusa subbasin, although surface water is the primary source of water to meet water supply needs, groundwater is also used to assist in meeting agricultural, domestic, municipal, and industrial water needs, primarily in areas outside of established water districts. The Tehama Colusa Canal Authority service area is also an area of groundwater use in the Colusa subbasin. Although the Tehama-Colusa Canal Authority delivers surface water to agricultural users when the CVP water supplies are restricted due to hydrologic conditions, water users rely upon groundwater to supplement limited surface water supplies.

Groundwater is the source of water for municipal and domestic uses in Yolo County except for the City of West Sacramento, as described in Chapter 5, Surface Water Resources and Water Supplies. Recently, in normal years, approximately 40 percent of the irrigation users in Yolo County rely on groundwater (Yolo County 2009). For the East Yolo South area of the County (eastern Yolo subbasin), a 2006 study estimated that groundwater supplies about 80 to 85 percent of the total annual water demand in the county (YCFCWCD 2012).

Within Yolo and Sacramento counties portions of the Solano subbasin, groundwater is primarily used for domestic and irrigation uses. Within Solano County, groundwater is used exclusively by most rural residential landowners and the cities of Rio Vista and Dixon (Solano County 2008). The City of Vacaville uses groundwater to provide approximately 30 percent of the water supply. Other communities rely upon surface water, as described in Chapter 5, Surface Water Resources and Water Supplies. Irrigation users within the Solano Irrigation District rely upon surface water. All other irrigation users rely upon groundwater.

7.3.3.1.4 Lower Sacramento Valley (East of Sacramento River)

The Lower Sacramento Valley area is located to the east of the Sacramento River, and includes seven groundwater subbasins: West Butte, East Butte, North Yuba, South Yuba, Sutter, North American, and South American (DWR 2003a, 2004o, 2004p, 2004q, 2006c, 2006d, 2006e, 2006f).

Hydrogeology and Groundwater Conditions

The aquifer system throughout the Lower Sacramento Valley east of the Sacramento River is composed of Tertiary to late Quaternary age deposits. The confined portion of the aquifer system includes the Tertiary-age Tuscan and Laguna formations. The Tuscan formation consists of volcanic mudflows, tuff breccia, tuffaceous sandstone, and volcanic ash deposits. The Laguna formation consists of moderately consolidated and poorly to well cemented interbedded alluvial sand, gravel, and silt with a low permeability, overall. The Quaternary portion of the aquifer system, typically unconfined, is largely composed of unconsolidated gravel, sand, silt, and clay stream channel and alluvial fan deposits. South and east of the Sutter Buttes, the deposits contain Pleistocene alluvium, which is composed of loosely compacted silts, sands, and gravels that are moderately permeable; however, nearly impermeable hardpans and claypans also exist in this deposit, which restrict the vertical movement of groundwater (DWR 2003a, 2004o, 2004p, 2004q, 2006c, 2006d, 2006e, 2006f).

West and East Butte Subbasins

The West Butte subbasin is located within Butte, Glenn, and Sutter counties. In the West Butte subbasin, groundwater levels declined during the 1976 to 1977 and 1987 to 1992 droughts, followed by a recovery in groundwater levels to pre-drought conditions of the early 1980s and 1990s (DWR 2004o, 2013a). A comparison of spring-to-spring groundwater levels from the 1950s and 1960s, to levels in the early 2000s, indicates about a 10-foot decline in groundwater levels in portions of this subbasin. Several groundwater depressions exist in the Chico area, due to year-round groundwater extraction for municipal uses. Between spring 2010 and spring 2014 in the West Butte subbasin, recent information indicates that groundwater levels declined at multiple wells at least 10 feet and in some areas up to 20 feet near Chico (DWR 2014c, 2014d). The groundwater levels in some areas declined up to 10 feet between fall 2013 and fall 2014.

The East Butte subbasin is located with Butte and Sutter counties. In the northern portion of the East Butte subbasin, annual groundwater fluctuations in the confined and semi-confined aquifer system ranges from 15 to 30 feet during normal years (DWR 2004p, 2013a). In the southern part of Butte County, groundwater fluctuations for wells constructed in the confined and semi-confined aquifer system average 4 feet during normal years and up to 5 feet during drought years. Between spring 2010 and spring 2014 in the East Butte subbasin, recent information indicates that groundwater levels either increased or declined at multiple wells by approximately 2 to 3 feet near Oroville (DWR 2014c, 2014d).

High nitrates occur near the Chico area in the West Butte subbasin. There are localized areas in the subbasin with high boron, calcium, electrical conductivity (EC), and TDS concentrations (DWR 2004 o, 2013a). There are several groundwater areas near Chico that historically had high perchloroethylene concentrations from industrial sites. Following implementation of groundwater treatment, the chemicals have not been detected (Butte County 2010).

There are localized high concentrations of calcium, salinity, iron, manganese, magnesium, and TDS throughout the East Butte subbasin (DWR 2004p, 2013a).

The West Butte subbasin was designated by the CASGEM program as high priority. The East Butte subbasin was designated as medium priority.

North and South Yuba Subbasins

The North Yuba subbasin is located within Butte and Yuba counties. The South Yuba subbasin is located within Yuba County. In the North Yuba and South Yuba subbasins areas along the Feather River, the groundwater levels have been generally stable since at least 1960, with some seasonal fluctuations between spring and summer conditions. Groundwater levels in the central parts of the two subbasins declined until about 1980, when surface water deliveries were extended to these areas and groundwater levels started to rise. Hydrographs in the central portions of the North and South Yuba subbasins also show the effect of groundwater substitution transfers (during 1991, 1994, 2001, 2002, 2008, and 2009), in the form of reduced groundwater levels followed by recovery to pre-transfer levels (YCWA 2010). Between spring 2010 and spring 2014 in the

North Yuba and South Yuba subbasins, recent information indicates that groundwater levels declined at multiple wells by 10 to 20 feet, especially near Yuba City (DWR 2014c, 2014d). The groundwater levels in some areas declined up to 10 feet between fall 2013 and fall 2014.

Historical water quality data show that in most areas of the North and South Yuba subbasins, trends of increasing concentrations of calcium, bicarbonate, chloride, alkalinity, and TDS occur. In general, groundwater salinity increases with distance from the Yuba River. No groundwater quality impairments were documented at the DWR monitoring wells in the North Yuba subbasin (DWR 2006c). High salinity occurred in the Wheatland area of the South Yuba subbasin within the South Yuba Water District and Brophy Irrigation District (DWR 2006d; YCWA 2010).

The North Yuba and South Yuba subbasins were designated by the CASGEM program as medium priority.

Sutter Subbasin

The Sutter subbasin is located in Sutter County. In the Sutter subbasin, groundwater levels have remained relatively constant. The water table is very shallow and most groundwater levels in the subbasin tend to be within about 10 feet of ground surface (DWR 2006e, 2013a). Between the spring 2010 and spring 2014 in the Sutter subbasin, recent information indicates that groundwater levels declined at multiple wells by up to 10 feet (DWR 2014c, 2014d). The groundwater levels in some areas declined up to 10 feet between fall 2013 and fall 2014, and in some areas more than 10 feet.

Groundwater quality in the western portion of the Sutter subbasin includes areas with high concentrations of arsenic, boron, calcium magnesium bicarbonate, chloride, fluoride, iron, manganese, sodium, and TDS. In the southern portion of the subbasin, groundwater in the upper aquifer system tends to be high in salinity (DWR 2003b, 2006e).

The Sutter subbasin was designated by the CASGEM program as medium priority.

North American Subbasin

The North American subbasin underlies portions of Sutter, Placer, and Sacramento Counties, including several dense urban areas. Since at least the 1950s, concentrated groundwater extraction occurred east of downtown Sacramento, which resulted in a regionally extensive cone of depression. Drawdown in the wells in this areas have been in excess of 70 feet over the past 60 years (SGA 2008). Water purveyors have constructed facilities to import surface water to allow groundwater levels to recover from the historic levels of drawdown. In general, since around the mid-1990s to the late 2000s, water levels remained stable in the southern portion of the subbasin and in some cases groundwater levels are continuing to increase slightly in response to increases in conjunctive use and reductions in pumping near McClellan Air Force Base (SGA 2014). Groundwater levels in Sutter and northern Placer Counties generally have remained stable, although some wells in southern Sutter County have experienced declines (DWR 2006f, 2013a). Overall, groundwater levels are higher along the eastern portion of the North American subbasin and decline towards the western portion (Roseville et al. 2007). There is a groundwater depression in the southern Placer-Sutter counties area near the border with Sacramento County. Between the spring 2010 and spring 2014 in the North American subbasin, recent information indicates that groundwater levels declined at multiple wells by up 10 feet (DWR 2014c, 2014d). The groundwater levels were relatively constant between fall 2013 and fall 2014.

The area along the Sacramento River extending from Sacramento International Airport northward to the Bear River contains high levels of arsenic, bicarbonate, chloride, manganese, sodium, and TDS (DWR 2006f, 2013a). In an area between Reclamation District 1001 and the Sutter Bypass, high TDS concentrations occur. There have been three sites within the subbasin with significant groundwater contamination issues: the former McClellan Air Force Base, the Union Pacific Railroad Rail Yard in Roseville, and the Aerojet Superfund Site. Mitigation operations have been initiated for all of these sites. In the deeper portions of the aquifer, the groundwater geochemistry indicates the occurrence of connate water from the marine sediments underlying the freshwater aquifer, which mixes with the fresh water. Water quality concerns due to this type of geology include elevated levels of arsenic, bicarbonate, boron, chloride, fluoride, iron, manganese, nitrate, sodium, and TDS (DWR 2003b).

The North American subbasin was designated by the CASGEM program as high priority.

South American Subbasin

The South American subbasin is located within Sacramento County. Groundwater levels in the South American subbasin have fluctuated over the past 40 years, with the lowest levels occurring during periods of drought. From 1987 to 1995, water levels declined by about 10 to 15 feet and then recovered to levels close to the mid-80s by 2000. Over the past 60 years, a general lowering of groundwater levels was caused by intensive use of groundwater in the region. Areas affected by municipal pumping show a lower groundwater level recovery than other areas (DWR 2004q, 2013a). A large cone of depression is centered in the southwestern portion of the subbasin. Between the spring 2010 and spring 2014 in the South American subbasin, recent information indicates that groundwater levels declined at multiple wells by up 10 feet (DWR 2014c, 2014d). The groundwater levels were relatively constant between fall 2013 and fall 2014.

The groundwater quality is characterized by low to moderate TDS concentrations (DWR 2004q, 2013a). Seven sites historically had significant groundwater contamination, including three Superfund sites near the Sacramento metropolitan area. These sites are in various stages of cleanup.

The South American subbasin was designated by the CASGEM program as high priority.

Groundwater Use and Management

In this area, groundwater is used for agricultural, domestic, municipal, and industrial purposes. Most of the groundwater extraction occurs via privately owned domestic and agricultural wells.

West and East Butte Subbasins

The primary water source in Butte County is surface water (approximately 70 percent, by volume), and groundwater use accounts for about 30 percent of total county water use. In Butte County, most of the irrigation users rely upon surface water and approximately 75 percent of the residential water users rely upon groundwater (Butte County 2004, 2010).

The cities of Chico and Hamilton City are served by groundwater provided by California Water Service Company (California Water Service Company 2011g).

North and South Yuba Subbasins

The Yuba County Water Agency actively manages surface water and groundwater conjunctively to prevent groundwater overdraft in the North and South Yuba subbasins. The majority of water demand in these subbasins is crop water use from irrigated agriculture (YCWA 2010).

Sutter Subbasin

Agricultural water use in Sutter County is composed, on average, of approximately 60 percent surface water, 20 percent groundwater, and 20 percent of land irrigated by both surface water and groundwater. Permanent crops are predominantly irrigated with groundwater. Groundwater is also used for small communities and rural domestic uses (Sutter County 2011).

North American Subbasin

Several agencies manage water resources in the North American subbasin: South Sutter Water District, Placer County Water Agency, Natomas Central Mutual Water Company, and several urban water purveyors which are part of the Sacramento Groundwater Authority (SGA), a joint powers authority (SGA 2014). The northern portion of this subbasin is rural and agricultural, while the southern portion is urbanized, including the Sacramento Metropolitan area. Many of the urban agencies in Placer County rely upon surface water for normal operations, and have developed or are planning on developing groundwater for emergency situations (Roseville et al. 2007). In the urban area encompassed by SGA, some agencies rely entirely on groundwater for their water supply (SGA 2014).

Local planning efforts have been implemented in a local groundwater planning area known as the American River Basin region. This area encompasses Sacramento County and the lower watershed portions of Placer and El Dorado counties, and overlies the productive North American and South American subbasins. Groundwater is a regionally significant source of water supply, and is used as a primary source for many agencies in the region. However, in recent years, regional conjunctive use programs have allowed for the optimization of water supplies and a decrease in groundwater use has been observed in the past 5 years (RWA 2013).

Since 2000, groundwater extraction decreased in the northeastern portion of the North American subbasin as additional surface water supplies were made available under conjunctive use operations implemented following the Water Forum Agreement in 2000. In 2007, groundwater extraction increased because additional surface water was not available due to dry surface water supply conditions (SGA 2008, 2011).

South American Subbasin

The South American subbasin lies entirely within Sacramento County and is overlain by a majority of urban and densely populated areas. Many of the water users in this subbasin use surface water.

The main water purveyors that use South American subbasin groundwater include the Elk Grove Water District, California-American Water Company, Golden State Water Company, and the Sacramento County Water Agency. The entities serve the communities of Antelope, Arden, Lincoln Oaks, Parkway, Rosemont, and portions of the City of Rancho Cordova (California-American Water Company 2011; EGWD 2011; Golden State Water Company 2011l; Sacramento County Water Agency 2011).The majority of groundwater pumping is for agricultural uses (SCGA 2010). The South American subbasin also includes portions of the area known as the American River Basin, as described above under the North American subbasin section.

7.3.3.2 Delta

The Delta overlies the western portion of the area where the Sacramento River and San Joaquin River groundwater basins converge, as shown in Figure 7.5. The Delta includes the Solano subbasin and the South American subbasin in the Sacramento Valley Groundwater Basin (as described above); the Tracy subbasin, the Eastern San Joaquin subbasin, and the Cosumnes subbasin in the San Joaquin Valley Groundwater Basin (as described in subsequent sections of this chapter for the San Joaquin); and the Suisun-Fairfield Valley Basin (as described in subsequent sections of this chapter for the San Francisco Bay Area Region).

7.3.3.2.1 Hydrogeology and Groundwater Conditions

In some areas of the western and central Delta floodplain, floodplain deposits contain organic material (peat) that range in thickness from 0 to 150 feet. Below the surficial floodplain deposits, unconsolidated non-marine sediments occur, at depths of a few hundred feet near the Coast Range to nearly 3,000 feet near the eastern margin of the Sacramento Valley Groundwater Basin. These non-marine sediments form the major water-bearing formations in the Delta.

In general, shallow groundwater conditions and extensive groundwater-surface water interaction characterize the Delta. Spring runoff generated by melting snow in the Sierra Nevada increases flows in the Sacramento and San Joaquin rivers and their tributaries and cause groundwater levels near the rivers to rise. Because the Delta is a large floodplain and the shallow groundwater is hydraulically connected to the surface water, changes in river stages affect groundwater levels and vice versa. Groundwater levels in the central Delta are very shallow, and land subsidence on several islands has resulted in groundwater levels close to the ground surface. Maintaining groundwater levels below crop rooting zones is critical for successful agriculture, especially for islands that lie below sea level. Many farmers rely on an intricate network of drainage ditches and pumps to maintain groundwater levels of about 3 to 6 feet below ground surface. The accumulated agricultural drainage is discharged into adjoining surface water bodies (USGS 2000a). Without this drainage system, many of the islands would be subject to extremely high groundwater, bogs, or localized flooding.

Groundwater generally flows from the Sierra Nevada in the east toward the low-lying lands of the Delta to the west. However, a number of pumping depressions have reversed this trend, and groundwater inflow from the Delta toward these pumping areas has been observed, primarily in the Stockton area.

Subsidence in the Delta is well-documented and a major source of concern for farming operations. The oxidation of peat soils is the primary mechanism of subsidence in the Delta, and some areas are located below sea level. Another mechanism for subsidence is wind erosion. There is a possibility that certain areas in the Delta could continue to subside 2 to 4 more feet over the next 35 years (DWR 2013i).

7.3.3.2.2 Groundwater Use and Management

Groundwater is used throughout the Delta for domestic and irrigation water supplies. Irrigation supplies are provided by wells and plant uptake in the root zone. An accurate accounting of groundwater used in the region is not available because wells are not metered and there is no method to measure root-zone irrigation.

Groundwater is used for potable water supplies by the Delta communities of Clarksburg, Courtland, Freeport, Hood, Isleton, Rio Vista, Ryde, and Walnut Grove. In the rural portions of the Delta, private groundwater wells provide residential and agricultural water supplies (Sacramento County 2010; Yolo County 2009; SCWA et al. 2005; Solano County 2008; San Joaquin County 2009; Contra Costa County 2005). In some portions of the Delta, groundwater use is limited because of low well yields and poor water quality. Shallow groundwater in the western Delta may be saline due to hydraulic connection with western Delta waterways that are influenced by sea water intrusion. Shallow groundwater levels can be detrimental if the groundwater encroaches into the crop root zones. Therefore, groundwater pumping frequently is used to drain shallow groundwater and surface water from agricultural fields.

7.3.3.3 Suisun Marsh

To the west, the Suisun Marsh overlies the Suisun–Fairfield Valley subbasin. The Suisun-Fairfield Groundwater Basin is adjacent to, but hydrogeologically distinct from, the Sacramento River Groundwater Basin, and is adjacent to Suisun Bay. This basin is bounded by the Coast Ranges to the north and west and the Sacramento River Groundwater Basin in the east, as shown in Figure 7.5. It is separated from the Sacramento River Groundwater Basin by the English Hills.

7.3.3.3.1 Hydrogeology and Groundwater Conditions

In the Suisun-Fairfield Valley Groundwater Basin, freshwater occurs within the alluvial deposits that overlie the Sonoma volcanics (Travis AFB 1997; USGS 1960).

The overall direction of groundwater flow in the Suisun-Fairfield Valley Groundwater Basin is from the uplands toward Suisun Marsh (USGS 1960; Reclamation et al. 2011). Depth to groundwater varies seasonally, with higher groundwater levels occurring during the rainy season (Solano County 2008). Prior to implementation of the Solano Project that conveys water into Solano County from Lake Berryessa as part of the Solano Project and the SWP North Bay Aqueduct, groundwater depressions were occurring near Fairfield. Following importation of surface water from the Solano Project and the North Bay Aqueduct, surface water was used more extensively to reduce the groundwater overdraft (Solano County 2008; Travis AFB 1997). Few groundwater monitoring sites exist in the basin, and most are near ongoing groundwater investigations. Data from these groundwater investigations suggest that groundwater levels in the basin are generally stable.

Groundwater quality issues within the Suisun-Fairfield Valley Groundwater Basin include high boron, TDS, and volatile organic compound concentrations near Travis Air Force Base (USGS 1960, 2008). Volatile organic compound plumes at Travis Air Force Base are largely contained on base, but volatile organic compound constituents have migrated up to 0.5-mile off base at three sites. Containment and remediation is occurring at each of these sites (Travis AFB 2005).

The Suisun-Fairfield Valley Groundwater Basin was designated by the CASGEM program as very low priority.

7.3.3.3.2 Groundwater Use and Management

Information on groundwater supplies in the Suisun-Fairfield Valley Groundwater Basin is limited. Groundwater was the primary water source for the Suisun–Fairfield Valley Groundwater Basin, including the cities of Fairfield and Suisun City, through the 1950s. This groundwater production resulted in local areas of depressed groundwater levels. As surface water became available, groundwater use declined. Studies have shown that the basin provides low well yields and therefore is probably not used as a major water supply (Reclamation et al. 2011). Many private well owners in the Suisun-Fairfield Valley Groundwater Basin use groundwater for irrigation. However, due to the brackish quality of the groundwater, surface water is used for potable water supplies (Reclamation et al. 2011).

7.3.3.4 San Joaquin Valley

The San Joaquin Valley Groundwater Basin extends from the Sacramento-San Joaquin Delta in the north to the Tehachapi Mountains in the South. Groundwater is estimated to provide over 47 percent of the overall water supply in the San Joaquin Valley, including 70 percent of municipal uses and 43 percent of irrigation supplies from 2005 through 2010 (DWR 2013i). The San Joaquin Valley has an average annual precipitation between 5 to 18 inches. Due to the low amounts of average annual precipitation, limited surface water supply and extensive agricultural water use, there are areas of significant overdraft that exist in the San Joaquin Valley Groundwater Basin. Eight subbasins in the San Joaquin Valley Groundwater Basin were identified in a state of critical overdraft: Chowchilla, Eastern San Joaquin, Madera, Kings, Kaweah, Tule, Tulare Lake, and Kern (DWR 1980). Three of these subbasins are on the eastern side of the San Joaquin River: Eastern San Joaquin, Chowchilla, and Madera. Recent studies have indicated that overdraft continues to exist in these subbasins (DWR 2013i). By 1970, over 5,200 square miles of irrigable land had subsided by a minimum of 1 foot. The maximum subsidence occurred near Mendota at almost 30 feet (9 meters) (Reclamation 2013a). Due to the drought that started in 2011, surface water supplies have declined and new wells have been constructed. Between January and October 2014, over 100 wells were drilled in both Kern and Kings counties, almost 200 in Stanislaus County, almost 250 in Merced County, and over 350 in both Fresno and Tulare counties (DWR 2014d).

The elevation of the base of freshwater in the western and central San Joaquin Valley ranges from 600 to 800 feet below mean sea level (WWD 2013). This area has experienced subsidence of up to 28 feet between 1926 and 1970 (USGS 2009). The water quality of the semi-perched aquifer on the western side of the San Joaquin Valley is impaired with high salinity, selenium, and boron concentrations. These constituents are from both naturally occurring deposits in the Coast Ranges to the west and agricultural activities. The chemicals become trapped in the soil matrix due to the low permeability clay layers close to the surface. There are also localized areas with high concentrations of naturally occurring arsenic or selenium.

Portions of the San Joaquin Valley Groundwater Basin in the Cosumnes, Tracy, and Eastern San Joaquin subbasins were designated by the State Water Resources Control Board in 2000 as Hydrogeologically Vulnerable Areas and Groundwater Protection Areas based on hydrogeologic permeability. These areas could be more vulnerable to groundwater quality impairment if applied surface water, including recycled water, contained high concentrations of constituents of concern to the beneficial users of the groundwater (CVRWQCB 2014b).

7.3.3.4.1 Northern Portions of the San Joaquin Valley Groundwater Basin

Extending south into the Central Valley from the Delta to the southern extent marked by the San Joaquin River, DWR has delineated nine subbasins within the northern portion of the San Joaquin Valley Groundwater Basin based on groundwater divides, barriers, surface water features, and political boundaries (DWR 2003a), as shown in Figure 7.6. The Cosumnes, Eastern San Joaquin, and Tracy subbasins partially underlie the Delta. The Delta-Mendota, Modesto, Turlock, Merced, Chowchilla, and Madera subbasins are located between the Delta and the San Joaquin River.

The northern portion of the San Joaquin Valley Groundwater Basin is marked by laterally extensive deposits of thick fine-grained materials deposited in lacustrine and marsh depositional systems. These units, which can be tens to hundreds of feet thick, create vertically differentiated aquifer systems within the subbasins. The Corcoran Clay (or E-Clay), occurs in the Tulare Formation and separates the alluvial water-bearing formations into confined and unconfined aquifers. The direction of groundwater flow generally coincides with the primary direction of surface water flows in the area, which is to the northwest toward the Delta (DWR 2003a, 2004r, 2004s, 2004t, 2004u, 2006g, 2006h, 2006k). Groundwater levels fluctuate seasonally and a strong correlation exists between depressed groundwater levels and periods of drought, when more groundwater is pumped in the area to support agricultural operations.

Water users in the northern portion of the San Joaquin Valley Groundwater Basin rely upon groundwater, which is used conjunctively with surface water for agricultural, industrial, and municipal supplies (DWR 2003a). Groundwater is estimated to account for about 38 percent of the overall water supply in the northern portion of the San Joaquin Valley Groundwater Basin (DWR 2013i). Annual groundwater pumping in the northern portion of the San Joaquin Valley Groundwater Basin accounts for about 19 percent of all groundwater pumped in the state of California. Groundwater use in the northern portion of the San Joaquin Valley Groundwater Basin is estimated to average 3.2 million acre-feet per year between 2005 and 2010.

According to the Draft California Water Plan 2013 Update (DWR 2013i), three planning areas within the northern portion of the San Joaquin Valley Groundwater Basin rely heavily on groundwater pumping: the Eastern Valley Floor Planning Area, the Lower Valley Eastside Planning Area, and the Valley West Side Planning Area. Each of these areas has limited local surface water supplies and uses extensive groundwater pumping for their agricultural water supply (DWR 2013i).

The northern portion of the San Joaquin Valley Groundwater Basin discussion is divided into two sub-regions: West of the San Joaquin River, and East of the San Joaquin River, as described below.

West of the San Joaquin River

The Tracy and the Delta-Mendota subbasins are located on the west side of the San Joaquin River.

Hydrogeology and Groundwater Conditions

Along the western portion of the San Joaquin Valley, the Tulare formation comprises the primary freshwater aquifer. The Tulare Formation originated as reworked sediments from the Coast Ranges re-deposited in the San Joaquin Valley as alluvial fan, flood basin, deltaic (pertaining to a delta) or lacustrine, and marsh deposits (USGS 1986).

Tracy Subbasin

The Tracy subbasin underlies eastern Contra Costa County and western San Joaquin County. A large portion of the subbasin is located within the Delta. In the Tracy subbasin, groundwater generally flows from south to north and discharges into the San Joaquin River. According to DWR and the San Joaquin County Flood Control and Water Conservation District, groundwater levels in the Tracy subbasin have been relatively stable over the past 10 years, apart from seasonal variations resulting from recharge and pumping (DWR 2006g, 2013b). Recent information indicates that between the spring 2010 and spring 2014, groundwater levels declined at some wells in the Tracy subbasin by up to 10 feet (DWR 2014c, 2014d). The groundwater levels in some areas declined up to 10 feet between fall 2013 and fall 2014, and in some areas more than 10 feet.

In the Tracy subbasin, areas of poor water quality exist throughout the area. Elevated chloride concentrations are found along the western side of the subbasin near the City of Tracy and along the San Joaquin River. Overall, Delta groundwater wells in the Tracy subbasin are characterized by high levels of chloride, TDS, arsenic, and boron (DWR 2006g, 2013b; USGS 2006). The Central Valley Regional Water Quality Board recently adopted general waste discharge requirements to protect groundwater, as well as surface water, within the San Joaquin County and Delta areas, including the Tracy subbasin (CVRWQCB 2014b). Supporting information recognizes the potential for groundwater impairment due to the water quality of applied water to crops if the applied water quality contains high concentrations of constituents of concern.

The Tracy subbasin was designated by the CASGEM program as medium priority.

Delta-Mendota Subbasin

The Delta-Mendota subbasin underlies portions of Stanislaus, Merced, Madera, and Fresno counties. The geologic units present in the Delta-Mendota subbasin consist of the Tulare Formation, terrace deposits, alluvium, and flood-basin deposits. Groundwater occurs in three water-bearing zones: the lower zone contains confined fresh water in the lower section of the Tulare Formation; the upper zone contains confined, semi-confined, and unconfined water in the upper section of the Tulare formation; and a shallow zone that contains unconfined water (DWR 2006h, 2013b). The groundwater is characterized by moderate to extremely high salinity with localized areas of high iron, fluoride, nitrate, and boron (DWR 2006h, 2013b).

In the Delta-Mendota subbasin, groundwater levels have generally declined by as much as 20 feet in the northern portion of the basin near Patterson between 1958 and 2006. Surface water imports in the early 1970s resulted in decreased pumping, and a steady recovery of groundwater levels. However, the lack of imported surface water availability during the drought periods of 1976 to 77, 1986 to 1992, and 2007 to 2009 resulted in increases in groundwater pumping, and associated declines in groundwater levels to near-historic lows (USGS 2012). Recent information indicates that between the spring 2010 and spring 2014, groundwater levels declined at some wells in the Delta-Mendota subbasin by up to 20 feet (DWR 2014c, 2014d).

In areas adjacent to the Delta-Mendota Canal in this subbasin, extensive groundwater withdrawal has caused land subsidence of up to 10 feet in some areas. Land subsidence can cause structural damage to the Delta-Mendota Canal which has caused operational issues for CVP water delivery. Historical wide-spread soil compaction and land subsidence between 1926 and 1970 has caused reduced freeboard and flow capacity of the Delta-Mendota Canal, the California Aqueduct, other canals, and roadways in the area. To better understand subsidence issues near the Delta-Mendota Canal and improve groundwater management in the area, the U.S. Geological Survey (USGS) provided and evaluated information on groundwater conditions and the potential for additional land subsidence in the San Joaquin Valley (USGS 2013a). Results show that at least 1.8 feet of subsidence occurred near the San Joaquin River and the Eastside Bypass from 2008 to 2010 period, affecting the southern part of the Delta-Mendota Canal by about 0.8 inches of subsidence during the same period. It was estimated that subsidence rates doubled in 2008 in some areas. The subsidence measured was primarily inelastic (or permanent, not reversible, due to the compaction of fine-grained material). The area of maximum active subsidence is shown to be located southwest of Mendota and extends into the Merced subbasin to the south of El Nido. Land subsidence in this area is expected to continue to occur due to uncertainties and limitations (especially climate-related changes) in surface water supplies to meet irrigation demand and the continuous need to supplement water supply with groundwater pumping.

Groundwater Use and Management

In this area, groundwater is used for agricultural, domestic, municipal, and industrial purposes.

Tracy Subbasin

The primary water source in Contra Costa County is surface water. Groundwater is used by individual homes and businesses and the communities of Brentwood, Bethel Island, Knightsen, Byron and Discovery Bay (Contra Costa County 2005).

The Diablo Water District groundwater blending facility provides water to users in the City of Oakley by blending groundwater and treated water from Contra Costa Water District (DWD 2011).

Contra Costa Water District has an agreement with the East Contra Costa Irrigation District to purchase surplus irrigation water for municipal and industrial purposes in East Contra Costa Irrigation District's service area (CCWD 2011). The agreement includes an option to implement an exchange of surface water for groundwater that can be used in the Contra Costa Water District service area when the CVP allocations are less than full contract amounts. This groundwater exchange water was implemented during the 2007 to 2009 drought.

Groundwater and surface water are used within western San Joaquin County for agricultural operations and for the cities of Stockton, Lathrop, and Tracy (San Joaquin 2009). In the 1980s, about 30 percent of the water supplies in San Joaquin County were based on groundwater (including the Tracy, Cosumnes, and Eastern San Joaquin subbasins). By 2007, groundwater was used to supply over 60 percent of water demand in the county.

Delta-Mendota Subbasin

Groundwater is used for agricultural and domestic water supplies in the Delta-Mendota subbasin (Reclamation and DWR 2011). Groundwater is primarily used for domestic and industrial water supplies in Stanislaus County, including for the City of Patterson (Stanislaus County 2010; Patterson 2014). In the Delta-Mendota subbasin within Merced County, approximately 3 percent of groundwater withdrawals are used for municipal and industrial purposes (including uses in the city of Gustine, Los Banos, and Santa Nella), and 97 percent of the groundwater withdrawals are used for agricultural purposes (Merced County 2012). Most of the portions of Madera County within the Delta-Mendota subbasin use groundwater for domestic and agricultural uses (Madera County 2002, 2008). In portions of Western Fresno County within the Delta-Mendota subbasin, domestic water users rely upon groundwater (including the cities of Mendota and Firebaugh), and agricultural water users rely upon surface water and/or groundwater (Mendota 2009; Firebaugh 2015; Fresno County 2000).

East of the San Joaquin River

The east side of the San Joaquin River is underlain by seven groundwater subbasins: the Cosumnes, Eastern San Joaquin, Modesto, Turlock, Merced, Chowchilla, and Madera subbasins. Three of these subbasins are in a critical state of overdraft: the Chowchilla, Eastern San Joaquin, and Madera (DWR 2013i).

Hydrogeology and Groundwater Conditions

Several of the hydrogeologic units present in the southern Sacramento Valley extend south into the San Joaquin Valley. Along the eastern boundary of the Central Valley, the Ione, Mehrten, Riverbank, and Modesto formations are primarily composed of sediments originating from the Sierra Nevada.

Historically, surface water and groundwater were hydraulically connected in most areas of the San Joaquin River and its tributaries. This resulted in a significant quantity of groundwater actively discharging into streams in most of this watershed. However this condition changed as increased groundwater pumping in the area lowered groundwater levels and reversed the hydraulic gradient between the surface water and groundwater systems, resulting in surface water recharging the underlying aquifer system through streambed seepage. Long-term groundwater production throughout this basin has lowered groundwater levels faster than natural recharge rates. Areas where this overdraft has occurred include eastern San Joaquin County, Merced County, and western Madera County. This occurs along the San Joaquin River where the riverbed is highly permeable and river water readily seeps into the underlying aquifer. This condition reduces groundwater and surface water outflows to the Delta, lowers the water table, and may increase the potential for land subsidence (USFWS 2012).

Generally, the groundwater in the San Joaquin River subbasins east of the San Joaquin River is of suitable quality for most urban and agricultural uses with only local impairments. There are localized areas with high concentrations of boron, chloride, iron, nitrate, TDS, and organic compounds (DWR 2003a, 2004r, 2004s, 2004t, 2004u, 2006i, 2006j, 2006k). The use of groundwater for agricultural supply is impaired in western Stanislaus and Merced counties due to elevated boron concentrations. Groundwater use for drinking water supply is also impaired in the Tracy, Modesto-Turlock, Merced, and Madera areas due to elevated nitrate concentrations (USFWS 2012).

Dibromochloropropane (DBCP), a soil fumigant that was extensively used on grapes and cotton before it was banned, is prevalent in groundwater near Merced and Stockton and in the Merced, Modesto, Turlock, Cosumnes, and Eastern San Joaquin subbasins (CVRWQCB 2011; DWR 2004r; USFWS 2012). Many areas with high concentrations of DBCP have undergone groundwater remediation, and the DBCP concentrations are declining.

Declining groundwater levels in the subbasins east of the San Joaquin River have resulted in an area approximately 16-miles long with high salinity due to saltwater intrusion from the Delta (USFWS 2012).

Cosumnes Subbasin

The Cosumnes subbasin underlies western Amador County, northwestern Calaveras County, southeastern Sacramento County, and northeastern San Joaquin County. Groundwater levels in the Cosumnes subbasin have fluctuated significantly over the past 40 years, with the lowest levels occurring during periods of drought. From 1987 to 1995, water levels declined by about 10 to 15 feet and then recovered by that same amount through 2000. Areas affected by municipal pumping show a lower magnitude of groundwater level recovery during this period than in other areas of the subbasin (DWR 2006i, 2013b). Within the portion of Sacramento County in the Cosumnes subbasin, it is estimated that the recent average annual decline in groundwater levels has been approximately 1 foot, with a lower rate of decline in more recent years (South Area Water Council 2011). Recent information indicates that between the spring 2010 and spring 2014, groundwater levels declined at some wells in the Cosumnes subbasin by up to 10 feet (DWR 2014c, 2014d).

The Cosumnes subbasin contains groundwater of very good quality, with localized high concentrations of calcium bicarbonate and pesticides (DWR 2006i, 2013b).

The Cosumnes subbasin was designated by the CASGEM program as medium priority.

Eastern San Joaquin Subbasin

The Eastern San Joaquin subbasin underlies western Calaveras County, a large portion of San Joaquin County, and a portion of Stanislaus County. Groundwater levels in the Eastern San Joaquin subbasin have continuously declined in the past 40 years due to groundwater overdraft. Cones of depression are present near major pumping centers such as the City of Stockton and the City of Lodi (DWR 2006j, 2013b). Groundwater level declines of up to 100 feet have been observed in some wells. In the 1990s, groundwater levels were so low that many wells were inoperable and many groundwater users were obligated to construct new deeper wells (NSJCGBA 2004). Recent information indicates that between the spring 2010 and spring 2014, groundwater levels declined at some wells in the Eastern San Joaquin subbasin by up to 20 feet (DWR 2014c, 2014d).

In the Eastern San Joaquin subbasin, the groundwater is characterized with low to high salinity levels and localized areas of high calcium or magnesium bicarbonate, salinity, nitrates, pesticides, and organic constituents (DWR 2006j, 2013b). The high groundwater salinity is attributed to poor-quality groundwater intrusion from the Delta caused by the pumping-induced decline in groundwater levels, especially in the groundwater underlying the Stockton area since the 1970s (SJCFCWCD 2008). High chloride concentrations have also been observed in the Eastern San Joaquin subbasin. Ongoing studies are evaluating the sources of chloride in groundwater along a line extending from Manteca to north of Stockton. Initial concern was that long-term overdraft conditions in the eastern portion of the subbasin were enabling more saline water from the Delta to migrate inland. Other possible sources include upward movement of deeper saline formation water and agricultural practices (USGS 2006). In addition, large areas of groundwater with elevated nitrate concentrations have been observed in several portions of the subbasin, such as areas southeast of Lodi and south of Stockton and east of Manteca, and in areas extending towards the San Joaquin-Stanislaus County line (USFWS 2012).

The Eastern San Joaquin subbasin was designated by the CASGEM program as high priority.

Modesto Subbasin

The Modesto subbasin underlies northern Stanislaus County. In the Modesto subbasin, water levels have declined nearly 15 feet on average between 1970 and 2000 (DWR 2004r, 2013b), with the major declines occurring in the eastern portion of the subbasin. Recent information indicates that between the spring 2010 and spring 2014, groundwater levels declined at some wells in the Modesto subbasin by up to 20 feet (DWR 2014c, 2014d).

The groundwater is characterized by low to high TDS concentrations with localized areas of boron, chlorides, DBCP, iron, manganese, and nitrate concentrations (DWR 2004r, 2013b; Stanislaus County 2010).

The Modesto subbasin was designated by the CASGEM program as high priority.

Turlock Subbasin

The Turlock subbasin underlies portions of Stanislaus and Merced counties. In the Turlock subbasin, water levels declined nearly 7 feet on average from 1970 through 2000 (DWR 2006k, 2013b). Comparison of groundwater contours from

1958 and 2006 shows that historically, groundwater flows occurred from east to west, toward the San Joaquin River. Groundwater pumping centers to the east of the City of Turlock have drawn the groundwater toward these cones of depression, allowing less water to flow toward the San Joaquin River, and diminishing the discharge of groundwater to the river. Recent information indicates that between the spring 2010 and spring 2014, groundwater levels declined at some wells in the Turlock subbasin by up to 20 feet (DWR 2014c, 2014d). The storage capacity of the Turlock subbasin is estimated at about 15,800,000 acre-feet (DWR 2006k, 2013b).

The groundwater quality is characterized with low to high concentrations of TDS and localized high concentrations of boron, chlorides, DBCP, nitrates, and TDS (DWR 2013b).

The Turlock subbasin was designated by the CASGEM program as high priority.

Merced Subbasin

The Merced subbasin underlies most of Merced County. In the Merced subbasin, water levels have declined nearly 30 feet on average from 1970 through 2000. Water level declines have been more severe in the eastern portion of the subbasin (DWR 2004s, 2013b). The estimated specific yield of the groundwater subbasin is 9 percent. Recent information indicates that between the spring 2010 and spring 2014, groundwater levels declined at some wells in the Merced subbasin by up to 20 feet (DWR 2014c, 2014d).

The groundwater quality is characterized by low to high TDS concentrations and localized areas with high concentrations of chloride, DBCP, iron, and nitrate (DWR 2004s, 2013b; USFWS 2012).

The Merced subbasin was designated by the CASGEM program as high priority.

Chowchilla Subbasin

The Chowchilla subbasin underlies southwestern Merced County and northwestern Madera County. In the Chowchilla subbasin, water levels declined nearly 40 feet on average from 1970 to 2000. Water level declines were more severe in the eastern portion of the subbasin from 1980 to present, but the western portion of the subbasin showed the strongest declines before 1980 (DWR 2004t, 2013b). Groundwater recharge in this subbasin is primarily from irrigation water percolation. Recent information indicates that between the spring 2010 and spring 2014, groundwater levels declined at some wells in the western Chowchilla subbasin by up to 10 feet (DWR 2014c, 2014d).

There are localized areas with high concentrations of chloride, iron, nitrate, and hardness (DWR 2004t, 2013b). Organic chemicals were detected in some wells in the Chowchilla subbasin between 1983 and 2003 (CVRWQCB 2011).

The Chowchilla subbasin was designated by the CASGEM program as high priority.

Madera Subbasin

The Madera subbasin underlies most of Madera County. In the Madera subbasin, water levels have declined nearly 40 feet on average from 1970 through 2000. Water level declines have been more severe in the eastern portion of the subbasin from 1980 to the present, but the western subbasin showed the strongest declines before this period (DWR 2004u, 2013b). Recent information indicates that between the spring 2010 and spring 2014, groundwater levels declined at some wells in the western Chowchilla subbasin by up to 10 feet (DWR 2014c, 2014d).

Groundwater in the Madera subbasin is characterized by low to high TDS and localized areas with high concentrations of chlorides, iron, nitrates, and hardness (DWR 2004u, 2013b). Occurrences of organic chemicals have been observed including DBCP and pesticides (CVRWQCB 2011; DWR 2004u, 2013b).

The Madera subbasin was designated by the CASGEM program as high priority.

Groundwater Use and Management

In this area, groundwater is used for agricultural, domestic, municipal, and industrial purposes.

Cosumnes Subbasin

Currently, urban and agricultural water users on the valley floor are reliant on groundwater for water supply. Water demands in the Cosumnes Subbasin area are supported by nearly 95 percent groundwater (South Area Water Council 2011). Groundwater and surface water are used for agricultural and domestic water supplies in the Cosumnes subbasin (CVRWQCB 2011). Groundwater is used by many agricultural water users and the community of Galt (CVRWQCB 2011; South Area Water Council 2011).

The Central Valley Regional Water Quality Board recently adopted general waste discharge requirements to protect groundwater, as well as surface water, within the San Joaquin County and Delta areas, including the Cosumnes subbasin. The new requirements do not address protection of groundwater related to use of recycled water on crops because those operations would require separate discharge permits from the Central Valley Regional Water Quality Board and are not anticipated to be widely used in this area due to availability of recycled water near farms. However, the supporting information recognizes the potential for groundwater impairment due to the water quality of applied water to crops if the applied water quality contains high concentrations of constituents of concern (CVRWQCB 2014b).

Eastern San Joaquin Subbasin

Groundwater and surface water are used for agricultural and domestic water supplies in the Eastern San Joaquin subbasin (CVRWQCB 2011). Groundwater is the major source of water supply for agricultural areas in eastern San Joaquin County (NSJCGBA 2007). Groundwater is used by many agricultural water users and the communities of Escalon, Lodi, Manteca, Ripon, and Stockton (NSJCGBA 2004, 2007). The cities of Manteca and Stockton use both groundwater and surface water, while Lodi, Escalon, and Ripon primarily use groundwater for their municipal needs.

The City of Stockton uses both surface water and groundwater for its municipal and industrial water needs. Due to overdraft of the aquifer beneath Stockton, the city has limited annual groundwater extraction. All of these demands on the finite groundwater resources available in the basin historically have resulted in annual groundwater withdrawals in excess of the natural recharge volume in the East San Joaquin subbasin (DWR 2003a, 2006j). This extensive use of groundwater to meet local demand results in localized overdraft conditions within the subbasin.

The Northeastern San Joaquin County Groundwater Banking Authority is a joint-powers authority that develops local projects to strengthen water supply reliability in Eastern San Joaquin County. The Northeastern San Joaquin County Groundwater Banking Authority facilitated the development and adoption of the Eastern San Joaquin Groundwater Basin Groundwater Management Plan and completed an Integrated Regional Water Management Plan (IRWMP). This plan outlines the requirements for an integrated conjunctive use program that takes into account the various surface water and groundwater facilities in eastern San Joaquin County and promotes better groundwater management to meet future basin demands (NSJCGBA 2004). Conjunctive use refers to the use and management of the groundwater resource in coordination with surface water supplies by users overlying the basin. Potential projects that could be implemented to improve groundwater conditions in the area include urban and agricultural water use efficiency projects, recycled municipal water projects, groundwater banking operations, new surface water storage opportunities, improved conveyance facilities, and utilizing new sources of surface water (NSJCGBA 2007). Pursuant to the IRWMP, a program-level Environmental Impact Report identified potential changes to the environmental and mitigation measures to reduce identified significant adverse impacts (NSJCGBA 2011).

The Farmington Groundwater Recharge Program led by Stockton East Water District, in conjunction with the U.S. Army Corp of Engineers, and other local water agencies, was developed to utilize flood-season and excess irrigation water supplies in the Eastern San Joaquin groundwater subbasin to recharge the groundwater aquifer. This program supports replenishment of a critically overdrafted groundwater basin by recharging an average of 35,000 acre-feet of water annually into the Eastern San Joaquin subbasin. The program includes recharge of surface water on 800 to 1,200 acres of land using direct field-flooding. In addition, the program increases surface water deliveries in-lieu of groundwater pumping to reduce overdraft (Farmington Program 2012).

A joint conjunctive use and groundwater banking project was evaluated by the East San Joaquin Parties Water Authority and East Bay Municipal Utility District, named the Mokelumne Aquifer Recharge and Storage Project (NSJCGBA 2004). The goal of this project was to store surface water underground in wet years, and in dry years, East Bay Municipal Utility District would extract and export the recovered water supply (NSJCGBA 2004, 2009). Several studies have concluded that the test area is suitable for recharge and recovery of groundwater; however, more testing needs to be done to further evaluate the feasibility of this project.

The Central Valley Regional Water Quality Control Board recently adopted general waste discharge requirements to protect groundwater, as well as surface water, within the San Joaquin County and Delta areas. The new requirements do not address protection of groundwater related to use of recycled water on crops because those operations would require separate discharge permits from the Central Valley Regional Water Quality Board and are not anticipated to be widely used in this area due to availability of recycled water near farms. However, the supporting information recognizes the potential for groundwater impairment due to the water quality of applied water to crops if the applied water quality contains high concentrations of constituents of concern (CVRWQCB 2014b).

Modesto Subbasin

Groundwater is used for agricultural and domestic water supplies in the Modesto subbasin (Reclamation and DWR 2011). Groundwater is used by many agricultural water users and the community of Modesto (DWR 2004r; Stanislaus County 2010).

Turlock Subbasin

Groundwater is used for agricultural and domestic water supplies in the Turlock subbasin (Reclamation and DWR 2011). Groundwater is used by many agricultural water users and the community of Turlock in Stanislaus County and the communities of Delhi and Hilmar in Merced County (DWR 2006k; Stanislaus County 2010; Merced County 2012).

Merced Subbasin

Groundwater is used for agricultural and domestic water supplies in the Merced subbasin (Reclamation and DWR 2011). Groundwater is used by many agricultural water users and the communities of Atwater, El Nido, Le Grand, Livingston, Merced, Planada, and Winton (DWR 2004s; Merced County 2012).

Chowchilla Subbasin

Groundwater is used for agricultural and domestic water supplies in the Chowchilla subbasin (Reclamation and DWR 2011). Groundwater is used by many agricultural water users and the community of Chowchilla (DWR 2006k; Madera County 2002).

Madera Subbasin

Groundwater is used for agricultural and domestic water supplies in the Madera subbasin (Reclamation and DWR 2011). Groundwater is used by many agricultural water users and the community of Madera (DWR 2006k; Madera County 2002, 2008).

7.3.3.4.2 Tulare Lake Area of the San Joaquin Valley Groundwater Basin

The Tulare Lake Area overlies seven groundwater subbasins of the San Joaquin Valley Groundwater Basin, as defined by DWR (DWR 2003a): the Westside, Kings, Tulare Lake, Kaweah, Tule, Pleasant Valley, and Kern subbasins, as shown in Figure 7.7. The Kern and Pleasant Valley subbasins have distinct hydrogeology and groundwater management from the other subbasins, and therefore are described separately.

Northern Tulare Lake Area: Westside, Kings, Tulare Lake, Kaweah, Tule, Pleasant Valley, and Kern Subbasins

Hydrogeology and Groundwater Conditions

Hydrogeology

The aquifer system in the Tulare Lake Area consists of younger and older alluvium, flood-basin deposits, lacustrine and marsh deposits and unconsolidated continental deposits. These deposits are configured within most parts of the basin to form an unconfined to semi-confined upper aquifer and a confined lower aquifer. These aquifers are separated by the Corcoran Clay (E-Clay) member of the Tulare Formation, which occurs at depths between 200 and 850 feet within the central and western portions of the basin, specifically in the Westside and Tulare Lake subbasins and in the western Kings, Kaweah, and Tule subbasins. Fine-grained lacustrine deposits up to 3,600 feet thick also are present in the Tulare Lake region (DWR 2003a, 2004v, 2004w, 2006l, 2006m, 2006n, 2006o, 2006p).

Prior to extensive use of groundwater in the basin, groundwater generally flowed toward Tulare Lake. Due to depressed groundwater levels and interception of surface water, the Tulare Lake Area is dry except during extreme flood events; and recharge of the Tulare Lake Area is limited.

Groundwater withdrawals in the Tulare Lake Area account for approximately 38 percent of the total groundwater withdrawals in the state of California (DWR 2013i). The CVP and SWP surface water supplies are used by many agricultural water users and several communities in the Tulare Lake Area to reduce reliance on groundwater and allow for groundwater recharge. In drier years when the CVP and SWP water supplies are limited, extensive groundwater pumping occurs to meet the water demands. In drier years, water users in the Westside, Kings, Tulare Lake, and Kaweah subbasins may use groundwater for up to 75 percent of their water supply (DWR 2013i).

Areal recharge from precipitation provides most of the groundwater recharge, and seepage from stream channels provides the remaining groundwater recharge. Most of the recharge occurs as mountain-front recharge in the coarse-grained upper alluvial fans where streams enter the basin (USGS 2009). Prior to development of the Tulare Lake Area, surface water and groundwater exchange occurred throughout the basin in response to hydrologic conditions. When rapid agricultural growth and groundwater development occurred, the primary interaction of surface water with groundwater occurred as stream flow loss to underlying aquifers. In areas of severe overdraft in the Tulare Lake Area of the San Joaquin Valley Groundwater Basin, complete disconnection between groundwater and overlying surface water systems has occurred. In some areas with disconnected hydrology where streambeds are used as conveyance elements for irrigation purposes and to recharge groundwater, the streams become losing streams. Recent information indicates that between the spring 2010 and spring 2014, groundwater levels declined at some wells in this area by up to 10 feet (DWR 2014c, 2014d). The groundwater levels in some areas declined up to 10 feet between fall 2013 and fall 2014, and in some areas more than 10 feet.

Groundwater Quality

In the northern Tulare Lake Area (including the Westside, Tulare Lake, Kings, Kaweah, and Tule subbasins), groundwater in the upper unconfined/semi-confined aquifer is characterized by high calcium and magnesium sulfate as well as high TDS (DWR 2006l, 2006m, 2006n, 2013c). The lower confined aquifer is approximately 300 feet below the ground surface and above the Corcoran Clay, and is characterized by high sodium sulfates and less dissolved solids than the upper aquifer.

Groundwater quality in the northern Tulare Lake Area is poor in portions of the upper aquifer, due to agricultural drainage issues and naturally occurring high salinity soils. Groundwater in the Westside subbasin is of poor quality due to historical agricultural drainage. The high clay content of the soils that comprise the upper aquifer restricts the movement of groundwater in the aquifer, further contributing to water quality impacts from root zone drainage. Studies have shown that the quality of the upper 20 to 200 feet of the saturated groundwater zone have been affected by crop irrigation and drainage issues (Reclamation 2006). The eastward movement of saline groundwater from the Westside subbasin also adversely affects the groundwater quality in adjacent subbasins, such as in the vicinity of the City of Mendota and Fresno Slough (Reclamation 2006).

The Westside and Kings subbasins also have localized areas with high boron concentrations (CVRWQCB 2011). The Kings and Tulare Lake subbasins have localized areas with high arsenic and hydrogen sulfide. In the Kaweah subbasin and the northern portion of the Tule subbasin, groundwater is of the calcium bicarbonate type with high TDS and localized areas with high nitrate concentrations (DWR 2004v, 2004w, 2013c). In the Kaweah subbasin, groundwater is characterized by moderate to high TDS concentrations (DWR 2004v, 2013c). In the Tule subbasin, low to moderate TDS concentrations occur in the most of the subbasin with high concentrations in areas with poor drainage (DWR 2004w, 2013c). On the western side of the subbasin there is shallow saline water. The eastern side of the subbasin has areas of high nitrates (DWR 2013c, 2004b). The Westside and Kings subbasins also have localized areas with high boron concentrations (CVRWQCB 2011). The Kings and Tulare Lake subbasins have localized areas with high arsenic and hydrogen sulfide. In the Kaweah subbasin and the northern portion of the Tule subbasin, groundwater is of the calcium bicarbonate type with high TDS and localized areas with high nitrate concentrations (DWR 2004v, 2004w, 2013c). Portions of the Kings subbasin is characterized by high nitrate concentrations due to historical agricultural practices (CVRWQCB 2011; DWR 2006n, 2013c). High DBCP and other pesticides concentrations occur in localized areas within the Westside, Kings, Tulare Lake, Kaweah, and Tule subbasins (CVRWQCB 2011).

A recent study evaluated high nitrate concentrations in groundwater and related public health issues in four community water systems with recorded violations related to nitrates in drinking water (Pacific Institute 2011). The communities served by the water systems were evaluated to assess the quality of groundwater provided by their water distribution systems and potential costs to the communities. Overall, this significant degradation of groundwater quality throughout the area has implications on public health and economic sustainability of the region. The findings of the report indicated that improved notification procedures, new funding mechanisms, and improved regulations and incentives are needed to provide safe drinking water, as described in Chapter 18, Public Health. The four water systems included Beverly Grand Mutual Water Company (Tule subbasin), Lemon Cove Water Company (east of Tule subbasin), El Monte Village Mobile Home Park (Kings subbasin), and Soults Mutual Water Company (Kings subbasin) in Tulare County.

High groundwater salinity occurs in many locations in the Tulare Lake Area. Salts are imported into the Tulare Lake Area through irrigation with Delta water and salts added through application of fertilizers, and other salt containing materials. Except in very wet years, the Tulare Lake Area has no natural drainage, so imported salts accumulate in the groundwater unless captured and sequestered. This salt accumulation causes groundwater quality degradation for potable and agricultural uses.

To the high nitrate and salinity problems, the Central Valley Salinity Alternatives for Long-Term Sustainability (CV-Salts) was formed as a strategic initiative to address accumulation of salts and nitrates throughout the region in a comprehensive, consistent and sustainable manner (CVRWQCB 2015; SWRCB 2015). The Central Valley Regional Water Quality Control Board and the State Water Resources Control Board in cooperation with stakeholders and the Central Valley Salinity Coalition collaborate to review and update the Water Quality Control Plans for the Sacramento Valley and San Joaquin Valley groundwater basins and the Delta Plan for salinity management, as described in Chapter 6, Surface Water Quality. The goals of this program are to address groundwater nitrate legacy conditions and current loadings, direct impacts of high nitrates on drinking water supplies from diverse sources, and economic costs for water treatment or alternate supplies. A final Salinity and Nitrate Management Plan is scheduled to be completed in May 2016.

Overall Groundwater Conditions

The Westside, Kings, Tulare Lake, Kaweah, Tule, and Kern subbasins were designated by the CASGEM program as high priority. The Pleasant Valley subbasin was designated as low priority.

Groundwater Use and Management

The northern Tulare Lake Area uses groundwater for its many water needs. Groundwater is used conjunctively with surface water, where possible, when surface water supplies are not sufficient to meet the region’s demand for agricultural, industrial, and municipal uses (DWR 2003a). For example, the cities of Fresno and Visalia are almost entirely dependent on groundwater for their water supplies. Most groundwater subbasins in the Tulare Lake Area are in a state of overdraft as a consequence of groundwater pumping that exceeds the basin's safe yield (the amount of natural and induced recharge available to replenish the basin). As a result, the aquifers in these groundwater basins contain a significant amount of potential storage space that can be filled with additional recharged water. However, cities in the northern Tulare Lake Area are considering other water sources and/or groundwater banking programs.

Westside Subbasin

The Westside subbasin is located within western Fresno County and northwestern Kings County. The majority of lands within the Westside subbasin are within the Westlands Water District which uses CVP surface water, water transferred from other agencies, and groundwater. Groundwater levels in the Westside subbasin have fluctuated over the past 46 years in response to the availability of surface water deliveries from the CVP (WWD 2013). The lowest recorded average groundwater level below the Corcoran Clay between 1950 and 1968 (prior to delivery of CVP water to the subbasin) was 156 feet below mean sea level, which occurred in 1967. Groundwater elevations increased after 1968 to 89 feet above mean sea level in 1987.

Groundwater levels are closely related to the availability of surface water. In the 1977 drought when CVP water supplies were substantially reduced, groundwater withdrawals decreased the groundwater elevation by 97 feet in 1 year (WWD 2013). In 1991 and 1992 (during the 1987 to 1992 drought), the groundwater elevation declined to 62 feet below mean sea level. In 1996, the Westlands Water District adopted a groundwater management plan to preserve and enhance reliable groundwater resources; provide long-term availability of high quality groundwater; maintain local control of groundwater in the district; and minimize the cost and impact of groundwater use (WWD 2013a). The groundwater levels recovered following the drought that ended in 1992. However, in 2010, the CVP allocation was 45 percent of the contract amount, and the average groundwater elevation was 9 feet above mean sea level (WWD 2011). In 2012, the CVP allocation was 40 percent of the contract amount, and the average groundwater elevation decreased to 1 foot above mean sea level (WWD 2013). Recent information indicates that between the spring 2013 and spring 2014, groundwater levels have declined at some wells in the Westside subbasin by up to 40 feet within the 1-year period (DWR 2014c, 2014d).

Subsidence has occurred in the Westside subbasin as a result of the high rate of historic groundwater pumping resulting in reduced groundwater levels and the compaction of fine grained soils. In some areas, the land surface elevation has decreased substantially. It is estimated that extensive groundwater pumping prior to delivery of CVP water resulted in compaction of water bearing sediments and land subsidence of 1 to 24 feet between 1926 and 1972 (WWD 2013). The Westland Water District has referenced that the Department of Water Resources estimated the amount of subsidence since 1983 to be almost 2 feet in some areas of the District with most of that subsidence occurring since 1989 (WWD 2013).

The USGS monitoring between 2003 and 2010 indicated no subsidence in the Westside subbasin area during the same time period while at least 1.8 feet of subsidence occurred in the Delta-Mendota subbasin area near the southern part of the Delta-Mendota Canal (USGS 2013a).

Kings Subbasin

The Kings subbasin includes most of central and eastern Fresno County, and northern Kings and Tulare County (DWR 2006n, 2013c). Two major groundwater depressions occur near the Fresno-Clovis urban area and approximately 20 miles southwest of Fresno in the Raisin City Water District (DWR 2013c). On average, the majority of this subbasin has experienced generalized declines in groundwater levels of approximately 20 feet between 2003 and 2011 (KRCD 2012a). The Kings subbasin is in overdraft condition and overdraft continues to be a major long-term problem due to increasing water demand and reduced surface water supply reliability. Recent information indicates that between the spring 2010 and spring 2014, groundwater levels declined at some wells in the Kings subbasin by up to 20 feet (DWR 2014c, 2014d).

Groundwater is used for a portion of agricultural water demands and for most of the domestic and industrial water demands in Fresno County, including for water users in the communities of Fresno, Clovis, Sanger, Fowler, Selma, Kingsburg, Reedley, Dinuba, Orange Cove, Raisin City, and Riverdale (CVRWQCB 2011; Fresno County 2000; KRCD 2012a).

The City of Fresno, which previously used groundwater for the municipal water supplies, has developed a surface water supply program. The groundwater is recharged through direct recharge and from applied agricultural water, and groundwater inflows from the adjacent foothills (City of Fresno 2015).

Several water agencies are coordinating efforts in the Kings subbasin to mitigate the extensive historical declines in groundwater levels resulting from pumping withdrawals. Current Kings subbasin groundwater recharge efforts include a total of 4,000 acres of dedicated recharge ponds (CGRA 2012). One of the biggest groundwater recharge efforts in the Kings subbasin area is the McMullin On-farm Flood Capture and Recharge Project near Raisin City (KRCD 2013).

Tulare Lake Subbasin

The Tulare Lake subbasin includes most of Kings County (DWR 2006m, 2013c). In the Tulare Lake subbasin, water levels have declined nearly 17 feet on average from 1970 through 2000. Fluctuations in water levels have been most exaggerated in the Tulare Lakebed area of the subbasin, which has experienced both the steepest declines and the steepest rises over time. Groundwater overdraft conditions also prevail in this subbasin, similar to the Kings subbasin. Recent information indicates that between the spring 2010 and spring 2014, groundwater levels declined at some wells in the Tulare Lake subbasin by up to 20 feet (DWR 2014c, 2014d).

Groundwater is used for a portion of agricultural water demands and for most of the domestic and industrial water demands in Kings County, including the communities of Corcoran, Hanford, Lemoore, and Kettleman Hills (CVRWQCB 2011; KRCD 2012a).

Kaweah Subbasin

The Kaweah subbasin includes a portion of eastern Kings County and northwestern Tulare County. Water levels in this subbasin declined about 12 feet on average from 1970 through 2000 (DWR 2004v, 2013c). The basin is subject to large fluctuations in water levels since the 1970s to as low as 35 feet lower than the 1970 water level in 1995 to 25 feet higher in 1988. These fluctuations correspond to successive dry years (declines) and wet years (rebounds), respectively. Recent information indicates that between the spring 2010 and spring 2014, groundwater levels declined at some wells in the Kaweah subbasin by up to 20 feet (DWR 2014c, 2014d). The Kaweah Delta Water Conservation District operates recharge facilities to supplement groundwater recharge that occurs along the natural stream channels (KDWCD 2006). Water is released from the Terminus Reservoir on the Kaweah River to flow into over 40 recharge basins throughout the basin. Use of CVP water from the Friant-Kern Canal by Tulare Irrigation District and Ivanhoe Irrigation District reduces the need for groundwater withdrawals when the CVP water is available.

Groundwater is used for a portion of agricultural water demands and for most of the domestic and industrial water demands in the subbasin, including for water users in the communities of Visalia, Tulare, and Lindsay (CVRWQCB 2011; Tulare County 2010).

Tule Subbasin

The Tule subbasin includes southwestern Tulare County. Water levels in this subbasin increased by about 4 feet on average from 1970 through 2000 (DWR 2004w, 2013c). Water levels have fluctuated during dry and wet years between 16 feet below the 1970 water level in 1995 to 20 feet above the 1970 water level in 1988. Recent information indicates that between the spring 2010 and spring 2014, groundwater levels declined at some wells in the Tule subbasin by up to 20 feet (DWR 2014c, 2014d). The Deer Creek and Tule River Authority implemented a groundwater management plan in 2006 in the Tule Subbasin (DCTRA 2012). The plan participants include Lower Tule River Irrigation District, Pixley Irrigation District, Porterville Irrigation District, Terra Bella Irrigation District, Saucelito Irrigation District, Tea Pot Dome Irrigation District, Vandalia Irrigation District, Tipton Community Services District, Poplar Community Services District (primarily the City of Porterville), and Woodville Public Utility District. Many of these agencies have CVP water service contracts and some of these agencies have surface water rights. Groundwater recharge occurs in more than 25 groundwater recharge basins and along the Tule River and Deer Creek channels.

Southern Tulare Lake Area: Kern County Subbasin

The Kern County subbasin is located between the Tule and Tulare Lake groundwater subbasins on the north, the Sierra Nevada and Tehachapi Mountains granitic rock on the east, and the marine sediments of the Coast Ranges on the west. The major water suppliers within the Kern County subbasin include Kern County Water Agency and the City of Bakersfield.

Hydrogeology and Groundwater Conditions

The unconfined aquifer in the Kern County Groundwater subbasin is composed primarily of sediments that were deposited during the tertiary and quaternary age. The Tulare Formation, located in the western portion of the subbasin, includes the Corcoran Clay unit which occurs at depths of 300 to 650 feet and overlies the confined aquifer (DWR 2006o, 2013c).

Net groundwater level changes in the Kern County subbasin varied in different portions of the subbasin between 1970 and 2000 (DWR 2006o, 2013c). Since the late 1970s, the groundwater levels have ranged from an increase of over 30 feet in the southeastern portion of the subbasin to a decrease of up to 25 feet near Bakersfield and 50 feet near McFarland/Shafter. Recent information indicates that between the spring 2013 and spring 2014, groundwater levels declined at some wells in the Kern County subbasin by up to 40 feet (DWR 2014c, 2014d). The groundwater levels in some areas declined up to 10 feet between fall 2013 and fall 2014, and in some areas more than 10 feet.

Complete hydraulic disconnection between the groundwater and overlying surface water systems has occurred in the Kern County area. Kern River, a losing stream, is used as a conveyance element for irrigation purposes and to recharge groundwater.

Groundwater quality in the region is generally characterized by calcium bicarbonate in the shallow aquifers, and the groundwater quality is generally suitable for most uses. Lower aquifers have higher sodium concentrations (DWR 2006o, 2013c). Salinity is a significant groundwater quality issue in the region. Salt from imported CVP and SWP water accumulates annually in groundwater because the Tulare Lake is a closed system without any natural outlets (KCWA 2011).

Shallow groundwater with high salinity occurs in the western and southern portions of the Kern County subbasin and is related to drainage problems for irrigated agriculture (DWR 2006o, 2013c). An agricultural drainage study showed that shallow groundwater occurs between 0 and 30 feet below the ground surface in the southern portion of the Kern County subbasin (DWR 2013j). The shallow groundwater is characterized by high TDS, sodium chloride, selenium, and sulfates (DWR 2013j). Areas with high nitrate and pesticide concentrations occur in localized areas due to historic agricultural practices including irrigation and dairy wastes (CVRWQCB 2011; DWR 2006o). Elevated arsenic concentrations tend to occur in isolated areas associated with lakebed deposits. Selenium and chromium also naturally occur in portions of the subbasin (KCWA 2011).

Groundwater Use and Management

The Kern County subbasin is located in western Kern County. The majority of the lands within the Kern County subbasin are within Kern County Water Agency or the City of Bakersfield. Water supplies in the subbasin include local surface water, CVP and SWP water supplies, and groundwater. The subbasin includes a portion of the land evaluated in the Tulare Lake Basin Portion of the Kern Region IRWMP. It is estimated that over the long-term, approximately 39 percent of water supplies in this area are met by groundwater (KCWA 2011). Groundwater can provide up to 60 percent of the total water supply in drier years.

Much of the groundwater is withdrawn by individuals or farmers who do not maintain groundwater extraction records. Historically, groundwater extractions were estimated based upon electricity use, changes in groundwater storage, or changes in crop patterns and/or water requirements (DWR 2004o, 2013c; KCWA 2011).

Most of the groundwater is used by agriculture and the communities of Bakersfield, Rosedale, Shafter, Delano, Taft, and Wasco (KCWA 2011). The City of Bakersfield and surrounding unincorporated areas use surface water and groundwater. The groundwater supplies in 2010 include water provided by California Water Service Company; East Niles Community Services District;, Kern County Water Agency Improvement District No. 4 and North of the River Municipal Water District; and Vaughn Water Company (California Water Service Company 2011a; ENCSD 2011; KCWA 2011; KCWA and NORMWD 2011; Vaughn Water Company, Inc. 2011). The water entities along with adjacent water agencies manage the groundwater basin levels through ongoing recharge projects and conjunctive use projects.

Conjunctive Use and Groundwater Banking

Conjunctive use is an important component of water management in the Kern County subbasin. Many groundwater banking facilities supplement water supplies delivered to customers in dry years, when insufficient surface water supplies are available to meet demands.

More than 30,000 acres of groundwater recharge ponds are estimated to exist in the Kern County subbasin area (KCWA 2011). Infrastructure used for groundwater banking includes recharge basins, recharge canals, recovery wells, and conveyance pipelines. In addition, connections to regional conveyance infrastructure conveys water from the local water supplies, including the Kern River; Friant-Kern Canal; the Cross Valley Canal; and California Aqueduct to the recharge areas. Groundwater banking programs have developed various interties to the regional conveyance systems, such as the Semitropic Water Storage District Intake Canal and the Kern Water Bank Canal (KCWA 2011).

The major groundwater banking programs in Kern County include the Kern Water Bank operated by the Kern Water Bank Authority; the Semitropic Groundwater Bank, operated by the Semitropic Water Storage District; a groundwater bank operated by the North Kern Water Storage District; a groundwater bank operated by the City of Bakersfield; and a groundwater bank operated by Rosedale-Rio Bravo Water Storage District.

The Kern Water Bank Authority is located west of Bakersfield and covers nearly 30 square miles of the Kern County subbasin. The Kern Water Bank includes recharge ponds where water from local surface streams and the SWP infiltrates into the aquifer (KCWA n.d.; KWBA 2011). Eighty-four recovery wells are used to pump groundwater out of the aquifer in dry years when additional water is needed for irrigation since the program began operations in 1995 (KCWA 2011).

The Semitropic Water Storage District is located west of Wasco and covers more than 220,000 acres (SWSD 2011a). The Semitropic Water Storage District Stored Water Recovery Unit (a subunit of the overall Semitropic Water Storage District Water Bank) partnered with the Antelope Valley Water Bank, located close to Rosamond in the Kern County portion of the Antelope Valley, to form the Semitropic-Rosamond Water Bank Authority (SWSD 2011b). The major banking partners of Semitropic Water Storage District include (SWSD 2014):

- Metropolitan Water District of Southern California
- Santa Clara Valley Water District
- Alameda County Water District
- Zone 7 Water Agency
- Poso Creek Water Company
- Newhall Land & Farming Company
- San Diego County Water Authority
- Homer, LLC
- City of Tracy
- Harris Farms

Other banking programs include (KCWA and NORMWD 2011; KCWA 2011, n.d.):

- Arvin-Edison Water Storage District Banking
- Buena Vista Water Storage District Banking
- Cawelo Water District Banking
- City of Bakersfield 2800 Acres Recharge Facility
- Kern County Water Agency Improvement District No. 4 Pioneer Project and Allen Road Complex Well Field
- Kern Delta Water District Banking
- Kern Tulare and Rag Gulch Water Districts Banking
- Rosedale-Rio Bravo Water Storage District Banking (developed with Kern County Water Agency Improvement District No. 4)

Western Tulare Lake Area: Pleasant Valley Subbasin

The Pleasant Valley subbasin is located within the western portions of Fresno and Kings Counties.

Hydrogeology and Groundwater Conditions

Tertiary continental and marine sediments of the Coast Ranges and Kettleman Hills form the western boundary of the Pleasant Valley subbasin (DWR 2006p, 2013c). Alluvium of the San Joaquin Valley extends into the subbasin from the north, east, and south. Ephemeral streams from the Coast Ranges and Kettleman Hills flow into the subbasin. Groundwater recharge occurs primarily along these and other streams within the subbasin.

In the Pleasant Valley subbasin, groundwater levels are generally continuing a historical trend of decline. DWR measurements indicated a decline of 5 to 25 feet during the 1990s (DWR 2006p, 2013c).

Water quality in the Pleasant Valley subbasin is characterized by high TDS (CVRWQCB 2011; DWR 2006p, 2013c). Localized areas of high concentrations of boron, calcium, chlorides, magnesium, pesticides, sodium, bicarbonates, and sulfates occur in the groundwater.

The Pleasant Valley subbasin was designated by the CASGEM program as low priority.

Groundwater Use and Management

Groundwater is used to meet agricultural and municipal water demands in the Pleasant Valley subbasin (DWR 2006p, 2013c). Due to limited recharge capabilities in the subbasin, surface water is used either completely or conjunctively in western Fresno and Kings Counties. The communities of Avenal and Coalinga use CVP surface water due to groundwater quality, as described in Chapter 5, Surface Water Resources and Water Supplies (Reclamation 2012).

7.3.4 San Francisco Bay Area Region

The San Francisco Bay Area Region includes portions of Contra Costa, Alameda, Santa Clara, and San Benito counties that are within the CVP and SWP service areas. The SWP water users in Napa County do not use groundwater. Therefore, groundwater resources for Napa County are not described in this EIS.

There are several groundwater basins in the San Francisco Bay Area Region; however, only some of the basins are within the CVP and SWP service areas evaluated in this EIS. The portions of the San Francisco Bay Area Region within the CVP and/or SWP service areas include the Pittsburg Plain, Clayton Valley, Ygnacio Valley, Arroyo Del Hambre Valley, San Ramon Valley, Livermore Valley, Castro Valley, and Santa Clara Valley groundwater basins within the San Francisco Bay Hydrologic Region; and Gilroy-Hollister Valley Groundwater Basin within the Central Coast Hydrologic Region.

Groundwater represents approximately 15 percent of the agricultural, municipal, and industrial water supplies in the San Francisco Bay Area (DWR 2013i).

Conjunctive use programs have been implemented by several agencies to optimize the use of groundwater and surface water sources.

Groundwater quality in the San Francisco Bay Area is generally suitable for most agricultural and municipal uses, but concerns exist about groundwater contamination from industrial and agricultural chemical spills, leaky underground and above ground storage tanks, landfill leachate, and poorer-quality surface water bodies. There were over 800 groundwater cleanup projects in the area with the majority resulting from leaky fuel tanks (DWR 2013i). Portions of the San Francisco Bay Area Region along the shorelines include aquifers that are susceptible to seawater intrusion.

In the southern San Francisco Bay Area Region, groundwater and surface water are connected through in-stream and off-stream artificial recharge projects, in which surface water is delivered to water bodies that permit the infiltration of water to recharge underlying aquifers. Surface waters recharge aquifers in other regions of the San Francisco Bay Area Region along streambeds, especially in areas with depressed groundwater levels that have resulted from extensive groundwater pumping.

This section describes groundwater in subbasins within CVP and/or SWP water service areas, including Pittsburg Plain, Clayton Valley, Arroyo Del Hambre Valley, Ygnacio Valley, and San Ramon Valley subbasins in Contra Costa County; East Bay Plain and Livermore Valley subbasins in Contra Costa and Alameda counties; Castro Valley subbasin in Alameda County; Santa Clara and Llagas Area subbasins in Santa Clara County; and Bolsa, Hollister, and San Juan Bautista Area subbasins in San Benito County, as shown in Figure 7.8.

7.3.4.1 San Francisco Bay Hydrologic Region

7.3.4.1.1 Hydrogeology and Groundwater Conditions

Each of these groundwater basins in the San Francisco Bay Hydrologic Region contains unique hydrogeologic characteristics. However, generally the water bearing materials consist of alluvial, unconsolidated sand, sand and gravel, and clay (DWR 2004x, 2004y, 2004z, 2004aa, 2004ab, 2004ac, 2004ad, 2004ae, 2006q, 2006r, 2013d). Aquifers in these basins are hydrologically connected to surface water bodies, such as the San Joaquin River, Suisun Bay, local streams, and San Francisco Bay.

The movement of groundwater is locally influenced by features such as faults and structural depressions and operating production wells; however, groundwater generally flows toward the nearby bays. Groundwater levels in the area exhibit seasonal variation and have been historically depressed from significant groundwater use. However, as groundwater use decreased over the last few decades following implementation of surface water projects, groundwater levels have risen significantly. Over the entire period of record, groundwater levels have shown only a slight decline and are stable in more recent years.

Pittsburg Plain, Clayton Valley, Ygnacio Valley, and Arroyo Del Hambre Valley Groundwater Basins

The Pittsburg Plain, Clayton Valley, Ygnacio Valley, and Arroyo Del Hambre Valley groundwater basins represent the majority of groundwater storage in northern Contra Costa County. Except for portions of the Pittsburg Plain, most of these groundwater basins are not located within the Delta.

These basins extend inland from Suisun Bay towards Mt. Diablo. The Pittsburg Plain Groundwater Basin is composed of Pleistocene deposits of consolidated and unconsolidated clay sediments; overlain by alluvial soft water-saturated muds, peat, and loose sands (DWR 2004x, 2013d). The Clayton Valley and Ygnacio Valley groundwater basins are composed of unconsolidated alluvium and semi-consolidated alluvium interbedded with clay, sand, and gravel lenses. Along Suisun Bay, the water bearing formations are composed of alluvial soft water-saturated muds, peat, and loose sands (DWR 2004y, 2004z, 2004aa, 2013d).

Groundwater levels are relatively stable because the groundwater is recharged from streams (DWR 2004x, 2004y, 2004z, 2004aa, 2013d). The streams include Kirker and Willow creeks in the Pittsburg Plain Groundwater Basin; Marsh Creek in the Clayton Valley Groundwater Basin; Walnut and Grayson creeks in the Ygnacio Valley Groundwater Basin; and Alhambra Creek in the Arroyo Del Hambre Valley Groundwater Basin. There are no recent data for these basins related to groundwater levels or storage capacities.

The groundwater in this area is characterized by moderate to high TDS (DWR 2004x, 2004y, 2004z, 2004aa, 2013d). High nitrate concentrations occur in some rural areas of these basins (Contra Costa County 2005).

The Pittsburg Plain, Clayton Valley, Ygnacio Valley, and Arroyo Del Hambre Valley groundwater basins were designated by the CASGEM program as very low priority.

San Ramon Valley Groundwater Basin

The San Ramon Valley Groundwater Basin is located in southern Contra Costa County and extends from the Alamo area southward under the Town of Danville and City of San Ramon to the county boundary.

The basin is a closed basin characterized by alluvial fan deposits of sand, gravel, silt, and clay sediments (DWR 2004ab, 2013d). Multiple faults within the basin affect groundwater movement.

There are no recent data for this basin related to groundwater levels, storage capacities, or quality (DWR 2004ab, 2013d).

The San Ramon Valley Groundwater Basin was designated by the CASGEM program as very low priority.

Livermore Valley Groundwater Basin

The Livermore Valley Groundwater Basin extends under northeastern Alameda County and southern Contra Costa County. The Livermore Valley Groundwater

Basin contains groundwater-bearing materials originating from continental deposits from alluvial fans, outwash plains, and lakes (DWR 2006q, 2013d).

The Main Basin is the aquifer that includes the highest yielding aquifers and highest quality groundwater (Zone 7 2012). The Main Basin generally is divided into the Upper Aquifer Zone and Lower Aquifer Zone which are separated by a relatively continuous silty clay lens. Water from the Upper Aquifer Zone moves into the Lower Aquifer Zone when groundwater levels in the upper zone are high.

Well yields are mostly adequate and in some areas can produce large quantities of groundwater for all types of wells (DWR 2006q, 2013d). The movement of groundwater is locally impeded by structural features such as faults that act as barriers to groundwater flow, resulting in varying water levels in the basin. Groundwater follows a westerly flow pattern, similar to the surface water streams, along the structural central axis of the valley toward municipal pumping centers (Zone 7 2005).

Groundwater levels in the main portion of the Livermore Valley Groundwater Basin started declining in the early 1900s when groundwater pumping removed large quantities of groundwater (Zone 7 2005, 2010, 2013). This trend continued until the late 1960s when Zone 7 Water Agency began importing SWP water. Subsequently, Zone 7 Water Agency developed surface water projects to capture local runoff. Local runoff and SWP water is stored in Lake Del Valle and used to recharge groundwater within the Livermore Valley. The importation of additional surface water alleviated the pressure on the aquifer, and groundwater levels started to rise in the 1970s. However, historical lows were reached during periods of drought. During the recent dry period, groundwater levels declined 7 to 17 feet throughout the aquifers used by Zone 7 Water Agency between 2011 and 2012.

The Livermore Valley Groundwater Basin is characterized by localized areas of high boron, nitrate, and TDS (DWR 2006q, 2013; Zone 7 2012). High boron levels can be attributed to marine sediments adjacent to the basin.

Nitrate concentrations generally are within potable water criteria; however, high nitrate concentrations occur in some locations of the upper aquifer (Zone 7 2012). The source of nitrates appears to be related to agricultural activities, wastewater disposal, and natural sources from decaying vegetation.

Salinity of the aquifer depends upon the quality of the water used for recharge operations. Salinity has increased over the past 30 years (Zone 7 2012) especially in the western portion of the Main Basin. Aquifers in the central and eastern portions of the Livermore Valley Groundwater Basin are generally recharged through streambeds and are characterized by lower salinity due to the high recharge rate.

The Livermore Valley Groundwater Basin was designated by the CASGEM program as medium priority.

Castro Valley Groundwater Basin

The Castro Valley Groundwater Basin is located in the Castro Valley area of Alameda County between San Lorenzo Creek on the east and the Hayward Fault on the west (Castro Valley 2012).

The basin is composed of alluvial deposits of sand, gravel, silt, and clay sediments (DWR 2004ac, 2013d). Previous studies indicated that the maximum yield was about 140,000 gallons per day (Castro Valley 2012).

The groundwater is characterized by bicarbonates with calcium and sodium. Localized contamination has occurred in this shallow aquifer related to agricultural activities and underground storage tanks (Castro Valley 2012).

The Castro Valley Groundwater Basin was designated by the CASGEM program as very low priority.

Santa Clara Valley Groundwater Basin

The Santa Clara Valley Groundwater Basin includes three subbasins in areas that are within the CVP and/or SWP service areas. The three subbasins include the East Bay Plain subbasin in Contra Costa and Alameda counties, Niles Cone subbasin in Alameda County, and Santa Clara subbasin in Santa Clara County.

East Bay Plain Subbasin

The East Bay Plain subbasin is an alluvial plain that extends from San Pablo Bay southward to the Niles Cone subbasin, and extends under San Francisco Bay (DWR 2004ad, 2013d; EBMUD 2013). The alluvium consists of unconsolidated sediments of mud, silts, sands, and clays. Multiple faults within the subbasin affect groundwater movement. Groundwater levels declined to approximately 250 feet below the ground surface until the mid-1960s when groundwater levels began to increase. By 2000, groundwater levels were close to the ground surface. The groundwater quality is characterized as calcium and sodium bicarbonate with moderate to high TDS. Higher TDS concentrations occur near San Francisco Bay where localized sea water intrusion has occurred. High nitrate concentrations occur in localized areas due to historic agricultural activities.

The East Bay Plain subbasin was designated by the CASGEM program as medium priority.

Niles Cone Subbasin

The Niles Cone subbasin is mainly comprised of the alluvial fan along Alameda Creek. The Hayward Fault crosses the Niles Cone subbasin and further separates the subbasin into the Below Hayward Fault (west of the Hayward Fault) and Above Hayward Fault (east of the Hayward Fault) subbasins (ACWD 2012; DWR 2006r, 2013d).

The Niles Cone subbasin was in overdraft condition through the early 1960s. After 1962, groundwater levels increased as SWP water was delivered to the area and used to recharge the groundwater subbasin (DWR 2006r, 2013d).

The main groundwater quality impairment in the Niles Cone subbasin is saltwater intrusion caused by groundwater pumping (ACWD 2012; DWR 2006r, 2013d).

In the 1950s the migration of saline water extended into the Above Hayward Fault subbasin, and migrated into deeper aquifers. Alameda County Water District has developed aquifer reclamation programs to help control the movement of saline water and restore the quality of groundwater in the affected aquifers, as described below.

Niles Cone subbasin was designated by the CASGEM program as medium priority.

Santa Clara Subbasin

The Santa Clara subbasin is located within Santa Clara County along a structural trough that parallels the Coast Ranges and extends from the Diablo Range and Santa Cruz Mountains. The water bearing formations of the Santa Clara subbasin include unconsolidated to semi-consolidated gravel, sand, silt and clay (DWR 2004ac, 2013d). The upper alluvial fan in the northern portion of the subbasin is characterized by coarse-grained sediments (SCVWD 2010). Towards the central portion of the subbasin, thick silty clay lenses are inter-bedded with thin sand and gravel lenses. The northern and central portions of the subbasin are referred to as the Santa Clara Plain subbasin of the Santa Clara subbasin (SCVWD 2011). The southern portion of the subbasin consists of extensive alluvial deposits of unconsolidated and semi-consolidated sediments and is referred to as the Coyote subbasin of the Santa Clara subbasin (SCVWD 2010). The central portions and areas along the edges of the Santa Clara Plain subbasin consist of unconfined aquifers that provide recharge, also known as the Shallow Aquifer (SCVWD 2010, 2011). The Principal Aquifer provides most of the groundwater supply for the Santa Clara Valley and is separated from the Shallow Aquifer by a confining lens. The groundwater recharge primarily occurs due to percolation of water on the soil from precipitation or artificial recharge operations (as described below), seepage from stream beds, and subsurface inflow from surrounding hills.

In the Coyote subbasin, the groundwater aquifer is primarily unconfined with areas of perched groundwater above discontinuous clay deposits (SCVWD 2010, 2011). Groundwater recharge occurs along the streambeds. When the groundwater levels are high in the Coyote subbasin, groundwater seeps into the streams.

The movement of groundwater in the Santa Clara subbasin is locally influenced by groundwater recharge activities, proximity to streams, and operating production wells (SCVWD 2010). Regionally, groundwater in Santa Clara County generally flows northwest toward the San Francisco Bay and Delta.

The Santa Clara subbasin has historically experienced decreasing groundwater level trends. Between 1900 and 1960, water level declines of more than 200 feet from groundwater pumping have induced unrecoverable land subsidence of nearly 13 feet (SCVWD 2011). Importation of surface water using CVP, SWP, and San Francisco Public Utilities District water supplies; and the development of an artificial recharge program has resulted in rising groundwater levels since 1965.

The groundwater levels in some portions of this subbasin declined up to 10 feet between fall 2013 and fall 2014, and in some areas more than 10 feet.

The groundwater quality in the Santa Clara subbasin is of good to excellent mineral composition and suitable for most beneficial uses. The groundwater meets all drinking water standards and can be used without additional treatment (SCVWD 2001, 2010). Some areas affected by historical saltwater intrusion exist in the northern portion of the Santa Clara subbasin in the Shallow Aquifer especially near areas of historical subsidence. Recent groundwater monitoring has indicated that seawater intrusion appears to be stabilizing (SCVWD 2012a). High nitrate and organic carbon concentrations occur in localized areas of the Santa Clara Plain subbasin. Ongoing programs have been implemented to cleanup contamination related to high perchlorate concentrations near historic industrial sites in southern Santa Clara County (SCVWD 2012b).

Santa Clara subbasin was designated by the CASGEM program as medium priority.

7.3.4.1.2 Groundwater Use and Management

Use of groundwater in the San Francisco Bay Hydrologic Region varies extensively. In the basins within Contra Costa County (Pittsburg Plain, Clayton Valley, Ygnacio Valley, Arroyo Del Hambre Valley, and San Ramon Valley), local wells are used for small agricultural activities and landscape irrigation by individual land owners. In the Livermore Valley Groundwater Basin, groundwater is used for a major portion of the water supply.

Pittsburg Plain, Clayton Valley, Ygnacio Valley, and Arroyo Del Hambre Valley Groundwater Basins

Groundwater use is limited within northern Contra Costa County within the Pittsburg Plain, Clayton Valley, Ygnacio Valley, and Arroyo Del Hambre Valley groundwater basins. This area is located within the Contra Costa Water District or East Bay Municipal Utilities District service areas. These districts provide surface water to most water users in this area.

Within the Contra Costa Water District service area, groundwater use is limited (CCWD 2011). The use of existing Contra Costa Water District wells at the Mallard Well Fields is limited because of the threat of contamination from adjacent industrial areas.

The City of Pittsburg operates two municipal wells from the Pittsburg Plain Groundwater Basin (Pittsburg 2011).

The City of Martinez operates up to two wells in the Arroyo Del Hambre Valley Groundwater Basin to provide irrigation water to a municipal park (Martinez 2011).

San Ramon Valley Groundwater Basin

Groundwater use is limited within the San Ramon Valley Groundwater Basin located in southern Contra Costa County. Local wells are used for small agricultural activities and landscape irrigation by individual land owners. This area is located within the East Bay Municipal Utilities District service area. The district provides surface water to most water users in this area.

Livermore Valley Groundwater Basin

In the Livermore Valley Groundwater Basin, Zone 7 Water Agency administers oversight of the groundwater basins used for water supply and provides water to California Water Service Company, Dublin San Ramon Services District, City of Livermore, and City of Pleasanton. Zone 7 Water Agency only withdraws groundwater that has been recharged using surface water supplies (Zone 7 2010). The California Water Service Company, Dublin San Ramon Services District, and City of Pleasanton also withdraw groundwater (California Water Service Company 2011h; DSRSD 2011; City of Livermore 2011; City of Pleasanton 2011).

Zone 7 Water Agency manages the groundwater levels and quality in the Livermore Valley Groundwater Basin to maintain groundwater levels that would avoid subsidence and provide emergency reserves for the worst credible drought (DWR 2006q, 2013d).

Zone 7 Water Agency artificially recharges the Livermore Valley Groundwater Basin with local surface water supplies and SWP water by releasing the surface waters into the Arroyo Mocho and Arroyo Valle (Zone 7 2005, 2010). The infiltrated water is then pumped from the groundwater basin for various uses, mostly during the summer and during drought periods when local surface water supplies are diminished and the available SWP water supplies are less than the entitlement value Zone 7 Water Agency, City of Livermore, City of Pleasanton, Dublin San Ramon Services District, and California Water Service Company are permitted to withdraw groundwater from this subbasin.

In 2009, the Zone 7 Water Agency began operation of the Mocho Groundwater Demineralization Plant (Zone 7 2010). This plant is a wellhead treatment plant that produces potable water using reverse osmosis to remove TDS and hardness from the Main Basin.

Castro Valley Groundwater Basin

Groundwater use is limited within the Castro Valley Groundwater Basin. Local wells are used for small agricultural activities and landscape irrigation by individual land owners (Castro Valley 2012). This area is located within the East Bay Municipal Utilities District service area. The district provides surface water to most water users in this area.

Santa Clara Valley Groundwater Basin

The Santa Clara Valley Groundwater Basin includes the East Bay Plain, Niles Cone, and Santa Clara subbasins.

East Bay Plain Subbasin

Groundwater use is limited within the East Bay Plains subbasin. Local wells are used for small agricultural activities and landscape irrigation by individual land owners (DWR 2004ad, 2013d; EBMUD 2013). Well fields that served the communities were initially constructed in the late 1800s and early 1900s, and were closed by 1930. This area is located within the East Bay Municipal Utilities District service area. The district provides surface water to most water users in this area. East Bay Municipal Utilities District initiated the Bayside Groundwater Project in 2009 to store surface water in wet years for use during droughts.

Niles Cone Subbasin

Alameda County Water District is the primary water agency that relies upon the Niles Cone subbasin. This Alameda County Water District uses fresh groundwater from the Niles Cone subbasin and desalinated brackish groundwater in addition to local and imported surface water supplies. The Niles Cone subbasin is primarily recharged in the Alameda Creek watershed by percolation of local runoff and SWP water (ACWD 2011, 2012). In wetter years, when local water supplies are abundant, Alameda County Water District diverts some of the SWP allocation to the Semitropic Water Storage District in Kern County through a water banking agreement (as described above for the Kern County subbasin). This agreement allows Alameda County Water District to subsequently recover this water during drier years through an exchange agreement with Semitropic Water Storage District (ACWD 2012).

Alameda County Water District provides retail water supplies to the cities of Fremont, Newark, and Union City. The district has implemented treatment of brackish groundwater to allow previously unused groundwater to be used as a potable water source (ACWD 2011, 2012). In 2003, the Alameda County Water District Newark Desalination Facility began to remove salts and other constituents from the Niles Cone subbasin groundwater that is subject to seawater intrusion using a reverse-osmosis process. The aquifer reclamation program also includes withdrawing water to prevent a plume of brackish water in the Centerville-Fremont Aquifer from further migrating toward the Alameda County Water District Mowry Wellfield. Future groundwater desalination facilities are being evaluated by the district.

Santa Clara Subbasin

Local water agencies and individual landowners use groundwater in the Santa Clara subbasin. The Santa Clara subbasin is primarily recharged from percolation of local runoff and water supplied by the CVP and/or SWP that is discharged to streambeds and recharge facilities (SCVWD 2011).

Treated water is provided by the Santa Clara Valley Water District to retail water agencies in order to promote conjunctive use of groundwater. The water entities in the Santa Clara subbasin that use treated surface water include the cities of Milpitas, Mountain View, Palo Alto, San Jose, Santa Clara, and Sunnyvale; California Water Service (Los Altos), Great Oaks Water Company, Purissima Water District, and San Jose Water Company. Several of these entities also use surface water from San Francisco Public Utilities Commission as part of their overall water supply.

In the Santa Clara subbasin, groundwater is withdrawn by local water suppliers and private well owners to meet municipal, domestic, agricultural, and industrial water needs (SCVWD 2011). Groundwater provides approximately 40 to

50 percent of total water supply in Santa Clara County in average water year conditions (SCVWD 2010). Within the Santa Clara subbasin, the users of the most groundwater include San Jose Water Company, City of Santa Clara, Great Oaks Water Company, California Water Service, and individual land owners primarily in the southern portion of the subbasin (SCVWD 2012a).

The Santa Clara Valley Water District is responsible for groundwater management in the Santa Clara subbasin, and operates a robust and flexible conjunctive use program that uses a variety of surface water sources: local supplies, imported SWP and CVP supplies, and imported transfer options in conjunction with surface water supplied to some water users by the San Francisco Public Utilities Commission (SCVWD 2001, 2010). The district operates an extensive system of in-stream and off-stream artificial recharge facilities to replenish the groundwater basin and provide more flexibility to manage water supplies. Eighteen major recharge systems allow local reservoir water and imported water to be released in over 30 local creeks and 71 percolation ponds that provide 393 acres for artificial recharge to the groundwater basin. Recharge in this subbasin occurs along streambeds and off-stream managed basins. Most of the recharge facilities are located in the Santa Clara subbasin. Two major recharge facilities, the Lower Llagas and Upper Llagas recharge systems) are located in the Llagas subbasin of the Gilroy-Hollister Groundwater Basin, as described below) (SCVWD 2011, 2012a). The amount of water artificially recharged throughout the entire district depends upon the availability of local, CVP, and/or SWP surface water supplies.

7.3.4.2 Central Coast Hydrologic Region: Gilroy-Hollister Valley Groundwater Basin

Portions of the Gilroy-Hollister Valley Groundwater Basin within the CVP and/or SWP water service areas include the Llagas Area, Hollister Area, and San Juan Bautista Area subbasins.

7.3.4.2.1 Hydrogeology and Groundwater Conditions

Each of these groundwater basins in the Gilroy-Hollister Valley Groundwater Basin contains unique hydrogeologic characteristics. However, generally the water bearing materials consist of alluvial, unconsolidated sand, sand and gravel, and clay. Within four subbasins in the Study Area of this EIS, groundwater flows towards the Pajaro River which flows to Monterey Bay (DWR 2004af, 2004ag, 2004ah, 2004ai, 2013d).

Llagas Area Subbasin

The water bearing formations of the Llagas subbasin include continental deposits of unconsolidated to semi-consolidated gravel, sand, silt and clay (DWR 2004af, 2013d; SCVWD 2010, 2011). Alluvium along the edges and the center portions of the subbasin are underlain by dense clayey soils. Younger alluvium does not have a well-defined clay subsoil.

As described above for the Santa Clara subbasin in the Santa Clara Valley Groundwater Basin, Santa Clara Valley Water District manages groundwater in the Llagas Area subbasin. Groundwater withdrawals in the Llagas subbasin have been relatively stable in recent years; and groundwater elevation has been stable since the late 1990s (SCVWD 2012a).

The groundwater quality in the Llagas subbasin is of good to excellent mineral composition and suitable for most beneficial uses (SCVWD 2010, 2012a). High nitrate concentrations occur in localized areas throughout the subbasin due to historical agricultural practices and wastewater effluent disposal. Santa Clara Valley Water District implemented a Nitrate Management Program in 1997 and nitrate concentrations are beginning to decline.

Bolsa Area, Hollister Area, and San Juan Bautista Subbasins

The Bolsa Area, Hollister Area, and San Juan Bautista Area subbasins extend over northern San Benito County. The subbasins are comprised of a sedimentary sequence that contains the principal aquifers underlying the Hollister and San Juan Valleys. The water bearing formation includes clay, silt, sand, and gravel (DWR 2004ag, 2004ah, 2004ai, 2013e).

The main water bearing formation in this area is composed of alluvium in the Bolsa Area and Hollister Area subbasins (San Benito County Water District 2012). The water bearing formations in the northern San Juan Bautista Area consist of alluvium (San Benito County Water District 2012). Groundwater movement within the aquifers is affected by the numerous faults, including the San Andreas and Calaveras Faults. Groundwater aquifers in this area include both unconfined and confined aquifer conditions with surficial clay deposits in the northern portions of these subbasins.

Groundwater in these subbasins is characterized by artesian conditions when groundwater levels are high, such as in the early 1900s (San Benito County Water District 2012). After the mid-1940s, groundwater levels declined with increased withdrawals. One of the lowest levels occurred in the late 1970s when the groundwater elevation was approximately 150 feet lower than the high water level conditions. In 2012, groundwater elevations ranged from 80 feet above mean sea level in the Bolsa Area subbasin to 700 feet above mean sea level in the San Juan Bautista Area subbasin.

The Bolsa Area, Hollister Area, and San Juan Bautista Area subbasins have localized areas with high concentrations of boron, chloride, hardness, metals, nitrate, sulfate, potassium, and TDS (San Benito County Water District 2012). The most substantial constituents include high TDS concentrations in the southeastern Bolsa Area subbasin, Hollister Area subbasin, and northern San Juan Bautista Area subbasin. High nitrate concentrations occur in the northern San Juan Bautista Area subbasin.

Overall Groundwater Conditions

The Llagas Area subbasin was designated by the CASGEM program as high priority. The Hollister Area and San Juan Bautista Area subbasins were designated as medium priority.

7.3.4.2.2 Groundwater Use and Management

Llagas Area Subbasin

As described in Chapter 5, Surface Water Resources and Water Supplies, groundwater is the primary water supply for local water agencies and individual landowners in the Llagas Area subbasin. The subbasin is primarily recharged from percolation of local runoff and water supplied by the CVP that is discharged to recharge facilities managed by Santa Clara Valley Water District, as described above for the Santa Clara subbasin in the Santa Clara Valley Groundwater Basin (SCVWD 2011). The two major recharge facilities in the Llagas Area subbasin include the Lower Llagas and Upper Llagas recharge systems (SCVWD 2010).

The primary municipal water suppliers are the cities of Gilroy and Morgan Hill. Groundwater is used by these local water suppliers and private well owners to meet municipal, domestic, agricultural, and industrial water needs (SCVWD 2011).

Bolsa Area, Hollister Area, and San Juan Bautista Subbasins

Local water agencies and individual landowners use groundwater in the Bolsa Area, Hollister Area, and San Juan Bautista subbasins. The subbasins are primarily recharged from percolation of local runoff in streambeds, including water from Hernandez and Paicines Reservoirs that is released to Tres Pinos Creek (San Benito County Water District 2012).

San Benito County Water District provides CVP water to the cities of Hollister and San Juan Bautista, Sunnyslope County Water District, residential areas surrounding Hollister and Tres Pinos, and agricultural areas in northern San Benito County to reduce groundwater use by these areas (San Benito County Water District 2012). Most other water users in the subbasins rely upon groundwater and/or local surface water stored in Hernandez and Paicines Reservoirs.

In 2011, groundwater supplies provided 49 percent of the water used for agriculture, municipal, domestic, and industrial supply in the areas of the subbasin supplied by CVP water (San Benito County Water District 2012).

7.3.5 Central Coast Region

The Central Coast Region includes portions of San Luis Obispo and Santa Barbara counties served by the SWP. The Central Coast Region encompasses the southern planning area of the Central Coast Hydrologic Region (DWR 2009a).

The SWP water is provided to the Central Coast Region by the Central Coast Water Authority (CCWA 2013a). The facilities divert water from the SWP California Aqueduct at Devil's Den and convey the water to the 43 million gallon per day water treatment plant at Polonto Pass. The treated water is conveyed to municipal water users in San Luis Obispo and Santa Barbara counties to reduce groundwater overdraft in these areas.

Portions of the Central Coast Region that use SWP water are included in the Central Coast Hydrologic Region which includes 50 delineated groundwater basins, as defined by DWR (DWR 2003a). The basins vary from large extensive alluvial aquifers to small inland valleys and coastal terraces. Groundwater in the large alluvial aquifers exists in thick unconfined and confined basins.

Groundwater is generally used for urban and agricultural use in the Central Coast Region.

7.3.5.1 Hydrogeology and Groundwater Conditions

The areas within the SWP service area in the Central Coast Region include the Morro Valley and Chorro Valley groundwater basins in San Luis Obispo County; Santa Maria River Valley Groundwater Basin in San Luis Obispo and Santa Barbara counties; and San Antonio Creek Valley, Santa Ynez River Valley, Goleta, Foothill, Santa Barbara, Montecito, and Carpinteria groundwater basins in Santa Barbara County, as shown in Figure 7.9.

7.3.5.1.1 Morro Valley and Chorro Valley Groundwater Basins

In the portions of San Luis Obispo County within the SWP service area near Morro Bay, groundwater is provided by Morro Valley and Chorro Valley groundwater basins. The water bearing formations are alluvium that consists of clays, silts, sands, and gravel that extend into the Pacific Ocean (DWR 2004aj, 2004ak, 2013e). The alluvium is recharged by seepage from streambeds and precipitation and irrigation water applied to the soils.

The groundwater has moderate TDS (DWR 2004aj, 2004ak, 2013e). Localized areas have high nitrate concentrations (Morro Bay 2011). Localized areas with organic contamination are also present; however, actions have been implemented to reduce the concentrations. Seawater intrusion occurs in localized areas near the Pacific Ocean.

The Morro Valley and Chorro Valley groundwater basins were designated by the CASGEM program as high priority.

7.3.5.1.2 Santa Maria River Valley Groundwater Basin

The Santa Maria River Valley Groundwater Basin is located in San Luis Obispo and Santa Barbara counties. The water bearing formation is primarily unconfined alluvium with localized confined areas near the coast (DWR 2004 al, 2013e; SMVMA 2012). Recharge occurs along the streambeds. Groundwater levels in the Basin have fluctuated over the past 100 years with declining groundwater levels until the mid-1970s, recovery through the mid-1980s, and declining levels through the mid-1990s. Following importation of SWP water, groundwater levels increased to historic high levels. However, in the last decade, groundwater levels have gradually declined which could be partially due to reductions in Twitchell Reservoir releases for groundwater recharge since 2000. Groundwater levels have been maintained at levels above 15 feet above mean sea level in shallow and deep aquifers near the coast to avoid seawater intrusion. Groundwater recharge occurs along streambeds. Water released from Twitchell and Lopez reservoirs increase groundwater recharge rates (SMVMA 2012).

Groundwater quality issues in the Santa Maria Valley Groundwater Basin include hardness, nitrates, salinity, sulfate and volatile organic compounds (DWR 2004al, 2013e; San Luis Obispo County 2011; SMVMA 2012). TDS concentrations are moderate to high. There are localized areas in the basin with high sulfate concentrations. Volatile organic compound contamination was a major issue for two wells used by the City of San Luis Obispo in the late 1980s. High nitrate concentrations occur in the shallow aquifer due to historic agricultural practices. Higher salinity levels occur in the shallow aquifer near the coast than within the inland areas or in the deep aquifer.

The Santa Maria River Valley Groundwater Basin was designated by the CASGEM program as high priority.

7.3.5.1.3 San Antonio Creek Valley Groundwater Basins

San Antonio Creek Valley Groundwater Basin is located along the Pacific Ocean within San Luis Obispo and Santa Barbara counties. The water bearing formations are characterized by unconsolidated alluvial and terrace deposits of sand, clay, silt, and gravel (DWR 2004dq, 2013e). Groundwater flows towards the Pacific Ocean. A groundwater barrier to the east of the Pacific Ocean creates the Barka Slough. Groundwater has declined in some areas of the basin over the past 60 years. Groundwater quality issues include areas with high salinity near the Pacific Ocean.

The San Antonio Creek Valley Groundwater Basin was designated by the CASGEM program as medium priority.

7.3.5.1.4 Santa Ynez River Valley Groundwater Basins

Several groundwater basins in Santa Barbara County are in a state of overdraft, including the Santa Ynez River Valley Groundwater Basin. The Santa Ynez Groundwater Basin is located along the Pacific Ocean in southwestern Santa Barbara County. The water bearing formations are characterized by unconsolidated alluvial and terrace deposits of gravel, sand, silt, and clay (DWR 2004an, 2013e). Groundwater flows towards the Santa Ynez River, and then towards the Pacific Ocean. Groundwater recharge occurs along the stream beds.

Groundwater quality is generally good for municipal and agricultural uses. There are localized areas with high TDS near the Pacific Ocean due to seawater intrusion (DWR 2004an, 2013e).

The Santa Ynez River Valley Groundwater Basin was designated by the CASGEM program as medium priority.

7.3.5.1.5 Goleta, Foothill, Santa Barbara, Montecito, and Carpinteria Groundwater Basins

The Goleta, Foothill, Santa Barbara, Montecito, and Carpinteria groundwater basins are located in southwestern Santa Barbara County along the Pacific Ocean and near the boundary with Ventura County. The water bearing formations in the Goleta, Foothill, Santa Barbara, and Montecito groundwater basins are unconsolidated alluvium of clay, silt, sand, and/or gravel that overlays the generally confined Santa Barbara Formation of marine sand, silt, and clay (DWR 2004an, 2004ao, 2004ap, 2004aq, 2013e).

In the Carpinteria Groundwater Basin, the alluvium extends under the agricultural plain (DWR 2004ar, 2013e). A confined aquifer occurs under a thick clay bed in the lower part of the alluvium. This basin includes the Santa Barbara Formation; as well as the Carpinteria Formation, of unconsolidated to poorly consolidated sand with gravel and cobble; and the Casitas Formation, of poorly to moderately consolidated clay, silt, sand, and gravel.

Several faults restrict groundwater flow throughout these basins. Recharge occurs along streambeds and from subsurface inflow into the basin from upland areas. Water released from Lake Cachuma increases groundwater recharge rates.

The groundwater levels in portions of these groundwater basins declined up to 10 feet between fall 2013 and fall 2014, and in some areas more than 10 feet (DWR 2014d).

Groundwater quality is generally good for municipal and agricultural uses. There are localized areas with high TDS near the Pacific Ocean due to seawater intrusion (DWR 2004an, 2004ao, 2004ap, 2004aq, 2004ar, 2013e; GWD and LCMWC 2010). High concentrations of nitrate, iron, and manganese occur in localized areas in the Goleta Groundwater Basin. Localized areas of high nitrate and sulfate concentrations occur within the Foothill Groundwater Basin. High concentrations of calcium, magnesium, bicarbonate, and sulfate occur in localized areas of the Santa Barbara Groundwater Basin. High concentrations of iron and manganese occur in localized areas of the Montecito Groundwater Basin. Localized areas with high nitrates occur within the Carpinteria Groundwater Basin. Other basins are in equilibrium due to management of the basin through conjunctive use by local water districts (Santa Barbara County 2007). The Goleta Groundwater Basin generally is near or above historical groundwater conditions (Goleta Groundwater Basin and La Cumbre Mutual Water Company 2010), with the northern and western portions of the basin having groundwater levels near the ground surface. High groundwater levels may result in degradation to building foundations and agricultural crops (water levels within the crop root zone).

The Goleta Groundwater Basin was designated by the CASGEM program as medium priority. Goleta, Foothill, Santa Barbara, Montecito, and Carpinteria groundwater basins were designated as very low priority.

7.3.5.2 Groundwater Use and Management

Groundwater is an important source of water supply for the population of the Central Coast; it is the region's primary water source.

7.3.5.2.1 Morro Valley and Chorro Valley Groundwater Basins

As described in Chapter 5, Surface Water Resources and Water Supplies, the City of Morro Bay uses groundwater from Morro Valley and Chorro Valley groundwater basins. These basins have been designated by the State Water Resources Control Board as riparian underflow basins. The City of Morro Bay and other users of these basins have received water rights permits which limits the rate and volume of groundwater withdrawals (Morro Bay 2011).

7.3.5.2.2 Santa Maria River Valley Groundwater Basin

The Santa Maria River Valley Groundwater Basin is the primary water supply for irrigation in southwestern San Luis Obispo County and northwestern Santa Barbara County. Groundwater also is a major portion of the water supplies for the communities of Pismo Beach, Grover Beach, Arroyo Grande, Oceano, Nipomo, and several smaller communities in San Luis Obispo County; and Guadalupe, Santa Maria, and Orcutt in Santa Barbara County (City of Grover Beach 2011). In many cases, groundwater is the total water supply for these communities including Nipomo Community Services District (NCSD 2011).

The groundwater basin was adjudicated as defined by a settlement agreement, or stipulation, in 2005 that was filed in 2008. The stipulation defined the safe yield of the basin and measures to protect groundwater supplies (Pismo Beach 2011, Arroyo Grande 2012, NCSD 2011, Santa Maria 2011). The stipulation provided for the Northern Cities Management Area, Nipomo Mesa Management Area, and Santa Maria Valley Management Area. The groundwater adjudication considers groundwater recharge from precipitation and applied irrigation water; and water released from Reclamation's Twitchell Reservoir and San Luis Obispo Flood Control and Water Conservation District's Lopez Reservoir that recharge the basin from the downstream stream beds.

The cities of Pismo Beach, Grover Beach, Arroyo Grande; Oceano Community Services District; San Luis Obispo County; and San Luis Obispo Flood Control and Water Conservation District have formed the Northern Cities Management Area to manage and protect groundwater supplies in accordance with the adjudication stipulation (Pismo Beach 2011, Arroyo Grande 2012, NCSD 2011). Historical monitoring reporting indicates that the groundwater levels have varied from 20 feet above to 20 feet below mean sea level. When groundwater levels are below mean sea level, there is a potential for sea water intrusion. In 2008, groundwater levels in this area were approximately 10 feet below mean sea level. In 2010, groundwater levels had recovered and ranged from 0 to 20 feet above mean sea level. Overdraft conditions occurred more frequently prior to the groundwater adjudication and completion of the Central Coast Water Authority project that provides SWP water supplies to the area. There is a deep aquifer under the City of Arroyo Grande (Pismo Formation) that provides groundwater not addressed in the adjudicated Santa Maria Groundwater Basin.

Agricultural water users and the communities of Guadalupe, Orcutt, and Santa Maria use groundwater in the Santa Maria Valley Management Area of the Santa Maria Groundwater Basin (SMVMA 2012). Historically, groundwater was used to provide almost 50 percent of the water supply to the City of Santa Maria. Recently, groundwater supplies have become 10 to 20 percent of the total water supply to the city (Santa Maria 2011). Groundwater provides most of the water supplies in Orcutt (Golden State Water Company 2011a).

7.3.5.2.3 San Antonio Creek Valley Groundwater Basin

Groundwater is used for agricultural and domestic water supplies in the San Antonio Creek Valley Groundwater Basin, including the Los Alamos area (DWR 2004dq, 2013e).

7.3.5.2.4 Santa Ynez River Valley Groundwater Basin

Groundwater is used for agricultural and domestic water supplies in the Santa Ynez River Valley Groundwater Basin. As described in Chapter 5, Surface Water Resources and Water Supplies, groundwater is used by all agricultural water users and the communities of Buellton, Lompoc, Solvang, Mission Hills, Vandenberg Village, and Santa Ynez (DWR 2004am, 2013e; Santa Barbara County 2007).

7.3.5.2.5 Goleta, Foothill, Santa Barbara, Montecito, and Carpinteria Groundwater Basins

Groundwater is used agricultural and domestic water supplies in the Goleta, Foothill, Santa Barbara, Montecito, and Carpinteria groundwater basins within Santa Barbara County. Goleta Water District and La Cumbre Mutual Water Company are the major communities that use groundwater in the Goleta Groundwater Basin (DWR 2004an; GWD 2011; GWD and LCMWC 2010). This basin is operated under an adjudication settlement in 1989 and a voter-passed groundwater management plan. Historically, Goleta Water District provided up to 14 percent of the water supply by groundwater. As described in Chapter 5, Surface Water Resources and Water Supplies, Goleta Water District has increased use of surface water from Lake Cachuma and the SWP; and decreased long-term average use of groundwater to about 5 percent of the total water supply.

Portions of the La Cumbre Mutual Water Company and City of Santa Barbara use groundwater from the Foothill Groundwater Basin. The City of Santa Barbara also relies upon groundwater from the Santa Barbara Groundwater Basin. The City of Santa Barbara manages groundwater in accordance with the Pueblo Water Rights (Santa Barbara 2011).

Montecito Water District uses groundwater from the Montecito Groundwater Basin. Carpinteria Valley Water District uses groundwater from the Carpinteria Groundwater Basin (Carpinteria Valley WD 2011). Total groundwater pumping averages approximately 3,700 acre-feet per year.

7.3.6 Southern California Region

The Southern California Region includes portions of Ventura, Los Angeles, Orange, San Diego, Riverside, and San Bernardino counties served by the SWP. The Southern California Region groundwater basins are as varied as the geology that occurs in different geographic portions of the region. Therefore, the following discussions are organized in the following subregions.

- Ventura County and northwestern Los Angeles County
- Central and southern Los Angeles County and Orange County
- Western San Diego County
- Western and central Riverside County and southern San Bernardino County
- Antelope Valley and Mojave Valley

7.3.6.1 Western Ventura County and Northwestern Los Angeles County

The areas within the SWP service area in Ventura County and northwestern Los Angeles County in the Southern California Region include the Acton Valley Groundwater Basin in Los Angeles County; Santa Clara River Valley, Thousand Oaks Area, and Russell Valley groundwater basins in Ventura and Los Angeles counties; and Simi Valley, Las Posas Valley, Pleasant Valley, Arroyo Santa Rosa Valley, Tierre Rejada, and Conejo Valley groundwater basins in Ventura County, as shown in Figure 7.10.

7.3.6.1.1 Hydrogeology and Groundwater Conditions

Acton Valley Groundwater Basin

The Acton Valley Groundwater Basin is located upgradient of the Santa Clara River Valley Groundwater Basin and drains towards the Santa Clara River. Water bearing formations include unconsolidated alluvium of sand, gravel, silt, and clay with cobbles and boulders; and poorly consolidated terraced deposits (DWR 2004as; 2013f). Recharge occurs along the streambed, water applied to the soils, and subsurface inflow. Groundwater is characterized by calcium, magnesium, and sulfate bicarbonate with localized areas of high concentrations of TDS, sulfate, nitrate, and chlorides.

Acton Valley Groundwater Basin was designated by the CASGEM program as very low priority.

Santa Clara River Valley Groundwater Basin

The Santa Clara River Valley Groundwater Basin is the source of local groundwater along the Santa Clara River watershed from the Santa Clarita Valley in northwestern Los Angeles County to the Pacific Ocean near the City of Oxnard in Ventura County. The Santa Clara River Valley Groundwater Basin includes the Piru, Fillmore, Santa Paula, Mound, and Oxnard subbasins in Ventura county; and Santa Clara River Valley East Subbasin in Los Angeles County. Groundwater movement is effected by the occurrence of several fault zones (DWR 2004at, 2004au, 2006s, 2006t, 2006u, 2013f). Groundwater recharge occurs along the Santa Clara River and its tributaries, and by percolation of precipitation and applied irrigation water.

The Santa Clara River Valley East Subbasin is characterized by unconsolidated alluvium of sand, gravel, silt, and clay; poorly consolidated terrace deposits of gravel, sand, and silt; and the Saugus Formation of poorly consolidated sandstone, siltstone, and conglomerate (DWR 2006s, 2013f).

The Piru, Fillmore, Santa Paula, Mound, and Oxnard subbasins are characterized by alluvium of silts and clays interbedded with sand and gravel lenses; and the San Pedro Formation of fine sands and gravels over the alluvium (DWR 2004at, 2004au, 2006t, 2006u, 2006v, 2013f).

Groundwater quality in the Santa Clara River Valley Groundwater Basin is suitable for a variety of beneficial uses. However, some areas have been impaired by elevated TDS, nitrate, and boron concentrations (DWR 2004at, 2004au, 2006t, 2006u, 2006v, 2013f; CLWA et al. 2012). Groundwater quality is characterized by fluctuating salinity that increases during dry periods. Localized areas of high nitrates and organic compounds occur due to historic agricultural activities and wastewater disposal.

The Piru, Oxnard, and Santa Clara River Valley East subbasins were designated by the CASGEM program as high priority. The Fillmore, Santa Paula, and Mound subbasins were designated as medium priority.

Simi Valley Groundwater Basin

The Simi Valley Groundwater Basin is located in Ventura County (DWR 2004av, 2013f). Water bearing formations in this basin are characterized by generally unconfined alluvium of gravel, clays, and sands; with local clay lenses that provide confined aquifers. The Simi Fault confines the basin on the northern boundary. Groundwater recharge occurs along stream beds. Groundwater quality is characterized as calcium sulfate with localized areas of high TDS and organic contaminants.

Simi Valley Groundwater Basin was designated by the CASGEM program as low priority.

Las Posas Valley and Pleasant Valley Groundwater Basins

The Las Posas Valley and Pleasant Valley groundwater basins are located in western Ventura County. Groundwater is found within these basins in thick alluvium that is dominated by sand and gravel in the eastern part of the Las Posas Valley Groundwater Basin; and by silts and clays with lenses of sands and gravels in the western part of the Las Posas Valley Groundwater Basin and the Pleasant Valley Groundwater Basin (DWR 2006w, 2006x, 2013f). Underlying the alluvium are the San Pedro and Santa Barbara formations of gravels, sands, silts and clays with a discontinuous aquitard located within the Santa Barbara Formation. The movement of groundwater is locally influenced by features such as faults, structural depressions and constrictions and operating production wells; however, groundwater generally flows west-southwest toward the Oxnard Subbasin. Hydrographs from the Las Posas Valley and Pleasant Valley Groundwater Basins have exhibited a variety of groundwater-level histories over the past couple decades. Most hydrographs in the eastern part of the Las Posas

Valley Groundwater Basin indicate relatively unchanged groundwater levels or a slight rise since 1994. Most hydrographs in the western Las Posas Valley and Pleasant Valley groundwater basins indicate that groundwater levels have risen to and been maintained at moderate levels since 1992.

Groundwater quality in the Las Posas Valley and Pleasant Valley groundwater basins is suitable for a variety of beneficial uses. Moderate to high TDS concentrations occur in the Las Posas Valley Groundwater Basin and the Pleasant Valley Groundwater Basin (DWR 2006w, 2006x, 2013f).

The Las Posas Valley and Pleasant Valley groundwater basins were designated by the CASGEM program as high priority.

Arroyo Santa Rosa Valley Groundwater Basin

The Arroyo Santa Rosa Valley Groundwater Basin is located within Ventura County. The water bearing formations include alluvium of gravel, sand, and clay; and the alluvial San Pedro Formation of sand and gravel (DWR 2006y, 2013f). Groundwater recharge occurs along the Santa Clara River and the tributaries, and by percolation of precipitation and applied irrigation water. Fault zones affect groundwater movement within the basin. Groundwater quality is adequate for community and agricultural water uses. Localized areas of high sulfate and nitrate concentrations occur within the basin.

Arroyo Santa Rosa Valley Groundwater Basin was designated by the CASGEM program as medium priority.

Tierra Rejada Valley, Conejo Valley, and Thousand Oaks Area Groundwater Basins

The Tierra Rejada Valley, Conejo Valley, and Thousand Oaks groundwater basins in southern Ventura County are characterized by shallow alluvium that overlays marine sandstone and shale of the Modelo and Topanga formations (DWR 2004aw, 2004ax, 2004ay, 2013f). In some portions of the basin, the Topanga Formation of volcanic tuff, debris flow, and basaltic flow occurs. Groundwater recharge occurs along the streambeds and by percolation of precipitation and applied irrigation water. Fault zones affect groundwater movement within the basins. Groundwater quality is adequate for community and agricultural water uses. Localized areas of high alkalinity and nitrate concentrations occur within the basins. High iron and TDS occur in the Thousand Oaks Area Groundwater Basin (Thousand Oaks 2011).

Conejo Valley Groundwater Basin was designated by the CASGEM program as low priority. The Tierra Rejada Valley and Thousand Oaks Area groundwater basin were designated as very low priority.

Russell Valley Groundwater Basin

The Russell Valley Groundwater Basin is located along the boundaries of Ventura and Los Angeles counties (DWR 2004az, 2013f). This small groundwater basin is characterized by unconsolidated, poorly bedded, sand, gravel, silt, and clay with cobbles and boulders. The groundwater is recharged by precipitation within the basin. Groundwater quality is characterized by sodium bicarbonate and calcium bicarbonate with high sulfates and TDS in some localized areas.

Russell Valley Groundwater Basin was designated by the CASGEM program as very low priority.

7.3.6.1.2 Groundwater Use and Management

Groundwater is an important water supply throughout the Southern California Region. Many of the basins have been adjudicated and groundwater management agencies have been established to manage, preserve, and regulate groundwater withdrawals and recharge actions. In Ventura County, the Fox Canyon Groundwater Management Agency was established in 1982 to implement a groundwater plan that identifies withdrawal allocations and groundwater elevation and quality criteria (MWDSC 2007).

Acton Valley Groundwater Basin

As described in Chapter 5, Surface Water Resources and Water Supplies, the Acton community primarily uses groundwater supplemented by SWP water treated at the Antelope Valley East Kern Acton Water Treatment Plant (Los Angeles County 2014b).

Santa Clara River Valley Groundwater Basin

Communities and agricultural water users in the Santa Clara River Valley Groundwater Basin use a combination of surface water and groundwater to meet water demands. Agricultural use of groundwater is greater than community use of groundwater in this basin (UCWD 2012).

Four retail water purveyors provide water service to most residents of the Santa Clara River Valley East Subbasin. These water purveyors include the Castaic Lake Water Agency; Santa Clarita Water Division, Los Angeles County Waterworks District Number 36; Newhall County Water District; and Valencia Water Company. Groundwater is used by the communities of Santa Clarita, Saugus, Canyon Country, Newhall, Val Verde, Hasley Canyon, Valencia, Castaic, Stevenson Ranch (CLWA et al. 2012).

Water purveyors in the Piru, Fillmore, Santa Paula, Mound, and Oxnard subbasins include United Water Conservation District and Ventura County. United Water Conservation District operates surface water facilities to encourage groundwater protection through conjunctive use (UWCD 2012). Groundwater issues within the United Water Conservation District service area (which includes all of the basin) include overdraft conditions, sea water intrusion, and high nitrate concentrations.

Simi Valley Groundwater Basin

The Simi Valley area primarily relies upon surface water supplies, including SWP water supplies. Groundwater is used to supplement these supplies and by users that cannot be easily served with surface water. Groundwater is provided by Golden State Water Company service area and Ventura County Waterworks District No. 8. The Golden State Water Company provides less 10 percent of the total water supply to the area (Golden State Water Company 2011b). Ventura County Waterworks District No. 8 provides groundwater to a golf course, nursery, and industrial user in the Simi Valley area (VCWD8 2011).

Las Posas Valley and Pleasant Valley Groundwater Basins

Communities and agricultural water users in the Las Posas Valley and Pleasant Valley groundwater basins use a combination of surface water and groundwater to meet water demands. Agricultural use of groundwater is greater than community use of groundwater in this basin (UCWD 2012). United Water Conservation District and Ventura County manage water service to many residents of the Las Posas Valley and Pleasant Valley groundwater basins.

As described above, United Water Conservation District operates surface water facilities to encourage groundwater protection through conjunctive use (UWCD 2012). Groundwater is used within the United Water Conservation District service area, which includes western Las Posas Valley and Pleasant Valley groundwater basins. The Oxnard Subbasin of the Santa Clara River Valley Groundwater Basin and Las Posas Valley and Pleasant Valley groundwater basins are within the groundwater management plan established by the Fox Canyon Groundwater Management Agency (Fox Canyon GMA 2013). The groundwater management agency manages and monitors groundwater in areas with groundwater overdraft and seawater intrusion which includes the communities of Port Hueneme, Oxnard, Camarillo, and Moorpark. The long-term average groundwater use within Fox Canyon Groundwater Management Agency includes a portion of the withdrawals reported by United Water Conservation District.

The Calleguas Municipal Water District, in partnership with Metropolitan Water District of Southern California (Metropolitan), operates the Las Posas Basin Aquifer Recharge and Recovery project. Calleguas Municipal Water District stores SWP surplus water in the Las Posas Valley Groundwater Basin, near the City of Moorpark. The current Aquifer Recharge and Recovery system includes 18 wells (Calleguas MWD 2011).

Arroyo Santa Rosa Valley Groundwater Basin

Communities and agricultural water users in the Arroyo Santa Rosa Valley Groundwater Basin use a combination of surface water and groundwater to meet water demands. Camarosa Water District and Fox Canyon Groundwater Management Agency manage groundwater supplies within the basin (Camarosa WD 2013).

Tierra Rejada Valley, Conejo Valley, and Thousand Oaks Area Groundwater Basins

Groundwater in the Tierra Rejada Valley, Conejo Valley, and Thousand Oaks Area groundwater basins is primarily used by agricultural and individual residential water users. Portions of the Tierra Rejada Valley Groundwater Basin is within the Camarosa Water District; however, this area is primarily open space and agricultural land uses with individual wells (Camarosa WD 2013). The City of Thousand Oaks does operate two wells; however, the city primarily relies upon

SWP water supplies because of the high iron concentrations and salinity in the groundwater (Thousand Oaks 2011).

Russell Valley Groundwater Basin

Most groundwater users in the Russell Valley Groundwater Basin are agricultural and individual residential water users. Portions of the basin are located within the Calleguas Municipal Water District. However, the district does not use water from this basin (Calleguas MWD 2011). The Las Virgenes Municipal Water District withdraws groundwater from the Russell Basin to augment recycled water supplies (GLCIRWMR 2014).

7.3.6.2 Western Los Angeles County and Orange County

The areas within the SWP service area in Central and Southern Los Angeles County and Orange County in the Southern California Region include the San Fernando Valley, Raymond, San Gabriel Valley, Coastal Plain of Los Angeles, and Malibu Valley groundwater basins in Los Angeles County; Coastal Plain of Orange County and San Juan Valley groundwater basins in Orange County, as shown in Figure 7.10.

7.3.6.2.1 Hydrogeology and Groundwater Conditions

San Fernando Valley Groundwater Basin

The San Fernando Valley Groundwater Basin extends under the Los Angeles River watershed. Groundwater flows toward the middle of the basin, beneath the Los Angeles River Narrows, to the Central Subbasin of the Coastal Plain of Los Angeles Basin. The water bearing formation is mainly unconfined gravel and sand with clay lenses that provide some confinement in the western part of the basin (DWR 2004ba).

Groundwater movement is affected by the occurrence of several fault zones (DWR 2004ba). Groundwater is recharged naturally from precipitation and stream flow and from imported water and reclaimed wastewater that percolates into the groundwater from stormwater spreading grounds.

In the San Fernando Valley Groundwater Basin, the groundwater is characterized by calcium, magnesium, radioactive material, and sulfate bicarbonate with localized areas of high TDS, volatile organic compounds, petroleum compounds, chloroform, pesticides, nitrate, and sulfate (DWR 2004ba, ULARAW 2013). There are several ongoing groundwater remediation programs within the groundwater basin to reduce volatile organic compounds and one program to reduce hexavalent chromium.

San Fernando Valley Groundwater Basin was designated by the CASGEM program as medium priority.

Raymond Groundwater Basin

The Raymond Groundwater Basin is located to the north of the San Gabriel Valley Groundwater Basin. Groundwater flow is affected by the occurrence of several fault zones; and causes the groundwater to flow into the San Gabriel Valley Groundwater Basin. The water bearing formations are mainly unconsolidated gravel, sand, and silt with local areas of confinement (DWR 2004bb). Groundwater is recharged naturally from precipitation and stream flow and from water that percolates into the groundwater from spreading grounds and local dams.

In the Raymond Groundwater Basin, the groundwater is characterized by calcium, magnesium, and sulfate bicarbonate with localized areas of high volatile organic compounds, nitrate, radioactive material, and perchlorate (DWR 2004bb). There is an ongoing groundwater remediation program within the groundwater basin to reduce volatile organic compounds and perchlorate.

Raymond Groundwater Basin was designated by the CASGEM program as medium priority.

San Gabriel Valley Groundwater Basin

Groundwater in the San Gabriel Valley Groundwater Basin flows from the San Gabriel Mountains towards the west under the San Gabriel Valley to the Whittier Narrows where it discharges into the Coastal Plain of the Los Angeles Groundwater Basin (DWR 2004bc). Groundwater in the San Gabriel Valley Groundwater Basin also is interconnected to groundwater in the Chino subbasin of the Upper Santa Ana Valley Groundwater Basin in Riverside County. The northeastern portion of the San Gabriel Valley Groundwater Basin adjacent to the Chino subbasin includes six subbasins and is known as "Six Basins." The water-bearing formations include unconsolidated to semi-consolidated alluvium deposits of gravel, sands, and silts.

Groundwater recharge occurs from direct percolation of precipitation and stream flow, including treated wastewater effluent conveyed in the San Gabriel River (DWR 2004bc). In the San Gabriel Valley Groundwater Basin, the groundwater is characterized by calcium bicarbonate with localized areas of high TDS, carbon tetrachloride nitrate, and volatile organic compounds (DWR 2004bc).

San Gabriel Valley Groundwater Basin was designated by the CASGEM program as high priority.

Coastal Plain of Los Angeles Groundwater Basin

The Coastal Plain of Los Angeles Groundwater Basin includes the Hollywood, Santa Monica, Central, and West Coast subbasins.

Hollywood Subbasin

The Hollywood subbasin is located to the north of the Central subbasin and upgradient of the Santa Monica subbasin. Groundwater flows towards the Pacific Ocean (DWR 2004bd). The water bearing formations are mainly alluvial gravel. Groundwater is recharged naturally from precipitation and stream flow.

The Hollywood subbasin was designated by the CASGEM program as very low priority.

Santa Monica Subbasin

The Santa Monica subbasin is located to the north of the West Coast subbasin and to the west of the Hollywood subbasin. Groundwater flows towards the west and the Hollywood subbasin (DWR 2004be). The water bearing formations are mainly alluvial gravel and sand with semi-perched areas over silt and clay deposits. Unconfined shallow aquifers occur in the northern and eastern portions of the subbasin. Confined deeper aquifers occur in the remaining portion of the subbasin. Groundwater is recharged naturally from precipitation and stream flow.

The Santa Monica subbasin was designated by the CASGEM program as high priority.

Central Subbasin

The Central subbasin is located to the east of the West Coast subbasin. The Central subbasin is characterized by shallow sediments and extends from the Los Angeles River Narrows with groundwater flows from the San Gabriel Valley (DWR 2004bf).

The non-pressurized, or forebay, portions of the subbasin are located in the northern portion of the subbasin in unconfined aquifers underlying the Los Angeles and San Gabriel rivers (DWR 2004bf). These areas provide the major recharge areas for the subbasin. The “pressure” areas are confined aquifers composed of permeable sands and gravel separated by less permeable sandy clay and clay, and constitute the main water-bearing formations. Several faults and uplifts create some restrictions to groundwater flow in the subbasin while others run parallel to the groundwater flow and do not restrict flow.

In the Central subbasin, the groundwater is characterized by localized areas of high inorganics and volatile organic compounds (DWR 2004bf).

The Central subbasin was designated by the CASGEM program as high priority.

West Coast Subbasin

The West Coast subbasin is located on the southern coast of Los Angeles County to the west of the Central subbasin. The water bearing formations are composed of unconfined and semi-confined aquifers composed of sands, silts, clays, and gravels (DWR 2004bg). Several fault zones paralleling the coast act as partial barriers to groundwater flow in certain areas. The general regional groundwater flow pattern is southward and westward toward the Pacific Ocean. Recharge occurs through groundwater flow from the Central subbasin, and from infiltration along the Los Angeles and San Gabriel rivers. Seawater intrusion occurs along the Pacific Ocean coast.

In the West Coast subbasin, the most critical issue is high TDS along the Pacific Ocean coast due to seawater intrusion. As described below, several agencies have implemented sea water barrier projects to protect the groundwater quality.

The West Coast subbasin was designated by the CASGEM program as high priority.

Malibu Valley Groundwater Basin

The Malibu Valley Groundwater Basin is an isolated alluvial basin in northern Los Angeles County along the Pacific Ocean Coast under the Malibu Creek watershed (DWR 2004bh). Groundwater flows towards the Pacific Ocean. The water bearing formations are mainly gravel, sand, clays, and silt (DWR 2004bb). Groundwater is recharged naturally from precipitation and stream flow.

In the Malibu Valley Groundwater Basin, the groundwater is characterized by localized areas of high TDS due to sea water intrusion along the Pacific Ocean coast (DWR 2004bh).

The Malibu Valley Groundwater Basin was designated by the CASGEM program as very low priority.

Coastal Plain of Orange County Groundwater Basin

The Coastal Plain of Orange County Groundwater Basin is located under a coastal alluvial plain in northern Orange County (DWR 2004 bi). Groundwater is recharged naturally from precipitation and injection wells to reduce seawater intrusion. The water bearing formations are mainly interbedded marine and continental sand, silt, and clay deposits (DWR 2004bi). The Newport-Inglewood fault zone parallels the coast and generally forms a barrier to groundwater flow. Groundwater recharge occurs along the Santa Ana River. Water levels are characterized by seasonal fluctuations (DWR 2013f; Orange County 2009). Groundwater flowed towards the Pacific Ocean prior to recent development. However, due to extensive groundwater withdrawals, there are groundwater depressions that result in potential sea water intrusion. Groundwater levels have increased since the 1990s following implementation of several recharge programs.

In the Coastal Plain of Orange County Groundwater Basin, the groundwater is characterized as sodium-calcium bicarbonate with localized areas of high TDS due to sea water intrusion along the Pacific Ocean coast, as well as nitrate, and volatile organic compounds (DWR 2004bi).

The Coastal Plain of Orange County Groundwater Basin was designated by the CASGEM program as medium priority.

San Juan Valley Groundwater Basin

The San Juan Valley Groundwater Basin is located in southern Orange County (DWR 2004bj). Groundwater flows towards the Pacific Ocean. The water bearing formations are mainly sand, clays, and silt. Groundwater is recharged naturally from precipitation and stream flows from San Juan and Oso creeks and Arroyo Trabuca.

In the San Juan Valley Groundwater Basin, the groundwater is characterized as calcium bicarbonate, bicarbonate-sulfate, calcium-sodium sulfate, and sulfate-chloride with localized areas of high TDS due to sea water intrusion along the Pacific Ocean coast and high fluoride near hot springs near Thermal Canyon (DWR 2004bj).

The San Juan Valley Groundwater Basin was designated by the CASGEM program as low priority.

7.3.6.2.2 Groundwater Use and Management

Groundwater is an important water supply throughout the Southern California Region. Many of the groundwater basins in Los Angeles and Orange counties have been adjudicated, as summarized in Table 7.1, and groundwater management agencies have been established to manage, preserve, and regulate groundwater withdrawals and recharge actions.

San Fernando Valley Groundwater Basin

The communities and agricultural users in the San Fernando Valley Groundwater Basin use a combination of surface water and groundwater to meet water demands (GLCIRWMR 2014; ULARAW 2013). The Metropolitan Water District of Southern California provides wholesale surface water supplies to several communities. The cities of Los Angeles, Glendale, Burbank, San Fernando, Crescenta Valley, Bell Canyon, and Hidden Hills provide retail water supplies, including groundwater, to the communities. The groundwater basin has been adjudicated and is managed by the Upper Los Angeles River Area Watermaster.

Groundwater is recharged in the San Fernando Valley Groundwater Basin through seepage of precipitation within the groundwater basin, including the recharge of stormwater at spreading grounds between 1968 and 2012; and storage of imported water (ULARAW 2013). The spreading basins for stormwater flows are operated by Los Angeles County and the cities of Los Angeles and Burbank. A portion of the extracted groundwater is exported to areas that overly other groundwater basins.

The operations of the San Fernando Valley Groundwater Basin are defined by the Upper Los Angeles River Area January 26, 1979 Final Judgment; the Sylmar Basin Stipulations of August 26, 1983; and subsequent agreements. These agreements, as managed by the Upper Los Angeles River Area Watermaster, provide for the right to extract a percent of surface water, including applied recycled water, that enters within specified subbasins of the San Fernando Valley Groundwater Basin with specific calculations to identify maximum withdrawals for the cities of Burbank, Glendale, Los Angeles, and San Fernando and Crescenta Valley Water District; the right to store and withdraw water within specified subbasins by the cities of Burbank, Glendale, Los Angeles, and San Fernando; and the acknowledgment that the City of Los Angeles has an exclusive Pueblo Water Right for the native safe yield of the San Fernando subbasin within the larger San Fernando Valley Groundwater Basin.

Raymond Groundwater Basin

The communities in the Raymond Groundwater Basin use a combination of surface water and groundwater to meet water demands (GLCIRWMR 2014). The Metropolitan Water District of Southern California and Foothills Municipal Water District provide wholesale surface water supplies to several communities. The cities of Alhambra, Arcadia, Pasadena, San Marino, and Sierra Madre; Upper San Gabriel Municipal Water District; and Valley Water Company and several other private water companies, provide retail water supplies, including groundwater, to the communities to Altadena, Las Crescenta-Montrose, La Cañada Flintridge, Rubio Canyon, and South Pasadena. The City of Alhambra and San Gabriel Valley Municipal Water District; can withdraw groundwater from the Raymond Basin, but currently are not operating wells within this groundwater basin (City of Alhambra 2011).

The groundwater basin was the first adjudicated groundwater basin in California and is managed by the Raymond Basin Management Board as the Watermaster (RBMB 2014). The Raymond Basin Management Board limits the amount of groundwater withdrawals in different areas of the basin, and allows for short-term and long-term storage of water in the groundwater basin.

Groundwater is recharged in the Raymond Groundwater Basin through seepage of precipitation within the groundwater basin, injection wells, and spreading basins operated by Los Angeles County and the cities of Pasadena and Sierra Madre (MWDSC 2007). Water from Metropolitan Water District of Southern California, which is generally a combination of SWP water and Colorado River water, cannot be used for direct recharge if the TDS is greater than 450 milligrams/liter (RBMB 2014). A portion of the extracted groundwater is exported to areas that overly other groundwater basins.

San Gabriel Valley Groundwater Basin

The communities in the San Gabriel Valley Groundwater Basin use a combination of surface water and groundwater to meet water demands (GLCIRWMR 2014; MWDSC 2007). The Metropolitan Water District of Southern California, San Gabriel Valley Municipal Water District, Upper San Gabriel Municipal Water District; Three Valleys Municipal Water District, and Covina Irrigating Company provide wholesale surface water and/or groundwater supplies to several communities. The cities of Alhambra, Arcadia, Azusa, Covina, El Monte, Glendora, La Verne, Monrovia, Pomona, San Marino, and Upland; San Gabriel County Water District and Valley County Water District; Golden State Water Company, San Antonio Water Company, San Gabriel Valley Water Company, Suburban Water Systems, Valencia Heights Water Company, and several other private water companies, provide retail water supplies, including groundwater, to users within their communities and to the communities of Baldwin Park, Bradbury, Claremont, Duarte, Hacienda Heights, Irwindale, La Puente, Montebello, Monterey Park, Pico Rivera, Rosemead, San Dimas, San Gabriel, Santa Fe Springs, Sierra Madre, South El Monte, South San Gabriel, Temple City, Valinda, and Whittier (City of Alhambra 2011; City of Arcadia 2011; City of La Verne 2011; City of Pomona 2011; City of Upland 2011; Golden State Water Company 2011c; SGCWD 2011; SGVWC 2011; Suburban Water Systems 2011; SAWCO 2011; TVMWD 2011; USGVMWD 2011).

The San Gabriel Valley Groundwater Basin includes several adjudicated basins. A portion of the groundwater basin is managed by the San Gabriel River Watermaster and the Main San Gabriel Basin Watermaster (MWDSC 2007; SGVWC 2011). The Watermasters coordinate groundwater elevation and water quality monitoring, coordinate imported water supplies, coordinate recharge operations with imported water and recycled water, manage the amount of groundwater withdrawals in different areas of the basin by balancing the amount of groundwater recharge, and allow for short-term and long-term storage of water in the groundwater basin. Groundwater is recharged through seepage of precipitation within the groundwater basin, injection wells, and spreading basins operated by Los Angeles County and a private water company (MWDSC 2007). Water recharged into the spreading basins from Metropolitan Water District of Southern California and San Gabriel Valley Municipal Water District.

The Six Basins portion of the groundwater basin also is adjudicated and managed by the Six Basins Watermaster Board (MWDSC 2007). The Watermaster manages withdrawals and requires replenishment obligation of equal amounts for withdrawals over the operating safe yield of the basin. The Pomona Valley Protective Agency conveys flows from San Antonio Creek and SWP water to the San Antonio Spreading Grounds; and from local waters to the Thompson Creek Spreading Grounds. The City of Pomona conveys flows from local surface waters to the Pomona Spreading Grounds. Los Angeles County Department of Public Works conveys flows from local surface water and SWP water to the Live Oak Spreading Grounds.

The cities of Alhambra, Arcadia, La Verne, Monterey Park, San Gabriel Valley Water Company, and other water entities operate groundwater treatment facilities to remove dichloroethane, chloroform, other volatile organic compounds, and/or nitrates (City of Alhambra 2011; City of Arcadia 2011; City of Monterey Park 2012; MWDSC 2007; SGVWC 2011).

Coastal Plain of Los Angeles Groundwater Basin

The Coastal Plain of Los Angeles Groundwater Basin includes four subbasins: Hollywood, Santa Monica, Central and West Coast.

Hollywood Subbasin

The primary user of groundwater in the Hollywood subbasin is the City of Beverly Hills (MWDSC 2007). The basin is not adjudicated. The city manages the groundwater subbasin through limits on withdrawals and discharges to the groundwater. Groundwater is recharged through seepage of precipitation within the groundwater subbasin (City of Beverly Hills 2011). All groundwater withdrawn by the city is treated to reduce salinity.

Santa Monica Subbasin

The primary user of groundwater in the Santa Monica subbasin is the City of Santa Monica (MWDSC 2007). The basin is not adjudicated. Groundwater is recharged through seepage of precipitation within the groundwater subbasin (City of Santa Monica 2011; MWDSC 2007). Groundwater treatment is provided to a portion of the subbasin withdrawals to reduce volatile organic compounds, and methyl tertiary butyl ether.

Central Subbasin

The communities in the Central subbasin use a combination of surface water and groundwater to meet water demands (GLCIRWMR 2014; MWDSC 2007). The Metropolitan Water District of Southern California and Central Basin Municipal Water District provide wholesale surface water supplies to several communities.

The cities of Bell, Bell Gardens, Cerritos, Compton, Cudahy, Downey, Huntington Park, Lakewood, Long Beach, Los Angeles, Lynwood, Monterey Park, Norwalk, Paramount, Pico Rivera, Santa Fe Springs, Signal Hill, South Gate, Vernon, and Whittier; Los Angeles County Water District, La Habra Heights County Water District, Orchard Dale Water District, and Paramount Water District; Golden State Water Company, Suburban Water Systems, Bellflower-Somerset Mutual Water Company, Montebello Land & Water Company; Park Water Company, Dominguez Water Corp, California Water Service Company, San Gabriel Valley Water Company, Walnut Park Mutual Water Company, and several other private water companies, provide retail water supplies, including groundwater, to users within their communities and to the communities of Artesia, Commerce, Dominguez, East La Mirada, East Los Angeles, East Rancho, Florence-Graham, Hawaiian Gardens, La Mirada, Los Nieto, Maywood, Montebello, South Whittier, Walnut Park, Westmount, West Whittier, and Willow Brook (CBMWD 2011; BSMWC 2011; City of Compton 2011; City of Downey 2012; City of Huntington Park 2011; City of Lakewood 2011; City of Long Beach 2011; City of Los Angeles 2011; City of Monterey Park 2012; City of Norwalk 2011; City of Paramount 2011; City of Pico Rivera 2011; City of Santa Fe Springs 2011; City of South Gate; City of Vernon 2011; City of Whittier 2011; LHHCWD 2012; Golden State Water Company 2011d, 2011e, 2011f, 2011g; Suburban Water Systems 2011).

The Central subbasin was adjudicated, and is managed by DWR. The adjudication specifies a total amount of allowed annual withdrawals (or Allowable Pumping Allocation) in the Central subbasin (MWDSC 2007; WRD 2013a). Approximately 25 percent of the water users of groundwater from the Central subbasin are not located on the land that overlies the subbasin (CBMWD 2011). Groundwater from the San Gabriel Valley Groundwater Basin also is used by water users that overlie the Central subbasin.

The Water Replenishment District of Southern California has the statutory authority to replenish the groundwater in the Central and West Coast subbasins of the Coastal Plain of Los Angeles Groundwater Basin. The Water Replenishment District of Southern California purchases water for water replenishment facilities operated by Los Angeles County Department of Public Works at the Montebello Forebay near the Rio Hondo and San Gabriel Rivers near the boundaries of the Central and West Coast subbasins (CBMWD 2011; Los Angeles County 2015; WRD 2013a). The Montebello Forebay includes the Rio Hondo Coastal Basin Spreading Grounds along the Rio Hondo Channel; the San Gabriel River Coastal Basin Spreading Grounds; and the unlined reach of the lower San Gabriel River from Whittier Narrows Dam to Florence Avenue (LACDPW 2014, WRD 2013a).

The replenishment water is purchased water from two different sources: recycled water from various regional treatment facilities, and imported water (WRD 2013a). The recycled water is used for groundwater recharge at the spreading grounds and at the seawater barrier wells. Water Replenishment District of Southern California must blend recycled water with other water sources to meet the groundwater recharge water quality and volumetric requirements established by the State Water Resources Control Board. This blended water is either imported water from the SWP and/or the Colorado River, or untreated surface water flows from the San Gabriel River, Rio Hondo River, and waterways in the San Gabriel Valley (CBMWD 2011). Up to 35 percent of the replenishment water can be provided from recycled water supplies. Several recent projects have been implemented to store stormwater flows for increased replenishment water volumes.

In the Central subbasin, the Water Replenishment District of Southern California also purchases imported and recycled water for injection by the Los Angeles County Department of Public Works into the portion of the Alamitos Barrier Project located in Los Angeles County to reduce seawater intrusion (MWDSC 2007; WRD 2007). Initially, imported SWP water was used to prevent seawater intrusion. However, over the past 20 years, recycled water has been used for a substantial amount of the groundwater injection program. The Water Replenishment District of Southern California is planning to fully use recycled water at the Alamitos Gap Barrier Project by 2014 (WRD 2013b).

The cities of Long Beach, Monterey Park, South Gate, and Whittier operate groundwater treatment facilities in the Central subbasin (City of Long Beach 2012; City of Monterey Park 2012; City of South Gate; City of Whittier 2011).

West Coast Subbasin

The communities in the Central subbasin use a combination of surface water and groundwater to meet water demands (GLCIRWMR 2014; MWDSC 2007). The Metropolitan Water District of Southern California and West Basin Municipal Water District provide wholesale surface water supplies to several communities. The cities of Inglewood, Lomita, Manhattan Beach, and Torrance; Golden State Water Company, California Water Service Company, and several other private water companies, provide retail water supplies, including groundwater, to users within their communities and to the communities of Athens, Carson, Compton, Del Aire, Gardena, Hawthorne, Hermosa Beach, Inglewood, Lawndale, Lennox, Redondo Beach, Torrance (WBMWD 2011a; City of Inglewood 2011; City of Lomita 2011; City of Manhattan Beach 2011; City of Torrance 2011; Golden State Water 2011h; California Water Service Company 2011b, 2011c, 2011d, 2011e). The communities of El Segundo, Long Beach, and Los Angeles overlie the West Coast subbasin; however, no groundwater from this subbasin is used in these communities due to water quality issues and facilities locations. Groundwater use is primarily for emergency uses, including firefighting, in the communities of Hawthorne, Lomita, and Torrance due to high concentrations of minerals (e.g., iron and manganese), sulfides, and/or volatile organic compounds.

The West Coast subbasin was adjudicated, and is managed by DWR. The adjudication specifies a total amount of allowed annual withdrawals (or Allowable Pumping Allocation) in the West Coast subbasin (MWDSC 2007; WBMWD 2011a; WRD 2013a). Groundwater from the Central subbasin is used by some water users that overlie the West Coast subbasin.

The Water Replenishment District of Southern California has the statutory authority to replenish the groundwater in the Central and West Coast subbasins of the Coastal Plain of Los Angeles Groundwater Basin. In the West Coast subbasin, the Water Replenishment District of Southern California purchases imported and recycled water for injection by the Los Angeles County Department of Public Works into the West Coast Barrier Project and the Dominguez Barrier Project (MWDSC 2007; WRD 2007; WRD 2013). Water is purchased by the Water Replenishment District of Southern California for injection at the barrier projects (WRD 2013). Initially, imported SWP water was used to prevent seawater intrusion. However, over the past 20 years, recycled water has been used for a substantial amount of the groundwater injection program. The Water Replenishment District of Southern California is planning to fully use recycled water at the West Coast Barrier Project and the Dominguez Barrier Project by 2014 and 2017, respectively (WRD 2013b).

California Water Service Company operates groundwater treatment facilities within the community of Hawthorne (California Water Service Company 2011b). The Water Replenishment District of Southern California operates the Robert W. Goldsworthy Desalter near Torrance to reduce salinity for up to 18,000 acre-feet/year of groundwater that is located inland of the West Coast Basin Barrier (WRD 2013a).

The West Basin Municipal Water District treats brackish groundwater at the C. Marvin Brewer Desalter Facility for two wells near Torrance that are affected by a saltwater plume in the West Coast subbasin (WBMWD 2011a).

Malibu Valley Groundwater Basin

No groundwater is used by the communities in this groundwater basin, including the Malibu area (Los Angeles County 2011; MWDSC 2007).

Coastal Plain of Orange County Groundwater Basin

The communities in the Coastal Plain of Orange County Groundwater Basin use a combination of surface water and groundwater to meet water demands (MWDSC 2007). The Municipal Water District of Orange County, Orange County Water District, and East Orange County Water District provide wholesale surface water supplies to several communities. The cities of Anaheim, Buena Park, Fountain Valley, Fullerton, Garden Grove, Huntington Beach, La Habra, La Palma, Newport Beach, Orange, Santa Ana, Seal Beach, Tustin, and Westminister; East Orange County Water District, Irvine Ranch Water District, Mesa Consolidated Water District, Rowland Water District, Serrano Water District, Walnut Valley Water District, and Yorba Linda Water District; Golden State Water Company, California Water Service Company, California Domestic Water Company, and several other private water companies, provide retail water supplies, including groundwater, to users within their communities and to the communities of Brea, Costa Mesa, Cypress, Diamond Bar, Garden Grove, Hacienda Heights, Industry, Irvine, La Palma, La Puente, Los Alamitos, Midway City, Newport Beach, Orange, Panorama Heights, Placentia, Pomona, Rowland Heights, Rossmoor, Seal Beach, Stanton, Villa Park, Walnut, West Covina, West

Orange, and Yorba Linda (City of Anaheim 2011; City of Brea 2011; City of Buena Park 2011; City of Fountain Valley 2011; City of Fullerton 2011; City of Garden Grove 2011; City of Huntington Beach 2011; City of La Habra 2011; City of La Palma 2011; City of Newport Beach 2011; City of Orange 2011; City of Santa Ana 2011; City of Seal Beach 2011; City of Tustin 2011; City of Westminister 2011; IRWD 2011; MCWD 2011; RWD 2011; SWD 2011; WVWD 2011; YLWD 2011; Golden State Water Company 2011i, 2011j). Groundwater use is primarily for non-potable water uses in West Covina and for supplemental supplies for users of recycled water in Rowland Heights.

The Coastal Plain of Orange County Groundwater Basin is managed by Orange County Water District in accordance with special State legislation to increase supply and provide uniform costs for groundwater (MWDSC 2007). The basin is managed to maintain a water balance over several years using two step pricing levels to incentivize users to obtain alternative water supplies after withdrawing a basin production target. The groundwater basin is managed to provide approximately a three-year drought supply.

Orange County Water District manages an extensive groundwater recharge program in the Coastal Plain of Orange County Basin (Orange County Water District 2014). The Orange County Water District manages spreading basins along the Santa Ana River and Santiago Creek for groundwater recharge (MWDSC 2007). Water is supplied to these basins with flows diverted from the Santa Ana River into the recharge basins at inflatable rubber dams, SWP water, and recycled water from the Orange County Water District/Orange County Sanitation District Groundwater Replenishment System Advanced Water Purification Facility (OCWD n.d.).

The Orange County Water District also injects water into the Talbert Barrier and the portion of the Alamitos Barrier Project within Orange County. Water supplies for the seawater barriers include water from the Groundwater Replenishment System and SWP water (GWRS n.d.; MWDSC 2007).

The Irvine Desalter Project was initiated in 2007 by Orange County Water District, Irvine Ranch Water District, Metropolitan Water District of Orange County, Metropolitan Water District of Southern California, and the U.S. Navy to reduce TDS and salts (IRWD 2011; MWDSC 2007). Several other treatment facilities remove volatile organic compounds. The city of Tustin operates the Tustin Seventeenth Street Desalter to reduce TDS within the Tustin community (MWDSC 2007). The City of Garden Grove and Mesa County Water District operate treatment facilities to reduce nitrates and compounds that change the color of the water, respectively (City of Garden Grove 2011; MCWD 2011).

San Juan Valley Groundwater Basin

The communities in the San Juan Groundwater Basin use a combination of surface water and groundwater to meet water demands (MWDSC 2007). The Municipal Water District of Orange County provides wholesale surface water supplies to several communities. The City of San Juan Capistrano; Moulton Niguel Water District, Santa Margarita Water District, and South Coast Water

District provide retail water supplies to users within their communities and to the communities of Coto de Caza, Dana Point, Laguna Forest, Laguna Woods, Las Flores, Ladera Ranch, Mission Viejo, Rancho Santa Margarita, South Laguna, Talega, (City of San Juan Capistrano 2011; MNWD 2011; SCWD 2011; SMWD 2011). Most of the groundwater use occurs within or near the City of San Juan Capistrano. Groundwater use is small or does not occur within the Santa Margarita Water District, South Coast Water District, and Moulton Niguel Water District service areas.

The San Juan Basin Authority manages water resources development in the San Juan Valley Groundwater Basin and in the surrounding San Juan watershed to protect water quality and water resources (MWDSC 2007; SJBA 2013). In addition to community uses, groundwater also is used for agricultural and industrial purposes and golf course irrigation. Overall, groundwater provides less than 10 percent of the total water supply within the groundwater basin.

The City of San Juan Capistrano Groundwater Recovery Plant reduces iron, manganese, and TDS concentrations. This city is modifying the treatment plant to reduce recently observed high concentrations of methyl tertiary butyl ether (MTBE) (City of San Juan Capistrano 2011; MWDSC 2007). The South Coast Water District operates the Capistrano Beach Groundwater Recovery Facility in Dana Point to reduce iron and manganese concentrations (SCWD 2011; MWDSC 2007).

7.3.6.3 Western San Diego County

The areas within the SWP service area in western San Diego County in the Southern California Region include the San Mateo Valley Groundwater Basin in Orange and San Diego counties; and the San Onofre Valley, Santa Margarita Valley, San Luis Rey Valley, Escondido Valley, San Marcos Area, Batiquitos Lagoon Valley, San Elijo Valley, San Dieguito Creek, Poway Valley, San Diego River Valley, El Cajon Valley, Mission Valley, Sweetwater Valley, Otay Valley, Tijuana Basin groundwater basins in San Diego County, as shown in Figure 7.11.

7.3.6.3.1 Hydrogeology and Groundwater Conditions

In San Diego County, several smaller groundwater basins exist, in the western portion of the county. The most productive groundwater basins are characterized by narrow river valleys filled with shallow sand and gravel deposits. Groundwater occurs farther inland in fractured bedrock and semi consolidated sedimentary deposits with limited yield and storage (SDCWA et al. 2013).

San Mateo Valley, San Onofre Valley, and Santa Margarita Valley Groundwater Basins

The San Mateo Valley Groundwater Basin is located in southern Orange County and northern San Diego County (DWR 2004bk). The San Onofre Valley and Santa Margarita Valley groundwater basins are located in northwestern San Diego County (DWR 2004bl, 2004bm). Groundwater flows towards the Pacific Ocean. The water bearing formations are mainly gravel, sand, clays, and silt. Groundwater is recharged naturally from precipitation and stream flows. In the

San Mateo Valley and San Onofre Valley groundwater basins, treated wastewater effluent discharged from the Marine Corps Base Camp Pendleton wastewater treatment plants into local streams also recharges the groundwater. In the San Mateo Valley and Santa Margarita Valley groundwater basins, the groundwater is characterized as calcium-sulfate-chloride. In the San Onofre Valley Groundwater Basin, the groundwater is characterized as calcium-sodium bicarbonate-sulfate. Localized areas with high boron, chloride, magnesium, nitrate, sulfate, and TDS occur in the Santa Margarita Valley Groundwater Basin.

Santa Margarita Valley Groundwater Basin was designated by the CASGEM program as medium priority. San Mateo Valley and San Onofre Valley groundwater basins were designated as very low priority.

San Luis Rey Valley Groundwater Basin

The San Luis Rey Valley Groundwater Basin is located in northwestern San Diego County (DWR 2004bn). Groundwater flows towards the Pacific Ocean. The water bearing formations are mainly gravel and sand. Under some portions of the alluvial aquifer, partially consolidated marine terrace deposits of partly consolidated sandstone, mudstone, siltstone, and shale occur. Groundwater is recharged naturally from precipitation and stream flows, and from runoff that flows into the streams from lands irrigated with SWP water. The groundwater is characterized as calcium-sodium bicarbonate-sulfate with localized areas of high magnesium, nitrate, and TDS (MWDSC 2007).

San Luis Rey Valley Groundwater Basin was designated by the CASGEM program as medium priority.

San Marcos Valley, Escondido Valley, San Pasqual Valley, Pamo Valley, Santa Maria Valley, and Poway Valley Groundwater Basins

The San Marcos Valley, Escondido Valley, San Pasqual Valley, Pamo Valley, Santa Maria Valley, and Poway Valley groundwater basins are located in the foothills within central, western San Diego County. The water bearing formations are mainly alluvium of sand, gravel, clay, and silt; consolidated sandstone; or weathered crystalline basement rock (DWR 2004bo, 2004bp, 2004bq, 2004br, 2004bs, 2004bt). The basins area bounded by semi-permeable marine and non-marine deposits and impermeable granitic and metamorphic rocks. Groundwater is recharged naturally from precipitation and stream flows, and from runoff that flows into the streams from irrigated lands. The groundwater is characterized with moderate to high concentrations of salinity. There are localized areas with high sulfate and nitrate concentrations in the Santa Maria Valley Groundwater Basin.

San Pasqual Valley Groundwater Basin was designated by the CASGEM program as medium priority. San Marcos Valley, Escondido Valley, Pamo Valley, Santa Maria, and Poway Valley groundwater basins were designated as very low priority.

Batiquitos Lagoon Valley, San Elijo Valley, and San Dieguito Valley Groundwater Basins

The Batiquitos Lagoon Valley, San Elijo Valley, and San Dieguito Valley groundwater basins are located along the central San Diego County coast of the Pacific Ocean. The water bearing formations are mainly alluvium of sand, gravel, clay, and silt with areas of consolidated sandstone (DWR 2004bu, 2004bv, 2004bw). Some areas of the Batiquitos Lagoon Valley Groundwater Basin are bounded by impermeable crystalline rock. Groundwater is recharged naturally from precipitation and stream flows, and from runoff that flows into the streams from irrigated lands. The groundwater is characterized with moderate to high concentrations of salinity.

Batiquitos Valley, San Elijo Valley, and San Dieguito Valley groundwater basins were designated by the CASGEM program as very low priority.

San Diego River Valley, El Cajon, Mission Valley, Sweetwater Valley, Otay Valley, and Tijuana Groundwater Basins

The San Diego River Valley, El Cajon, Mission Valley, Sweetwater Valley, Otay Valley, and Tijuana groundwater basins are located in the southwestern portion of San Diego County. The water bearing formations are mainly alluvium of sand, gravel, cobble, clay, and silt; or siltstone and sandstone (DWR 2004bx, 2004by, 2004bz, 2004ca, 2004cb, 2004cc). Groundwater is recharged naturally from precipitation and stream flows, and from runoff that flows into the streams from irrigated lands. The groundwater is characterized with moderate to high levels of salinity. A recent study by USGS evaluated the sources and movement of saline groundwater in these groundwater basins (USGS 2013b). The chloride concentrations ranged from 57 to 39,400 mg/L. The sources of salinity were natural geologic sources and sea water intrusion. There are localized areas with high sulfate and magnesium concentrations.

San Diego River Valley Groundwater Basin was designated by the CASGEM program as medium priority. El Cajon, Mission Valley, Sweetwater Valley, Otay Valley, and Tijuana groundwater basins were designated as very low priority.

7.3.6.3.2 Groundwater Use and Management

Groundwater production and use in the San Diego region is currently limited due to a lack of aquifer storage capacity, available recharge, and degraded water quality due to high salinity. Groundwater currently represents about 3 percent of the water supply portfolio within the areas of San Diego County that could be served by SWP water (SDCWA et al. 2013).

San Mateo Valley, San Onofre Valley, and Santa Margarita Valley Groundwater Basins

The primary user of groundwater in the San Mateo Valley, San Onofre Valley, and Santa Margarita Valley groundwater basins is the Marine Corps Base Camp Pendleton (FPUD 2011; MWDSC 2007; SCWD 2011; SDCWA et al. 2013). The Marine Corps Base Camp Pendleton withdraws approximately 8,500 acre-feet/year from the three groundwater basins and operates spreading basins to recharge the groundwater in the Santa Margarita Valley Groundwater Basin. Portions of the South Coast Water District overlie the northern portions of the San Mateo Valley Groundwater Basin; however, the district does not withdraw water from that basin. Fallbrook Public Utility District overlies northern portions of the Santa Margarita Valley Groundwater Basin; however, the district currently uses a small amount of groundwater to meet their water demand (FPUD 2011).

The Santa Margarita Valley Groundwater Basin is within an adjudicated watershed (SMRW 2011). The Santa Margarita River Watermaster manages both surface water and groundwater that contributes direct or indirect flows into the Santa Margarita River in accordance with the Modified Final Judgment and Decrees of 1966 by the U.S. District Court in the *United States v. Fallbrook Public Utility et al*. The watershed includes the Santa Margarita Valley Groundwater Basin near the Pacific Ocean and the Temecula Valley groundwater basins in the upper Santa Margarita River Watershed within Riverside County, as discussed in the following subsection. Within San Diego County, the only groundwater user in the Santa Margarita Valley Groundwater Basin is the Marine Corps Base Camp Pendleton.

San Luis Rey Valley Groundwater Basin

The communities in the San Luis Rey Valley Groundwater Basin use a combination of surface water and groundwater to meet water demands (City of Oceanside 2011; MWDSC 2007; RMWD 2011; VCMWD 2011; YMWD 2014a, 2014b). The San Diego County Water Authority provides wholesale surface water supplies to several communities. The City of Oceanside; Rainbow Municipal Water District, Valley Center Municipal Water District, and Yuima Municipal Water District; and Rancho Pauma Mutual Water Company and several other private water companies provide retail water supplies to users within their communities. Groundwater use is small or does not occur within the Rainbow Municipal Water District or Valley Center Municipal Water District. Groundwater also is used on agricultural lands, especially for orchards in the Pauma area (San Diego County 2010). The Tribal lands also depend upon groundwater including lands within the La Jolla Reservation, Los Coyotes Reservation, Pala Reservation, Pauma & Yuima Reservation, Rincon Reservation, and Santa Ysabel Reservation (SDCWA et al. 2013).

There are three municipal water districts that overlie the San Luis Rey Valley Groundwater Basin that manage water rights protection efforts. Groundwater is the only water supply within the Pauma Municipal Water District and the primary water supplies within the Mootamai Municipal Water District and the San Luis Rey Municipal Water District (SDLAFCO 2011; SDCWA et al. 2013). The districts protect groundwater, surface water rights, and water storage; and to coordinate planning studies and legal activities within the San Luis Rey River watershed. Vista Irrigation District withdraws and stores groundwater in Lake Henshaw and withdraws groundwater in a subbasin located upgradient the San Luis Rey Valley Groundwater Basin.

San Marcos, Escondido Valley, San Pasqual Valley, Pamo Valley, Santa Maria Valley, and Poway Valley Groundwater Basins

The communities in the San Marcos, Escondido Valley, San Pasqual Valley, Pamo Valley, Santa Maria Valley, and Poway Valley groundwater basins use a combination of surface water and groundwater to meet water demands (City of Escondido 2011; City of Poway 2011; Ramona MWD 2011; RDDMWD 2011; VWD 2011). The San Diego County Water Authority provides wholesale surface water supplies to several communities. The cities of Escondido and Poway; Ramona Municipal Water District, Rincon del Diablo Municipal Water District, Vallecitos Water District, and Vista Irrigation District; and private water companies provide retail water supplies to users within their communities. Groundwater use is small or does not occur within the cities of Escondido and Poway, Ramona Municipal Water District, Rincon del Diablo Municipal Water District, and Vallecitos Water District. Ramona Municipal Water District used to use groundwater until high nitrate concentrations required the district to abandon the wells.

Batiquitos Lagoon Valley, San Elijo Valley, and San Dieguito Valley Groundwater Basins

The communities in the Batiquitos Lagoon Valley, San Elijo Valley, and San Dieguito Valley groundwater basins primarily use surface water to meet water demands (CMWD 2011; OMWD 2011; SDLAFCO 2011; SDWD 2011; SFID 2011). The San Diego County Water Authority provides wholesale surface water supplies to several communities. Groundwater use is limited to private wells within the Carlsbad Municipal Water District, including the City of Carlsbad; Olivenhain Municipal Water District, including the cities of Encinitas, Carlsbad, San Diego, Solano Beach, and San Marcos, and the communities of Olivenhain, Leucadia, Elfin Forest, Rancho Santa Fe, Fairbanks Ranch, Santa Fe Valley, and 4S Ranch; San Dieguito Water District, including the communities of Encinitas, Cardiff-by-the-Sea, New Encinitas, and Old Encinitas; and Santa Fe Irrigation District, including the City of Solana Beach and the communities of Rancho Santa Fe and Fairbanks Ranch. Groundwater was used within the Carlsbad Municipal Water District area until high salinity caused the area to abandon the wells. Questhaven Municipal Water District manages groundwater for a recreation community located to the west of Escondido.

San Diego River Valley, El Cajon, Mission Valley, Sweetwater Valley, Otay Valley, and Tijuana Groundwater Basins

The communities in the San Diego River Valley, El Cajon, Mission Valley, Sweetwater Valley, Otay Valley, and Tijuana groundwater basins use a combination of surface water and groundwater to meet water demands (California American Water Company 2012; City of San Diego 2011; HWD 2011; OWD 2011; PDMWD 2011; SDCWA et al. 2013; Sweetwater Authority 2011). The San Diego County Water Authority provides wholesale surface water supplies to several communities. The City of San Diego, Helix Water District, and Sweetwater Authority provide retail surface water and/or groundwater supplies to users within cities of La Mesa, Lemon Grove, National City, and San Diego;

portions of Chula Vista and El Cajon; and all or portions of the communities of Bonita, Lakeside, and Spring Valley. The County of San Diego–Campo Water and Sewer Maintenance District, Cuyamaca Water District, Decanso Community Services District, Julian Community Services District, Majestic Pines Community Services District, Wynola Water District, Lake Morena Oak Shores Mutual Water Company, Pine Hills Mutual Water Company, and Pine Valley Mutual Water Company rely upon groundwater to meet their water demands. Groundwater is not used for water supplies within Padre Dam Municipal Water District which serves the City of Santee and portions of the City of El Cajon; Otay Water District which serves portions of the cities of Chula Vista, El Cajon, and La Mesa, and several unincorporated communities; and California American Water which serves the City of Imperial Beach and portions of the cities of Chula Vista, Coronado, and San Diego. Sweetwater Authority operates the Desalination Facility to treat brackish groundwater (San Diego County LAFCO 2011).

7.3.6.4 Western Riverside County and Southwestern San Bernardino County

The areas within the SWP service area in western and central Riverside County and southern San Bernardino County in the Southern California Region include the Upper Santa Ana Valley Groundwater Basin in Riverside and San Bernardino counties; the Elsinore, San Jacinto Groundwater Basin in Riverside County; and the Temecula Valley Groundwater Basin in Riverside and San Diego counties, as shown in Figure 7.12.

7.3.6.4.1 Hydrogeology and Groundwater Conditions

Upper Santa Ana Valley Groundwater Basin

The Upper Santa Ana Valley Groundwater Basin consists of the Cucamonga, Chino, Riverside-Arlington, Temescal, Rialto-Colton, Cajon, Bunker Hill, Yucaipa, and San Timoteo groundwater subbasins.

Cucamonga Subbasin

The Cucamonga subbasin is located within San Bernardino County in the upper Santa Ana River watershed (DWR 2004 cd; MWDSC 2007). Groundwater is contained within the basin by the Red Hill fault. The water bearing formations are mainly alluvium of gravel, sand, and silt with beds of compacted clay. Groundwater is recharged naturally from precipitation and stream flows, water discharged to spreading basins, and runoff that flows into the streams from irrigated lands, including lands irrigated with SWP water. The groundwater is characterized as calcium-sodium bicarbonate with moderate to high TDS and nitrates, and localized areas with high volatile organic compounds, perchlorate, and dibromochloropropane (DBCP) (MWDSC 2007).

The Cucamonga subbasin was designated by the CASGEM program as medium priority.

Chino Subbasin

The Chino subbasin is located in San Bernardino County. The Chino subbasin is composed of alluvial material. The Rialto-Colton, San Jose, and the Cucamonga faults act as groundwater flow barriers (DWR 2006z). Along the southern boundary of the subbasin, groundwater can rise to the elevation of the Santa Ana River and be discharged into the stream. Groundwater is recharged naturally from precipitation and stream flows along the Santa Ana River and its tributaries, water discharged to spreading basins, and runoff that flows into the streams from irrigated lands, including lands irrigated with SWP water.

The Chino subbasin is characterized with high TDS and nitrate concentrations and localized areas of high volatile organic compounds, and perchlorate (MWDSC 2007).

The Chino subbasin was designated by the CASGEM program as high priority.

Riverside-Arlington Subbasin

The Riverside-Arlington subbasin is located within the Santa Ana River Valley in southwestern San Bernardino County and northwestern Riverside County (DWR 2004ce). Water bearing formations include alluvial deposits of sand, gravel, silt, and clay. The Rialto-Colton Fault separates this subbasin from the Rialto-Colton subbasin. The Riverside and Arlington portions of the subbasin are also separated. Groundwater flows to the northwest and to the Arlington Gap in the southwest area of the subbasin; and continues into the Temescal subbasin. Groundwater is recharged naturally from precipitation and stream flows in the Santa Ana River, and flow from adjacent subbasins. The groundwater is characterized as calcium-sodium bicarbonate with moderate to high TDS and nitrates, and localized areas with high volatile organic compounds, perchlorate, and DBCP (MWDSC 2007).

The Riverside-Arlington subbasin was designated by the CASGEM program as high priority.

Temescal Subbasin

The Temescal subbasin is located within the Santa Ana River Valley in Riverside County. Water bearing formations consist of alluvium bounded by the Elsinore fault zone on the west and the Chino fault zone on the northwest (DWR 2006aa). Groundwater is recharged naturally from precipitation and stream flows in the tributaries of the Santa Ana River. The groundwater is characterized as calcium-sodium bicarbonate with moderate to high TDS and nitrates, and localized areas with high volatile organic compounds, perchlorate, iron, and manganese (MWDSC 2007).

The Temescal subbasin was designated by the CASGEM program as medium priority.

Cajon Subbasin

The Cajon subbasin is located within the upper Santa Ana River Valley in San Bernardino County. Water bearing formations consist of alluvium bounded by the San Andreas Fault zone on the south and impermeable rock formations on the east and west (DWR 2004cf). Groundwater is recharged naturally from precipitation, stream flows in the tributaries of the Santa Ana River, and runoff that flows into the streams from irrigated lands, including lands irrigated with SWP water. The groundwater quality is good for the beneficial uses.

The Cajon subbasin was designated by the CASGEM program as very low priority.

Rialto-Colton Subbasin

The Rialto-Colton subbasin is located within the upper Santa Ana River Valley in southwestern San Bernardino County and northwestern Riverside County. Water bearing formations consist of alluvium bounded by the Rialto-Colton and San Jacinto fault zones (DWR 2004cg). Groundwater is recharged naturally from precipitation and stream flows. The groundwater quality is good for the beneficial uses with localized areas of high volatile organic compounds.

The Rialto-Colton subbasin was designated by the CASGEM program as medium priority.

Bunker Hill Subbasin

The Bunker Hill subbasin is located in San Bernardino County. The water bearing formations include alluvium of sand, gravel, and boulders with deposits of silt and clay bounded by the Rialto-Colton and San Jacinto fault zones (DWR 2004ch). Groundwater is recharged naturally from precipitation, stream flows in the Santa Ana River and its tributaries, water discharged to spreading basins, and runoff that flows into the streams from irrigated lands, including lands irrigated with SWP water. The groundwater quality is good for the beneficial uses. The groundwater is characterized as calcium- bicarbonate with localized areas of high volatile organic compounds and perchlorate within several contamination plumes (*Lockheed Martin Corporation v. United States, Civil Action No. 2008-1160*).

The Bunker Hill subbasin was designated by the CASGEM program as high priority.

Yucaipa Subbasin

The Yucaipa subbasin is located within the upper Santa Ana River Valley in San Bernardino County. Water bearing formations include alluvial deposits of sand, gravel, boulders, silt, and clay (DWR 2004ci). Several fault zones restrict groundwater movement. The San Timoteo formation along the western boundary of the basin causes the water to rise to the elevation of the San Timoteo Wash, a tributary of the Santa Ana River. Groundwater is recharged naturally from precipitation and stream flows, and water discharged to recharge basins. The groundwater is characterized as calcium-sodium bicarbonate with moderate TDS and high nitrate concentrations, and localized areas with high volatile organic compounds.

The Yucaipa subbasin was designated by the CASGEM program as medium priority.

San Timoteo Subbasin

The San Timoteo subbasin is located within the upper Santa Ana River Valley in Riverside County. Water bearing formations include alluvial deposits of gravel, silt, and clay (DWR 2004cj). Several fault zones restrict groundwater movement. Groundwater is recharged naturally from precipitation and stream flows, and water discharged to recharge basins. The groundwater is characterized as calcium-sodium bicarbonate and good quality for the beneficial uses.

The San Timoteo subbasin was designated by the CASGEM program as medium priority.

San Jacinto Groundwater Basin

The San Jacinto Groundwater Basin is located in upper Santa Ana River Valley in Riverside County, and underlies the San Jacinto, Perris, Moreno and Menifee valleys and Lake Perris. The water bearing formations are alluvium over crystalline basement rock (DWR 2006ab). Several fault zones restrict groundwater movement. Groundwater is recharged naturally from precipitation and stream flows along the San Jacinto River and its tributaries, percolation from Lake Perris, and water discharged to recharge basins. The groundwater is characterized as calcium-sodium bicarbonate with high TDS and nitrate concentrations and localized areas with high iron, manganese, sulfides, volatile organic compounds, and perchlorate (DWR 2006ac; MWDSC 2007).

The San Jacinto Groundwater Basin was designated by the CASGEM program as high priority.

Elsinore Groundwater Basin

The Elsinore Groundwater Basin is located in upper Santa Ana River Valley in Riverside County. The water bearing formations are alluvial fan, floodplain, and lacustrine deposits underlain by alluvium of gravel, sand, silt, and clay (DWR 2006ac). Several fault zones restrict groundwater movement. Groundwater is recharged naturally from precipitation and stream flows along the San Jacinto River, and water discharged to recharge basins. The groundwater is characterized as calcium-sodium bicarbonate with moderate salinity and localized areas with high fluoride, arsenic, nitrate, iron, manganese, volatile organic compounds, and perchlorate (DWR 2006ac; MWDSC 2007).

The Elsinore Groundwater Basin was designated by the CASGEM program as high priority.

Temecula Valley Groundwater Basin

The Temecula Valley Groundwater Basin is located in the upper Santa Margarita River watershed within Riverside and San Diego counties. The water bearing formations are alluvium of sand, tuff, and silt underlain by fractured bedrock (DWR 2004ck). Several fault zones restrict groundwater movement. Groundwater is recharged naturally from precipitation and stream flows. The groundwater is characterized as calcium-sodium bicarbonate with high TDS, fluoride, nitrate, volatile organic compounds, and perchlorate (DWR 2006ac; MWDSC 2007).

The Temecula Valley Groundwater Basin was designated by the CASGEM program as high priority.

7.3.6.4.2 Groundwater Use and Management

Upper Santa Ana Valley Groundwater Basin

The Upper Santa Ana Valley Groundwater Basin consists of the Cucamonga, Chino, Riverside-Arlington, Temescal, Rialto-Colton, Cajon, Bunker Hill, Yucaipa, and San Timoteo groundwater subbasins.

Cucamonga and Chino Subbasins

The communities in the Cucamonga and Chino subbasins use a combination of surface water and groundwater to meet water demands (City of Chino 2011; City of Ontario 2011; City of Pomona 2011; City of Upland 2011; Cucamonga Valley WD 2011; FWC 2011; JCSD 2011; MWDSC 2007; MVWD 2011; SAWC 2011; WMWD 2011). The cities of Chino, Ontario, Pomona, and Upland; Cucamonga Valley Water District, Jurupa Community Services District, Monte Vista Water District, and Western Municipal Water District; San Antonio Water Company, Fontana Water Company, Santa Ana River Water Company, and Marygold Mutual Water Company, and Golden State Water Company provide wholesale and/or retail water supplies, including groundwater, to users within their communities and to portions of the City of Rialto, Montclair, Rancho Cucamonga, and San Antonio Heights.

The Cucamonga subbasin was adjudicated in 1958 to allocate groundwater rights in the basin and surface water rights to Cucamonga Creek (City of Chino 2011; Cucamonga Valley WD 2011; MWDSC 2007). The water supplies are allocated to the Cucamonga Valley Water District, San Antonio Water Company, and the West End Consolidated Water Company. The City of Upland has agreements with San Antonio Water Company and the West End Consolidated Water Company to divert from the subbasin.

The Chino subbasin was adjudicated in 1978 through the Chino Basin Judgment which established the Chino Basin Watermaster to manage the subbasin and enforce the provisions of the judgment (City of Chino 2011; Cucamonga Valley WD 2011; MWDSC 2007). The judgment and subsequent agreements allocated the available safe yield to three categories, or pools: Overlying Agricultural Pool, including dairies, farms, and the State of California; Overlying Non-Agricultural Pool for industrial users; and the Appropriative Pool Committee, including local cities, public water agencies, and private water companies. The judgment and subsequent agreements included provisions for reallocation of water rights, groundwater replenishment if the subbasin is operated in a controlled overdraft condition, and development of a groundwater management plan. Through "Peace Agreements" adopted in 2000 and amended in 2004, included provisions to allow: members of the Overlying Non-Agricultural Pool to transfer their water within their pool or to the Watermaster, appropriators to provide water service to overlying lands, and the Watermaster to allocate unallocated safe yield. The Peace Agreement also addressed use of local storage facilities, management of the subbasin under the Dry Year Yield program when imported water, including SWP water, is not fully available. Groundwater replenishment is allowed through spreading basins, percolation, groundwater injection, and in-lieu use of other water supplies, including SWP water. The Chino Basin Watermaster also was required to develop an Optimum Basin Management Plan, adopted in 1998, to address approaches that would enhance basin water supplies, protect and enhance water quality, enhance management of the basin, and equitably finance implementation of programs identified in the plan. The Peace II Agreement was adopted in 2007 addressed procedures related to basin reoperation under controlled overdraft conditions using the Chino Desalters to meet the replenishment obligation and to maintain hydraulic control in the subbasin, and transfers. The Groundwater Recharge Master Plan update was prepared by the Watermaster in 2010.

The Santa Ana Regional Water Quality Control Board adopted a Water Quality Control Plan in 2004 for the entire Santa Ana River Basin which included a Maximum Benefit Basin Plan, recommended by the Chino Basin Watermaster and the Inland Empire Utilities Agency. The plan established water quality objectives in groundwater quality objectives for TDS and Total Inorganic Nitrogen and wasteload allocations to allow use of recycled water for groundwater recharge. The Maximum Benefit Basin Plan includes commitments for surface water and groundwater monitoring programs; implementation of up to 40 million gallons/day of treated groundwater at desalters; implementation of recharge facilities, conjunctive use programs, and recycled water quality management programs; and groundwater management to provide hydraulic controls to protect the Santa Ana River water quality.

Operations of the Chino Basin portion of the upper Santa Ana River are also affected by surface water right judgments administered by the Santa Ana River Watermaster.

A large portion of the natural runoff in the upper Santa Ana River watershed is captured and used to recharge the groundwater aquifers. Flood control channels and percolation basins are operated by San Bernardino County Flood Control District to allow for flood control and groundwater recharge (MWDSC 2007). Groundwater recharge also occurs in spreading basins operated by the City of Upland, San Antonio Water Company, and San Antonio Water Company. The Chino Basin Water Conservation District operates percolation ponds and spreading basins to facilitate groundwater recharge (IEUA 2011).

The Inland Empire Utilities Agency manages production and treatment of recycled water supplies that are used in groundwater recharge operations and as part of conjunctive use programs in the cities of Chino, Chino Hills, Ontario, and Upland; and in the service areas of the Cucamonga Valley Water District, Monte Vista Water District, Fontana Water Company, and San Antonio Water Company (IEUA 2011). The district is a member of the Chino Basin Watermaster Board of Directors. The Inland Empire Utilities Agency operates several recharge facilities in the Chino subbasin. Recharge water comes from three sources: recycled water, stormwater, and imported SWP water. The Inland Empire Utilities Agency operates the Chino Desalter Authority's Chino I and Chino II Desalters that treat water from 22 wells. The Chino Desalter Authority is a joint powers authority that includes the cities of Chino, Chino Hills, Norco, and Ontario; and the Jurupa Community Services District, Santa Ana River Water Company, Western Municipal Water District, and Inland Empire Utilities Agency. The treated water from the desalters is used for potable water supplies, groundwater recharge with water with reduced salts and nitrates, and improved water quality of the Santa Ana River.

Riverside-Arlington and Temescal Subbasins

The communities in the Riverside-Arlington and Temescal subbasins use a combination of surface water and groundwater to meet water demands (City of Corona 2011; City of Norco 2014; City of Rialto 2011; City of Riverside 2011; JCSD 2011; MWDSC 2007; RCWD 2011; SBVMWD 2011; WMWD 2011). The San Bernardino Valley Municipal Water District and Western Municipal Water District provide wholesale and retail water supplies, including groundwater, in the areas that overlay the Riverside-Arlington and Temescal subbasins. The cities of Colton, Corona, Norco, Rialto, and Riverside; Elsinore Valley Municipal Water District; Jurupa Community Services District, Lee Lake Water District; Rubidoux Community Services District, San Bernardino Valley Municipal Water District, Western Municipal Water District, and West Valley Water District; and Box Springs Mutual Water Company, Riverside Highland Mutual Water Company, and Terrace Water Company provide retail water supplies, including groundwater, to users within their communities. The Jurupa Community Services District uses wells within the Riverside-Arlington subbasin for non-potable uses (JCSD 2011).

The Riverside portion of the Riverside-Arlington subbasin was adjudicated in 1969 through the stipulated judgment for the *Western Municipal Water District of Riverside County et al. versus East San Bernardino County Water District, et al*. The judgment provided average annual extraction volumes and replenishment schedules for the separate sections of the subbasin as defined by the San Bernardino County and Riverside County boundary (Riverside North and Riverside South portions of the subbasin) (City of Riverside 2011; MWDSC 2007). Within the Riverside North portion, the judgment affects only withdrawals that are to be used in Riverside County because withdrawals for use of water in San Bernardino County are not limited. The Western-San Bernardino Watermaster manages the monitoring and reporting of groundwater conditions of the Riverside portion of the subbasin.

The northern portion of the Riverside portion of the subbasin also was part of the 1969 judgment in the *Orange County Water District v. City of Chino et al.* This judgment primarily includes the Bunker Hill subbasin and small portions of the northern Riverside, Rialto-Colton, and Yucaipa subbasins; and requires minimum downstream flows into the lower Santa Ana River (SBVMWD 2011). To meet the flow obligations, the San Bernardino Valley Municipal Water District is responsible to manage groundwater and surface waters within the San Bernardino Basin Area, as defined in the judgment. The district manages the groundwater by allocation of groundwater withdrawal amounts and requiring replenishment when additional groundwater is withdrawn.

The Arlington portion of the Riverside-Arlington subbasin and the Temescal subbasins are not adjudicated (City of Corona 2011; MWDSC 2007). In 2008, an agreement was adopted between Elsinore Valley Municipal Water District and the City of Corona for use of water from the southern portion of the Temescal subbasin.

The City of Riverside operates two water treatment plants as part of the North Riverside Water Project to remove volatile organic compounds. The City of Corona operates the Temescal Basin Desalter Treatment Plant/Facility and the Western Municipal Water District operates the Arlington Desalter (City of Corona 2011; WMWD 2011) to reduce TDS. The City of Norco operates a groundwater treatment plant to reduce iron, manganese, and hydrogen sulfide (City of Norco 2014).

Cajon, Rialto-Colton, Bunker Hill, Yucaipa, and San Timoteo Subbasins

The communities in the Cajon, Rialto-Colton, Bunker Hill, Yucaipa, and San Timoteo subbasins use a combination of surface water and groundwater to meet water demands (City of Rialto 2011; City of Riverside 2011; MWDSC 2007; SBVMWD 2011; YVWD 2011; WMWD 2011; West Valley WD 2014a). The San Bernardino Valley Municipal Water District and Western Municipal Water District provide wholesale and retail water supplies, including groundwater, in the areas that overlay the Cajon, Rialto-Colton, Bunker Hill, Yucaipa, and San Timoteo subbasins. The cities of Colton, Loma Linda, Redlands, Rialto, Riverside, and San Bernardino; Beaumont-Cherry Valley Water District, East Valley Water District, South Mesa Water District, West Valley Water District, Western Municipal Water District, West Valley Water District, and Yucaipa Valley Water District; and several private water companies provide retail water supplies, including groundwater, to users within their communities and to portions of the cities of Beaumont, Calimesa, and Yucaipa; the communities of Cherry Valley, Mission Grove, Orange Crest, and Woodcrest; and numerous private water companies.

Groundwater adjudication in these subbasins have occurred over the past 90 years. A portion of the Bunker Hill subbasin underlays the Lytle Creek watershed (City of Rialto 2011). The remaining portion of the Lytle Creek watershed overlays the Lytle Creek groundwater basin that is not included in the DWR Bulletin 118. The entire Lytle Creek groundwater basin, including the portion in the Bunker Hill subbasin, is a major groundwater recharge source to the Bunker Hill and Rialto-Colton subbasins; and was adjudicated in 1924. The stipulation of the judgment allocated groundwater withdrawal right to the City of Rialto, Citizens Land and Water Company, Lytle Creek Water and Improvement Company, Rancheria Water Company, and Mutual Water Company.

The Rialto-Colton subbasin was adjudicated in 1961 under the *Lytle Creek Water & Improvement Company vs. Fontana Ranchos Water Company et al* (City of Rialto 2011). The adjudication allocated groundwater withdrawals between the cities of Rialto and Colton, West Valley Water District, and Fontana Union Water Company based upon spring groundwater levels at three index wells between March and May of each water year. The groundwater subbasin is managed by the Rialto Basin Management Association. The stipulation of the judgment allocated groundwater withdrawal right to the City of Rialto, Citizens Land and Water Company, Lytle Creek Water and Improvement Company, and private well users. Use of this aquifer has been limited due to contamination with volatile organic compounds which are currently being treated. The City of Rialto also has agreements with San Bernardino Municipal Water District to store SWP water in the Rialto subbasin. The city can withdraw the stored water without affecting the water allowed to be withdrawn under the 1961 decree.

As described above under the Riverside-Arlington and Temescal Subbasins section, in 1969 the stipulated judgment for the *Western Municipal Water District of Riverside County et al. versus East San Bernardino County Water District, et al*. to preserve the safe yield of the San Bernardino Basin Area through entitlements to groundwater withdrawals to protect the safe yield and establishment of replenishment schedules when the safe yield is exceeded (City of Rialto 2011; SBVMWD 2011). The San Bernardino Basin Area includes the Bunker Hill subbasin and portions of the Rialto-Colton and Yucaipa subbasins; and portions of the Mill Creek, Lytle Creek, and upper Santa Ana River watersheds. The Western-San Bernardino Watermaster, which includes Western Municipal Water District and San Bernardino Municipal Water District, manages the monitoring and reporting of groundwater conditions. The primary users of the groundwater under this decree include the cities of Colton, Loma Linda, Redlands, and Rialto; East Valley Water District, San Bernardino Municipal Water District, West Valley Water District, and Yucaipa Valley Water District; Riverside-Highland Water Company and 13 private water companies.

In 2002, the City of Beaumont, Beaumont-Cherry Valley Water District, South Mesa Water Company, and Yucaipa Valley Water District formed the San Timoteo Watershed Management Authority to enhance water supplies and water quality, manage groundwater in the Beaumont Basin (part of the San Timoteo subbasin), protect riparian habitat in San Timoteo Creek, and allocate benefits and costs of these programs (Beaumont Basin Watermaster 2013; SBVMWD 2011). One of the issues that the authority initiated was negotiations related to groundwater withdrawals by the City of Banning. A Stipulated Agreement was adopted in 2004 in accordance with the judgment for the *San Timoteo Watershed Management Authority, vs. City of Banning et al.* The judgment established a Watermaster committee of the cities of Banning and Beaumont, Beaumont-Cherry Valley Water District, South Mesa Water Company, and Yucaipa Valley Water District. The judgment allocated groundwater supplies in a manner that allows for storage of groundwater recharge from spreading basins or in-lieu programs.

The Seven Oaks Accord, a settlement agreement, was signed by the City of Redlands; East Valley Water District, San Bernardino Valley Municipal Water District, and Western Municipal Water District; and Bear Valley Mutual Water Company, Lugonia Water Company, North Fork Water Company, and Redlands

Water Company to recognize prior rights of water users of a portion of the natural flow of the Santa Ana River (SBVMWD 2011). The Seven Oaks Accord requires that San Bernardino Valley Municipal Water District, and Western Municipal Water District develop a groundwater spreading program to recharge the groundwater in cooperation with other parties to the accord to maintain relatively constant groundwater levels.

In 2005, the San Bernardino Valley Municipal Water District entered into an agreement with the San Bernardino Valley Water Conservation District to work cooperatively to develop and implement a groundwater management plan which includes groundwater banking programs (SBVMWD 2011).

The City of Rialto, San Bernardino Valley Municipal Water District, West Valley Water District, and Riverside Highland Water District have jointly constructed the Baseline Feeder to convey groundwater from the Bunker Hill subbasin to the Rialto area and West Valley Water District to be used in an in-lieu program that would reduce reliance on SWP water supplies (City of Rialto 2011; West Valley WD 2014c, 2014d).

West Valley Water District implemented a bioremediation wellhead treatment system (West Valley Water District 2014b).

San Jacinto Groundwater Basin

The communities in the San Jacinto Groundwater Basin use a combination of surface water and groundwater to meet water demands (City of Hemet 2011; City of San Jacinto 2011; EMWD 2011; LHMWD 2011; MWDSC 2007; RCWD 2011). The Eastern Municipal Water District provides wholesale and retail water supplies, including groundwater, in the areas that overlay the San Jacinto Groundwater Basin. The cities of Hemet and San Jacinto; and Eastern Municipal Water District and Rancho California provide retail water supplies, including groundwater, to users within their communities and to portions of the cities of Menifee, Moreno Valley, Murrieta, and Temecula; Lake Hemet Municipal Water District; Nuevo Water Company and numerous private water companies; and the communities of Edgemont, Homeland, Juniper Flats, Lakeview, Mead Valley, North Perris Water System, Romoland, Sunnymead, Valle Vista, and Winchester. The City of Perris overlays a portion of the San Jacinto Groundwater Basin; however, the city does not use groundwater. A substantial portion of the groundwater supplies within the San Jacinto Groundwater Basin are used by agricultural water users.

The 1954 Fruitvale Judgment allows for Eastern Municipal Water District to withdraw water from the San Jacinto Groundwater Basin if the groundwater elevation is greater than a specified elevation (EMWD 2009, 2011, 2014). The judgment includes a maximum withdrawal volume for use outside of the groundwater basin. There are further restrictions within the Canyon Basin subbasin of the San Jacinto Groundwater Basin. DWR worked with the cities of Hemet and San Jacinto, Lake Hemet Municipal Water District, Eastern Municipal Water District, and private groundwater companies to file a stipulated judgment in 2007 to form a Watermaster to develop and implement the Hemet/San Jacinto

Water Management Plan, including the Hemet/San Jacinto Integrated Recharge and Recovery Program, Recycled Water In-Lieu Project, and Hemet Filtration Plant. The stipulated judgment also limited groundwater withdrawals to protect the groundwater basin, provide for recharge programs, expand water production, and protect water quality. The program uses SWP water and San Jacinto River runoff to recharge the San Jacinto-Upper Pressure Groundwater Management Zone. In 2013, the judgment was filed with the court to adopt the Hemet/San Jacinto Water Management Plan and create the Watermaster Board.

The stipulated judgment also addressed methods to fulfil the Soboaba Band of Luiseño Indians water rights in accordance with the findings of the Court for the *Soboba Band of Luiseño Indians Water Settlement Agreement* in 2006. In 2008, the Soboba Settlement Act was signed by the President of the United States to provide an annual water supply and provide funds for economic development. The legislation also provides funds to construct recharge facilities and provisions for the Soboba Tribe to participate in restoration efforts.

The Eastern Municipal Water District adopted the West San Jacinto Groundwater Basin Management Plan in 1995. The management plan includes the Nuevo Water Company, City of Moreno Valley, City of Perris, and McCanna Ranch Water Company (MWDSC 2007).

Eastern Municipal Water District operates two desalination plants to treat brackish water within the San Jacinto Groundwater Basin as part of the Groundwater Salinity Management Program (EMWD 2011). Other wells within the Eastern Municipal Water District also include treatment facilities to reduce hydrogen sulfide, iron, and/or manganese.

Elsinore Groundwater Basin

The communities in the Elsinore Groundwater Basin use a combination of surface water and groundwater to meet water demands (EVMWD 2011; MWDSC 2007). The Elsinore Valley Municipal Water District provides wholesale and retail water supplies, including groundwater, in the areas that overlay the Elsinore Groundwater Basin. The cities of Lake Elsinore, Canyon Lake, and Wildomar; Elsinore Valley Municipal Water District and Elsinore Water District; and Farm Mutual Water Company provide retail water supplies, including groundwater, to users within their communities and to portions of Cleveland Ranch, Farm, Horsethief Canyon, Lakeland Village, Meadowbrook, Rancho Capistrano – El Cariso Village, and Temescal Canyon.

The Elsinore Groundwater Basin is not adjudicated. The Elsinore Valley Municipal Water District was responsible for over 90 percent of the groundwater withdrawals in mid-2000s (EVMWD 2011). The Elsinore Basin Groundwater Management Plan, adopted by Elsinore Valley Municipal Water District in 2005, identifies conjunctive use projects, including direct recharge projects. The direct recharge projects use imported water, including SWP water.

Temecula Valley Groundwater Basin

The communities in the Temecula Valley Groundwater Basin use a combination of surface water and groundwater to meet water demands (MWDSC 2007; RCSD 2011; WMWD 2011). The Rancho California Water District and Western Municipal Water District (including Murrieta County Water District) provide wholesale and retail water supplies, including groundwater, in the areas that overlay the Temecula Valley Groundwater Basin, including the cities of Murrieta and Temecula. The Pechanga Indian Reservation operates groundwater wells within the Temecula Valley Groundwater Basin (MWDSC 2007).

The Temecula Valley Groundwater Basin is located within the Santa Margarita River watershed. As described above for the San Mateo Valley, San Onofre Valley, and Santa Margarita Valley Groundwater Basins, the groundwater basins that contribute direct or indirect flows into the Santa Margarita River have been adjudicated and are managed by the Santa Margarita River Watermaster in accordance with the 1940 Stipulated Judgment, the 1966 Modified Final Judgment and Decree, and subsequent court orders (MWDSC 2007; RCWD 2011; SMRW 2011; WMWD 2011). The court-appointed steering committee for the Watermaster includes Eastern Municipal Water District, Fallbrook Public Utility District, Metropolitan Water District of Southern California, Pechanga Band of Luiseno Mission Indians of the Pechanga Reservation, Rancho California Water District, Western Municipal Water District, and Marine Corps Base Camp Pendleton. In accordance with the judgment, the Rancho California Water District prepares the annual Groundwater Audit and Recommended Groundwater Production Report that allocates groundwater withdrawals based upon rainfall, recharge area, and pumping capacity. The subsequent orders adopted following 1966 included the Cooperative Water Resource Management Agreement between Rancho California Water District and the Marine Corps Base Camp Pendleton to manage groundwater levels and surface water flows; water rights to Vail Lake on Temecula Creek; and an agreement between the Rancho California Water District and the Pechanga Band of Luiseno Mission Indians of the Pechanga Reservation.

Rancho California Water District provides imported water, including SWP water, and natural runoff released from Vail Lake to the Valle de Los Caballos Recharge Basins (RCWD 2011). The district also has implemented the Vail Lake Stabilization and Conjunctive Use Project to store imported water in Vail Lake for subsequent groundwater recharge (RCWD et al. 2014).

7.3.6.5 Central Riverside County

The areas within the SWP service area which receive Colorado River water in-lieu of SWP water deliveries are located within the Coachella Valley Groundwater Basin. The Coachella Valley Groundwater Basin includes the Desert Hot Springs, Indio, Mission Creek, and San Gorgonio Pass subbasins, as shown in Figure 7.12.

7.3.6.5.1 Hydrogeology and Groundwater Conditions

The Coachella Valley Groundwater Basin underlies the entire floor of the Coachella Valley. Primary water-bearing materials in the Coachella Valley Groundwater Basin are unconsolidated alluvial deposits along the valley floor which consist of older alluvium and a thick sequence of poorly bedded coarse sand and gravel; terrace deposits under the surrounding foothills in the Mission Creek subbasin; and partly consolidated fine to coarse sandstone in the surrounding mountains in the San Gorgonio Pass subbasin (DWR 2004cm, 2004cn, 2004co, 2004cp). The movement of groundwater is locally influenced by features such as faults, structural depressions, and constrictions; however, groundwater generally flows to the southeast towards the Salton Sea. Groundwater recharge occurs along stream beds and from groundwater inflows from adjacent subbasins. Within the Indio subbasin, groundwater also is recharged from spreading basins and injection wells.

The groundwater quality is characterized as calcium-sodium bicarbonate. Groundwater quality is adequate for community and agricultural water uses within the San Gorgonio Pass, Mission Creek, and Indio subbasins. There are localized areas with high fluoride near the Banning and San Andreas fault zones. Groundwater quality in the Desert Hot Springs subbasin due to the geothermal activity which results in high sodium sulfate, TDS, and chlorides. The hot springs water is only used by a resort for bathing.

Desert Hot Springs Groundwater Basin was designated by the CASGEM program as low priority. Indio, Mission Creek, and San Gorgonio Pass groundwater basins were designated as medium priority.

7.3.6.5.2 Groundwater Use and Management

Coachella Valley Groundwater Basin

The Coachella Valley Groundwater Basin includes the San Gorgonio Pass, Mission Creek, Desert Hot Springs, and Indio subbasins.

San Gorgonio Pass Subbasin

The communities in the San Gorgonio Pass subbasin use a combination of surface water and groundwater to meet water demands (BCVWD 2013; City of Banning 2011; SGPWA 2010). The City of Banning, Beaumont-Cherry Valley Water District, Cabazon Water District, and High Valley Water District provide retail water supplies, including groundwater, in the areas that overlay the San Gorgonio Pass subbasin, including the City of Banning and the eastern portion of the City of Beaumont; Banning Heights Mutual Water Company; and the community of Cabazon. The Morongo Band of Mission Indians operates groundwater wells within the San Gorgonio Pass subbasin.

The western portion of the San Gorgonio Pass subbasin is located within the Beaumont Basin (USGS 1974). As described above, the City of Beaumont, Beaumont-Cherry Valley Water District, South Mesa Water Company, and Yucaipa Valley Water District formed the San Timoteo Watershed Management Authority to enhance water supplies and water quality, manage groundwater, protect riparian habitat in San Timoteo Creek, and allocate benefits and costs of these programs (Beaumont Basin Watermaster 2013). One of the issues that the authority initiated was negotiations related to groundwater withdrawals by the City of Banning. A Stipulated Agreement was adopted in 2004 in accordance with the judgment for the *San Timoteo Watershed Management Authority, vs. City of Banning et al.* The judgment established a Watermaster committee of the cities of Banning and Beaumont, Beaumont-Cherry Valley Water District, South Mesa Water Company, and Yucaipa Valley Water District. The judgment allocated groundwater supplies in a manner that allows for storage of groundwater recharge from spreading basins or in-lieu programs.

Mission Creek, Desert Hot Springs, and Indio Subbasins

The communities in the Mission Creek, Desert Hot Springs, and Indio subbasins use a combination of surface water and groundwater to meet water demands (City of Coachella 2011; CVWD 2011, 2012; DWA 2011; IWA 2010; MSWD 2011). The City of Coachella, Coachella Valley Water District, Desert Water Agency, Indio Water Authority, and Mission Springs Water District provide retail water supplies, including groundwater, in the areas that overlay the Mission Creek, Desert Hot Springs, and Indio subbasins, including the cities of Cathedral City, Coachella, Desert Hot Springs, Indian Wells, Indio, La Quinta, Palm Desert, Palm Springs, and Rancho Mirage; and the communities of Barton Canyon, Bermuda Dunes, Bombay Beach, Desert Crest, Desert Edge, Indio Hills, Mecca, Mecca Hills, Palm Springs Crest, Salton City, Thermal, and West Palm Springs Village. The Cabazon Band of Mission Indians and the Torres-Martinez Desert Cahuilla Indians operate groundwater wells within the subbasins.

The Coachella Valley Water District, Desert Water Agency, and Mission Springs Water District all participate in groundwater management programs within the subbasins (CVWD 2011, 2012; DWA 2011; MSWD 2011). These programs include purchasing imported Colorado River water for groundwater recharge and in-lieu programs, conjunctive use programs, and conservation programs. Coachella Valley Water District and Desert Water Agency are SWP water contractors. However, because no conveyance facilities exist to deliver the SWP water, these districts have agreements with the Metropolitan Water District of Southern California to exchange SWP water for Colorado River water (CVWD 2012). Since 1973, these agencies have recharged more than 2.6 million acre-feet of water in the groundwater basin with delivery of Colorado River water to the Whitewater River Recharge Facility. The Metropolitan Water District of Southern California also has an agreement with Coachella Valley Water District and Desert Water Agency to store water in the Coachella Valley Groundwater Basin. The Coachella Valley Water District also operates the Thomas E. Levy Groundwater Replenishment Facility and the Martinez Canyon Pilot Recharge Facility. Coachella Valley Water District and Desert Water Agency also provide recycled water for in-lieu programs. The Coachella Valley Water District has agreed to operate groundwater recharge facilities to store Colorado River water for Imperial Irrigation District (CVWD 2011).

These groundwater recharge programs and broader groundwater management programs for the Indio subbasin have been developed in accordance with the Whitewater Basin Water Management Plan developed by Coachella Valley Water District and Desert Water Agency, and the Coachella Valley Water Management Plan developed by Coachella Valley Water District (CVWD 2011, 2012; DWA 2011).

The Coachella Valley Water District, Desert Water Agency, and Mission Springs Water District jointly manage the Mission Creek subbasin in accordance with the 2004 Mission Creek Settlement Agreement (DWA 2011; MSWD 2011). The Coachella Valley Water District and Desert Water Agency also manage portions of the subbasin in accordance with the 2003 Mission Creek Groundwater Replenishment Agreement. These agreements provide for the allocation of available Colorado River water under the SWP water exchange agreement with the Metropolitan Water District of Southern California between the Mission Creek and Indio (also known as the Whitewater) subbasins.

7.3.6.6 Antelope Valley and Mojave Valley

The areas within the SWP service area in the Antelope Valley and Mojave Valley include Salt Wells Valley, Cuddeback Valley, Pilot Knob Valley, Grass Valley, Superior Valley, El Mirage Valley, Upper Mojave River Valley, Middle Mojave River Valley, Lower Mojave River Valley, Caves Canyon Valley, Langford Valley, Cronise Valley, Coyote Lake Valley, Kane Wash Area, Iron Ridge Area, Bessemer Valley, Lucerne Valley, Johnson Valley, Means Valley, Deadman Valley, Twentynine Palms Valley, Joshua Tree, Ames Valley, Copper Mountain Valley, Warren Valley, and Morongo Valley groundwater basins in San Bernardino County; Harper Valley and Fremont Valley groundwater basins in San Bernardino Kern counties; Lost Horse Valley in Riverside and San Bernardino counties; Antelope Valley Groundwater Basin in San Bernardino, Kern, and Los Angeles counties; and Indian Wells and Searles Valley groundwater basin in San Bernardino, Inyo, and Kern counties, as shown in Figure 7.13.

7.3.6.6.1 Hydrogeology and Groundwater Conditions

Indian Wells Valley Groundwater Basin

Indian Wells Valley Groundwater Basin is located in Inyo, Kern, and San Bernardino Counties. Water bearing formations consist of unconsolidated lakebed, stream, and alluvial fan deposits with upper and lower aquifers (DWR 2004cn). The lower aquifer is more productive and has a saturated thickness of approximately 1000 feet. The upper aquifer provides low yield and has low quality. The lower aquifer is considered unconfined in most of the valley. There is indication that some faults within the valley could obstruct groundwater flow. Groundwater is recharged from runoff on the southwest to northeast sides of the valley. Groundwater levels have been declining since 1945. Groundwater quality varies throughout the groundwater basin from appropriate for beneficial uses to areas with poor water quality due to wastewater disposal practices. Areas near geothermal activity are characterized by high chloride, boron, and arsenic concentrations.

Indian Wells Valley Groundwater Basin was designated by the CASGEM program as medium priority.

Salt Wells Valley Groundwater Basin

Salt Wells Valley Groundwater Basin is located in San Bernardino County. Water bearing formations consist of unconsolidated to poorly consolidated alluvium (DWR 2004co). Groundwater is recharged from the Indian Wells Groundwater Basin and percolation of rainfall on the valley floor. The regional groundwater flow direction is towards the east into the Searles Valley Groundwater Basin. The groundwater has extremely high salinity, TDS, and boron.

Salt Wells Valley Groundwater Basin was designated by the CASGEM program as very low priority.

Searles Valley Groundwater Basin

Searles Valley Groundwater Basin is located in San Bernardino, Inyo, and Kern Counties. Water bearing formations consist of alluvium with unconsolidated to semi-consolidated deposits (DWR 2004cp). The Garlock fault may be a barrier to groundwater flow in the southern part of the basin. Groundwater is recharged from percolation of mountain runoff through the alluvial fan deposits and subsurface inflow from Salt Wells Valley and Pilot Knob Valley groundwater basins. Groundwater flows towards Searles Lake except in the northern portion of the basin where pumping by industrial water users has altered the groundwater flow. Groundwater levels near Searles Lake are close to the lake bed elevations. Groundwater quality is generally appropriate for beneficial uses with localized areas with high levels of fluoride and nitrate. In the vicinity of Searles Lake, the groundwater quality is poor with high levels of fluoride, boron, sodium, chloride, sulfate, and TDS.

Searles Valley Groundwater Basin was designated by the CASGEM program as very low priority.

Cuddeback Valley, Pilot Knob Valley, Grass Valley, and Superior Valley, Groundwater Basins

Cuddeback Valley, Pilot Knob Valley, Grass Valley, and Superior Valley Groundwater basins are located in northern San Bernardino County. Water bearing formations consist of unconsolidated to poorly consolidated alluvium (DWR 2004cq, 2004cr, 2004cs, 2004ct). Several fault zones restrict groundwater movement. Groundwater is recharged in the Cuddeback Valley, Pilot Knob Valley, Grass Valley, and Superior Valley groundwater basins primarily through groundwater inflow into the basins and percolation of precipitation at the valley margins. Groundwater within Cuddeback Valley, Grass Valley, and Superior Valley groundwater basins flows towards the Harper Valley Groundwater Basin. Groundwater in the Cuddeback Valley Groundwater Basin also flows towards Cuddeback Lake. Groundwater in Pilot Knob Valley Groundwater Basin flows towards the Searles Valley and Brown Mountain Valley groundwater basins. Groundwater quality is characterized as sodium chloride-bicarbonate with high salinity and TDS in the Cuddeback Valley Groundwater Basin and high concentrations of sodium and fluoride in the Superior Valley Groundwater Basin.

Cuddeback Valley, Pilot Knob Valley, Grass Valley, and Superior Valley groundwater basins were designated by the CASGEM program as very low priority.

Harper Valley Groundwater Basin

Harper Valley Groundwater Basin is located in western San Bernardino County and eastern Kern County. Water bearing formations consist of lacustrine deposits and unconsolidated to semi-consolidated alluvial deposits (DWR 2004cu). The alluvial deposits at the center of the basin is generally more interbedded with lacustrine silty clay. Faults in the Harper Valley Groundwater Basin cause at least partial barriers to groundwater flow. Groundwater is recharged from percolation of rainfall and runoff through alluvial fan material at the valley edges and underflow from Cuddeback Valley, Grass Valley, Superior Valley, and Middle Mojave River Valley groundwater basins. Regional groundwater flows toward the south and Harper Lake. Groundwater quality is characterized as sodium chloride-bicarbonate with high concentrations of boron, fluoride, and sodium.

Harper Valley Groundwater Basin was designated by the CASGEM program as low priority.

Fremont Valley Groundwater Basin

The Fremont Valley Groundwater Basin is located in eastern Kern County and in northwestern San Bernardino County. Water bearing formations consist of alluvial and lacustrine deposits (DWR 2004cv). The alluvial deposits are generally unconfined and the lacustrine deposits may exhibit locally confined conditions. Fault zones, including the Garlock and El Paso fault zones, are barriers to groundwater flow. Groundwater is recharged along streambeds in the Sierra Nevada Mountains. Groundwater flow is generally toward the center of the valley and Koehn Lake. Groundwater is characterized as sodium bicarbonate with high concentrations of calcium, chloride, fluoride, and sodium.

Fremont Valley Groundwater Basin was designated by the CASGEM program as low priority.

Antelope Valley Groundwater Basin

The Antelope Valley Groundwater Basin is located in Kern, Los Angeles, and San Bernardino counties. Water bearing formations consist of unconsolidated alluvial and lacustrine deposits consisting of compact gravels, sand, silt, and clay (DWR 2004cw). Several fault zones restrict groundwater movement. Groundwater is recharged along streams from the surrounding mountains, including Big Rock Creek and Little Rock Creek. The regional groundwater flow direction historically was towards the dry lakebeds of Rosamond, Rogers, and Buckhorn Lakes. However, extensive groundwater pumping has caused subsidence and reduced the groundwater storage and flow direction. The groundwater is characterized as sodium bicarbonate with localized areas of high nitrate and boron.

Antelope Valley Groundwater Basin was designated by the CASGEM program as high priority.

El Mirage Valley Groundwater Basin

The El Mirage Valley Groundwater Basin is located in San Bernardino County. Water bearing formations consist of unconsolidated to semi-consolidated alluvium (DWR 2003c). Several fault zones restrict groundwater movement. Groundwater is recharged in alluvial deposits at the mouth of Sheep Creek. The regional groundwater flow directions is generally north toward El Mirage Lake. The groundwater is characterized as sodium bicarbonate with localized areas of high levels of fluoride, sulfate, sodium, and TDS.

El Mirage Valley Groundwater Basin was designated by the CASGEM program as medium priority.

Upper Mojave River Valley, Middle Mojave River Valley, Lower Mojave River Valley, and Caves Canyon Valley Groundwater Basins

The Upper Mojave River Valley, Middle Mojave River Valley, Lower Mojave River Valley, and Caves Canyon Valley groundwater basins are located along the Mojave River in southwestern and central San Bernardino County. The water bearing formations consist of alluvial fan deposits overlain by river channel, floodplain, or lake deposits (DWR 2004cx, 2004cy, 2003d, 2003e). The general groundwater flow direction follows the Mojave River north through the Upper Mojave River Valley Groundwater Basin, and east through the Middle Mojave River Valley, Lower Mojave River Valley, and Caves Canyon Valley groundwater basins. Several fault zones restrict groundwater movement. Groundwater is recharged from precipitation on the valley floor, underflow from the Mojave River, streamflow, and flow between the basins. Treated wastewater and irrigation return flows also provide a source of groundwater recharge in these basins. Groundwater quality in the Upper Mojave River Valley, Middle Mojave River Valley, Lower Mojave River Valley, and Caves Canyon Valley groundwater basins varies throughout the basins due to geological formations and includes areas dominated by calcium bicarbonate, calcium-sodium bicarbonate, calcium-sodium sulfate, sodium-calcium sulfate, and sodium sulfate-chloride. There are localized areas of high nitrate, iron, and manganese in the Upper Mojave River Valley Groundwater Basin; and areas with high nitrates, fluoride, and boron in the Middle Mojave River Valley and Lower Mojave River Valley groundwater basins. Localized areas with high volatile organic compounds occur in the Upper Mojave River Valley and Lower Mojave River Valley groundwater basins.

Upper Mojave River Valley Groundwater Basin was designated by the CASGEM program as high priority. Lower Mojave River Valley Groundwater Basin was designated as medium priority. Middle Mojave River Valley Groundwater Basin was designated as low priority. Caves Canyon Valley Groundwater Basin was designated as very low priority.

Langford Valley Groundwater–Langford Well Lake Subbasin, and Cronise Valley and Coyote Lake Valley Groundwater Basins

The Langford Well Lake subbasin and the Cronise Valley and Coyote Lake Valley groundwater basins are located in central San Bernardino County. Water bearing formations consist of unconsolidated to semi-consolidated alluvium (DWR 2004cz, 2004da, 2004db). Groundwater is recharged from precipitation, stream flows into alluvial deposits along the mountains at the basin boundaries, and subsurface inflow from other groundwater basins including the Superior Valley Groundwater Basin. Groundwater quality is poor due to high concentrations of fluoride, boron, and TDS, and localized areas with high iron in the Langford Well Lake subbasin.

Langford Well Lake subbasin and the Cronise Valley and Coyote Lake Valley groundwater basins were designated by the CASGEM program as very low priority.

Kane Wash Area Groundwater Basin

The Kane Wash Area Groundwater Basin is located in San Bernardino County. Water bearing formations consist of unconsolidated to semi-consolidated alluvium with undissected coarse gravel to sand in the younger deposits and dissected gravel sand and silt in the older deposits (DWR 2004dc). Groundwater is recharged from precipitation and stream flows. The groundwater is characterized as sodium sulfate-bicarbonate with moderate TDS concentrations.

Kane Wash Area Groundwater Basin was designated by the CASGEM program as very low priority.

Iron Ridge Area Groundwater Basin

The Iron Ridge Area Groundwater Basin is located in southern San Bernardino County. Water bearing formations consist of unconsolidated to semi-consolidated alluvium (DWR 2004dd). Several fault zones restrict groundwater movement. Groundwater is recharged from precipitation and stream flows from the nearby mountains.

Iron Ridge Area Groundwater Basin was designated by the CASGEM program as very low priority.

Bessemer Valley Groundwater Basin

The Bessemer Valley Groundwater Basin is located in eastern San Bernardino County. Water bearing formations consist of unconsolidated to semi-consolidated alluvial deposits, fanglomerate, and playa lake deposits (DWR 2004de). More recent deposits consist of unconsolidated, undissected coarse gravel to sand. Older deposits consist of gravel, sand, and silt from dissected alluvial fans. Several fault zones restrict groundwater movement. Groundwater is recharged from precipitation and stream flows at the valley margins.

Bessemer Valley Groundwater Basin was designated by the CASGEM program as very low priority.

Lucerne Valley Groundwater Basin

The Lucerne Valley Groundwater basin is located in San Bernardino County. Water bearing formations consist of unconsolidated or semi-consolidated alluvial deposits and dune sand deposits composed of gravel, sand, silt, clay, and occasional boulders (DWR 2004df). Several fault zones restrict groundwater movement. Groundwater is recharged from precipitation and stream flows. Groundwater levels have declined throughout the basin and caused subsidence. The groundwater is characterized as calcium-magnesium bicarbonate or magnesium-sodium sulfate with TDS and nitrates.

Lucerne Valley Groundwater Basin was designated by the CASGEM program low priority.

Johnson Valley Groundwater Basin

The Johnson Valley Groundwater Basin is located in San Bernardino County and includes the Soggy Lake and Upper Johnson Valley subbasins. Water bearing formations in both subbasins consist of alluvial deposits with mainly sand and gravel in the Soggy Lake subbasin and silt, clay, sand, and gravel in the Upper Johnson Valley subbasin (DWR 2004dg, 2004dh). Springs occur throughout the Soggy Lake subbasin. Groundwater flows from Soggy Lake subbasin into the Upper Johnson Valley subbasin. Several fault zones restrict groundwater movement. The groundwater is characterized with moderate to high TDS and localized areas with high fluoride.

Johnson Valley Groundwater Basin was designated by the CASGEM program as very low priority.

Means Valley Groundwater Basin

The Means Valley Groundwater Basin is located in south central part of San Bernardino County. Water bearing formations consist of alluvial and lacustrine deposits with unconsolidated fine to coarse grained sand, pebbles, and boulders; and varying silt and clay deposits throughout the basin (DWR 2004di). Several fault zones restrict groundwater movement. Groundwater is recharged from precipitation and subsurface inflow from the Johnson Valley Groundwater Basin. The groundwater is characterized as sodium-chloride bicarbonate with high TDS, fluoride, and nitrates.

Means Valley Groundwater Basin was designated by the CASGEM program as very low priority.

Deadman Valley Groundwater Basin

The Deadman Valley Groundwater Basin is located in San Bernardino County. The Deadman Valley Groundwater Basin includes the Deadman Lake and Surprise Spring subbasins. Water bearing formations consist of unconsolidated to partly consolidated continental deposits including interbedded gravels, conglomerates, clays, and silts in alluvial fan units (DWR 2004dj, 2004dk). Several fault zones restrict groundwater movement. Groundwater is recharged from precipitation and stream flows. Groundwater flows from the Surprise Spring subbasin into the Deadman Lake subbasin, and from Deadman Lake subbasin to the dry Mesquite Lake. Groundwater also flows from the Ames Valley Groundwater Basin into the Surprise Spring subbasin. The groundwater is characterized as sodium bicarbonate with moderate to high TDS and localized areas of high fluoride.

Deadman Valley Groundwater Basin was designated by the CASGEM program as very low priority.

Twentynine Palms Valley, Joshua Tree, Ames Valley, Copper Mountain Valley, and Warren Valley Groundwater Basins

The Twentynine Palms Valley, Ames Valley, and Copper Mountain Valley groundwater basins are located in southern San Bernardino County. The Joshua Tree and Warren Valley groundwater basins are located in southern San Bernardino County and northern Riverside County. Water bearing formations consist of unconfined, unconsolidated to partly consolidated continental deposits with interbedded gravels, conglomerates, lake playa, silts, clays, and sandy-clay deposits (DWR 2004di, 2004dj, 2004dk, 2004dl, 2004dm). Several fault zones restrict groundwater movement. Groundwater is recharged from precipitation, stream flows, and wastewater effluent disposal. Groundwater flows from the Joshua Tree Groundwater Basin into the Copper Mountain Valley Groundwater Basin. Groundwater recharge in the Warren Valley Groundwater Basin also occurs at spreading grounds. The groundwater is characterized as calcium-sodium bicarbonate or sodium sulfate with moderate to high TDS in all of the basins except the Copper Mountain Valley Groundwater Basin; and localized areas with high fluoride, nitrate, sulfate, and chloride.

Warren Valley Groundwater Basin was designated by the CASGEM program as medium priority. Twentynine Palms Valley was designated as low priority. Joshua Tree, Ames, and Copper Mountain Valley groundwater basins were designated as very low priority.

Morongo Valley Groundwater Basin

The Morongo Valley Groundwater basin is located in southern San Bernardino County. Water bearing formations consist of alluvial deposits composed of sand, gravel, silt, and clay (DWR 2003f). Several fault zones restrict groundwater movement. Groundwater is recharged from precipitation and stream flows in the Big Morongo and Little Morongo creeks. The groundwater is characterized as calcium-sodium bicarbonate with moderate TDS.

Morongo Valley Groundwater Basin was designated by the CASGEM program as very low priority.

Lost Horse Valley Groundwater Basin

The Lost Horse Valley Groundwater Basin is located on the border between southeastern San Bernardino County and northeastern Riverside County. Water bearing formations consist of unconsolidated to semi-consolidated alluvial deposits (DWR 2004dn). Groundwater is recharged from precipitation and stream flows.

Lost Horse Valley Groundwater Basin was designated by the CASGEM program as very low priority.

7.3.6.6.2 Groundwater Use and Management

Within the Antelope Valley and Mojave Valley, groundwater management is facilitated by the Antelope Valley-East Kern Water Agency and Mojave Water Agency. These agencies purchase SWP water and other water supplies to be used for groundwater recharge or in-lieu uses to protect groundwater within the Antelope and Mojave valleys.

Antelope Valley

The Antelope Valley-East Kern Water Agency (AVEK) provides SWP water to areas that overlay portions of the Antelope Valley, Fremont Valley, and Indian Wells Valley groundwater basins. To maintain groundwater aquifers in the area, the AVEK provides treated SWP water to users through the Domestic-Agricultural Water Network and untreated SWP water to some agricultural users (AVEK 2011a). The AVEK participates in groundwater banking programs. Communities within the AVEK service area also use groundwater, including the cities of California City, Lancaster, and Palmdale; Edwards Air Force Base; County of Los Angeles Waterworks District No. 40; Boron Community Services District, Desert Lake Community Services District, Indian Wells Water District (including the City of Ridgecrest), Mojave Public Utilities District, Palmdale Water District, Palm Ranch Irrigation District, Quartz Hill Water District, and Rosamond Community Services District; and California Water Service Company (Antelope Valley, Lake Hughes, areas outside of the City of Lancaster, and Leona Valley), Edgemont Crest Municipal Water Company, El Dorado Mutual Water Company, Lake Elizabeth Mutual Water Company, Shadow Acres Mutual Water Company, Sunnyside Farm Mutual Water Company, Westside Park Mutual Water Company, and White Fence Farms Mutual Water Company provide retail groundwater supplies (AVEK 2011a; AVRWC 2011; California Water Service Company 2011f; City of California City 2013; IWVWD 2011; Los Angeles County et al. 2011; PWD 2011; Rosamond CSD 2011).

In 2004, the County of Los Angeles Waterworks District No. 40 and Palmdale Water District filed for the adjudication of the Antelope Valley Groundwater Basin (DWR 2014a; Los Angeles County et al. 2011; PWD 2011). The request of the filing is to allocate groundwater rights within the basin to these districts, other municipal and industrial water users, and Overlying Landowners and provide for a program to replace groundwater withdrawals in excess of a specified yield in order to stabilize or reverse groundwater declines.

Mojave Valley

Within the Mojave Water Agency service area, most of the water supply is from groundwater (AVRWC 2011; City of Adelanto 2011; Golden State Water Company 2011k; HDWD 2011; Hesperia Water District 2011; JBWD 2011; MWA 2011; PPHCSD 2011; San Bernardino County 2012; TPWD 2014; Victorville Water District 2011). The Mojave Water Agency uses natural surface water flows, recycled water imported from outside of the agency's service area, SWP water, and return flows from water users of groundwater within the service area to recharge groundwater. These water supplies are provided as wholesale water supplies to retail groundwater users to maintain groundwater levels in the area. The Mojave Water Agency overlays all or portions of all of the groundwater basins described in this subsection. The City of Adelanto; Hesperia Water District, Hi-Desert Water District, Joshua Water District, Twentynine Palms Water District, Victorville Water District, Apple Foothill County Water District, Apple Heights County Water District, Juniper Riviera County Water District, Thunderbird County Water District, Daggett Community Services District, Helendale Community Services District, Phelan Piñon Hills Community Services District, Yermo Community Services District, Bighorn-Desert View Water Agency, and San Bernardino County Service Areas numbers 64 and 70; and Golden State Water Company, Apple Valley Ranchos Water Company, Jubilee Water Company, and Rancheritos Mutual Water Company provide retail groundwater supplies. These entities provide water to the cities of Adelanto, Barstow, Hesperia, Twentynine Palms, Victorville; towns of Apple Valley and Yucca; Joshua Tree National Park; Twentynine Palms Marine Corps Base; and the communities of Apple Heights, Apple Valley, Daggett, Flamingo Heights, Helendale, Johnson Valley, Landers, Lucerne Valley, Newberry Springs, Oak Hills, Spring Valley Lake, Yermo, and users between these communities. The Morongo Band of Mission Indians also rely upon groundwater from this area.

The Mojave Water Agency has implemented 13 groundwater recharge facilities (MWA 2011). The SWP water is delivered to the recharge facilities throughout the Mojave Water Agency service area.

The area known as the Mojave Basin Area has been adjudicated. This area includes all or portions of Cuddeback Valley, Superior Valley, Harper Valley, Antelope Valley, El Mirage Valley, Upper Mojave River Valley, Middle Mojave River Valley, Lower Mojave River Valley, Caves Canyon Valley, Langford Valley, Cronise Valley, Coyote Lake Valley, Kane Wash Area, Iron Ridge Area, Lucerne Valley, and Johnson Valley groundwater basins (Golden State Water Company 2011k; MWA 2011). The Mojave Basin Judgment allocated groundwater withdrawals in the area and required groundwater users that withdraw more than the allocated amount to purchase replenishment SWP water from the Watermaster or from another entity within the judgment. The judgment considers local surface water sources, including groundwater recharge near Hesperia with treated wastewater effluent from Lake Arrowhead Community Services District (LACSD 2011). The judgment also provides for carry over storage between water years. The Mojave Water Agency has been appointed as the Watermaster.

The Warren Valley Groundwater Basin was adjudicated in 1977 (MWA 2011). The Hi-Desert Water District was appointed as the Watermaster to manage groundwater withdrawals and groundwater quality; to provide SWP water, captured stormwater, and recycled water; and to encourage conservation.

In 1991, the Bighorn-Desert Water Agency and the Hi-Desert Water District agreed to the court approved Ames Valley Basin Water Management Agreement. In accordance with this agreement, the Hi-Desert Water District implemented the Mainstream Wells and expansion to conveyance and monitoring approaches.

7.4 Impact Analysis

This section describes the potential mechanisms and analytical methods for change in groundwater resources, results of the impact analysis, potential mitigation measures, and cumulative effects.

7.4.1 Potential Mechanisms for Change and Analytical Methods

As described in Chapter 4, Approach to Environmental Analysis, the impact analysis considers changes in groundwater conditions related to changes in CVP and SWP operations under the alternatives as compared to the No Action Alternative and Second Basis of Comparison.

7.4.1.1 Changes in Groundwater Use and Groundwater Levels

Changes in availability of CVP and SWP water supplies could result in changes in groundwater use. For example, if CVP and SWP water supplies are decreased, water users may increase the amount of groundwater withdrawals in response.

As previously described in Section 7.2.3, Sustainable Groundwater Management Act, most groundwater users in California must develop Groundwater Sustainability Plans (GSPs) by 2020 or 2022, and meet the sustainable goal within 20 years after adoption of the plan. This EIS analysis assumes that groundwater users have developed the GSPs by 2030, and have begun to plan, design, and possibly construct alternative water supply facilities or implement water conservation measures to achieve full compliance by 2042. However, this EIS analysis assumes that the new facilities or conservation measures are not implemented by 2030. Therefore, reductions in groundwater use in accordance with the SGMA are not anticipated until after 2030 and are analyzed under the Cumulative Effects analysis.

Changes in groundwater use by users of or providers to CVP and SWP water supplies could result in changes in groundwater storage and groundwater levels. For example, if CVP and SWP water supplies are decreased and water users increase the amount of groundwater withdrawals, groundwater levels could decline. Changes in groundwater levels resulting in levels declining could result in a decrease in well yields. Changes in groundwater levels also could result in different groundwater pumping costs, as analyzed in Chapter 12, Agricultural Resources, and Chapter 14, Socioeconomics, for agricultural and municipal water users of CVP and SWP water supplies, respectively

7.4.1.1.1 Use of Central Valley Hydrologic Model

There are many groundwater models that have been developed for portions of the Central Valley. However, most of these models were not developed in a manner that would allow for analysis of groundwater changes throughout the Central Valley which includes the majority of CVP and SWP agricultural water users. As described in Appendix 7A, Groundwater Model Documentation, changes in groundwater use, and levels in the Central Valley have been evaluated using the Central Valley Hydrologic Model (CVHM) because this model is readily available and covers the entire Central Valley. CVHM is a regional-scale calibrated historical finite-difference, block-centered saturated groundwater flow model application developed by the USGS and uses the MODFLOW-2000 computer code (USGS 2000b). The CVHM model spans a 42-year simulation period between water years 1962 and 2003.

CVHM is used to estimate the changes in groundwater levels and groundwater withdrawals under the alternatives as compared to the No Action Alternative and Second Basis of Comparison. CVHM model output is also used as input files of the State Wide Agricultural Production (SWAP) model to simulate agricultural production changes based on groundwater pumping costs, as described in Chapter 12, Agricultural Resources.

The CVHM domain is subdivided into 21 WBSs, as summarized in Figure 7.14 (USGS 2009). Applied water requirements for each WBS are computed based on crop type and available water from precipitation, shallow groundwater uptake, and surface water, as limited by surface water rights and CVP and SWP water supply deliveries.

CVHM simulates primarily subsurface and limited surface hydrologic processes over the entire Central Valley at a uniform grid-cell spacing of 1 mile. Boundary conditions were modified to reflect anticipated changes in surface water availability, including the effects of climate change.

Surface water inflows from the CalSim II model were used to define boundary conditions for CVHM for each alternative and the Second Basis of Comparison. The CalSim II model simulates the operation of the major SWP and CVP facilities in the Central Valley by calculating river flows; and CVP and SWP reservoir storage, exports, and deliveries (see Appendix 5A for more details on CalSim II). The CalSim II outputs are included in the CVHM input files.

Changes in agricultural groundwater pumping under the alternatives are compared to groundwater pumping under the No Action Alternative and Second Basis of Comparison. The data for these results were processed from the FMP output files, which include the amount of water used from each available source by the farm, based on the computed crop water demand for each WBS.

For the analyses presented in this chapter, changes in groundwater use, elevation, and pumping volumes between the alternatives, No Action Alternative, and Second Basis of Comparison are described for agricultural water users only in the Central Valley Region.

7.4.1.1.2 Analysis of Changes in Municipal and Industrial Groundwater Use

Due to the regional scale of the CVHM model, municipal and industrial groundwater use is a very small portion of total groundwater use due to the predominance of agricultural groundwater use. Therefore, in the CVHM model, municipal and industrial groundwater use in the Central Valley was assumed to continue at the 2003 calibrated volume throughout the predictive simulations.

For municipal and industrial groundwater use in the Central Valley, the CWEST model is a more appropriate model than CVHM. The CWEST model evaluates total water use by municipal and industrial water users in the Central Valley, San Francisco Bay Area, Central Coast, and Southern California regions based upon economic decisions.

It is recognized that municipal and industrial pumping in urban areas in the Central Valley could cause localized impacts to groundwater levels from increased drawdown. The increased withdrawals could also impact groundwater quality due to the migration of existing plumes, as described in the Affected Environment section.

7.4.1.1.3 Analysis of Changes in Agricultural Groundwater Use Outside of the Central Valley Region

Agricultural groundwater use by CVP and SWP water users located outside of the Central Valley primarily occurs in Santa Clara and San Benito counties in the San Francisco Bay Area Region; San Luis Obispo and Santa Barbara counties in the Central Coast Region; and Ventura, Orange, San Bernardino, and Riverside counties in the Southern California Region. Groundwater management plans or basin adjudication programs in many portions of these counties will minimize changes in groundwater use and levels as a result of changes in CVP and SWP water supplies. There are no regional models that uniformly analyze groundwater use and elevation in these areas in a similar manner as CVHM in the Central Valley. Therefore, changes in groundwater use and related changes in groundwater levels are assumed to be related to availability of CVP and SWP water supplies. However, due to the implementation of groundwater management plans or adjudicated basin requirements in many groundwater basins, increase in CVP and SWP water supplies could result in a decrease in groundwater use. Similarly, a decrease in CVP and SWP water supplies could result in a short-term increase in groundwater use; however, due to groundwater use restrictions in the groundwater management plans or adjudicated basin requirements, long-term groundwater use is assumed to not increase. Therefore, agricultural production could decrease if CVP and SWP water supplies decrease.

7.4.1.2 Changes in Land Subsidence

Extensive groundwater withdrawals from confined and unconfined aquifers increases the potential for land subsidence. In aquifers with clay and silt lenses, decreased groundwater levels can result in compaction of fine-grained deposits which could lead to irreversible land subsidence. Subsidence could result in structural damage to roads, railroad tracks, pipelines and associated structures, drainage, buildings, and wells. Subsidence can also result in the permanent loss of groundwater storage potential within an aquifer system.

Subsidence is related to changes in groundwater levels; and a review of simulated changes in groundwater elevation output from the CVHM model as compared between alternatives is used to provide an indication of the potential occurrence of subsidence.

CVHM includes a module known as the SUB package that computes the cumulative compaction of each model layer during the model simulation. The cumulative layer compactions at the end of the simulation are summed into a total subsidence. However, this version of the SUB package does not consider the potential reduction in the rate of subsidence that would occur as the magnitude of compaction approaches the physical thickness of the affected fine-grained interbeds. Thus, subsidence forecasts from the predictive versions of CVHM were judged to be overly conservative. Therefore, a qualitative approach was used for the estimation of the potential for increased land subsidence in areas of the Central Valley that have historically experienced inelastic subsidence due to the compaction of fine-grained interbeds.

Potential changes in subsidence due to changes in municipal and industrial groundwater use were qualitatively analyzed for regions with historic or existing subsidence issues, such as in Santa Clara County in the San Francisco Bay Area Region.

7.4.1.3 Changes in Groundwater Quality

Changes in groundwater quality could occur in several ways under implementation of the alternatives as compared to the No Action Alternative and Second Basis of Comparison. Reductions in groundwater levels could change groundwater flow directions, potentially causing poorer quality groundwater to migrate into areas with higher quality groundwater, or cause intrusion of poor water quality (e.g. from aquitards) as water levels decline.

Groundwater quality also could change due to changes in availability of CVP and/or SWP water supplies used by agricultural water users. For example, if reductions in CVP and/or SWP water supplies result in increased use of groundwater with higher salinity than CVP and/or SWP supplies, shallow groundwater could become more saline and soil salinity could increase, as described in Chapter 11, Geology and Soils.

Changes in groundwater quality due to changes in CVP and SWP water supply availability could occur under the following mechanisms:

- Migration of reduced quality groundwater towards areas of groundwater withdrawals, including seawater intrusion and migration of contaminant plumes
- Depletion of the freshwater aquifer that overlays poorer quality groundwater, and the upwelling of the poorer quality groundwater into the upper aquifers

- Percolation of applied water with poorer water quality than underlying groundwater

Within the Central Valley, changes in groundwater use and groundwater flow direction are analyzed using the CVHM. The model does not directly simulate changes in groundwater quality. However, in regions with existing poorer quality groundwater, changes in groundwater levels or flow directions can be used to evaluate potential impacts to groundwater quality. For example, declines in groundwater levels that result in seawater intrusion, or the migration of good quality groundwater into areas with poor quality can result in groundwater quality degradation. Further, reduction in groundwater quality could also occur due to migration or upwelling of poorer quality groundwater into areas with good quality groundwater.

Long-term use of poorer quality groundwater due to changes in CVP and SWP water supplies could also result in a reduction in shallow aquifer groundwater quality. Application of poorer quality groundwater also could increase soil salinity, as described in Chapter 11, Geology and Soils Resources.

7.4.1.4 Effects Related to Water Transfers

Historically water transfer programs have been developed on an annual basis.

The demand for water transfers is dependent upon the availability of water supplies to meet water demands. Water transfer transactions have increased over time as CVP and SWP water supply availability has decreased, especially during drier water years.

Parties seeking water transfers generally acquire water from sellers who have available surface water who can make the water available through releasing previously stored water, pump groundwater instead of using surface water (groundwater substitution); idle crops; or substitute crops that uses less water in order to reduce normal consumptive use of surface water.

Water transfers using CVP and SWP Delta pumping plants and south of Delta canals generally occur when there is unused capacity in these facilities. These conditions generally occur drier water year types when the flows from upstream reservoirs plus unregulated flows are adequate to meet the Sacramento Valley water demands and the CVP and SWP export allocations. In non-wet years, the CVP and SWP water allocations would be less than full contract amounts; therefore, capacity may be available in the CVP and SWP conveyance facilities to move water from other sources.

Projecting future groundwater conditions related to water transfer activities is difficult because specific water transfer actions required to make the water available, convey the water, and/or use the water would change each year due to changing hydrological conditions, CVP and SWP water availability, specific local agency operations, and local cropping patterns. Reclamation recently prepared a long-term regional water transfer environmental document which evaluated potential changes in surface water conditions related to water transfer actions (Reclamation 2014c). Results from this analysis were used to inform the impact assessment of potential effects of water transfers under the alternatives as compared to the No Action Alternative and the Second Basis of Comparison.

7.4.2 Conditions in Year 2030 without implementation of Alternatives 1 through 5

The impact analysis in this EIS is based upon the comparison of the alternatives to the No Action Alternative and the Second Basis of Comparison in the Year 2030. Changes that would occur over the next 15 years without implementation of the alternatives are not analyzed in this EIS. However, the changes that are assumed to occur by 2030 under the No Action Alternative and the Second Basis of Comparison are summarized in this section. Many of the changed conditions would occur in the same manner under both the No Action Alternative and the Second Basis of Comparison.

This section of Chapter 7 provides qualitative projections of the No Action Alternative as compared to existing conditions described under the Affected Environment; and qualitative projections of the Second Basis of Comparison as compared to "recent historical conditions." Recent historical conditions are not the same as existing conditions which include implementation of the 2008 U.S. Fish and Wildlife Service (USFWS) biological opinion (BO) and 2009 National Marine Fisheries Service (NMFS) BO; and consider changes that would have occurred without implementation of the 2008 USFWS BO and the 2009 NMFS BO.

7.4.2.1 Common Changes in Conditions under the No Action Alternative and Second Basis of Comparison

Conditions in 2030 would be different than existing conditions due to:

- Climate change and sea-level rise
- General plan development throughout California, including increased water demands in portions of Sacramento Valley
- Implementation of reasonable and foreseeable water resources management projects to provide water supplies

These changes would result in a decline of the long-term average CVP and SWP water supply deliveries by 2030 as compared to recent historical long-term average deliveries, as described in Chapter 5, Surface Water Resources and Water Supplies.

7.4.2.1.1 Changes in Conditions due to Climate Change and Sea-Level Rise

It is anticipated that climate change would result in more short-duration high-rainfall events and less snowpack in the winter and early spring months. The reservoirs would be full more frequently by the end of April or May by 2030 than in recent historical conditions. However, as the water is released in the spring, there would be less snowpack to refill the reservoirs. This condition would reduce reservoir storage and available water supplies to downstream uses in the summer. The reduced end of September storage also would reduce the ability to release stored water to downstream regional reservoirs. These conditions would occur for all reservoirs in the California foothills and mountains, including non-CVP and SWP reservoirs.

Climate change also would reduce groundwater supplies due to reduced groundwater recharge potential and increased groundwater overdraft potential as surface water supplies decline. However, in some locations, sustainable groundwater supplies could remain similar to recent historical conditions or rise due to implementation of groundwater management plans to reduce groundwater overdraft, including the completion of ongoing groundwater recharge and recovery programs.

7.4.2.1.2 General Plan Development in California

Counties and cities throughout California have adopted general plans which identify land use classifications including those for municipal and industrial uses and those for agricultural uses. Preparation of general plans includes an environmental evaluation under the California Environmental Quality Act to identify adverse impacts to the physical environment and to provide mitigation measures to reduce those impacts to a level of less than significance. Most of the counties where CVP and SWP water supplies are delivered have adopted general plans following the environmental review of the plans and appropriate alternatives. Population projections from those general plan evaluations are provided to the State Department of Finance and are used to project future water needs and the potential for conversion of existing undeveloped lands and agricultural lands. Many of the existing general plans for counties with municipal areas recently have been modified to include land use and population projections through 2030. The No Action Alternative and the Second Basis of Comparison assume that land uses will develop through 2030 in accordance with existing general plans.

The assumptions related to 2030 municipal water demands are based upon a review of the 2010 Urban Water Management Plans (UWMPs) prepared by CVP and SWP water users. The No Action Alternative and the Second Basis of Comparison assumptions related to future water supplies presented in the UWMPs were evaluated to determine if the projects were reasonable and certain to occur by 2030. Projects that had undergone environmental review, were under design, or under construction were included in the future water supply assumptions for 2030 in the No Action Alternative and the Second Basis of Comparison. Projects described in the UWMPs that currently were under evaluation were included in the Cumulative Effects analysis for future water supplies.

Under the No Action Alternative and Second Basis of Comparison, it is assumed that water demands would be met on a long-term basis and in dry and critical dry years using a combination of conservation, CVP and SWP water supplies, other imported water supplies, groundwater, recycled water, infrastructure improvements, desalination water treatment, and water transfers and exchanges. It is anticipated that individual communities or users could be in a situation that would not allow for affordable water supply options, and that water demands could not be fully met. However, on a regional scale, it is anticipated that water demands would be met.

7.4.2.1.3 Reasonable and Foreseeable Water Resources Management Projects

The No Action Alternative and the Second Basis of Comparison assumes completion of water resources management and environmental restoration projects that would have occurred without implementation of the 2008 USFWS BO and 2009 NMFS BO by 2030, as described in Chapter 3, Description of Alternatives. Many of these future actions could affect groundwater conditions and use of groundwater.

The No Action Alternative and the Second Basis of Comparison assume that groundwater would continue to be used even if groundwater overdraft conditions continue or become worse. It is recognized that SGMA was enacted in September 2014. The SGMA requires the formation of GSPs in groundwater basins or subbasins that DWR designates as medium or high priority based upon groundwater conditions identified using the CASGEM results by 2022. Sustainable groundwater operations must be achieved within 20 years following completion of the GSPs. In some areas with adjudicated groundwater basins, sustainable groundwater management could be achieved and/or maintained by 2030. However, to achieve sustainable conditions in many areas, measures could require several years to design and construct water supply facilities to replace groundwater, such as seawater desalination. Therefore, it does not appear to be reasonable and foreseeable that sustainable groundwater management would be achieved by 2030; and it is assumed that groundwater pumping will continue to be used to meet water demands not fulfilled with surface water supplies or other alternative water supplies in 2030.

7.4.2.1.4 Potential Future Groundwater Conditions in 2030 due to Common Changes

Groundwater Conditions

In the Central Valley Region, the combination of increased groundwater withdrawals due to reductions in CVP and SWP water deliveries as compared to recent historical long-term deliveries and reduced groundwater recharge due to climate change could result in continued reductions in groundwater levels in the same manner as recent declines of up to 10 feet in the Sacramento Valley and more than 20 feet in the San Joaquin Valley, as described in Section 7.3.4, Central Valley Region. Under the No Action Alternative and Second Basis of Comparison, groundwater banks and other management programs would continue to be implemented, and possibly expanded, including ongoing groundwater recharge efforts in the Eastern San Joaquin, Kings, Kaweah, and Kern subbasins in the San Joaquin Valley Groundwater Basin. These programs could result in groundwater levels that are similar or higher as compared to recent groundwater conditions. If local agencies fully implement GSPs in accordance with the state

SGMA prior to the regulatory deadline, groundwater levels could remain similar to recent conditions or increase.

Localized groundwater levels in portions of the Central Valley Region could increase due to seepage in lands adjacent to the ecosystem restoration areas in the Yolo Bypass, Cache Slough, and Suisun Marsh areas depending upon local geological and soil conditions.

In the Southern California Region, several SWP water users have purchased transferred water, expanded groundwater storage within their service areas, implemented wastewater recycling and stormwater recycling programs to provide water supplies for groundwater recharge, and participated in groundwater banks outside of their service areas as part of ongoing sustainable groundwater management programs. Under the No Action Alternative and the Second Basis of Comparison, groundwater banks and other management programs would continue to be implemented, and possibly expanded. Several of the programs include expansion of groundwater storage by Kern County and Antelope Valley-East Kern Water Agency; groundwater recharge programs using recycled stormwater by the Los Angeles Department of Water and Power; groundwater recharge programs using recycled wastewater by the Water Replenishment District; and groundwater treatment by City of Oxnard and Western Municipal Water District (AVEK 2011b; City of Los Angeles 2011; City of Oxnard 2013; Reclamation 2010b; WMWD 2012; WRD 2015). Expansion of these programs could result in maintenance of groundwater levels in accordance with objectives in the current groundwater management plans even with reduced SWP water supplies under the No Action Alternative and Second Basis of Comparison.

Potential Land Subsidence

Land subsidence due to groundwater withdrawals historically occurred in the Yolo subbasin of the Sacramento Valley Groundwater Basin and Delta-Mendota and Westside subbasins of the San Joaquin Valley Groundwater Basin in the Central Valley Region; Santa Clara Valley Groundwater Basin in the San Francisco Bay Area Region; and the Antelope Valley and Lucerne Valley groundwater basins in the Southern California Region. Under the No Action Alternative, it is anticipated that increased groundwater withdrawals due to reductions in CVP and SWP water supplies and reduced groundwater recharge due to climate change could result in increased irreversible land subsidence in these areas.

Groundwater Quality

Central Valley Region

As described in Section 7.3, Affected Environment, in the Central Valley, there are localized areas of high salinity related to natural geologic formations and/or historic land uses; high naturally occurring arsenic, calcium, iron, and/or manganese; and high levels of boron, and/or phosphates related to historic land use practices. High concentrations of nitrates due to current anthropogenic sources and legacy sources occur in many locations in the San Joaquin Valley Groundwater Basin, especially in the Eastern San Joaquin, Modesto, Merced, Kings, Kaweah, Tule, and Tulare Lake subbasins. Under the No Action Alternative, it is anticipated that these conditions would continue to occur; and that groundwater quality could be further degraded due to reduction of groundwater elevation that can cause adjacent poorer quality water to flow towards the groundwater withdrawals.

Groundwater quality in the Grasslands Drainage Area and near Mud Slough and the San Joaquin River is anticipated to improve as compared with historic conditions due to the implementation of the Grasslands Bypass project. This program would reduce seepage from unlined canals and capture, treat, and/or reuse drainage flows (Reclamation 2009).

In the Tulare Lake Area of the San Joaquin Valley Groundwater Basin (in the Westside, Tulare Lake, Kings, Kaweah, and Tule subbasins within Fresno, Kern, Kings, and Tulare counties) high salinity groundwater occurs in the shallow aquifers due to agricultural drainage issues and naturally occurring high saline soils. Salts are imported into the Tulare Lake Area through the use of CVP and SWP irrigation water supplies and introduced into groundwater from dissolution of salts in the local soil from agricultural land use. Groundwater salinity increases because the Tulare Lake Area is a closed basin.

The CV-SALTS program is preparing a Salinity and Nitrate Management Plan for publication in 2016 (CVRWQCB 2015). The plan will include sustainable salt management alternatives, including treatment and salt recovery technologies, such as, reverse osmosis; and related brine disposal/storage options that could range from deep well injection to dedicated disposal locations to conveyance of brine to locations outside of the San Joaquin Valley. This plan also will address current and legacy sources of nitrates; assimilative capacity of the groundwater subbasins and aquifers; drinking water protection measures, including waste discharge requirements from irrigated lands and dairies; and measurable and enforceable milestones that do not disproportionately impact disadvantaged communities; and measures that minimize costs and maximize benefits to the community and water users. The 2015 CV-SALTS work plan projects completion of Central Valley Basin Plan amendments and Water Quality Control Plans for the Sacramento Valley and San Joaquin Valley updates to incorporate recommendations of CV-SALTS by 2018, including source control strategies and real time management strategies (CVRWQCB 2015; SWRCB 2015). The *2015 CV-SALTS Annual Report* indicated that structural best management practices would not be fully selected until 2018 and may not be implemented until after 2030 (SWRCB 2015). Under the No Action Alternative and Second Basis of Comparison it is assumed that non-structural measures would be implemented by 2030 to reduce salinity and nitrate loadings; however, structural improvements that would reduce total groundwater salinity and nitrate concentrations generally would not be implemented. Therefore, water quality under the No Action Alternative and the Second Basis of Comparison is anticipated to be poorer in some portions of the Central Valley than under recent groundwater quality conditions.

Poor groundwater quality occurs near urban areas in the Central Valley due to contamination from municipal and industrial land use practices. In many of these areas, groundwater quality improvement programs have been implemented, as described above. However, in many areas, groundwater quality is managed by reducing groundwater drawdown near contaminant plumes to avoid transporting the contaminants into other portions of the aquifer. Under the No Action Alternative and the Second Basis of Comparison, it is assumed that these programs would continue. However, as CVP and SWP water supplies become less available in 2030 as compared to recent conditions, increased reliance on groundwater could cause groundwater contamination of portions of the aquifers near existing wells.

San Francisco Bay Area Region

In the San Francisco Bay Area Region, there are localized areas of moderate to high salinity due to natural geologic formations and/or seawater intrusion near San Francisco Bay. High levels of boron due to natural geologic formations and nitrates related to historic land use practices occur in the Livermore Valley and the Gilroy-Hollister- Valley groundwater basins. Under the No Action Alternative and the Second Basis of Comparison, it is anticipated that these conditions would continue to occur; and that groundwater quality could be further degraded due to reduction of groundwater elevation that can cause adjacent poorer quality water to flow towards the groundwater withdrawals, especially in locations with seawater intrusion near the coast.

Central Coast Region

In the Central Coast Region, there are localized areas of moderate to high salinity due to seawater intrusion near the coast. High levels of iron and manganese due to natural geologic formations and nitrates related to historic land use practices occur in local areas of the Central Coast Region. Under the No Action Alternative and Second Basis of Comparison, it is anticipated that these conditions would continue to occur. Seawater intrusion could increase and further degrade groundwater quality in groundwater adjacent to the coast if groundwater levels decline in the future.

Southern California Region

In the Southern California Region, there are localized areas of moderate to high salinity due to natural geologic formations, percolation of high salinity applied water supplies, and/or seawater intrusion near the coast. High levels of calcium, sulfate, magnesium, iron, manganese, and fluoride due to natural geologic formations, and nitrates and organic compounds related to historic land use practices. Under the No Action Alternative and the Second Basis of Comparison, it is anticipated that these conditions would continue to occur; and that groundwater quality could be further degraded due to reduction of groundwater elevation that can cause adjacent poorer quality water or seawater to flow towards the groundwater withdrawals.

7.4.2.2 Changes in Conditions under the No Action Alternative

Due to the climate change and sea-level rise and increased water demands in the Sacramento Valley, CVP and SWP water deliveries would be less in 2030 than under recent historical conditions. It is anticipated that these reductions in CVP and SWP water availability would result in a greater reliance on groundwater, especially during dry and critical dry year.

7.4.2.3 Changes in Conditions under the Second Basis of Comparison

Due to the climate change and sea-level rise and increased water demands in the Sacramento Valley, CVP and SWP water deliveries would be less in 2030 than under recent historical conditions. It is anticipated that these reductions in CVP and SWP water availability would result in a greater reliance on groundwater, especially during dry and critical dry year. However, as described in Chapter 5, Surface Water Resources and Water Supplies, the availability of CVP and SWP water supplies would be greater under the Second Basis of Comparison as compared to the No Action Alternative because CVP and SWP water operations would not include requirements of the 2008 USFWS BO and 2009 NMFS BO. However, reliance on groundwater in 2030 under the Second Basis of Comparison is anticipated to increase as compared to recent historical conditions due to the climate change and sea-level rise and increased water demands in the Sacramento Valley.

7.4.3 Evaluation of Alternatives

As described in Chapter 4, Approach to Environmental Analysis, Alternatives 1 through 5 have been compared to the No Action Alternative; and the No Action Alternative and Alternatives 1 through 5 have been compared to the Second Basis of Comparison.

During review of the numerical modeling analyses used in this EIS, an error was determined in the CalSim II model assumptions related to the Stanislaus River operations for the Second Basis of Comparison, Alternative 1, and Alternative 4 model runs. Appendix 5C includes a comparison of the CalSim II model run results presented in this chapter and CalSim II model run results with the error corrected. Appendix 5C also includes a discussion of changes in the comparison of groundwater conditions for the following alternative analyses.

- No Action Alternative compared to the Second Basis of Comparison
- Alternative 1 compared to the No Action Alternative
- Alternative 3 compared to the Second Basis of Comparison
- Alternative 5 compared to the Second Basis of Comparison.

7.4.3.1 No Action Alternative

The No Action Alternative is compared to the Second Basis of Comparison.

7.4.3.1.1 Trinity River Region

Groundwater conditions in the Trinity River Region are not directly related to CVP and SWP water supplies or operations. Therefore, groundwater use, related groundwater levels, potential for land subsidence, and groundwater quality under the No Action Alternative would be the same as under the Second Basis of Comparison.

7.4.3.1.2 Central Valley Region

Groundwater Use and Elevation

In areas of the Central Valley Region that do not use CVP and SWP water supplies, areas that use CVP water under Sacramento River Exchange Settlement Contracts, and areas that use San Joaquin River Exchange Contracts under the No Action Alternative water supplies would be the same as under the Second Basis of Comparison. Therefore, in these areas of the Central Valley Region, groundwater use and groundwater levels under the No Action Alternative would be the same as under the Second Basis of Comparison.

In areas of the Central Valley Region that use CVP water service contract and SWP entitlement contract water supplies, the CVP and SWP water supplies would be less under the No Action Alternative as compared to the Second Basis of Comparison. The differences would result in increased groundwater use and decreased groundwater levels in the San Joaquin Valley Groundwater Basin under the No Action Alternative as compared to the Second Basis of Comparison. Results of CVHM simulations indicate that groundwater levels would be similar in the Redding and Sacramento Valley Groundwater Basins and the northern portion of the San Joaquin Valley Groundwater Basin, as shown in Figures 7.15 through 7.19.

Groundwater levels decline under the No Action Alternative in the central and southern San Joaquin Valley Groundwater Basin as compared to the Second Basis of Comparison with greater reductions occurring in wet years than in critical dry years. Figures 7.20 and 7.21 present the simulated changes in groundwater levels over the 42-year CVHM study period. Simulated average July agricultural groundwater pumping under the No Action Alternative as compared to the Second Basis of Comparison is presented in Figures 7.22 and 7.23.

Overall, under the No Action Alternative as compared to the Second Basis of Comparison, July average groundwater levels decrease approximately 2 to 10 feet in most of the central and southern San Joaquin Valley Groundwater Basin in all water year types. July average groundwater levels decline 10 to 50 feet in the Delta-Mendota, Tulare Lake, and Kern County subbasins; and 100 to over 200 feet in the Westside subbasin in all water year types. In critical dry years, groundwater levels decline by up to 200 feet in the Westside subbasin. Groundwater level changes in the Sacramento Valley are forecast to be less than 2 feet. The groundwater level change hydrographs show that in the central and southern San Joaquin Valley, groundwater levels can fluctuate up to 200 feet in some areas due to climatic variations under the No Action Alternative compared to the Second Basis of Comparison.

The change in groundwater pumping in the Sacramento Valley would result in similar conditions (less than 5 percent change). Therefore, groundwater pumping in the Sacramento Valley is similar under the No Action Alternative compared to the Second Basis of Comparison.

Groundwater pumping in the San Joaquin and Tulare Basins would increase by approximately 8 percent under the No Action Alternative as compared to the Second Basis of Comparison. Figure 7.23 shows that the biggest change in groundwater pumping under the No Action Alternative as compared to the Second Basis of Comparison occurs in the Westside subbasin, with an average July increase close to 40 thousand acre-feet (TAF).

Land Subsidence

Land subsidence due to groundwater withdrawals historically occurred in the Yolo subbasin of the Sacramento Valley Groundwater Basin. CVP and SWP water supplies are not used extensively in this area. The conditions under the No Action Alternative would be similar as conditions under the Second Basis of Comparison.

Under the No Action Alternative, potential for land subsidence due to groundwater withdrawals in the Delta-Mendota and Westside subbasins of the San Joaquin Valley Groundwater Basin would increase as compared to the Second Basis of Comparison due to the increased groundwater withdrawals.

Groundwater level-induced land subsidence has the highest potential to occur in the San Joaquin Groundwater Basin, based on historical data, if groundwater pumping substantially increases. Under the No Action Alternative, CVP and SWP water supplies are expected to decrease in the San Joaquin Valley as compared to the Second Basis of Comparison. Decreased surface water deliveries could result in an increase in groundwater pumping. The increased groundwater pumping would result in lower groundwater levels, and therefore, the potential for groundwater level-induced land subsidence is increased under the No Action Alternative as compared to the Second Basis of Comparison.

Groundwater Quality

Under the No Action Alternative, groundwater conditions, including groundwater quality, in areas that do not use CVP and SWP water supplies would be the same as under the Second Basis of Comparison.

In areas that use CVP and SWP water supplies, groundwater quality under the No Action Alternative could be reduced as compared to the Second Basis of Comparison in the central and southern San Joaquin Valley Groundwater Basin due to increased groundwater withdrawals and resulting potential changes in groundwater flow patterns. As described above, it is assumed that measures implemented in accordance with the CV-SALTS program or future sustainable groundwater management plans implemented in accordance with SGMA would not be fully implemented by 2030. Therefore, groundwater quality could decline under the No Action Alternative as compared to the Second Basis of Comparison.

Effects Related to Cross Delta Water Transfers

Potential effects to groundwater resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c). Potential effects to groundwater were identified as reduced groundwater levels and potentially subsidence in areas that sold water using groundwater substitution practices. The water transfer programs would Because all water transfers would be required to avoid adverse impacts to other water users and biological resources (see Section 3.A.6.3, Transfers), including impacts to other groundwater users, the analysis indicated that water transfers would not result in substantial changes in groundwater because mitigation and monitoring plans would be required. The mitigation measures would require reductions in providing water from groundwater substitutions if the monitoring results indicated substantial declines in groundwater levels. For the purposes of this EIS, it is anticipated that similar conditions would occur during implementation of cross Delta water transfers under the No Action Alternative and the Second Basis of Comparison.

Groundwater use in areas that purchase the transferred water could be reduced if additional surface water is provided. However, if the transferred water is used to meet water demands that would not have been met (e.g., crops that had been idled), groundwater conditions would be similar with or without water transfers.

Under the No Action Alternative, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Under the Second Basis of Comparison, water could be transferred throughout the year without an annual volumetric limit. Overall, the potential for cross Delta water transfers would be less under the No Action Alternative than under the Second Basis of Comparison.

7.4.3.1.3 San Francisco Bay Area, Central Coast, and Southern California Regions

Groundwater Use and Elevation

Under the No Action Alternative, it is anticipated that CVP and SWP water supplies in the San Francisco Bay Area, Central Coast, and Southern California regions would be reduced as compared to CVP and SWP water supplies under the Second Basis of Comparison, as discussed in Chapter 5, Surface Water Resources and Water Supplies. The reduction in surface water supplies could result in increased groundwater withdrawals, decreased groundwater recharge, and decreased groundwater levels in areas with CVP and SWP water users. It may be legally impossible to extract additional groundwater in adjudicated basins without gaining the permission of watermasters and accounting for groundwater pumping entitlements and various parties under their adjudicated rights.

Land Subsidence

Increased use of groundwater and reductions in groundwater levels would result in an increased potential for additional land subsidence under the No Action Alternative as compared to the Second Basis of Comparison in the Santa Clara Valley Groundwater Basin in the San Francisco Bay Area Region, and the Antelope Valley and Lucerne Valley groundwater basins in the Southern California Region.

Groundwater Quality

As described in Section 7.3, Affected Environment, there are localized areas of moderate to high salinity due to natural geologic formations and/or seawater intrusion in the San Francisco Bay Area, Central Coast, and Southern California regions. Under the No Action Alternative as compared to the Second Basis of Comparison, it is anticipated that the increased groundwater withdrawals would cause poorer quality groundwater to flow towards the groundwater withdrawals, especially near the coast. This would result in poorer quality groundwater in some areas under the No Action Alternative as compared to the Second Basis of Comparison.

7.4.3.2 Alternative 1

Alternative 1 is identical to the Second Basis of Comparison. As described in Chapter 4, Approach to Environmental Analysis, Alternative 1 is compared to the No Action Alternative and the Second Basis of Comparison. However, because groundwater conditions under Alternative 1 are identical to groundwater conditions under the Second Basis of Comparison; Alternative 1 is only compared to the No Action Alternative.

7.4.3.2.1 Alternative 1 Compared to the No Action Alternative

Trinity River Region

Groundwater conditions in the Trinity River Region are not directly related to CVP and SWP water supplies or operations. Therefore, groundwater use, related groundwater levels, potential for land use subsidence, and groundwater quality degradation under Alternative 1 would be the same as under the No Action Alternative.

Central Valley Region

Groundwater Use and Elevation

In areas of the Central Valley Region that do not use CVP and SWP water supplies, areas that use CVP water under Sacramento River Exchange Settlement Contracts, and areas that use San Joaquin River Exchange Contracts under Alternative 1 water supplies would be the same as under the No Action Alternative. Therefore, in these areas of the Central Valley Region, groundwater use and groundwater levels under Alternative 1 would be the same as under the No Action Alternative.

In areas of the Central Valley Region that use CVP water service contract and SWP entitlement contract water supplies, the CVP and SWP water supplies would be greater under Alternative 1 as compared to the No Action Alternative. The differences would result in decreased groundwater use and increased groundwater levels in the San Joaquin Valley Groundwater Basin under Alternative 1 as compared to the No Action Alternative. Results of CVHM simulation indicate that groundwater levels would be similar in the Redding and Sacramento Valley groundwater basins and the northern portion of the San Joaquin Valley Groundwater Basin, as shown in Figures 7.24 through 7.28.

Groundwater levels increase under Alternative 1 in the central and southern San Joaquin Valley Groundwater Basin as compared to the No Action Alternative with greater increases occurring in wet years than in critical dry years (up to 500 feet). Figures 7.29 and 7.30 present the simulated changes in groundwater levels over the 42-year CVHM study period. Simulated average July agricultural groundwater pumping under Alternative 1 as compared to the No Action Alternative is presented in Figures 7.31 and 7.32.

Overall, under Alternative 1 as compared to the No Action Alternative, July average groundwater levels increase approximately 2 to 10 feet in most of the central and southern San Joaquin Valley Groundwater Basin in all water year types. July average groundwater levels rise 10 to 50 feet in the Delta-Mendota, Tulare Lake, and Kern County subbasins; and 100 to 500 feet in Westside subbasin. In critical dry years, groundwater levels increase by up to 200 feet in the Westside subbasin. The groundwater level change hydrographs show that in the central and southern San Joaquin Valley subbasins, groundwater levels can fluctuate up to 200 feet in some areas due to climatic variations under Alternative 1 compared to the No Action Alternative.

The change in groundwater pumping in the Sacramento Valley is less than 5 percent. Therefore, groundwater pumping in the Sacramento Valley is similar under Alternative 1 as compared to the No Action Alternative.

Groundwater pumping in the San Joaquin and Tulare Basins would decrease by approximately 8 percent under Alternative 1 as compared to the No Action Alternative. Figure 7.32 shows that the biggest change in groundwater pumping under the Alternative 1 compared to the No Action Alternative occurs in the Westside subbasin with an average July decrease close to 40 TAF.

Land Subsidence

Land subsidence due to groundwater withdrawals historically occurred in the Yolo subbasin of the Sacramento Valley Groundwater Basin. CVP and SWP water supplies are not used extensively in this area. The conditions under Alternative 1 would be similar as conditions under the No Action Alternative.

Under Alternative 1, potential for land subsidence due to groundwater withdrawals in the Delta-Mendota and Westside subbasins of the San Joaquin Valley Groundwater Basin would decrease under Alternative 1 as compared to the No Action Alternative due to the decreased groundwater withdrawals.

Groundwater level-induced land subsidence has the highest potential to occur in the San Joaquin Valley Groundwater Basin, based on historical data, if groundwater pumping substantially increases. Under Alternative 1 CVP and SWP water supplies are expected to increase in the San Joaquin Valley as compared to the No Action Alternative. Increased surface water deliveries could result in a decrease in groundwater pumping. The decreased groundwater pumping would result in higher groundwater levels, and therefore, the potential for groundwater level-induced land subsidence is reduced under Alternative 1 as compared to the No Action Alternative.

Groundwater Quality

Under Alternative 1, groundwater conditions, including groundwater quality, in areas that do not use CVP and SWP water supplies would be the same as under the No Action Alternative.

In areas that use CVP and SWP water supplies, groundwater quality under Alternative 1 could be improved as compared to the No Action Alternative in the central and southern San Joaquin Valley Groundwater Basin due to decreased groundwater withdrawals. As described above, it is assumed that measures implemented in accordance with the CV-SALTS program or future sustainable groundwater management plans implemented in accordance with SGMA would not be fully implemented by 2030. However, due to the increased availability of CVP and SWP water supplies and related reduction in groundwater use, the groundwater quality would be improved under Alternative 1 as compared to the No Action Alternative.

Effects Related to Water Transfers

Potential effects to groundwater resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c), as described above under the No Action Alternative compared to the Second Basis of Comparison. For the purposes of this EIS, it is anticipated that similar conditions would occur during implementation of cross Delta water transfers under Alternative 1 and the No Action Alternative, and that groundwater impacts would not be substantial in the seller’s service area due implementation requirements of the transfer programs.

Groundwater use in areas that purchase the transferred water could be reduced if additional surface water is provided. However, if the transferred water is used to meet water demands that would not have been met (e.g., crops that had been idled), groundwater conditions would be similar with or without water transfers.

Under Alternative 1, water could be transferred throughout the year without an annual volumetric limit. Under the No Action Alternative, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Overall, the potential for cross Delta water transfers would be greater under Alternative 1 as compared to the No Action Alternative.

San Francisco Bay Area, Central Coast, and Southern California Regions
Groundwater Use and Elevation

Under Alternative 1, it is anticipated that CVP and SWP water supplies in the San Francisco Bay Area, Central Coast, and Southern California regions would be increased as compared to CVP and SWP water supplies under the No Action Alternative, as discussed in Chapter 5, Surface Water Resources and Water Supplies. The increase in surface water supplies could result in decreased groundwater withdrawals by CVP and SWP water users, resulting in increased groundwater recharge, and increased groundwater levels in areas with CVP and SWP water users.

Land Subsidence

Decreased use of groundwater and higher groundwater levels would result in a decreased potential for additional land subsidence under Alternative 1 as compared to the No Action Alternative in the Santa Clara Valley Groundwater Basin in the San Francisco Bay Area Region, and the Antelope Valley and Lucerne Valley groundwater basins in the Southern California Region.

Groundwater Quality

As described in Section 7.3, Affected Environment, there are localized areas of moderate to high salinity due to natural geologic formations and/or seawater intrusion in the San Francisco Bay Area, Central Coast, and Southern California regions. Under Alternative 1 as compared to the No Action Alternative, it is anticipated that the decreased groundwater withdrawals would cause improved groundwater quality, especially near the coast.

7.4.3.2.2 Alternative 1 Compared to the Second Basis of Comparison

Alternative 1 is identical to the Second Basis of Comparison.

7.4.3.3 Alternative 2

The CVP and SWP operations under Alternative 2 are identical to the CVP and SWP operations under the No Action Alternative; therefore, the groundwater conditions under Alternative 2 is only compared to the Second Basis of Comparison.

7.4.3.3.1 Alternative 2 Compared to the Second Basis of Comparison

Changes to groundwater resources under Alternatives 2 as compared to the Second Basis of Comparison would be the same as the impacts described in Section 7.4.3.1, No Action Alternative.

7.4.3.4 Alternative 3

As described in Chapter 3, Description of Alternatives, CVP and SWP operations under Alternative 3 are similar to the Second Basis of Comparison and Alternative 1 with modified Old and Middle River flow criteria. Alternative 3 is compared to the No Action Alternative and the Second Basis of Comparison.

7.4.3.4.1 Alternative 3 Compared to the No Action Alternative

Trinity River Region

Groundwater conditions in the Trinity River Region are not directly related to CVP and SWP water supplies or operations. Therefore, groundwater use, related groundwater levels, potential for land use subsidence, and groundwater quality under Alternative 3 would be the same as under the No Action Alternative.

Central Valley Region

Groundwater Use and Elevation

In areas of the Central Valley Region that do not use CVP and SWP water supplies, areas that use CVP water under Sacramento River Exchange Settlement Contracts, and areas that use San Joaquin River Exchange Contracts under Alternative 3 water supplies would be the same as under the No Action Alternative. Therefore, in these areas of the Central Valley Region, groundwater use and groundwater levels under Alternative 3 would be the same as under the No Action Alternative.

In areas of the Central Valley Region that use CVP water service contract and SWP entitlement contract water supplies, the CVP and SWP water supplies would be greater under Alternative 3 as compared to the No Action Alternative. The differences would result in decreased groundwater use and increased groundwater levels in the San Joaquin Valley Groundwater Basin under Alternative 3 as compared to the No Action Alternative. Results of CVHM simulation indicate that groundwater levels would be similar in the Redding and Sacramento Valley groundwater basins and the northern portion of the San Joaquin Valley Groundwater Basin (changes would plus/minus 2 feet), as shown in Figures 7.33 through 7.37.

Groundwater levels increase under Alternative 3 in the central and southern San Joaquin Valley Groundwater Basin as compared to the No Action Alternative with greater increases occurring in wet years than in critical dry years. Figures 7.38 and 7.39 present the simulated changes in groundwater levels over the 42-year CVHM model study period. Simulated average July agricultural groundwater pumping under Alternative 3 as compared to the No Action Alternative is presented in Figures 7.31 and 7.32.

Overall, under Alternative 3 as compared to the No Action Alternative, July average groundwater levels increase approximately 2 to 10 feet in most of the central and southern San Joaquin Valley Groundwater Basin in all water year types. July average groundwater levels increase 10 to 50 feet in the Delta-Mendota, Tulare Lake, and Kern County subbasins; and 100 to 500 feet in the Westside subbasin in most year types. In critical dry years, groundwater levels increase by up to 200 feet in the Westside subbasin. The groundwater level change hydrographs show that in the central and southern San Joaquin Valley, groundwater levels can fluctuate up to 200 feet in some areas due to climatic variations under Alternative 3 compared to the No Action Alternative.

The change in groundwater pumping in the Sacramento Valley is less than 5 percent. Therefore, groundwater pumping in the Sacramento Valley is similar under Alternative 3 compared to the No Action Alternative.

Groundwater pumping in the San Joaquin and Tulare Basins decreases by approximately 6 percent under Alternative 3 as compared to the No Action Alternative. Figure 7.32 shows that the largest change in groundwater pumping under Alternative 3 as compared to the No Action Alternative occurs in the Westside subbasin with an average July decrease of approximately 35 TAF.

Land Subsidence

Land subsidence due to groundwater withdrawals historically occurred in the Yolo subbasin of the Sacramento Valley Groundwater Basin. CVP and SWP water supplies are not used extensively in this area. The conditions under Alternative 3 would be similar as conditions under the No Action Alternative.

Under Alternative 3, potential for land subsidence due to groundwater withdrawals in the Delta-Mendota and Westside subbasins of the San Joaquin Valley Groundwater Basin would decrease under Alternative 3 as compared to the No Action Alternative due to the decreased groundwater withdrawals.

Groundwater level-induced land subsidence has the highest potential to occur in the San Joaquin Valley Groundwater Basin, based on historical data, if groundwater pumping substantially increases. Under Alternative 3 CVP and SWP water supplies are expected to increase in the San Joaquin Valley as compared to the No Action Alternative. Increased surface water deliveries could result in a decrease in groundwater pumping. The decreased groundwater pumping would result in higher groundwater levels, and therefore, the potential for groundwater level-induced land subsidence is reduced under Alternative 3 as compared to the No Action Alternative.

Groundwater Quality

Under Alternative 3, groundwater conditions, including groundwater quality, in areas that do not use CVP and SWP water supplies would be the same as under the No Action Alternative.

In areas that use CVP and SWP water supplies, groundwater quality under Alternative 3 could be improved as compared to the No Action Alternative in the central and southern San Joaquin Valley Groundwater Basin due to decreased groundwater withdrawals. As described above, it is assumed that measures implemented in accordance with the CV-SALTS program or future sustainable groundwater management plans implemented in accordance with SGMA would not be fully implemented by 2030. However, due to the increased availability of CVP and SWP water supplies and related reduction in groundwater use, the groundwater quality would be improved under Alternative 3 as compared to the No Action Alternative.

Effects Related to Water Transfers

Potential effects to groundwater resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c), as described above under the No Action Alternative compared to the Second Basis of Comparison. For the purposes of this EIS, it is anticipated that similar conditions would occur during implementation of cross Delta water transfers under Alternative 3 and the No Action Alternative, and that groundwater impacts would not be substantial in the seller's service area due implementation requirements of the transfer programs.

Groundwater use in areas that purchase the transferred water could be reduced if additional surface water is provided. However, if the transferred water is used to meet water demands that would not have been met (e.g., crops that had been idled), groundwater conditions would be similar with or without water transfers.

Under Alternative 3, water could be transferred throughout the year without an annual volumetric limit. Under the No Action Alternative, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Overall, the potential for cross Delta water transfers would be greater under Alternative 3 as compared to the No Action Alternative.

San Francisco Bay Area, Central Coast, and Southern California Regions

Groundwater Use and Elevation

Under Alternative 3, it is anticipated that CVP and SWP water supplies in the San Francisco Bay Area, Central Coast, and Southern California regions would be increased as compared to CVP and SWP water supplies under the No Action Alternative, as discussed in Chapter 5, Surface Water Resources and Water Supplies. The increase in surface water supplies could result in decreased groundwater withdrawals by CVP and SWP water users, resulting in increased groundwater recharge, and increased groundwater levels. It may be legally impossible to extract additional groundwater in adjudicated basins without gaining the permission of watermasters and accounting for groundwater pumping entitlements and various parties under their adjudicated rights.

Land Subsidence

Decreased use of groundwater and higher groundwater levels would result in a decreased potential for additional land subsidence under Alternative 3 as compared to the No Action Alternative in the Santa Clara Valley Groundwater Basin in the San Francisco Bay Area Region, and the Antelope Valley and Lucerne Valley groundwater basins in the Southern California Region.

Groundwater Quality

As described in Section 7.3, Affected Environment, there are localized areas of moderate to high salinity due to natural geologic formations and/or seawater intrusion in the San Francisco Bay Area, Central Coast, and Southern California regions. Under Alternative 3 as compared to the No Action Alternative, it is anticipated that the decreased groundwater withdrawals would cause improved groundwater quality, especially near the coast.

7.4.3.4.2 Alternative 3 Compared to the Second Basis of Comparison

Trinity River Region

Groundwater conditions in the Trinity River Region are not directly related to CVP and SWP water supplies or operations. Therefore, groundwater use, related groundwater levels, potential for land use subsidence, and groundwater quality under Alternative 3 would be the same as under the Second Basis of Comparison.

Central Valley Region

Groundwater Use and Elevation

In areas of the Central Valley Region that do not use CVP and SWP water supplies, areas that use CVP water under Sacramento River Exchange Settlement Contracts, and areas that use San Joaquin River Exchange Contracts under Alternative 3 water supplies would be the same as under the Second Basis of Comparison. Therefore, in these areas of the Central Valley Region, groundwater use and groundwater levels under Alternative 3 would be the same as under the Second Basis of Comparison.

In areas of the Central Valley Region that use CVP water service contract and SWP entitlement contract water supplies, the CVP and SWP water supplies would be less under Alternative 3 as compared to the Second Basis of Comparison. The differences would result in increased groundwater use and decreased groundwater levels in the San Joaquin Valley Groundwater Basin under Alternative 3 as compared to the Second Basis of Comparison. Results of CVHM simulation indicate that groundwater levels would be similar in the Redding and Sacramento Valley groundwater basins and the northern portion of the San Joaquin Valley Groundwater Basin, as shown in Figures 7.40 through 7.44.

Groundwater levels generally decrease under Alternative 3 in the central and southern San Joaquin Valley Groundwater Basin as compared to the Second Basis of Comparison. Figures 7.45 and 7.46 present the simulated change in groundwater levels over the 42-year CVHM study period. Simulated average July agricultural groundwater pumping under Alternative 3 as compared to the Second Basis of Comparison is presented in Figures 7.22 and 7.23.

Overall, under Alternative 3 as compared to the Second Basis of Comparison, July average groundwater levels decrease approximately 2 to 10 feet in most of the central and southern San Joaquin Valley Groundwater Basin in all water year types. July average groundwater levels decline 10 to 50 feet in the Delta-Mendota, Tulare Lake, and Kern County subbasins; and decline up to 100 feet in Westside subbasin, in most water year types. However, groundwater levels in the Westside subbasin increase by up to 25 feet in wet years, due to increased CVP water deliveries to this region in wet years. Groundwater level changes in the Sacramento Valley are forecast to be less than 2 feet. The groundwater level change hydrographs show that in the central and southern San Joaquin Valley, groundwater levels can fluctuate up to 200 feet in some areas due to climatic variations under Alternative 3 compared to the Second Basis of Comparison.

The change in groundwater pumping in the Sacramento Valley is less than 5 percent. Therefore, groundwater pumping in the Sacramento Valley is similar under Alternative 3 compared to the Second Basis of Comparison.

Groundwater pumping in the San Joaquin and Tulare Basins changes by less than 5 percent under Alternative 3 as compared to the Second Basis of Comparison, and is therefore considered similar. Figure 7.23 shows that the biggest change in groundwater pumping under Alternative 3 compared to the Second Basis of Comparison occurs in WBS 18, with an average July increase close to 10 TAF.

Land Subsidence

Groundwater pumping would be similar in the Sacramento and San Joaquin valleys, therefore, the potential for groundwater level-induced land subsidence would be similar under Alternative 3 as compared to the Second Basis of Comparison.

Groundwater Quality

Groundwater pumping would be similar in the Sacramento and San Joaquin valleys, therefore, groundwater quality would be similar under Alternative 3 as compared to the Second Basis of Comparison.

Effects Related to Water Transfers

Potential effects to groundwater resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c), as described above under the No Action Alternative compared to the Second Basis of Comparison. For the purposes of this EIS, it is anticipated that similar conditions would occur during implementation of cross Delta water transfers under Alternative 3 and the Second Basis of Comparison, and that groundwater impacts would not be substantial in the seller's service area due implementation requirements of the transfer programs.

Groundwater use in areas that purchase the transferred water could be reduced if additional surface water is provided. However, if the transferred water is used to meet water demands that would not have been met (e.g., crops that had been idled), groundwater conditions would be similar with or without water transfers.

Under Alternative 3 and the Second Basis of Comparison, water could be transferred throughout the year without an annual volumetric limit. Therefore, the potential for cross Delta water transfers would be similar under Alternative 3 and the Second Basis of Comparison.

San Francisco Bay Area, Central Coast, and Southern California Regions

Groundwater Use and Elevation

Under Alternative 3, it is anticipated that CVP and SWP water supplies in the San Francisco Bay Area, Central Coast, and Southern California regions would be decreased as compared to CVP and SWP water supplies under the Second Basis of Comparison, as discussed in Chapter 5, Surface Water Resources and Water Supplies. The decrease in surface water supplies could result in increased groundwater withdrawals by CVP and SWP water users, resulting in decreased groundwater recharge, and decreased groundwater levels in areas with CVP and SWP water users.

Land Subsidence

Increased use of groundwater and lower groundwater levels would result in a decreased potential for additional land subsidence under Alternative 3 as compared to the Second Basis of Comparison in the Santa Clara Valley Groundwater Basin in the San Francisco Bay Area Region, and the Antelope Valley and Lucerne Valley groundwater basins in the Southern California Region.

Groundwater Quality

As described in Section 7.3, Affected Environment, there are localized areas of moderate to high salinity due to natural geologic formations and/or seawater intrusion in the San Francisco Bay Area, Central Coast, and Southern California regions. Under Alternative 3 as compared to the Second Basis of Comparison, it is anticipated that the increased groundwater withdrawals would cause poorer groundwater quality, especially near the coast.

7.4.3.5 Alternative 4

Groundwater conditions under Alternative 4 would be identical to groundwater conditions under the Second Basis of Comparison; therefore, Alternative 4 is only compared to the No Action Alternative.

7.4.3.5.1 Alternative 4 Compared to the No Action Alternative

Changes in groundwater conditions under Alternative 4 as compared to the No Action Alternative would be the same as the impacts described in Section 7.4.3.2.1, Alternative 1 Compared to the No Action Alternative.

7.4.3.6 Alternative 5

CVP and SWP operations under Alternative 5 are similar to the No Action Alternative with modified Old and Middle River flow criteria and New Melones Reservoir operations. As described in Chapter 4, Approach to Environmental Analysis, Alternative 5 is compared to the No Action Alternative and the Second Basis of Comparison.

7.4.3.6.1 Alternative 5 Compared to the No Action Alternative

Trinity River Region

Groundwater conditions in the Trinity River Region are not directly related to CVP and SWP water supplies or operations. Therefore, groundwater use, related groundwater levels, potential for land use subsidence, and groundwater quality under Alternative 5 would be the same as under the No Action Alternative.

Central Valley Region

Groundwater Use and Elevation

In areas of the Central Valley Region that do not use CVP and SWP water supplies, areas that use CVP water under Sacramento River Exchange Settlement Contracts, and areas that use San Joaquin River Exchange Contracts under Alternative 5 water supplies would be the same as under the No Action Alternative. Therefore, in these areas of the Central Valley Region, groundwater use and groundwater levels under Alternative 5 would be the same as under the No Action Alternative.

In areas of the Central Valley Region that use CVP water service contract and SWP entitlement contract water supplies, the CVP and SWP water supplies would be slightly lower under Alternative 5 as compared to the No Action Alternative. The differences would result in increased groundwater use and decreased groundwater levels in the San Joaquin Valley Groundwater Basin under Alternative 5 as compared to the No Action Alternative. Results of CVHM simulations indicate that groundwater levels would be similar in the Redding and Sacramento Valley groundwater basins and the northern portion of the San Joaquin Valley Groundwater Basin, as shown in Figures 7.47 through 7.51.

Groundwater levels decrease under Alternative 5 in the central and southern San Joaquin Valley Groundwater Basin as compared to the No Action Alternative with the greatest decreases occurring in above normal years. Figures 7.52 and 7.53 present the simulated change in groundwater levels over the 42-year CVHM study period. Simulated average July agricultural groundwater pumping under Alternative 5 as compared to the No Action Alternative is presented in Figures 7.31 and 7.32.

Overall, under Alternative 5 as compared to the No Action Alternative, July average groundwater levels decrease approximately 2 to 10 feet in the Westside subbasin and the northern portion of the Kern County subbasin in critical dry and wet water years, and decrease approximately by up to 25 feet in dry and below normal water years in the Westside subbasin, with a maximum decrease of 50 feet in above normal water years. The groundwater level change hydrographs show that in the central and southern San Joaquin Valley, groundwater levels usually fluctuate approximately 50 feet in some areas due to seasonal and climatic variations under Alternative 5 compared to the No Action Alternative.

The change in groundwater pumping in the Sacramento Valley is less than 5 percent. Therefore, groundwater pumping in the Sacramento Valley is similar under Alternative 5 compared to the No Action Alternative.

Groundwater pumping in the San Joaquin and Tulare Basins changes by less than 5 percent under Alternative 5 as compared to the No Action Alternative, and is therefore considered similar. Figure 7.32 shows that the biggest change in groundwater pumping under Alternative 5 compared to the No Action Alternative occurs in the Western San Joaquin Valley.

Land Subsidence

Groundwater pumping would be similar in the Sacramento and San Joaquin valleys, therefore, the potential for groundwater level-induced land subsidence would be similar under Alternative 5 as compared to the No Action Alternative.

Groundwater Quality

Groundwater pumping would be similar in the Sacramento and San Joaquin valleys, therefore, groundwater quality would be similar under Alternative 5 as compared to the No Action Alternative.

Effects Related to Water Transfers

Potential effects to groundwater resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c), as described above under the No Action Alternative compared to the Second Basis of Comparison. For the purposes of this EIS, it is anticipated that similar conditions would occur during implementation of cross Delta water transfers under Alternative 5 and the No Action Alternative, and that groundwater impacts would not be substantial in the seller's service area due implementation requirements of the transfer programs.

Groundwater use in areas that purchase the transferred water could be reduced if additional surface water is provided. However, if the transferred water is used to meet water demands that would not have been met (e.g., crops that had been idled), groundwater conditions would be similar with or without water transfers.

Under Alternative 5 and the No Action Alternative, the timing of cross Delta water transfers would be limited to July through September and include annual volumetric limits, in accordance with the 2008 USFWS BO and 2009 NMFS BO. Overall, the potential for cross Delta water transfers would be similar under Alternative 5 as compared to the No Action Alternative.

San Francisco Bay Area, Central Coast, and Southern California Regions

Groundwater Use and Elevation

Under Alternative 5, it is anticipated that CVP and SWP water supplies in the San Francisco Bay Area, Central Coast, and Southern California regions would be similar to CVP and SWP water supplies under the No Action Alternative, as discussed in Chapter 5, Surface Water Resources and Water Supplies. Therefore, groundwater pumping would be similar.

Land Subsidence

Because the groundwater pumping would be similar under Alternative 5 as compared to the No Action Alternative; therefore, the potential for additional land subsidence would be similar.

Groundwater Quality

Because the groundwater pumping would be similar under Alternative 5 as compared to the No Action Alternative; therefore, groundwater quality would be similar.

7.4.3.6.2 Alternative 5 Compared to the Second Basis of Comparison

Trinity River Region

Groundwater conditions in the Trinity River Region are not directly related to CVP and SWP water supplies or operations. Therefore, groundwater use, related groundwater levels, potential for land use subsidence, and groundwater quality under Alternative 5 would be the same as under the Second Basis of Comparison.

Central Valley Region

Groundwater Use and Elevation

In areas of the Central Valley Region that do not use CVP and SWP water supplies, areas that use CVP water under Sacramento River Exchange Settlement Contracts, and areas that use San Joaquin River Exchange Contracts under Alternative 5 water supplies would be the same as under the Second Basis of Comparison. Therefore, in these areas of the Central Valley Region, groundwater use and groundwater levels under Alternative 5 would be the same as under the Second Basis of Comparison.

In areas of the Central Valley Region that use CVP water service contract and SWP entitlement contract water supplies, the CVP and SWP water supplies would be lower under Alternative 5 as compared to the Second Basis of Comparison. The differences would result in increased groundwater use and decreased groundwater levels in the San Joaquin Valley Groundwater Basin under Alternative 5 as compared to the Second Basis of Comparison. Results of CVHM simulations indicate that groundwater levels would be similar in the Redding and Sacramento Valley groundwater basins and the northern portion of the San Joaquin Valley Groundwater Basin, as shown in Figures 7.54 through 7.58.

Groundwater levels generally decrease under Alternative 5 in the central and southern San Joaquin Valley Groundwater Basin as compared to the Second Basis of Comparison. Figures 7.59 and 7.60 present the simulated change in groundwater levels over the 42-year CVHM study period. Simulated average July agricultural groundwater pumping under Alternative 5 as compared to the Second Basis of Comparison is presented in Figures 7.22 and 7.23.

Overall, under Alternative 5 as compared to the Second Basis of Comparison, July average groundwater levels decrease approximately 2 to 10 feet in most of the central and southern San Joaquin Valley Groundwater Basin in all water year types. July average groundwater levels decline 10 to 100 feet in the Delta-Mendota and Tulare Lake subbasins, and up to 200 feet in the Kern County subbasin; and can decline more than 500 feet in the Westside subbasin, in most water year types (except in critical dry years, when the difference in groundwater levels is closer to 200 feet). Groundwater level changes in the Sacramento Valley are forecast to be less than 2 feet. The groundwater level change hydrographs show that in the central and southern San Joaquin Valley, groundwater levels can fluctuate up to 200 feet in some areas due to seasonal and climatic variations under Alternative 5 compared to the Second Basis of Comparison.

The change in groundwater pumping in the Sacramento Valley is less than 5 percent. Therefore, groundwater pumping in the Sacramento Valley is similar under Alternative 5 compared to the Second Basis of Comparison.

Groundwater pumping in the San Joaquin and Tulare Basins increases by approximately 8 percent under the Alternative 5 as compared to the Second Basis of Comparison. Figure 7.23 shows that the biggest change in groundwater pumping under Alternative 5 compared to the Second Basis of Comparison occurs in WBS 14, with an average July increase of almost 40 TAF.

Land Subsidence

Land subsidence due to groundwater withdrawals historically occurred in the Yolo subbasin of the Sacramento Valley Groundwater Basin. CVP and SWP water supplies are not used extensively in this area. The conditions under Alternative 5 would be similar as conditions under the Second Basis of Comparison.

Under Alternative 5, potential for land subsidence due to groundwater withdrawals in the Delta-Mendota and Westside subbasins of the San Joaquin Valley Groundwater Basin would increase under Alternative 5 as compared to the Second Basis of Comparison due to the increased groundwater withdrawals.

Groundwater level-induced land subsidence has the highest potential to occur in the San Joaquin Groundwater Basin, based on historical data, if groundwater pumping substantially increases. Under Alternative 5, CVP and SWP water supplies are expected to decrease in the San Joaquin Valley as compared to the Second Basis of Comparison. Decreased surface water deliveries could result in an increase in groundwater pumping. The increased groundwater pumping would result in lower groundwater levels, and therefore, the potential for groundwater level-induced land subsidence is increased under Alternative 5 as compared to the Second Basis of Comparison.

Groundwater Quality

Under Alternative 5, groundwater conditions, including groundwater quality, in areas that do not use CVP and SWP water supplies would be the same as under the Second Basis of Comparison.

In areas that use CVP and SWP water supplies, groundwater quality under Alternative 5 could be reduced as compared to the Second Basis of Comparison in the central and southern San Joaquin Valley Groundwater Basin due to increased groundwater withdrawals and resulting potential changes in groundwater flow patterns. As described above, it is assumed that measures implemented in accordance with the CV-SALTS program or future sustainable groundwater management plans implemented in accordance with SGMA would not be fully implemented by 2030. Therefore, groundwater quality may be affected under Alternative 5 as compared to the Second Basis of Comparison.

Effects Related to Water Transfers

Potential effects to groundwater resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014c), as described above under the No Action Alternative compared to the Second Basis of Comparison. For the purposes of this EIS, it is anticipated that similar conditions would occur during implementation of cross Delta water transfers under Alternative 5 and the Second Basis of Comparison, and that groundwater impacts would not be substantial in the seller's service area due implementation requirements of the transfer programs.

Groundwater use in areas that purchase the transferred water could be reduced if additional surface water is provided. However, if the transferred water is used to meet water demands that would not have been met (e.g., crops that had been idled), groundwater conditions would be similar with or without water transfers.

Under Alternative 5 and the Second Basis of Comparison, water could be transferred throughout the year without an annual volumetric limit. Therefore, the potential for cross Delta water transfers would be similar under Alternative 5 and the Second Basis of Comparison.

San Francisco Bay Area, Central Coast, and Southern California Regions

Groundwater Use and Elevation

Under Alternative 5, it is anticipated that CVP and SWP water supplies in the San Francisco Bay Area, Central Coast, and Southern California regions would be decreased as compared to CVP and SWP water supplies under the Second Basis of Comparison, as discussed in Chapter 5, Surface Water Resources and Water Supplies. The decrease in surface water supplies could result in increased groundwater withdrawals by CVP and SWP water users, resulting in decreased groundwater recharge, and decreased groundwater levels in areas with CVP and SWP water users. It may be legally impossible to extract additional groundwater in adjudicated basins without gaining the permission of watermasters and accounting for groundwater pumping entitlements and various parties under their adjudicated rights.

Land Subsidence

Increased use of groundwater and lower groundwater levels would result in a decreased potential for additional land subsidence would increase under Alternative 5 as compared to the Second Basis of Comparison in the Santa Clara Valley Groundwater Basin in the San Francisco Bay Area Region, and the Antelope Valley and Lucerne Valley groundwater basins in the Southern California Region.

Groundwater Quality

As described in Section 7.3, Affected Environment, there are localized areas of moderate to high salinity due to natural geologic formations and/or seawater intrusion in the San Francisco Bay Area, Central Coast, and Southern California regions. Under Alternative 5 as compared to the Second Basis of Comparison, it is anticipated that the increased groundwater withdrawals would cause poorer groundwater quality, especially near the coast.

7.4.3.7 Summary of Impact Analysis

The results of the impact analysis of implementation of Alternatives 1 through 5 as compared to the No Action Alternative and the Second Basis of Comparison are presented in Tables 7.3 and 7.4.

Table 7.3 Comparison of Alternatives 1 through 5 to No Action Alternative

Alternative	Potential Change	Consideration for Mitigation Measures
Alternative 1	**Trinity River Region** Groundwater conditions would be similar. **Central Valley Region** Groundwater pumping and levels in the Sacramento Valley would be similar. Groundwater pumping in the San Joaquin Valley would decrease by approximately 8 percent. July groundwater levels in all water year types would be higher by approximately 2 to 10 feet in the in most of the central and southern San Joaquin Valley; 10 to 50 feet in the Delta-Mendota, Tulare Lake, and Kern County subbasins; and 100 to over 500 feet in the Westside subbasin. The higher groundwater levels would reduce the potential for land subsidence. Groundwater quality in the San Joaquin Valley Groundwater Basin could decline. **San Francisco Bay Area, Central Coast, and Southern California Regions** Increases in CVP and SWP water supplies, could decrease groundwater pumping and decrease the potential for land subsidence.	None needed
Alternative 2	No effects on groundwater resources or water supplies.	None needed
Alternative 3	**Trinity River Region** Groundwater conditions would be similar. **Central Valley Region** Groundwater pumping and levels in the Sacramento Valley would be similar. Groundwater pumping in the San Joaquin Valley would decrease by approximately 6 percent. July groundwater levels in all water year types would be higher by approximately 2 to 10 feet in the in most of the central and southern San Joaquin Valley; 10 to 50 feet in the Delta-Mendota, Tulare Lake, and Kern County subbasins; and 100 to over 500 feet in the Westside subbasin. The higher groundwater levels would reduce the potential for land subsidence. Groundwater quality in the San Joaquin Valley Groundwater Basin could decline. **San Francisco Bay Area, Central Coast, and Southern California Regions** Increases in CVP and SWP water supplies, could decrease groundwater pumping and decrease the potential for land subsidence.	None needed
Alternative 4	Same effects as described for Alternative 1 compared to the No Action Alternative.	None needed

Alternative	Potential Change	Consideration for Mitigation Measures
Alternative 5	**Trinity River Region** Groundwater conditions would be similar. **Central Valley Regions** Groundwater pumping and levels in the Sacramento Valley would be similar. Groundwater pumping, levels, and quality in the San Joaquin Valley would be similar. July groundwater levels in all water year types would decline approximately 2 to 10 feet in the in most of the central and southern San Joaquin Valley; and 25 to 50 feet in the Westside subbasin. **San Francisco Bay Area, Central Coast, and Southern California Regions** Because the CVP and SWP water deliveries would be similar; groundwater pumping would be similar the potential for land subsidence would be similar.	None needed

Table 7.4 Comparison of No Action Alternative and Alternatives 1 through 5 to Second Basis of Comparison

Alternative	Potential Change	Consideration for Mitigation Measures
No Action Alternative	**Trinity River Region** Groundwater conditions would be similar. **Central Valley Regions** Groundwater pumping and levels in the Sacramento Valley would be similar. Groundwater pumping in the San Joaquin Valley would increase by approximately 8 percent. July groundwater levels in all water year types would decline approximately 2 to 10 feet in the in most of the central and southern San Joaquin Valley; 10 to 50 feet in the Delta-Mendota, Tulare Lake, and Kern County subbasins; and 100 to over 200 feet in the Westside subbasin. The reduction in groundwater levels could cause additional land subsidence. Groundwater quality in the San Joaquin Valley Groundwater Basin could decline. **San Francisco Bay Area, Central Coast, and Southern California Regions** Reductions in CVP and SWP water supplies, could increase groundwater pumping and increase the potential for land subsidence.	Not considered for this comparison.
Alternative 1	No effects on groundwater resources or water supplies.	None needed.
Alternative 2	Same effects as described for No Action Alternative as compared to the Second Basis of Comparison.	Not considered for this comparison.

Alternative	Potential Change	Consideration for Mitigation Measures
Alternative 3	**Trinity River Region** Groundwater conditions would be similar. **Central Valley Regions** Groundwater pumping and levels in the Sacramento Valley would be similar. Groundwater pumping, levels, and quality in the San Joaquin Valley would be similar. July groundwater levels in all water year types would decline approximately 2 to 10 feet in the in most of the central and southern San Joaquin Valley; 10 to 50 feet in the Delta-Mendota, Tulare Lake, and Kern County subbasins; and up to 100 feet in the Westside subbasin. **San Francisco Bay Area, Central Coast, and Southern California Regions** Reductions in CVP and SWP water supplies, could increase groundwater pumping and increase the potential for land subsidence.	Not considered for this comparison.
Alternative 4	No effects on groundwater resources or water supplies.	None needed
Alternative 5	**Trinity River Region** Groundwater conditions would be similar. **Central Valley Regions** Groundwater pumping and levels in the Sacramento Valley would be similar. Groundwater pumping in the San Joaquin Valley would increase by approximately 8 percent. July groundwater levels in all water year types would decline approximately 2 to 10 feet in the in most of the central and southern San Joaquin Valley; 10 to 100 feet in the Delta-Mendota and Tulare Lake subbasins; up to 200 feet in the Kern County subbasins; and up to 500 feet in the Westside subbasin. The reduction in groundwater levels could cause additional land subsidence. Groundwater quality in the San Joaquin Valley Groundwater Basin could decline. **San Francisco Bay Area, Central Coast, and Southern California Regions** Reductions in CVP and SWP water supplies, could increase groundwater pumping and increase the potential for land subsidence.	Not considered for this comparison.

7.4.3.8 Potential Mitigation Measures

As described above and summarized in Table 7.3, implementation of Alternatives 1 through 5 as compared to the No Action Alternative would result in either similar or less groundwater pumping and potential for land subsidence; and similar groundwater quality conditions. Therefore, there would be no adverse impacts to groundwater; and no mitigation measures are needed.

7.4.3.9 Cumulative Effects Analysis

As described in Chapter 3, the cumulative effects analysis considers projects, programs, and policies that are not speculative; and are based upon known or reasonably foreseeable long-range plans, regulations, operating agreements, or other information that establishes them as reasonably foreseeable.

The No Action Alternative, Alternatives 1 through 5, and Second Basis of Comparison include climate change and sea-level rise, implementation of general plans, and completion of ongoing projects and programs (see Chapter 3, Description of Alternatives). The effects of these items were analyzed quantitatively and qualitatively, as described in the Impact Analysis of this chapter. The discussion below focuses on the qualitative effects of the alternatives and other past, present, and reasonably foreseeable future projects identified for consideration of cumulative effects (see Chapter 3, Description of Alternatives).

7.4.3.9.1 No Action Alternative and Alternatives 1 through 5

Continued coordinated long-term operation of the CVP and SWP under the No Action Alternative would result in reduced CVP and SWP water supply availability as compared to recent conditions due to climate change and sea-level rise by 2030. These conditions are included in the analysis presented above.

Future groundwater management projects considered in cumulative effects analysis (see Chapter 3, Description of Alternatives), could improve groundwater conditions, including development or expansion of groundwater banks (City of Roseville 2012; MORE 2015; NSJCGBA 2007; SEWD 2012; MWDSC 2010; KRCD 2012b; BVWSD 2015; City of Los Angeles 2010, 2013; Los Angeles County 2013; City of San Diego 2009a, 2009b; RCWD 2011, 2012; Reclamation 2011b; EMWD 2014a; JCSD et al. 2010).

Implementation of SGMA, will have a beneficial effect on groundwater resources, as most areas will develop plans to manage groundwater extractions to not exacerbate further groundwater level declines. The implementation of the SGMA in high and medium groundwater basins would reduce the impacts on groundwater levels, storage and groundwater supply by implementing sustainable groundwater management plans and actions at the local level.

As part of the SGMA actions and implementation, there will be several measures available to CVP and SWP water users, even with reduced surface water supply reliability. The CVP and SWP water contractors receive variable water supplies due to variations in hydrology and regulatory constraints and are accustomed to responding accordingly. As a result of this variability, many water users have developed or are developing complex water management strategies that include numerous options. It is recognized that in some basins and subbasins, SGMA actions could be implemented early, and sustainable groundwater management might be fully underway by 2030. This would result in beneficial impacts on groundwater resources in these areas.

There would be no adverse impacts associated with implementation of the alternatives as compared to the No Action Alternative. Therefore, Alternatives 1 through 5 would not contribute cumulative impacts to groundwater as compared to the No Action Alternative. However, implementation of No Action Alternative and Alternative 5 (in the Central Valley, San Francisco Bay Area, Central Coast, and Southern California regions) and Alternative 3 (in the San Francisco Bay Area, Central Coast, and Southern California regions) as compared to the Second Basis of Comparison would result in increased groundwater pumping and associated potential for land subsidence and poorer groundwater quality; and could contribute to cumulative impacts related to groundwater conditions as compared to the Second Basis of Comparison conditions.

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