Appendix I Groundwater Technical Appendix

This appendix documents the groundwater technical analysis to support the impact analysis in the environmental impact statement (EIS).

I.1 Background Information

Groundwater occurs throughout the study area. However, the groundwater resources that could be directly or indirectly affected through implementation of the alternatives analyzed in the EIS are related to groundwater basins, which include users of Central Valley Project (CVP) and State Water Project (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 descriptions are limited to these areas and do not include groundwater basins or subbasins that area not directly or indirectly affected by changes in CVP and SWP operations. Changes in groundwater resources because of changes in CVP and SWP operations may occur in the Trinity River, Sacramento Valley (Sacramento River, Feather River, and American River), Clear Creek, San Joaquin Valley (Stanislaus River, San Joaquin River), and Sacramento–San Joaquin Delta (Delta) areas. The additional areas where CVP and SWP deliveries are exported (Central Coast and Southern California regions) are also included.

I.1.1 Overview

Groundwater is a vital resource in California and supplied about 37% of the state's average agricultural, municipal, and industrial water needs between 1998 and 2010, and 40% or more during dry and critical water years in that period (California Department of Water Resources [DWR] 2013a). About 20% 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 (U.S. Geological Survey [USGS] 2009). The three Central Valley hydrologic regions (Tulare Lake, San Joaquin River, and Sacramento River) account for about 75% of the state's average annual groundwater use (DWR 2013a).

DWR has delineated distinct groundwater systems throughout the state, as described in Bulletin 118-03 (DWR 2003a), that are 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 nonconsolidated (nonfractured rock) aquifers. Through the Sustainable Groundwater Management Act (SGMA), DWR accepted applications to modify the delineation of groundwater basins if enough newer information was available. DWR released final basin boundary modifications on February 11, 2019 (DWR 2019a). The groundwater basin descriptions provided in this appendix are primarily based on the information provided in DWR Bulletin 118.

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% of the agricultural, municipal, and industrial water supplies by groundwater in an average year. The Sacramento Valley and northern portion of the San Joaquin Valley Groundwater Basin use groundwater to meet approximately 30% and 40% of the agricultural, municipal, and industrial water demand, respectively. On an annual average basis in the coastal areas of Southern California, groundwater use varies from less than 10% in western San Diego

County to between 35% and 50% of the agricultural, municipal, and industrial water supplies in counties along the coast in western Ventura, Los Angeles, and Riverside Counties and in Orange County. In the inland areas of Southern California, groundwater use varies from approximately 45% to over 90% of the agricultural, municipal, and industrial water supplies (DWR 2013b).

DWR developed a priority ranking for the groundwater basins and subbasins as part of the 2009 Comprehensive Water package. The priority rankings were released in 2014 as part of the California Statewide Groundwater Elevation Monitoring (CASGEM) Program. The SGMA legislation that went into effect in 2015 required DWR to reassess the basin prioritization. Basins were prioritized based on 8 factors: population, population growth, public supply wells in the basin, total wells in the basin, acres of irrigated agriculture, reliance on groundwater as a primarily supply source, documented impacts to groundwater (overdraft, subsidence, saline intrusion, water quality issues) and “other” factors (such as habitat and streamflow). DWR developed four prioritization categories by weighting these factors: high, medium, low, and very low priority. Of the 517 groundwater basins evaluated statewide, DWR identified 109 as high- and medium-priority basins. These basins account for approximately 98% of the groundwater use in California.

I.1.2 Trinity River

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 (United States Department of the Interior, Bureau of Reclamation [Reclamation] et al. 2006; North Coast Regional Water Quality Control Board [RWQCB] 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 and leakage of steam flow to underlying aquifers are expected to occur at various locations.

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

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 (North Coast RWQCB 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 2010). 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.

Both the Hoopa Valley and Lower Klamath River Valley Groundwater Basins were designated by DWR as very low priority under SGMA.

Groundwater quality is suitable for many beneficial uses in the region. In other locations, groundwater can include naturally occurring metals, including manganese, cadmium, zinc, and barium (Hoopa Valley Tribe 2008). Other groundwater quality issues include nitrate contamination (DWR 2013a). 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 because of 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 (North Coast RWQCB 2005).

I.1.3 Sacramento River Valley

The Sacramento Valley includes the Redding Area 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, or evaporation directly, becomes recharge to the groundwater aquifer or flows back to surface waterways.

Overall, the Sacramento Valley 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 because of 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. Several areas have localized aquifers with high nitrate, total dissolved solids (TDS), or boron concentrations. High nitrate concentrations frequently occur because of 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 but can also be a marker for effects of wastewater discharge.

The groundwater conditions in areas surrounding the major rivers in the Sacramento Valley, including the Sacramento, Feather, and American Rivers, are described in the subsequent sections. The descriptions of these areas are combined in this section as they all cover the Sacramento Valley Groundwater Basin.

I.1.3.1 *Overview of Groundwater Basins in the Sacramento Valley*

The Sacramento Valley Groundwater Basin has been divided into 17 subbasins by DWR. 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. The Redding Area Groundwater Basin is situated in the extreme northern end of the valley and is a separate, isolated groundwater basin but is discussed as part of the overall Sacramento Valley because of similarities in geology and stratigraphy.

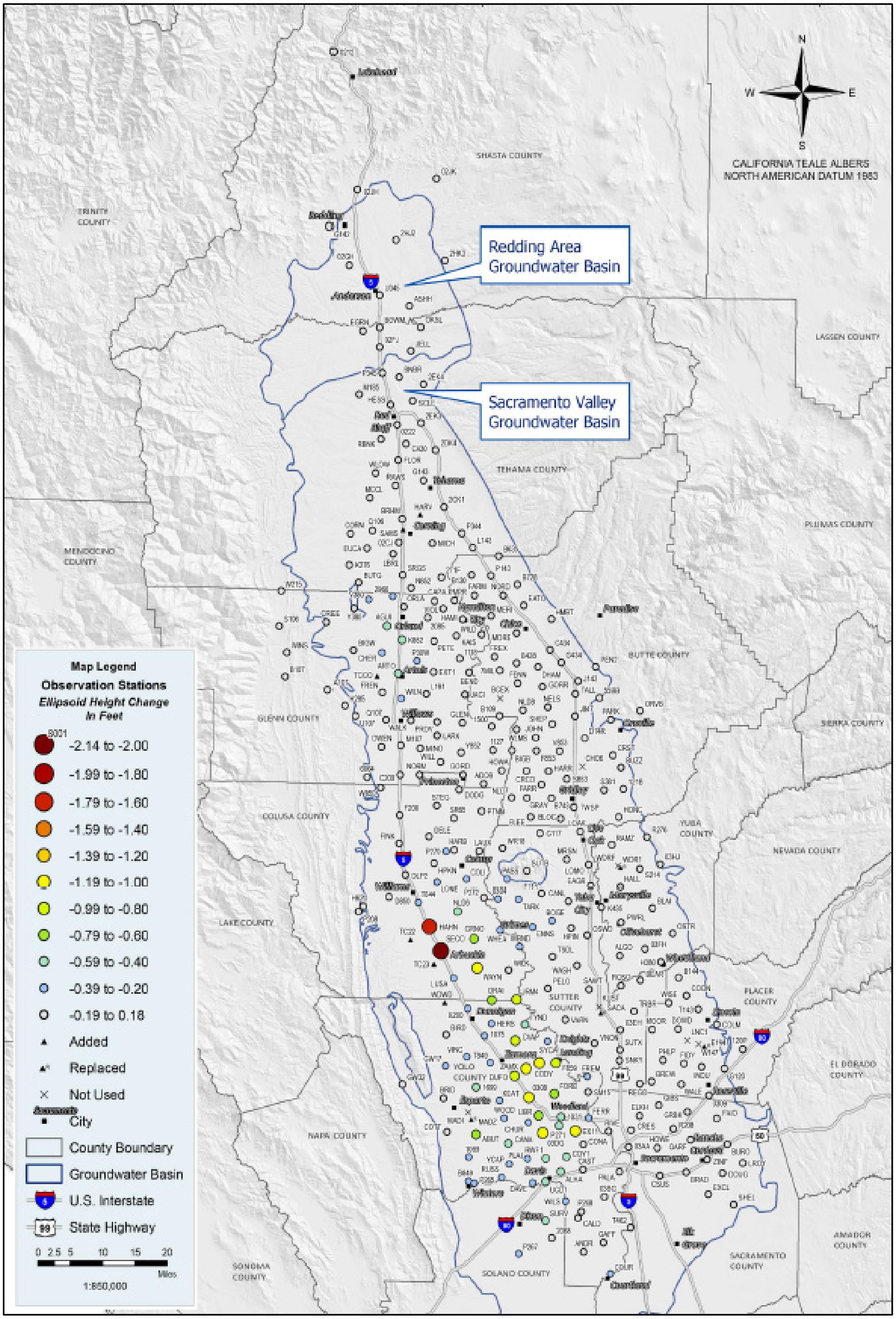
This basin is subdivided into six subbasins by DWR. The basin is bordered by the Coast Ranges on the west and by the Cascade Range and Sierra Nevada mountains on the east.

For discussion purposes and because of their common characteristics, the Sacramento Valley is further subdivided into the Upper Sacramento Valley, the Lower Sacramento Valley west of the Sacramento River, and the Lower Sacramento Valley east of the Sacramento River.

Fresh water in the Sacramento Valley Groundwater Basin generally occurs within continental deposits. Hydrogeologic units containing fresh water 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 fresh water in the Sacramento Valley ranges between 400 and 3,350 feet below mean sea level (Berkstresser 1973). The location where the base of fresh water is the deepest occurs in the Delta near Rio Vista. Near the valley margins and the Sutter Buttes, the base of fresh water is relatively shallow, suggesting that the base of fresh water may coincide with bedrock or connate water trapped in shallower deposits close to the basin margins (Berkstresser 1973).

Groundwater levels are generally in balance across the Sacramento Valley, with pumping matched by recharge from the various sources annually. Some locales show 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, 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. As a result of the 2011 through 2016 drought, surface water supplies 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 2014a). In general, periods of drought cause an increased reliance on groundwater.

Land subsidence in the Sacramento Valley has resulted from inelastic deformation (nonrecoverable 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 4 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 foot 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. Figure I.1-1, Measured Subsidence, 2008 to 2017, shows the measured subsidence in the Sacramento Valley from 2008 to 2017 (DWR 2018). There are areas on the west side of the valley near Arbuckle and Zamora/Woodland that have seen subsidence of 1 foot or more since 2008.



Source: DWR 2018.

Figure I.1-1. Measured Subsidence, 2008 to 2017

I.1.3.2 *Upper Sacramento Valley*

The Upper Sacramento Valley includes the Redding Area Groundwater Basin and upper portions of the Sacramento Valley Groundwater Basin (DWR 2003a). The Redding Area 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, Cascade, and Coast Ranges and drain to the Sacramento River (DWR 2003a).

I.1.3.2.1 Hydrogeology and Groundwater Conditions

The Redding Area 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 interbedded, 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, 2004c, 2004d, 2004e, 2004f, 2004g, 2004h).

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 toward the Sacramento River (DWR 2003a, 2004c, 2004d, 2004e, 2004f, 2004g, 2004h). The Tuscan formation is derived from the Cascade Range to the east and primarily composed of volcaniclastic sediments.

The Redding Area Groundwater Basin includes six subbasins: Anderson, Rosewood, Bowman, Enterprise, Millville, and South Battle Creek (DWR 2003a, 2004c, 2004d, 2004e, 2004f, 2004g, 2004h). 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). Information indicates that groundwater levels declined at multiple wells by up to 10 feet between spring 2013 and spring 2018 in the Redding Area Groundwater Basin. Many wells experienced changes over this period of ± 2.5 feet (DWR 2019b). The groundwater levels in some areas declined up to 10 feet between fall 2012 and fall 2017, with many wells recording changes of ± 2.5 feet, and several showing increases of up to 10 feet (DWR 2019b).

Tehama County overlies three subbasins within the Redding Area Groundwater Basin and seven subbasins in the Sacramento Valley Groundwater Basin. The Rosewood, South Battle Creek, and Bowman subbasins in the Redding Area 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 2004d, 2004e, 2004h, 2004i, 2004j, 2004k, 2004l, 2004m, 2004n, 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 substantial seasonal variation because of high groundwater use for irrigation during the summer months. Groundwater levels showed substantial 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 because of 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). Information indicates that groundwater levels in the upper portion of the Sacramento Valley Groundwater Basin declined at multiple wells approximately 2.5 to 10 feet, with some decreases of over 10 feet, between spring 2013 and spring 2018 (DWR 2019b). Similar changes were also observed from fall 2012 to fall 2017 (DWR 2019b).

Groundwater quality in the Redding Area Groundwater Basin is generally good to excellent for most uses. Some areas of poor quality because of 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 2004c, 2004d, 2004e, 2004f, 2004g, 2004h). 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 2004i, 2004j, 2004k, 2004l, 2004m, 2004n, 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 Tuscan Springs, which is a source of high boron and sulfates.

The CASGEM Program prioritized the subbasins in this area as medium priority except for the Bowman, Millville, and South Battle Creek subbasins, which were prioritized as very low. SGMA designated the Antelope subbasin as high priority and the Anderson, Enterprise, and Red Bluff subbasins as medium priority. The other subbasins in the area have final SGMA designations that are pending (DWR 2019b).

I.1.3.2.2 Groundwater Use and Management

Tehama County uses groundwater to meet approximately 65% 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% of the irrigated acres rely upon groundwater (DWR 2003b). Groundwater also is the primary water supply for residences and small-scale agricultural operations.

I.1.3.3 *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, 2004o, 2004p, 2006b).

I.1.3.3.1 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 and 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 2014a, 2014b). Historically, groundwater levels fluctuate by approximately 5 feet seasonally during normal and dry years (DWR 2006b, 2013a). Measurements indicate that groundwater levels declined at multiple wells in the Colusa subbasin over 10 feet from spring 2013 to spring 2018, especially in the northern and southern portions of the subbasin (DWR 2019b). Similar results were measured between fall 2012 and fall 2017.

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 2006b, 2013a). 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 is prioritized as a medium priority basin by CASGEM. The final SGMA priority designation is pending.

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 substantial 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 (DWR 2004o, 2013b). However, information indicates that groundwater levels in the Yolo subbasin declined at multiple wells at least 10 feet between spring 2013 and spring 2018 (DWR 2019b). There are also multiple wells that showed groundwater level increases over 10 feet. Similar results were measured between fall 2012 and fall 2017.

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 2004o, 2013b). The Cities of Davis and Woodland, which rely heavily on groundwater supply, lost nine municipal wells since 2011 due to high nitrate concentrations (Yolo County Flood Control and Water Conservation District [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 CASGEM prioritization of the Yolo subbasin is a combination of high, medium, and low prioritizations because of recent subbasin modifications. The Yolo subbasin final SGMA priority designation is pending.

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 2004p, 2013b). Increasing agricultural and urban development in the 1940s in the

Solano subbasin has caused substantial groundwater level declines. Groundwater levels are relatively stable but show substantial declines during drought cycles. However, information indicates that groundwater levels in the Solano subbasin declined at multiple wells at least 10 feet between spring 2013 and spring 2018 (DWR 2019b). There are also multiple wells that showed groundwater level increases over 10 feet. Similar results were measured between fall 2012 and fall 2017.

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

The CASGEM prioritization of the Solano subbasin was set to be a medium priority. The Solano subbasin final SGMA priority designation is pending.

I.1.3.3.2 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. In normal years, approximately 40% of the irrigation users in Yolo County rely on groundwater (Yolo County 2009). In the eastern portion of the Yolo subbasin, a 2006 study estimated that groundwater supplies about 80 to 85% of the total annual water demand in the county (YCFCWCD 2012).

Within Yolo and Sacramento Counties' portions of the Solano subbasin, groundwater is used primarily 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% of the water supply. Other communities rely upon surface water. Irrigation users within the Solano Irrigation District rely upon surface water. All other irrigation users rely upon groundwater.

I.1.3.4 *Lower Sacramento Valley (East of Sacramento River)*

The Lower Sacramento Valley area is east of the Sacramento River and includes seven groundwater subbasins: Butte, Wyandotte Creek, North Yuba, South Yuba, Sutter, North American, and South American (DWR 2003a, 2004q, 2004r, 2004s, 2006c, 2006d, 2006e, 2006f).

I.1.3.4.1 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 an overall low permeability. 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, 2004q, 2004r, 2004s, 2006c, 2006d, 2006e, 2006f).

Butte and Wyandotte Creek Subbasins

The Butte subbasin is in Butte, Colusa, 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 2004q, 2013b). 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 2012 and spring 2018, groundwater measurements indicate that groundwater levels were relatively stable, within 2.5 feet over the period, at many wells. There were a few wells with water level declines of 2.5 to 4 feet during this period (DWR 2019b). The results were similar for the period from fall 2012 to fall 2017, with more wells showing decreases. (DWR 2019b).

The Wyandotte Creek subbasin is in Butte County. In the northern portion of the Wyandotte Creek subbasin, annual groundwater fluctuations in the confined and semiconfined aquifer system range from 15 to 30 feet during normal years (DWR 2004r, 2013b). In the southern part of Butte County, groundwater fluctuations for wells constructed in the confined and semiconfined aquifer system average 4 feet during normal years and up to 5 feet during drought years. Between spring 2013 and spring 2018, several wells showed changes of ± 2.5 feet. At least one well showed a decline of 7.5 feet while at least two wells showed groundwater level increases of over 10 feet. From fall 2012 to fall 2017, a similar combination of decreased, increased, and stable water levels, though at smaller changes, were measured (DWR 2019b).

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, and TDS concentrations (DWR 2004q, 2013b). 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 2004r, 2013b).

Both the Butte and Wyandotte Creek subbasins were designated by the CASGEM program as medium priority. The SGMA designations for these subbasins are still pending.

North and South Yuba Subbasins

The North Yuba subbasin is in Butte and Yuba Counties. The South Yuba subbasin is in 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 (Yuba County Water Agency [YCWA] 2010). Between spring 2013 and spring 2018, most wells showed a stable (±2.5 feet of change) or an increased water level in the North Yuba subbasin. The South Yuba subbasin showed more wells with a decrease on the order of 3 feet combined with wells with an increased water level (DWR 2019b).

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. The SGMA designations for these subbasins are still pending.

Sutter Subbasin

The Sutter subbasin is 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, 2013b). Information indicates that groundwater levels in the Sutter subbasin changed less than 2.5 feet between spring 2013 and spring 2018 (DWR 2019b). At least one well had a decrease of approximately 7 feet while another had an increase of more than 9 feet. The changes from fall 2012 to fall 2017 were similar.

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 CASGEM program designated the Sutter subbasin as medium priority. The SGMA designation for this subbasin is still pending.

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 area has been more than 70 feet over the past 60 years (Sacramento Groundwater Authority [SGA] 2014). Water purveyors have constructed facilities to import surface water to allow groundwater levels to recover from the historical drawdown levels. 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; however, some wells in southern Sutter County have experienced declines (DWR 2006f, 2013b). Overall, groundwater levels are higher along the eastern portion of the North American subbasin and decline toward the western portion (City of Roseville et al. 2007). There is a groundwater depression in the southern Placer and Sutter Counties near the border with Sacramento County. Between spring 2013 and spring 2018, many wells in the southern portion of the subbasin showed a change of less than 2.5 feet. Several wells in the northern portion of the subbasin showed a decrease of over 15 feet. However, some wells in the same area showed increases of over 10 feet (DWR 2019b). The groundwater level changes between fall 2012 and fall 2017 are similar.

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, 2013b). In an area between Reclamation District 1001 and the Sutter Bypass, high TDS concentrations occur. There have been three sites within the subbasin with substantial groundwater contamination issues: the former McClellan Air Force Base (North Highlands), the Union Pacific Railroad Rail Yard (Roseville), and the Aerojet Superfund Site (Rancho Cordova). 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 because of this type of geology include elevated levels of arsenic, bicarbonate, boron, chloride, fluoride, iron, manganese, nitrate, sodium, and TDS (DWR 2003b).

The CASGEM program designated the North American subbasin as high priority. The SGMA designation for this subbasin is still pending.

South American Subbasin

The South American subbasin is in 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-1980s 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 2004s, 2013b). Between fall 2012 and fall 2017, groundwater levels varied from an increase of 40 feet to a decrease of 13 feet. Generally, the water levels increased in the western portion and decreased in the eastern portion of the subbasin (DWR 2019b). Less data exists for the spring 2013 to spring 2018 period. The data show a range from an increase of 14 feet to a decrease of 14 feet.

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

The CASGEM program designated the South American subbasin as high priority. The SGMA designation for this subbasin is still pending.

I.1.3.4.2 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.

Butte and Wyandotte Creek Subbasins

The primary water source in Butte County is surface water (approximately 70% by volume), and groundwater use accounts for about 30% of total county water use. In Butte County, most of the irrigation users rely upon surface water, and approximately 75% 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 2011a).

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 for irrigated agriculture (YCWA 2010).

Sutter Subbasin

Agricultural water use in Sutter County is composed, on average, of approximately 60% surface water, 20% groundwater, and 20% 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 2012).

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 that are part of SGA, a joint powers authority (SGA 2014). The northern portion of this subbasin is rural and agricultural, whereas 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 (City of 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 substantial source of water supply and 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 (Regional Water Authority 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 2013, 2014).

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; Elk Grove Water District 2011; Golden State Water Company 2011a; Sacramento County Water Agency 2011). The majority of groundwater pumping is for agricultural uses (Sacramento Central Groundwater Authority 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.

I.1.4 Clear Creek

Clear Creek is a major tributary to the Sacramento River that lies just below Shasta Dam. Clear Creek originates in the mountains east of Clair Engle Reservoir and flows approximately 35 miles to its confluence with the Sacramento River, just south of the town of Redding in Shasta County. Clear Creek drains approximately 249 square miles and receives the majority of its inflow from rainfall and snowmelt.

Given that Clear Creek flows primarily through the mountain valleys, there is little in the way of substantial groundwater basins underlying this area. Any groundwater present in these valleys is likely in close hydraulic connection with Clear Creek. Both groundwater discharge to surface streams and leakage of steam flow to underlying aquifers are expected to occur at various locations.

I.1.5 San Joaquin Valley

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). 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, 2004t, 2004u, 2004v, 2004w, 2006g, 2006h, 2006i). 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 on groundwater, which is used conjunctively with surface water for agricultural, industrial, and municipal supplies (DWR 2003a). Groundwater is estimated to account for about 38% of the overall water supply in the northern portion of the San Joaquin Valley Groundwater Basin (DWR 2013a). Annual groundwater pumping in the northern portion of the San Joaquin Valley Groundwater Basin accounts for about 19% 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 (AFY) between 2005 and 2010.

According to the *California Water Plan Update 2013* (DWR 2013a), 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 2013a).

The northern portion of the San Joaquin Valley Groundwater Basin is divided into two subregions: West of the San Joaquin River and East of the San Joaquin River. These are described below.

I.1.5.1 *West of the San Joaquin River*

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

I.1.5.1.1 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 redeposited in the San Joaquin Valley as alluvial fan, flood plain, 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 in 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, 2013a). Measurement data indicate that between spring 2013 and spring 2018, groundwater levels declined at some wells in the Tracy subbasin by up to 12 feet (DWR 2019b). Groundwater levels in some areas declined up to 14 feet between fall 2012 and fall 2017. In both the spring and fall measurements, many of the wells had decreased between 0 and 3 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, 2013c; USGS 2006). The Central Valley RWQCB recently adopted general waste discharge requirements to protect groundwater and surface water within the San Joaquin County and Delta areas, including the Tracy subbasin (Central Valley RWQCB 2014). 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 CASGEM program designated the Tracy subbasin as medium priority. The SGMA designation for this subbasin is still pending.

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 that contains confined fresh water in the lower section of the Tulare formation; the upper zone that contains confined, semiconfined, and unconfined water in the upper section of the Tulare formation; and a shallow zone that contains unconfined water (DWR 2006h, 2013c). The groundwater is characterized by moderate to extremely high salinity, with localized areas of high iron, fluoride, nitrate, and boron (DWR 2006h, 2013c).

In the Delta-Mendota subbasin, groundwater levels generally declined between 1958 and 2006 by as much as 20 feet in the northern portion of the basin near Patterson. 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 1977, 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). Between measurements in spring 2012 and spring 2018, groundwater levels generally declined. Many wells have decreased between 20 and 50 feet (DWR 2019b). There are two wells with reported decreases over 150 feet. Even given the few well measurements available, many wells showed a decrease of at least 10 feet between fall 2012 and fall 2017 (DWR 2019b).

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 widespread soil compaction and land subsidence between 1926 and 1970 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, USGS evaluated and provided information on groundwater conditions and the potential for additional land subsidence in the San Joaquin Valley (USGS 2013b). Results show that a subsidence rate of up to 0.75 foot per year between 2011 and 2018 has been measured near the San Joaquin River and the Eastside Bypass, affecting the southern part of the Delta-Mendota Canal by about 0.8 inch 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.

I.1.5.1.2 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 (CCWD) (Diablo Water District 2011).

CCWD 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 CCWD 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 County 2009). In the 1980s, about 30% 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% 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 2012). Groundwater is primarily used for domestic and industrial water supplies in Stanislaus County, including for the City of Patterson (Stanislaus County 2010; City of Patterson 2014). In the Delta-Mendota subbasin within Merced County, approximately 3% of groundwater withdrawals are used for municipal and industrial purposes (including uses in the Cities of Gustine and Los Banos, and Santa Nella), and 97% 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 (City of Mendota 2009; City of Firebaugh 2015; Fresno County 2000).

I.1.5.2 *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. The Chowchilla, Eastern San Joaquin, and Madera subbasins are in a critical state of overdraft (DWR 2013a).

I.1.5.2.1 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 connection resulted in a substantial 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 exceeded natural recharge rates and thereby lowered groundwater levels. Areas where this overdraft has occurred include eastern San Joaquin County, Merced County, and western Madera County. Substantial surface water infiltrates from the river to the groundwater system occurs along the San Joaquin River where the riverbed is highly permeable and river water readily seeps into the underlying aquifer. As such, groundwater overdraft reduces both groundwater and surface water outflows to the Delta, lowers the water table, and may increase the potential for land subsidence (U.S. Fish and Wildlife Service [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, 2004t, 2004u, 2004v, 2004w, 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 (Central Valley RWQCB 2011; DWR 2004t; USFWS

2012). Many areas with high concentrations of DBCP have undergone groundwater remediation, and 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 substantially 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 2006j, 2013c). 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). Between measurements in spring 2013 and spring 2018, groundwater levels declined between 4 and 7 feet. There were also increases up to 40 feet (DWR 2019b). Between fall 2012 and fall 2017, measurements at many wells showed water levels declined by 5 to 16 feet.

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

The CASGEM program designated the Cosumnes subbasin as medium priority. The SGMA designation for this subbasin is still pending.

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 2006k, 2013c). 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 (Northeastern San Joaquin County Groundwater Banking Authority [NSJCGBA] 2004). Between spring 2014 and spring 2018, many wells, especially in the central and southern portion of the subbasin, showed water level decreases greater than 10 feet (DWR 2019b). Groundwater level increases were seen in wells in the northern portion of the subbasin. Similar trends were also seen in the data for measurements between fall 2012 and fall 2017.

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 2006k, 2013c). 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 (San Joaquin County Flood Control and Water Conservation District 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 toward the San Joaquin-Stanislaus County line (USFWS 2012).

The CASGEM program designated the Eastern San Joaquin subbasin as high priority. The SGMA designation for this subbasin is still pending.

Modesto Subbasin

The Modesto subbasin underlies northern Stanislaus County. In the Modesto subbasin, water levels declined nearly 15 feet on average between 1970 and 2000 (DWR 2004t, 2013c), with the major declines occurring in the eastern portion of the subbasin. Groundwater level data indicate that many wells showed groundwater levels decreased by more than 15 to 20 feet between spring 2013 and spring 2018 and also between fall 2012 and fall 2017 (DWR 2019b).

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

The CASGEM program designated the Modesto subbasin as high priority. The final SGMA designation for this subbasin is 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 2006j, 2013c). 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. Groundwater level data indicate that many wells showed groundwater levels decreased by more than 15 to 20 feet between spring 2013 and spring 2018 and also between fall 2012 and fall 2017 (DWR 2019b). The storage capacity of the Turlock subbasin is estimated at about 15,800,000 acre-feet (AF) (DWR 2006j, 2013c).

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

The CASGEM program designated the Turlock subbasin as high priority. The final SGMA designation for this subbasin is 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 2004u, 2013c). The estimated specific yield of the groundwater subbasin is 9%. From spring 2013 to spring 2018, several wells, especially in the northwest and southeast portions of this subbasin, showed groundwater level declines over 10 feet, approaching 50 feet (DWR 2019b). There are also several wells with water level declines between fall 2012 and fall 2017; however, there are also wells with water level increases over 10 feet in this period.

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

The CASGEM program designated the Merced subbasin 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 2004v, 2013c). Groundwater recharge in this subbasin is primarily from irrigation water percolation. Groundwater level data show that between spring 2013 and spring 2018, groundwater levels declined at some wells over 25 feet (DWR 2019b).

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

The CASGEM program designated the Chowchilla subbasin as high priority. The SGMA prioritization for this subbasin is still pending.

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 2004w, 2013c). At the single well with water levels collected in spring 2013 and spring 2018, a water level decline of over 50 feet was recorded (DWR 2019b).

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 2004w, 2013c). Occurrences of organic chemicals, including DBCP and pesticides, have been observed (Central Valley RWQCB 2011; DWR 2004w, 2013c).

The CASGEM program designated the Madera subbasin as high priority. The SGMA prioritization for this subbasin is still pending.

I.1.5.2.2 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% groundwater (South Area Water Council 2011). Groundwater and surface water are used for agricultural and domestic water supplies in the Cosumnes subbasin (Central Valley RWQCB 2011). Groundwater is used by many agricultural water users and the community of Galt (Central Valley RWQCB 2011; South Area Water Council 2011).

Central Valley RWQCB recently adopted general waste discharge requirements to protect groundwater and 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 Central Valley RWQCB and are not anticipated to be widely used in this area because of limited availability of recycled water near farms. However, the supporting information recognizes the potential for groundwater impairment due to the water quality of applied water (Central Valley RWQCB 2014).

Eastern San Joaquin Subbasin

Groundwater and surface water are used for agricultural and domestic water supplies in the Eastern San Joaquin subbasin (Central Valley RWQCB 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 (Eastern San Joaquin County Groundwater Basin Authority [ESJCGBA] 2004, 2007). The Cities of Manteca and Stockton use both groundwater and surface water, whereas 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. 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, 2006k). This extensive use of groundwater to meet local demand results in localized overdraft conditions within the subbasin.

The NSJCGBA, now called the ESJCGBA, is a joint-powers authority that develops local projects to strengthen water supply reliability in Eastern San Joaquin County. ESJCGBA facilitated the development and adoption of the *Eastern San Joaquin Groundwater Basin Groundwater Management Plan* (NSJCGBA 2004) 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 substantial adverse effects (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 AF 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 (EBMUD), 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, EBMUD 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.

Central Valley RWQCB recently adopted general waste discharge requirements to protect groundwater and surface water within the San Joaquin County and Delta areas. The new requirements do not address protection of groundwater related to the use of recycled water on crops because those operations would require separate discharge permits from Central Valley RWQCB and are not anticipated to be widely used in this area because of the 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 (Central Valley RWQCB 2014).

Modesto Subbasin

Groundwater is used for agricultural and domestic water supplies in the Modesto subbasin (Reclamation and DWR 2012). Groundwater is used by many agricultural water users and the community of Modesto (DWR 2004t; Stanislaus County 2010).

Turlock Subbasin

Groundwater is used for agricultural and domestic water supplies in the Turlock subbasin (Reclamation and DWR 2012). 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 2006i; Stanislaus County 2010; Merced County 2012).

Merced Subbasin

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

Chowchilla Subbasin

Groundwater is used for agricultural and domestic water supplies in the Chowchilla subbasin (Reclamation and DWR 2012). Groundwater is used by many agricultural water users and the community of Chowchilla (DWR 2006i; Madera County 2002).

Madera Subbasin

Groundwater is used for agricultural and domestic water supplies in the Madera subbasin (Reclamation and DWR 2012). Groundwater is used by many agricultural water users and the community of Madera (DWR 2006i; Madera County 2002, 2008).

I.1.6 Bay-Delta

The Delta overlies the western portion of the area where the Sacramento River and San Joaquin River Groundwater Basins converge. The Delta includes the Solano subbasin and the South American subbasin in the Sacramento Valley Groundwater Basin (as described previously); the Tracy subbasin, the Eastern

San Joaquin subbasin, and the Cosumnes subbasin in the San Joaquin Valley Groundwater Basin (as described previously); and the Suisun-Fairfield Valley Basin (as described subsequently).

I.1.6.1 *Hydrogeology and Groundwater Conditions*

Each groundwater basin in the San Francisco Bay Hydrologic Region contains unique hydrogeologic characteristics. However, generally, water-bearing materials consist of alluvial, unconsolidated sand, sand and gravel, and clay (DWR 2004x, 2004y, 2004z, 2004aa, 2004ab, 2004ac, 2004ad, 2004ae, 2006l, 2006m, 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 substantial groundwater use. However, as groundwater use decreased over the last few decades following implementation of surface water projects, groundwater levels have risen substantially. Over the entire period of record, groundwater levels have shown only a slight decline and are stable in more recent years.

I.1.6.1.1 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 toward 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 semiconsolidated 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 CASGEM program designated the Pittsburg Plain, Clayton Valley, Ygnacio Valley, and Arroyo Del Hambre Valley Groundwater Basins as very low priority. These subbasins are also prioritized as very low in the final SGMA rankings.

I.1.6.1.2 San Ramon Valley Groundwater Basin

The San Ramon Valley Groundwater Basin is 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 CASGEM program and SGMA designated the San Ramon Valley Groundwater Basin as very low priority.

I.1.6.1.3 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 2006l, 2013d).

The Main Basin is the aquifer that includes the highest yielding aquifers and highest quality groundwater (Zone 7 Water Agency [Zone 7] 2018). 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 2006l, 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 began importing SWP water. Subsequently, Zone 7 developed surface water projects to capture local runoff. Local runoff and SWP water are 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. Between spring 2013 and spring 2018, groundwater levels at the majority of wells in the subbasin showed an increase in groundwater level, some approaching 20 or more feet of increase. Differences between fall 2012 and fall 2017 showed similar results.

The Livermore Valley Groundwater Basin is characterized by localized areas of high boron, nitrate, and TDS (DWR 2006l, 2013d; Zone 7 2018). 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 2018). 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 2018), 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 characterized by lower salinity due to the high recharge rate.

The CASGEM program and SGMA designated the Livermore Valley Groundwater Basin as medium priority.

I.1.6.1.4 Castro Valley Groundwater Basin

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

The CASGEM program and SGMA designated the Castro Valley Groundwater Basin as very low priority.

I.1.6.1.5 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 seawater intrusion has occurred. High nitrate concentrations occur in localized areas due to historic agricultural activities.

The CASGEM program and SGMA designated the East Bay Plain subbasin 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 (Alameda County Water District [ACWD] 2012; DWR 2006m, 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 2006m, 2013d).

The main groundwater quality impairment in the Niles Cone subbasin is saltwater intrusion caused by groundwater pumping (ACWD 2012; DWR 2006m, 2013d). In the 1950s, the migration of saline water extended into the Above Hayward Fault subbasin and migrated into deeper aquifers. ACWD 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.

The CASGEM program and SGMA designated the Niles Cone subbasin as medium priority.

Santa Clara Subbasin

The Santa Clara subbasin is in Santa Clara County along a structural trough that parallels the Coast Ranges and extends from the Diablo Range and Santa Cruz Mountains. Water-bearing formations of the Santa Clara subbasin include unconsolidated to semiconsolidated 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 (Santa Clara Valley Water District [SCVWD] 2010). Toward 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 locally referred to as the Santa Clara Plain (SCVWD 2011). The southern portion of the subbasin consists of extensive alluvial deposits of unconsolidated and semiconsolidated sediments and is referred to as the Coyote Valley (SCVWD 2010). The central portions and areas along the edges of the Santa Clara Plain subbasin consist of unconfined aquifers that provide recharge to the basin (SCVWD 2010, 2011). The Shallow Aquifer consists of water-bearing sediments that are less than 150 feet deep. 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 in some areas of the Santa Clara Plain. The groundwater recharge primarily occurs due to percolation of water on the soil from precipitation or artificial recharge operations (as described below), seepage from streambeds, and subsurface inflow from surrounding hills.

In the Coyote Valley, 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 Valley, 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 the Santa Clara subbasin generally flows northwest toward the San Francisco Bay.

The Santa Clara subbasin has historically experienced decreasing groundwater level trends; between 1900 and 1970, water level declines of more than 200 feet from groundwater pumping caused unrecoverable land subsidence of nearly 13 feet in San Jose (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 have resulted in rising groundwater levels and sustainable conditions since the late 1960s. The groundwater levels in some portions of this subbasin increased up to 15 feet between spring 2013 and spring 2018, whereas a few wells decreased approximately 3 feet (DWR 2019b). Similar results are seen between fall 2012 and fall 2017 readings.

The groundwater quality in the Santa Clara subbasin is good to excellent 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. Recent groundwater monitoring has indicated that seawater intrusion appears to be stabilizing (SCVWD 2012). High nitrate concentrations occur in portions of the Coyote Valley.

The Santa Clara subbasin was designated by the CASGEM program as medium priority and as high priority in the final SGMA rankings.

I.1.6.2 *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 landowners. In the Livermore Valley Groundwater Basin, groundwater is used for a major portion of the water supply.

I.1.6.2.1 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 in the CCWD or EBMUD service areas. These districts provide surface water to most water users in this area.

Within the CCWD service area, groundwater use is limited (CCWD 2011). The use of existing CCWD wells at the Mallard wellfields 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 (City of 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 (City of Martinez 2011).

I.1.6.2.2 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 landowners. This area is in the EBMUD service area. The district provides surface water to most water users in this area.

I.1.6.2.3 Livermore Valley Groundwater Basin

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

Zone 7 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 2006l, 2013d).

Zone 7 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, City of Livermore, City of Pleasanton, DSRSD, and California Water Service Company are permitted to withdraw from this subbasin.

In 2009, Zone 7 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.

I.1.6.2.4 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 landowners (City of Castro Valley 2012). This area is in the EBMUD service area. The district provides surface water to most water users in this area.

I.1.6.2.5 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 landowners (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 in the EBMUD service area. The district provides surface water to most water users in this area. EBMUD initiated the Bayside Groundwater Project in 2009 to store surface water in wet years for use during droughts.

Niles Cone Subbasin

ACWD is the primary water agency that relies upon the Niles Cone subbasin. ACWD 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, ACWD diverts some of the SWP allocation to the Semitropic Water Storage District in Kern County through a water banking agreement (as described for the Kern County subbasin). This agreement allows ACWD to subsequently recover this water during drier years through an exchange agreement with Semitropic Water Storage District (ACWD 2012).

ACWD 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 ACWD 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 recharge facilities including streambeds and percolation ponds (SCVWD 2016).

Treated water is provided by the SCVWD to retail water agencies 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, San Jose, Santa Clara, and Sunnyvale; California Water Service (Los Altos 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% of total water use 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 landowners primarily in the southern portion of the subbasin (SCVWD 2012).

SCVWD 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. Surface water is also 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. Five major recharge systems allow local reservoir water and imported water to be released into in-stream recharge and percolation pond facilities for artificial recharge in the Santa Clara subbasin. Recharge in this subbasin occurs along streambeds and off-stream managed basins.

I.1.7 Central Valley Project and State Water Project Service Areas

I.1.7.1 *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 2013a).

SWP water is provided to the Central Coast Region by the Central Coast Water Authority (Central Coast Water Authority 2013). 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 CVP and 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.

I.1.7.1.1 Hydrogeology and Groundwater Conditions

The areas within the CVP and SWP service areas in the Central Coast Region include the Gilroy-Hollister Valley Groundwater Basin in Santa Clara County; 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.

Gilroy-Hollister Valley Groundwater Basin

Llagas Subbasin

The Llagas subbasin is part of the larger Gilroy-Hollister Valley Groundwater Basin, which extends into San Benito County to the south (SCVWD 2016). Similar to the Santa Clara subbasin, the Llagas subbasin consists of unconsolidated alluvial sediments. SCVWD is responsible for groundwater management in the Llagas subbasin and operates a robust and flexible program that uses a variety of surface water sources—local supplies, imported SWP and CVP supplies—for recharge water.

In the Llagas subbasin, groundwater is used by municipal and private well owners to meet domestic, agricultural, and industrial water needs (SCVWD 2016). Groundwater provides over 95% of the total use supply in Llagas Subbasin. Almost half of the pumping in Llagas subbasin is for agricultural use. The major water users in Llagas subbasin include the cities of Morgan Hill and Gilroy, unincorporated San Martin, private well users, private water companies, and golf courses.

The Llagas subbasin generally produces groundwater of good quality that does not need treatment beyond disinfection at public water supply wells. However, the presence of elevated nitrate is an ongoing groundwater protection challenge, particularly in domestic wells (SCVWD 2016). Most wells tested show stable or decreasing trends over time. SCVWD continues to coordinate with land use and regulatory agencies to influence policies, regulations, and decisions related to nitrate management. More directly, SCVWD’s managed recharge program helps dilute nitrate, and water quality testing and nitrate treatment system rebates help reduce well owner exposure (SCVWD 2018).

The Llagas subbasin was designated by the CASGEM program and SGMA as a high priority basin.

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. Water-bearing formations are alluvium that consists of clays, silts, sands, and gravel that extend into the Pacific Ocean (DWR 2004af, 2004ag, 2013e). The alluvium is recharged by seepage from streambeds and precipitation and irrigation water applied to the soils.

The groundwater has moderate TDS (DWR 2004af, 2004ag, 2013e). Localized areas have high nitrate concentrations (City of 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 CASGEM program designated Morro Valley and Chorro Valley Groundwater Basins as high priority.

Santa Maria River Valley Groundwater Basin

The Santa Maria River Valley Groundwater Basin is in San Luis Obispo and Santa Barbara Counties. The water-bearing formation is primarily unconfined alluvium, with localized confined areas near the coast (DWR 2004ah, 2013e; Santa Maria Valley Management Area [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 increases 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 2004ah, 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 CASGEM program designated the Santa Maria River Valley Groundwater Basin as high priority. The final SGMA priority for this subbasin is pending.

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 2004b, 2013e). Groundwater flows toward 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 CASGEM program and final SGMA rankings designated the San Antonio Creek Valley Groundwater Basin as medium priority.

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 2004ai, 2013e). Groundwater flows toward the Santa Ynez River and then toward the Pacific Ocean. Groundwater recharge occurs along the streambeds.

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 2004ai, 2013e).

The CASGEM program and SGMA final rankings designated the Santa Ynez River Valley Groundwater Basin as medium priority.

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 2004ai, 2004aj, 2004ak, 2004al, 2013e).

In the Carpinteria Groundwater Basin, the alluvium extends under the agricultural plain (DWR 2004am, 2013e). A confined aquifer occurs under a thick clay bed in the lower part of the alluvium. This basin includes the Santa Barbara formation; 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 spring 2013 and spring 2018 and more than 70 feet in some areas (DWR 2019b).

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 2004ai, 2004aj, 2004ak, 2004al, 2004am, 2013e; Goleta Water District [GWD] and La Cumbre Mutual Water Company [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 (GWD and LCMWC 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 CASGEM program designated the Goleta Groundwater Basin as medium priority. Goleta, Foothill, Santa Barbara, Montecito, and Carpinteria Groundwater Basins were designated as very low priority. The final SGMA priority ranking lists the Foothill, Goleta, and Santa Barbara groundwater basins as very low priority. The SGMA priority for the Carpinteria and Montecito groundwater basins is still pending.

I.1.7.1.2 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.

Gilroy-Hollister Valley Groundwater Basin

In the Llagas subbasin, groundwater is withdrawn by local water suppliers and private well owners to meet municipal, domestic, agricultural, and industrial water needs (SCVWD 2016). Groundwater provides over 95% of the total water use in Llagas Subbasin. Almost half of the pumping in Llagas subbasin is for agricultural use. The major pumpers in Llagas subbasin include Cities of Morgan Hill and Gilroy, private well users, private water companies, and golf courses.

SCVWD is responsible for groundwater management in the Llagas subbasin and operates a flexible conjunctive use program that uses a variety of surface water sources—local supplies, imported SWP and CVP supplies, and imported transfer options. SCVWD operates a system of in-stream and off-stream artificial recharge facilities to replenish the groundwater basin and provide more flexibility to manage water supplies. Artificial recharge in this subbasin occurs in two major recharge systems that release water in streambeds and off-stream managed basins. Both local reservoir water and imported water are used in the Upper Llagas recharge system, while the Lower Llagas system uses only local water. The amount of water artificially recharged throughout the entire service area depends upon the availability of local, CVP, and/or SWP surface water supplies. The subbasin is in long-term balance, with sustainable conditions.

Morro Valley and Chorro Valley Groundwater Basins

The City of Morro Bay uses groundwater from Morro Valley and Chorro Valley Groundwater Basins. These basins have been designated by the California State Water Resources Control Board (SWRCB) as riparian underflow basins. The City of Morro Bay and other users of these basins have received water rights permits, which limit the rate and volume of groundwater withdrawals (City of Morro Bay 2011).

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) (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 (City of Pismo Beach 2011; City of Arroyo Grande 2012; NCSD 2011; City of 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 streambeds.

The Cities of Pismo Beach, Grover Beach, and 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 (City of Pismo Beach 2011; City of 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 seawater 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% of the water supply to the City of Santa Maria. Recently, groundwater supplies have become 10% to 20% of the total water supply to the city (City of Santa Maria 2011). Groundwater provides most of the water supplies in Orcutt (Golden State Water Company 2011b).

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 2004an, 2013e).

Santa Ynez River Valley Groundwater Basin

Groundwater is used for agricultural and domestic water supplies in the Santa Ynez River Valley Groundwater Basin. Groundwater is used by all agricultural water users and the communities of Buellton, Lompoc, Solvang, Mission Hills, Vandenberg Village, and Santa Ynez (DWR 2004ao, 2013e; Santa Barbara County 2007).

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

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

Portions of the LCMWC 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 (City of 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 AFY.

I.1.8 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.

- 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

I.1.8.1 *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.

I.1.8.1.1 Hydrogeology and Groundwater Conditions

Acton Valley Groundwater Basin

The Acton Valley Groundwater Basin is upgradient of the Santa Clara River Valley Groundwater Basin and drains toward 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.

The CASGEM program and SGMA designated the Acton Valley Groundwater Basin 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 affected by the occurrence of several fault zones (DWR 2004aq, 2004ar, 2006n, 2006o, 2006p, 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 2006n, 2013f).

The Piru, Fillmore, Santa Paula, Mound, and Oxnard subbasins are characterized by alluvium of silts and clays interbedded with sand and gravel lenses. The San Pedro formation includes fine sands and gravels over the alluvium (DWR 2004aq, 2004ar, 2006o, 2006p, 2006q, 2013f).

Groundwater levels throughout the Santa Clara River Valley Groundwater Basin showed declines of at least 10 feet between spring 2013 and spring 2018 (DWR 2019b). Similar changes were observed between fall 2012 and fall 2017.

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 2004aq, 2004ar, 2006o, 2006p, 2006q, 2013f; Castaic Lake Water Agency [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 CASGEM program designated Piru, Oxnard, and Santa Clara River Valley East subbasins as high priority. The Fillmore, Santa Paula, and Mound subbasins were designated as medium priority. Each of the subbasins in the Santa Clara River Valley Groundwater Basin have their final SGMA priorities pending, with the exception of the Santa Clara River Valley East subbasin, which is listed as a high priority.

Simi Valley Groundwater Basin

The Simi Valley Groundwater Basin is in Ventura County (DWR 2004at, 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 streambeds. Groundwater quality is characterized as calcium sulfate, with localized areas of high TDS and organic contaminants.

The Simi Valley Groundwater Basin was designated by the CASGEM program as low priority and by SGMA as very 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 2006r, 2006s, 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 2o to 30 years. 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 levels throughout the Las Posas Valley and Pleasant Valley Groundwater Basins showed declines of at least 10 feet between spring 2013 and spring 2018 (DWR 2019b), with decreases approaching 70 feet in some areas. Similar changes were observed between fall 2012 and fall 2017.

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 2006r, 2006s, 2013f).

The CASGEM program and SGMA designated Las Posas Valley and Pleasant Valley Groundwater Basins as high priority.

Arroyo Santa Rosa Valley Groundwater Basin

The Arroyo Santa Rosa Valley Groundwater Basin is in Ventura County. The water-bearing formations include alluvium of gravel, sand, and clay and the alluvial San Pedro formation of sand and gravel (DWR 2006t, 2013f). Groundwater recharge occurs along the Santa Clara River and its 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.

The CASGEM program designated the Arroyo Santa Rosa Valley Groundwater Basin as medium priority. The final SGMA priority for this basin is pending.

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 2004au, 2004av, 2004aw, 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 (City of Thousand Oaks 2011).

The CASGEM program designated the Conejo Valley Groundwater Basin as low priority. The Tierra Rejada Valley and Thousand Oaks Area Groundwater Basins were designated as very low priority. The three groundwater basins have a very low priority in the final SGMA listing.

Russell Valley Groundwater Basin

The Russell Valley Groundwater Basin is located along the boundaries of Ventura and Los Angeles counties (DWR 2004ax, 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.

The CASGEM program and SGMA designated the Russell Valley Groundwater Basin as very low priority.

I.1.8.1.2 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 (Metropolitan Water District of Southern California [MWDSC] 2007).

Acton Valley Groundwater Basin

The Acton community primarily uses groundwater supplemented by SWP water treated at the Antelope Valley East Kern Acton Water Treatment Plant (Los Angeles County 2014).

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 (United Water Conservation District [UWCD] 2012).

Four retail water purveyors provide water service to most residents of the Santa Clara River Valley East Subbasin. These water purveyors include the CLWA; 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, and Stevenson Ranch (CLWA et al. 2012).

Water purveyors in the Piru, Fillmore, Santa Paula, Mound, and Oxnard subbasins include UWCD and Ventura County. UWCD operates surface water facilities to encourage groundwater protection through conjunctive use (UWCD 2012). Groundwater issues within the UWCD service area (which includes all of the basin) include overdraft conditions, seawater 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 and Ventura County Waterworks District No. 8. The Golden State Water Company provides less than 10% of the total water supply to the area (Golden State Water Company 2011c). Ventura County Waterworks District No. 8 provides groundwater to a golf course, nursery, and industrial users in the Simi Valley area (Ventura County Waterworks District No. 8 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 (UWCD 2012). United Water Conservation District and Ventura County manage water service to many residents of the Las Posas Valley and Pleasant Valley Groundwater Basins.

UWCD operates surface water facilities to encourage groundwater protection through conjunctive use (UWCD 2012). Groundwater is used within the UWCD 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). Fox Canyon GMA 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 GMA includes a portion of the withdrawals reported by UWCD.

The Calleguas Municipal Water District (MWD), in partnership with MWDSC, operates the Las Posas Basin Aquifer Recharge and Recovery project. Calleguas MWD 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 GMA manage groundwater supplies within the basin (Camarosa Water District 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 provides agricultural land uses with individual wells (Camarosa Water District 2013). The City of Thousand Oaks operates two wells; however, the city primarily relies upon SWP water supplies because of the high iron concentrations and salinity in the groundwater (City of 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 MWD. However, the district does not use water from this basin (Calleguas MWD 2011). The Las Virgenes MWD withdraws groundwater from the Russell Basin to augment recycled water supplies (Greater Los Angeles County Integrated Regional Water Management Region [Greater Los Angeles County IRWMR] 2014).

I.1.8.2 *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 and Coastal Plain of Orange County and San Juan Valley Groundwater Basins in Orange County.

I.1.8.2.1 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 Groundwater 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 2004ay).

Groundwater movement is affected by the occurrence of several fault zones (DWR 2004ay). 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 2004ay; Upper Los Angeles River Area Watermaster [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.

The CASGEM program designated the San Fernando Valley Groundwater Basin as medium priority. The SGMA priority for this basin is very low.

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 2004az). 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 2004az). There is an ongoing groundwater remediation program within the groundwater basin to reduce volatile organic compounds and perchlorate.

The CASGEM program designated the Raymond Groundwater Basin as medium priority. The SGMA priority for this basin is very low.

San Gabriel Valley Groundwater Basin

Groundwater in the San Gabriel Valley Groundwater Basin flows from the San Gabriel Mountains toward the west under the San Gabriel Valley to the Whittier Narrows where it discharges into the Coastal Plain of Los Angeles Groundwater Basin (DWR 2004ba). 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. Water-bearing formations include unconsolidated to semiconsolidated alluvium deposits of gravel, sands, and silts.

Groundwater recharge occurs from spreading basins and direct percolation of precipitation and stream flow, including treated wastewater effluent conveyed in the San Gabriel River (DWR 2004ba). 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 2004ba).

The CASGEM program designated the San Gabriel Valley Groundwater Basin as high priority. The SGMA priority for this basin is very low.

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. Groundwater flows toward the Pacific Ocean (DWR 2004bb). The water-bearing formations are mainly alluvial gravel. Groundwater is recharged naturally from precipitation and stream flow.

The CASGEM program and SGMA designated the Hollywood subbasin 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 toward the west and the Hollywood subbasin (DWR 2004bc). The water-bearing formations are mainly alluvial gravel and sand with semiperched 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 CASGEM program designated the Santa Monica subbasin as high priority. The SGMA priority is medium.

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 and Whittier Narrows, with groundwater flows from the San Gabriel Valley (DWR 2004bd).

The nonpressurized, 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 2004bd). 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 2004bd).

The CASGEM program designated the Central subbasin as high priority. The SGMA priority for this basin is very low.

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 semiconfined aquifers composed of sands, silts, clays, and gravels (DWR 2004be). 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. Several agencies have implemented seawater barrier projects to protect the groundwater quality.

The CASGEM program designated the West Coast subbasin as high priority. The SGMA priority for this basin is very low.

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 2004bf). Groundwater flows toward the Pacific Ocean. The water-bearing formations are mainly gravel, sand, clays, and silt (DWR 2004az). 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 seawater intrusion along the Pacific Ocean coast (DWR 2004bf).

The CASGEM program and SGMA designated the Malibu Valley Groundwater Basin as very low priority.

Coastal Plain of Orange County Groundwater Basin

The Coastal Plain of Orange County Groundwater Basin is under a coastal alluvial plain in northern Orange County (DWR 2004bg). 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 toward the Pacific Ocean prior to recent development. However, due to extensive groundwater withdrawals, there are groundwater depressions that result in potential seawater 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 seawater intrusion along the Pacific Ocean coast, nitrate, and volatile organic compounds (DWR 2004bg).

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

San Juan Valley Groundwater Basin

The San Juan Valley Groundwater Basin is in southern Orange County (DWR 2004bh). Groundwater flows toward 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 seawater intrusion along the Pacific Ocean coast and high fluoride near hot springs near Thermal Canyon (DWR 2004bh).

The CASGEM program designated the San Juan Valley Groundwater Basin as low priority. The SGMA priority is very low.

I.1.8.2.2 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, 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 (Greater Los Angeles County IRWMR 2014; ULARAW 2013). MWDSC 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 ULARAW.

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 overlie 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 ULARAW, provide for the right to extract a portion of surface water, including applied recycled water, that enters 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 agreements also provide the right to store and withdraw water within specified subbasins by the Cities of Burbank, Glendale, Los Angeles, and San Fernando and 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 (Greater Los Angeles County IRWMR 2014). The MWDSC 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 of Altadena, La 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 (RBMB) as the watermaster (RBMB 2014). RBMB limits the amount of groundwater withdrawals in different areas of the basin and allows for short- 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 MWDSC, 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 overlie 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 (Greater Los Angeles County IRWMR 2014; MWDSC 2007). MWDSC, 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; and private water companies such as Golden State Water Company, San Antonio Water Company (SAWC), San Gabriel Valley Water Company, Suburban Water Systems, Valencia Heights Water Company, and others provide retail water supplies, including groundwater, to users within their communities. Additionally, they provide retail water supplies, including groundwater, 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 2011d; San Gabriel County Water District 2011; San Gabriel Valley Water Company [SGVWC] 2011; Suburban Water Systems 2011; SAWC 2011; Three Valleys Municipal Water District 2011; Upper San Gabriel Valley Municipal Water District 2011, 2013).

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- 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 is from MWDSC 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 (MTBE).

Central Subbasin

The communities in the Central subbasin use a combination of surface water and groundwater to meet water demands (Greater Los Angeles County IRWMR 2014; MWDSC 2007). MWDSC 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; and private water companies such as 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 others provide retail water supplies, including groundwater, to users within their communities. Additionally, they provide retail water supplies, including groundwater, 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 (Central Basin Municipal Water District [CBMWD] 2011; Bellflower-Somerset Mutual Water Company 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; La Habra Heights County Water District 2012; Golden State Water Company 2011e, 2011f, 2011g, 2011h; 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; Water Replenishment District of Southern California [WRD] 2013a). Approximately 25% 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.

WRD 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. WRD 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 (WRD 2013a).

The replenishment water is purchased water from two 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. WRD of Southern California must blend recycled water with other water sources to meet the groundwater recharge water quality and volumetric requirements established by the SWRCB. 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% 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, WRD 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. WRD 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).

<u>West Coast Subbasin</u>

The communities in the West Coast subbasin use a combination of surface water and groundwater to meet water demands (Greater Los Angeles County IRWMR 2014; MWDSC 2007). MWDSC and West Basin Municipal Water District (WBMWD) provide wholesale surface water supplies to several communities. The Cities of Inglewood, Lomita, Manhattan Beach, and Torrance and private water companies such as Golden State Water Company, California Water Service Company, and others 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, and Torrance (WBMWD 2011; City of Inglewood 2011; City of Lomita 2011; City of Manhattan Beach 2011; City of Torrance 2011; Golden State Water Company 2011i; California Water Service Company 2011c, 2011d, 2011e, 2011f). 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 because of 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 2011; WRD 2013a). Groundwater from the Central subbasin is used by some water users that overlie the West Coast subbasin.

WRD 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, WRD 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 2013b). Water is purchased WRD of Southern California for injection at the barrier projects (WRD 2013b). 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. WRD 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 2011c). WRD of Southern California operates the Robert W. Goldsworthy Desalter near Torrance to reduce salinity for up to 18,000 AFY of groundwater located inland of the West Coast Basin Barrier (WRD 2013a).

The WBMWD 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 2011).

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 (OCWD), 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 Westminster; 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; and private water companies such as Golden State Water Company, California Water Service Company, California Domestic Water Company, and others 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 Westminster 2011; Irvine Ranch Water District 2011; Mesa Consolidated Water District 2011; Rowland Water District 2011; Serrano Water District 2011; Walnut Valley Water District 2011; Yorba Linda Water District 2011; Golden State Water Company 2011i, 2011j, 2011k). Groundwater use is primarily for nonpotable 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 OCWD 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 3-year drought supply.

OCWD manages an extensive groundwater recharge program in the Coastal Plain of Orange County Basin (OCWD 2014). OCWD 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 OCWD/Orange County Sanitation District Groundwater Replenishment System Advanced Water Purification Facility (OCWD n.d.).

OCWD 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 (OCWD n.d.; MWDSC 2007).

The Irvine Desalter Project was initiated in 2007 by OCWD, Irvine Ranch Water District, Metropolitan Water District of Orange County, MWDSC, and the U.S. Navy to reduce TDS and salts (Irvine Ranch Water District 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; Mesa Consolidated Water District 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 (MNWD), Santa Margarita Water District (SMWD), and South Coast Water District (SCWD) 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 SMWD, SCWD, and MNWD 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; San Juan Basin Authority 2013). In addition to community uses, groundwater is used for agricultural and industrial purposes and golf course irrigation. Overall, groundwater provides less than 10% 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 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).

I.1.8.3 *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.

I.1.8.3.1 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 semiconsolidated sedimentary deposits with limited yield and storage (San Diego County Water Authority [SDCWA] et al. 2013).

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

The San Mateo Valley Groundwater Basin is in southern Orange County and northern San Diego County (DWR 2004bi). The San Onofre Valley and Santa Margarita Valley Groundwater Basins are located in northwestern San Diego County (DWR 2004bj, 2004bk). Groundwater flows toward 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.

The CASGEM program designated the Santa Margarita Valley Groundwater Basin as medium priority. San Mateo Valley and San Onofre Valley Groundwater Basins were designated as very low priority. All three basins are listed as low priority by SGMA.

San Luis Rey Valley Groundwater Basin

The San Luis Rey Valley Groundwater Basin is in northwestern San Diego County (DWR 2004bl). Groundwater flows toward 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).

The CASGEM program designated the San Luis Rey Valley Groundwater Basin as medium priority. The SGMA priority for this basis in pending.

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 2004bm, 2004bn, 2004bo, 2004bp, 2004bq, 2004br). The basins area is bounded by semipermeable marine and nonmarine 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.

The CASGEM program designated the San Pasqual Valley Groundwater Basin 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 2004bs, 2004bt, 2004bu). 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.

The CASGEM program and SGMA designated Batiquitos Valley, San Elijo Valley, and San Dieguito Valley Groundwater Basins 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 2004bv, 2004bw, 2004bx, 2004by, 2004bz, 2004ca). 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 USGS study evaluated the sources and movement of saline groundwater in these groundwater basins (USGS 2013a). The chloride concentrations ranged from 57 to 39,400 milligrams per liter. The sources of salinity were natural geologic sources and seawater intrusion. There are localized areas with high sulfate and magnesium concentrations.

SGMA designated the San Diego River Valley Groundwater Basin as medium priority. El Cajon, Mission Valley, Sweetwater Valley, Otay Valley, and Tijuana Groundwater Basins were designated as very low priority.

I.1.8.3.2 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 because of high salinity. Groundwater currently represents about 3% 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 (Fallbrook Public Utility District [FPUD] 2011; MWDSC 2007; SCWD 2011; SDCWA et al. 2013). The Marine Corps Base Camp Pendleton withdraws approximately 8,500 AFY from the three groundwater basins and operates spreading basins to recharge the groundwater in the Santa Margarita Valley Groundwater Basin. Portions of the SCWD overlie the northern portions of the San Mateo Valley Groundwater Basin; however, the district does not withdraw water from that basin. FPUD 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 (Santa Margarita River Watershed Watermaster 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; Rainbow Municipal Water District (RMWD) 2011; Valley Center Municipal Water District [VCMWD] 2011; Yuima Municipal Water District 2014a, 2014b). SDCWA provides wholesale surface water supplies to several communities. The City of Oceanside; RMWD, VCMWD, and Yuima Municipal Water District; and Rancho Pauma Mutual Water Company and other private water companies provide retail water supplies to users within their communities. Groundwater use is small or does not occur within the RMWD or VCMWD. 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 and 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 (San Diego Local Agency Formation Commission 2011; SDCWA et al. 2013). The districts protect groundwater, surface water rights, and water storage and 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 Municipal Water District 2011; Rincon del Diablo Municipal Water District [RDDMWD] 2011; Vallecitos Water District 2011). SDCWA provides wholesale surface water supplies to several communities. The Cities of Escondido and Poway; Ramona Municipal Water District, RDDMWD, 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, RDDMWD, and Vallecitos Water District. Ramona WMD 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 (Carlsbad Municipal Water District [CMWD] 2011; OMWD 2011; San Diego Local Agency Formation Commission 2011; San Dieguito Water District 2011; Santa Fe Irrigation District 2011). SDCWA provides wholesale surface water supplies to several communities. Groundwater use is limited to private wells within the CMWD, 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 CMWD 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; Helix Water District 2011; Otay Water District 2011; Padre Dam Municipal Water District 2011; SDCWA et al. 2013; Sweetwater Authority 2011). SDCWA 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 the 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 (Sweetwater Authority 2016).

I.1.8.4 *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 Valley and San Jacinto Groundwater Basins in Riverside County; and the Temecula Valley Groundwater Basin in Riverside and San Diego Counties.

I.1.8.4.1 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 in San Bernardino County in the upper Santa Ana River watershed (DWR 2004cb; MWDSC 2007). Groundwater is contained within the subbasin 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 DBCP (MWDSC 2007).

The CASGEM program designated the Cucamonga subbasin as medium priority, and it was designated very low priority by SGMA.

Chino Subbasin

The Chino subbasin is 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 2006u). 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 CASGEM program designated the Chino subbasin as high priority, and it was designated very low priority by SGMA.

Riverside-Arlington Subbasin

The Riverside-Arlington subbasin is in the Santa Ana River Valley in southwestern San Bernardino County and northwestern Riverside County (DWR 2004cc). 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 CASGEM program designated the Riverside-Arlington subbasin as high priority, and it was designated very low priority by SGMA.

Temescal Subbasin

The Temescal subbasin is in 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 2006v). 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 CASGEM program and SGMA designated the Temescal subbasin as medium priority.

Cajon Subbasin

The Cajon subbasin is in 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 2004cd). 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 CASGEM program and SGMA designated the Cajon subbasin as very low priority.

Rialto-Colton Subbasin

The Rialto-Colton subbasin is in 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 2004ce). 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 CASGEM program designated the Rialto-Colton subbasin as medium priority, and SGMA designated it as very low.

Bunker Hill Subbasin

The Bunker Hill subbasin is 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 2004cf). 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 CASGEM program designated the Bunker Hill subbasin as high priority, and SGMA designated it as very low.

Yucaipa Subbasin

The Yucaipa subbasin is in the upper Santa Ana River Valley in San Bernardino County. Water-bearing formations include alluvial deposits of sand, gravel, boulders, silt, and clay (DWR 2004cg). 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 CASGEM program designated the Yucaipa subbasin as medium priority, and SGMA designated it as high priority.

San Timoteo Subbasin

The San Timoteo subbasin is in the upper Santa Ana River Valley in Riverside County. Water-bearing formations include alluvial deposits of gravel, silt, and clay (DWR 2004ch). 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 CASGEM program designated the San Timoteo as medium priority. The SGMA priority for this subbasin is pending.

San Jacinto Groundwater Basin

The San Jacinto Groundwater Basin is in the 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 2006w). 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 2006x; MWDSC 2007).

The CASGEM program designated the San Jacinto Groundwater Basin as high priority. The SGMA priority for this subbasin is pending.

Elsinore Valley Groundwater Basin

The Elsinore Valley Groundwater Basin is 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 2006x). 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 2006x; MWDSC 2007).

The CASGEM program designated the Elsinore Valley Groundwater Basin as high priority. The SGMA priority for this subbasin is medium.

Temecula Valley Groundwater Basin

The Temecula Valley Groundwater Basin is 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 2004ci). 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 2006x; MWDSC 2007).

The CASGEM program designated the Temecula Valley Groundwater Basin as high priority. The SGMA priority for this basin is very low.

I.1.8.4.2 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 Water District 2011; Fontana Water Company 2011; Jurupa Community Services District [JCSD] 2011; MWDSC 2007; Monte Vista Water District 2011; SAWC 2011; Western Municipal Water District [WMWD] 2011). The Cities of Chino, Ontario, Pomona, and Upland; Cucamonga Valley Water District, JCSD, Monte Vista Water District, and Western Municipal Water District; and SAWC, 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 Water District 2011; MWDSC 2007). The water supplies are allocated to the Cucamonga Valley Water District, SAWC, and the West End Consolidated Water Company. The City of Upland has agreements with SAWC 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 Water District 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. *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 and 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, adopted in 2007, addressed procedures related to basin reoperation under controlled overdraft conditions, using the Chino Desalters to meet the replenishment obligation and 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 (IEUA). The plan established water quality objectives in groundwater 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 rights 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 and SAWC. The Chino Basin Water Conservation District operates percolation ponds and spreading basins to facilitate groundwater recharge (IEUA 2011).

IEUA 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 SAWC (IEUA 2011). The district is a member of the Chino Basin Watermaster Board of Directors. IEUA operates several recharge facilities in the Chino subbasin. Recharge water comes from three sources: recycled water, stormwater, and imported SWP water. IEUA 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 JCSD, Santa Ana River Water Company, WMWD, and IEUA. 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; Rancho California Water District [RCWD] 2011; San Bernardino Valley Municipal Water District [SBVMWD] 2011; WMWD 2011). The SBVMWD and

WMWD 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 (EVMWD), JCSD, Lee Lake Water District; Rubidoux Community Services District, SBVMWD, WMWD, 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. JCSD uses wells within the Riverside-Arlington subbasin for nonpotable 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. v. 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 SBVMWD 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 EVMWD 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 WMWD 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; Yucaipa Valley Water District [YVWD] 2011; WMWD 2011; West Valley Water District 2014a). The SBVMWD and WMWD 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 (BCVWD), East Valley Water District, South Mesa Water District, West Valley Water District, Western Municipal Water District, Walnut Valley Water District, and YVWD t; 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 has 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 v. 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 under the Riverside-Arlington and Temescal Subbasins section, in 1969 there was a stipulated judgment for the *Western Municipal Water District of Riverside County et al. v. 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 WMWD 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 YVWD; and Riverside-Highland Water Company and 13 private water companies.

In 2002, the City of Beaumont, BCVWD, South Mesa Water Company, and YVWD 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 v. City of Banning et al.* The judgment established a Watermaster committee of the Cities of Banning and Beaumont, BCVWD, South Mesa Water Company, and YVWD. 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, SBVMWD, and WMWD; and Bear Valley Mutual Water Company, Lugonia Water Company, North Fork Water Company, and Redlands Water Company to recognize prior rights of water users to a portion of the natural flow of the Santa Ana River (SBVMWD 2011). The Seven Oaks Accord requires that SBVMWD, and WMWD develop a groundwater spreading program, in cooperation with other parties to the accord, to recharge the groundwater to maintain relatively constant groundwater levels.

In 2005, the SBVMWD 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, SBVMWD, 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 Water District 2014b, 2014c).

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; Eastern Municipal Water District [EMWD] 2011; Lake Hemet Municipal Water District 2011; MWDSC 2007; RCWD 2011). EMWD 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 EMWD 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 EMWD 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, EMWD, 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.

EMWD 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).

EMWD 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 EMWD 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). EVMWD 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; EVMWD 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. EVMWD was responsible for over 90% of the groundwater withdrawals in mid-2000s (EVMWD 2011). The Elsinore Basin Groundwater Management Plan, adopted by EVMWD 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; Rubidoux Community Services District 2011; WMWD 2011). RCWD and WMWD (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 in the Santa Margarita River watershed. As described 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; Santa Margarita River Watershed Watermaster 2011; WMWD 2011). The court-appointed steering committee for the Watermaster includes EMWD, FPUD, MWDSC, Pechanga Band of Luiseno Mission Indians of the Pechanga Reservation, RCWD, WMWD, 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 RCWD 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 RCWD and the Pechanga Band of Luiseno Mission Indians of the Pechanga Reservation.

RCWD 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).

I.1.8.5 *Central Riverside County*

The areas within the SWP service area that 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.

I.1.8.5.1 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 2004cj, 2004ck, 2004cl, 2004cm). The movement of groundwater is locally influenced by features such as faults, structural depressions, and constrictions; however, groundwater generally flows to the southeast toward the Salton Sea. Groundwater recharge occurs along streambeds 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 is poor due to the geothermal activity that results in high sodium sulfate, TDS, and chlorides. The hot springs water is only used by a resort for bathing.

The CASGEM program designated the Desert Hot Springs Groundwater Basin as low priority, SGMA designated it as very low. Indio, Mission Creek, and San Gorgonio Pass Groundwater Basins were designated as medium priority as part of both the CASGEM program and SGMA.

I.1.8.5.2 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; San Gorgonio Pass Water Agency 2010). The City of Banning, BCVWD, 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 in the Beaumont Basin (USGS 1974). The City of Beaumont, BCVWD, South Mesa Water Company, and YVWD 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 v. City of Banning et al.* The judgment established a Watermaster committee of the Cities of Banning and Beaumont, BCVWD, South Mesa Water Company, and YVWD. 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; Coachella Valley Water District [CVWD] 2011, 2012; Desert Water Agency [DWA] 2011; Indio Water Authority 2010; Mission Springs Water District [MSWD] 2011). The City of Coachella, CVWD, DWA, Indio Water Authority, and MSWD 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 CVWD, DWA, and MSWD 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. CVWD and DWA are SWP water contractors. However, because no conveyance facilities exist to deliver the SWP water, these districts have agreements with the MWDSC to exchange SWP water for Colorado River water (CVWD 2012). Since 1973, these agencies have recharged more than 2.6 million AF in the groundwater basin with delivery of Colorado River water to the Whitewater River Recharge Facility. The MWDSC also has an agreement with CVWD and DWA to store water in the Coachella Valley Groundwater Basin. The CVWD also operates the Thomas E. Levy Groundwater Replenishment Facility and the Martinez Canyon Pilot Recharge Facility. CVWD and DWA also provide recycled water for in-lieu programs. CVWD 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 CVWD and DWA and the Coachella Valley Water Management Plan developed by CVWD (CVWD 2011, 2012; DWA 2011).

The CVWD, DWA, and MSWD jointly manage the Mission Creek subbasin in accordance with the 2004 Mission Creek Settlement Agreement (DWA 2011; MSWD 2011). CVWD and DWA 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 MWDSC between the Mission Creek and Indio (also known as the Whitewater) subbasins.

I.1.8.6 *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 and 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 Basins in San Bernardino, Inyo, and Kern Counties.

I.1.8.6.1 Hydrogeology and Groundwater Conditions

Indian Wells Valley Groundwater Basin

Indian Wells Valley Groundwater Basin is 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 1,000 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 because of wastewater disposal practices. Areas near geothermal activity are characterized by high chloride, boron, and arsenic concentrations.

The CASGEM program designated the Indian Wells Valley Groundwater Basin as medium priority. This basin is prioritized as high by SGMA.

Salt Wells Valley Groundwater Basin

Salt Wells Valley Groundwater Basin is 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 toward the east into the Searles Valley Groundwater Basin. The groundwater has extremely high salinity, TDS, and boron.

The CASGEM program and SGMA designated the Salt Wells Valley Groundwater Basin as very low priority.

Searles Valley Groundwater Basin

Searles Valley Groundwater Basin is in San Bernardino, Inyo, and Kern Counties. Water-bearing formations consist of alluvium with unconsolidated to semiconsolidated deposits (DWR 2004cm). 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 toward 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.

The CASGEM program and SGMA designated the Searles Valley Groundwater Basin 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 in northern San Bernardino County. Water-bearing formations consist of unconsolidated to poorly consolidated alluvium (DWR 2004cp, 2004cq, 2004cr, 2004cs). 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 toward the Harper Valley Groundwater Basin. Groundwater in the Cuddeback Valley Groundwater Basin also flows toward Cuddeback Lake. Groundwater in Pilot Knob Valley Groundwater Basin flows toward 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.

The CASGEM program designated the Cuddeback Valley, Pilot Knob Valley, Grass Valley, and Superior Valley Groundwater Basins as very low priority.

Harper Valley Groundwater Basin

Harper Valley Groundwater Basin is in western San Bernardino County and eastern Kern County. Water-bearing formations consist of lacustrine deposits and unconsolidated to semiconsolidated alluvial deposits (DWR 2004ct). The alluvial deposits at the center of the basin are 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.

The CASGEM program designated the Harper Valley Groundwater Basin as low priority, and SGMA designated it as very low.

Fremont Valley Groundwater Basin

The Fremont Valley Groundwater Basin is in eastern Kern County and northwestern San Bernardino County. Water-bearing formations consist of alluvial and lacustrine deposits (DWR 2004cu). 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.

The CASGEM program and SGMA designated the Fremont Valley Groundwater Basin as low priority.

Antelope Valley Groundwater Basin

The Antelope Valley Groundwater Basin is 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 2004cv). 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 toward 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.

The CASGEM program designated the Antelope Valley Groundwater Basin as high priority. The basin is listed as very low priority in SGMA.

El Mirage Valley Groundwater Basin

The El Mirage Valley Groundwater Basin is in San Bernardino County. Water-bearing formations consist of unconsolidated to semiconsolidated 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 direction 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.

The CASGEM program designated the El Mirage Valley Groundwater Basin as medium priority. The basin is listed as very low priority in SGMA.

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 2004cw, 2004cx, 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.

The CASGEM program designated the Upper Mojave River Valley Groundwater Basin as high priority. The Lower Mojave River Valley Groundwater Basin was designated as medium priority. The Middle Mojave River Valley Groundwater Basin was designated as low priority, and the Caves Canyon Valley Groundwater Basin was designated as very low priority. All four groundwater basins are listed as low priority per SGMA.

Langford Valley Groundwater Basin–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 semiconsolidated alluvium (DWR 2004cy, 2004cz, 2004da). 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.

The CASGEM program and SGMA designated the Langford Well Lake subbasin and the Cronise Valley and Coyote Lake Valley Groundwater Basins as very low priority.

Kane Wash Area Groundwater Basin

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

The CASGEM program and SGMA designated the Kane Wash Area Groundwater Basin as very low priority.

Iron Ridge Area Groundwater Basin

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

The CASGEM program and SGMA designated the Iron Ridge Area Groundwater Basin as very low priority.

Bessemer Valley Groundwater Basin

The Bessemer Valley Groundwater Basin is in eastern San Bernardino County. Water-bearing formations consist of unconsolidated to semiconsolidated alluvial deposits, fanglomerate, and playa lake deposits (DWR 2004dd). 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.

The CASGEM program and SGMA designated the Bessemer Valley Groundwater Basin as very low priority.

Lucerne Valley Groundwater Basin

The Lucerne Valley Groundwater basin is in San Bernardino County. Water-bearing formations consist of unconsolidated or semiconsolidated alluvial deposits and dune sand deposits composed of gravel, sand, silt, clay, and occasional boulders (DWR 2004de). 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.

The CASGEM program designated the Lucerne Valley Groundwater Basin as low priority, and SGMA designated it as very low.

Johnson Valley Groundwater Basin

The Johnson Valley Groundwater Basin is 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 2004df, 2004dg). 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.

The CASGEM program and SGMA designated the Johnson Valley Groundwater Basin as very low priority.

Means Valley Groundwater Basin

The Means Valley Groundwater Basin is 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 2004dh). 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.

The CASGEM program and SGMA designated the Means Valley Groundwater Basin as very low priority.

Deadman Valley Groundwater Basin

The Deadman Valley Groundwater Basin is 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 2004di, 2004dj). 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.

The CASGEM program and SGMA designated the Deadman Valley Groundwater Basin 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 in southern San Bernardino County. The Joshua Tree and Warren Valley Groundwater Basins are 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 2004dh, 2004di, 2004dj, 2004dk, 2004dl). 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.

The CASGEM program designated the Warren Valley Groundwater Basin 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. Each of these basins is listed as very low priority per SGMA. The SGMA priority for Joshua Tree basin is pending.

Morongo Valley Groundwater Basin

The Morongo Valley Groundwater basin is 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.

The CASGEM program and SGMA designated the Morongo Valley Groundwater Basin 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 semiconsolidated alluvial deposits (DWR 2004dm). Groundwater is recharged from precipitation and stream flows.

The CASGEM program and SGMA designated the Lost Horse Valley Groundwater Basin as very low priority.

I.1.8.6.2 Groundwater Use and Management

Within the Antelope Valley and Mojave Valley, groundwater management is facilitated by the Antelope Valley-East Kern Water Agency (AVEK) and Mojave Water Agency (MWA). 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

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 2011). 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 (PWD), 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 2011; Apple Valley Ranchos Water Company 2011; California Water Service Company 2011g; City of California City 2013; Indian Wells Valley Water District 2011; Los Angeles County et al. 2011; PWD 2011; Rosamond Community Services District 2011).

In 2004, the County of Los Angeles Waterworks District No. 40 and PWD filed for the adjudication of the Antelope Valley Groundwater Basin (DWR 2014c; 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 (Apple Valley Ranchos Water Company 2011; City of Adelanto 2011; Golden State Water Company 2011l; Hi-Desert Water District [HDWD] 2011; Hesperia Water District 2011; Joshua Basin Water District 2011; MWA 2011; Phelan Piñon Hills Community Services District 2011; San Bernardino County 2012; Twentynine Palms Water District 2014; Victorville Water District 2011). MWA 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. MWA overlays all or portions of all of the groundwater basins described in this subsection. The City of Adelanto; Hesperia Water District, HDWD, 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.

MWA 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 2011l; 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 (Lake Arrowhead Community Services District 2011). The judgment also provides for carryover storage between water years. MWA has been appointed as the Watermaster.

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

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

I.2 Evaluation of Alternatives

This section describes the technical background for the evaluation of environmental consequences associated with the action alternatives and the No Action Alternative.

I.2.1 Methods and Tools

While the changes in CVP and SWP operations under the alternatives compared with the No Action Alternative do not directly result in pumping more or less groundwater, changes to CVP and SWP operations may change the amount of surface water delivered to users along the systems. A change in surface water deliveries may result in users changing the amount of groundwater pumping to account for this change in surface water supply. For example, if less surface water is supplied to an agricultural area, additional groundwater would need to be pumped and supplied to maintain cropping. The surface water supply analysis was conducted using the CalSim II model, as described in Appendix F, *Model Documentation*, to simulate the operational assumptions of each alternative. The CalSim II results were then applied to the Central Valley Hydrologic Model (CVHM) groundwater flow model (see Appendix F) to simulate changes in groundwater conditions, including the changes to pumping, groundwater-surface water interaction, and groundwater elevation. The CVHM modeling was conducted for the basins and subbasins in the Sacramento and San Joaquin Valleys. A qualitative assessment was conducted in the other project areas.

The effects of the 2014 SGMA legislation was not explicitly simulated as part of the action alternatives. SGMA requires that groundwater basins be operated sustainably by a Groundwater Sustainability Agency (GSA) under a Groundwater Sustainability Plan (GSP) by either January 31, 2020 (for medium and high priority basins with overdraft conditions) or January 31, 2022 (for medium and high priority basins without overdraft conditions). Basins designated as low or very-low priority are not subject to SGMA. Adjudicated basins are not required to develop a GSP. Given the fact that GSPs for areas in the Central

Valley have not been fully developed and adopted yet, the exact details of sustainable management under SGMA for each basin and subbasin are not known. However, there are six identified effects caused by groundwater conditions that are to be sustainable managed under a GSP: (1) chronic lowering of groundwater levels, (2) reduction in groundwater storage, (3) seawater intrusion, (4) degraded water quality, (5) land subsidence, and (6) depletion of interconnected surface water. For the development of the GSP, the GSA is required to manage the basin sustainability according to these criteria. Operation of the action alternatives will need to be incorporated in the development of the GSP.

I.2.2 No Action Alternative

Under the No Action Alternative, conditions would be the same as those under existing conditions. Therefore, there would be no changes from existing conditions that would affect groundwater.

I.2.3 Alternative 1

I.2.3.1 *Project-Level Effects*

I.2.3.1.1 <u>Potential Changes in Groundwater Pumping</u>

Trinity River Region

Project level actions in Alternative 1 will likely result in changes to flows of surface water in this region. However, there is expected to be little change to groundwater pumping resulting from these actions because groundwater is not a substantial supply source in this area.

Central Valley Region

Compared with the No Action Alternative, Alternative 1 is expected to result in additional surface water supply to both the Sacramento and San Joaquin Valleys. Refer to Appendix H, *Water Supply Technical Appendix,* for additional information related to changes in deliveries. This increase in supply, especially when made to meet agricultural demands, will result in a decrease in the need for groundwater pumping to meet demands. Most of the change in pumping is expected to be in the San Joaquin Valley because that is the location of the majority of CVP and SWP contractors that will have increases in their surface water supply. Little change in delivery is expected in the Sacramento Valley.

The changes in CVP and SWP deliveries projected by the CalSim II model to the San Joaquin Valley region were input to the CVHM. The CVHM then simulated the amount of groundwater pumping required to meet agricultural needs as the difference between demand and the supply from surface water. With the increase in surface water supply, the amount of groundwater pumping decreased. Table I.2-1, Simulated Central Valley Hydrologic Model Groundwater Pumping, shows the amount of groundwater pumping simulated by CVHM under the No Action Alternative and Alternative 1. Table I.2-2, Change in Central Valley Hydrologic Model Simulated Groundwater Pumping, shows the percent change in simulated groundwater pumping between Alternative 1 and the No Action Alternative.

Tables I.2-1 and I.2-2 also include information related to Alternatives 2, 3, and 4, which will be described in later sections.

Table I.2-1. Simulated Central Valley Hydrologic Model Groundwater Pumping

Year	Sacramento Valley	San Joaquin Valley	Groundwater Pumping				
	Water Year Type[1]	Water Year Type[1]	No Action Alternative (TAF)	Alternative 1 (TAF)	Alternative 2 (TAF)	Alternative 3 (TAF)	Alternative 4 (TAF)
1	BN	BN	8,825	8,396	7,690	7,693	8,975
2	W	AN	6,816	6,572	6,002	5,991	6,849
3	D	C	9,536	9,382	9,131	9,142	9,466
4	W	AN	7,004	6,795	6,420	6,399	7,005
5	BN	D	9,465	8,890	8,533	8,546	9,491
6	W	W	6,452	6,274	6,196	6,145	6,511
7	BN	D	8,483	7,949	7,434	7,431	8,132
8	W	W	4,672	4,663	4,622	4,626	4,624
9	W	AN	6,760	6,264	6,173	6,242	6,759
10	W	BN	7,318	6,970	6,574	6,580	7,514
11	BN	C	9,553	9,476	8,782	8,873	9,606
12	AN	AN	5,834	5,475	5,278	5,274	5,827
13	W	AN	5,663	5,550	5,104	5,103	5,641
14	W	AN	5,781	5,612	5,108	5,104	5,911
15	C	C	8,530	8,352	8,167	8,215	8,551
16	C	C	12,022	11,672	11,700	11,651	11,940
17	AN	W	4,790	4,582	4,521	4,529	4,678
18	BN	AN	6,361	5,910	5,837	5,887	6,324
19	AN	W	4,913	4,707	4,678	4,679	4,935
20	D	D	7,756	7,382	7,004	6,990	8,080
21	W	W	3,918	3,890	3,760	3,757	4,056
22	W	W	3,143	3,126	3,105	3,106	3,143
23	W	W	5,864	5,421	5,369	5,414	5,832
24	D	D	6,689	6,392	6,221	6,187	6,879
25	W	W	5,179	5,073	4,831	4,912	5,254
26	D	C	8,245	7,698	7,585	7,612	7,944
27	C	C	9,722	9,465	9,021	9,000	9,576
28	D	C	9,264	8,837	8,705	8,645	9,223
29	C	C	10,678	10,520	10,508	10,502	10,747
30	C	C	10,771	10,465	10,076	10,113	10,749
31	C	C	10,400	10,031	9,987	9,992	10,289
32	AN	AN	5,480	5,129	4,849	4,857	5,511
33	C	C	8,368	8,369	7,582	7,660	9,031
34	W	W	4,388	4,348	4,198	4,262	4,485
35	W	W	5,693	5,371	5,067	5,135	5,491
36	W	W	5,925	5,396	5,350	5,724	5,746
37	W	W	3,334	3,307	3,261	3,293	3,332

Year	Sacramento Valley	San Joaquin Valley	Groundwater Pumping				
	Water Year Type[1]	Water Year Type[1]	No Action Alternative (TAF)	Alternative 1 (TAF)	Alternative 2 (TAF)	Alternative 3 (TAF)	Alternative 4 (TAF)
38	W	AN	5,726	5,224	5,030	5,070	5,605
39	AN	AN	6,365	6,071	5,389	5,393	6,496
40	D	C	7,641	7,512	7,260	7,252	7,615
41	D	C	8,237	8,136	7,599	7,635	8,690
42	AN	BN	7,101	6,906	6,507	6,485	7,253
Average			**7,111**	**6,847**	**6,577**	**6,598**	**7,137**

[1] Water year types: W – Wet, AN – Above Normal, BN – Below Normal, D – Dry, C – Critically Dry
TAF = thousand acre-feet

Table I.2-2. Change in Central Valley Hydrologic Model Simulated Groundwater Pumping

Year	Sacramento Valley	San Joaquin Valley	Change in Groundwater Pumping							
	Water Year Type[1]	Water Year Type[1]	Alternative 1 versus No Action Alternative (TAF)	Alternative 1 versus No Action Alternative (percent)	Alternative 2 versus No Action Alternative (TAF)	Alternative 2 versus No Action Alternative (percent)	Alternative 3 versus No Action Alternative (TAF)	Alternative 3 versus No Action Alternative (percent)	Alternative 4 versus No Action Alternative (TAF)	Alternative 4 versus No Action Alternative (percent)
1	BN	BN	-430	-4.9%	-1,135	-12.9%	-1,132	-12.8%	149	1.7%
2	W	AN	-244	-3.6%	-814	-11.9%	-825	-12.1%	33	0.5%
3	D	C	-154	-1.6%	-406	-4.3%	-395	-4.1%	-70	-0.7%
4	W	AN	-209	-3.0%	-584	-8.3%	-605	-8.6%	1	0.0%
5	BN	D	-575	-6.1%	-932	-9.9%	-919	-9.7%	25	0.3%
6	W	W	-178	-2.8%	-257	-4.0%	-307	-4.8%	59	0.9%
7	BN	D	-534	-6.3%	-1,049	-12.4%	-1,052	-12.4%	-351	-4.1%
8	W	W	-10	-0.2%	-50	-1.1%	-46	-1.0%	-48	-1.0%
9	W	AN	-496	-7.3%	-586	-8.7%	-518	-7.7%	-1	0.0%
10	W	BN	-349	-4.8%	-744	-10.2%	-739	-10.1%	196	2.7%
11	BN	C	-77	-0.8%	-771	-8.1%	-680	-7.1%	54	0.6%
12	AN	AN	-359	-6.2%	-556	-9.5%	-560	-9.6%	-7	-0.1%
13	W	AN	-113	-2.0%	-558	-9.9%	-560	-9.9%	-22	-0.4%
14	W	AN	-169	-2.9%	-673	-11.6%	-677	-11.7%	130	2.2%
15	C	C	-178	-2.1%	-363	-4.3%	-315	-3.7%	21	0.2%
16	C	C	-350	-2.9%	-322	-2.7%	-371	-3.1%	-82	-0.7%
17	AN	W	-209	-4.4%	-269	-5.6%	-261	-5.4%	-112	-2.3%
18	BN	AN	-451	-7.1%	-524	-8.2%	-474	-7.5%	-37	-0.6%
19	AN	W	-206	-4.2%	-235	-4.8%	-234	-4.8%	22	0.5%
20	D	D	-374	-4.8%	-753	-9.7%	-766	-9.9%	323	4.2%
21	W	W	-28	-0.7%	-159	-4.1%	-161	-4.1%	138	3.5%
22	W	W	-17	-0.6%	-38	-1.2%	-36	-1.2%	0	0.0%
23	W	W	-443	-7.6%	-495	-8.4%	-450	-7.7%	-32	-0.5%

Year	Sacramento Valley	San Joaquin Valley	Change in Groundwater Pumping							
	Water Year Type[1]	Water Year Type[1]	Alternative 1 versus No Action Alternative (TAF)	Alternative 1 versus No Action Alternative (percent)	Alternative 2 versus No Action Alternative (TAF)	Alternative 2 versus No Action Alternative (percent)	Alternative 3 versus No Action Alternative (TAF)	Alternative 3 versus No Action Alternative (percent)	Alternative 4 versus No Action Alternative (TAF)	Alternative 4 versus No Action Alternative (percent)
24	D	D	-297	-4.4%	-468	-7.0%	-502	-7.5%	189	2.8%
25	W	W	-106	-2.0%	-347	-6.7%	-266	-5.1%	75	1.5%
26	D	C	-547	-6.6%	-660	-8.0%	-633	-7.7%	-301	-3.7%
27	C	C	-257	-2.6%	-701	-7.2%	-722	-7.4%	-146	-1.5%
28	D	C	-428	-4.6%	-559	-6.0%	-619	-6.7%	-41	-0.4%
29	C	C	-158	-1.5%	-170	-1.6%	-176	-1.7%	69	0.6%
30	C	C	-306	-2.8%	-694	-6.4%	-658	-6.1%	-22	-0.2%
31	C	C	-369	-3.5%	-413	-4.0%	-408	-3.9%	-111	-1.1%
32	AN	AN	-351	-6.4%	-631	-11.5%	-623	-11.4%	31	0.6%
33	C	C	1	0.0%	-786	-9.4%	-708	-8.5%	663	7.9%
34	W	W	-40	-0.9%	-190	-4.3%	-126	-2.9%	97	2.2%
35	W	W	-323	-5.7%	-626	-11.0%	-558	-9.8%	-202	-3.5%
36	W	W	-529	-8.9%	-575	-9.7%	-201	-3.4%	-179	-3.0%
37	W	W	-27	-0.8%	-73	-2.2%	-41	-1.2%	-2	-0.1%
38	W	AN	-502	-8.8%	-697	-12.2%	-656	-11.5%	-121	-2.1%
39	AN	AN	-293	-4.6%	-976	-15.3%	-972	-15.3%	132	2.1%
40	D	C	-129	-1.7%	-381	-5.0%	-389	-5.1%	-26	-0.3%
41	D	C	-101	-1.2%	-638	-7.7%	-601	-7.3%	453	5.5%
42	AN	BN	-195	-2.8%	-594	-8.4%	-616	-8.7%	152	2.1%
Average			**-264**	**-3.7%**	**-535**	**-7.5%**	**-513**	**-7.1%**	**26**	**0.4%**

[1] Water year types: W – Wet, AN – Above Normal, BN – Below Normal, D – Dry, C – Critically Dry
TAF = thousand acre-feet

The model simulations show that, on average, groundwater pumping is 3.7% lower in Alternative 1 than the No Action Alternative.

Central Valley Project and State Water Project Service Areas

Alternative 1 is expected to increase water supply to the CVP and SWP service areas. With this increase in supply, the reliance on groundwater pumping is expected to stay the same or be reduced compared with the No Action Alternative. Therefore, there is expected to be similar or less groundwater pumping in Alternative 1.

I.2.3.1.2 Potential Changes in Groundwater-Surface Water Interaction

Trinity River Region

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. Given this hydrogeologic nature of this region, changes in surface water flow will likely result in little change to the groundwater-surface water interaction flow.

Central Valley Region

The amount of groundwater-surface water interaction flow simulated in the CVHM, throughout the Central Valley, is shown in Table I.2-3, Simulated Central Valley Hydrologic Model Groundwater-Surface Water Interaction Flow, for Alternative 1. Table I.2-4, Simulated Change in Central Valley Hydrologic Model Groundwater-Surface Water Interaction, shows the change in groundwater-surface water interaction for Alternative 1 compared with the No Action Alternative. Over the length of the CVHM simulation, the change in groundwater-surface water interaction is 10.3% (reduced flow from groundwater to surface water) in Alternative 1 compared with the No Action Alternative.

Tables I.2-3 and I.2-4 also include information related to Alternatives 2, 3, and 4, which will be described in later sections.

Table I.2-3. Simulated Central Valley Hydrologic Model Groundwater-Surface Water Interaction Flow

Year	Sacramento Valley	San Joaquin Valley	Groundwater Gain (+) or Lost (−) from/to Surface Water				
	Water Year Type[1]	Water Year Type[1]	No Action Alternative (TAF)	Alternative 1 (TAF)	Alternative 2 (TAF)	Alternative 3 (TAF)	Alternative 4 (TAF)
1	BN	BN	2454	2377	2488	2385	2560
2	W	AN	739	717	660	638	697
3	D	C	247	272	340	292	278
4	W	AN	1153	1047	1101	1068	1230
5	BN	D	568	623	566	605	595
6	W	W	1653	1668	1660	1619	1613
7	BN	D	290	236	157	217	319
8	W	W	3636	3468	3484	3401	3638
9	W	AN	262	16	-11	90	379
10	W	BN	-461	-484	-502	-486	-420
11	BN	C	-202	-189	-249	-214	-250
12	AN	AN	313	298	228	231	297
13	W	AN	264	207	172	226	194
14	W	AN	-168	-174	-255	-276	-65
15	C	C	-432	-492	-418	-474	-425
16	C	C	-278	-256	-254	-252	-248
17	AN	W	2561	2043	2277	2314	2368
18	BN	AN	192	228	190	205	198
19	AN	W	1060	1011	1048	1095	1112
20	D	D	44	70	-35	-48	-31
21	W	W	1032	1101	971	991	1058

Year	Sacramento Valley	San Joaquin Valley	Groundwater Gain (+) or Lost (−) from/to Surface Water				
	Water Year Type[1]	Water Year Type[1]	No Action Alternative (TAF)	Alternative 1 (TAF)	Alternative 2 (TAF)	Alternative 3 (TAF)	Alternative 4 (TAF)
22	W	W	1886	1893	1863	1806	1992
23	W	W	-705	-746	-749	-782	-743
24	D	D	-802	-820	-897	-870	-819
25	W	W	721	659	593	635	780
26	D	C	-695	-719	-721	-720	-722
27	C	C	-498	-506	-485	-403	-487
28	D	C	-147	-186	-208	-243	-146
29	C	C	-176	-254	-288	-188	-196
30	C	C	473	253	235	253	290
31	C	C	160	106	136	85	110
32	AN	AN	896	877	808	842	836
33	C	C	-73	-165	-96	-114	-145
34	W	W	3880	3952	4567	3730	3965
35	W	W	-148	-270	-466	-256	-143
36	W	W	875	881	730	842	904
37	W	W	2650	2526	2563	2777	2997
38	W	AN	-1119	-1197	-1340	-1296	-1204
39	AN	AN	-538	-565	-591	-558	-517
40	D	C	-753	-790	-793	-784	-784
41	D	C	-361	-387	-550	-524	-293
42	AN	BN	-215	-170	-360	-333	-248
Average			**482**	**432**	**418**	**417**	**489**

[1] Water year types: W – Wet, AN – Above Normal, BN – Below Normal, D – Dry, C – Critically Dry
TAF = thousand acre-feet

Table I.2-4. Simulated Change in Central Valley Hydrologic Model Groundwater-Surface Water Interaction Flow

Year	Sacramento Valley	San Joaquin Valley	Change in Groundwater Gain (+) or Lost (−) from/to Surface Water							
	Water Year Type[1]	Water Year Type[1]	Alt 1 versus No Action Alternative (TAF)	Alt 1 versus No Action Alternative (percent)	Alt 2 versus No Action Alternative (TAF)	Alt 2 versus No Action Alternative (percent)	Alt 3 versus No Action Alternative (TAF)	Alt 3 versus No Action Alternative (percent)	Alt 4 versus No Action Alternative (TAF)	Alt 4 versus No Action Alternative (percent)
1	BN	BN	-77	-3.1%	34	1.4%	-69	-2.8%	106	4.3%
2	W	AN	-22	-3.0%	-80	-10.8%	-102	-13.8%	-42	-5.7%
3	D	C	25	10.1%	93	37.4%	44	17.9%	31	12.5%
4	W	AN	-107	-9.3%	-52	-4.5%	-85	-7.4%	77	6.7%
5	BN	D	55	9.7%	-2	-0.4%	36	6.4%	26	4.7%
6	W	W	15	0.9%	7	0.5%	-34	-2.1%	-40	-2.4%
7	BN	D	-55	-18.9%	-134	-46.0%	-74	-25.4%	29	9.9%
8	W	W	-168	-4.6%	-152	-4.2%	-235	-6.5%	2	0.1%
9	W	AN	-247	-94.1%	-273	-104.3%	-172	-65.8%	117	44.7%
10	W	BN	-23	5.0%	-41	9.0%	-25	5.5%	41	-8.9%
11	BN	C	13	-6.5%	-47	23.3%	-11	5.6%	-48	23.6%
12	AN	AN	-14	-4.5%	-85	-27.1%	-81	-26.0%	-16	-5.0%
13	W	AN	-58	-21.8%	-92	-34.9%	-38	-14.3%	-70	-26.4%
14	W	AN	-6	3.6%	-87	51.9%	-108	64.6%	103	-61.4%
15	C	C	-60	13.8%	14	-3.3%	-42	9.6%	7	-1.7%
16	C	C	21	-7.7%	24	-8.6%	26	-9.4%	30	-10.7%
17	AN	W	-518	-20.2%	-284	-11.1%	-247	-9.6%	-193	-7.5%
18	BN	AN	36	18.6%	-2	-1.3%	13	6.8%	6	3.2%
19	AN	W	-49	-4.6%	-12	-1.2%	34	3.2%	51	4.8%
20	D	D	26	59.0%	-79	-180.3%	-92	-209.4%	-75	-171.1%
21	W	W	68	6.6%	-62	-6.0%	-41	-4.0%	26	2.5%
22	W	W	7	0.4%	-23	-1.2%	-80	-4.2%	106	5.6%
23	W	W	-41	5.8%	-44	6.3%	-77	10.9%	-38	5.4%
24	D	D	-17	2.1%	-95	11.8%	-68	8.4%	-17	2.1%
25	W	W	-62	-8.6%	-129	-17.8%	-87	-12.0%	58	8.1%
26	D	C	-24	3.4%	-26	3.8%	-25	3.6%	-27	3.9%
27	C	C	-8	1.5%	13	-2.7%	95	-19.1%	12	-2.3%
28	D	C	-39	26.7%	-62	41.9%	-96	65.5%	1	-0.8%
29	C	C	-78	44.4%	-112	63.9%	-12	6.6%	-20	11.3%
30	C	C	-220	-46.5%	-238	-50.4%	-220	-46.4%	-183	-38.8%
31	C	C	-54	-33.8%	-24	-14.8%	-75	-46.6%	-50	-31.2%
32	AN	AN	-20	-2.2%	-88	-9.9%	-55	-6.1%	-61	-6.8%
33	C	C	-93	127.8%	-24	32.7%	-41	56.5%	-72	99.8%

Year	Sacramento Valley	San Joaquin Valley	Change in Groundwater Gain (+) or Lost (−) from/to Surface Water							
	Water Year Type[1]	Water Year Type[1]	Alt 1 versus No Action Alternative (TAF)	Alt 1 versus No Action Alternative (percent)	Alt 2 versus No Action Alternative (TAF)	Alt 2 versus No Action Alternative (percent)	Alt 3 versus No Action Alternative (TAF)	Alt 3 versus No Action Alternative (percent)	Alt 4 versus No Action Alternative (TAF)	Alt 4 versus No Action Alternative (percent)
34	W	W	72	1.9%	687	17.7%	-150	-3.9%	85	2.2%
35	W	W	-122	82.9%	-319	216.0%	-109	73.5%	5	-3.2%
36	W	W	6	0.7%	-145	-16.5%	-33	-3.7%	29	3.3%
37	W	W	-124	-4.7%	-87	-3.3%	127	4.8%	347	13.1%
38	W	AN	-78	7.0%	-222	19.8%	-177	15.9%	-85	7.6%
39	AN	AN	-27	5.0%	-53	9.9%	-21	3.8%	20	-3.8%
40	D	C	-37	4.9%	-40	5.3%	-31	4.1%	-31	4.1%
41	D	C	-26	7.1%	-188	52.1%	-162	44.9%	68	-18.8%
42	AN	BN	46	-21.2%	-145	67.4%	-117	54.5%	-33	15.2%
Average			**-50**	**-10.3%**	**-64**	**-13.2%**	**-65**	**-13.4%**	**7**	**1.4%**

[1] Water year types: W – Wet, AN – Above Normal, BN – Below Normal, D – Dry, C – Critically Dry
TAF = thousand acre-feet

Central Valley Project and State Water Project Service Areas

Alternative 1 increases water supply to the CVP and SWP service areas and, therefore, likely results in little change, or potentially a reduction, in the amount of groundwater pumping. With little change to groundwater pumping, there would be little change in the groundwater system to result in a change in the amount of groundwater-surface water interaction flow. Therefore, Alternative 1, compared with the No Action Alternative, may result in groundwater levels rising, allowing for additional infiltration of groundwater to surface water or reduced infiltration of surface water to groundwater.

I.2.3.1.3 Potential Changes in Groundwater Elevation

Trinity River Region

Given that there is likely to be little change to the volume of groundwater either through pumping or groundwater-surface water interaction flow, there will be little change to groundwater levels in the area are also not expected to change.

Central Valley Region

The CVHM simulations indicate that the amount of groundwater pumping in Alternative 1 will be less than in the No Action Alternative. Simulations also suggest that less water will recharge to the groundwater system in Alternative 1 than in the No Action Alternative. These two factors combine to potentially affect groundwater elevations. Less groundwater pumping would work to increase groundwater levels while less recharge from surface water to groundwater could lower groundwater levels. CVHM was used to estimate change to groundwater levels resulting from the combined effects of project level changes.

CVHM results at 24 locations across the San Joaquin Valley are presented in the following figures. The results, presented in two types of figures, show changes in groundwater levels with time at a specific location (first type of figures) and contours of the simulated change in groundwater level between Alternative 1 and the No Action Alternative (second type of figures). Figure I.2-1, Location of 24 Hydrographs, shows the 24 arbitrary locations selected for presentation. Hydrographs are not shown in the Sacramento Valley because there is relatively little change in simulated groundwater level.

In the first type of graphic, the x-axis of these figures is the over 40 years of the CVHM simulation. The y-axis is either the groundwater elevation at the specified location for a simulation or the difference between groundwater elevations between two different simulations. Figures in this first type are identified below:

- Figures I.2-2 through I.2-25 show the simulated groundwater elevations at the 24 arbitrary locations throughout the San Joaquin Valley. Groundwater level changes of less than 2 feet are considered minimal. Therefore, modeled groundwater elevations in the Sacramento Valley are not shown in these figures. Where possible the vertical scale of these figures was set at 200 feet for consistency.
- Figures I.2-26 through I.2-49 show the simulated change in groundwater elevation at these 24 locations. The vertical scales of these figures vary based on location.

Figures of the second type, which show contours of the simulated change in groundwater level between Alternative 1 and the No Action Alternative, are identified below:

- Figures I.2-50 through I.2-54 show the simulated change in groundwater level spatially across the Central Valley under Alternative 1 compared with the No Action Alternative. These figures show the average change in groundwater levels in July during each of the five water year types (Wet, Above Normal, Below Normal, Dry, Critical Dry).

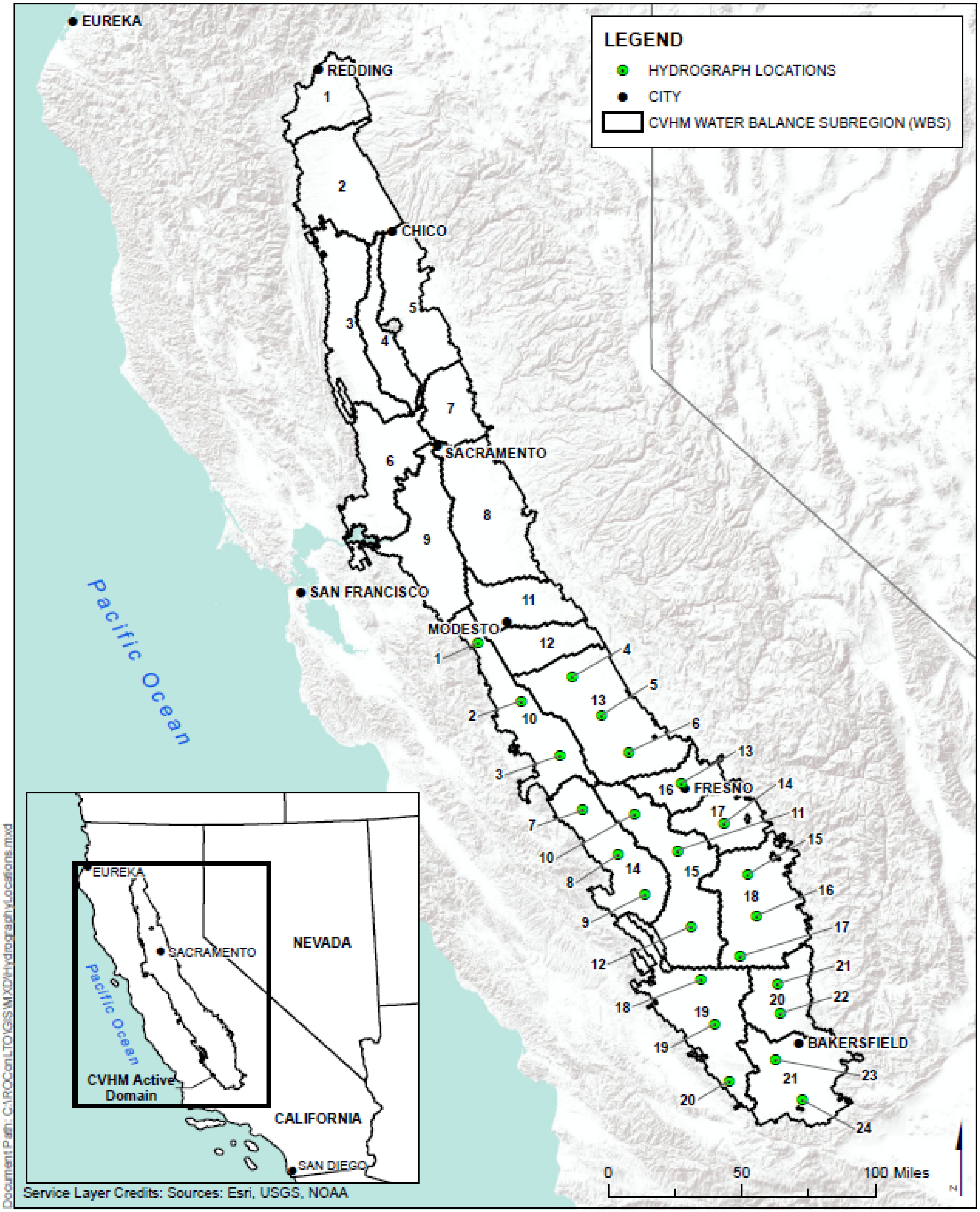


Figure I.2-1. Location of 24 Hydrographs

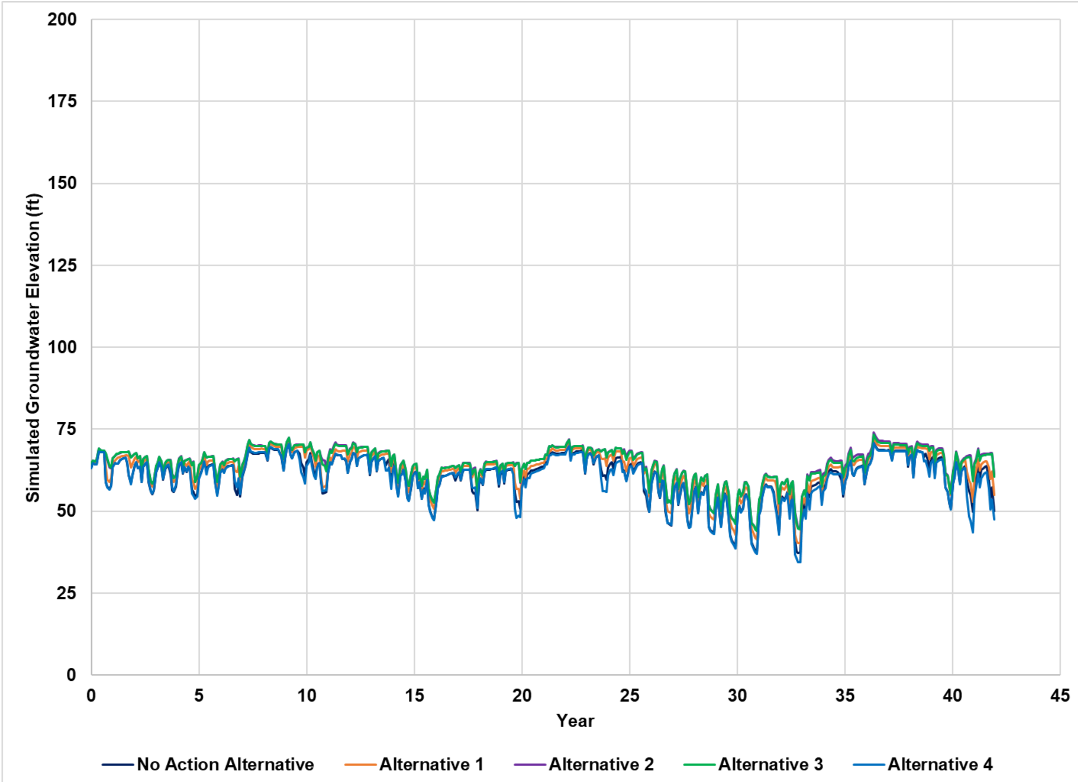


Figure I.2-2. Simulated Groundwater Elevation Location 1

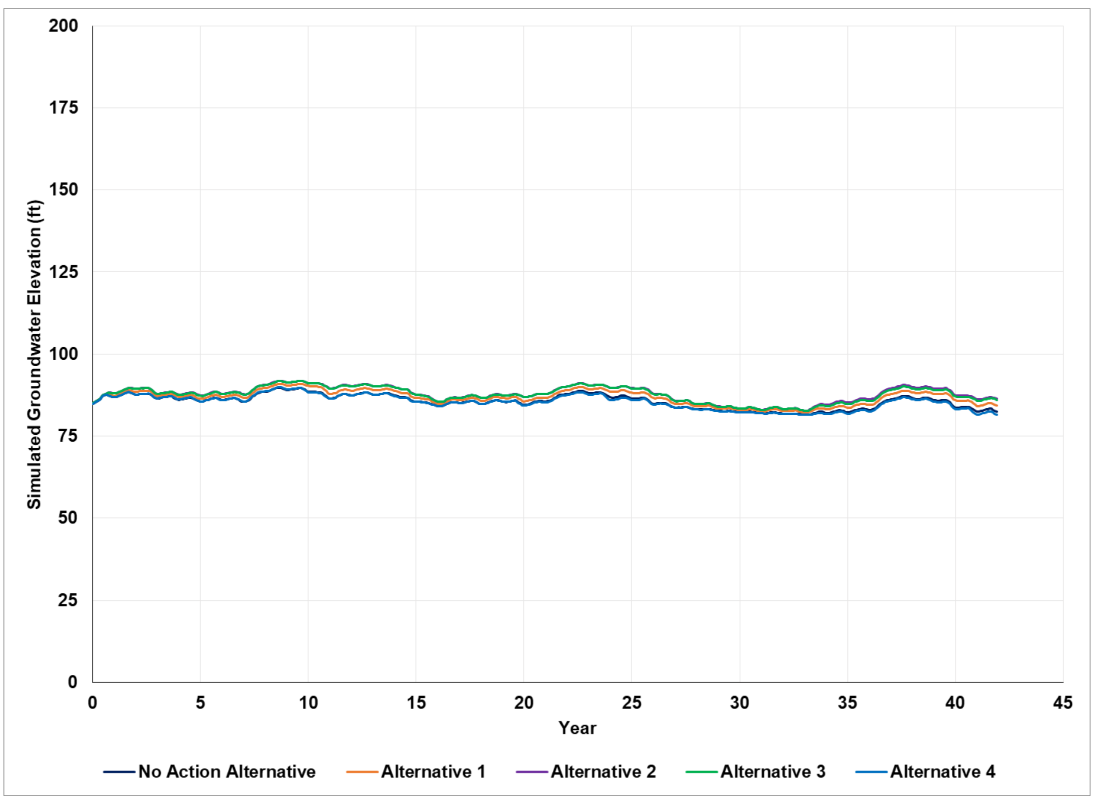


Figure I.2-3. Simulated Groundwater Elevation Location 2

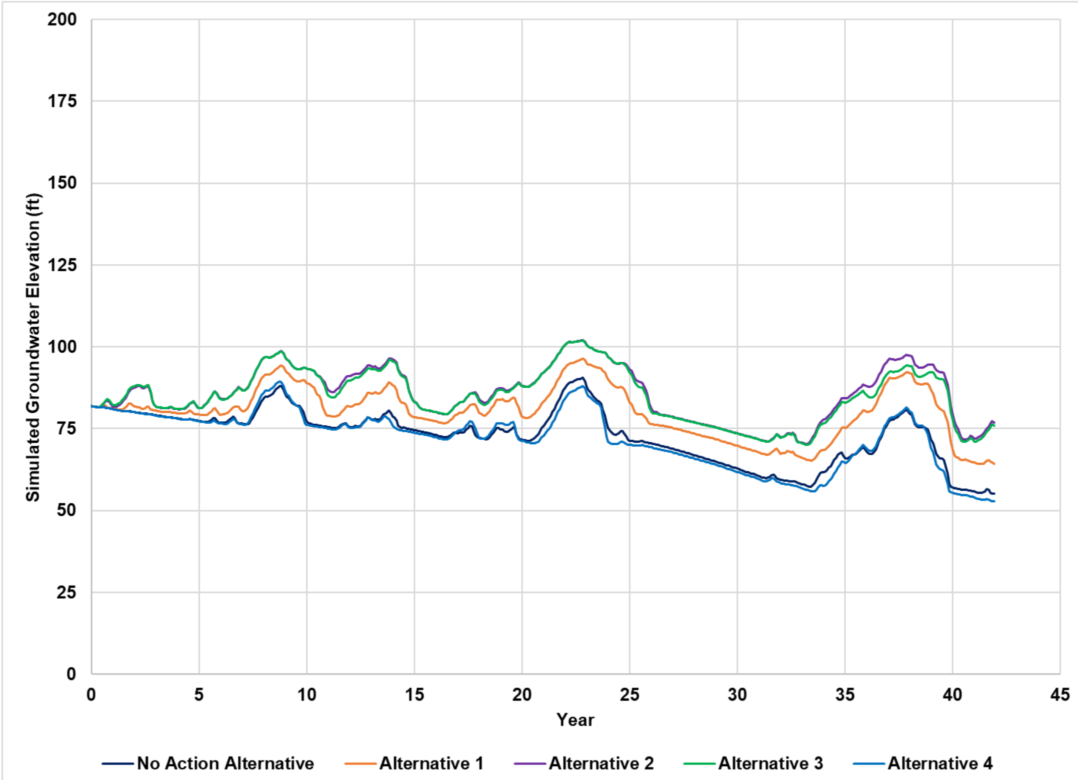


Figure I.2-4. Simulated Groundwater Elevation Location 3

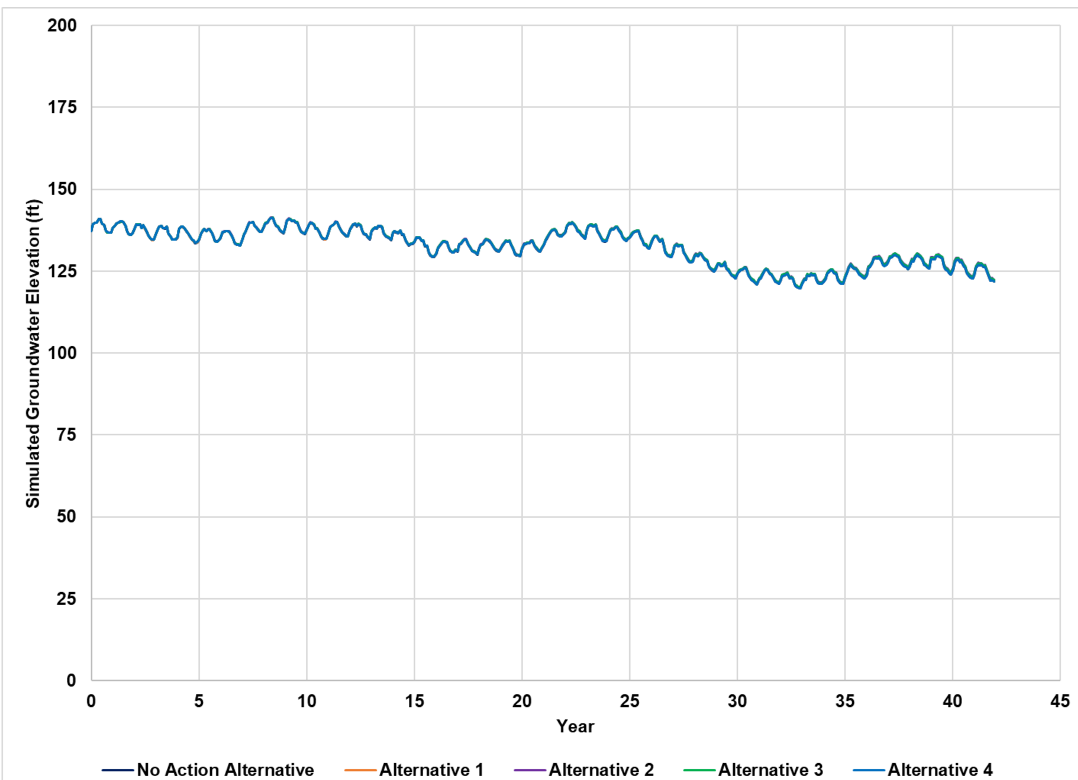


Figure I.2-5. Simulated Groundwater Elevation Location 4

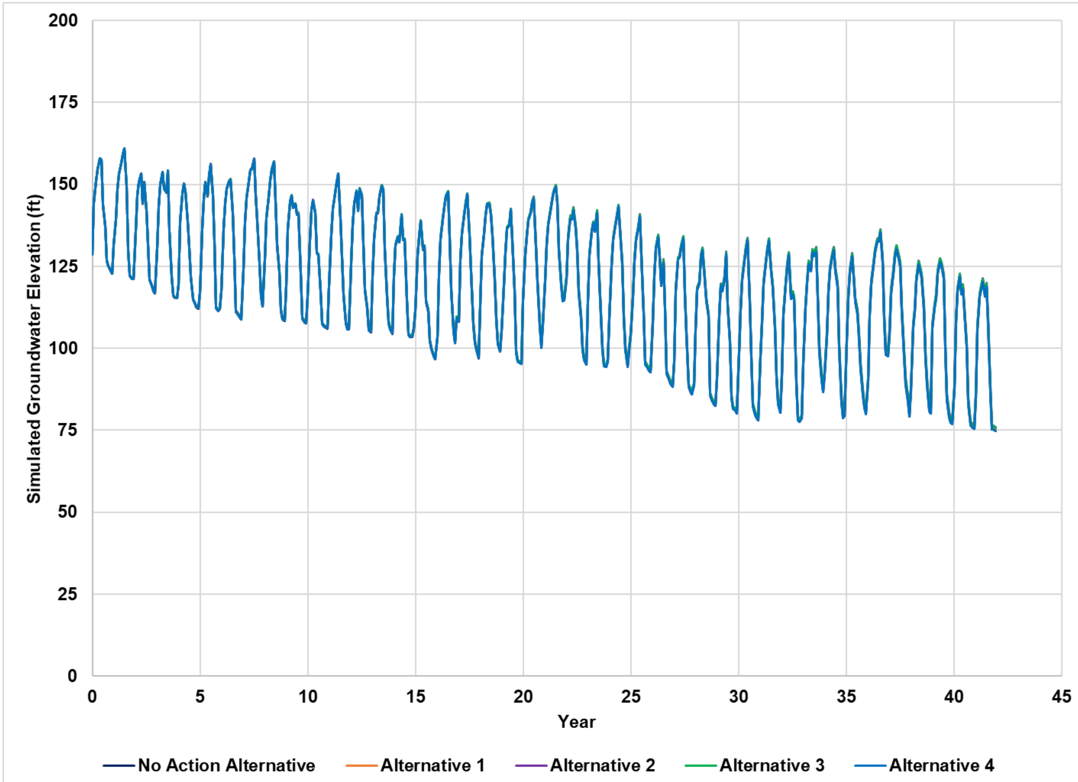


Figure I.2-6. Simulated Groundwater Elevation Location 5

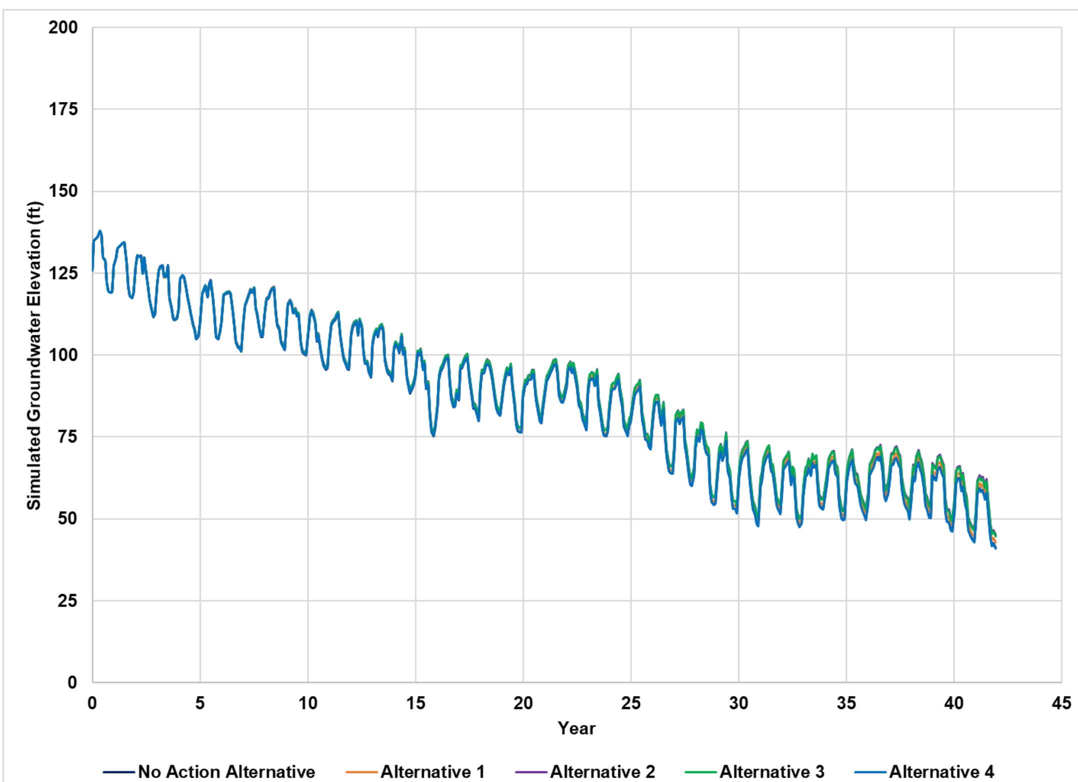


Figure I.2-7. Simulated Groundwater Elevation Location 6

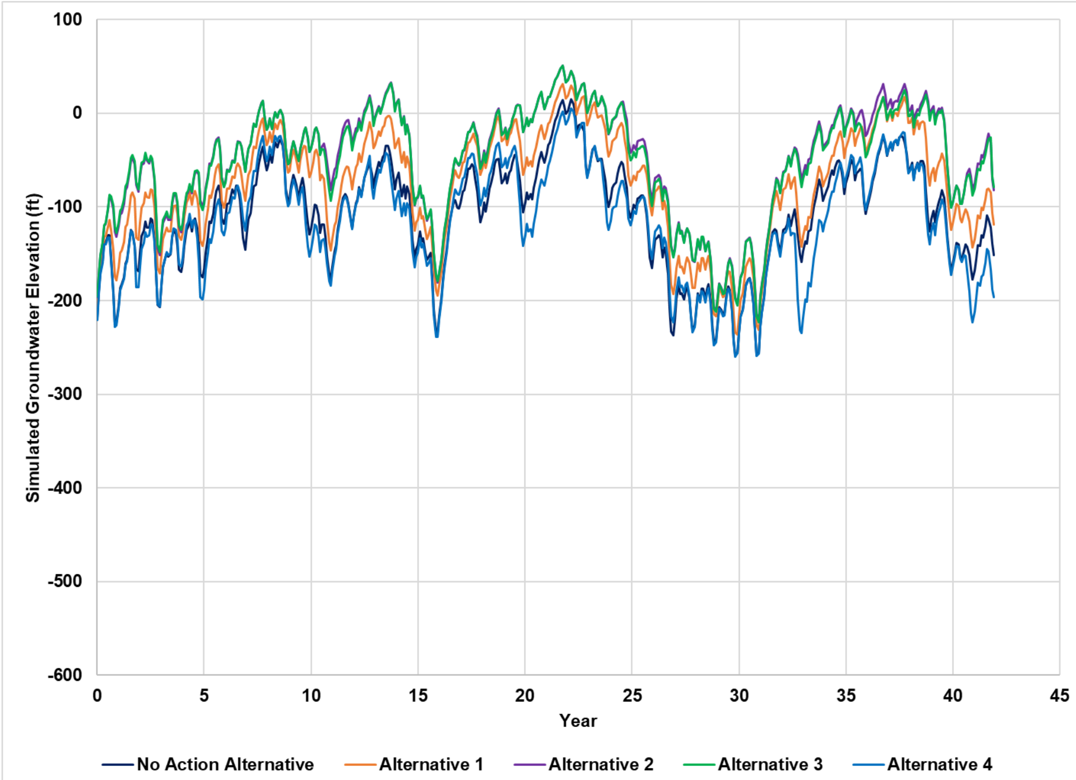


Figure I.2-8. Simulated Groundwater Elevation Location 7

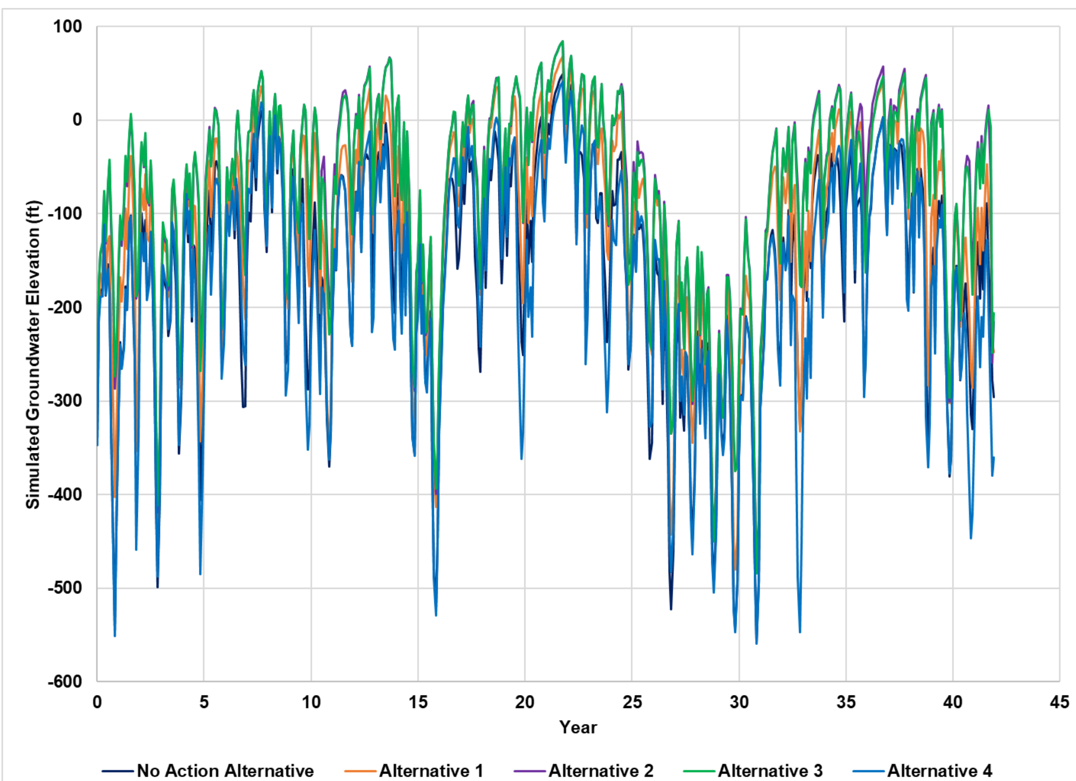


Figure I.2-9. Simulated Groundwater Elevation Location 8

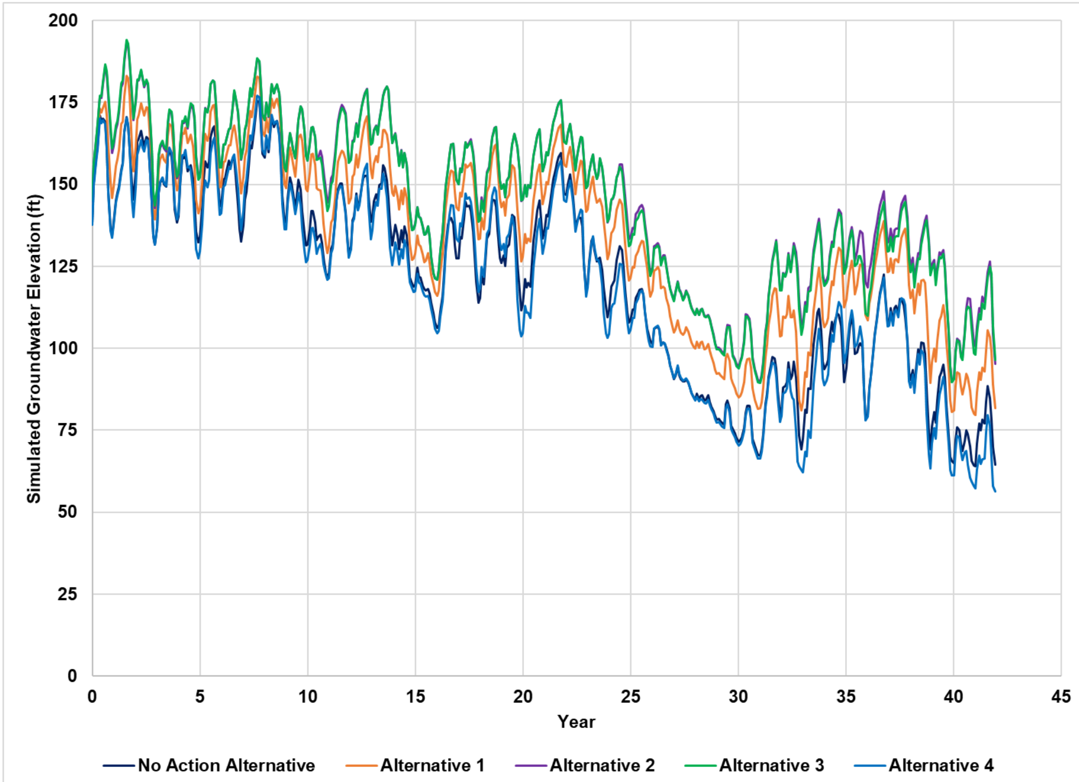
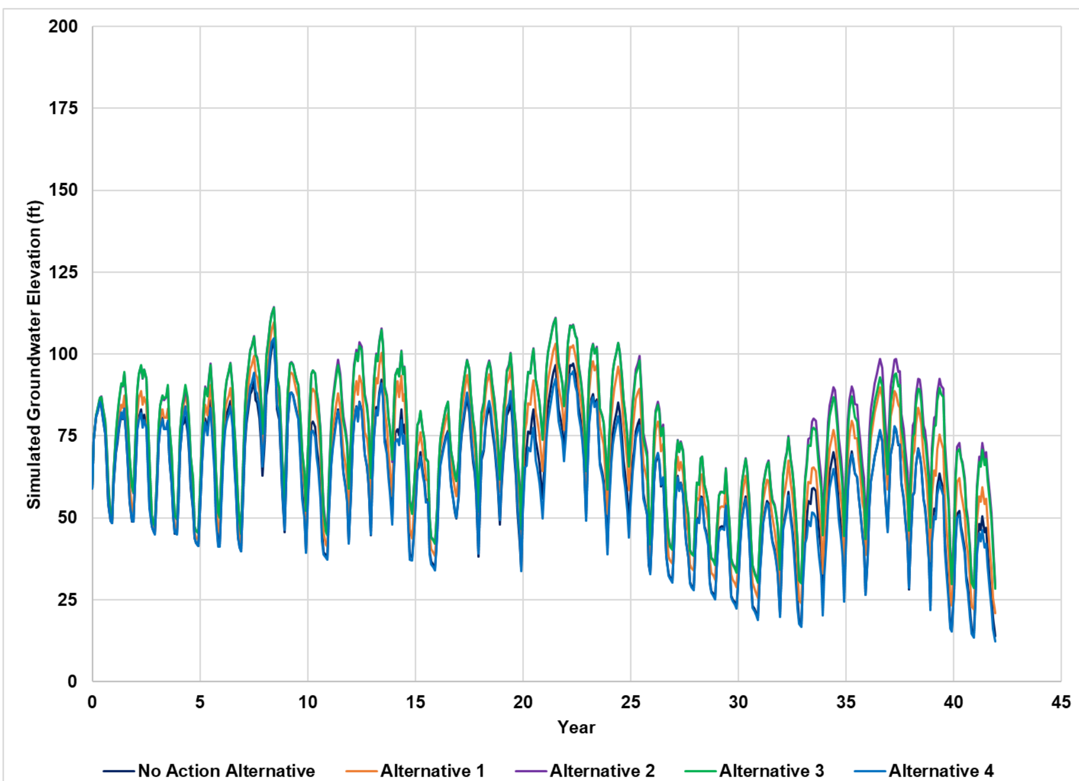


Figure I.2-10. Simulated Groundwater Elevation Location 9



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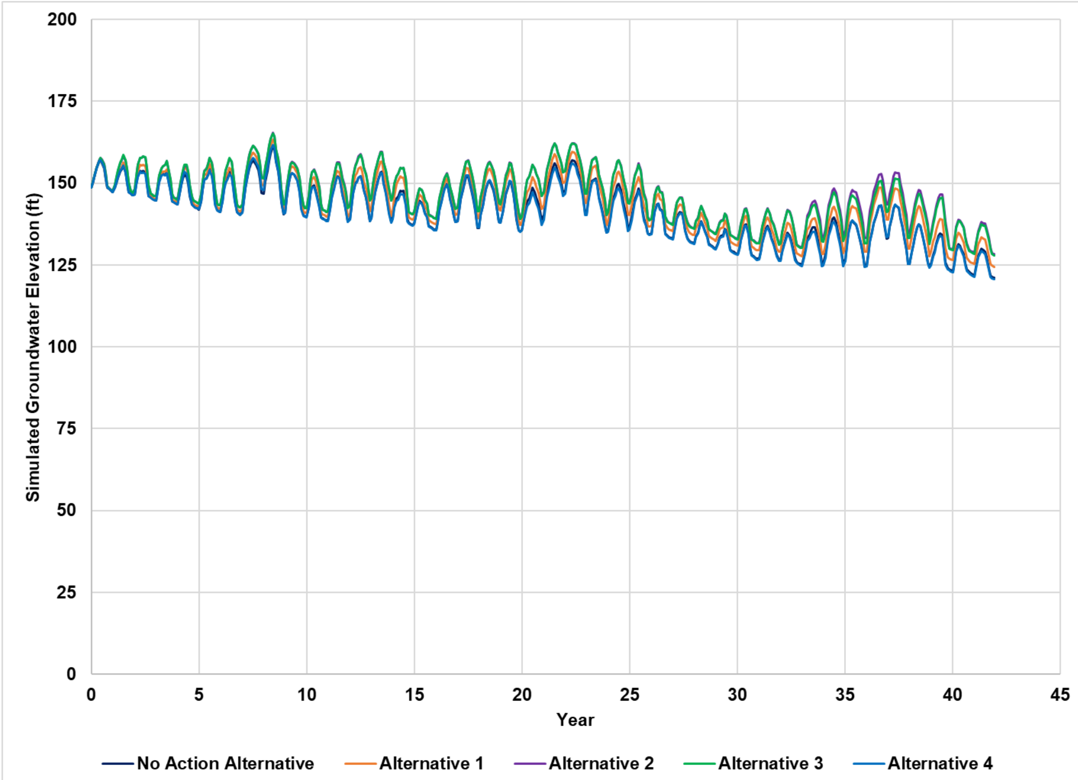

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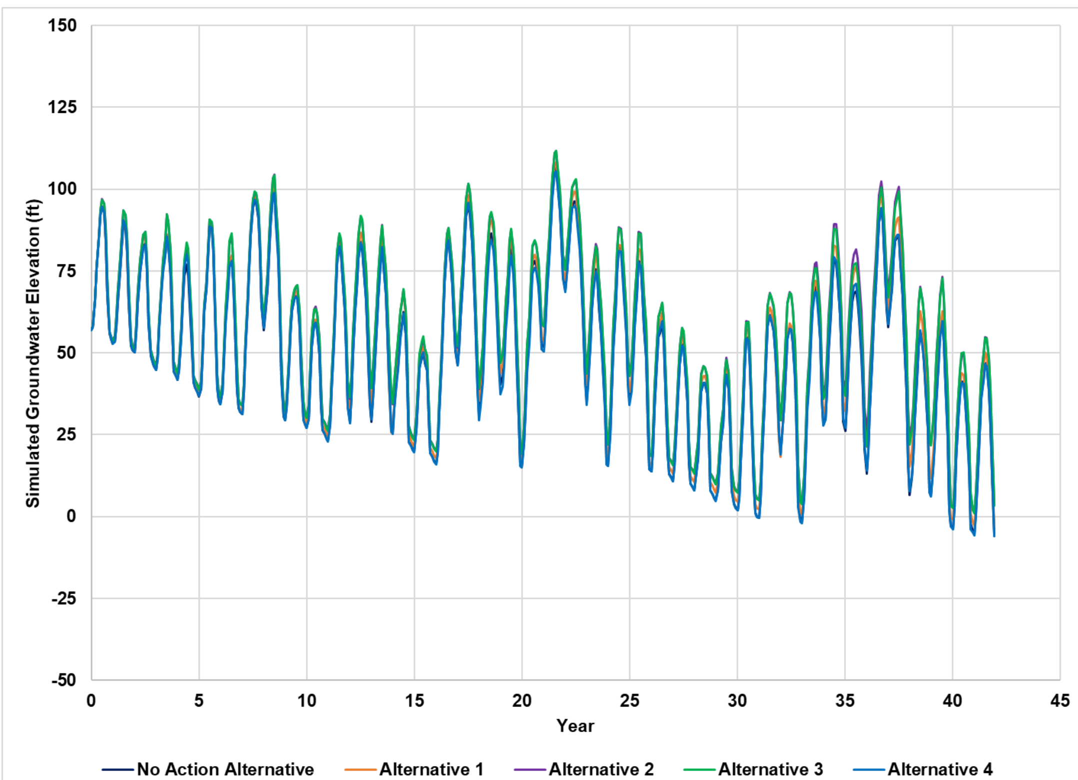

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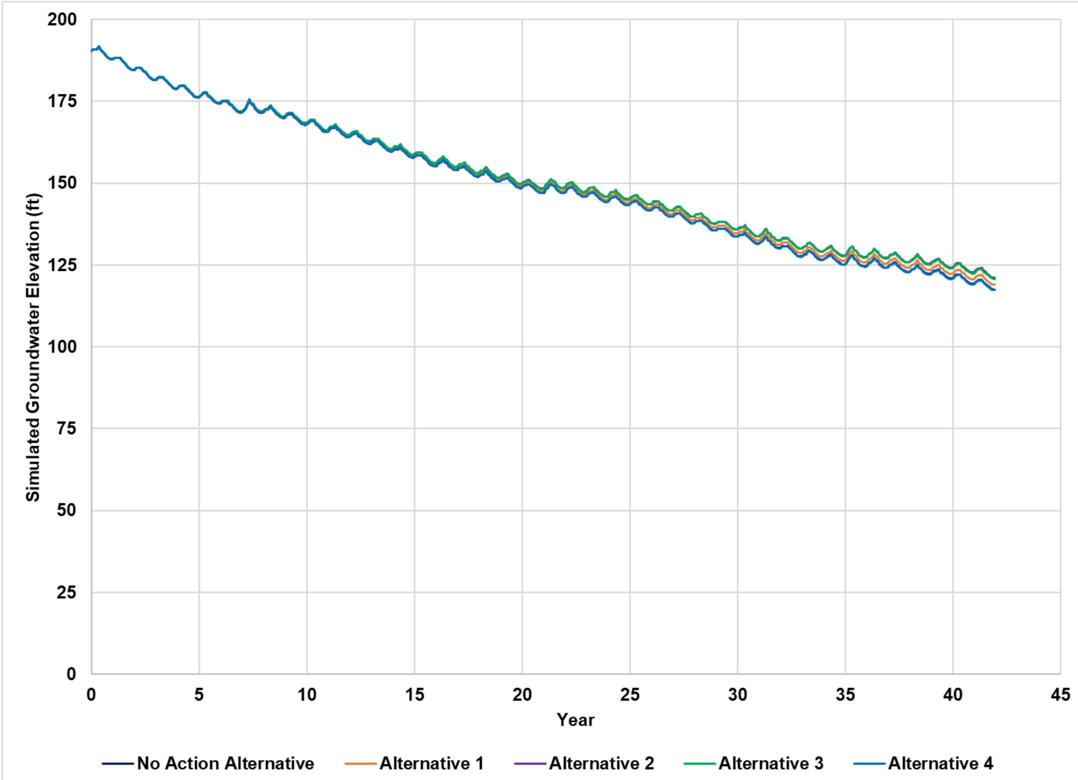

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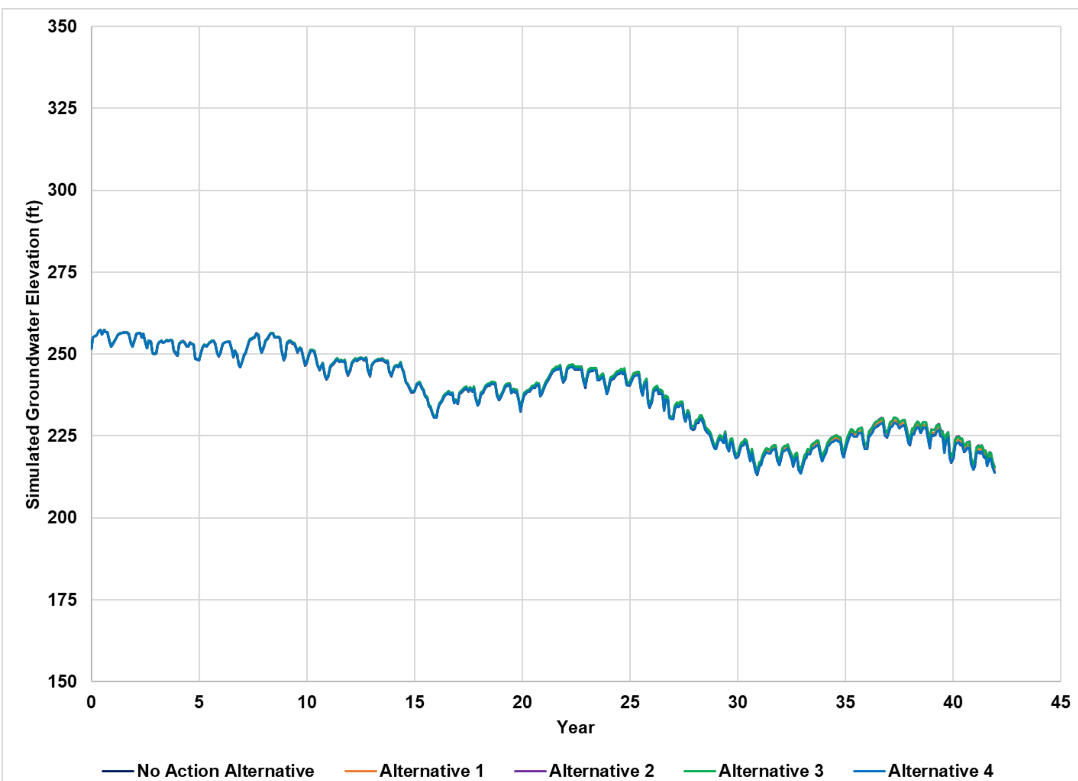

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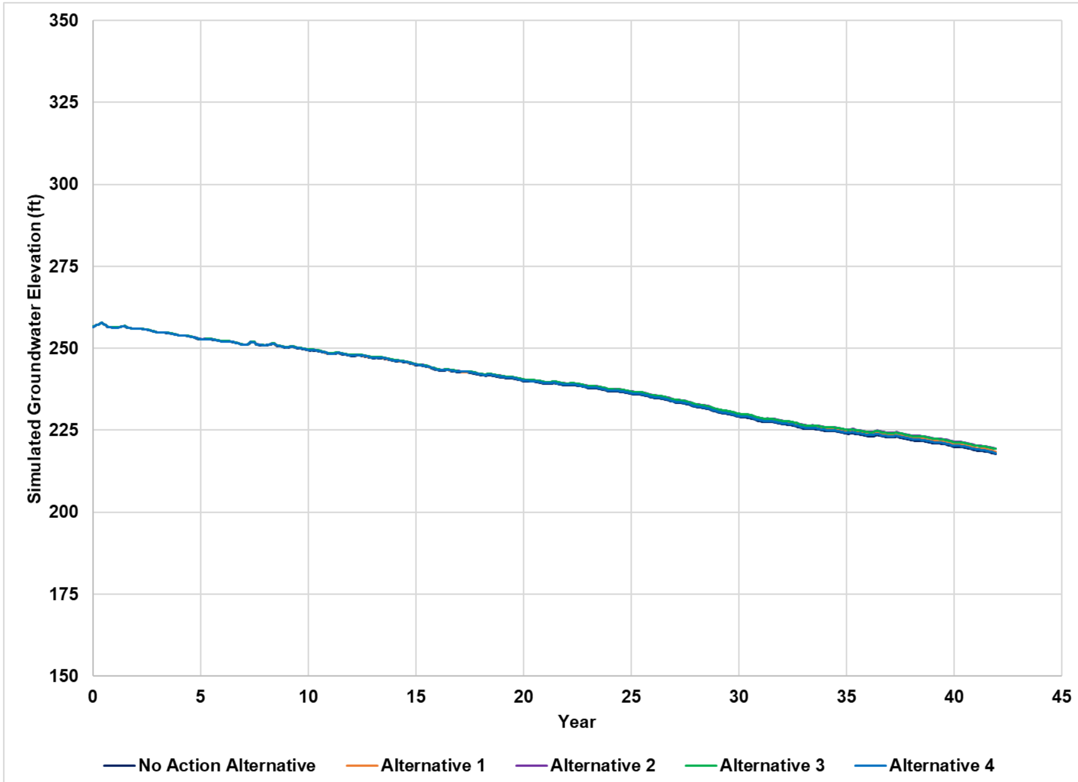

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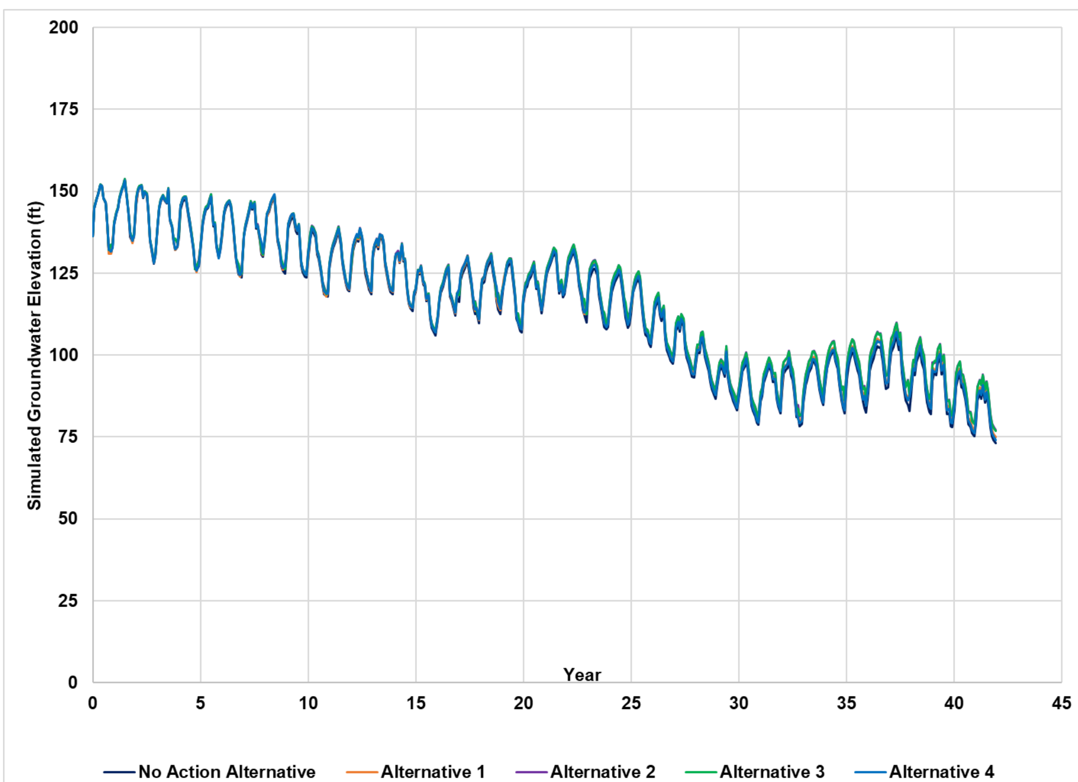

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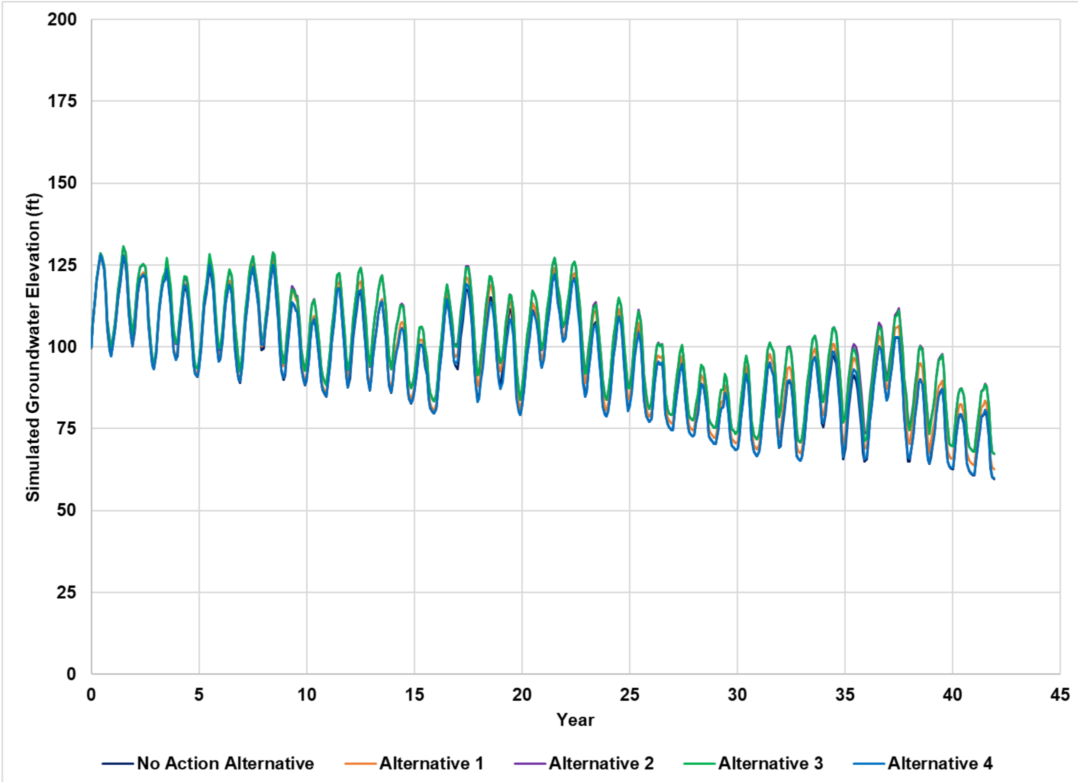

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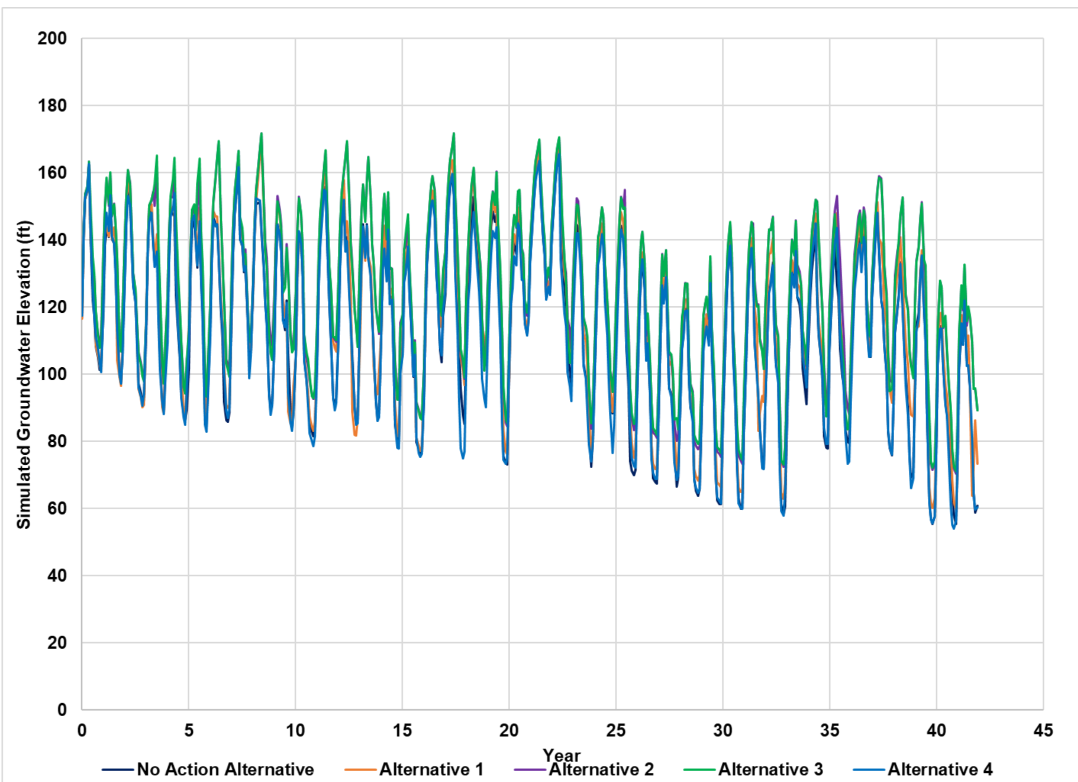

Figure I.2-19. Simulated Groundwater Elevation Location 18

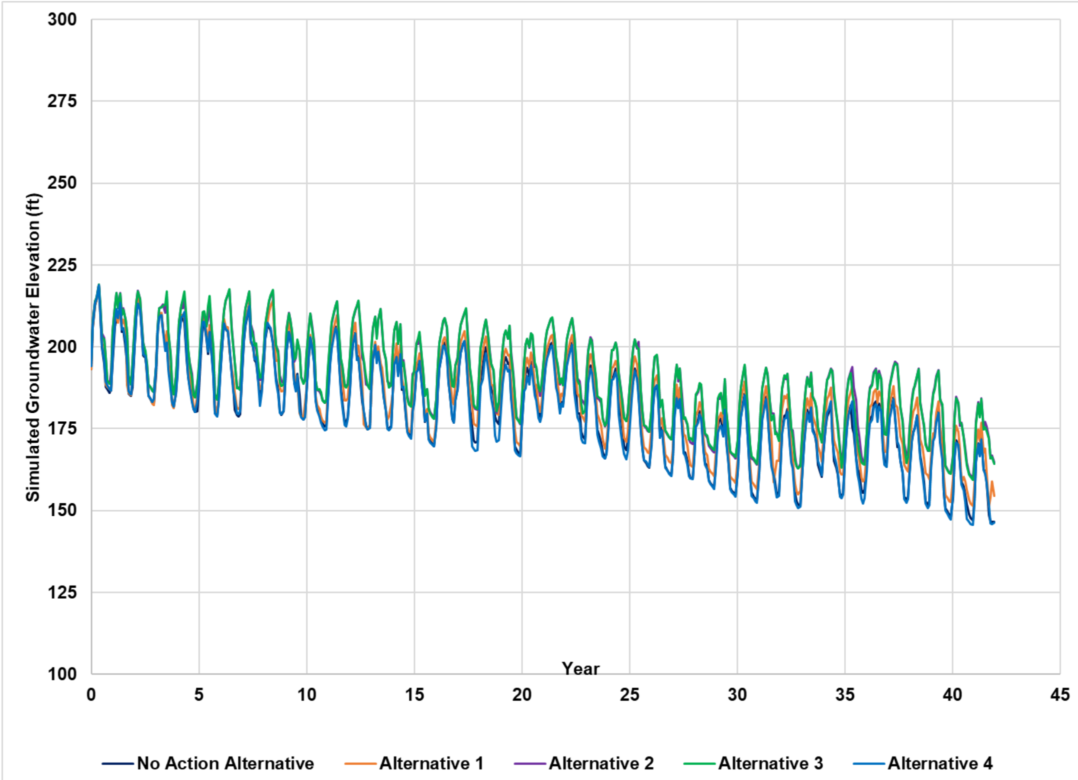

Figure I.2-20. Simulated Groundwater Elevation Location 19

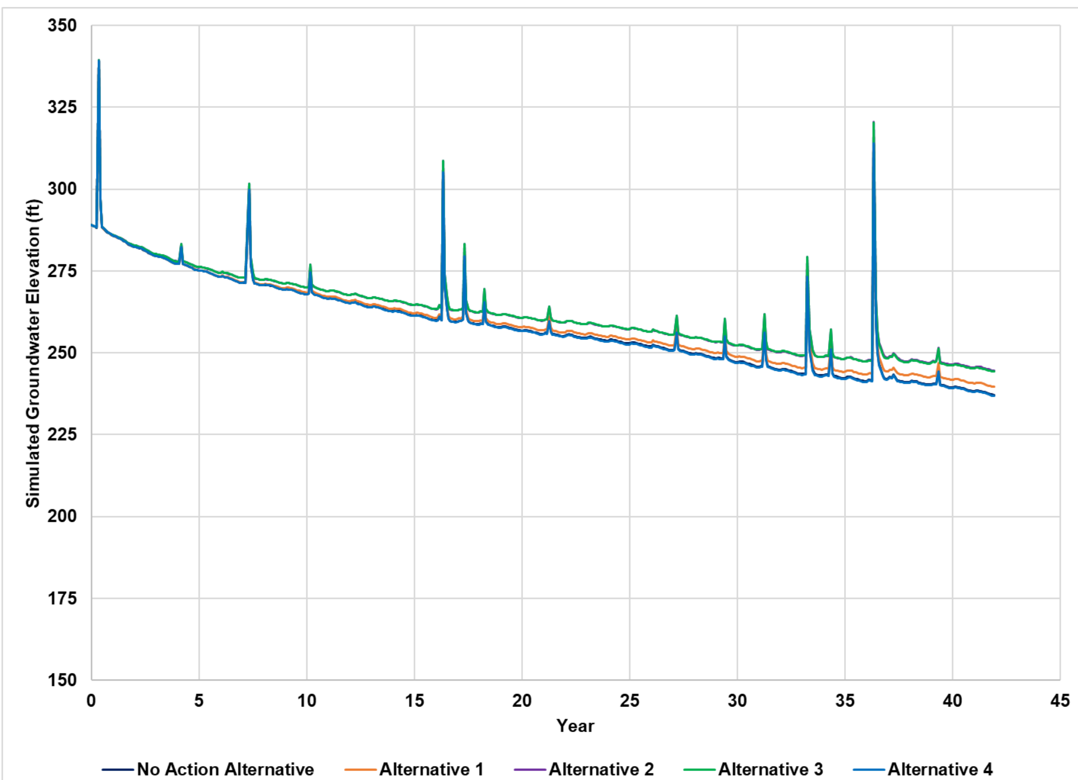

Figure I.2-21. Simulated Groundwater Elevation Location 20

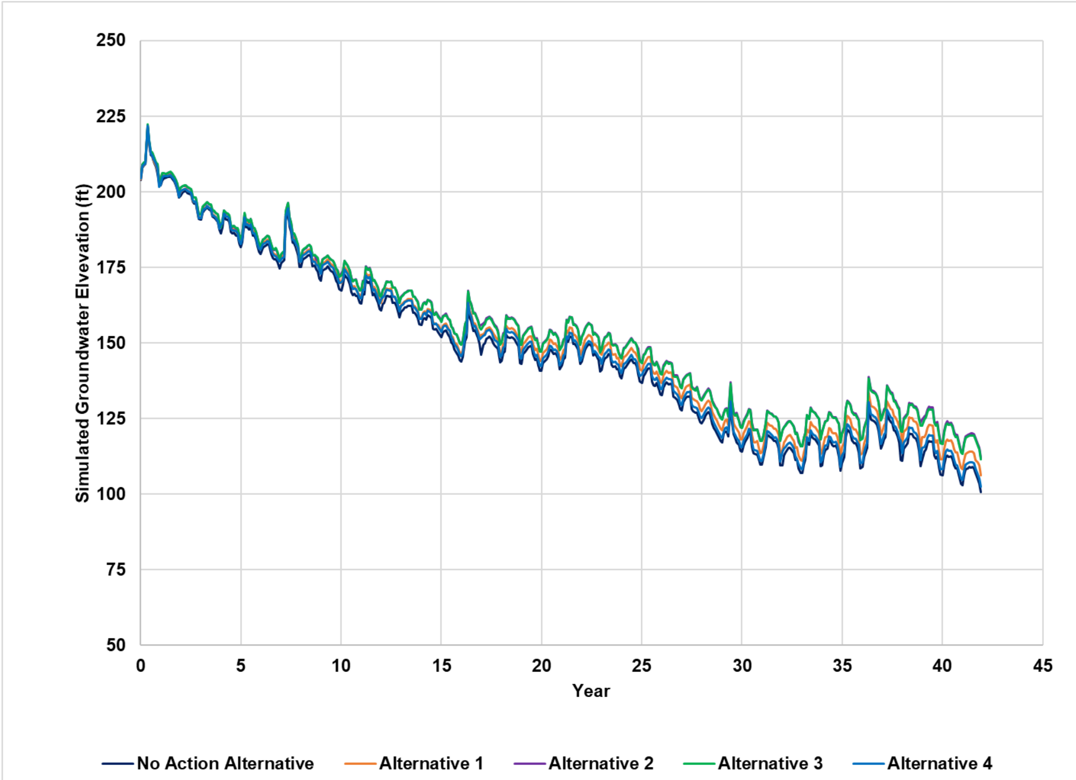

Figure I.2-22. Simulated Groundwater Elevation Location 21

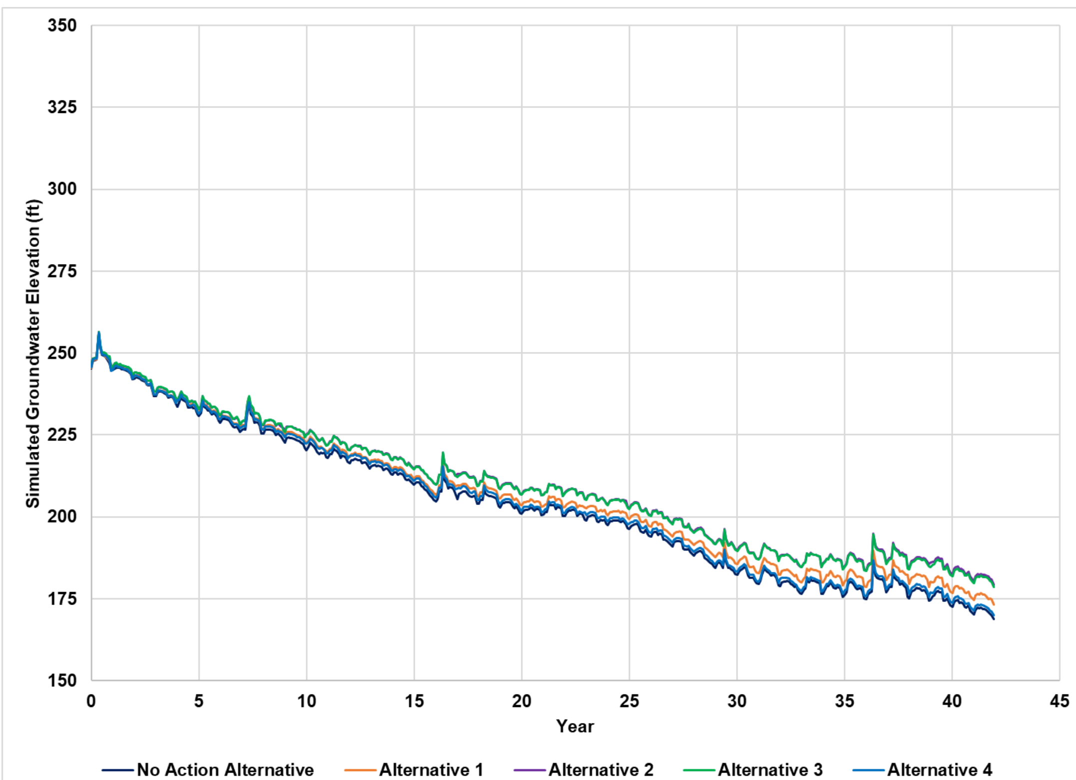

Figure I.2-23. Simulated Groundwater Elevation Location 22

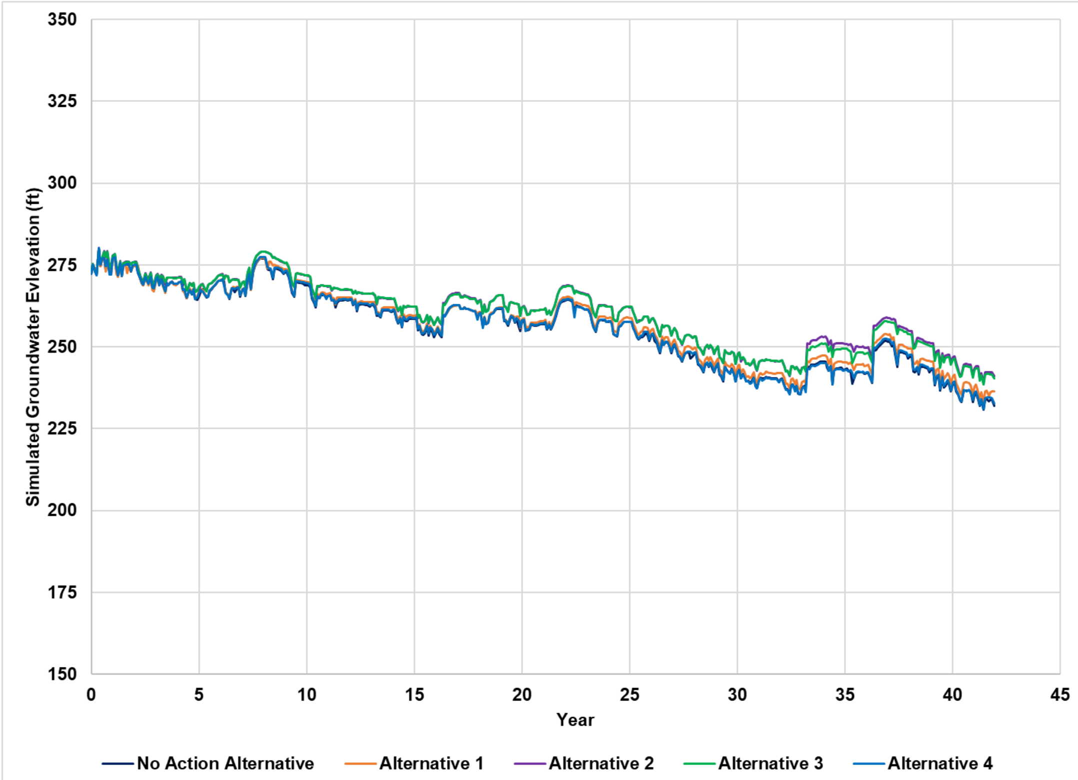

Figure I.2-24. Simulated Groundwater Elevation Location 23

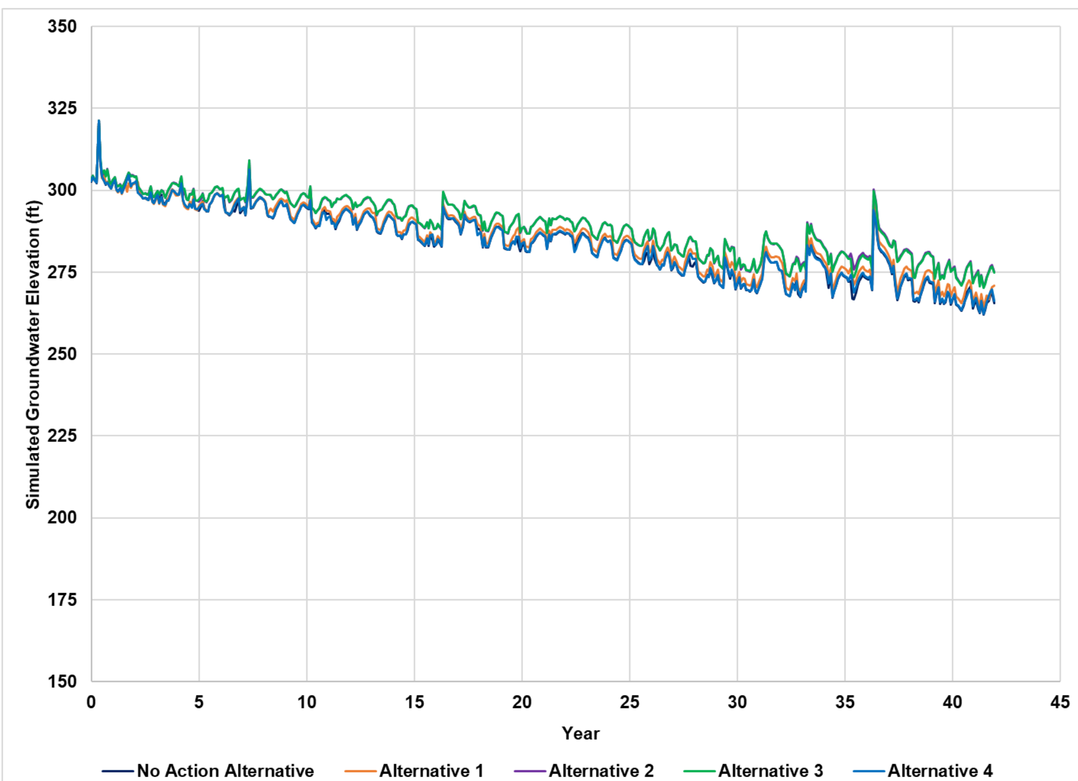

Figure I.2-25. Simulated Groundwater Elevation Location 24

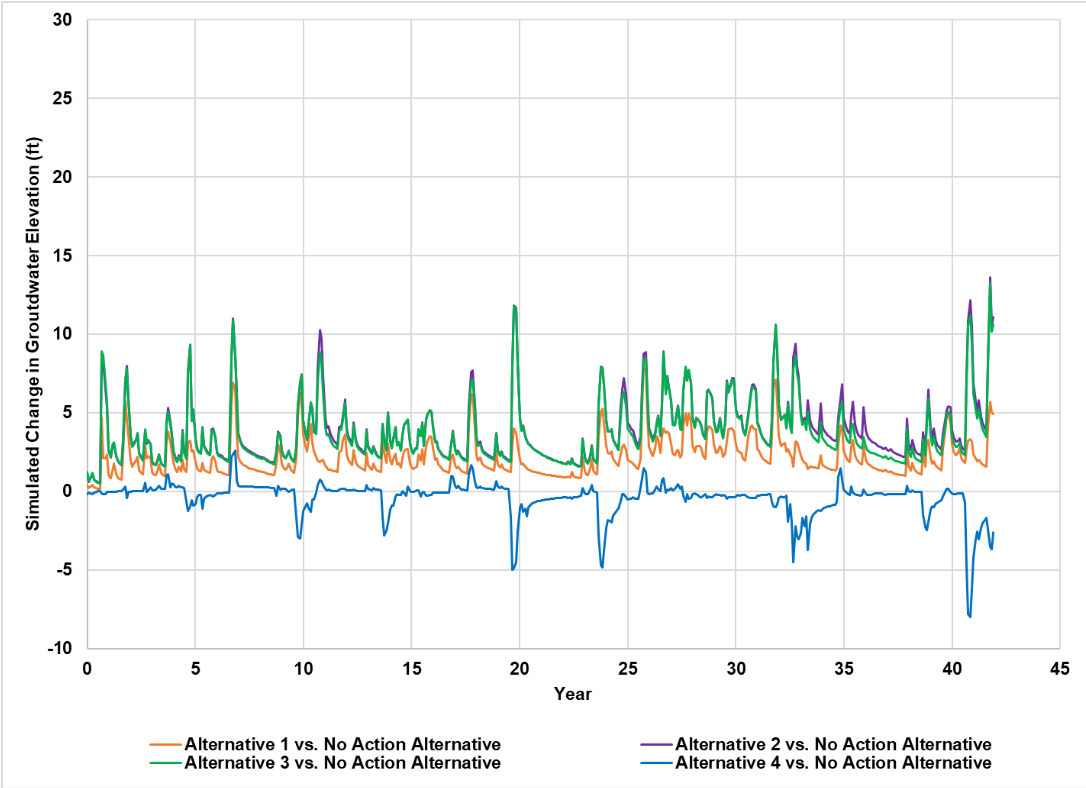

Figure I.2-26. Simulated Change in Groundwater Elevation Location 1

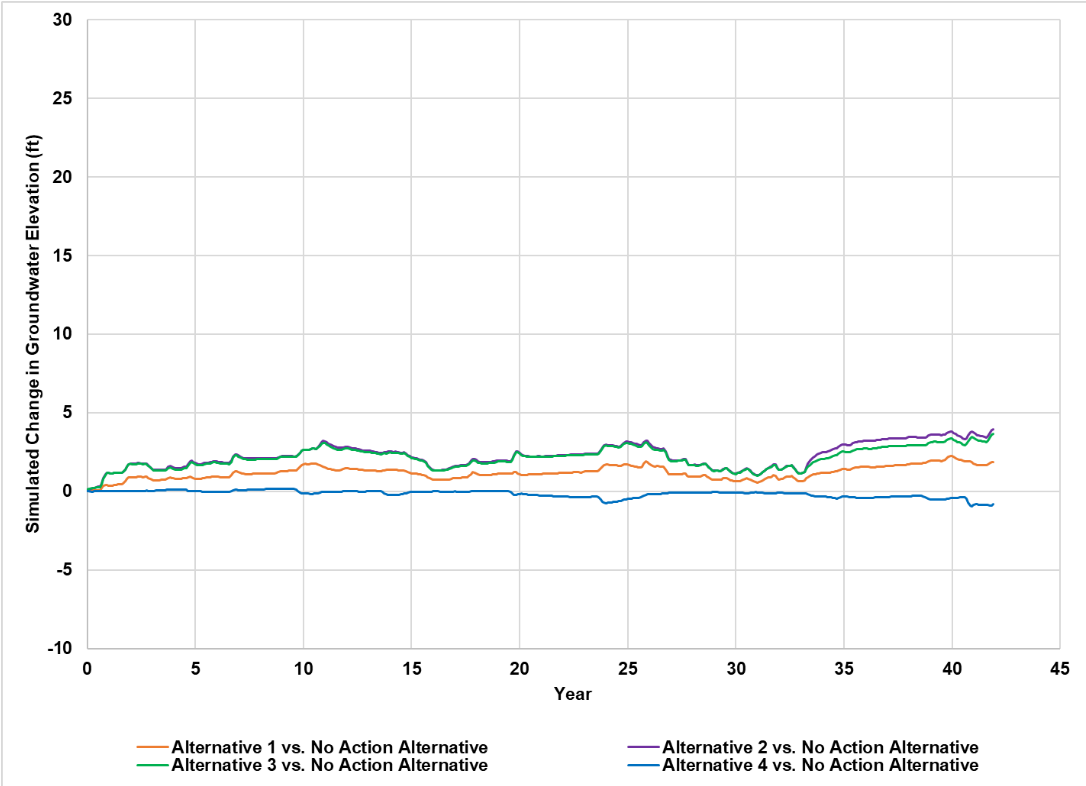

Figure I.2-27. Simulated Change in Groundwater Elevation Location 2

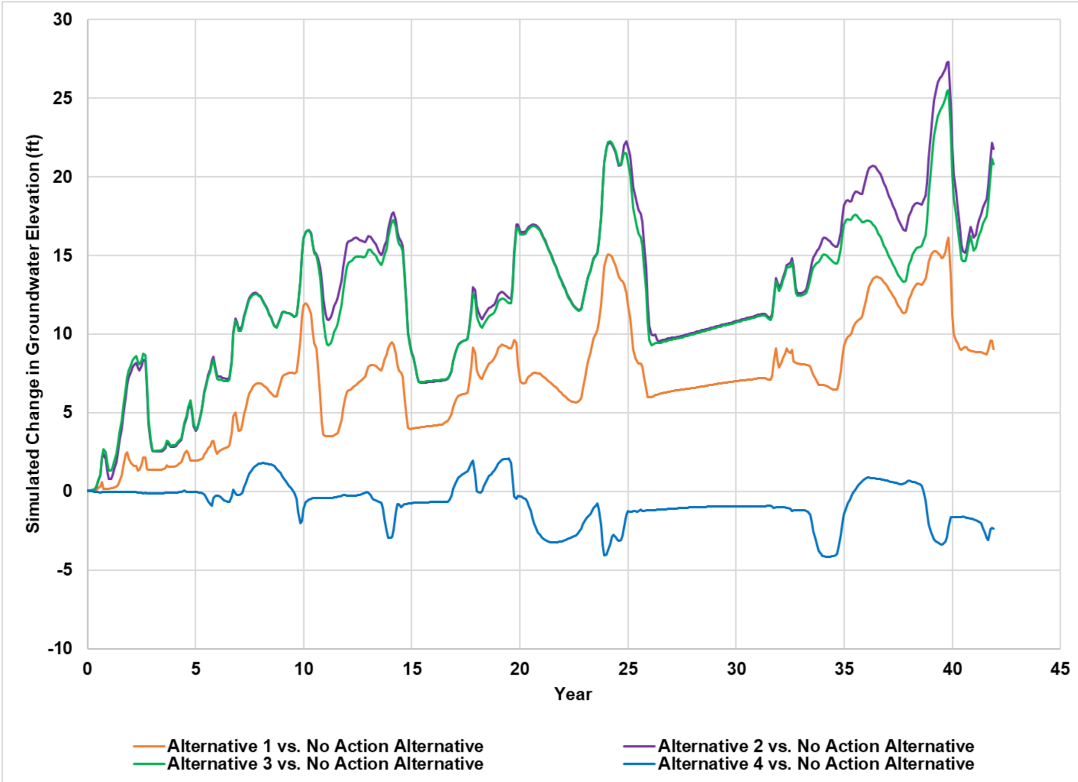

Figure I.2-28. Simulated Change in Groundwater Elevation Location 3

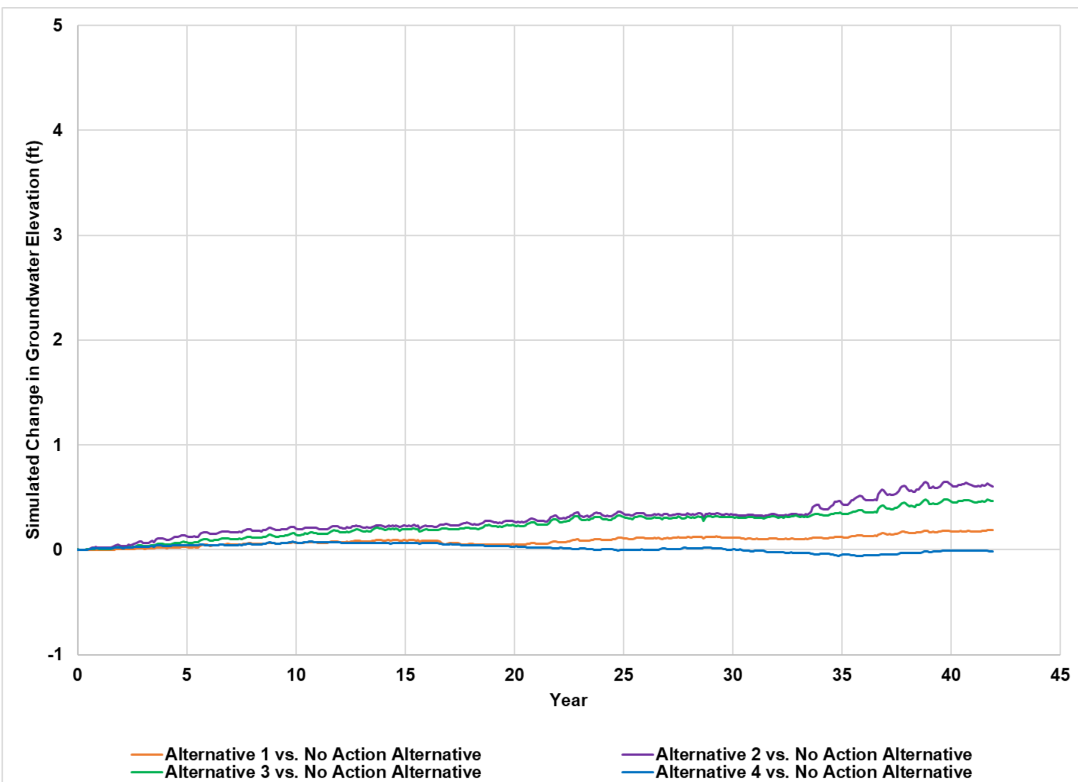

Figure I.2-29. Simulated Change in Groundwater Elevation Location 4

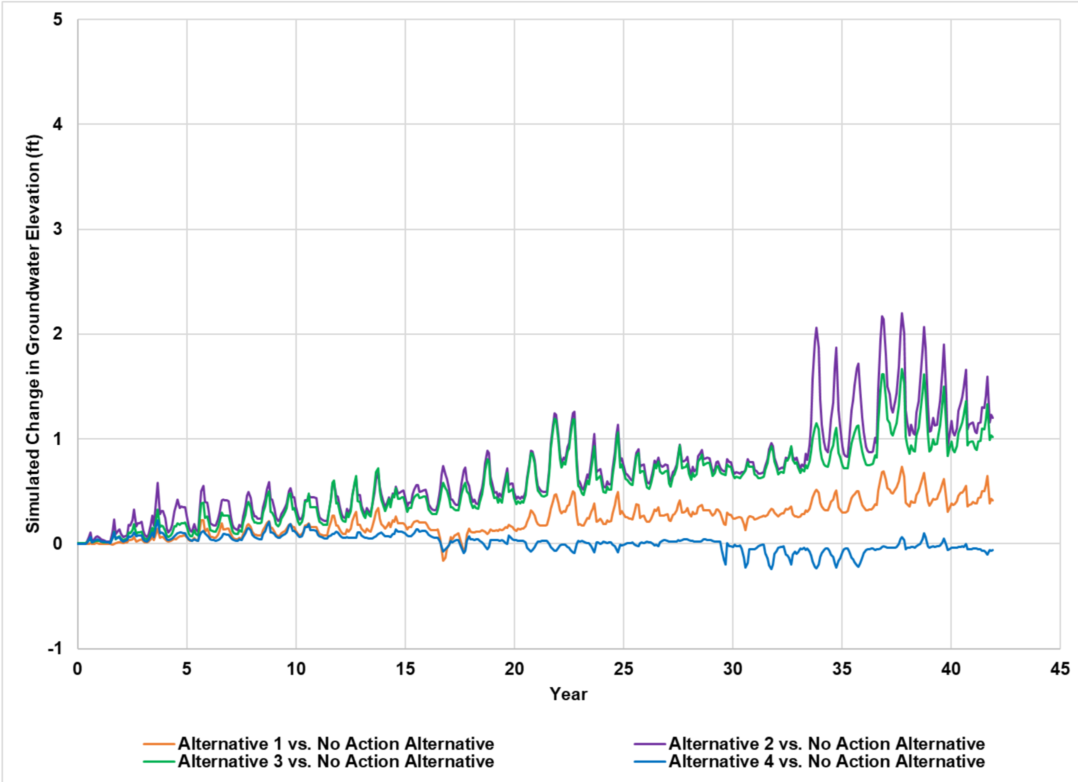

Figure I.2-30. Simulated Change in Groundwater Elevation Location 5

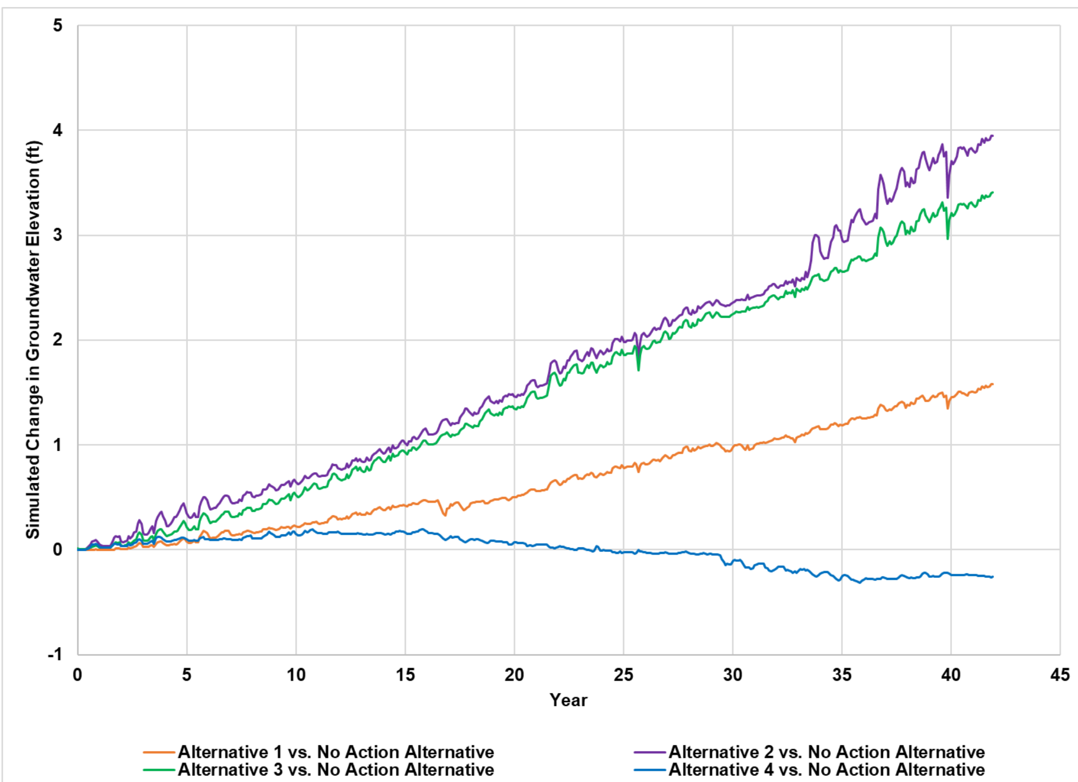

Figure I.2-31. Simulated Change in Groundwater Elevation Location 6

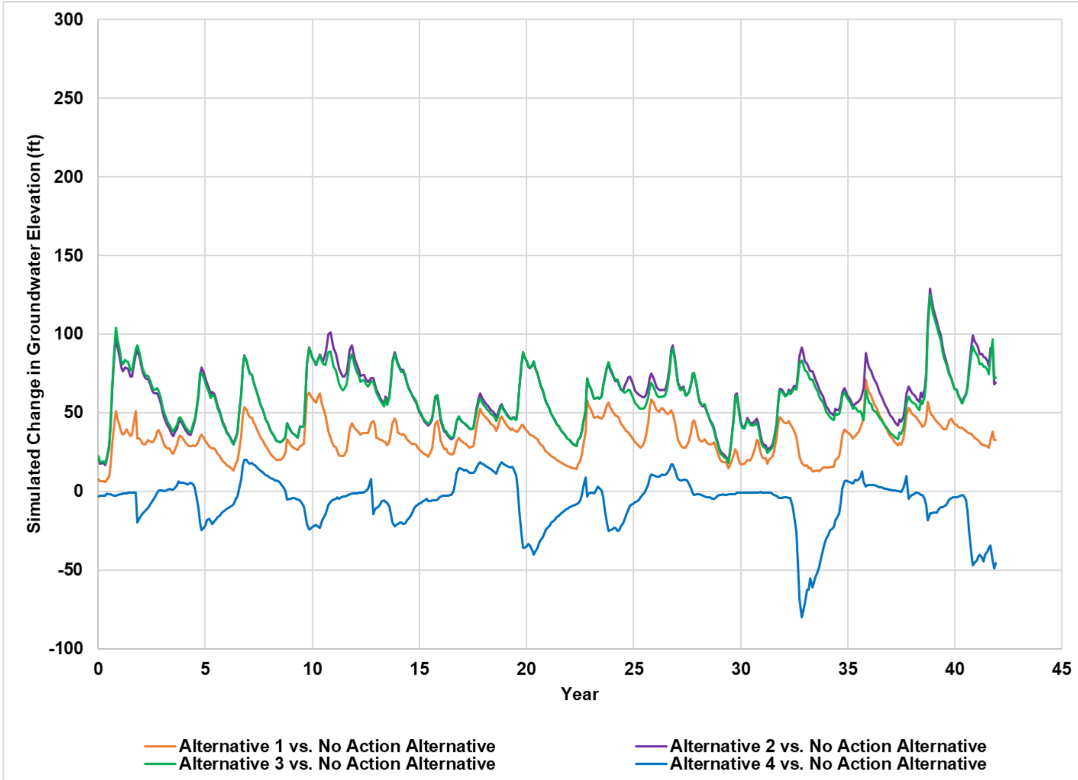

Figure I.2-32. Simulated Change in Groundwater Elevation Location 7

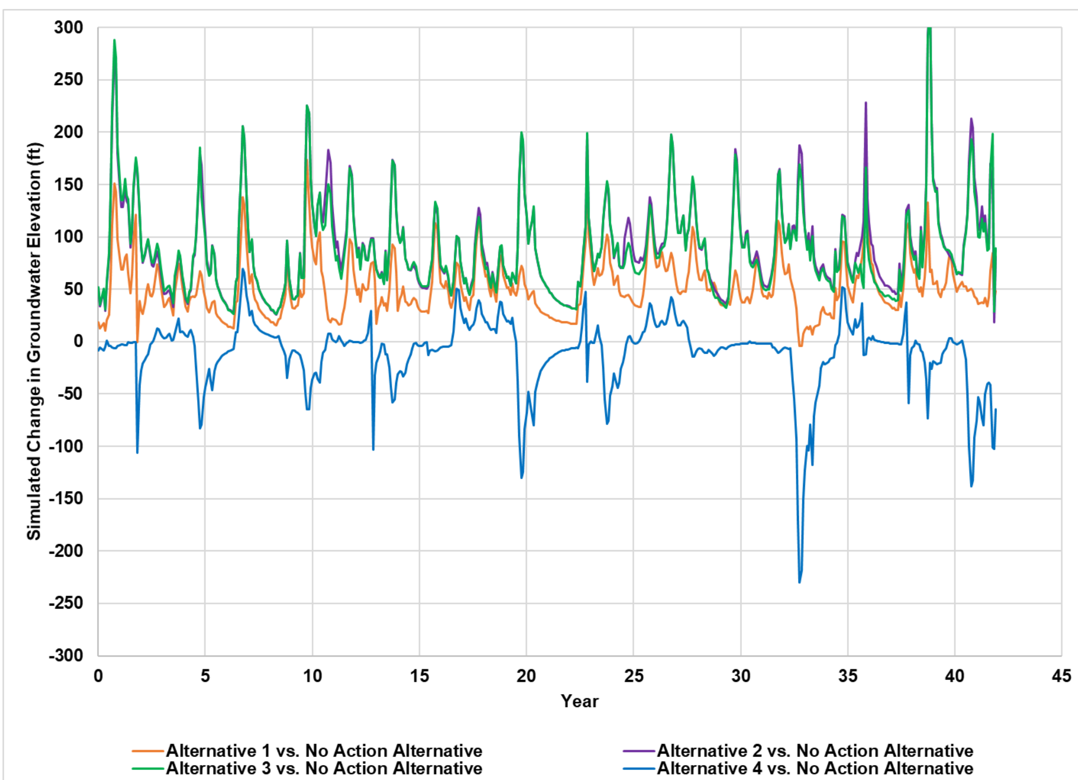

Figure I.2-33. Simulated Change in Groundwater Elevation Location 8

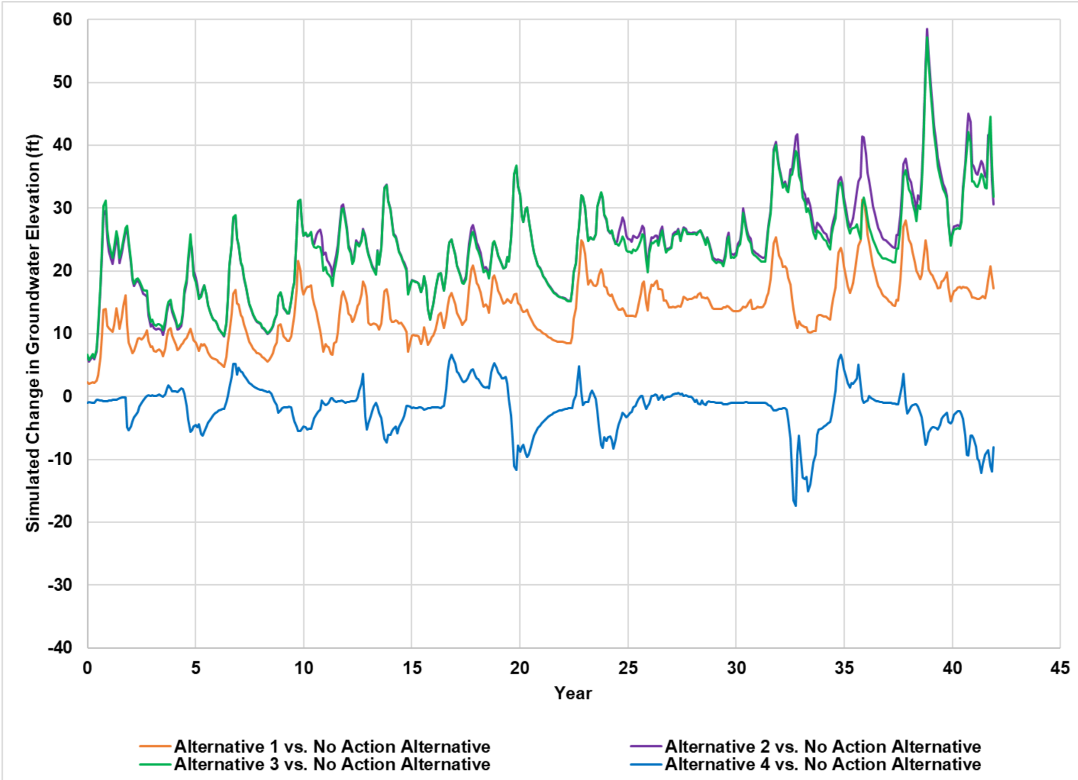

Figure I.2-34. Simulated Change in Groundwater Elevation Location 9

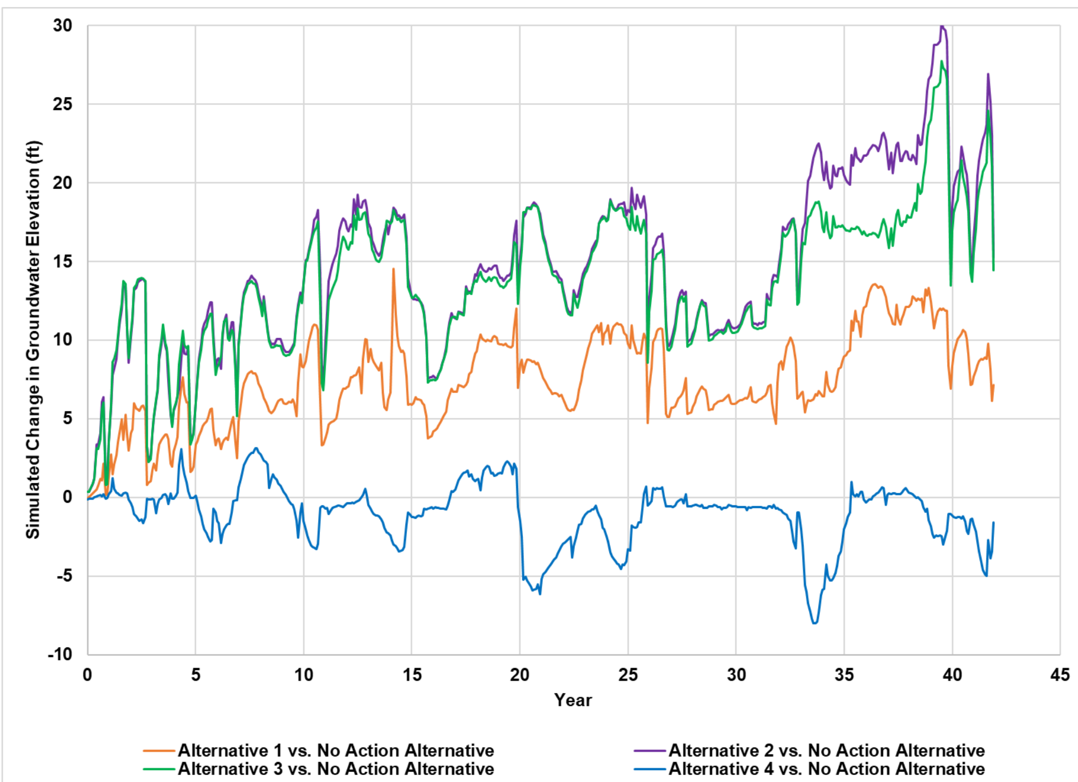

Figure I.2-35. Simulated Change in Groundwater Elevation Location 10

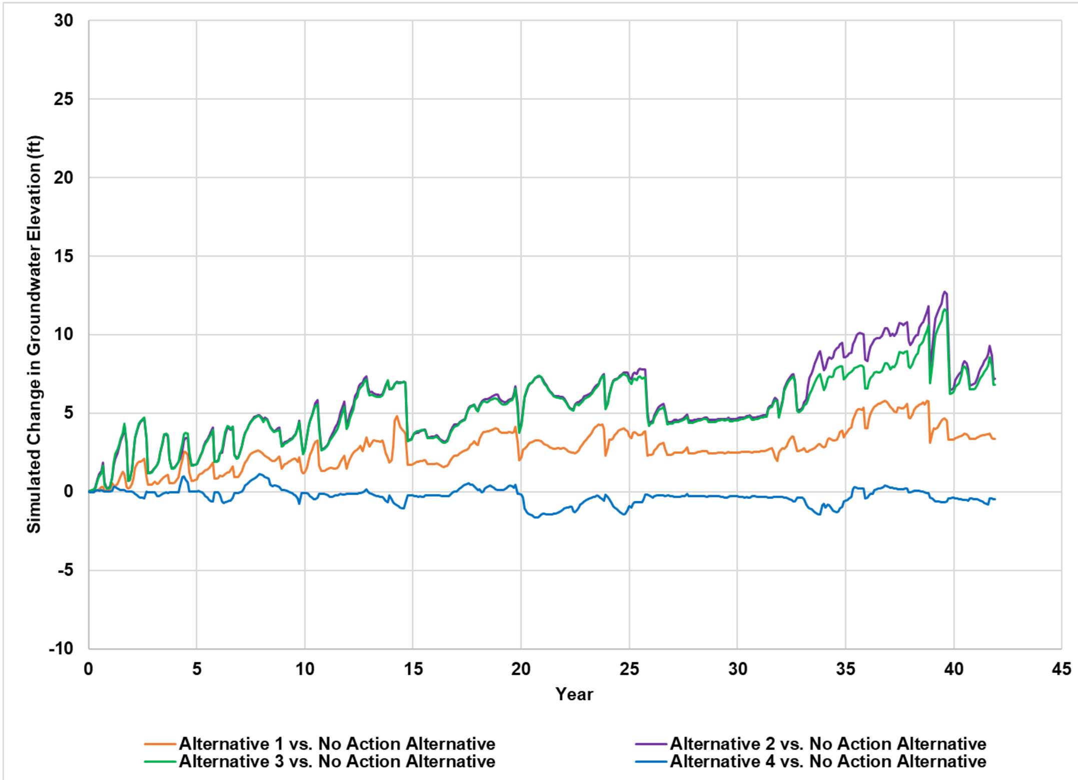

Figure I.2-36. Simulated Change in Groundwater Elevation Location 11

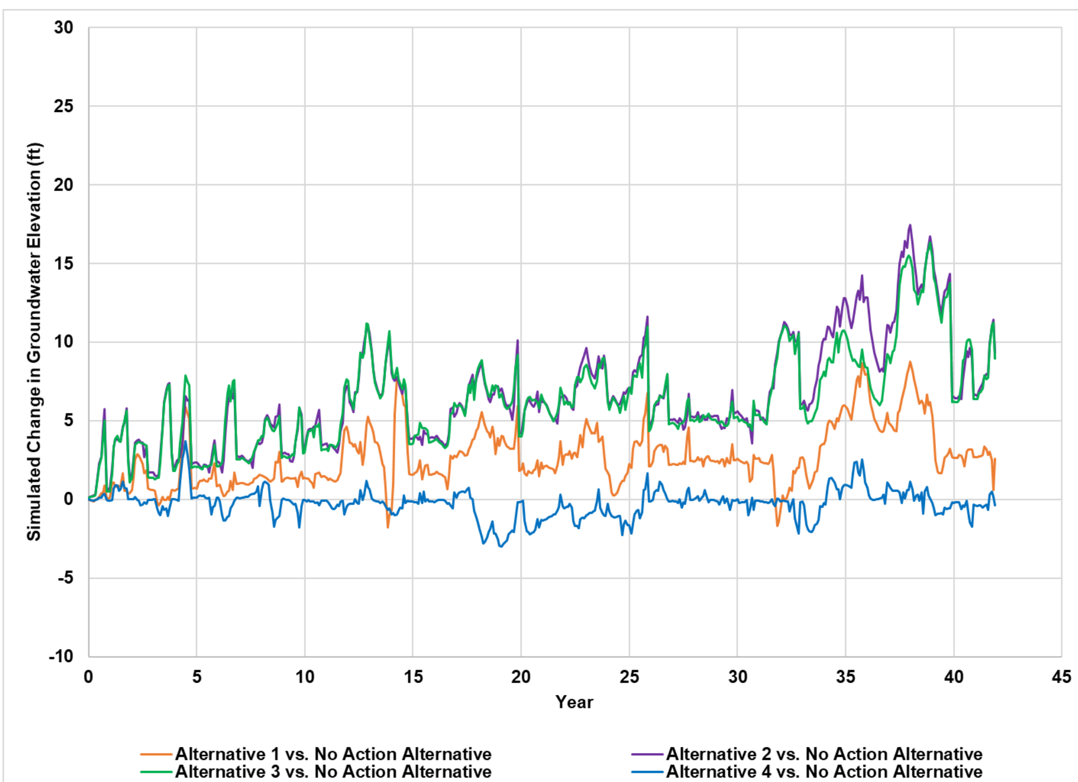

Figure I.2-37. Simulated Change in Groundwater Elevation Location 12

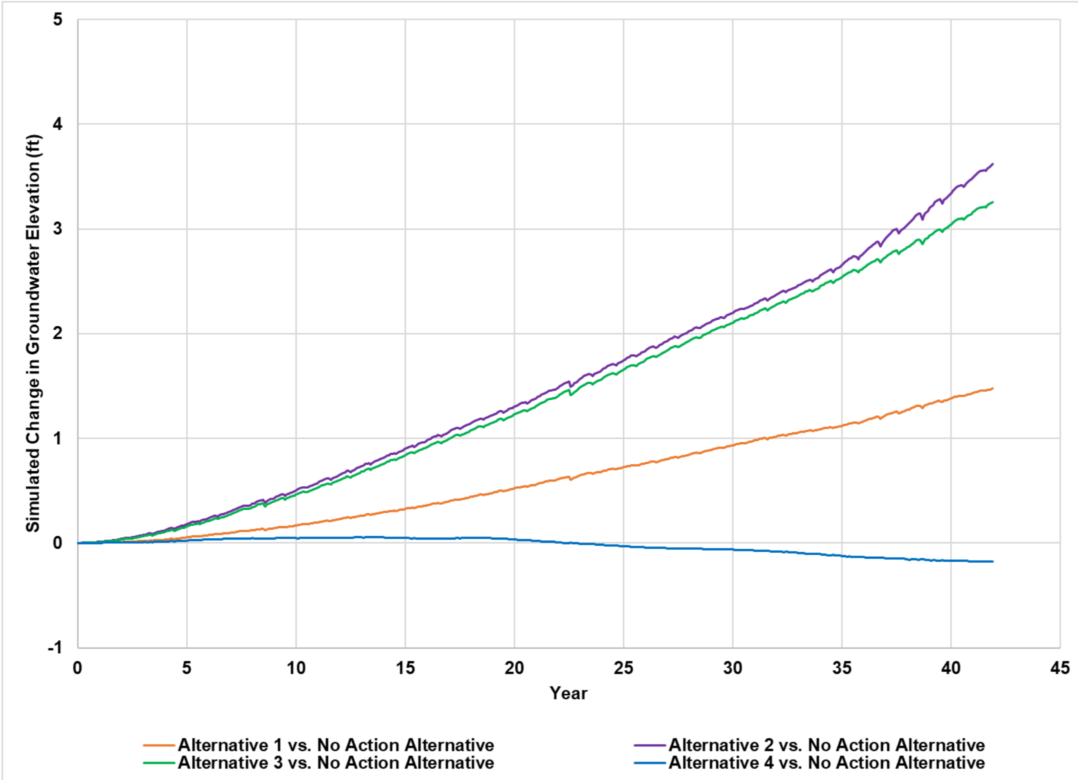

Figure I.2-38. Simulated Change in Groundwater Elevation Location 13

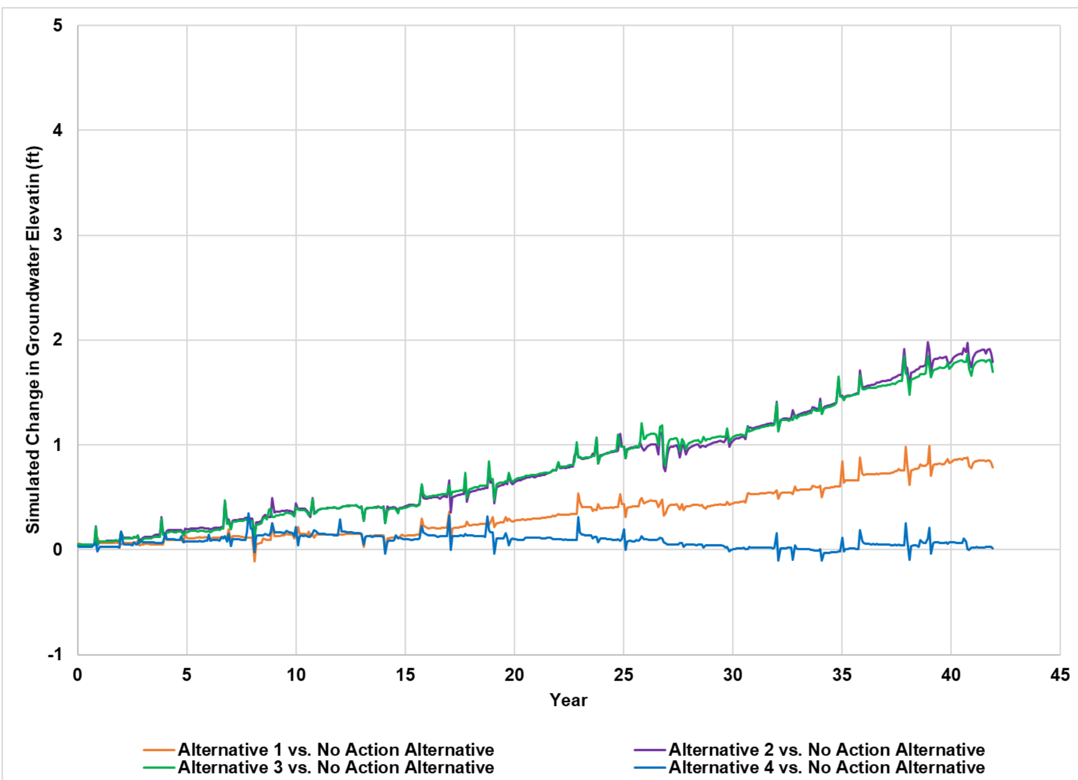

Figure I.2-39. Simulated Change in Groundwater Elevation Location 14

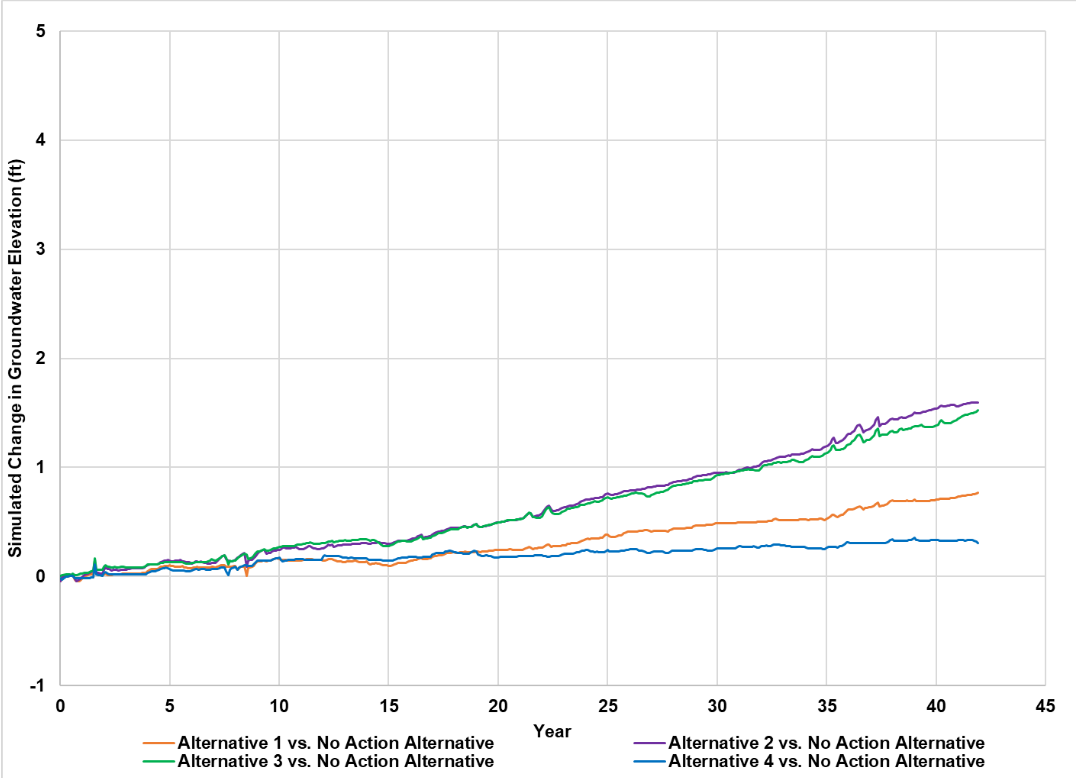

Figure I.2-40. Simulated Change in Groundwater Elevation Location 15

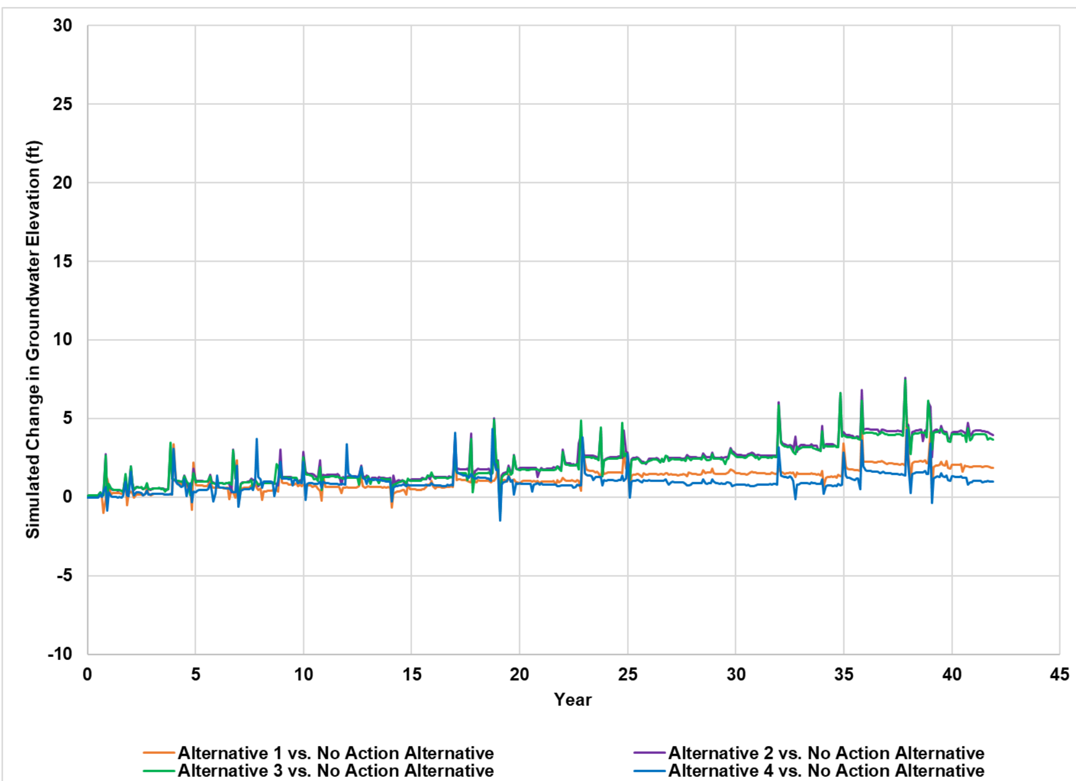

Figure I.2-41. Simulated Change in Groundwater Elevation Location 16

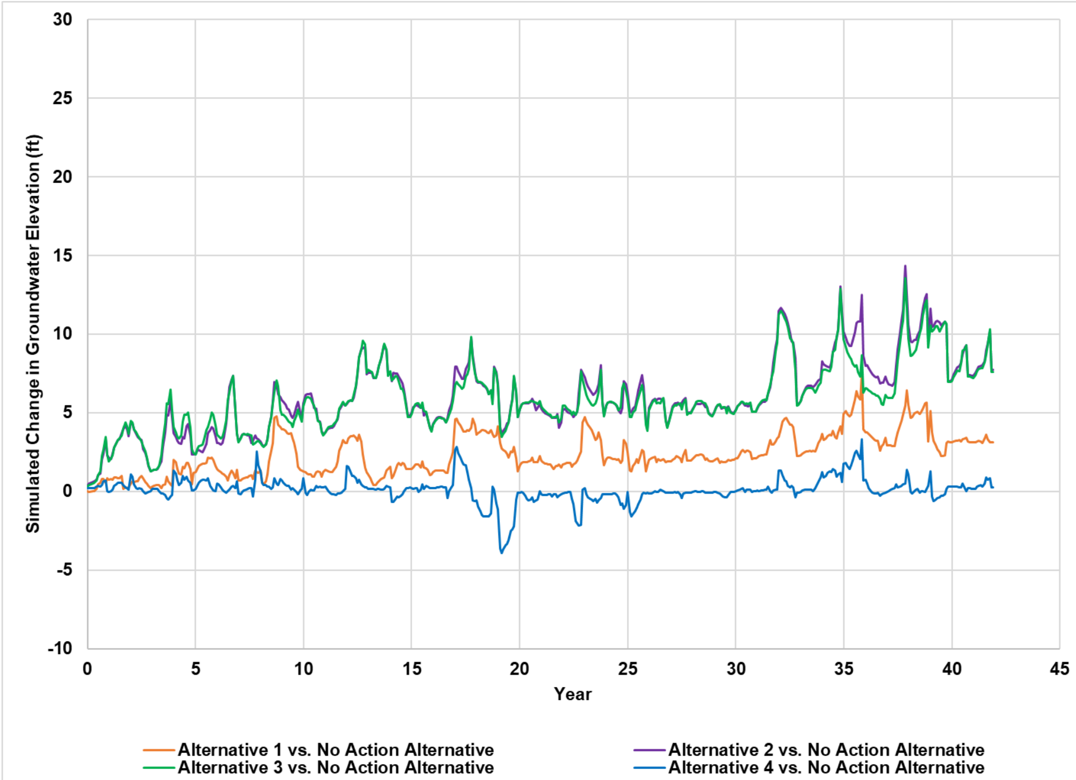

Figure I.2-42. Simulated Change in Groundwater Elevation Location 17

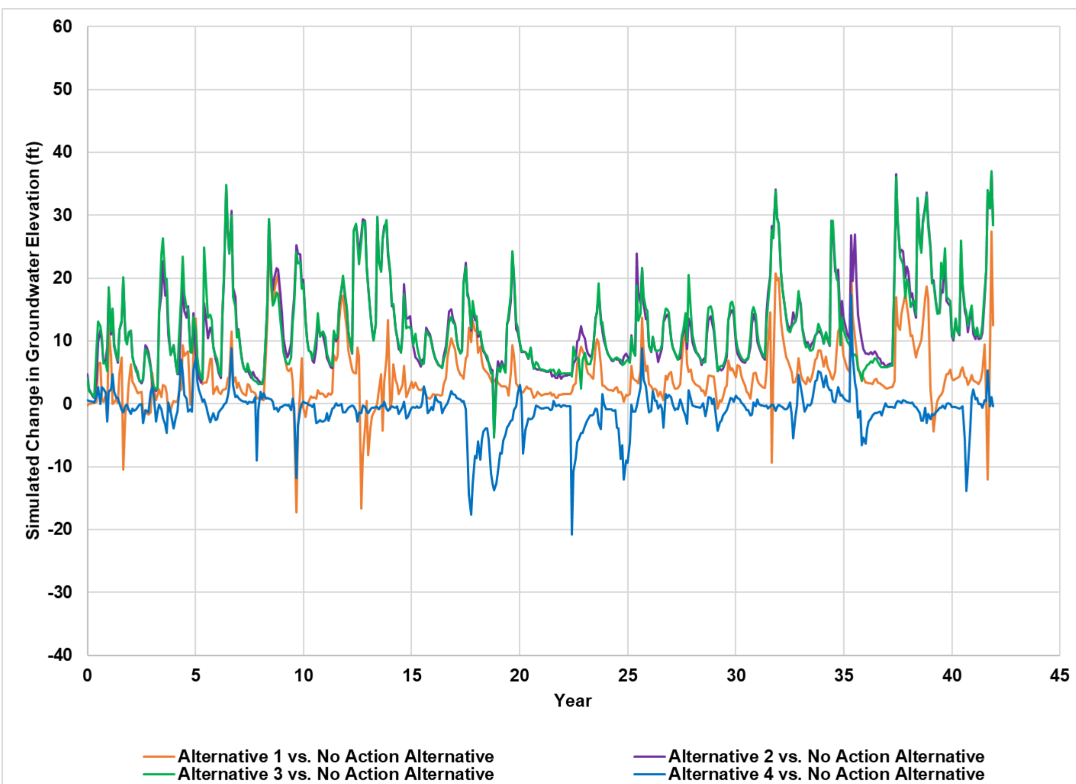

Figure I.2-43. Simulated Change in Groundwater Elevation Location 18

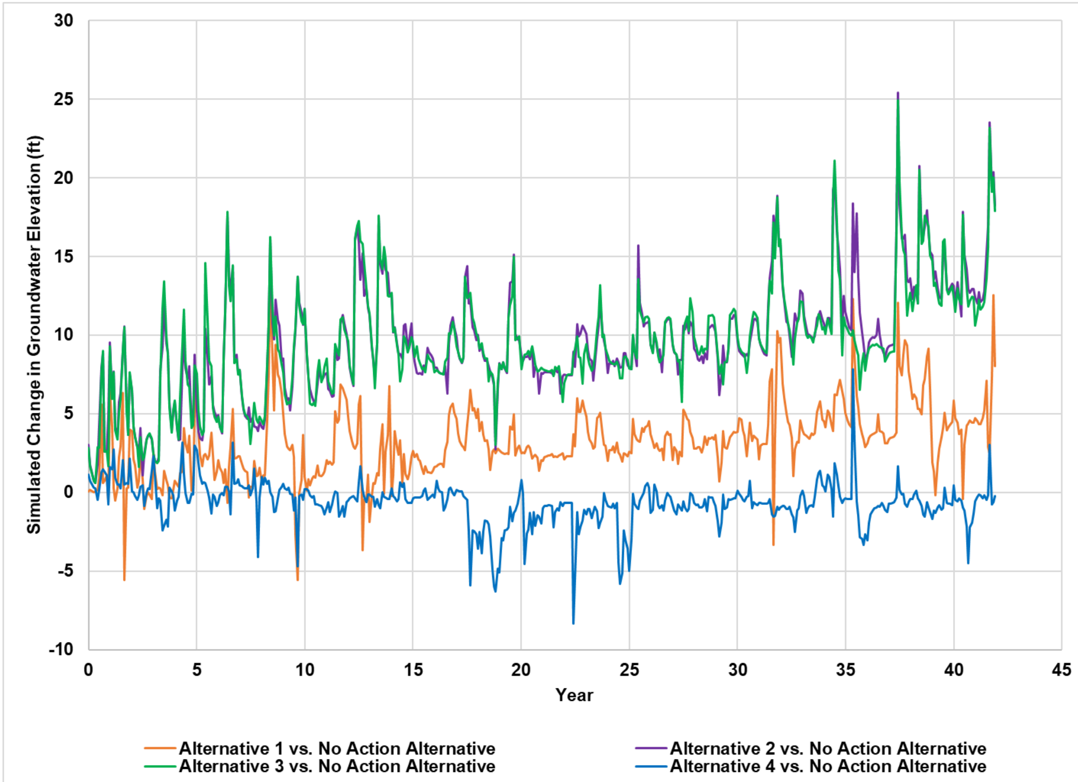

Figure I.2-44. Simulated Change in Groundwater Elevation Location 19

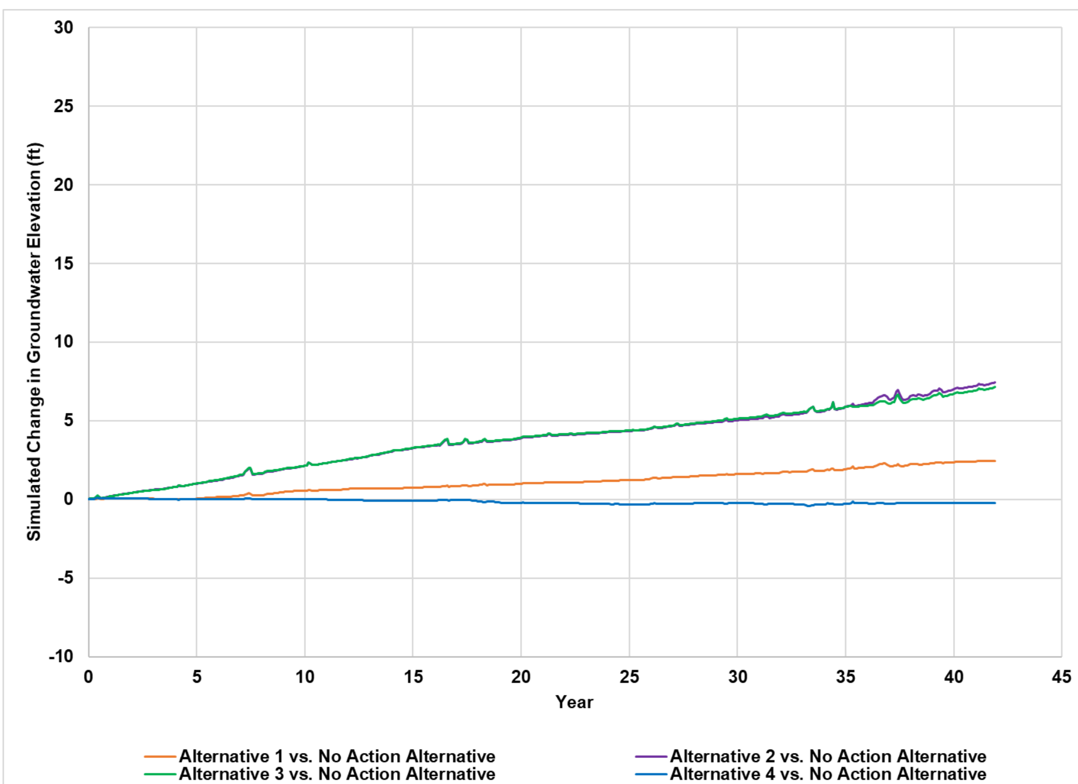

Figure I.2-45. Simulated Change in Groundwater Elevation Location 20

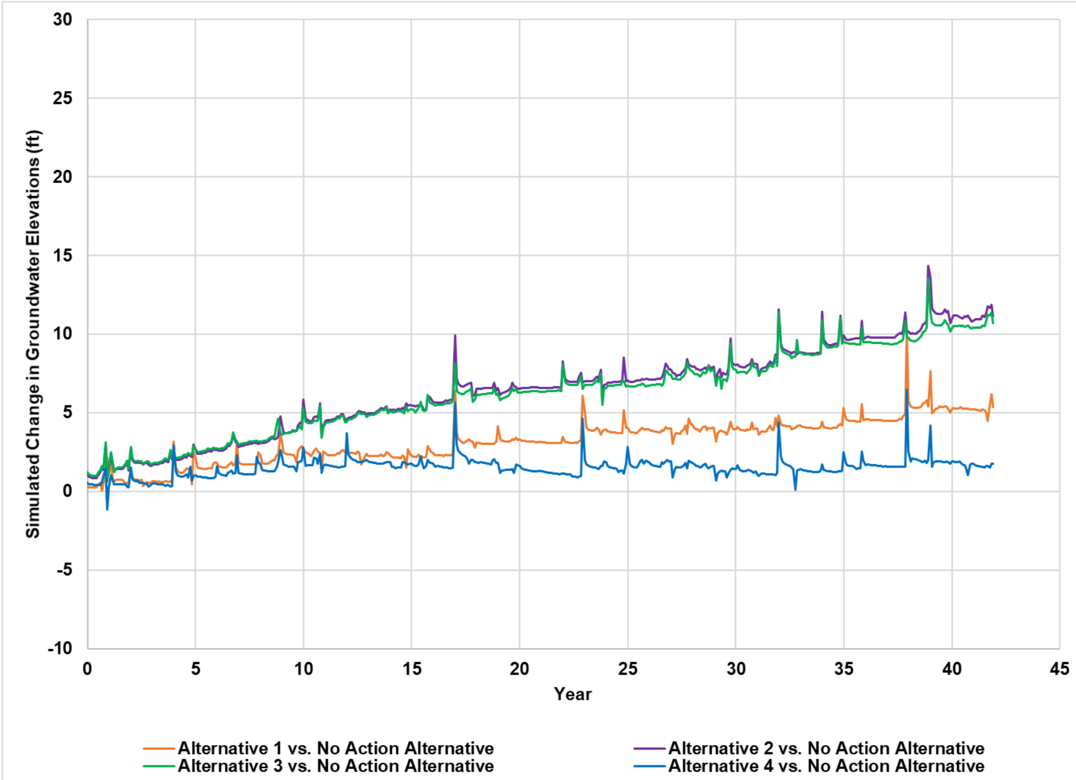

Figure I.2-46. Simulated Change in Groundwater Elevation Location 21

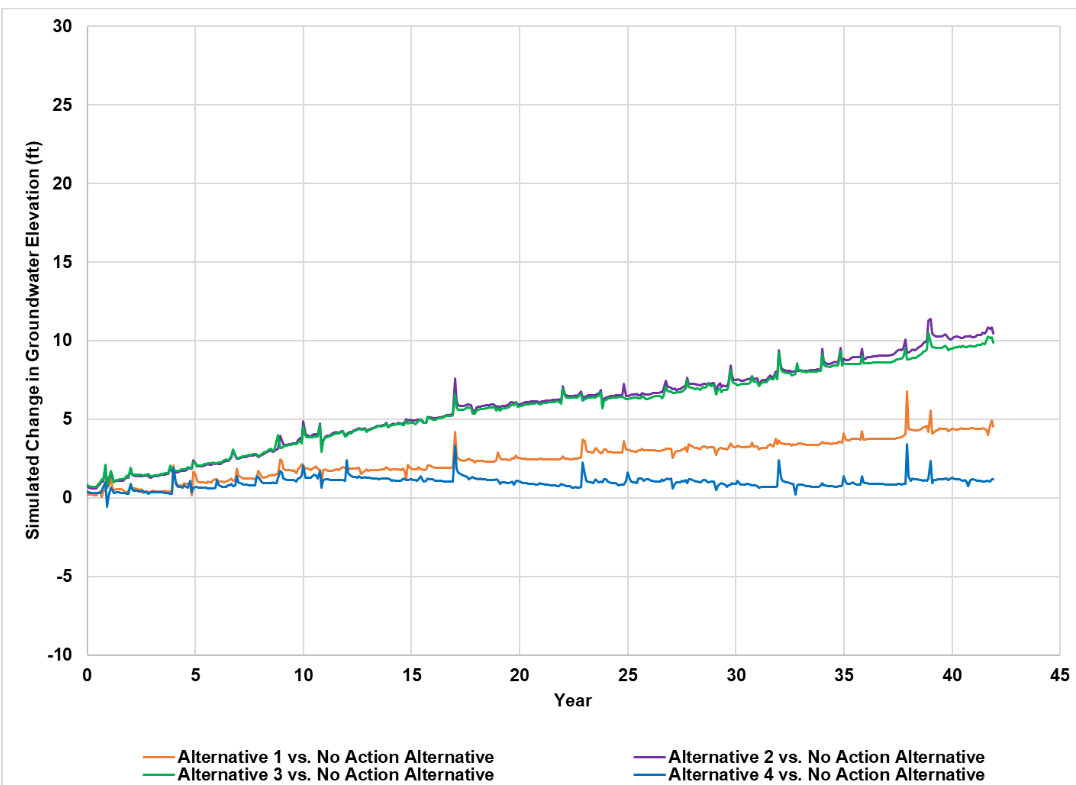

Figure I.2-47. Simulated Change in Groundwater Elevation Location 22

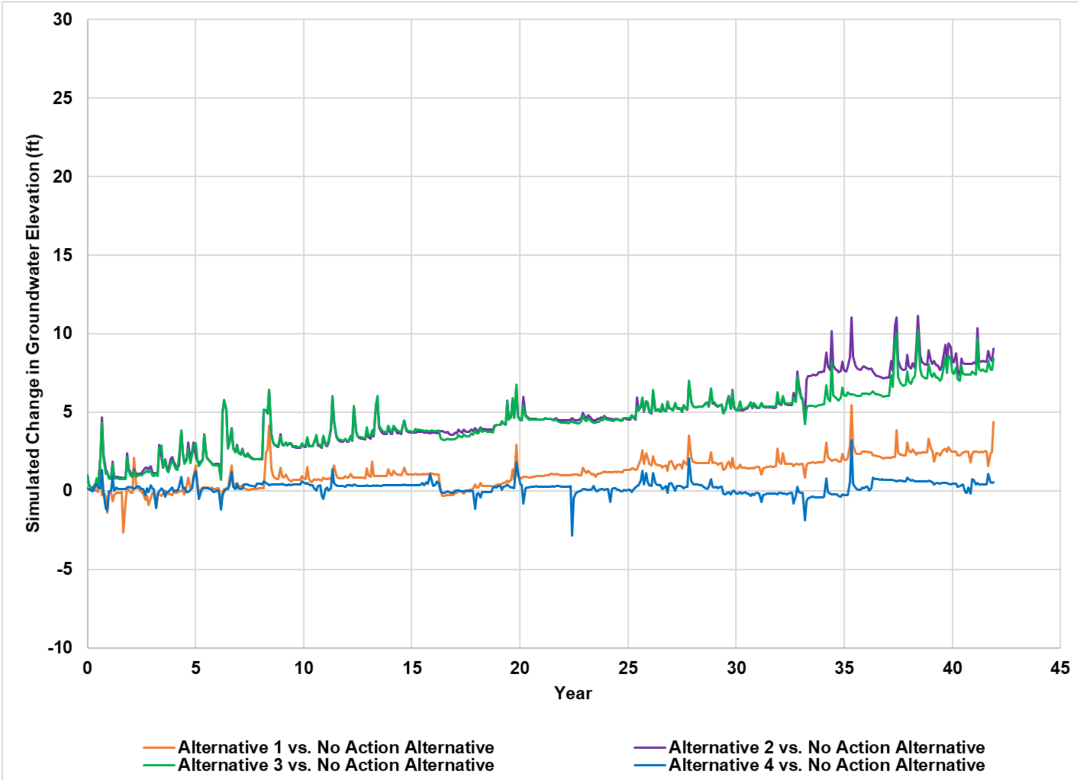

Figure I.2-48. Simulated Change in Groundwater Elevation Location 23

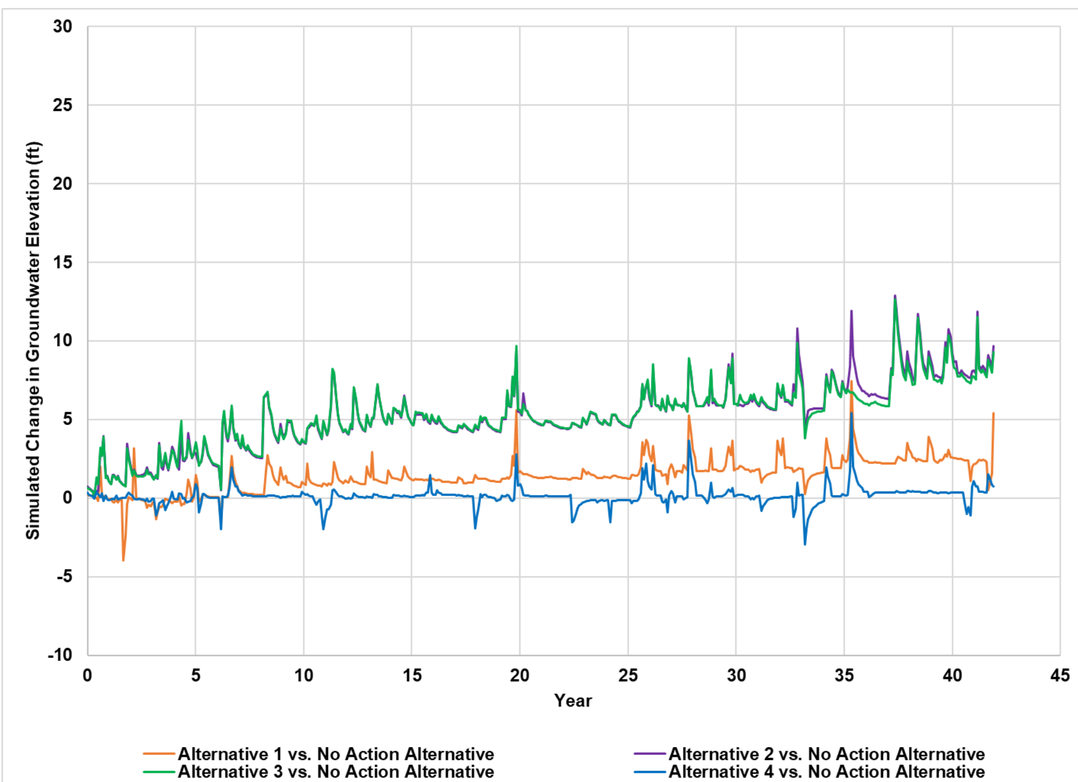

Figure I.2-49. Simulated Change in Groundwater Elevation Location 24

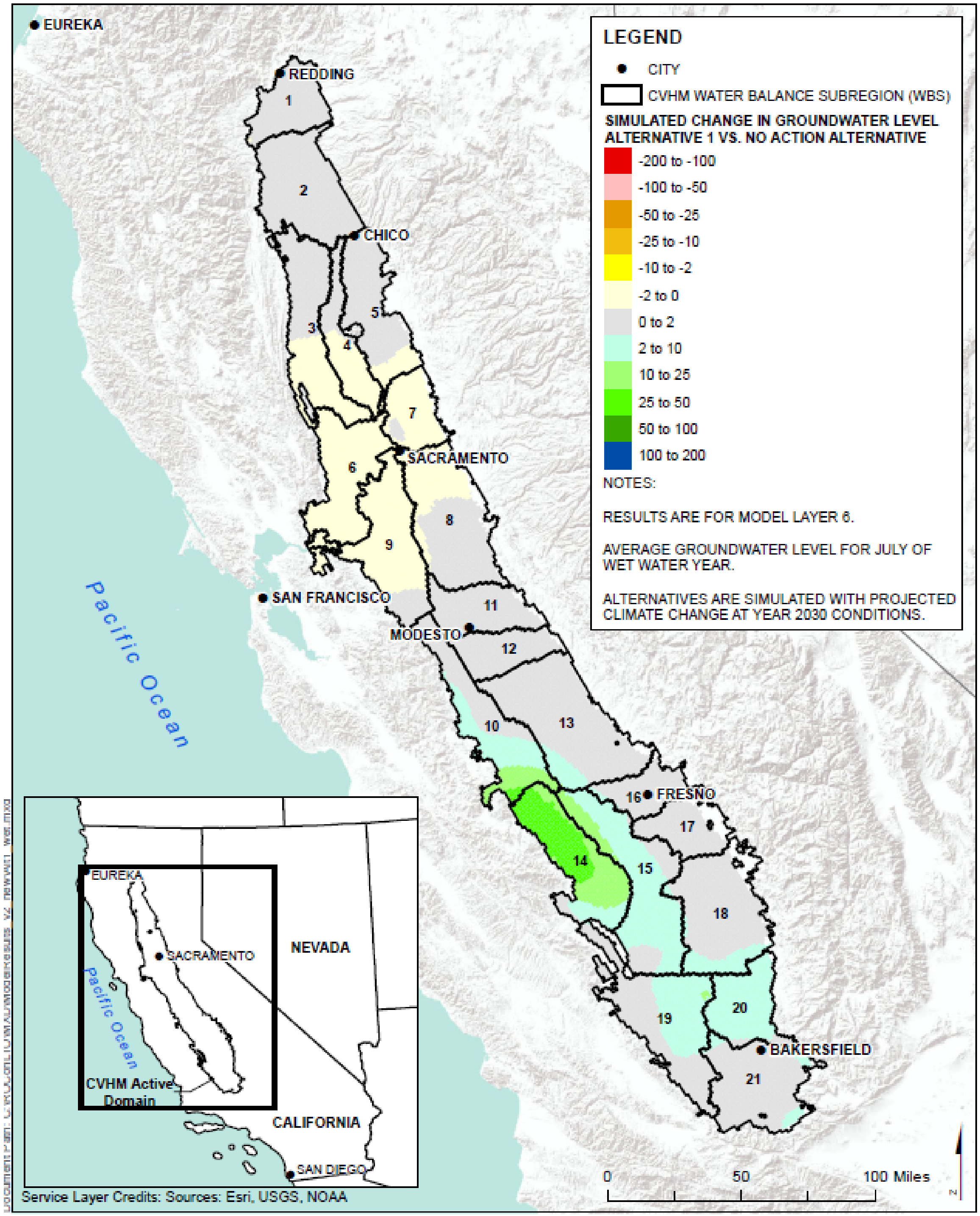

Figure I.2-50. Simulated Change in Groundwater Level, July of Wet Years, Alternative 1 versus No Action Alternative

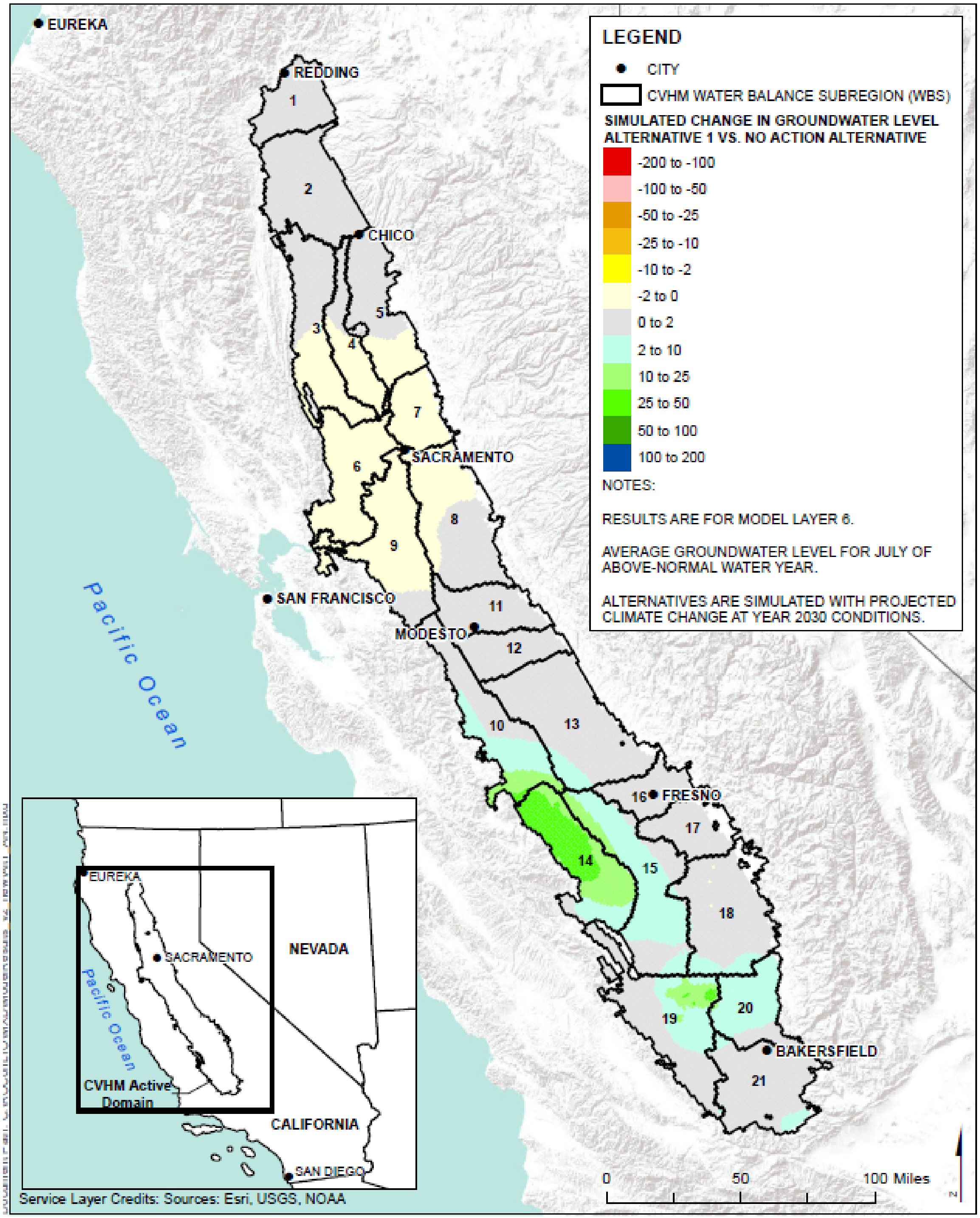

Figure I.2-51. Simulated Change in Groundwater Level, July of Above Normal Years, Alternative 1 versus No Action Alternative

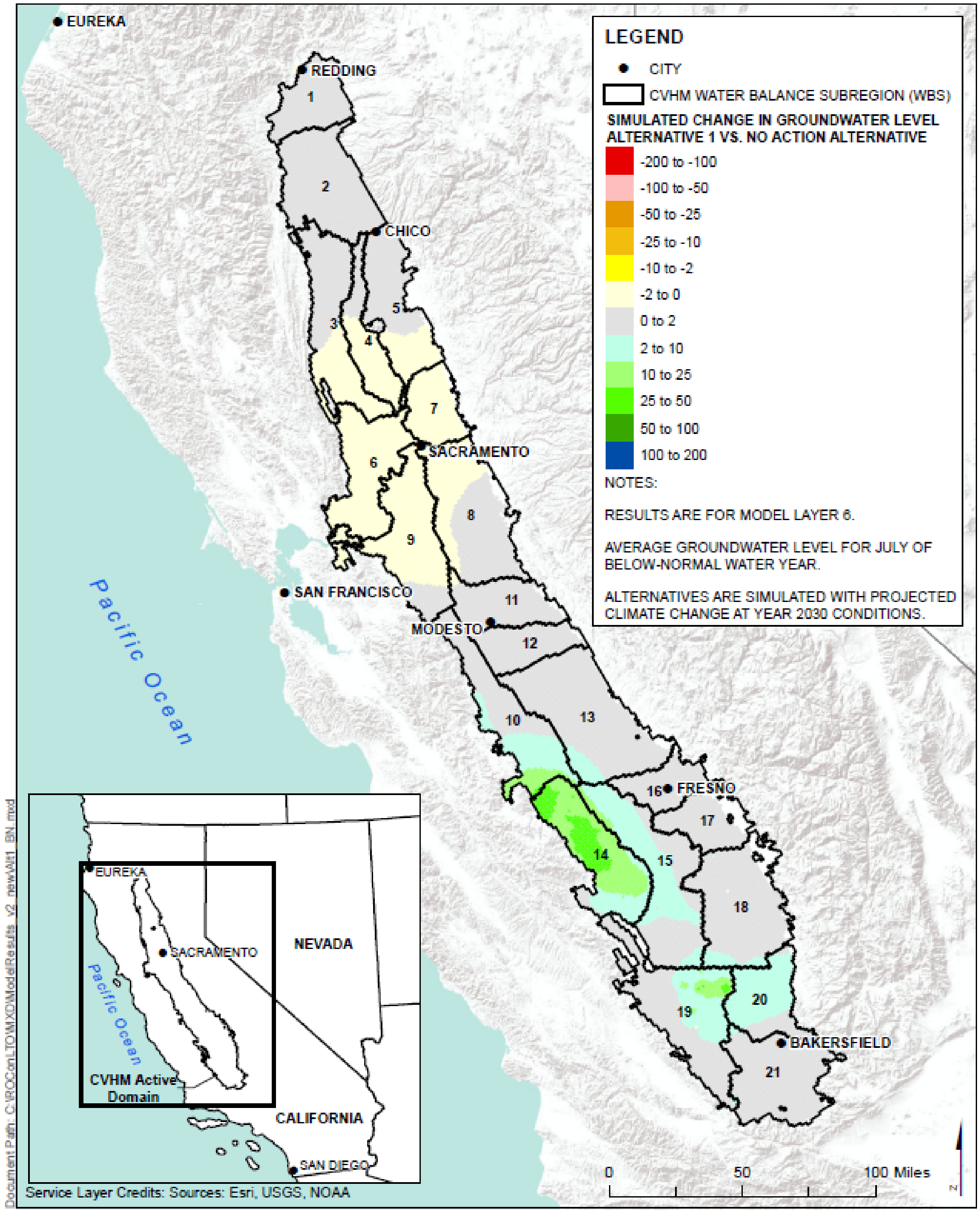

Figure I.2-52. Simulated Change in Groundwater Level, July of Below Normal Years, Alternative 1 versus No Action Alternative

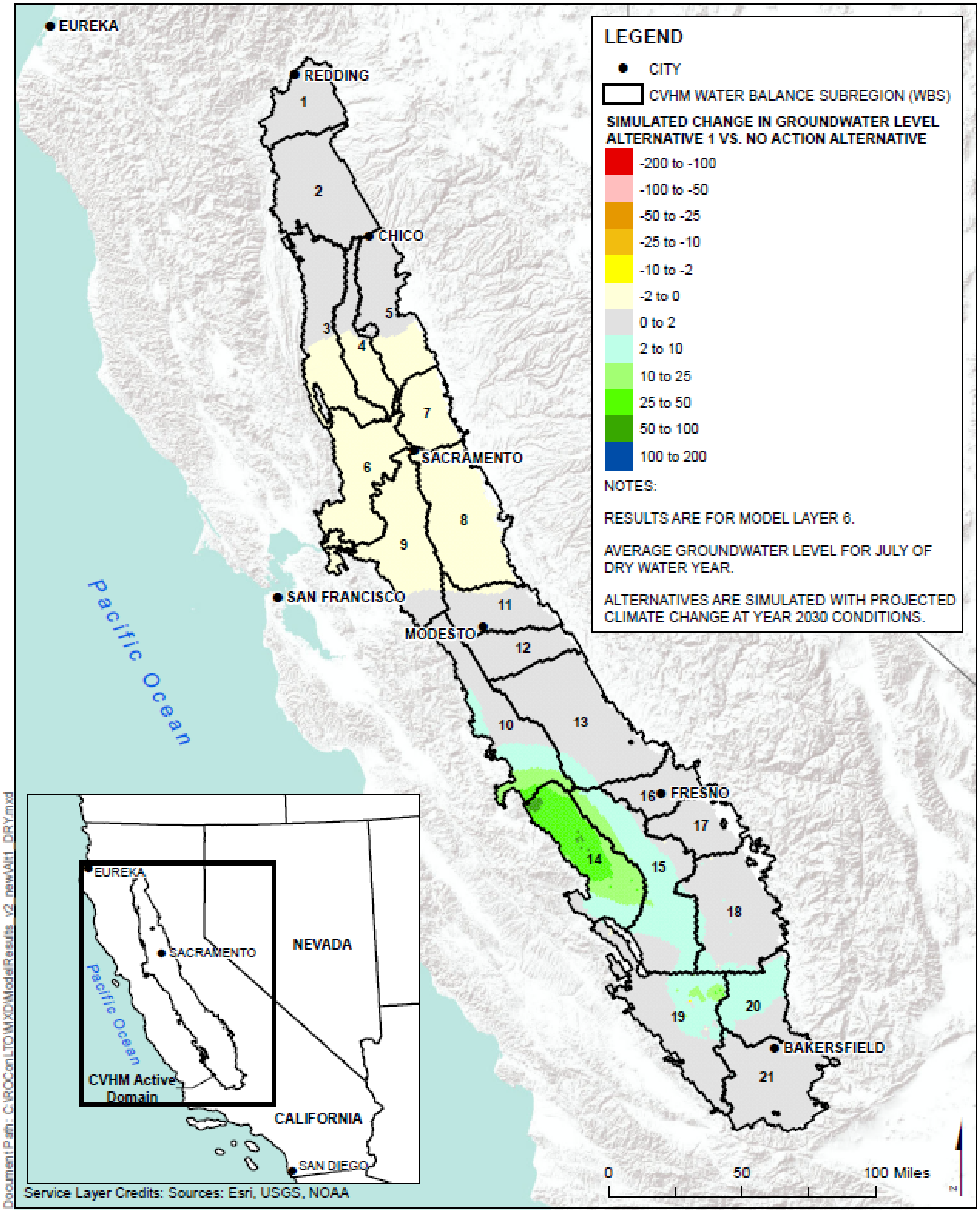

Figure I.2-53. Simulated Change in Groundwater Level, July of Dry Years, Alternative 1 versus No Action Alternative

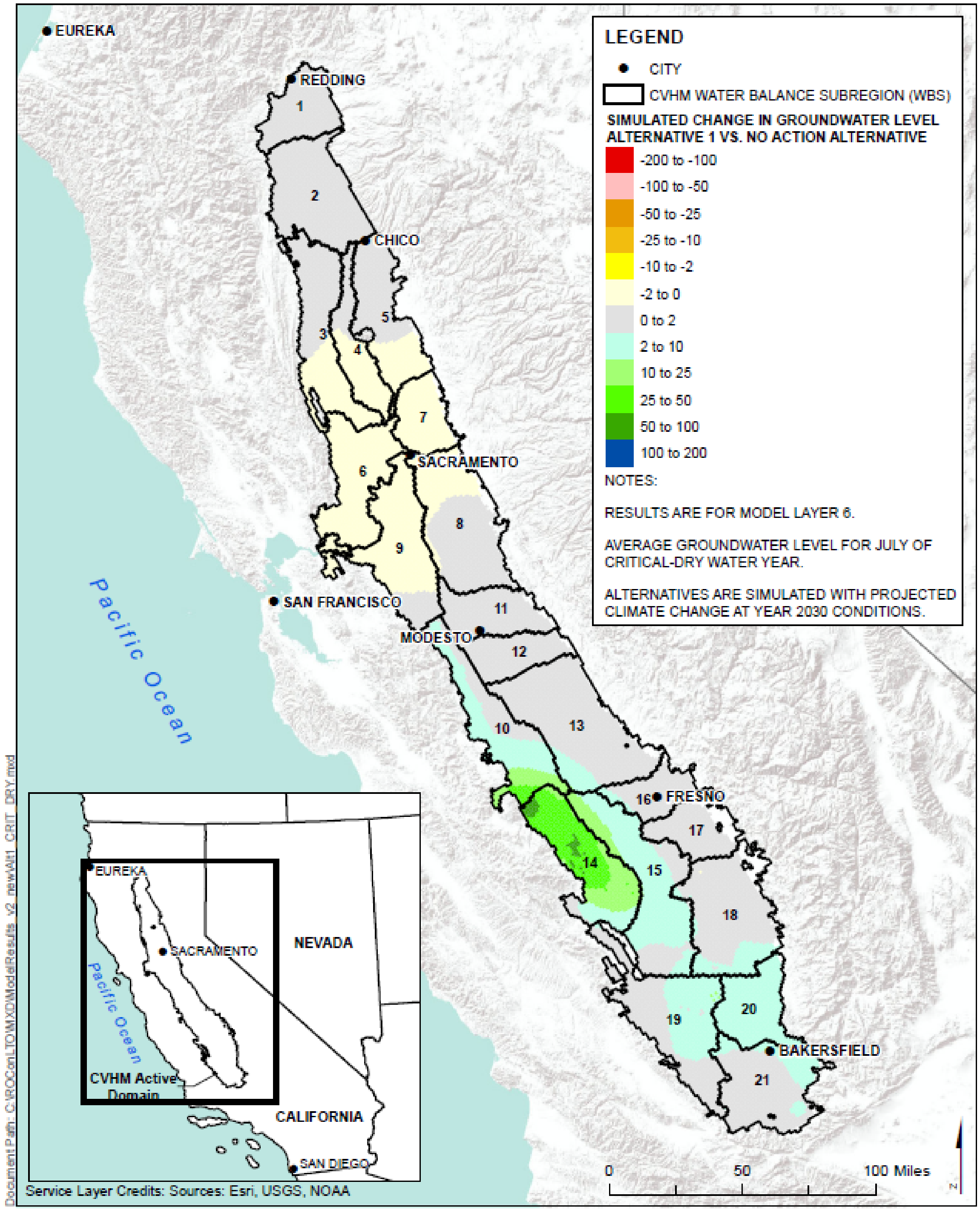

Figure I.2-54. Simulated Change in Groundwater Level, July of Critical Dry Years, Alternative 1 versus No Action Alternative

These figures show that, on average, groundwater levels increase as a result of Alternative 1 compared with the No Action Alternative in the areas south of the Delta. There is a slight decrease in groundwater levels near and north of the Delta.

Central Valley Project and State Water Project Service Areas

There is not expected to be an increase in the amount of groundwater pumping in Alternative 1 compared with the No Action Alternative. If pumping is not increased and groundwater-surface water interaction is not substantially changed, then groundwater levels in this area would be expected to remain similar to the No Action Alternative or potentially increase.

I.2.3.1.4 Potential Changes in Land Subsidence

Trinity River Region

The fact that the area along the Trinity River is not known to be susceptible to subsidence and that groundwater pumping is not expected to increase in this region suggests that subsidence will not be a concern in this area.

Central Valley Region

Land subsidence is caused by the consolidation of certain subsurface soils when the pore pressure in those soils is reduced. In the Sacramento and San Joaquin Valleys, that reduction in pore pressure is usually caused by groundwater pumping that causes groundwater levels to fall below historical low levels. Given that groundwater levels are generally expected to increase or remain unchanged due to Alternative 1, it is unlikely that Alternative 1 would cause additional subsidence compared with the No Action Alternative.

Central Valley Project and State Water Project Service Areas

Land subsidence is caused by the consolidation of certain subsurface soils when the pore pressure in those soils is reduced. That reduction in pore pressure is usually caused by groundwater pumping that causes groundwater levels to fall below historical low levels. Given that groundwater levels are generally not expected to decrease due to Alternative 1, it is unlikely that Alternative 1 would cause additional subsidence compared with the No Action Alternative.

I.2.3.2 *Program-Level Effects*

Alternative 1 includes habitat restoration and improvement projects, fish passage improvements, fish hatchery operation programs, and studies to identify further opportunities for habitat improvement. Given their collective implementation to improve habitat conditions and survival rates for the biological resources across the study area, it is assumed that they could improve conditions relative to those resources' future survival and population health. These actions are focused on surface water conditions and/or activities on the ground surface. The effects to groundwater are likely to be minimal as a result of these actions.

I.2.4 Alternative 2

I.2.4.1 *Project-Level Effects*

I.2.4.1.1 Potential Changes in Groundwater Pumping

Trinity River Region

Project-level actions in Alternative 2 will likely result in changed in flows of surface water in this region. However, there is expected to be little change to groundwater pumping resulting from these actions because groundwater is not a substantial supply source in this region.

Central Valley Region

Compared with the No Action Alternative, Alternative 2 is expected to result in additional surface water supply to both the Sacramento and San Joaquin Valleys. This increase in supply, especially when made to meet agricultural demands, will result in a decrease in the need for groundwater pumping to meet demands. Most of the change in pumping is expected to be in the San Joaquin Valley.

The changes in CVP and SWP deliveries projected by the CalSim II model to the San Joaquin Valley region were input to the CVHM. The CVHM then simulated the amount of groundwater pumping required to meet agricultural needs as the difference between demand and the supply from surface water. With the increase in surface water supply, the amount of groundwater pumping would decrease. Table I.2-1 shows the amount of groundwater pumping simulated by CVHM under the No Action Alternative and Alternative 2. Table I.2-2 shows the percent change in simulated groundwater pumping between Alternative 2 and the No Action Alternative.

The model simulations show that, on average, groundwater pumping is 7.5% lower in Alternative 2 than the No Action Alternative.

Central Valley Project and State Water Project Service Areas

Alternative 2 is expected to increase water supply to the CVP and SWP service areas. With this increase in supply, the reliance on groundwater pumping is expected to stay the same or be reduced compared with the No Action Alternative. Therefore, there is expected to be similar or less groundwater pumping in Alternative 2 compared with the No Action Alternative.

I.2.4.1.2 Potential Changes in Groundwater-Surface Water Interaction

Trinity River Region

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. Given this hydrogeologic nature of this region, changes in surface water flow will likely result in little change to the groundwater-surface water interaction flow.

Central Valley Region

The amount of groundwater-surface water interaction flow simulated in the CVHM for Alternative 2, throughout the Central Valley, is shown in Table I.2-3. Table I.2-4 shows the change in groundwater-surface water interaction for Alternative 2 compared with the No Action Alternative. Over the length of the CVHM simulation, the change in groundwater-surface water interaction is 13.2% (reduced flow from groundwater to surface water) in Alternative 2 compared with the No Action Alternative.

Central Valley Project and State Water Project Service Areas

Alternative 2 increases water supply to the CVP and SWP service areas and, therefore, likely results in little change, or potentially a reduction, in the amount of groundwater pumping. With little change to groundwater pumping, there would be little change in the groundwater system to result in a change in the amount of groundwater-surface water interaction flow. Therefore, Alternative 2, compared with the No Action Alternative, may result in groundwater levels rising, allowing for additional infiltration of groundwater to surface water features.

I.2.4.1.3 Potential Changes in Groundwater Elevation

Trinity River Region

Given that there is likely to be little change in groundwater pumping and also little change in the groundwater-surface water interaction flow, there will be little change to groundwater levels in the area compared with the No Action Alternative.

Central Valley Region

The CVHM simulations indicate that the amount of groundwater pumping in Alternative 2 will be less than in the No Action Alternative. Simulations also suggest that less water will recharge to the groundwater system in Alternative 2 than in the No Action Alternative. These two factors combine to potentially affect groundwater elevations. Less groundwater pumping would work to increase groundwater levels, whereas less recharge from surface water to groundwater could lower groundwater levels. CVHM was used to estimate change to groundwater levels resulting from the combined effects of project level changes.

Figures I.2-2 through I.2-25 show the simulated groundwater elevations at 24 arbitrary locations throughout the San Joaquin Valley. Changes in groundwater pumping were not simulated in the Sacramento Valley; therefore, modeled groundwater elevations in the Sacramento Valley are not shown. Figures I.2-26 through I.2-49 show the simulated change in groundwater elevation at these 24 locations.

Figures I.2-55 through I.2-59 show the simulated change in groundwater level spatially across the Central Valley under Alternative 2 compared with the No Action Alternative. These figures show the average change in groundwater levels in July during each of the five water year types (Wet, Above Normal, Below Normal, Dry, Critical Dry).

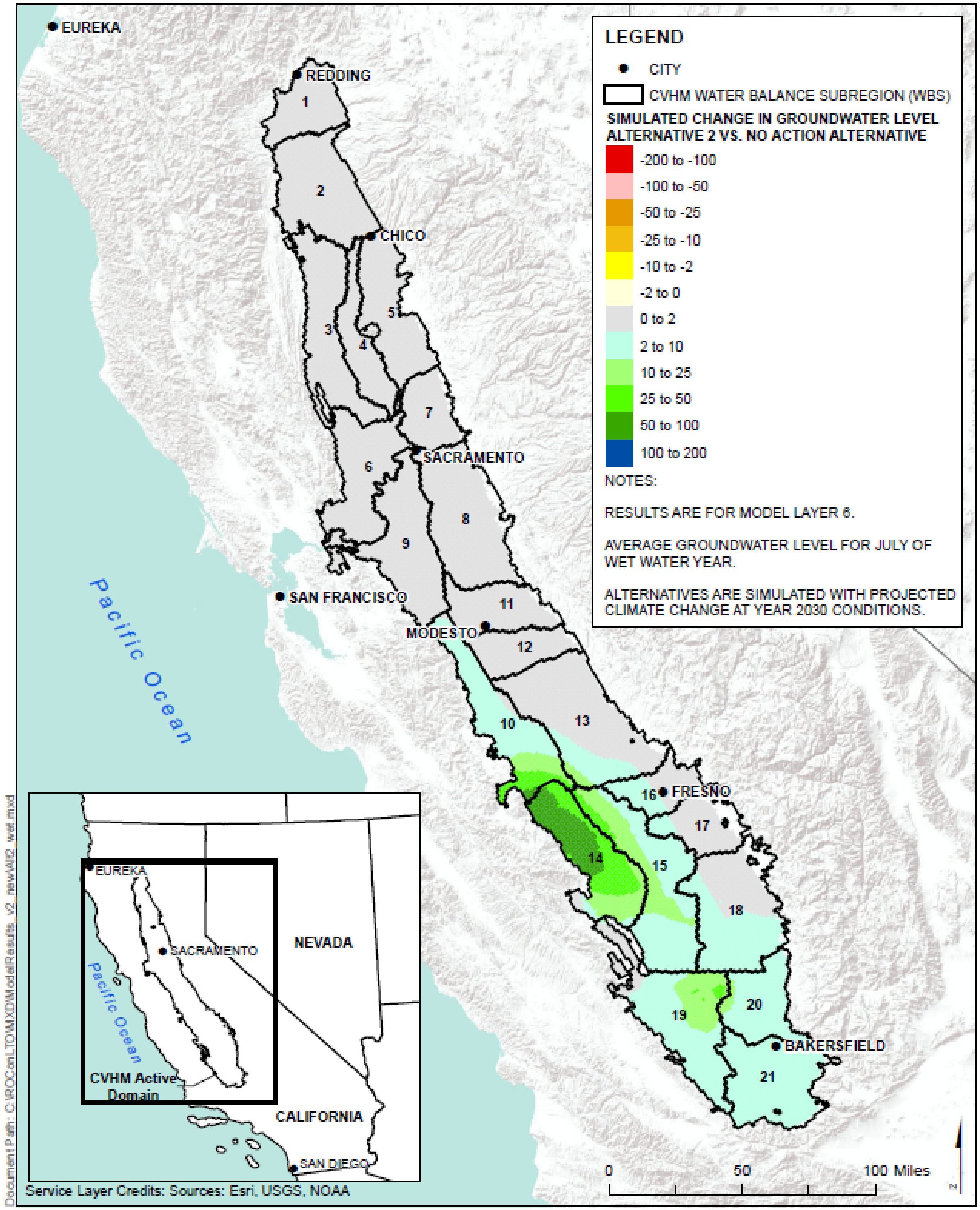

Figure I.2-55. Simulated Change in Groundwater Level, July of Wet Years, Alternative 2 versus No Action Alternative

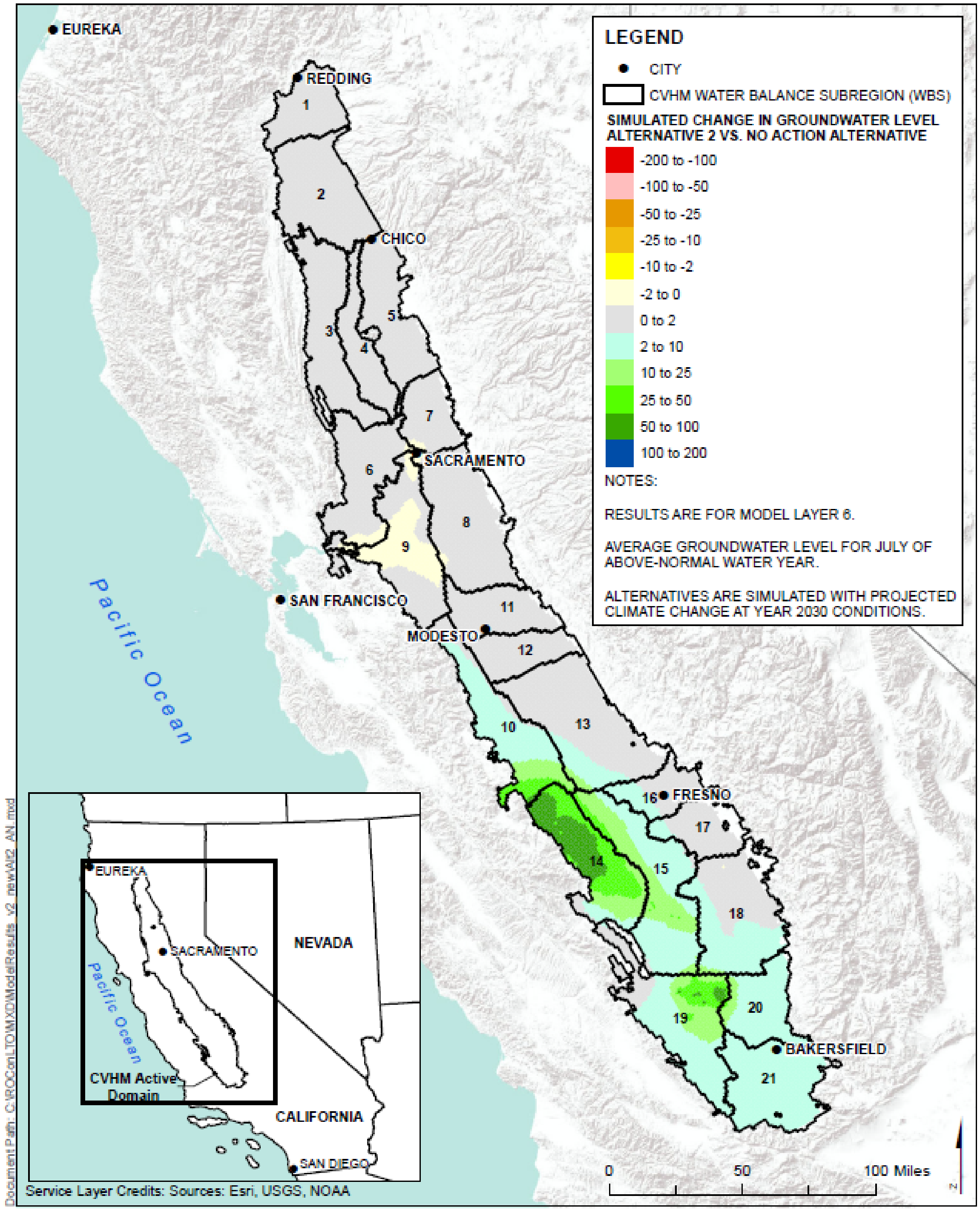

Figure I.2-56. Simulated Change in Groundwater Level, July of Above Normal Years, Alternative 2 versus No Action Alternative

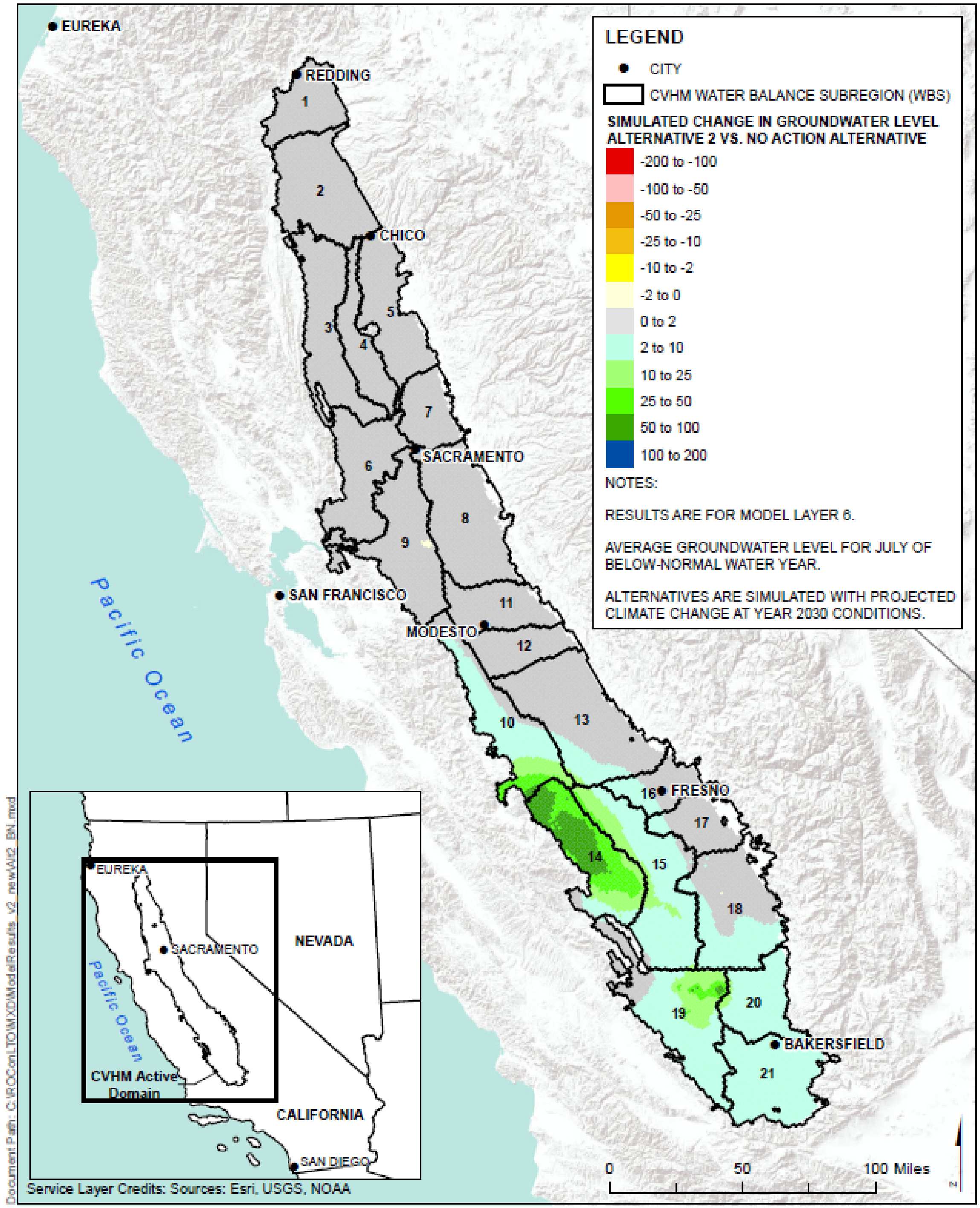

Figure I.2-57. Simulated Change in Groundwater Level, July of Below Normal Years, Alternative 2 versus No Action Alternative

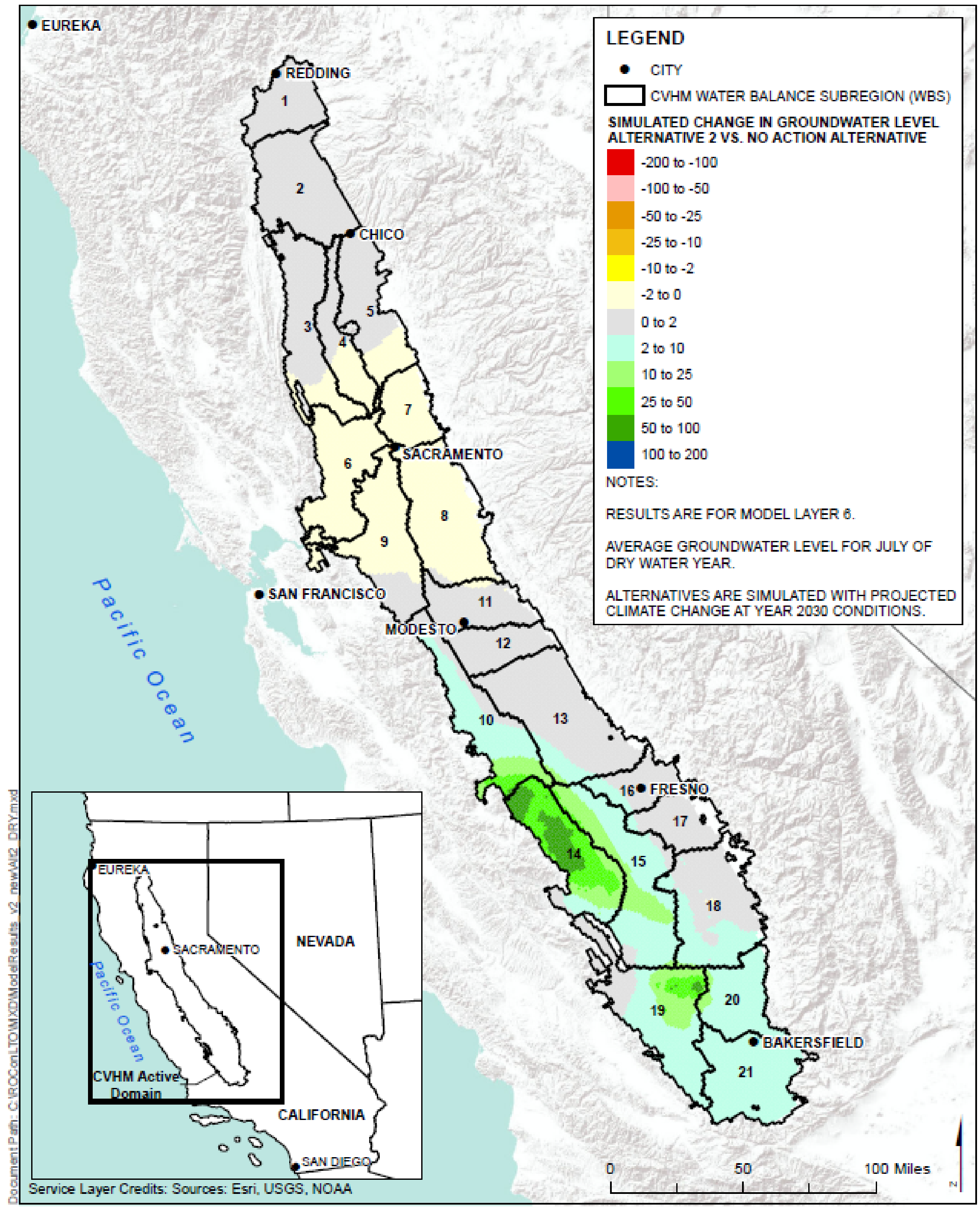

Figure I.2-58. Simulated Change in Groundwater Level, July of Dry Years, Alternative 2 versus No Action Alternative

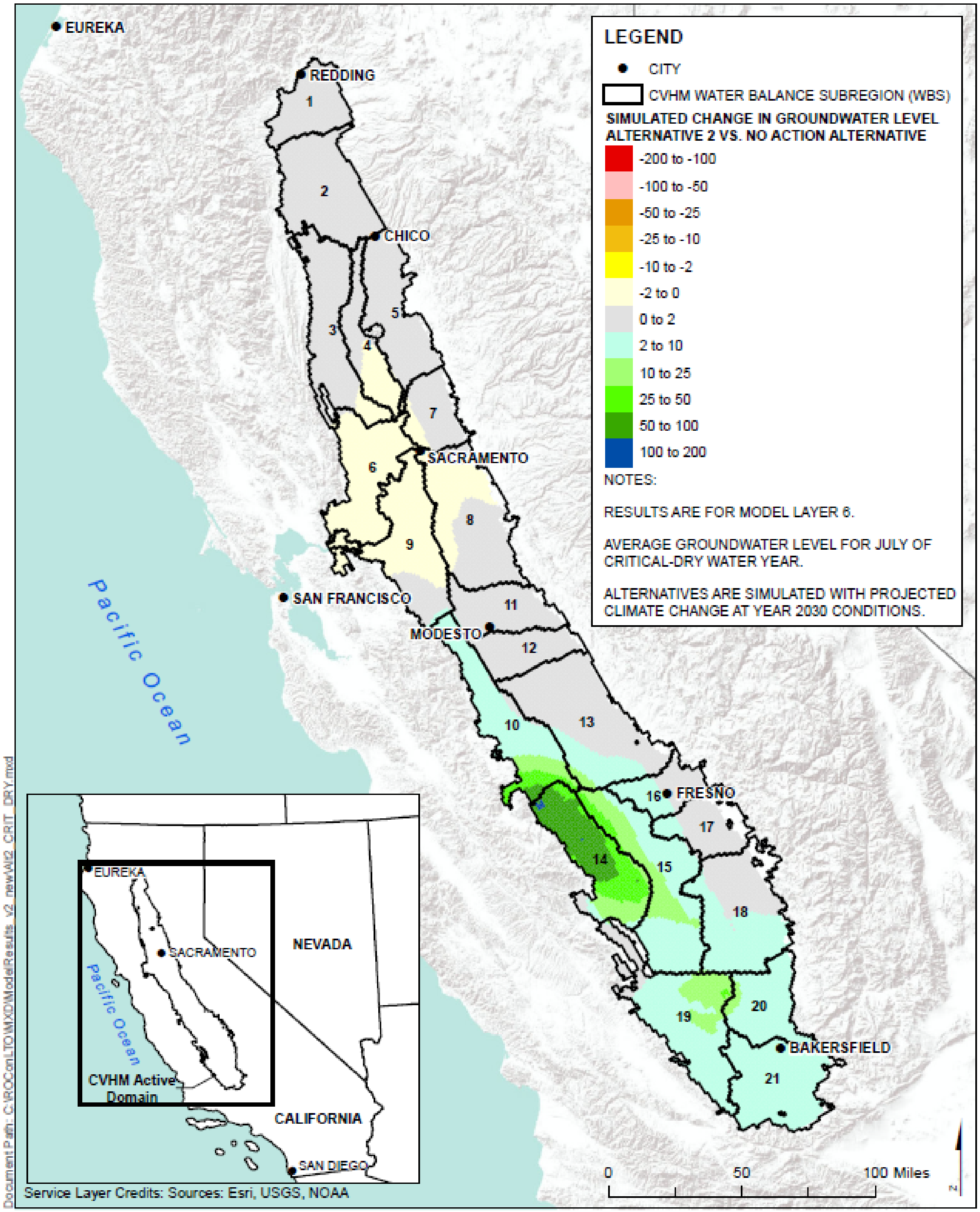

Figure I.2-59. Simulated Change in Groundwater Level, July of Critical Dry Years, Alternative 2 versus No Action Alternative

These figures show that, on average, groundwater levels increase in the areas south of the Delta as a result of Alternative 2 compared with the No Action Alternative. There is a slight decrease in groundwater levels near and north of the Delta in certain water year types.

Central Valley Project and State Water Project Service Areas

There is not expected to be an increase in the amount of groundwater pumping in Alternative 2 compared to the No Action Alternative. If pumping is not increased and groundwater-surface water interaction remains unchanged, groundwater levels in this area would be expected to remain similar to the No Action Alternative or potentially increase.

I.2.4.1.4 Potential Changes in Land Subsidence

Trinity River Region

The fact that the area along the Trinity River is not known to be susceptible to subsidence and that groundwater pumping is not expected to increase in this region suggests that subsidence will not be a concern in this area.

Central Valley Region

Land subsidence is caused by the consolidation of certain subsurface soils when the pore pressure in those soils is reduced. In the Sacramento and San Joaquin Valleys, that reduction in pore pressure is usually caused by groundwater pumping that causes groundwater levels to fall below historical low levels. Given that groundwater levels are generally not expected to decrease, it is unlikely that Alternative 2 would cause additional subsidence compared to the No Action Alternative given that groundwater levels are expected to remain stable or increase.

Central Valley Project and State Water Project Service Areas

Land subsidence is caused by the consolidation of certain subsurface soils when the pore pressure in those soils is reduced. That reduction in pore pressure is usually caused by groundwater pumping that causes groundwater levels to fall below historical low levels. Given that groundwater levels are generally not expected to decrease, it is unlikely that Alternative 2 would cause additional subsidence compared to the No Action Alternative.

I.2.4.2 *Program-Level Effects*

Alternative 2 does not include any program-level components.

I.2.5 Alternative 3

I.2.5.1 *Project-Level Effects*

I.2.5.1.1 Potential Changes in Groundwater Pumping

Trinity River Region

Project level actions in Alternative 3 will likely result in changes in flows of surface water in this region. However, there is expected to be little change to groundwater pumping resulting from these actions because groundwater is not a substantial supply source in this region.

Central Valley Region

Compared to the No Action Alternative, Alternative 3 is expected to result in additional surface water supply to both the Sacramento and San Joaquin Valleys. This increase in supply, especially when made to meet agricultural demands, will result in a decrease in the need for groundwater pumping to meet demands. Most of the change in pumping is expected to be in the San Joaquin Valley.

The changes in CVP and SWP deliveries projected by the CalSim II model to the San Joaquin Valley region were input to the CVHM. The CVHM then simulated the amount of groundwater pumping required to meet agricultural needs as the difference between demand and the supply from surface water. With the increase in surface water supply, the amount of groundwater pumping decreased. Table I.2-1 shows the amount of groundwater pumping simulated by CVHM under the No Action Alternative and Alternative 3. Table I.2-2 shows the percent change in simulated groundwater pumping between Alternative 3 and the No Action Alternative.

The model simulations show that, on average, groundwater pumping is 7.1% lower in Alternative 3 than the No Action Alternative.

Central Valley Project and State Water Project Service Areas

Alternative 3 is expected to increase water supply to the CVP and SWP service areas. With this increase in supply, the reliance on groundwater pumping is expected to stay the same or be reduced compared to the No Action Alternative. Therefore, there is expected to be similar or less groundwater pumping in Alternative 3.

I.2.5.1.2 Potential Changes in Groundwater-Surface Water Interaction

Trinity River Region

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. Given this hydrogeologic nature of this region, changes in surface water flow will likely result in little change to the groundwater-surface water interaction flow.

Central Valley Region

The amount of groundwater-surface water interaction flow simulated in the CVHM, throughout the Central Valley, is shown in Table I.2-3 for Alternative 3. Table I.2-4 shows the change in groundwater-surface water interaction for Alternative 3 compared to the No Action Alternative. Over the length of the CVHM simulation, the change in groundwater-surface water interaction is 13.4% (additional flow from groundwater to surface water) in Alternative 3 compared with the No Action Alternative.

Central Valley Project and State Water Project Service Areas

Alternative 3 increases water supply to the CVP and SWP service areas and, therefore, likely results in little change, or potentially a reduction, in the amount of groundwater pumping. With little change to groundwater pumping, there would be little change in the groundwater system to result in a change in the amount of groundwater-surface water interaction flow. Therefore, Alternative 3, compared with the No Action Alternative, may result in groundwater levels rising, allowing for additional infiltration of groundwater to surface water features.

I.2.5.1.3 Potential Changes in Groundwater Elevation

Trinity River Region

Given that there is likely to be little change in groundwater pumping and also little change in the groundwater-surface water interaction flow, there will be little change to groundwater levels in the area.

Central Valley Region

The CVHM simulations indicate that the amount of groundwater pumping in Alternative 3 will be less than in the No Action Alternative. Simulations also suggest that less water will recharge to the groundwater system in Alternative 3 than in the No Action Alternative. These two factors combine to potentially affect groundwater elevations. Less groundwater pumping would work to increase groundwater levels, whereas less recharge from surface water to groundwater could lower groundwater levels. CVHM was used to estimate change to groundwater levels resulting from the combined effects of project level changes.

Figures I.2-2 through I.2-25 show the simulated groundwater elevations at 24 arbitrary locations throughout the San Joaquin Valley. Changes in groundwater pumping were not simulated in the Sacramento Valley; therefore, modeled groundwater elevations in the Sacramento Valley are not shown. Figures I.2-26 through I.2-49 show the simulated change in groundwater elevation at these 24 locations.

Figures I.2-60 through I.2-64 show the simulated change in groundwater level spatially across the Central Valley under Alternative 3 compared with the No Action Alternative. These figures show the average change in groundwater levels in July during each of the five water year types (Wet, Above Normal, Below Normal, Dry, Critical Dry).

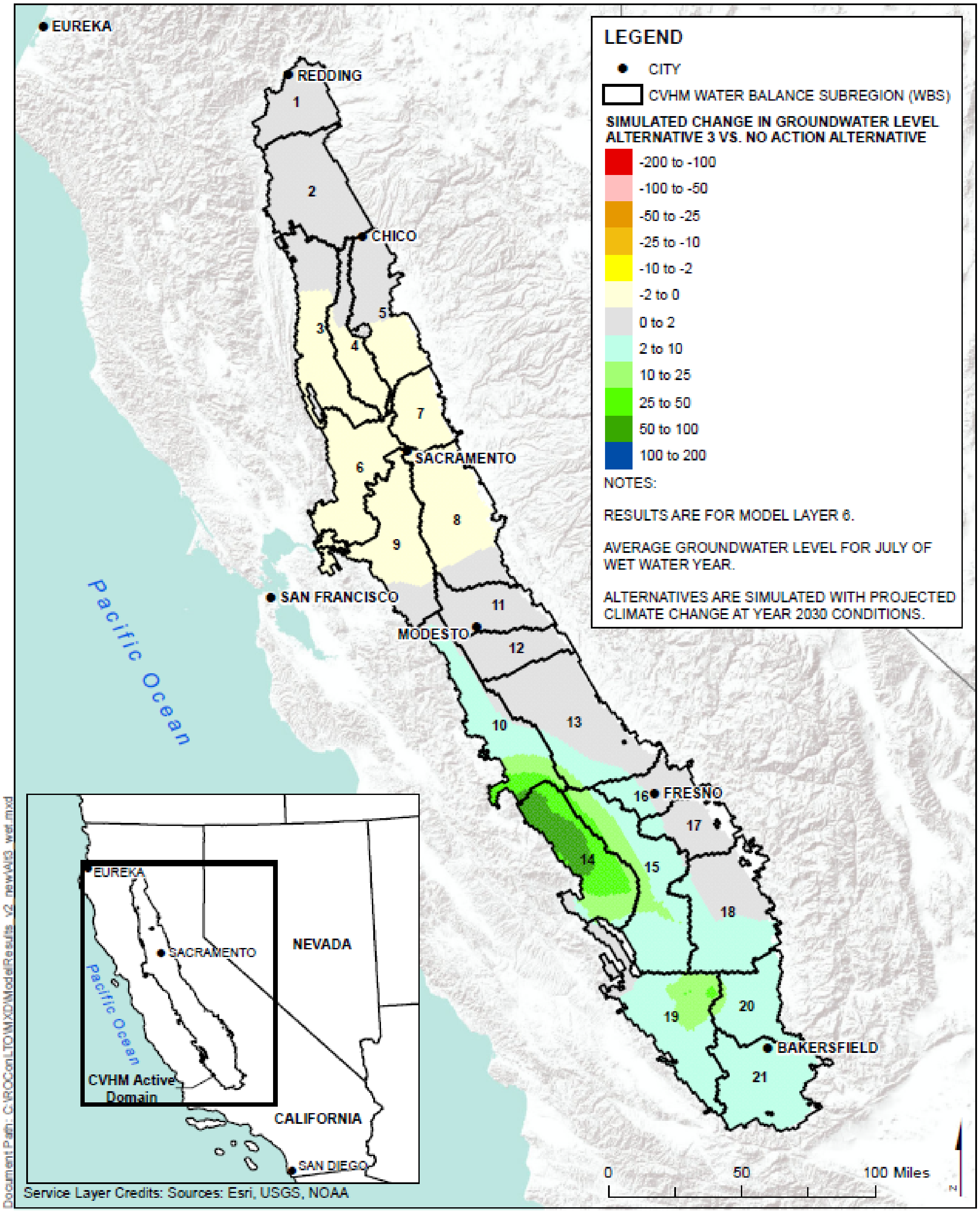

Figure I.2-60. Simulated Change in Groundwater Level, July of Wet Years, Alternative 3 versus No Action Alternative

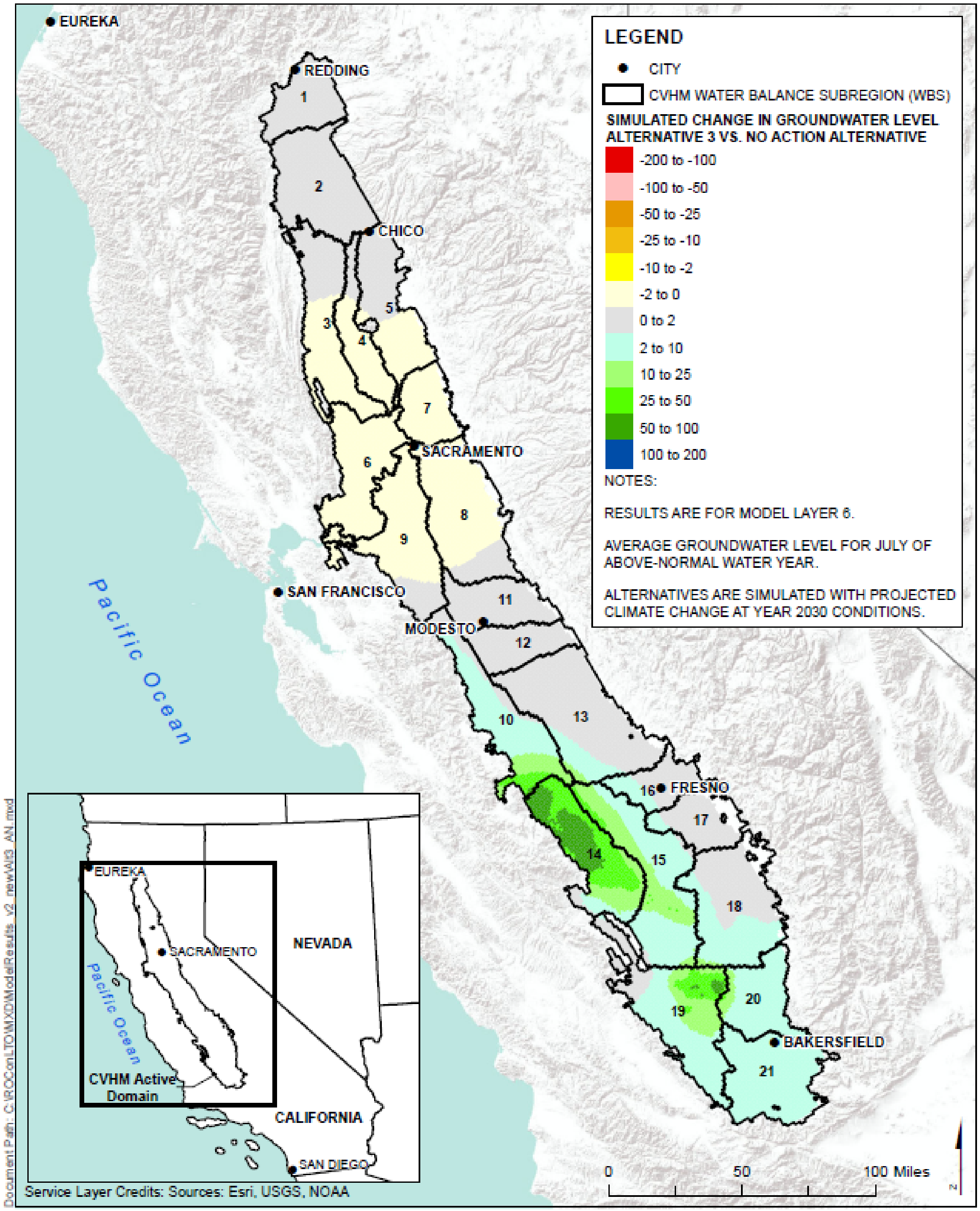

Figure I.2-61. Simulated Change in Groundwater Level, July of Above Normal Years, Alternative 3 versus No Action Alternative

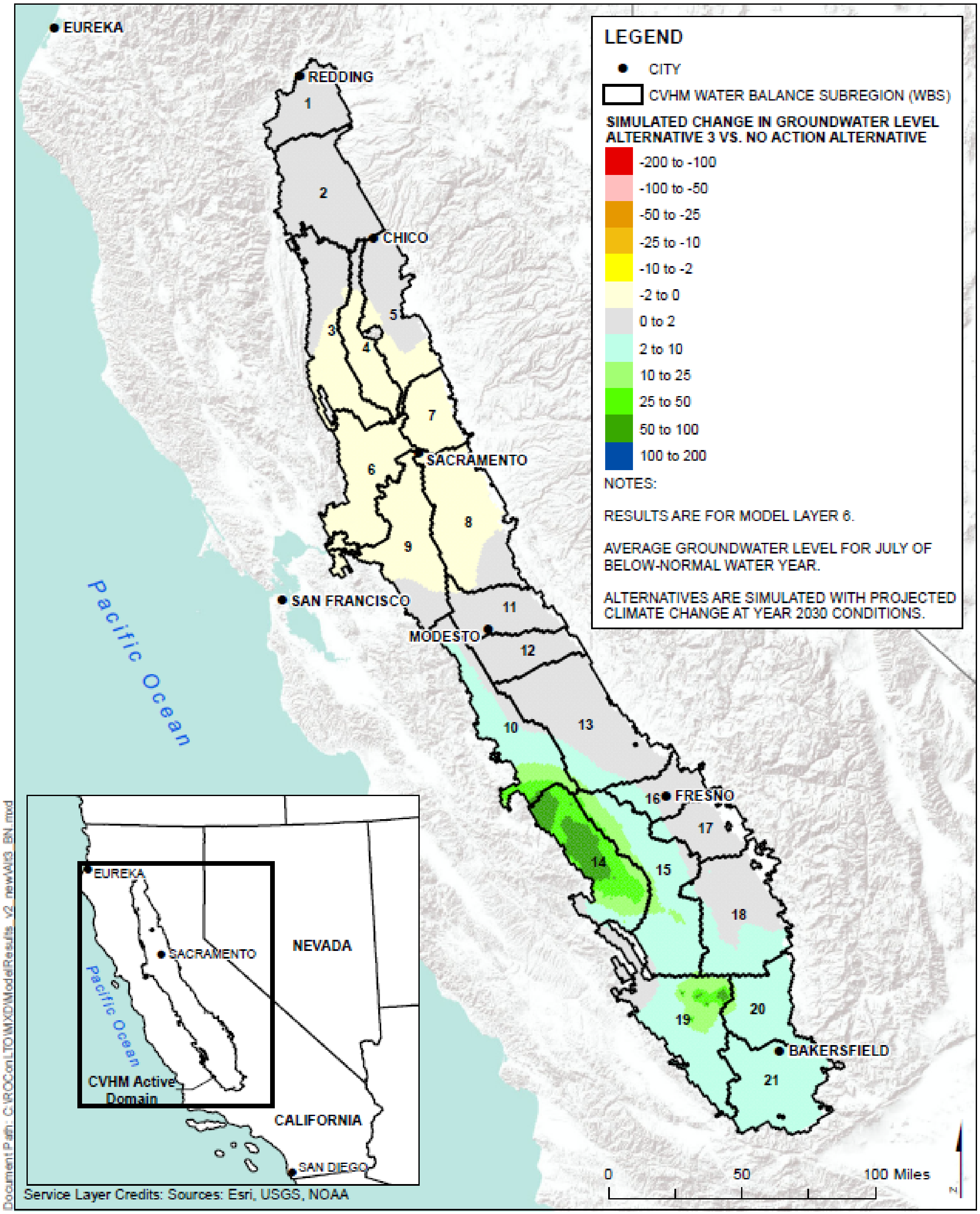

Figure I.2-62. Simulated Change in Groundwater Level, July of Below Normal Years, Alternative 3 versus No Action Alternative

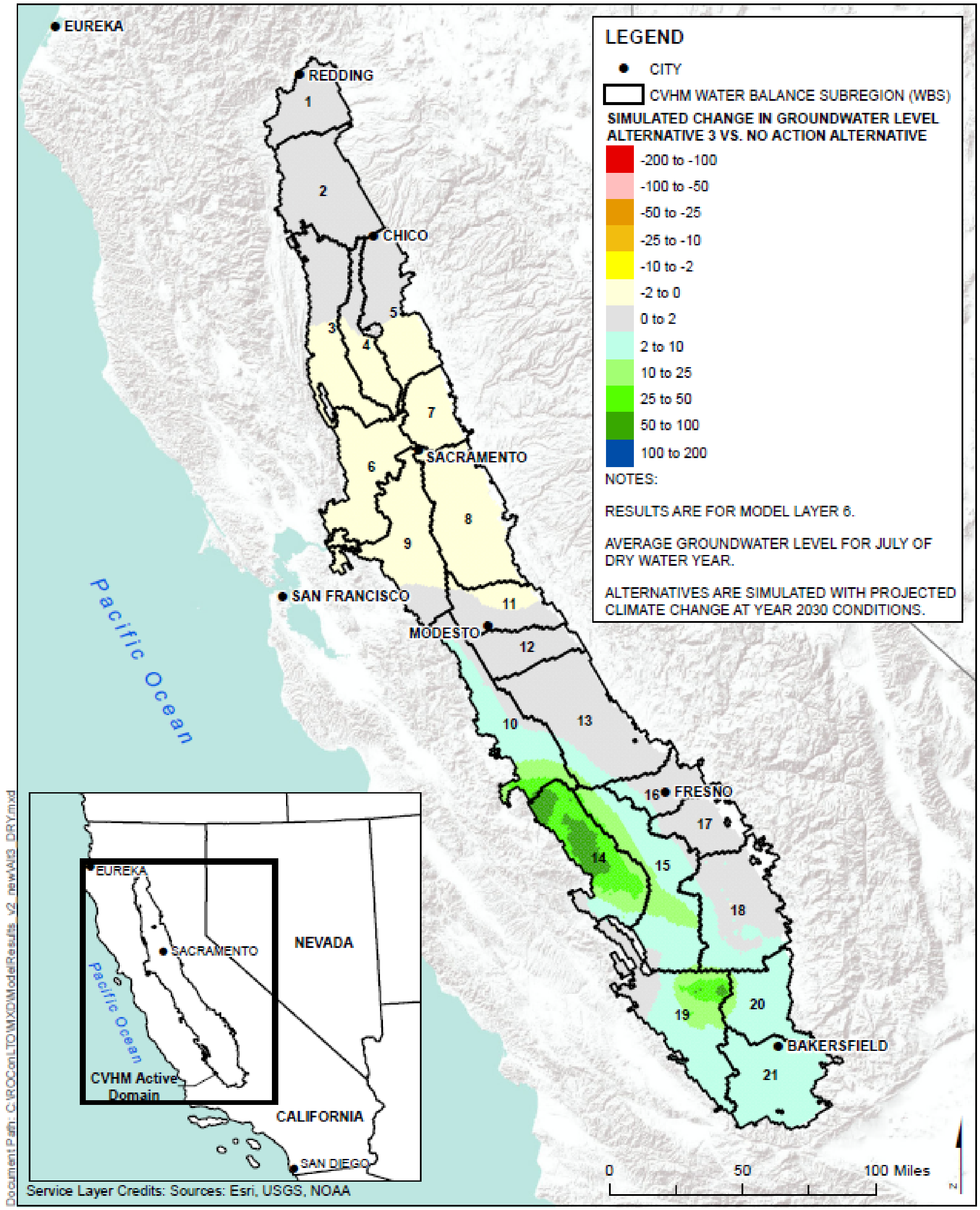

Figure I.2-63. Simulated Change in Groundwater Level, July of Dry Years, Alternative 3 versus No Action Alternative

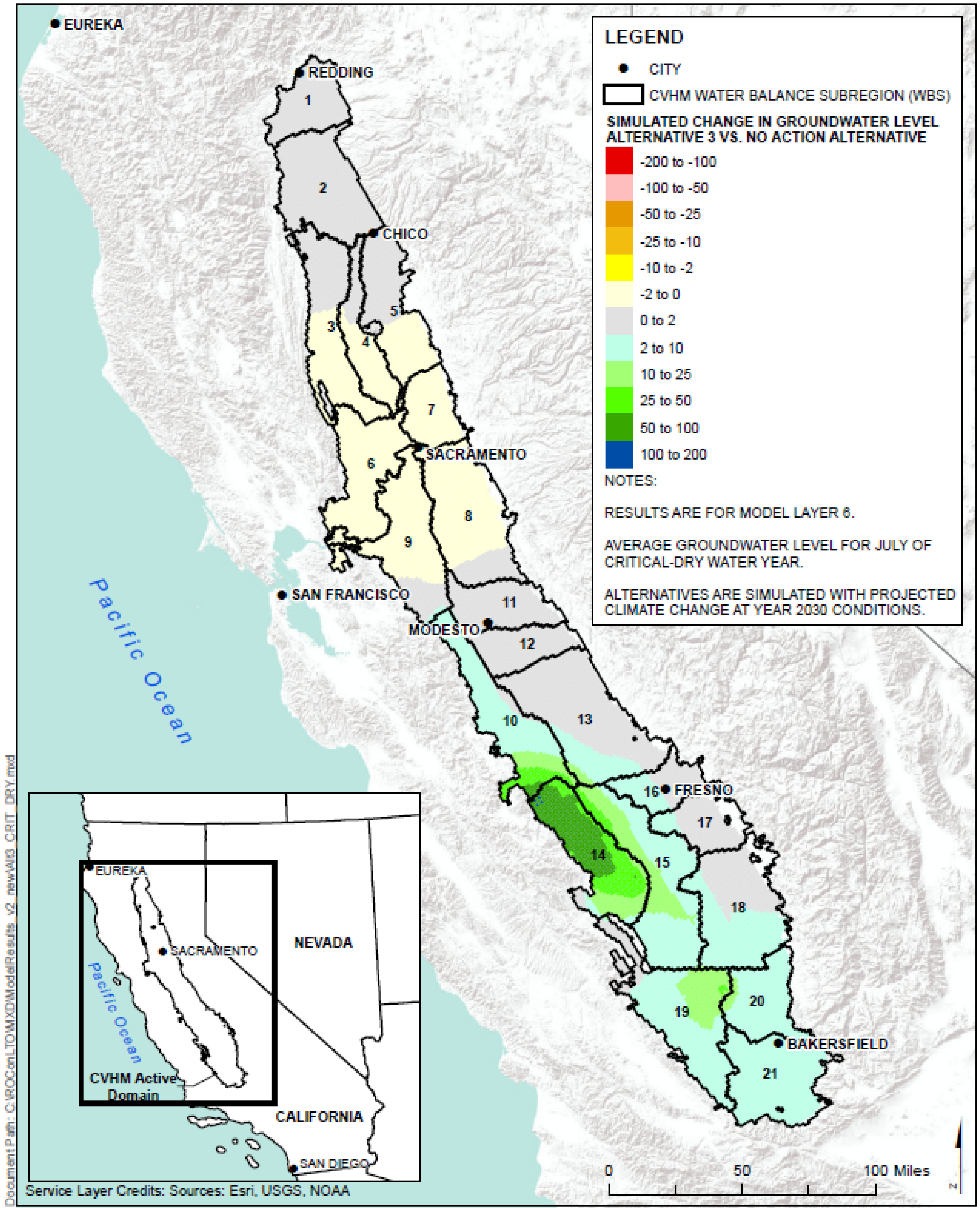

Figure I.2-64. Simulated Change in Groundwater Level, July of Critical Dry Years, Alternative 3 versus No Action Alternative

These figures show that, on average, groundwater levels increase as a result of Alternative 3 compared with the No Action Alternative in the areas south of the Delta. There is a slight decrease in groundwater levels near and north of the Delta.

Central Valley Project and State Water Project Service Areas

There is not expected to be an increase in the amount of groundwater pumping in Alternative 3 compared with the No Action Alternative. If pumping is not increased and groundwater-surface water interaction remains unchanged, groundwater levels in this area would be expected to remain similar to the No Action Alternative or potentially increase.

I.2.5.1.4 Potential Changes in Land Subsidence

Trinity River Region

The fact that the area along the Trinity River is not known to be susceptible to subsidence and that groundwater pumping is not expected to increase in this region suggests that subsidence will not be a concern in this area.

Central Valley Region

Land subsidence is caused by the consolidation of certain subsurface soils when the pore pressure in those soils is reduced. In the Sacramento and San Joaquin Valleys, that reduction in pore pressure is usually caused by groundwater pumping that causes groundwater levels to fall below historical low levels. Given that groundwater levels are generally not expected to decrease, it is unlikely that Alternative 3 would cause additional subsidence compared with the No Action Alternative given that groundwater levels are expected to remain stable or increase.

Central Valley Project and State Water Project Service Areas

Land subsidence is caused by the consolidation of certain subsurface soils when the pore pressure in those soils is reduced. That reduction in pore pressure is usually caused by groundwater pumping that causes groundwater levels to fall below historical low levels. Given that groundwater levels are generally not expected to decrease, it is unlikely that Alternative 3 would cause additional subsidence compared with the No Action Alternative.

I.2.5.2 *Program-Level Effects*

Alternative 3 includes habitat restoration and improvement projects, fish passage improvements, fish hatchery operation programs, and studies to identify further opportunities for habitat improvement. Given their collective implementation to improve habitat conditions and survival rates for the biological resources across the study area, it is assumed that they could improve conditions relative to those resources' future survival and population health. These actions are focused on surface water conditions and/or activities on the ground surface. The effects to groundwater are likely to be minimal as a result of these actions.

I.2.6 Alternative 4

I.2.6.1 *Project-Level Effects*

I.2.6.1.1 Potential Changes in Groundwater Pumping

Trinity River Region

Project-level actions in Alternative 4 will likely result in changes in flows of surface water in this region. However, there is expected to be little change to groundwater pumping resulting from these actions because groundwater is not a substantial supply source in this region.

Central Valley Region

Compared with the No Action Alternative, Alternative 4 is expected to result in surface water supply to both the Sacramento and San Joaquin Valleys increasing and decreasing, depending on the year. An increase in supply, especially when made to meet agricultural demands, will result in a decrease in the need for groundwater pumping to meet demands. A decrease in supply may result in an increase in groundwater pumping. Most of the change in pumping is expected to be in the San Joaquin Valley.

The changes in CVP and SWP deliveries projected by the CalSim II model to the San Joaquin Valley region were input to the CVHM. The CVHM then simulated the amount of groundwater pumping required to meet agricultural needs as the difference between demand and the supply from surface water. With the increase in surface water supply, the amount of groundwater pumping would decrease. Table I.2-1 shows the amount of groundwater pumping simulated by CVHM under the No Action Alternative and Alternative 4. Table I.2-2 shows the percent change in simulated groundwater pumping between Alternative 4 and the No Action Alternative.

The model simulations show that, on average, groundwater pumping is 0.4% higher in Alternative 4 than the No Action Alternative.

Central Valley Project and State Water Project Service Areas

Alternative 4 is expected to decrease water supply to the CVP and SWP service areas. With this decrease in supply, the reliance on groundwater pumping is expected to stay the same or increase compared with the No Action Alternative. Therefore, there is expected to be a similar or increased amount of groundwater pumping in Alternative 4 compared with the No Action Alternative.

I.2.6.1.2 Potential Changes in Groundwater-Surface Water Interaction

Trinity River Region

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. Given this hydrogeologic nature of this region, changes in surface water flow will likely result in little change to the groundwater-surface water interaction flow.

Central Valley Region

The amount of groundwater-surface water interaction flow simulated in the CVHM for Alternative 4, throughout the Central Valley, is shown in Table I.2-3. Table I.2-4 shows the change in groundwater-surface water interaction for Alternative 4 compared with the No Action Alternative. Over the length of the CVHM simulation, the change in groundwater-surface water interaction is 1.4% (increased flow from groundwater to surface water) in Alternative 4 compared with the No Action Alternative.

Central Valley Project and State Water Project Service Areas

Alternative 4, in general, decreases water supply to the CVP and SWP service areas and therefore likely results in little change (or potentially an increase) in the amount of groundwater pumping because of increased reliance on groundwater compared to the No Action Alternative. With a potential increase in groundwater pumping, there could be a decrease in groundwater levels that may result in a change in the amount of groundwater-surface water interaction flow. Therefore, Alternative 4, compared with the No Action Alternative, may result in groundwater levels decreasing, allowing for additional exfiltration of surface water to groundwater.

I.2.6.1.3 Potential Changes in Groundwater Elevation

Trinity River Region

Given there is likely to be little change in groundwater pumping in this region and also little change in the groundwater-surface water interaction flow, there will be little change to groundwater levels in the area compared with the No Action Alternative.

Central Valley Region

The CVHM simulations indicate that the amount of groundwater pumping in Alternative 4 increases in some years and decreases in other years, with an average increase of approximately 0.7% over the No Action Alternative. Simulations also suggest that less water would recharge to the groundwater system in Alternative 4 than in the No Action Alternative. These two factors (more pumping, less recharge) combine to potentially lower groundwater levels. CVHM was used to estimate change to groundwater levels resulting from the combined effects of project-level changes.

Figures I.2-2 through I.2-25 show the simulated groundwater elevations at 24 arbitrary locations throughout the San Joaquin Valley. Changes in groundwater pumping were not simulated in the Sacramento Valley, therefore, modeled groundwater elevations in the Sacramento Valley are not shown. Figures I.2-26 through I.2-49 show the simulated change in groundwater elevation at these 24 locations.

Figures I.2-65 through I.2-69 show the simulated change in groundwater level spatially across the Central Valley under Alternative 4 compared with the No Action Alternative. These figures show the average change in groundwater levels in July during each of the five water year types (Wet, Above Normal, Below Normal, Dry, Critical Dry).

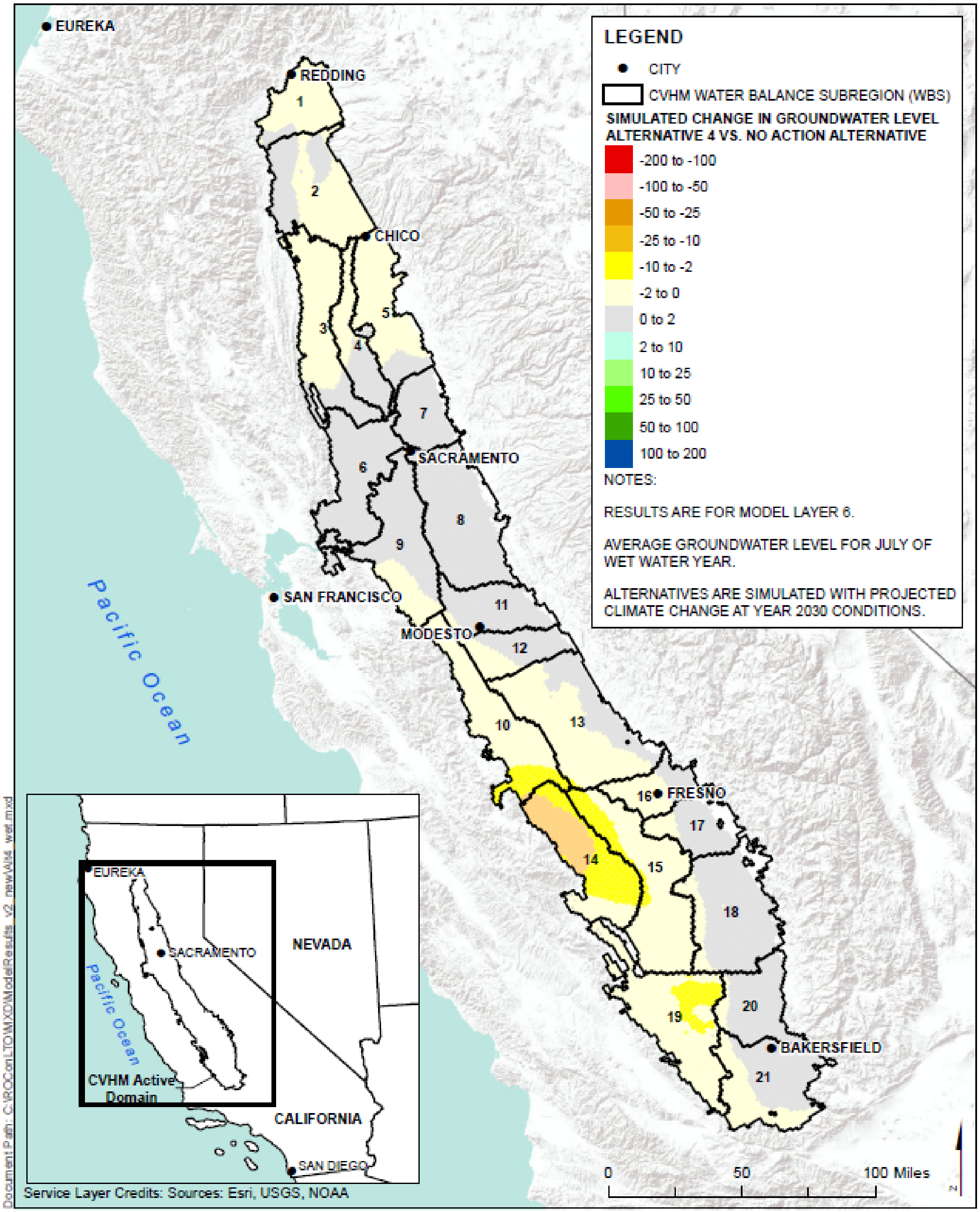

Figure I.2-65. Simulated Change in Groundwater Level, July of Wet Years, Alternative 4 versus No Action Alternative

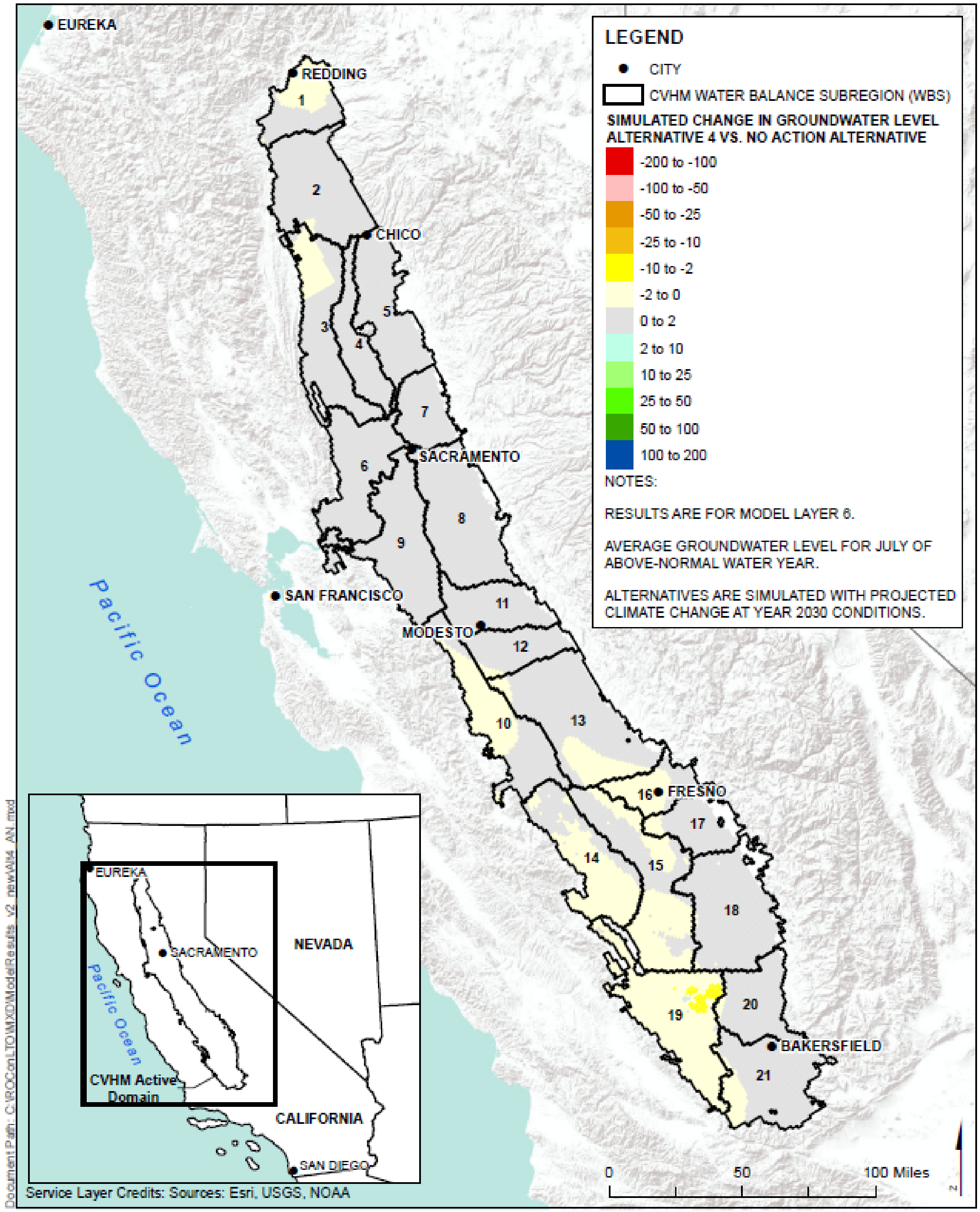

Figure I.2-66. Simulated Change in Groundwater Level, July of Above Normal Years, Alternative 4 versus No Action Alternative

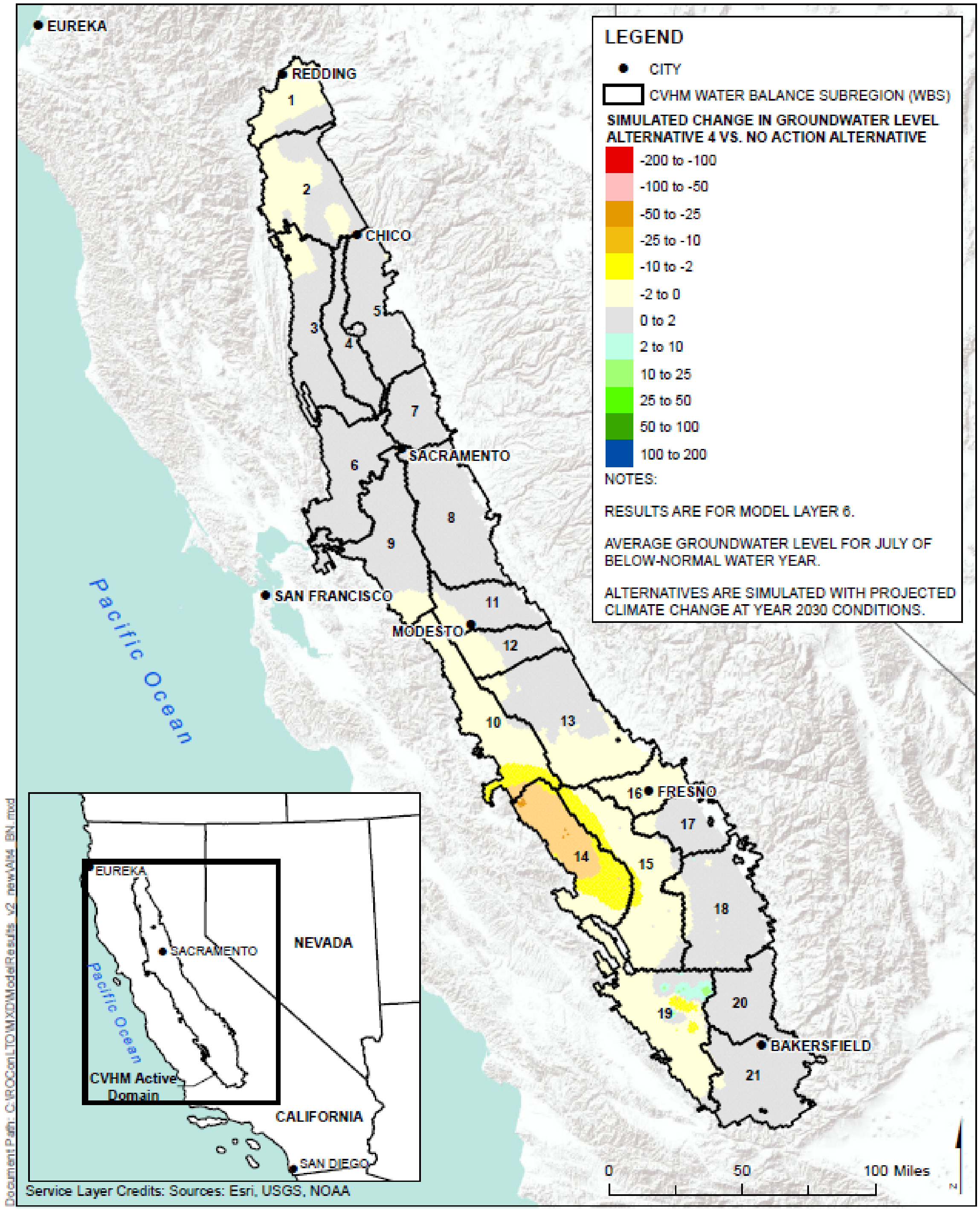

Figure I.2-67. Simulated Change in Groundwater Level, July of Below Normal Years, Alternative 4 versus No Action Alternative

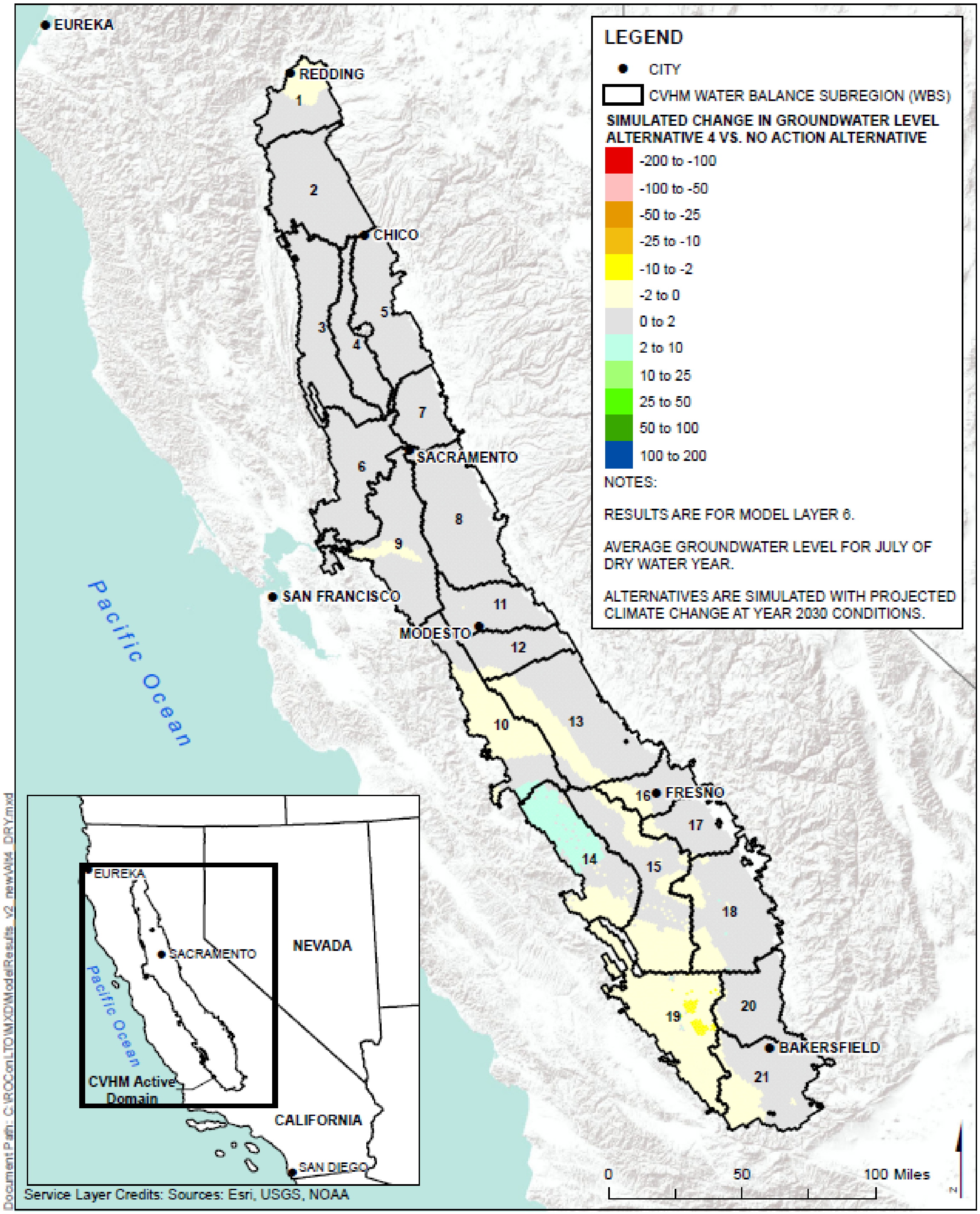

Figure I.2-68. Simulated Change in Groundwater Level, July of Dry Years, Alternative 4 versus No Action Alternative

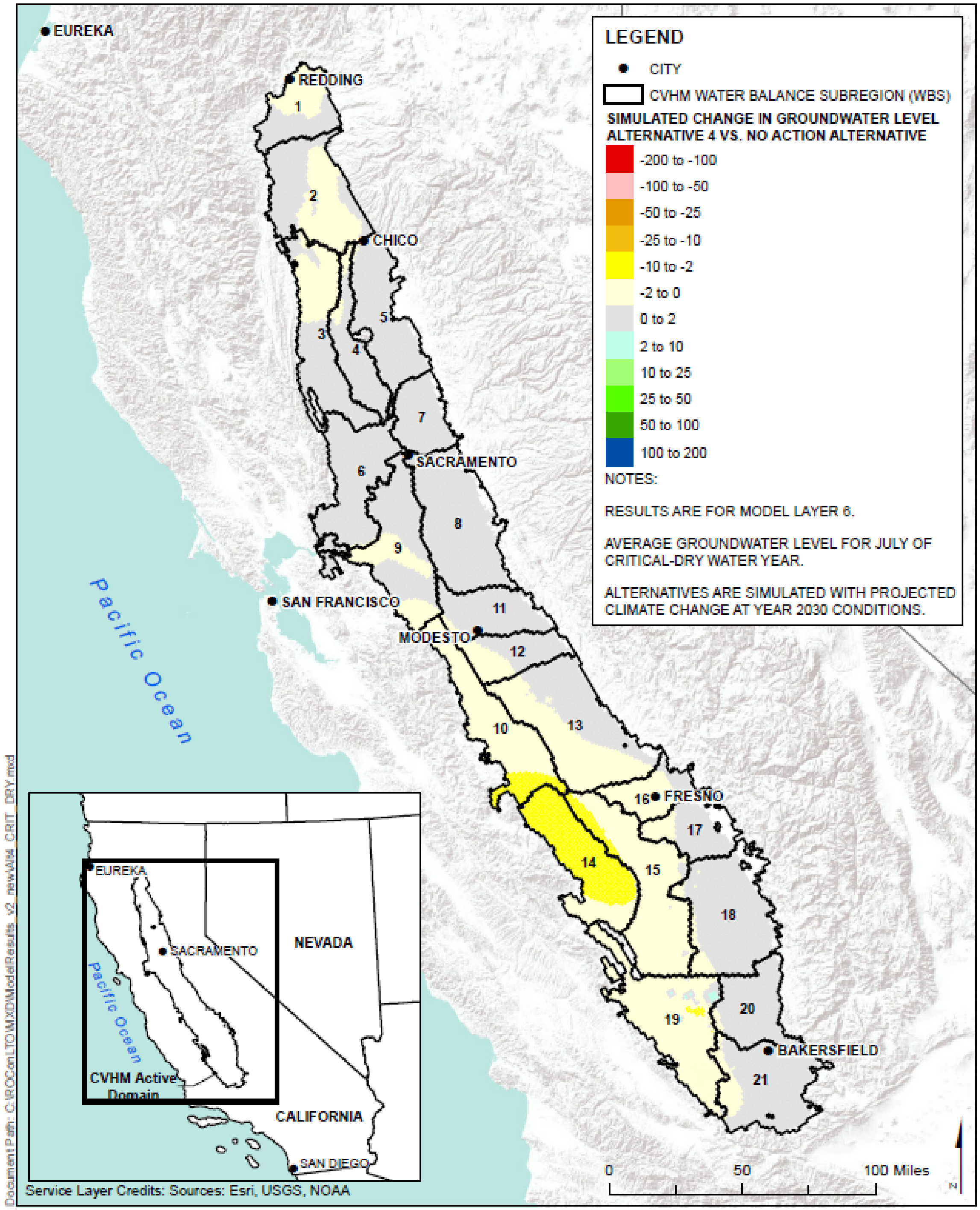

Figure I.2-69. Simulated Change in Groundwater Level, July of Critical Dry Years, Alternative 4 versus No Action Alternative

These figures show that, on average, groundwater levels decrease in the areas south of the Delta as a result of Alternative 4 compared with the No Action Alternative.

Central Valley Project and State Water Project Service Areas

Alternative 4, in general, increases water supply to the CVP and SWP service areas and therefore likely results in little change (or potentially an decrease) in the amount of groundwater pumping because of decreased reliance on groundwater compared to the No Action Alternative. With a potential increase in groundwater pumping, there could be a decrease in groundwater levels. Therefore, Alternative 4, compared with the No Action Alternative, may result in decreased groundwater levels.

I.2.6.1.4 Potential Changes in Land Subsidence

Trinity River Region

The fact that the area along the Trinity River is not known to be susceptible to subsidence and that groundwater pumping is not expected to increase in this region suggests that subsidence will not be a concern in this area.

Central Valley Region

Land subsidence is caused by the consolidation of certain subsurface soils when the pore pressure in those soils is reduced. Portions of the Central Valley, in both the Sacramento and San Joaquin Valleys, contain subsurface sediments that are susceptible to subsidence. In the Central Valley, subsidence is typically associated with a reduction in groundwater pore pressure caused by groundwater pumping. That pumping causes groundwater levels (and pore pressures) to decrease. If those levels are lowered below the historical low values for that area, subsidence can occur.

As noted in previous sections, groundwater pumping may increase under Alternative 4 compared to the No Action Alternative, causing groundwater levels to decrease. A decrease in groundwater levels below historical low levels may occur. However, the certainty of those low levels occurring is not clear because water levels vary from year to year based on hydrologic conditions. If the groundwater levels are lowered below historic low levels in areas that are geologically susceptible to subsidence, it is possible that Alternative 4 would cause additional subsidence compared to the No Action Alternative, given that groundwater levels are expected to remain stable or increase and there are areas of active subsidence in both the Sacramento and San Joaquin Valleys.

Central Valley Project and State Water Project Service Areas

As noted in previous sections, groundwater pumping may increase under Alternative 4 compared to the No Action Alternative, causing groundwater levels to decrease. A decrease in groundwater levels below historical low levels may occur. However, the certainty of those low levels occurring is not clear because water levels vary from year to year based on hydrologic conditions. If the groundwater levels are lowered below historic low levels in areas that are geologically susceptible to subsidence, it is possible that Alternative 4 would cause additional subsidence compared to the No Action Alternative, given that groundwater levels are expected to remain stable or decrease and there are areas of active subsidence in both the Sacramento and San Joaquin Valleys.

I.2.6.2 *Program-Level Effects*

Alternative 4 includes increased water efficiency measures. The implementation of these measures would likely result in decreased reliance on groundwater supplies. A decrease in groundwater supply reliance could reduce the amount of groundwater pumped and therefore increase groundwater levels.

I.2.7 Mitigation Measures

No mitigation measures are identified for the effects acknowledged in this appendix.

I.2.8 Summary of Impacts

Table I.2-5, Impact Summary, includes a summary of effects, the magnitude and direction of those effects, and potential mitigation measures for consideration.

Table I.2-5. Impact Summary

Impact	Alternative	Magnitude and Direction of Impacts	Potential Mitigation Measures
Potential Changes in Groundwater Pumping	No Action	No Change	–
	1	There is not expected to be a change in groundwater pumping in the Trinity River region. In the Central Valley region, groundwater pumping is expected to decrease an average of 264 TAF per year (3.7%) compared with the No Action Alternative. In the CVP and SWP service areas, groundwater pumping is expected to remain the same or decrease.	–
	2	There is not expected to be a change in groundwater pumping in the Trinity River region. In the Central Valley region, groundwater pumping is expected to decrease an average of 535 TAF per year (7.5%) compared with the No Action Alternative. In the CVP and SWP service areas, groundwater pumping is expected to remain the same or decrease.	–

Impact	Alternative	Magnitude and Direction of Impacts	Potential Mitigation Measures
	3	There is not expected to be a change in groundwater pumping in the Trinity River region. In the Central Valley region, groundwater pumping is expected to decrease an average of 513 TAF per year (7.1%) compared with the No Action Alternative. In the CVP and SWP service areas, groundwater pumping is expected to remain the same or decrease.	–
	4	There is not expected to be a change in groundwater pumping in the Trinity River region. In the Central Valley region, groundwater pumping is expected to increase an average of 26 TAF per year (0.4%) compared with the No Action Alternative. In the CVP and SWP service areas, groundwater pumping is expected to remain the same or slightly increase.	–
Potential Changes in Groundwater-Surface Water Interaction	No Action	No Change	–
	1	Any increased surface water flow in the Trinity River region would potential result in additional recharge to groundwater from surface water. In the Central Valley region, the average change in groundwater/surface water interaction flow is 50 TAF per year (10.3%) of a reduction in surface water discharging to groundwater compared with the No Action Alternative. In the CVP and SWP service areas, there is not expected to be any increased discharge of surface water to groundwater.	–

Impact	Alternative	Magnitude and Direction of Impacts	Potential Mitigation Measures
	2	Any increased surface water flow in the Trinity River region would potential result in additional recharge to groundwater from surface water. In the Central Valley region, the average change in groundwater/surface water interaction flow is 64 TAF per year (13.2%) of a reduction in surface water discharging to groundwater compared with the No Action Alternative. In the CVP and SWP service areas, there is not expected to be any increased discharge of surface water to groundwater.	–
	3	Any increased surface water flow in the Trinity River region would potential result in additional recharge to groundwater from surface water. In the Central Valley region, the average change in groundwater/surface water interaction flow is 65 TAF per year (13.4%) of a reduction in surface water discharging to groundwater compared with the No Action Alternative. In the CVP and SWP service areas, there is not expected to be any increased discharge of surface water to groundwater.	–
	4	Any increased surface water flow in the Trinity River region would potential result in additional recharge to groundwater from surface water. In the Central Valley region, the average change in groundwater/surface water interaction flow is an increase of 7 TAF per year (1.4%) of a reduction in surface water discharging to groundwater compared with the No Action Alternative. In the CVP and SWP service areas, there is not expected to be any increased discharge of surface water to groundwater.	–

Impact	Alternative	Magnitude and Direction of Impacts	Potential Mitigation Measures
Potential Changes in Groundwater Elevation	No Action	No Change	–
	1	There is expected to be negligible change in groundwater elevation in the Trinity River region. Groundwater elevations in the northern portion of the Central Valley region are expected to remain constant or decrease slightly. Groundwater elevations in the southern portion of Central Valley region are expected to remain constant or increase. Groundwater elevations in the CVP and SWP service area region are expected to remain constant or increase.	–
	2	There is expected to be negligible change in groundwater elevation in the Trinity River region. Groundwater elevations in the northern portion of the Central Valley region are expected to remain constant or decrease slightly. Groundwater elevations in the southern portion of Central Valley region are expected to remain constant or increase. Groundwater elevations in the CVP and SWP service area region are expected to remain constant or increase.	–
	3	There is expected to be negligible change in groundwater elevation in the Trinity River region. Groundwater elevations in the northern portion of the Central Valley region are expected to remain constant or decrease slightly. Groundwater elevations in the southern portion of Central Valley region are expected to remain constant or increase. Groundwater elevations in the CVP and SWP service area region are expected to remain constant or increase.	–

Impact	Alternative	Magnitude and Direction of Impacts	Potential Mitigation Measures
	4	There is expected to be negligible change in groundwater elevation in the Trinity River region. Groundwater elevations in the Central Valley region are expected to remain constant or decrease. Groundwater elevations in the CVP and SWP service area region are expected to remain constant or decrease.	–
Potential Changes in Land Subsidence	No Action	No Change	–
	1	There is expected to be negligible change in land subsidence in the Trinity River region. Alternative 1 is not expected to increase land subsidence in the Central Valley region. There is expected to be negligible change in land subsidence in the CVP and SWP service area region.	–
	2	There is expected to be negligible change in land subsidence in the Trinity River region. Alternative 2 is not expected to increase land subsidence in the Central Valley region. There is expected to be negligible change in land subsidence in the CVP and SWP service area region.	–
	3	There is expected to be negligible change in land subsidence in the Trinity River region. Alternative 3 is not expected to increase land subsidence in the Central Valley region. There is expected to be negligible change in land subsidence in the CVP and SWP service area region.	–

Impact	Alternative	Magnitude and Direction of Impacts	Potential Mitigation Measures
	4	There is expected to be negligible change in land subsidence in the Trinity River region. Alternative 4 may increase land subsidence in the Central Valley region. There is expected to be negligible change in land subsidence in the CVP and SWP service area region.	–

TAF = thousand acre-feet
CVP = Central Valley Project
SWP = State Water Project

I.2.9 Cumulative Effects

The No Action Alternative would not result in any changes to water operations, and there would be no additional effects on groundwater pumping. As such, the No Action Alternative is not evaluated further in this section.

Alternatives 1, 2, and 3 would generally increase surface water supplies to CVP and SWP contractors. An increase in surface water supply would decrease the reliance on groundwater and result in less groundwater pumping. Alternative 4 would generally decrease surface water supplies to contractors.

The past, present, and reasonably foreseeable projects described in Appendix Y, *Cumulative Methodology*, may have effects on water supply. These cumulative projects include actions across California to develop new water storage capacity, new water conveyance infrastructure, new water recycling capacity, and the reoperation of existing water supply infrastructure, including surface water reservoirs and conveyance infrastructure. The cumulative projects also include ecosystem improvement and habitat restoration actions to improve conditions for species whose special status, in many cases, can constrain water supply delivery operations. Collectively, these cumulative projects would be anticipated to directly or indirectly generate improvements in either local or broader regional water supply conditions. An increase in surface water supply from these cumulative projects would also have the effect of decreasing reliance on groundwater and reducing groundwater pumping.

I.2.9.1 *Changes in Groundwater Pumping*

Alternative 1’s contribution to cumulative conditions would not be substantial. In the case of cumulative projects anticipated to potentially generate temporary reductions in water supply deliveries or reduce surplus water supply availability to neighboring water users, Alternative 1’s reduction in groundwater pumping would help to reduce the severity of any potential cumulative effect. Alternatives 2 and 3 would have similar effects as Alternative 1 and would not generate substantial contributions to cumulative groundwater pumping conditions.

Alternative 4’s contribution to these cumulative conditions is also not expected to be substantial. The increase in groundwater pumping under Alternative 4 is relatively small (0.7%) and would not worsen groundwater conditions.

I.2.9.2 *Potential Changes in Groundwater Elevation*

Alternative 1 would generally decrease the amount of groundwater pumping due to an increase in surface water supplies available to CVP and SWP contractors. The decrease in groundwater pumping would result in an increase in groundwater elevations. Since Alternative 1's contribution to groundwater pumping conditions is not expected to be substantial, Alternative 1's contribution to cumulative changes in groundwater elevation is also not expected to be substantial. Alternatives 2 and 3 would have similar effects as Alternative 1 and would not generate substantial contributions to cumulative groundwater elevations.

Alternative 4 would slightly increase the amount of groundwater pumping due to a decrease in surface water supplies available to CVP and SWP contractors. The increase in groundwater pumping would result in a decrease in groundwater elevations. Since Alternative 4's contribution to groundwater pumping conditions is relatively small (0.7%) and not expected to be substantial, Alternative 4's contribution to cumulative changes in groundwater elevation is also not expected to be substantial.

I.2.9.3 *Potential Changes in Groundwater-Surface Water Interaction*

Alternative 1 would generally decrease the amount of groundwater that discharges to surface water. due to an increase in surface water supplies available to CVP and SWP contractors. The amount of decrease is relatively low (6.6%). Therefore, Alternative 1's contribution to changes in groundwater elevation is also not expected to be substantial. Alternatives 2, 3, and 4 would have similar effects as Alternative 1 and would not generate substantial contributions to cumulative groundwater-surface water interaction.

I.2.9.4 *Potential Changes in Land Subsidence*

Alternative 1's contribution to groundwater pumping conditions is not expected to be substantial; therefore, Alternative 1's contribution to changes in groundwater elevation is also not expected to be substantial. Without a substantial change to groundwater elevations, there would also not be a substantial change to land subsidence. Alternatives 2 and 3 would have similar effects as Alternative 1 and would not generate substantial contributions to cumulative land subsidence.

Alternative 4 has the potential to increase groundwater pumping by approximately 0.7%. An increase in pumping, if occurring in areas susceptible to subsidence, may result in additional subsidence. However, given the relatively low amount of increase in groundwater pumping that occurs during select hydrologic conditions, Alternative 4's contribution to cumulative subsidence is not expected to be substantial.

I.3 References

Alameda County Water District (ACWD). 2011. *Urban Water Management Plan 2010-2015*. July.

Alameda County Water District (ACWD). 2012. *Survey Report on Groundwater Conditions*. February.

Antelope Valley-East Kern Water Agency (AVEK). 2011. *2010 Urban Water Management Plan*. June 20.

Apple Valley Ranchos Water Company. 2011. *2010 Urban Water Management Plan*. June 23.

Beaumont Basin Watermaster. 2013. *Annual Report for Calendar Year 2012*. December.

Beaumont-Cherry Valley Water District (BCVWD). 2013. *2013 Urban Water Management Plan Update*. July.

Bellflower-Somerset Mutual Water Company. 2011. *Urban Water Management Plan*. June 30.

Berkstresser, C.F. Jr. 1973. Base of Fresh Ground-Water – Approximately 3,000 micromhos – in the Sacramento Valley and Sacramento-San Joaquin Delta, California. U.S. Geological Survey Water-Resource Inv. 40–73.

Butte County. 2004. *Butte County Groundwater Management Plan*. September.

Butte County. 2010. *General Plan Draft Environmental Impact Report*. April 8.

California American Water Company. 2011. *Sacramento District 2010 Urban Water Management Plan*. October 17.

California American Water Company. 2012. *2010 Urban Water Management Plan for the Southern Division – San Diego County District*. February.

California Department of Water Resources (DWR). 2003a. *California's Groundwater. Bulletin 118, Update 2003*.

California Department of Water Resources (DWR). 2003b. *Sacramento River Basinwide Water Management Plan. Groundwater Hydrology*. January.

California Department of Water Resources (DWR). 2003c. *California's Groundwater, Bulletin 118 Update, South Lahontan Hydrologic Region, El Mirage Valley Groundwater Basin*. October 1.

California Department of Water Resources (DWR). 2003d. *California's Groundwater, Bulletin 118 Update, South Lahontan Hydrologic Region, Middle Mojave River Valley Groundwater Basin*. October 1.

California Department of Water Resources (DWR). 2003e. *California's Groundwater, Bulletin 118 Update, South Lahontan Hydrologic Region, Caves Canyon Valley Groundwater Basin*. October 1.

California Department of Water Resources (DWR). 2003f. *California's Groundwater, Bulletin 118 Update, Colorado River Hydrologic Region, Morongo Valley Groundwater Basin*. October 1.

California Department of Water Resources (DWR). 2004a. *California's Groundwater, Bulletin 118 Update, North Coast Hydrologic Region, Hoopa Valley Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004b. *California's Groundwater, Bulletin 118 Update, North Coast Hydrologic Region, Lower Klamath River Valley Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004c. *California's Groundwater, Bulletin 118 Update, Sacramento River Hydrologic Region, Redding Groundwater Basin, Anderson Subbasin*. February 27.

California Department of Water Resources (DWR). 2004d. *California's Groundwater, Bulletin 118 Update, Sacramento River Hydrologic Region, Redding Groundwater Basin, Bowman Subbasin*. February 27.

California Department of Water Resources (DWR). 2004e. *California's Groundwater, Bulletin 118 Update, Sacramento River Hydrologic Region, Redding Groundwater Basin, Rosewood Subbasin*. February 27.

California Department of Water Resources (DWR). 2004f. *California's Groundwater, Bulletin 118 Update, Sacramento River Hydrologic Region, Redding Groundwater Basin, Enterprise Subbasin*. February 27.

California Department of Water Resources (DWR). 2004g. *California's Groundwater, Bulletin 118 Update, Sacramento River Hydrologic Region, Redding Groundwater Basin, Millville Subbasin*. February 27.

California Department of Water Resources (DWR). 2004h. *California's Groundwater, Bulletin 118 Update, Sacramento River Hydrologic Region, Redding Groundwater Basin, South Battle Creek Subbasin*. February 27.

California Department of Water Resources (DWR). 2004i. *California's Groundwater, Bulletin 118 Update, Sacramento River Hydrologic Region, Sacramento Valley Groundwater Basin, Red Bluff Subbasin*. February 27.

California Department of Water Resources (DWR). 2004j. *California's Groundwater, Bulletin 118 Update, Sacramento River Hydrologic Region, Sacramento Valley Groundwater Basin, Bend Subbasin*. February 27.

California Department of Water Resources (DWR). 2004k. *California's Groundwater, Bulletin 118 Update, Sacramento River Hydrologic Region, Sacramento Valley Groundwater Basin, Antelope Subbasin*. February 27.

California Department of Water Resources (DWR). 2004l. *California's Groundwater, Bulletin 118 Update, Sacramento River Hydrologic Region, Sacramento Valley Groundwater Basin, Dye Creek Subbasin*. February 27.

California Department of Water Resources (DWR). 2004m. *California's Groundwater, Bulletin 118 Update, Sacramento River Hydrologic Region, Sacramento Valley Groundwater Basin, Los Molinos Subbasin*. February 27.

California Department of Water Resources (DWR). 2004n. *California's Groundwater, Bulletin 118 Update, Sacramento River Hydrologic Region, Sacramento Valley Groundwater Basin, Vina Subbasin*. February 27.

California Department of Water Resources (DWR). 2004o. *California's Groundwater, Bulletin 118 Update, Sacramento River Hydrologic Region, Sacramento Valley Groundwater Basin, Yolo Subbasin*. February 27.

California Department of Water Resources (DWR). 2004p. *California's Groundwater, Bulletin 118 Update, Sacramento River Hydrologic Region, Sacramento Valley Groundwater Basin, Solano Subbasin*. February 27.

California Department of Water Resources (DWR). 2004q. *California's Groundwater, Bulletin 118 Update, Sacramento River Hydrologic Region, Sacramento Valley Groundwater Basin, West Butte Subbasin*. February 27.

California Department of Water Resources (DWR). 2004r. *California's Groundwater, Bulletin 118 Update, Sacramento River Hydrologic Region, Sacramento Valley Groundwater Basin, East Butte Subbasin*. February 27.

California Department of Water Resources (DWR). 2004s. *California's Groundwater, Bulletin 118 Update, Sacramento River Hydrologic Region, Sacramento Valley Groundwater Basin, South American Subbasin*. February 27.

California Department of Water Resources (DWR). 2004t. *California's Groundwater, Bulletin 118 Update, San Joaquin River Hydrologic Region, San Joaquin Valley Groundwater Basin, Modesto Subbasin*. February 27.

California Department of Water Resources (DWR). 2004u. *California's Groundwater, Bulletin 118 Update, San Joaquin River Hydrologic Region, San Joaquin Valley Groundwater Basin, Merced Subbasin*. February 27.

California Department of Water Resources (DWR). 2004v. *California's Groundwater, Bulletin 118 Update, San Joaquin River Hydrologic Region, San Joaquin Valley Groundwater Basin, Chowchilla Subbasin*. February 27.

California Department of Water Resources (DWR). 2004w. *California's Groundwater, Bulletin 118 Update, San Joaquin River Hydrologic Region, San Joaquin Valley Groundwater Basin, Madera Subbasin*. February 27.

California Department of Water Resources (DWR). 2004x. *California's Groundwater, Bulletin 118 Update, San Francisco Bay Hydrologic Region, Pittsburg Plain Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004y. *California's Groundwater, Bulletin 118 Update, San Francisco Bay Hydrologic Region, Clayton Valley Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004z. *California's Groundwater, Bulletin 118 Update, San Francisco Bay Hydrologic Region, Ygnacio Valley Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004aa. *California's Groundwater, Bulletin 118 Update, San Francisco Bay Hydrologic Region, Arroyo del Hambre Valley Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004ab. *California's Groundwater, Bulletin 118 Update, San Francisco Bay Hydrologic Region, San Ramon Valley Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004ac. *California's Groundwater, Bulletin 118 Update, San Francisco Bay Hydrologic Region, Castro Valley Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004ad. *California's Groundwater, Bulletin 118 Update, San Francisco Bay Hydrologic Region, Santa Clara Valley Groundwater Basin, East Bay Plain Subbasin*. February 27.

California Department of Water Resources (DWR). 2004ae. *California's Groundwater, Bulletin 118 Update, San Francisco Bay Hydrologic Region, Santa Clara Valley Groundwater Basin, Santa Clara Subbasin*. February 27.

California Department of Water Resources (DWR). 2004af. *California's Groundwater, Bulletin 118 Update, Central Coast Hydrologic Region, Morro Valley Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004ag. *California's Groundwater, Bulletin 118 Update, Central Coast Hydrologic Region, Chorro Valley Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004ah. *California's Groundwater, Bulletin 118 Update, Central Coast Hydrologic Region, Santa Maria Valley Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004ai. *California's Groundwater, Bulletin 118 Update, Central Coast Hydrologic Region, Goleta Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004aj. *California's Groundwater, Bulletin 118 Update, Central Coast Hydrologic Region, Foothill Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004ak. *California's Groundwater, Bulletin 118 Update, Central Coast Hydrologic Region, Santa Barbara Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004al. *California's Groundwater, Bulletin 118 Update, Central Coast Hydrologic Region, Montecito Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004am. *California's Groundwater, Bulletin 118 Update, Central Coast Hydrologic Region, Carpinteria Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004an. *California's Groundwater, Bulletin 118 Update, Central Coast Hydrologic Region, San Antonio Creek Valley Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004ao. *California's Groundwater, Bulletin 118 Update, Central Coast Hydrologic Region, Santa Ynez River Valley Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004aq. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Santa Clara River Valley Groundwater Basin, Piru Subbasin*. February 27.

California Department of Water Resources (DWR). 2004ar. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Santa Clara River Valley Groundwater Basin, Santa Paula Subbasin*. February 27.

DWR (California Department of Water Resources) California Department of Water Resources (DWR). 2004as. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Acton Valley Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004at. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Simi Valley Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004au. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Tierra Rejada Valley Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004av. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Conejo Valley Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004aw. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Thousand Oaks Area Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004ax. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Russell Valley Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004ay. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, San Fernando Valley Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004az. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Raymond Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004ba. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, San Gabriel Valley Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004bb. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Coastal Plain of Los Angeles Groundwater Basin, Hollywood Subbasin*. February 27.

California Department of Water Resources (DWR). 2004bc. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Coastal Plain of Los Angeles Groundwater Basin, Santa Monica Subbasin*. February 27.

California Department of Water Resources (DWR). 2004bd. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Coastal Plain of Los Angeles Groundwater Basin, Central Subbasin*. February 27.

California Department of Water Resources (DWR). 2004be. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Coastal Plain of Los Angeles Groundwater Basin, West Coast Subbasin*.

California Department of Water Resources (DWR). 2004bf. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Malibu Valley Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004bg. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Coastal Plain of Orange County Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004bh. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, San Juan Valley Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004bi. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, San Mateo Valley Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004bj. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, San Onofre Valley Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004bk. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Santa Margarita Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004bl. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, San Luis Rey Valley Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004bm. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, San Marcos Valley Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004bn. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Escondido Valley Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004bo. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, San Pasqual Valley Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004bp. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Pamo Valley Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004bq. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Santa Maria Valley Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004br. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Poway Valley Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004bs *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Batiquitos Lagoon Valley Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004bt. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, San Elijo Valley Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004bu. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, San Dieguito Valley Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004bv. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, San Diego River Valley Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004bw. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, El Cajon Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004bx. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Mission Valley Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004by. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Sweetwater Valley Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004bz. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Otay Valley Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004ca. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Tijuana Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004cb. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Upper Santa Ana Valley Groundwater Basin, Cucamonga Subbasin*. February 27.

California Department of Water Resources (DWR). 2004cc. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Upper Santa Ana Valley Groundwater Basin, Riverside-Arlington Subbasin*. February 27.

California Department of Water Resources (DWR). 2004cd. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Upper Santa Ana Valley Groundwater Basin, Cajon Subbasin*. February 27.

California Department of Water Resources (DWR). 2004ce. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Upper Santa Ana Valley Groundwater Basin, Rialto-Colton Subbasin*. February 27.

California Department of Water Resources (DWR). 2004cf. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Upper Santa Ana Valley Groundwater Basin, Bunker Hill Subbasin*. February 27.

California Department of Water Resources (DWR). 2004cg. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Upper Santa Ana Valley Groundwater Basin, Yucaipa Subbasin*. February 27.

California Department of Water Resources (DWR). 2004ch. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Upper Santa Ana Valley Groundwater Basin, San Timoteo Subbasin*. February 27.

California Department of Water Resources (DWR). 2004ci. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Temecula Valley Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004cj. *California's Groundwater, Bulletin 118 Update, Colorado River Hydrologic Region, Coachella Valley Groundwater Basin, San Gorgonio Subbasin*. February 27.

California Department of Water Resources (DWR). 2004ck. *California's Groundwater, Bulletin 118 Update, South Lahontan Hydrologic Region, Indian Wells Valley Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004cl. *California's Groundwater, Bulletin 118 Update, South Lahontan Hydrologic Region, Salt Wells Valley Groundwater Basin*. February 29.

California Department of Water Resources (DWR). 2004cm. *California's Groundwater, Bulletin 118 Update, South Lahontan Hydrologic Region, Searles Valley Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004cn. *California's Groundwater, Bulletin 118 Update, Colorado River Hydrologic Region, Coachella Valley Groundwater Basin, Indio Subbasin*. February 27.

California Department of Water Resources (DWR). 2004co. *California's Groundwater, Bulletin 118 Update, Colorado River Hydrologic Region, Coachella Valley Groundwater Basin, Mission Creek Subbasin*. February 27.

California Department of Water Resources (DWR). 2004cp. *California's Groundwater, Bulletin 118 Update, South Lahontan Hydrologic Region, Cuddeback Valley Groundwater Basin, Desert Hot Springs Subbasin*. February 27.

California Department of Water Resources (DWR). 2004cq. *California's Groundwater, Bulletin 118 Update, South Lahontan Hydrologic Region, Pilot Knob Valley Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004cr. *California's Groundwater, Bulletin 118 Update, South Lahontan Hydrologic Region, Grass Valley Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004cs. *California's Groundwater, Bulletin 118 Update, South Lahontan Hydrologic Region, Superior Valley Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004ct. *California's Groundwater, Bulletin 118 Update, South Lahontan Hydrologic Region, Harper Valley Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004cu. *California's Groundwater, Bulletin 118 Update, South Lahontan Hydrologic Region, Fremont Valley Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004cv. *California's Groundwater, Bulletin 118 Update, South Lahontan Hydrologic Region, Antelope Valley Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004cw. *California's Groundwater, Bulletin 118 Update, South Lahontan Hydrologic Region, Upper Mojave River Valley Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004cx. *California's Groundwater, Bulletin 118 Update, South Lahontan Hydrologic Region, Lower Mojave Valley Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004cy. *California's Groundwater, Bulletin 118 Update, South Lahontan Hydrologic Region, Langford Valley Groundwater Basin, Langford Well Lake Subbasin*. February 27.

California Department of Water Resources (DWR). 2004cz. *California's Groundwater, Bulletin 118 Update, South Lahontan Hydrologic Region, Cronise Valley Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004da. *California's Groundwater, Bulletin 118 Update, South Lahontan Hydrologic Region, Coyote Lake Valley Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004db. *California's Groundwater, Bulletin 118 Update, South Lahontan Hydrologic Region, Kane Wash Area Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004dc. *California's Groundwater, Bulletin 118 Update, Colorado River Hydrologic Region, Iron Ridge Area Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004dd. *California's Groundwater, Bulletin 118 Update, Colorado River Hydrologic Region, Bessemer Valley Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004de. *California's Groundwater, Bulletin 118 Update, Colorado River Hydrologic Region, Lucerne Valley Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004df. *California's Groundwater, Bulletin 118 Update, Colorado River Hydrologic Region, Johnson Valley Groundwater Basin, Soggy Lake Subbasin*. February 27.

California Department of Water Resources (DWR). 2004dg. *California's Groundwater, Bulletin 118 Update, Colorado River Hydrologic Region, Johnson Valley Groundwater Basin, Upper Johnson Valley Subbasin*. February 27.

California Department of Water Resources (DWR). 2004dh. *California's Groundwater, Bulletin 118 Update, Colorado River Hydrologic Region, Means Valley Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004di. *California's Groundwater, Bulletin 118 Update, Colorado River Hydrologic Region, Deadman Valley Groundwater Basin, Surprise Spring Subbasin*. February 27.

California Department of Water Resources (DWR). 2004dj. *California's Groundwater, Bulletin 118 Update, Colorado River Hydrologic Region, Deadman Valley Groundwater Basin, Deadman Lake Subbasin*. February 27.

California Department of Water Resources (DWR). 2004dk. *California's Groundwater, Bulletin 118 Update, Colorado River Hydrologic Region, Copper Mountain Valley Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004dl. *California's Groundwater, Bulletin 118 Update, Colorado River Hydrologic Region, Warren Valley Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2004dm. *California's Groundwater, Bulletin 118 Update, Colorado River Hydrologic Region, Lost Horse Valley Groundwater Basin*. February 27.

California Department of Water Resources (DWR). 2006a. *California's Groundwater, Bulletin 118 Update, Sacramento River Hydrologic Region, Sacramento Valley Groundwater Basin, Corning Subbasin*. January 20.

California Department of Water Resources (DWR). 2006b. *California's Groundwater, Bulletin 118 Update, Sacramento River Hydrologic Region, Sacramento Valley Groundwater Basin, Colusa Subbasin*. January 20.

California Department of Water Resources (DWR). 2006c. *California's Groundwater, Bulletin 118 Update, Sacramento River Hydrologic Region, Sacramento Valley Groundwater Basin, North Yuba Subbasin*. January 20.

California Department of Water Resources (DWR). 2006d. *California's Groundwater, Bulletin 118 Update, Sacramento River Hydrologic Region, Sacramento Valley Groundwater Basin, South Yuba Subbasin*. January 20.

California Department of Water Resources (DWR). 2006e. *California's Groundwater, Bulletin 118 Update, Sacramento River Hydrologic Region, Sacramento Valley Groundwater Basin, Sutter Subbasin*. January 20.

California Department of Water Resources (DWR). 2006f. *California's Groundwater, Bulletin 118 Update, Sacramento River Hydrologic Region, Sacramento Valley Groundwater Basin, North American Subbasin*. January 20.

California Department of Water Resources (DWR). 2006g. *California's Groundwater, Bulletin 118 Update, San Joaquin River Hydrologic Region, San Joaquin Valley Groundwater Basin, Tracy Subbasin*. January 20.

California Department of Water Resources (DWR). 2006h. *California's Groundwater, Bulletin 118 Update, San Joaquin River Hydrologic Region, San Joaquin Valley Groundwater Basin, Delta-Mendota Subbasin*. January 20.

California Department of Water Resources (DWR). 2006i. *California's Groundwater, Bulletin 118 Update, San Joaquin River Hydrologic Region, San Joaquin Valley Groundwater Basin, Turlock Subbasin*. January 20.

California Department of Water Resources (DWR). 2006j. *California's Groundwater, Bulletin 118 Update, San Joaquin River Hydrologic Region, San Joaquin Valley Groundwater Basin, Cosumnes Subbasin*. February 3.

California Department of Water Resources (DWR). 2006k. *California's Groundwater, Bulletin 118 Update, San Joaquin River Hydrologic Region, San Joaquin Valley Groundwater Basin, East San Joaquin Subbasin*. January 20.

California Department of Water Resources (DWR). 2006l. *California's Groundwater, Bulletin 118 Update, San Francisco Bay Hydrologic Region, Livermore Valley Groundwater Basin*. January 20.

California Department of Water Resources (DWR). 2006m. *California's Groundwater, Bulletin 118 Update, San Francisco Bay Hydrologic Region, Santa Clara Valley Groundwater Basin*, *Niles Cone Subbasin.* January 20.

California Department of Water Resources (DWR). 2006n. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Santa Clara River Valley Groundwater Basin, Santa Clara River Valley East Subbasin*. January 20.

California Department of Water Resources (DWR). 2006o. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Santa Clara River Valley Groundwater Basin, Fillmore Subbasin*. January 20.

California Department of Water Resources (DWR). 2006p. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Santa Clara River Valley Groundwater Basin, Mound Subbasin*. January 20.

California Department of Water Resources (DWR). 2006q. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Santa Clara River Valley Groundwater Basin, Oxnard Subbasin*. January 20.

California Department of Water Resources (DWR). 2006r. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Las Posas Valley Groundwater Basin*. January 20.

California Department of Water Resources (DWR). 2006s. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Pleasant Valley Groundwater Basin*. January 20.

California Department of Water Resources (DWR). 2006t. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Arroyo Santa Rosa Valley Groundwater Basin*. January 20.

California Department of Water Resources (DWR). 2006u. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Upper Santa Ana Valley Groundwater Basin, Chino Subbasin*. January 20.

California Department of Water Resources (DWR). 2006v. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Upper Santa Ana Valley Groundwater Basin, Temescal Subbasin*. January 20.

California Department of Water Resources (DWR). 2006w. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, San Jacinto Groundwater Basin*. January 20.

California Department of Water Resources (DWR). 2006x. *California's Groundwater, Bulletin 118 Update, South Coast Hydrologic Region, Elsinore Groundwater Basin*. January 20.

California Department of Water Resources (DWR). 2013a. *California Water Plan Update 2013*.

California Department of Water Resources (DWR). 2013b. *Hydrologic Regions of California: Sacramento River–Basins and Subbasins of the Sacramento River Hydrologic Region. Groundwater Basin Descriptions added to Bulletin 118-03*. Available: http://www.water.ca.gov/groundwater/bulletin118/sacramento_river.cfm. Accessed: March 11, 2013.

California Department of Water Resources (DWR). 2013c. *Hydrologic Regions of California: San Joaquin River–Basins and Subbasins of the San Joaquin River Hydrologic Region. Groundwater Basin Descriptions added to Bulletin 118-03*. Available: http://www.water.ca.gov/groundwater/bulletin118/san_joaquin_river.cfm. Accessed: March 11, 2013.

California Department of Water Resources (DWR). 2013d. *Hydrologic Regions of California: San Francisco Bay–Basins and Subbasins of the San Francisco Bay Hydrologic Region. Groundwater Basin Descriptions added to Bulletin 118-03*. Available: http://www.water.ca.gov/groundwater/bulletin118/san_francisco_bay.cfm. Accessed: March 11, 2013.

California Department of Water Resources (DWR). 2013e. *Hydrologic Regions of California: Central Coast–Basins and Subbasins of the Central Coast Hydrologic Region. Groundwater Basin*

Descriptions added to Bulletin 118-03. Available: http://www.water.ca.gov/groundwater/bulletin118/central_coast.cfm. Accessed: March 11, 2013.

California Department of Water Resources (DWR). 2013f. *Hydrologic Regions of California: South Coast–Basins and Subbasins of the South Coast Hydrologic Region. Groundwater Basin Descriptions added to Bulletin 118-03*. Available: http://www.water.ca.gov/groundwater/bulletin118/south_coast.cfm. Accessed: March 11, 2013.

California Department of Water Resources (DWR). 2014a. *Public Update for Drought Response, Groundwater Basins with Potential Water Shortages, Gaps in Groundwater Monitoring, Monitoring of Land Subsidence, and Agricultural Land Fallowing*. November.

California Department of Water Resources (DWR). 2014b. *Public Update for Drought Response, Groundwater Basins with Potential Water Shortages and Gaps in Groundwater Monitoring*. April 30.

California Department of Water Resources (DWR). 2014c. *Groundwater Management: Court Adjudications*. Available: http://www.water.ca.gov/groundwater/gwmanagement/court_adjudications.cfm. Accessed: April 22, 2013.

California Department of Water Resources (DWR). 2018. *2017 GPS Survey of the Sacramento Valley Subsidence Network.* December.

California Department of Water Resources (DWR). 2019a. DWR Finalizes Groundwater Basin Boundary Modifications under SGMA. February 11. Available: https://water.ca.gov/News/News-Releases/2019/February/Final-Basin-Boundary-Modifications-Released.

California Department of Water Resources (DWR). 2019b. Groundwater Information Center Interactive Map Application. Available: https://gis.water.ca.gov/app/gicima/.

California Water Service Company. 2011a. *2010 Urban Water Management Plan, Chico-Hamilton City District, Adopted.* June.

California Water Service Company. 2011b. *2010 Urban Water Management Plan, Livermore District, Adopted.* June.

California Water Service Company. 2011c. *2010 Urban Water Management Plan, City of Hawthorne, Adopted*. June.

California Water Service Company. 2011d. *2010 Urban Water Management Plan, Hermosa-Redondo District, Adopted*. June.

California Water Service Company. 2011e. *2010 Urban Water Management Plan, Dominguez District, Adopted*. June.

California Water Service Company. 2011f. *2010 Urban Water Management Plan, Palos Verdes District, Adopted*. June.

California Water Service Company. 2011g. *2010 Urban Water Management Plan, Antelope Valley District, Adopted*. June.

Calleguas Municipal Water District (Calleguas MWD). 2011. *2010 Urban Water Management Plan, Final*. May.

Camarosa Water District. 2013. *Santa Rosa Basin Groundwater Management Plan*. August.

Carlsbad Municipal Water District (CMWD). 2011. *2010 Urban Water Management Plan*. June.

Carpinteria Valley Water District (Carpinteria Valley WD). 2011. *Final 2010 Urban Water Management Plan Update*. June.

Castaic Lake Water Agency (CLWA), Santa Clarita Water Division, Los Angeles County Waterworks District 36, Newhall County Water District, and Valencia Water Company. 2012. *14th Annual Santa Clarita Valley Water Report 2011*. June.

Central Basin Municipal Water District (CBMWD). 2011. *Draft, 2010 Urban Water Management Plan*. March.

Central Coast Water Authority. 2013. *Central Coast Water Authority fiscal year 2013/14 Budget*. April 25.

Central Valley Regional Water Quality Control Board (Central Valley RWQCB). 2011. *Irrigated Lands Regulatory Program, Program Environmental Impact Report*. March.

Central Valley Regional Water Quality Control Board (Central Valley RWQCB). 2014. *Order R5-2014-0029, Waste Discharge Requirements General Order for Growers within the San Joaquin County and Delta Area That are Members of a Third-Party Group.* March.

City of Adelanto. 2011. *2010 Urban Water Management Plan*. June.

City of Alhambra. 2011. *2010 Urban Water Management Plan Update, Final Draft*. June.

City of Anaheim. 2011. *Urban Water Management Plan, 2010 Update*. June.

City of Arcadia. 2011. *Urban Water Management Plan, 2010 Update*. June.

City of Arroyo Grande. 2012. *Urban Water Management Plan, 2010 Update, Final*. January 17.

City of Banning. 2011. *2010 Urban Water Management Plan*. July 22.

City of Beverly Hills. 2011. *2010 Urban Water Management Plan*. August.

City of Brea. 2011. *Urban Water Management Plan, 2010 Update*. June.

City of Buena Park. 2011. *2010 Urban Water Management Plan*. June.

City of California City. 2013. *Urban Water Management Plan 2010 Update*. March.

City of Castro Valley. 2012. *Castro Valley General Plan*. March.

City of Chino. 2011. *Urban Water Management Plan*. June 21.

City of Coachella. 2011. *2010 Urban Water Management Plan*. July 13.

City of Compton. 2011. *2010 Urban Water Management Plan*. June 28.

City of Corona. 2011. *2010 Urban Water Management Plan*. June.

City of Downey. 2012. *2010 Urban Water Management Plan*. January.

City of Escondido. 2011. *2010 Urban Water Management Plan*. July.

City of Firebaugh. 2015. *2030 Firebaugh General Plan*. Available: http://www.ci.firebaugh.ca.us/general-plan.shtml. Accessed: April 25, 2015.

City of Fountain Valley. 2011. *Urban Water Management Plan, 2010 Update*. June.

City of Fullerton. 2011. *2010 Urban Water Management Plan*. July.

City of Garden Grove. 2011. *Urban Water Management Plan, 2010 Update*. June.

City of Grover Beach. 2011. *2010 Urban Water Management Plan*. June.

City of Hemet. 2011. *2010 2010 Urban Water Management Plan*. September 13.

City of Huntington Beach. 2011. *Urban Water Management Plan, 2010 Update*. June.

City of Huntington Park. 2011. *2010 Urban Water Management Plan*. July 5.

City of Inglewood. 2011. *2010 Urban Water Management Plan*. June.

City of La Habra. 2011. *2010 Urban Water Management Plan*. May.

City of La Palma. 2011. *Urban Water Management Plan, 2010 Update*. May.

City of Lakewood. 2011. *Urban Water Management Plan Update, 2010*. May 24.

City of La Verne. 2011. *Urban Water Management Plan, 2010*. June.

City of Livermore. 2011. *2010 Urban Water Management Plan*. June.

City of Lomita. 2011. *2010 Urban Water Management Plan*. May.

City of Long Beach. 2011. *2010 Urban Water Management Plan*. September 15.

City of Long Beach. 2012. *Long Beach 90H20*. January.

City of Los Angeles. 2011. *Urban Water Management Plan, 2010*. May 3.

City of Martinez. 2011. *Urban Water Management Plan 2010 Update*. June.

City of Manhattan Beach. 2011. *2010 Urban Water Management Plan*. December.

City of Mendota. 2009. *City of Mendota General Plan Update 2005-2025*. August 11.

City of Monterey Park. 2012. *Water System Financial Evaluations and Water Rate Recommendations*. September 17.

City of Morro Bay. 2011. *Final Report, 2010 Urban Water Management Plan*. June.

City of Newport Beach. 2011. *Urban Water Management Plan, 2010 Update*. June.

City of Norco. 2014. *Welcome to the Public Works Department, Water Maintenance Division*. Available: http://www.ci.norco.ca.us/depts/pw/default.asp. Accessed: July 17, 2014.

City of Norwalk. 2011. *2010 Urban Water Management Plan*. June.

City of Oceanside. 2011. *2010 Urban Water Management Plan*. July.

City of Ontario. 2011. *2010 Urban Water Management Plan*. June.

City of Orange. 2011. *Urban Water Management Plan, 2010 Update*. June.

City of Paramount. 2011. *2010 Urban Water Management Plan*. July 5.

City of Patterson. 2014. *The City of Patterson, Water Operations, 2012 Annual CCR Report*. Accessed: May 6, 2014.

City of Pico Rivera. 2011. *2010 Urban Water Management Plan*. July 26.

City of Pismo Beach. 2011. *2010 Urban Water Management Plan*. September.

City of Pittsburg. 2011. *City of Pittsburg 2010 Urban Water Management Plan*. August.

City of Pleasanton. 2011. *2010 Urban Water Management Plan*. June 21.

City of Pomona. 2011. *Final 2010 Urban Water Management Plan*. July.

City of Poway. 2011. *2010 Urban Water Management Plan*. June 7.

City of Rialto. 2011. *Urban Water Management Plan*. August.

City of Riverside. 2011. *Final 2010 Urban Water Management Plan*. July.

City of Roseville, Placer County Water Agency, City of Lincoln, California American Water Company. 2007. *Western Placer County Groundwater Management Plan*. November.

City of San Diego. 2011. *2010 Urban Water Management Plan*. June 28.

City of San Jacinto. 2011. *2010 Urban Water Management Plan*. December 6.

City of San Juan Capistrano. 2011. *Urban Water Management Plan, 2010 Update*. June.

City of Santa Ana. 2011. *Urban Water Management Plan, 2010 Update*. June.

City of Santa Barbara. 2011. *Urban Water Management Plan, 2010 Update, Adopted June 2011*. June.

City of Santa Fe Springs. 2011. *Urban Water Management Plan (2010–2014)*. June.

City of Santa Maria. 2011. *2010 Urban Water Management Plan*. July.

City of Santa Monica. 2011. *2010 Urban Water Management Plan, Draft Copy*. May.

City of Seal Beach. 2011. *Urban Water Management Plan, 2010 Update*. July.

City of South Gate. 2011. *2010 Urban Water Management Plan*. June.

City of Thousand Oaks. 2011. *2010 Urban Water Management Plan*. June.

City of Torrance. 2011. *2010 Urban Water Management Plan*. July.

City of Tustin. 2011. *Urban Water Management Plan, 2010 Update*. June.

City of Upland. 2011. *2010 Urban Water Management Plan*. June.

City of Vernon. 2011. *Final 2010 Urban Water Management Plan*. June.

City of Westminster. 2011. *Urban Water Management Plan, 2010 Update*. June.

City of Whittier. 2011. *2010 Urban Water Management Plan*. May.

Cucamonga Valley Water District. 2011. *2010 Urban Water Management Plan, Final*. June 28.

Coachella Valley Water District (CVWD). 2011. *2010 Urban Water Management Plan, Final Report*. July.

Coachella Valley Water District (CVWD). 2012. *Coachella Valley Water Management Plan Update, Final Report*. January.

Contra Costa County. 2005. *Contra Costa County General Plan, 2005-2020*. January.

Contra Costa Water District (CCWD). 2011. *Urban Water Management Plan*. June.

Dublin San Ramon Services District (DSRSD). 2011. *2010 Urban Water Management Plan*. June.

Desert Water Agency (DWA). 2011. *2010 Urban Water Management Plan*. March.

Diablo Water District. 2011. *Final 2010 Urban Water Management Plan*. June.

Eastern San Joaquin County Groundwater Basin Authority (ESJCGBA). 2004. *Eastern San Joaquin Groundwater Basin Groundwater Management Plan*.

Eastern San Joaquin County Groundwater Basin Authority (ESJCGBA). 2007. *Integrated Regional Water Management Plan*.

East Bay Municipal Utility District (EBMUD). 2013. *South East Bay Plain Basin Groundwater Management Plan*. March.

Eastern Municipal Water District (EMWD). 2009. *Executive Summary Substitute Environmental Document Basin Plan Amendment San Jacinto–Upper Pressure Groundwater Management Zone Total Dissolved Solids and Total Inorganic Nitrogen Objectives*. November.

Eastern Municipal Water District (EMWD). 2011. *2010 Urban Water Management Plan*. June.

Eastern Municipal Water District (EMWD). 2014. *Hemet/San Jacinto Groundwater Management Area, 2013 Annual Report, Prepared for Hemet-San Jacinto Watermaster*. April.

Elk Grove Water District. 2011. *2010 Urban Water Management Plan*. June 22.

Elsinore Valley Municipal Water District (EVMWD). 2011. *Urban Water Management Plan, Final*. July.

Farmington Program. 2012. *Overview*. Available: http://www.farmingtonprogram.org/about.html. Accessed: November 30, 2012.

Fontana Water Company. 2011. *2010 Urban Water Management Plan*. July.

Fallbrook Public Utility District (FPUD). 2011. *Draft 2010 Urban Water Management Plan*. June.

Fox Canyon Groundwater Management Agency (Fox Canyon GMA). 2013. *Annual Report for Calendar Year 2012*.

Frame Surveying and Mapping. 2006. *The Yolo County GPS Subsidence Network Recommendations and Continued Monitoring*. March.

Fresno County. 2000. *Fresno County General Plan Background Report*. October.

Golden State Water Company. 2011a. Final Report, 2010 Urban Water Management Plan, Cordova. July.

Golden State Water Company. 2011b. *Final Report, 2010 Urban Water Management Plan, Orcutt*. August.

Golden State Water Company. 2011c. *Final Report, 2010 Urban Water Management Plan, Simi Valley*. August.

Golden State Water Company. 2011d. *Final Report, 2010 Urban Water Management Plan, South San Gabriel*. August.

Golden State Water Company. 2011e. *Final Report, 2010 Urban Water Management Plan, Artesia*. September.

Golden State Water Company. 2011f. *Final Report, 2010 Urban Water Management Plan, Bell/Bell Gardens*. September.

Golden State Water Company. 2011g. *Final Report, 2010 Urban Water Management Plan, Florence-Graham*. September.

Golden State Water Company. 2011h. *Final Report, 2010 Urban Water Management Plan, Norwalk*. September.

Golden State Water Company. 2011i. *Final Report, 2010 Urban Water Management Plan, Southwest*. July.

Golden State Water Company. 2011j. *Final Report, 2010 Urban Water Management Plan, Placentia*. August.

Golden State Water Company. 2011k. *Final Report, 2010 Urban Water Management Plan, West Orange*. August.

Golden State Water Company. 2011l. *Final Report, 2010 Urban Water Management Plan, Barstow*. July.

Goleta Water District (GWD). 2011. *Final 2010 Urban Water Management Plan Update*. November.

Goleta Water District (GWD) and La Cumbre Mutual Water Company (LCMWC). 2010. *Groundwater Management Plan–Goleta Groundwater Basin – Final*. May.

Greater Los Angeles County Integrated Regional Water Management Region (Greater Los Angeles County IRWMR). 2014. *The Greater Los Angeles County Integrated Regional Water Management Plan*. February.

Helix Water District. 2011. *2010 Urban Water Management Plan*. July.

Hesperia Water District. 2011. *2010 Urban Water Management Plan*. August 16.

Hi-Desert Water District (HDWD). 2011. *2010 Urban Water Management Plan*. June 27.

Hoopa Valley Tribe. 2008. *Water Quality Control Plan, Hoopa Valley Indian Reservation*. February.

Ikehara, M. E. 1994. Global Positioning System Surveying to Monitor Land Subsidence in Sacramento Valley, California, USA. *Hydrological Sciences Journal*. Volume 29 (5)

Indian Wells Valley Water District. 2011. *2010 Urban Water Management Plan*. June.

Indio Water Authority. 2010. *2010 Urban Water Management Plan*. May.

Inland Empire Utilities Agency (IEUA). 2011. *2010 Regional Urban Water Management Plan*. June.

Irvine Ranch Water District. 2011. *2010 Urban Water Management Plan*. June.

Joshua Basin Water District. 2011. *2010 Urban Water Management Plan*. June.

Jurupa Community Services District (JCSD). 2011. *2010 Urban Water Management Plan*. May.

La Habra Heights County Water District. 2012. *2011 Water Master Plan Update*. March.

Lake Arrowhead Community Services District. 2011. *Final 2010 Urban Water Management Plan*. June 7.

Lake Hemet Municipal Water District. 2011. *Urban Water Management Plan, 2010*. June.

Lockheed Martin Corporation v. United States, Civil Action No. 2008-1160. 2014. District Court, District of Columbia. April 24.

Los Angeles Department of Public Works (Los Angeles County). 2011. *Waterworks District No. 29, Malibu and the Marina del Rey Water System, 2010 Urban Water Management Plan*. July.

Los Angeles County Department of Public Works (Los Angeles County). 2014. *Los Angeles County Waterworks Districts*. Available: http://dpw.lacounty.gov/wwd/web/About/Overview.aspx. Accessed: May 23, 2014.

Los Angeles County Department of Public Works (Los Angeles County). 2015. *San Gabriel River and Montebello Forebay Water Conservation System*. Available: http://ladpw.org/wrd/publication/system/downstream.cfm. Accessed: April 25, 2015.

Los Angeles County Department of Public Works (Los Angeles County), Waterworks District No. 40 and Quartz Hill Water District. 2011. *2010 Integrated Regional Urban Water Management Plan for the Antelope Valley*. June.

Madera County. 2002. *AB3030 Groundwater Management Plan, Madera County, Final Draft*. January.

Madera County. 2008. *Integrated Regional Water Management Plan*. April.

Merced County. 2012. *Merced County General Plan Revised Background Report*. November.

Mesa Consolidated Water District. 2011. *2010 Urban Water Management Plan*. June.

Moulton Niguel Water District (MNWD). 2011. *2010 Urban Water Management District*. June.

Monte Vista Water District. 2011. *2010 Urban Water Management Plan*. April.

Mission Springs Water District (MSWD). 2011. *2010 Urban Water Management Plan*. June 28.

Metropolitan Water District of Southern California (MWDSC). 2007. *Groundwater Assessment Study*. September.

Mojave Water Agency (MWA). 2011. *Final 2010 Urban Water Management Plan*. June 9.

Nipomo Community Services District (NCSD). 2011. *2010 Urban Water Management Plan*. June 29.

North Coast Regional Water Quality Control Board (North Coast RWQCB). 2005. *Integrated Plan for Implementation of the Watershed Management Initiative–Watershed Planning Chapter*. February.

North Coast Regional Water Quality Control Board (North Coast RWQCB) and U.S. Department of the Interior, Bureau of Reclamation (Reclamation). 2009. *Channel Rehabilitation and Sediment Management for Remaining Phase 1 and Phase 2 Sites, Draft Master Environmental Impact Report and Environmental Assessment*. June.

Northeastern San Joaquin County Groundwater Banking Authority (NSJCGBA). 2004. *Eastern San Joaquin Groundwater Basin Groundwater Management Plan*. September.

Northeastern San Joaquin County Groundwater Banking Authority (NSJCGBA). 2007. *Eastern San Joaquin Integrated Regional Water Management Plan*. July.

Northeastern San Joaquin County Groundwater Banking Authority (NSJCGBA). 2009. *Eastern San Joaquin Basin Integrated Conjunctive Use Draft Program Programmatic Environmental Impact Report*. September.

Northeastern San Joaquin County Groundwater Banking Authority (NSJCGBA). 2011. *Eastern San Joaquin Basin Integrated Conjunctive Use Program Programmatic Environmental Impact Report*. February.

Olivenhain Municipal Water District (OMWD). 2011. *2010 Urban Water Management Plan*. June 22.

Orange County Water District (OCWD). n.d. *Groundwater Replenishment System*.

Orange County Water District (OCWD). 2014. *Long-Term Facilities Plan, 2014 Update.* November 19.

Orange County. 2009. *Nitrogen and Selenium Management Program. Conceptual Model for Selenium–Newport Bay Watershed*. May.

Otay Water District. 2011. 2010 Urban Water Management Plan. June 1.

Padre Dam Municipal Water District. 2011. *2010 Urban Water Management Plan*. June 28.

Palmdale Water District (PWD). 2011. *2010 Urban Water Management Plan*. June.

Phelan Piñon Hills Community Services District. 2011. *2010 Urban Water Management Plan*. June.

Ramona Municipal Water District. 2011. *2010 Urban Water Management Plan*. December.

Rancho California Water District (RCWD). 2011. *2010 Urban Water Management Plan Update*. June 30.

Rancho California Water District (RCWD), Riverside County Flood Control and Water Conservation District, County of Riverside, Stakeholder Advisory Committee. 2014. *Upper Santa Margarita Watershed, Integrated Regional Water Management Plan Update, Final*. April.

Raymond Basin Management Board (RBMB). 2014. *About Us*. Available: http://raymondbasin.org/?page_id=25. Accessed: June 30, 2014.

Rincon del Diablo Municipal Water District (RDDMWD). 2011. *2010 Urban Water Management Plan*. June 14.

Regional Water Authority. 2013. *American River Basin Integrated Regional Water Management Plan 2013 Update*.

Rainbow Municipal Water District (RMWD). 2011. *2010 Urban Water Management Plan*. June 28.

Rosamond Community Service District. 2011. *Urban Water Management Plan 2010*. June.

Rowland Water District. 2011. *2010 Urban Water Management Plan*. July.

Rubidoux Community Services District. 2011. *2010 Urban Water Management Plan*. November.

Sacramento Central Groundwater Authority. 2010. *Basin Management Report 2009-2010*.

Sacramento County Water Agency. 2011. *2010 Zone 41 Urban Water Management Plan*. July.

Sacramento Groundwater Authority (SGA). 2013. *Basin Management Report Update 2013*.

Sacramento Groundwater Authority (SGA). 2014. *Groundwater Management Plan*. December.

County of San Bernardino, Special Districts County Service Area 64 (San Bernardino County). 2012. *Urban Water Management Plan–2010*. July.

San Antonio Water Company (SAWC). 2011. *2010 Urban Water Management Plan*. June.

San Bernardino Valley Municipal Water District (SBVMWD). 2011. *2010 San Bernardino Valley Regional Urban Water Management Plan*. June.

San Diego County. 2010. *General Plan Update Groundwater Study*. April.

San Diego County Water Authority (SDCWA), City of San Diego, and County of San Diego. 2013. *2013 San Diego Integrated Regional Water Management Plan, An Update of the 2007 IRWM Plan, Final*. September.

San Diego Local Agency Formation Commission. 2011. *Directory of Special Districts in San Diego County*.

San Dieguito Water District. 2011. *2010 Urban Water Management Plan*. June.

San Gabriel County Water District. 2011. *2010 Urban Water Management Plan*. May.

San Gabriel Valley Water Company (SGVWC). 2011. *2010 Urban Water Management Plan*. July.

San Gorgonio Pass Water Agency. 2010. *2010 Urban Water Management Plan for the San Gorgonio Pass Water Agency*. December.

San Joaquin County. 2009. *General Plan Update Background Report*. July.

San Juan Basin Authority. 2013. *San Juan Basin Groundwater and Facilities Management Plan*. November.

San Luis Obispo County. 2011. *Groundwater Basin Management Plan*. March.

Santa Barbara County. 2007. *Santa Barbara Countywide Integrated Regional Water Management Plan*. May.

Santa Clara Valley Water District (SCVWD). 2001. *Santa Clara Valley Water District Groundwater Management Plan*. July.

Santa Clara Valley Water District (SCVWD). 2010. *Revised Final Groundwater Vulnerability Study, Santa Clara County, California*. October.

Santa Clara Valley Water District (SCVWD). 2011. *Urban Water Management Plan*. May.

Santa Clara Valley Water District (SCVWD). 2012. *Annual Groundwater Report for Calendar Year 2012*.

Santa Clara Valley Water District (SCVWD). 2016. *Groundwater Management Plan, Santa Clara and Llagas Subbasins.* November.

Santa Clara Valley Water District (SCVWD). 2018. *Annual Groundwater Report, for Calendar year 2017.* July.

Santa Fe Irrigation District. 2011. *2010 Urban Water Management Plan*. June.

Santa Margarita River Watershed Watermaster. 2011. *Santa Margarita River Watershed Annual Watermaster Report, Water Year 2009-10*. September.

Serrano Water District. 2011. *2010 Urban Water Management Plan*. June.

South Coast Water District (SCWD). 2011. *2010 Urban Water Management Plan*. July.

San Joaquin County Flood Control and Water Conservation District (SJCFCWCD). 2008. *Groundwater Report: Fall 1999–Spring 2007*.

Santa Maria Valley Management Area (SMVMA). 2012. *2011 Annual Report of Hydrogeologic Conditions, Water Requirements, Supplies, and Disposition*. April.

Santa Margarita Water District (SMWD). 2011. *2010 Urban Water Management Plan*. July.

Solano County. 2008. *Solano County 2008 Draft General Plan, Final Environmental Impact Report*. July.

South Area Water Council. 2011. *South Basin Groundwater Management Plan*. *Working Draft*. April.

Stanislaus County. 2010. *Stanislaus County General Plan Support Documentation, Revised April 2010*. April.

Suburban Water Systems. 2011. *2010 Urban Water Management Plan*. June.

Sutter County. 2012. *Groundwater Management Plan*. Available: https://www.suttercounty.org/assets/pdf/pw/wr/gmp/Sutter_County_Final_GMP_20120319.pdf. March.

Sweetwater Authority. 2011. *2010 Urban Water Management Plan*. June 8.

Sweetwater Authority. 2016. *2015 Urban Water Management Plan*. June 27.

Tehama County Flood Control and Water Conservation District. 1996. *Coordinated AB 3030 Groundwater Management Plan*. November.

Tehama County Flood Control and Water Conservation District. 2008. *Tehama County AB-3030 Groundwater Management Plan. Background Document. Proposing Groundwater Trigger levels for Awareness Actions for Tehama County*. July.

Three Valleys Municipal Water District. 2011. *Urban Water Management Plan, 2010*. June 16.

Twentynine Palms Water District. 2014. *Mission History*. Available: http://www.29palmswater.net/mission-history.html. Accessed: July 22, 2014.

United Water Conservation District (UWCD). 2012. *Groundwater and Surface Water Conditions Report – 2011, Open File Report 2012-02*. May.

Upper Los Angeles River Area Watermaster (ULARAW). 2013. *Annual Report, Upper Los Angeles River Area Watermaster, 2011-12 Water Year, October 1, 2011 – September 30, 2012*. May.

Upper San Gabriel Valley Municipal Water District. 2011. *Urban Water Management Plan*. June.

Upper San Gabriel Valley Municipal Water District. 2013. *Integrated Resources Plan*. January.

U.S. Department of the Interior, Bureau of Reclamation (Reclamation). 2010. *Resighini Rancheria Water Resources Development Project, Environmental Assessment*. July.

U.S. Department of the Interior, Bureau of Reclamation (Reclamation) and California Department of Water Resources (DWR). 2012. *San Joaquin River Restoration Program, Final Program Environmental Impact Statement/ Environmental Impact Report*. July.

U.S. Department of the Interior, Bureau of Reclamation (Reclamation), Bureau of Land Management (BLM), and Trinity County Planning Department. 2006. *Indian Creek Rehabilitation Site: Trinity River Mile 93.7 to 96.5, Environmental Assessment/Draft Environmental Impact Report*. July.

U.S. Fish and Wildlife Service (USFWS). 2012. *Proposed Expansion San Joaquin River National Wildlife Refuge. Environmental Assessment, Land Protection Plan, and Conceptual Management Plan*. San Luis National Wildlife Refuge Complex Merced, Stanislaus, and San Joaquin Counties, CA.

U.S. Geological Survey (USGS). 1974. *Analog Model Study of the Ground-Water Basin of the Upper Coachella Valley, California*.

U.S. Geological Survey (USGS). 1986. *Geology of the Fresh Ground*‑*Water Basin of the Central Valley, California, with Texture Maps and Sections: Regional Aquifer-System Analysis. USGS Professional Paper 1401*‑*C. U.S. Government Printing Office, Washington, D.C.*

U.S. Geological Survey (USGS). 2006. *Sources of High-Chloride Water to Wells, Eastern San Joaquin Ground*‑*Water Subbasin, California. USGS Open File Report 2006*‑*1309. Prepared in cooperation with Northeastern San Joaquin Groundwater Banking Authority and California Department of Water Resources*. November.

U.S. Geological Survey (USGS). 2009. *Groundwater Availability of the Central Valley Aquifer, California. U.S. Geological Survey Professional Paper 1766. Groundwater Resources Program.*

U.S. Geological Survey (USGS). 2012. *Subsidence along the Delta-Mendota Canal*. Available: http://ca.water.usgs.gov/projects/central-valley/delta-mendota-canal-subsidence.html. Accessed: November 30, 2012.

U.S. Geological Survey (USGS). 2013a. *A Geochemical Approach to Determine Sources and Movement of Saline Groundwater in a Coastal Aquifer*. Published by National Ground Water Association. July.

U.S. Geological Survey (USGS). 2013b. *Land Subsidence along the Delta-Mendota Canal in the Northern Part of the San Joaquin Valley, California, 2003-10. Scientific Investigations Report 2013-5142*.

Vallecitos Water District. 2011. *2010 Urban Water Management Plan*. June 15.

Valley Center Municipal Water District (VCMWD). 2011. *Urban Water Management Plan 2010 Update*. July.

Ventura County Waterworks District No. 8. 2011. *2010 Urban Water Management Plan, City of Simi Valley*. May.

Victorville Water District. 2011. *2010 Urban Water Management Plan*. June.

Walnut Valley Water District. 2011. *2010 Urban Water Management Plan*. July.

Water Replenishment District of Southern California (WRD). 2007. *Battling Seawater Intrusion in the Central & West Coast Basins. Technical Bulletin. Volume 13*. Fall.

Water Replenishment District of Southern California (WRD). 2013a. *Engineering Survey and Report*. May 10.

Water Replenishment District of Southern California (WRD). 2013b. *Moving Towards 100% Recycled Water at the Seawater Intrusion Barrier Wells, Central Basin and West Coast Basin. Volume 25*. Spring.

Water Resources Association of Yolo County. 2007. *Final Integrated Regional Water Management Plan*. April.

West Basin Municipal Water District (WBMWD). 2011. *2010 Urban Water Management Plan*. May.

West Valley Water District. 2014a. *History of West Valley Water District*. Available: https://www.wvwd.org/index.aspx?nid=92. Accessed: August 7, 2014.

West Valley Water District. 2014b. *Groundwater Wellhead Treatment System Project*. Available: https://www.wvwd.org/index.aspx?NID=169. Accessed: August 7, 2014.

West Valley Water District. 2014c. *Baseline Feeder Water Supply Project*. Available: http://www.wvwd.org/index.aspx?NID=197. Accessed: August 7, 2014.

Western Municipal Water District (WMWD). 2011. *2010 Urban Water Management Plan Update*. June.

Yolo County. 2009. *Yolo County 2030 Countywide General Plan Environmental Impact Report*. April.

Yolo County Flood Control and Water Conservation District (YCFCWCD). 2012. *Regional Conjunctive Use Enhancement: Nitrate Fingerprinting and Groundwater Age Determination*. December.

Yorba Linda Water District. 2011. *2010 Urban Water Management Plan*. May.

Yuba County Water Agency (YCWA). 2010. *Groundwater Management Plan*. December.

Yucaipa Valley Water District (YVWD). 2011. *2010 Urban Water Management Plan*. July.

Yuima Municipal Water District. 2014a. *Yuima Municipal Water District, History*. Available: http://www.yuimamwd.com/content.php?ID=19. Accessed: July 11, 2014.

Yuima Municipal Water District. 2014b. *2013 Consumer Confidence Report*. June 1.

Yurok Tribe. 2012. *NPS Assessment and Management Program Plan*. December.

Zone 7 Water Agency (Zone 7). 2005. *Groundwater Management Plan for the Livermore-Amador Valley Groundwater Basin*. September.

Zone 7 Water Agency (Zone 7). 2010. *2010 Urban Water Management Plan*. December.

Zone 7 Water Agency (Zone 7). 2013. *Annual Report for the Groundwater Management Program 2012 Water Year Livermore Valley Groundwater Basin*. May.

Zone 7 Water Agency (Zone 7). 2018. Groundwater Management Program Annual Report, Livermore Valley Groundwater Basin. 2017 Water Year. March.

For publications staff use:

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