Chapter 2
Water Resources

This chapter discusses existing surface and groundwater resources and the management of those resources within the plan area and extended plan area, as described in Chapter 1, *Introductio*n, as well as resources upstream that drain to the plan area and extended plan area. The information in this chapter provides context for the description of the Lower San Joaquin River (LSJR) alternatives and southern Delta water quality (SDWQ) alternatives in Chapter 3, *Alternatives Description*. As needed, this recirculated substitute environmental document (SED) present additional existing setting and modeling information for each relevant resource area and impact analysis.

This chapter is generally organized by large geographic areas within the plan area: the San Joaquin River (SJR) Basin, Delta, and San Joaquin Groundwater Basin. Section 2.1, *Overview*, provides a general overview of the existing surface, delta, and groundwater resources within the SJR Basin, Delta, and San Joaquin Groundwater Basin and the water supply and uses those resources provide. Sections 2.2 through 2.6 further discuss surface water resources by tributary from south to north (upstream to downstream) in the SJR Basin, including the operation of rim dams[1] for hydropower and water storage, existing water diversions, current flow requirements for fish protection, and hydrology (unimpaired and historical flow). Section 2.7, *Southern Delta*, describes existing salinity and water quality conditions and water management in the southern Delta that influence water quality. Management, in this context, includes operations of the Central Valley Project (CVP) and State Water Project (SWP), existing water diversions, and existing municipal and agricultural drainage discharges. Finally, Section 2.8, *San Joaquin Valley Groundwater Basin*, describes general characteristics of existing groundwater resources within the San Joaquin Groundwater Basin geographically from north to south.

2.1 Overview

This section generally describes the surface and groundwater resources located within the SJR Basin, the Delta, and the San Joaquin Valley Groundwater Basin that occur primarily within in the plan area and the extended plan area and that could be affected by the LSJR alternatives. Major water supplies and uses are summarized.

2.1.1 San Joaquin River Basin

The Central Valley Basin of California is surrounded by mountains except for a narrow gap on its western edge at the Carquinez Strait. Streamflow in the Central Valley is chiefly derived from runoff from the Cascade and Sierra Nevada ranges, with minor amounts from the Coast Ranges. Precipitation varies, with approximately four-fifths of the total occurring between the end of October and the beginning of April. Snowpack in the high Sierra delays runoff until the snow melts,

[1] In this document, the term *rim dams* is used when referencing the three major dams and reservoirs on each of the eastside tributaries: New Melones Dam and Reservoir on the Stanislaus River; New Don Pedro Dam and Reservoir on the Tuolumne River; and New Exchequer Dam and Lake McClure on the Merced River.

typically in April, May, and June. Normally, approximately half of the annual runoff occurs in these months. The 450-mile-long Central Valley Basin of California is divided into the Sacramento Valley in the north and the San Joaquin Valley in the south. The San Joaquin Valley spans two basins: the SJR Basin and the Tulare Lake Basin (DWR 2009). These two basins are distinct drainage areas separated by a low divide formed by coalescing alluvial fans. The divide lies between the SJR to the north, part of which is in the plan area and extended plan area, and Kings River to the south, which is not in the plan area or extended plan area (Figure 2-1a shows the SJR Basin).

The SJR Basin drains approximately 15,550 square miles of the Sierra Nevada and the southern portion of the Central Valley of California. The headwaters of the SJR are on the western slope of the Sierra Nevada at elevations in excess of 10,000 feet (ft). The Upper SJR and the LSJR tributaries drain large areas of high-elevation watersheds that supply snowmelt runoff during the late spring and early summer. Other SJR tributaries on the east side of the SJR Basin include the Chowchilla and Fresno Rivers, which drain the Sierra Nevada foothills. Most of the runoff in these smaller SJR tributaries results from rainfall, which is stored in reservoirs for irrigation purposes. A few small tributaries to the west, with headwaters in the rain shadow of the Coast Ranges, contribute little flow to the LSJR.

At the foot of the mountains (in the foothills), the SJR is impounded by Friant Dam, which forms Millerton Lake. The SJR reaches the valley floor near Fresno. Infrequent floodwaters from the Kings River flow into the SJR at Mendota Pool reservoir via the Fresno Slough. The river then flows north-northwest, and three eastside tributaries[2] enter it before it flows into the southern Delta at Vernalis (Vernalis is a unincorporated community in San Joaquin County downstream of the Stanislaus River and upstream of tidal effects from the Delta, where the LSJR enters the southern Delta).

In the Upper SJR, Friant Dam diverts water into the Friant-Kern and Madera canals. Until the SJR Restoration Program[3] began in 2009, only a small seasonal flow (125 cubic feet per second [cfs] maximum) was released from Friant Dam for downstream riparian water uses. Flood control releases have frequently been necessary in above-normal and wet years.[4] Downstream of Friant Dam, the primary sources of surface water to the SJR are its three eastside tributaries that drain the western slope of the Sierra Nevada. Table 2-1 summarizes the SJR Basin characteristics and existing reservoirs the tributaries.

In this document, the LSJR is defined as the portion of the SJR between its confluence with the Merced River and downstream to Vernalis. It receives flow from the three eastside tributaries. These tributaries provide the primary sources of surface water to the LSJR together with flow from the Upper SJR. The LSJR extends through San Joaquin, Stanislaus, and Merced Counties. The three eastside tributaries and rim dams, New Melones, New Don Pedro, and New Exchequer, are located in several different counties. Table 2-2 and Figure 2-1b identify the tributaries, rim dams, and localities within the plan area and extended plan area

[2] In this document, the term *three eastside tributaries* refers to the Stanislaus, Tuolumne, and Merced Rivers.

[3] Implementation of the settlement and the Friant Dam release flows required by the San Joaquin River Restoration Program are expected to increase the existing SJR flows at Stevinson in the near future.

[4] Flows released from Friant Dam for fish protection or for flood control would contribute to the SJR flow at Vernalis, but they are not part of the plan amendments or alternatives evaluated in this document as described in Chapter 3, *Alternatives Description*.

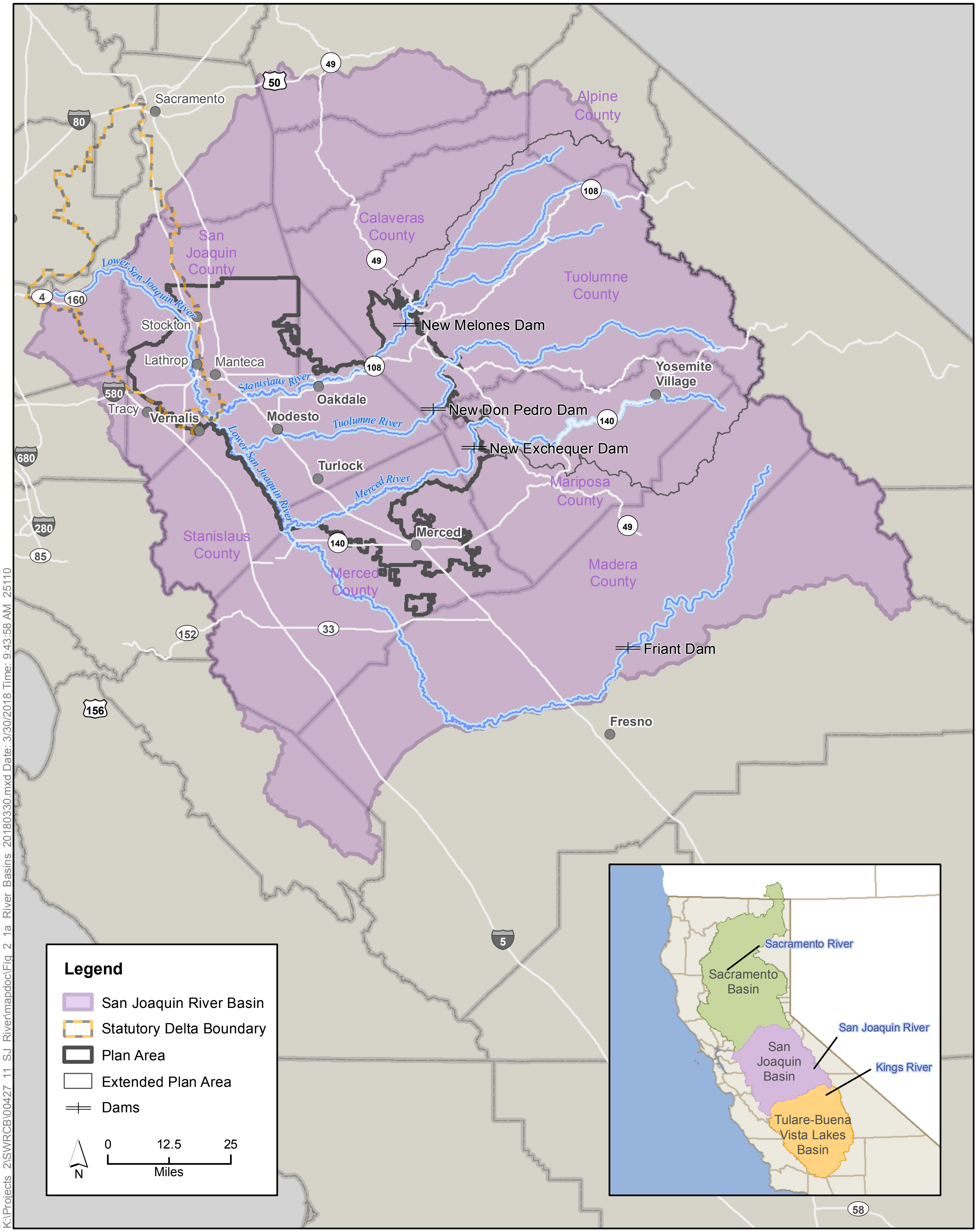

Figure 2-1a
Central Valley Basin and San Joaquin River Basin

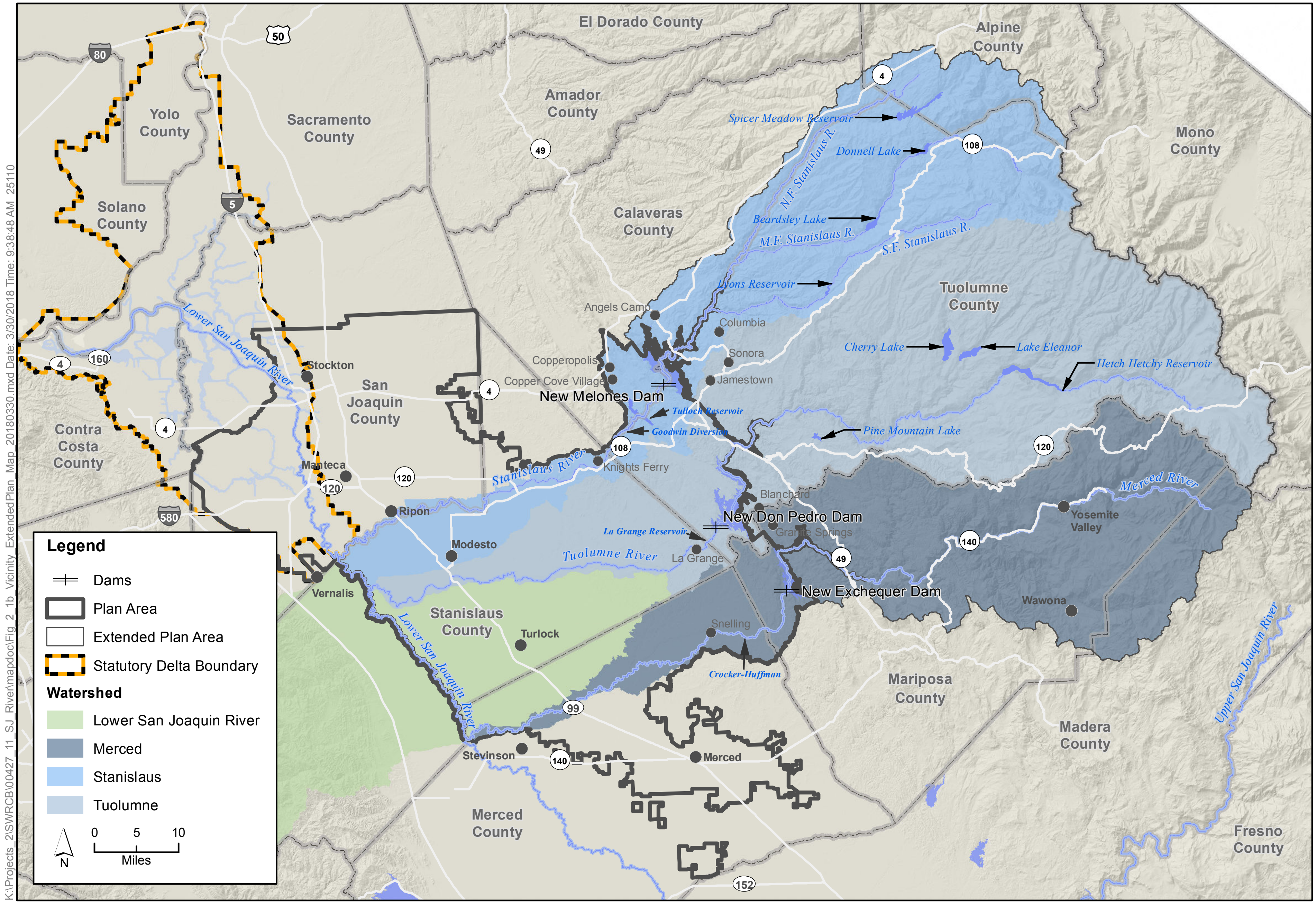

Figure 2-1b
Vicinity Map of Plan Area and Extended Plan Area

Table 2-1. Summary of Watershed and Reservoir Characteristics in San Joaquin River Basin

	Lower San Joaquin River			
Characteristic	Stanislaus River	Tuolumne River	Merced River	Upper San Joaquin River
Median annual unimpaired flow (1923–2008) [a]	1.08 MAF	1.72 MAF	0.85 MAF	1.44 MAF (upstream of Friant Dam)
Drainage area of tributary at confluence SFR —(and percent of tributary upstream of mouth)[b]	1,195 square miles (82% upstream of Goodwin)	1,870 square miles (82% upstream of La Grange)	1,270 square miles (84% upstream of Merced Falls)	1,675 square miles (100% upstream of Friant Dam)
Total river length	161 miles	155 miles	135 miles	330 miles
Miles downstream of major dam	New Melones: 62 miles Goodwin: 59 miles	New Don Pedro: 55 miles La Grange: 52 miles	New Exchequer: 63 miles Crocker Huffman: 52 miles	Friant: 266 miles
Confluence with LSJR—River Miles (RM) upstream of Sacramento River confluence	RM 75	RM 83	RM 118	RM 266
Number of dams[c]	28 DSOD[d]	27 DSOD	8 DSOD	19 DSOD
Total reservoir storage[c]	2.85 MAF	2.94 MAF	1.04 MAF	1.15 MAF
Most downstream dam (with year built and capacity)[e]	Goodwin, 59 miles upstream of LSJR (1912, 500 AF).	LaGrange, 52 miles upstream of LSJR (1894, 500 AF).	Crocker-Huffman, 52 miles upstream of LSJR (1910, 200 AF).	Friant, 260 miles upstream of the Merced confluence (1942, 520 TAF)
Major downstream dams (with year built and reservoir capacity)[e]	New Melones (1978, 2.4 MAF) ; Tulloch, Beardsley, Donnells "Tri-dams project" (1958, 203 TAF)	New Don Pedro (1970, 2.03 MAF)	New Exchequer/Lake McClure (1967, 1.02 MAF); McSwain (1966, 9.7 TAF)	Friant (1942, 520 TAF)
Major upstream dams (with year built and reservoir capacity)	New Spicer Meadows (1988, 189 TAF)	O'Shaughnessy/Hetch Hetchy Reservoir (1923, 360 TAF); Cherry Valley (1956, 273 TAF)	None	Shaver Lake (1927, 135 TAF); Thomas Edison Lake (1965, 125 TAF); Mammoth Pool (1960, 123 TAF)

Source: Appendix C, *Technical Report on the Scientific Basis for Alternative San Joaquin River Flow and Southern Delta Salinity Objectives*.
MAF = million acre-feet; RM = river mile; DSOD = Division of Safety of Dams; AF = acre feet; TAF = thousand acre-feet
[a] Median annual unimpaired flow adjusted from Cain et al. 2003.
[b] Source: NRCS Watershed Boundary Dataset (2009).
[c] Source: Cain et al. 2003.
[d] DSOD dams are those greater than 50 feet in height and/or greater than 50 acre-feet of capacity, with some exceptions.
[e] Source: Cain et al. 2003.

Table 2-2. Location of LSJR Tributaries and Rim Dams

River	Rim Dam/ Reservoir	Downstream Dam(s)	Plan Area Counties	Extended Plan Area Counties	Communities within General Proximity of the Rim Dams
Stanislaus	New Melones/ New Melones	Tulloch Goodwin	Calaveras Tuolumne San Joaquin	Alpine Calaveras Tuolumne	Angels Camp, Copperopolis, Columbia, Sonora, Jamestown, Copper Cove
Tuolumne	New Don Pedro/ New Don Pedro	La Grange	Tuolumne Stanislaus	Tuolumne	Blanchard, Granit Springs
Merced	New Exchequer/ Lake McClure	Crocker Huffman	Mariposa Merced	Mariposa Madera	Granite Springs

The hydrology of the LSJR tributaries and the SJR at Vernalis is dominated by precipitation in winter and early spring and snowmelt runoff in late spring and early summer (McBain and Trush 2002). The components of the unimpaired flow[5] regime in the Sierra Nevada are fall and winter storms (rainfall-runoff), spring snowmelt, and summer declining base flow (McBain and Trush 1999; Cain et al. 2003). In recent years, only a small fraction of the estimated unimpaired flow reaches Vernalis, except in high runoff years (e.g., 1986). During these high runoff years, flood control releases are made and a majority of the unimpaired runoff reaches Vernalis. In most years, a large fraction of the unimpaired flow is diverted directly for beneficial uses, such as irrigation or diverted to storage reservoirs for later use. Construction of storage reservoirs with hydropower diversions in the Sierra Nevada and the major tributary reservoirs with irrigation diversions in the Central Valley have greatly altered the natural flow regime of the LSJR and the three eastside tributaries (McBain and Trush 1999; Kondolf et al. 2001; Cain et al. 2003; Brown and Bauer 2009).

2.1.2 Delta

The Delta, with legal boundaries established by California Water Code Section 12220, encompasses a 738,000-acre area generally bordered by the cities of Sacramento, West Sacramento, Stockton, Tracy, Antioch, and Pittsburg (Figure 2-2). This former wetland area has been reclaimed into more than 60 islands and tracts, 700 miles of waterways, and roughly 520,000 acres devoted primarily to farming (CALFED 2005). The largest source of fresh water for the Delta is the Sacramento River, which transports an average of approximately 18.3 million acre-feet (MAF) per year into the Delta (DWR 2012). Additional flows from the Yolo Bypass, the LSJR, the Mokelumne River, and the Cosumnes River contribute an average of 5.8 MAF, with Delta precipitation adding approximately another 1.0 MAF (DWR 2009, 2012). Of the 5.8 MAF contributed from sources to the south of the Delta, an average of 1.9 MAF comes from the three LSJR tributaries. During low-flow periods, the hydrodynamics of the channels within the Delta are influenced primarily by the tides, with secondary effects from inflows and CVP and SWP exports (Burau et al. 1999; Kimmerer 2004).

[5] *Unimpaired flow* represents the water production of a river basin, unaltered by upstream diversions, storage, or by export or import of water to or from other watersheds. It differs from natural flow because unimpaired flow is the flow that occurs at a specific location under the current configuration of channels, levees, floodplain, wetlands, deforestation and urbanization.

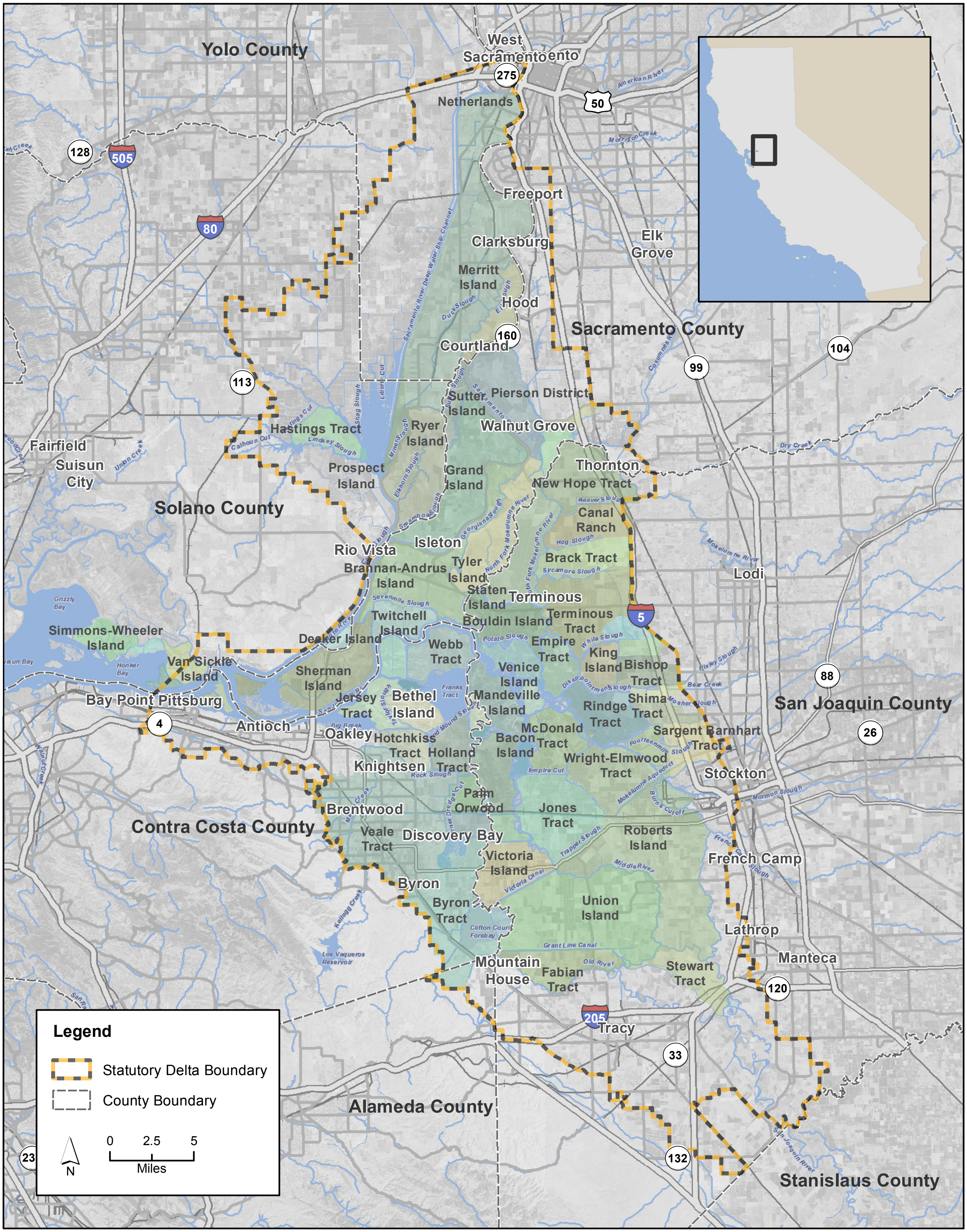

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Figure 2-2
The Sacramento–San Joaquin Delta

Tidal rise and fall varies with location, from less than 1 foot in the eastern Delta to more than 5 ft in the western Delta (DWR 2009). Approximately half of the tidal flows follow the Sacramento River channel and about half follow the SJR channel into the southern Delta. The magnitude and movement of tidal flows diminish at locations farther into the Delta, and one-directional riverine movement begins to become more prominent. The twice-daily tides and varying inputs from rivers and streams result in highly dynamic Delta conditions that change continuously (Deltares 2009).

Major diversions in the southern Delta include the SWP (Banks Pumping Plant), CVP (Jones Pumping Plant), and Contra Costa Water District (CCWD). Both the CVP and the SWP use Delta channels to convey water released from the upstream Sacramento River Basin reservoirs to pumping stations in the southern Delta. The use of the Delta channels to convey water from the northern Delta to the southern Delta export facilities modifies the natural net flow patterns (i.e., direction) in some of the southern Delta channels (i.e., Old and Middle Rivers).

The southern portion of the Delta overlies the Tracy Groundwater Subbasin. The Tracy Subbasin is defined by the areal extent of unconsolidated to semiconsolidated sedimentary deposits that are bounded by the Diablo Range on the west, the Mokelumne River and SJR on the north, the SJR on the east, and the San Joaquin–Stanislaus County line on the south. The Eastern San Joaquin Subbasin is adjacent to the east of the Tracy Subbasin and the Delta-Mendota Subbasin is adjacent to the south. These subbasins are all within the San Joaquin Valley Groundwater Basin. The Tracy Subbasin lies south of the Sacramento Valley Groundwater Basin and Solano Subbasin. The Tracy Subbasin is drained by the SJR and one of its major westside tributaries, Corral Hollow Creek (DWR 2003f).

2.1.3 San Joaquin Valley Groundwater Basin

The plan area lies within the northern portion of the San Joaquin Valley Groundwater Basin. This portion of the San Joaquin Valley Groundwater Basin, as defined in the California Department of Water Resources (DWR) Bulletin 118,[6] approximately coincides with the western portion of the River (SJR) Hydrologic Region. The SJR Hydrologic Region covers approximately 3.73 million acres of the larger San Joaquin Valley Groundwater Basin, with the remaining 5 million acres in the Tulare Lake Hydrologic Region.

The San Joaquin Valley Groundwater Basin is comprised of 17 subbasins, of which 9 subbasins underlie within the SJR Hydrologic Region. Two additional groundwater basins, the Los Banos Creek Valley Basin and Yosemite Valley Basin, are not part of the San Joaquin Valley Groundwater Basin, but also underlie the SJR Hydrologic Region. The plan area lies almost entirely within the boundaries of four subbasins on the east side of the San Joaquin Valley Groundwater Basin: Eastern San Joaquin, Modesto, Turlock, and Merced (Figure 2-3). Portions of the plan area also lie within small parts of three additional subbasins: Tracy, Chowchilla, and Delta-Mendota (Figure 2-3). Groundwater extracted from these subbasins provides water for agricultural and municipal uses. Many San Joaquin Valley cities rely either wholly or partially on groundwater to meet municipal needs. Groundwater levels in the San Joaquin Valley Groundwater Basin have generally declined as a result of extensive agricultural pumping—by as much as 100 ft in some areas, primarily in the southern and western-most portions of the basin (USGS 1999). Groundwater pumping in the region continues to increase in response to growing urban and reduced surface water deliveries from north of the Delta.

[6] DWR's Bulletin 118 series of reports summarize and evaluate California groundwater resources.

Groundwater quality varies throughout the San Joaquin Valley Groundwater Basin and its subbasins. Variation in groundwater quality is attributed to the composition of the subsurface and the quality of the surface water infiltrating into the aquifer. Adverse water quality conditions—caused by naturally occurring constituents, as well as by agricultural and industrial contaminants—can affect the beneficial uses of groundwater. Salinity is one of the primary water quality issues, particularly in the western portion of the basin.

The Eastern San Joaquin, Modesto, Turlock, and Merced[7] Subbasins are further described, along with a summary of agricultural and municipal uses, in Sections 2.8.1 through 2.8.4, respectively. Additional information and the evaluation of groundwater impacts are provided in Chapter 9, *Groundwater Resources*.

2.1.4 Water Supply and Use

Surface Water

Several irrigation and water districts hold pre-1914 and/or appropriative water rights or contracts to divert surface waters from each of the three LSJR tributaries. These districts provide primarily agricultural supply and, in some limited cases through existing agreements, local municipal supply. Some of these districts also provide power to their service areas from hydropower generated by the rim dams. These dams also provide flood control, recreation, and other uses. Property owners with riparian water rights also divert surface water from the LSJR tributaries, primarily for agricultural uses. A summary of the irrigation district and riparian diversions from the LSJR tributaries is presented in Table 2-3, and Figure 2-4 shows the service areas of the irrigation and water districts. The information in Table 2-3 is from the irrigation districts' most recent agricultural water management plans (AWMPs) or water management plans. This information is provided to illustrate surface water diversions based on published irrigation district data. It is possible that surface water diversions may have been higher in the past, at levels not reflected by the numbers in the table, depending on the time frames and available data reported in the agricultural water management plans. The general description of various water rights in this chapter, and other chapters of this SED, are for informational purposes only, and do not constitute any confirmation by the State Water Board of the validity of any given water right claim. A more detailed description of the major irrigation districts is presented in Sections 2.3.2, 2.4.2, and 2.5.2 for diversions from the Merced, Tuolumne, and Stanislaus Rivers, respectively.

A representation of the water balance associated with the surface water diversions is shown in Figure 2-5. Diverted water is delivered separately to riparian diverters and irrigation districts. Riparian diverters directly deliver water for crop irrigation. Irrigation districts deliver water to a distribution system that may deliver water to a municipal water system that is separate from the delivery system for crop irrigation. Water delivery to crops is defined as applied surface water. Consumptive Use of Applied Water (CUAW) accounts for water losses due to crop irrigation. CUAW is generally defined in this analysis as irrigation water consumed by crops (not returned to the system), and it includes evaporation. Water losses separate from CUAW include deep percolation from agricultural fields, recharge and system seepage, and surface water returns. To promote water use efficiency, irrigation districts engage in conjunctive use of groundwater to

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[7] As described in Chapter 9, *Groundwater Resources*, the Merced Subbasin was extended for the analysis to include a part of the Chowchilla Subbasin.

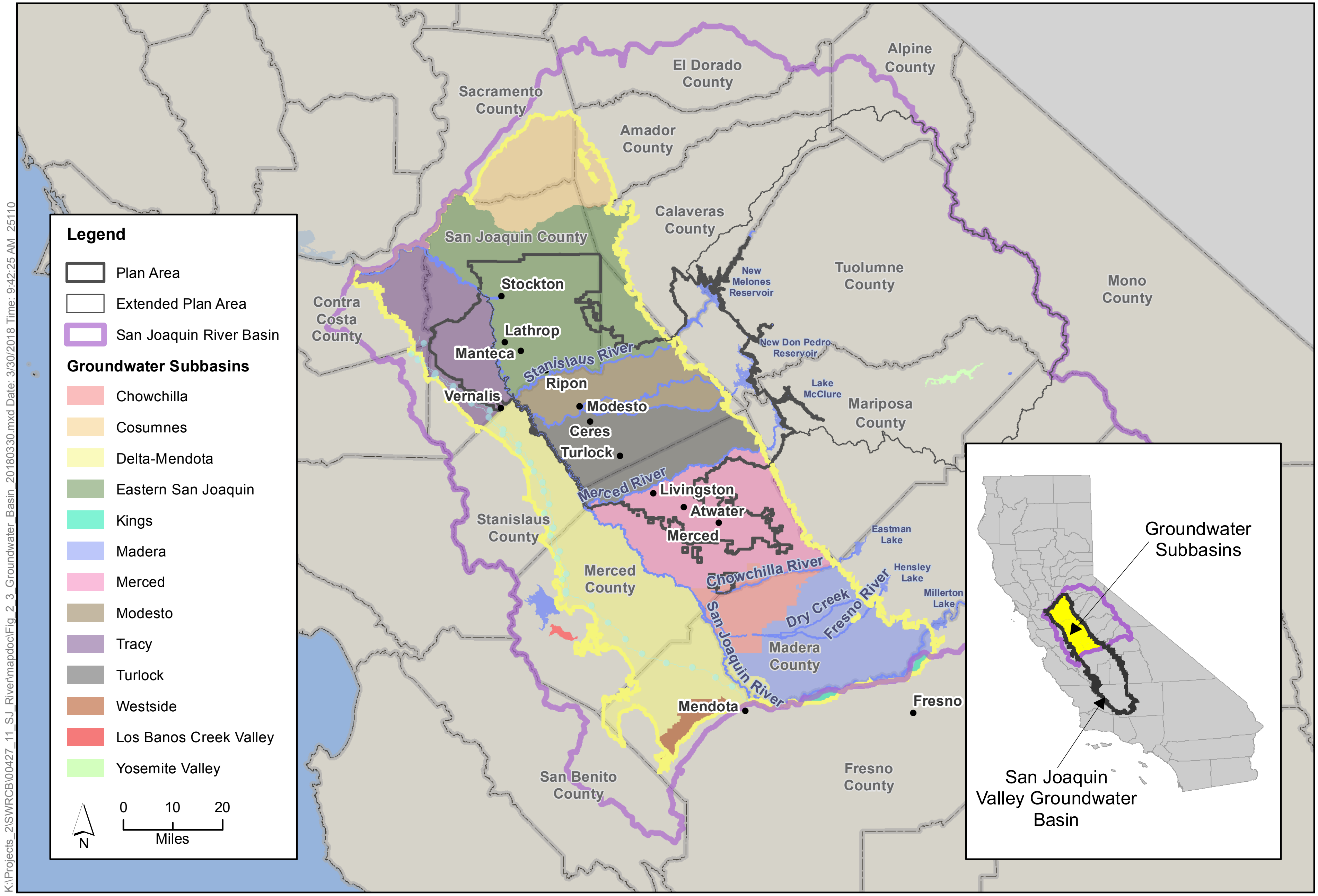

Figure 2-3
San Joaquin River Basin and Groundwater Subbasins

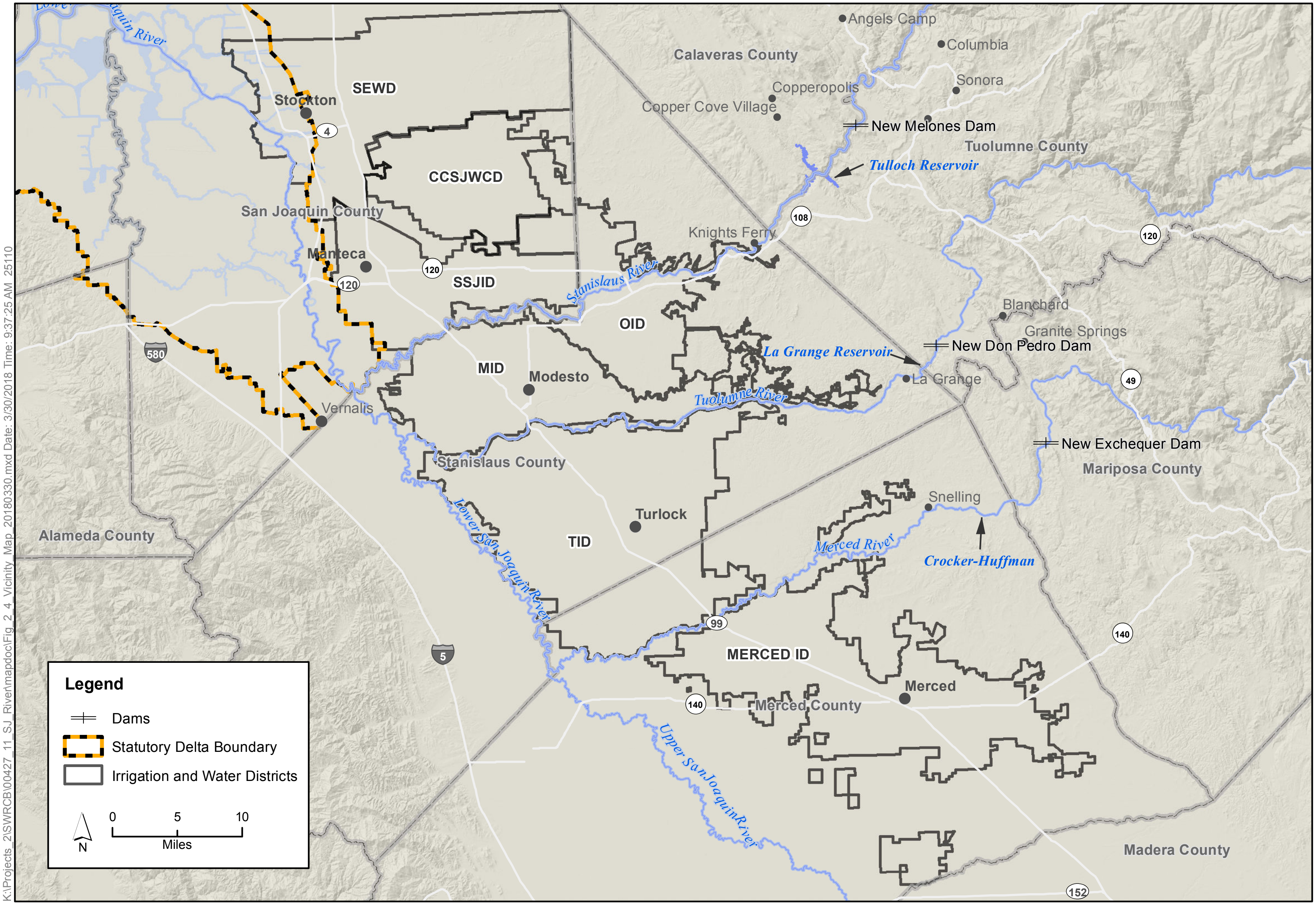

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Figure 2-4
Vicinity Map of Irrigation Districts

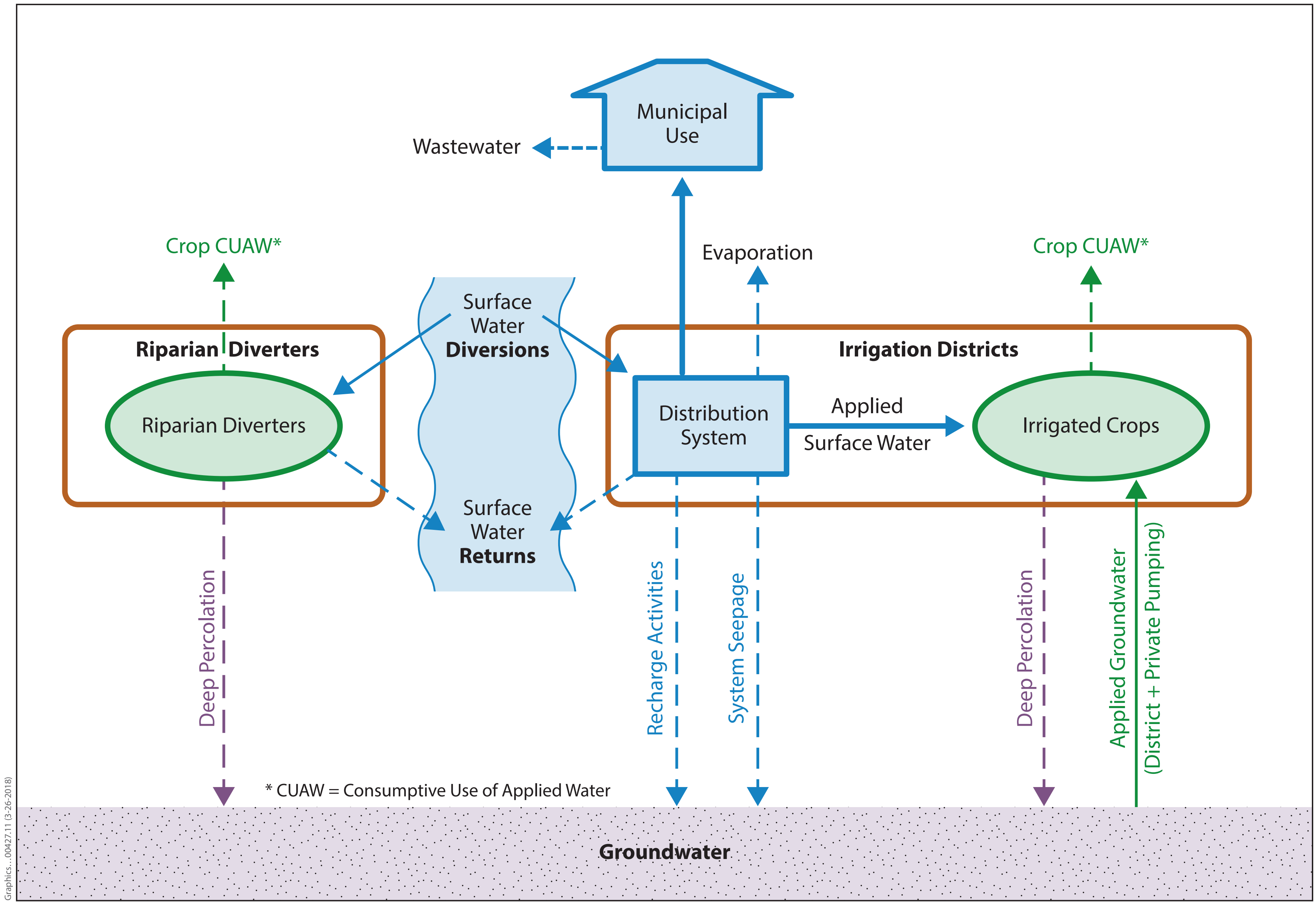

Figure 2-5
Schematic Representation of Water Use by Irrigation Districts and Riparian Diverters

supplement surface water deliveries and in-lieu recharge practices in years of adequate surface water supplies. These practices are intended to provide a net input to the groundwater over the long term.

Table 2-3. Summary of Major LSJR Surface Water Diverters and Surface Water Diversions as Reported by Irrigation District Agricultural Water Management Plans

River	Rim Dam	Surface Water Diverters	Surface Diversion Water (AF/y)[a]	Surface Water Users [b]
Stanislaus	New Melones	South San Joaquin Irrigation District (SSJID)	259,165 [c]	SSJID City of Lathrop City of Manteca City of Tracy City of Ripon SEWD
		Oakdale Irrigation District (OID)	261,896 [d]	OID SEWD
		Stockton East Water District (SEWD)	118,216 [e]	SEWD City of Stockton CalWater San Joaquin County
		Central San Joaquin Water Conservation District (CSJWCD)	32,000 [f]	CSJWCD
Tuolumne	New Don Pedro	Turlock Irrigation District (TID)	537,685 [g]	TID
		Modesto Irrigation District (MID)	315,912 [h]	MID City of Modesto
Merced	New Exchequer	Merced Irrigation District (Merced ID)	484,759 [i]	Merced ID City of Merced Stevinson Water District

[a] These are assumed maximum diversions based on a review of published data by irrigation districts. The recent documents contain diversion values for multiple years; the year with the maximum value was selected for this table. Because the published data do not necessarily represent a lengthy time series (i.e., many years over the past 82 years), surface water diversions could be greater for these various surface water diverters than are reported in this table.

[b] Surface water users include those entities with rights to divert surface water released from the rim dams as well as those entities that have contracts to receive surface water. In some cases the diverters and the users are the same; in other cases, the diverters provide surface water to additional users.

[c] SSJID 2012. (maximum diversions from Joint Supply Canal [Table 5-13 value for 2004] and maximum direct diversions from Main Canal [Table 5-15 value for 2008]).

[d] OID 2012. (system inflows for 2007 in Table 5-13).

[e] SEWD 2014. (Table 1, surface water supply in 2010).

[f] CSJWCD 2013 (Stanislaus River surface water use in 2009).

[g] TID 2012. (Table 3.3, surface water supply in 2011).

[h] MID 2012a. (Table 30, diverted water for 2011).

[i] Merced ID 2013. (Table C-3, diverted water for 2006).

Groundwater

Figure 2-6 illustrates a conceptual representation of municipal and agricultural groundwater usage. Many San Joaquin Valley cities rely either wholly or partially on groundwater to meet municipal needs (DWR 2003a). Some agricultural and municipal uses are supplied only by groundwater pumping within the plan area. Additionally, applied groundwater is pumped by private users—those outside of irrigation district jurisdiction yet within the same groundwater basin. Generally, little information is available regarding irrigated acres and crop types for areas outside the irrigation districts irrigated primarily by groundwater.

2.2 Upper San Joaquin River

2.2.1 Basin Overview

The Upper SJR is the river south (upstream) of the confluence of the Merced River and the LSJR and includes the north, middle, and south forks.[8] The forks converge upstream of Mammoth Pool Reservoir and are impounded at the uppermost region of the valley floor by Friant Dam, approximately 25 miles northeast of Fresno—the location for measuring the unimpaired flow from the Upper SJR Watershed.[9] As identified in Table 2-1, the Upper SJR above Friant Dam drains an area of approximately 1,676 square miles with an annual average unimpaired runoff of 1.7 MAF. While the Upper SJR Watershed is outside the plan area, it is drained by the SJR and abuts the plan area at the Merced River confluence; accordingly, it is included in the description below.

Several dams and reservoirs on the Upper SJR are primarily used for seasonal storage for hydroelectric power generation. These dams and reservoirs—Edison, Florence, Huntington, Mammoth Pool, and Shaver Lakes—are upstream of Friant Dam. Friant Dam, completed in 1942 and placed into full operation (with canal diversions) in 1951, has a capacity of 520 thousand acre-feet (TAF) and provides flood control, releases for senior water rights diversions, and diversions into the Madera and Friant-Kern Canals (discussed below). Friant Dam forms Millerton Lake; upstream reservoir operations affect inflows to Millerton Lake. Flood control storage space in Millerton Lake is limited, and additional flood control is provided by the upstream reservoirs.

2.2.2 Water Diversion and Use

The Friant Water Authority delivers water to more than a million acres of agricultural land in Fresno, Kern, Madera, and Tulare Counties in the San Joaquin Valley. Two major canal systems divert water from Friant Dam and deliver it via the 152-mile Friant-Kern Canal south into the Tulare Lake Basin and via the 36-mile Madera Canal north to the Madera and Chowchilla Irrigation Districts. The average annual water diversion at Friant Dam is approximately 1.1 MAF. Under their water contracts, irrigation districts receive Class I (reliable) and Class II (less dependable) deliveries, as well as surplus water during flood control operations.

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[8] The SJR Restoration Program defines the Middle SJR as the region between Friant Dam and the Merced River. There is very little runoff from the middle SJR as the Fresno and Chowchilla Rivers are the only two tributaries in this part of the river.

[9] Most of the information in Sections 2.2 through 2.6 is based on several reports including USBR 2008, EA EST 1999, and State Water Board 1999. Throughout this chapter, if no citation is given, the information was taken from one or a combination of these reports.

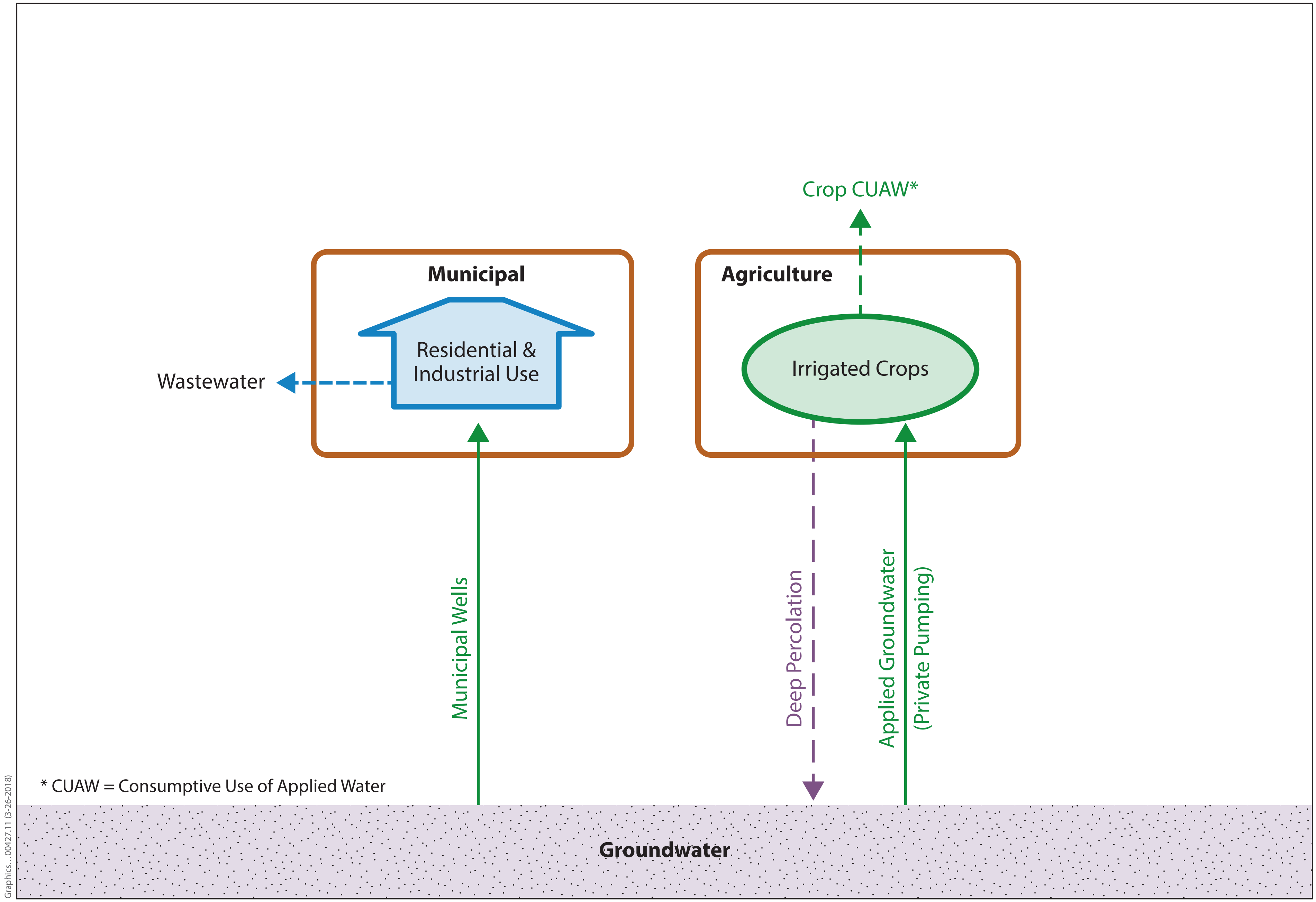

Figure 2-6
Schematic Representation of Groundwater Pumping with Associated Consumptive Use and Returns

2.2.3 Flow Requirements

Two requirements for flow are in effect below Friant Dam, primarily to convey irrigation water to downstream diversion points: (1) a minimum of 5 cfs to bypass the last water right diversion about 40 miles downstream near Gravelly Ford, and (2) a maximum river release of approximately 125 cfs in the summer months to supply downstream riparian and water rights users. These flows generally do not make it past the Mendota Pool on the Upper SJR; consequently, water released from Friant Dam often does not reach the LSJR and Merced River confluence. The U.S. Bureau of Reclamation (USBR) is undertaking an SJR Restoration Program[10] that would provide water throughout the year to reconnect the river upstream of Friant Dam to the Upper SJR at the mouth of the Merced River. In 2006, parties to federal lawsuit *NRDC v. Rodgers* executed a stipulation of settlement that calls for, among other things, restoration of flows on the Upper SJR from Friant Dam to the confluence of the LSJR with the Merced River. Required release flows from Friant Dam for each water year type have been identified, but the amount of this Upper SJR water observed at the mouth of the Merced River is uncertain.[11]

2.2.4 Hydrology

The average annual unimpaired flow for the Upper SJR at Friant Dam from 1984 through 2009 was 1,702 TAF. This represents approximately 28 percent of the unimpaired flow on the SJR at Vernalis. Most of this water is seasonally stored in upstream reservoirs and in Millerton Lake and diverted to the Friant-Kern and Madera Canals for irrigation. Historically, during high flow years, there are considerable flood control releases from Friant Dam. The historical monthly flows on the Upper SJR at Friant Dam were less than 125 cfs in all months, except when releases were made for flood control purposes. From 1984 through 2009, Friant Dam releases averaged 420 TAF per year (TAF/y), or approximately 25 percent of the unimpaired flow.

As an example of these historical releases, Figure 2-7 shows the monthly unimpaired flow and the historical flow below Friant Dam for the recent 10-year period of water years 2000 through 2009.[12] The average Friant Dam release for this period was approximately 20 percent of the unimpaired flow. Often, however, releases were less than 20 percent of the unimpaired flow, with flood control releases providing the majority of the flow below Friant Dam.

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[10] Implementation of the settlement and the Friant Dam release flows required by the SJR Restoration Program are not part of the alternatives described in Chapter 3, *Alternatives Description*. The State Water Board expects the SJR Restoration Program would increase the existing SJR flows at Stevinson (the existing flows are currently simulated in CALSIM).

[11] In 2006, a settlement was reached in *Natural Resources Defense Council et al. v. Rodgers et al.*, and the San Joaquin River Restoration Settlement Act (Settlement Act), Public Law No. 111-11, Section 1001 et seq., 123 Stat. 991, 1349 was established. The settlement addressed restoration of fish habitat in the SJR below Friant Dam and ended an 18-year legal dispute over the operation of Friant Dam. The San Joaquin River Restoration Program was established to implement the settlement.

[12] A water year begins in October of the previous year. For example, water year 2000 begins in October, 1999.

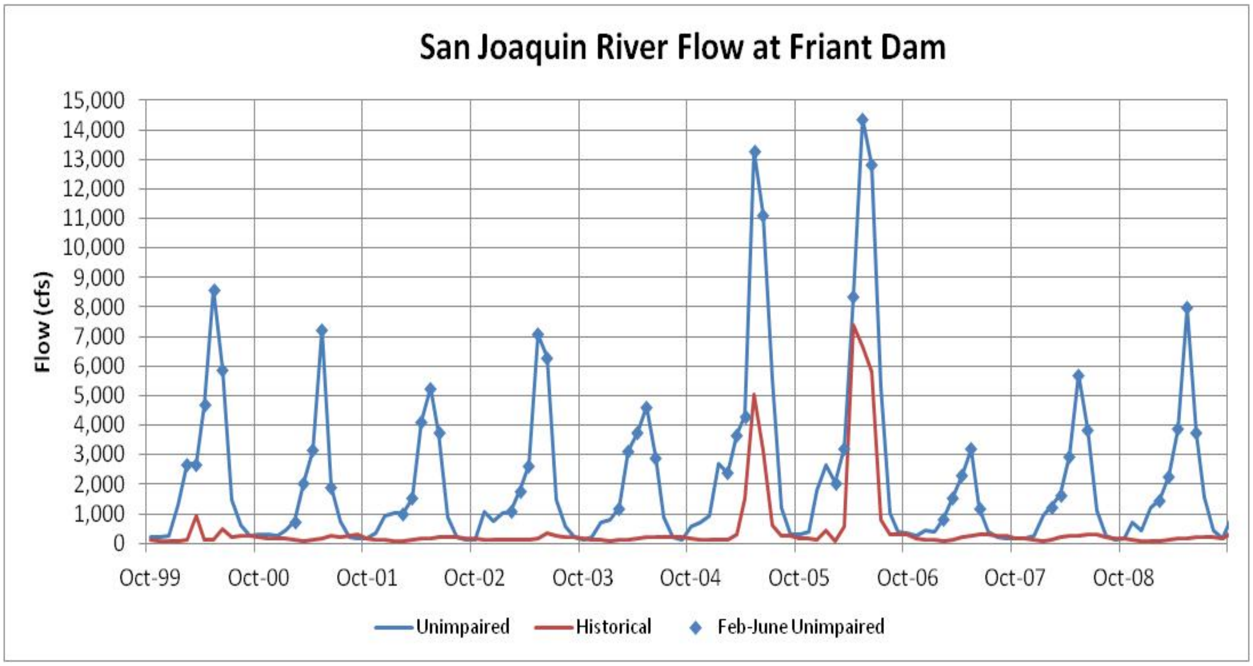

Figure 2-7. Monthly Unimpaired and Historical San Joaquin River Flows at Friant Dam for Water Years 2000–2009 (cfs = cubic feet per second)

2.3 Merced River

2.3.1 Basin Overview

As shown in Table 2-1, the Merced River is 135 miles long and drains a 1,270-square-mile watershed. The Merced River originates high in the Sierra Nevada and flows into the LSJR approximately 35 miles upstream of the Tuolumne River confluence. Approximately 52 miles of the Merced River are downstream of Crocker Huffman Dam, the most downstream barrier to fish migration. Like the Stanislaus and Tuolumne Rivers, reservoir operations have increased average monthly flows during late summer and early fall and reduced the average monthly flows during the remainder of the year (Stillwater Sciences 2001a).

Four mainstem dams and eight Division of Safety of Dams (DSOD) dams on the Merced River regulate flow conditions. The four mainstem dams, which are known collectively as the Merced River Development Project, are owned by Merced ID and licensed by the Federal Energy Regulatory Commission (FERC). New Exchequer Dam and McSwain Dam, a regulating dam downstream of New Exchequer, are the largest of the four mainstem dams; Merced Falls Dam and Crocker-Huffman Dam are the smallest. Tributaries of the Merced River upstream of New Exchequer Dam are regulated by three small dams MacMahon, Green Valley, and Metzger (Stillwater Sciences 2001b). New Exchequer Dam is the largest dam on the Merced River. It creates Lake McClure, which has a capacity of approximately 1 MAF and regulates releases to the Merced River. The New Exchequer powerhouse has a capacity of approximately 95 megawatts (MW) with a maximum flow of approximately 3,200 cfs. Water released for peaking power is regulated at the approximately 10 TAF McSwain Reservoir.

2.3.2 Water Diversion and Use

Water is withdrawn from the Merced River and used at numerous locations and by many users, including the Cowell Agreement Diverters and Merced ID, both discussed below. In the entire Merced River Watershed there are 105 post-1914 appropriative water rights, with a combined face value of approximately 5.5 MAF. Of these 105 rights, 101 are non-power water rights with a face value of approximately 1.04 MAF. Of the 101 rights, three are non-power water rights held by the Merced ID. The face value[13] of these three water rights totals approximately 1.01 MAF, accounting for approximately 98 percent of the water authorized for diversion (based on face value) under non-power water rights in the Merced River Watershed.

Cowell Agreement Diverters

The downstream Merced River diverters of water released from storage from Lake McClure are known as the Cowell Agreement Diverters (CAD). The Cowell Agreement was established on January 17, 1926, in an effort to supply riparian diverters and pre-1914 claims of water rights with releases from Lake McClure. The Merced Superior Court Order stipulates a scheduled quantity of flow rates in the Merced River to be maintained by the Merced ID and measured at Crocker-Huffman Dam (State Water Board 2007).

The Agreement requires the Merced ID to bypass and release water in the summer so that the riparian and pre-1914 downstream users experience the same hydrologic conditions that were in place prior to the construction of the New Exchequer Dam (State Water Board 2007).

The water diverted under the Cowell Agreement is used on acreage outside the Merced ID service area. The ID has at times been required to supplement downstream flows in the Merced River with releases from storage when inflow to Lake McClure has been insufficient to satisfy the flow requirements downstream of the Crocker-Huffman Dam (State Water Board 2007).

Merced Irrigation District

Merced ID provides water and electric service to approximately 164,000 acres in the Central Valley in portions of Merced County (Merced ID 2008a), using primarily surface water diversions from the Merced River to supply irrigation water to its service area. The ID diverts approximately 100 cfs from the Merced Falls reservoir via the Northside Canal, serving roughly 10,000 acres of farmland. Merced ID diverts up to another 2,000 cfs of water from the Merced River via the Main Canal at the Crocker-Huffman Dam primarily for agricultural purposes (Merced ID 2008b). These diversions are approximately 500,000 AF/y (MAGPI 2008). In conjunction with the surface water diversions from the Merced River, Merced ID owns, operates, and maintains 239 deep irrigation wells, of which 170 wells are currently active (Merced ID 2008b). These deep irrigation wells have historically produced a maximum of 182,900 AF/y. The amount of water diverted from the Merced River and pumped from groundwater varies from year to year, so not all estimates of these volumes are the same.

Table 2-4 presents a summary of Merced ID water supply and use values from the most recent AWMP. This plan was prepared by the ID as required by Senate Bill X7-7, which was adopted by California in 2009. The AWMP does not provide one summary table for all the values incorporated in

[13] The *face value* of a water right refers to the maximum amount of water the right authorizes for diversion. Typically the amount diverted is less.

Table 2-4; rather it presents a wide array of values over multiple years or different time frames. Because the values represent different time frames there may be inherent inconsistencies between the reported values in Table 2-4. This information is presented to illustrate estimated water supply and use of surface water diversions based on published irrigation district data.

Table 2-4. Merced Irrigation District—Water Supply and Use

Water Supply/Use	Amount (thousand acre-feet)
Surface water diversions[a]	445.6
Irrigated acres[a]	100,237
Applied water[b]	279.3
CUAW (surface water & groundwater)[b]	237.8
Pumped groundwater—district[c]	7.6
Pumped groundwater—private[c]	44.1
Deep percolation of applied water[b]	60.1
Groundwater recharge from precipitation[b]	42.8
Canal system seepage[c]	103.0

Source: Merced ID 2013.
CUAW = Consumptive Use of Applied Water
[a] Reported as 2000–2008 average.
[b] Reported as 2000–2003 average.
[c] Reported as 1995–2008 average.

Merced ID generates electricity at New Exchequer Dam and McSwain Dam and sells it to utility companies (Merced ID 2008c). It also provides electric services to customers in eastern Merced County, including the Cities of Livingston, Atwater, and Merced, and to the Castle Airport and Aviation Development Center (Merced ID 2008c).

2.3.3 Flow Requirements

Flows released from the Crocker-Huffman Dam to the Merced River must satisfy FERC requirements, a Davis-Grunsky Contract between the State of California and Merced ID, and the Cowell Agreement. Flood control release limits are established by the U.S. Army Corps of Engineers (USACE) such that the combination of Dry Creek and Merced River flows must not exceed 6,000 cfs.

Merced ID holds the initial FERC license (Project Number 2179) for the Merced River Hydroelectric Project, issued on April 18, 1964. As shown in Table 2-5, FERC Project Number 2179 requires the licensee to provide minimum streamflows in the Merced River downstream from the project reservoirs.

Table 2-5. FERC Project Number 2179 Streamflow Requirements for the Merced River (cfs)

Period	Normal Year	Dry Year
June 1–October 15	25	15
October 16–October 31	75	60
November 1–December 31	100–200	75–150
January 1–May 31	75	60

FERC Project Number 2179 also requires that during the period November 1–December 31, the Merced River streamflow downstream from McSwain Dam be regulated between 100 and 200 cfs, except during dry years when the streamflow should be maintained between 75 and 150 cfs. Streamflows are measured at Shaffer Bridge on the Merced River downstream of McSwain Dam. These flows are required during the fall-run Chinook salmon egg incubation period to prevent redd scouring or dewatering. The Project is currently undergoing relicensing with the Commission, and a Section 401 water quality certification issued by the State Water Board is required. (33 U.S.C. § 1341.)

In 1967, Merced ID executed a Davis-Grunsky Contract with the California Department of Fish and Wildlife (CDFW, formerly the California Department of Fish and Game). The contract provides minimum flow standards that require flows no less than 180–220 cfs to be maintained between November and March from Crocker-Huffman Dam to Shaffer Bridge.

The Cowell Agreement, between Merced ID and the Cowell Agreement Diverters, calls for flows downstream of the Crocker-Huffman Dam to meet the water rights of other diverters. The Cowell Agreement Diverters are downstream riparian and pre-1914 water users. This water can then be diverted from the river at a number of private ditches between Crocker-Huffman Dam and Shaffer Bridge. The minimum flow requirements are provided in Table 2-6.

Table 2-6. Cowell Agreement Streamflow Requirements for the Merced River (cubic feet per second)

Month	Flow
October 1–15	50
October 16–31	50
November–February	50
March	100
April	175
May	225
June	250
July	225
August	175
September	150

2.3.4 Hydrology

The unimpaired flow of the Merced River is the flow that would occur without existing diversions. The historical flow of the Merced River is influenced by the operation of the existing dams and diversions. The hydrographs in Figure 2-8 depict both types of flows and show the monthly unimpaired historical flow below Crocker-Huffman Dam for the recent 10-year period of water years 2000 through 2009. During this period, the unimpaired flow at New Exchequer Dam averaged 884 TAF/y and the historical releases (including flood flows in 2000, 2005, and 2006) averaged 403 TAF/y.

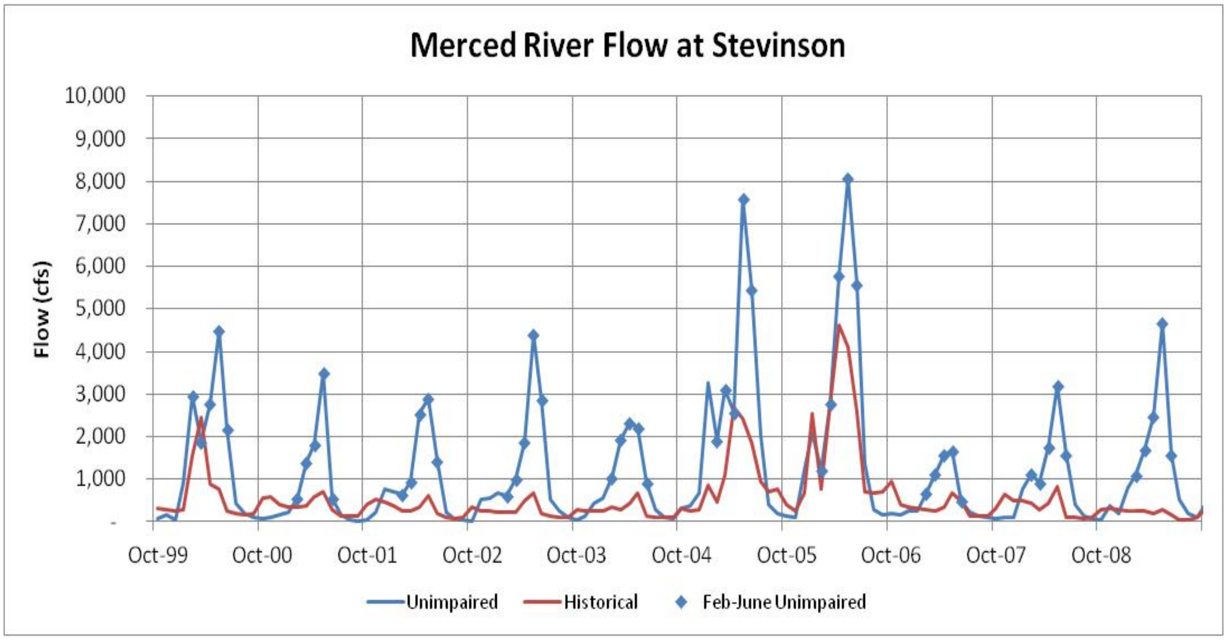

Figure 2-8. Monthly Unimpaired and Historical Merced River Flows February–June for Water Years 2000–2009 (cfs = cubic feet per second)

The Crocker-Huffman Dam releases averaged approximately 45 percent of the unimpaired flow, but the releases were usually less than 40 percent of the unimpaired flow, with flood control releases providing the majority of the flow below Crocker-Huffman Dam. The historical monthly flows at Stevinson (near the mouth of the Merced) are generally lower than the unimpaired flows in the winter and spring months, and often slightly higher than the unimpaired flows in the fall months. Table 2-7 summarizes the range of historical and unimpaired flows on the Merced River February–June. The peak historical flows were in April and May 2006 because Lake McClure was nearly full, and the relatively high flow of 4,500 cfs was for flood control purposes.

Table 2-7. Historical and Unimpaired Flow February–June on the Merced River (cubic feet per second)

Water Year	Historical (observed) Range	Unimpaired Range
2000	250–2,500	2,000–4,500
2001	250–750	500–3,500
2002	250–500	750–3,000
2003	250–750	500–4,500
2004	250–750	1,000–2,250
2005[a]	750–2,500	2,000–7,500
2006[a]	1,000–4,500	1,000–8,000
2007	250–750	750–1,750
2008	250–750	1,000–3,000
2009	250	1,000–5,000

[a] The high historical flows in 2005 and 2006 were because Lake McClure was nearly full, and releases for flood control purposes were made in each of these years.

The Merced River monthly unimpaired flows (at New Exchequer Dam) are summarized in Table 2-8, with the cumulative distributions of unimpaired flow (in 10 percent increments) for each month from 1984 to 2009. Each month has a range of runoff depending on the rainfall and accumulated snowpack. The median flows (50 percent cumulative) can be used to characterize generally the seasonal runoff pattern. The peak runoff for the Merced River is observed in May and highest runoff (median monthly runoff greater than 90 TAF, or 1,500 cfs) is observed March–June. The minimum flows are observed in August, September, October, and November. The distribution of annual unimpaired flow ranged from 410 TAF (10th percentile) to 1,746 TAF (90th percentile), with a median runoff of 721 TAF. The average unimpaired flow was 884 TAF/y, 23 percent more than the median runoff, representing approximately 15 percent of the unimpaired flow at Vernalis.

Table 2-9 provides a monthly summary of the historical flows observed at Stevinson. The Merced River flows are subject to minimum flow requirements, as described above. The majority of the historical monthly flows were between 5 TAF and 30 TAF (75 cfs and 500 cfs). The annual river flow volume ranged from 102 TAF (10th percentile) to 1,167 TAF (90th percentile). The median historical annual river flow was 398 TAF. The average historical flow was 452 TAF/y for these years, 14 percent higher than the median. The average historical flow was approximately 48 percent of the average unimpaired flow, but the majority of the flow occurred in the wet years due to flood control releases. Lake McClure is the smallest of the three eastside tributary reservoirs and is generally filled and drawn down each year. Nevertheless, flood control releases are not necessary each year; consequently, it is difficult to anticipate when reservoir releases for flood control storage will be required.

Table 2-8. Monthly and Annual Unimpaired Flow in the Merced River 1984–2009 (thousand acre-feet)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
10	2	5	6	11	22	50	93	104	32	11	4	1	410
20	2	6	8	13	28	56	104	117	48	13	5	2	450
30	3	7	10	18	34	61	113	153	56	18	6	3	548
40	4	9	13	35	37	69	129	184	85	25	7	4	608
50	5	11	19	45	60	96	143	233	104	31	9	5	721
60	7	13	25	49	68	105	151	270	130	33	11	6	906
70	10	18	29	62	91	118	163	280	156	42	13	6	1,195
80	13	22	34	103	105	161	181	316	228	51	15	7	1,559
90	16	30	61	195	181	181	199	386	328	110	23	10	1,746

Note: The cumulative distribution indicates the probability of occurrence for the variable. For example, a 10^{th} value of 2 indicates that 10 percent of the time, the value would be expected to be less than 2. This term is not referring to, and should not be confused with, the term cumulative impacts, which is a specific CEQA term. A discussion of cumulative impacts for CEQA purposes is provided in Chapter 4, *Introduction to Analysis*, and Chapter 17, *Cumulative Impacts, Growth-Inducting Effects, and Irreversible Commitment of Resources*.

Table 2-9. Monthly and Annual Historical Flow in the Merced River 1984–2009 (thousand acre-feet)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
10	5	11	12	13	12	15	10	9	6	2	2	3	102
20	11	14	13	14	14	15	11	12	8	4	4	5	148
30	17	15	14	15	15	17	19	21	10	6	6	6	193
40	19	15	15	16	18	18	22	39	11	8	6	7	224
50	20	15	16	20	18	20	27	41	13	9	8	8	271
60	25	17	19	30	21	24	34	44	16	11	9	11	363
70	28	21	25	36	26	59	56	52	23	15	11	13	550
80	34	31	30	47	71	144	66	82	35	19	17	19	764
90	67	36	57	104	90	168	169	160	127	50	39	43	1,167

2.4 Tuolumne River

2.4.1 Basin Overview

As shown in Table 2-1, the Tuolumne River is approximately 155 miles long and drains an area of approximately 1,900 square miles. The Tuolumne River originates in the high elevations of the Sierra Nevada and flows into the LSJR approximately 8 miles upstream of the Stanislaus River confluence. Like the other two eastside tributaries of the LSJR, the Tuolumne River receives most of its flow from late spring and early summer snowmelt; however, peak flows generally occur during winter rain events.

Existing dams, water diversions, and downstream minimum flow agreements influence the hydrology of the Tuolumne River. New Don Pedro Dam, the major dam on the Tuolumne River, provides water to the Turlock Irrigation District (TID) and Modesto Irrigation District (MID). The dams constructed on tributaries in the upper Tuolumne River Watershed provide hydropower and water supply for the City and County of San Francisco (CCSF). CCSF operates several water supply and hydroelectric facilities in the upper reaches of the Tuolumne above New Don Pedro Dam. O'Shaughnessy Dam on the mainstem Tuolumne River impounds approximately 360 TAF in the Hetch Hetchy Reservoir to address CCSF's water needs of and to provide instream flows in the Tuolumne River below O'Shaughnessy Dam. Two other storage facilities upstream of New Don Pedro Reservoir, Lake Eleanor and Cherry Lake, are also operated by CCSF for hydropower and water supply purposes. The combined capacity of these two reservoirs is approximately 300 TAF. Water from Lake Eleanor is diverted through the Lake Eleanor Diversion Tunnel and into Cherry Lake where it is released to supplement flows of the upper Tuolumne River. The Hetch-Hetchy aqueduct conveys water from the Tuolumne River to the CCSF service area; the physical capacity of approximately 500 cfs is limited by the Coastal Tunnel.

New Don Pedro Dam, the major dam on the Tuolumne River, was constructed in 1971 to replace the original Don Pedro Dam. The hydroelectric power plant with four units has a combined capacity of 203 MW, with a maximum flow of 5,500 cfs. Flows in the lower portion of the Tuolumne River are controlled primarily by operation of New Don Pedro Dam. The 2 MAF reservoir stores water for irrigation, hydroelectric generation, fish and wildlife enhancement, recreation, and flood control purposes (340,000 AF for flood control). Water released from the New Don Pedro Dam is regulated at LaGrange Dam and Reservoir. La Grange Dam, 2.5 miles downstream of New Don Pedro Dam, is the diversion point for the TID and Merced ID canals.

2.4.2 Water Diversion and Use

Water is withdrawn from the Tuolumne River and used at numerous locations and by many users, including TID, MID, and CCSF, discussed below. In the Tuolumne River Watershed there are 165 post-1914 appropriative water rights with a combined face value of approximately 7.2 MAF. Of these 165 rights, 160 are non-power water rights with a face value of approximately 2.65 MAF. Of the 160 rights, 5 are non-power water rights held by TID and MID. The face value of these five water rights totals approximately 2.62 MAF, accounting for approximately 99 percent of the water authorized for diversion (based on face value) under non-power water rights in the Tuolumne River Watershed (State Water Board 2015).

The amount and uses of water actually diverted vary. On average, more than 60 percent of the annual flow of the Tuolumne River is diverted for agricultural or municipal and industrial use by TID and MID. Each year, approximately 575 TAF of water is diverted to TID's canal into Turlock Lake and 310 TAF is diverted to MID's canal into the Modesto Reservoir for use in the service districts. Nearly all the diverted surface water irrigates crops in the two districts. Many of the TID and MID diversions from the Tuolumne River occur at New Don Pedro and La Grange reservoirs.

City and County of San Francisco

The current CCSF demand for water is approximately 290 TAF/y, or about 15 percent of the annual average unimpaired flow of the Tuolumne River. The water rights and operating agreement for New Don Pedro Reservoir includes seasonal storage in the CCSF upstream reservoirs and water banking (accounting) between TID, MID, and CCSF. CCSF has the right to store up to 740,000 AF/y in New Don Pedro Reservoir (CCSF, TID, and MID 1966).

Turlock Irrigation District

TID has an irrigation service area of approximately 307 square miles (196,000 acres) (TID 2013). It provides water and electric services to areas in Stanislaus and Merced Counties, as well as portions of Tuolumne and Mariposa Counties (TID 2010a, 2010b). TID uses primarily surface water diversions from the Tuolumne River and supplements them with groundwater to supply irrigation water (TID 2010c) (Table 2-10).

Table 2-10 presents a summary of TID water supply and use values from the most recent AWMP. This plan was prepared by the irrigation district as required by Senate Bill X7-7, which was adopted by California in 2009. The AWMP does not provide one summary table for all of the values incorporated in Table 2-10. Rather it presents a wide array of values over multiple years or different time frames. Because the values represent different time frames there may be inherent inconsistencies between the reported values in Table 2-10. This information is provided to illustrate estimated water supply and use of surface water diversions based on published irrigation district data.

Table 2-10. Turlock Irrigation District - Water Supply and Use

Water Supply/Use	Amount (thousand acre-feet)
Surface water supply [a]	503.6
Ground water supply [a]	100.0
Irrigated acres [b]	157,800
Agricultural water delivered [c]	499.0
Pumped groundwater— district [a]	99.8
Pumped groundwater— private [c]	19.0
Total Recharge [a]	243.2

Source: TID 2012.
[a] Reported as 1991–2011 average.
[b] Reported in 2012.
[c] Reported as 2007–2011 average.

TID provides electrical service to an area encompassing approximately 660 square miles and includes more than 98,000 accounts. TID is the majority owner and operating partner of the Don Pedro Hydroelectric Project. TID owns approximately 68 percent of the total capacity, which is approximately 139 MW of power (TID 2010b, 2010d).

Modesto Irrigation District

MID is an independent, publicly owned utility that provides water and electric services to parts of Stanislaus County, San Joaquin County and a small portion located in ~~Calaveras~~ Tuolumne County around the New Don Pedro Dam. The water service area encompasses approximately 113,000 acres (MID 2012a) (Table 2-11). MID has pre-1914 water rights to obtain surface water supply at diversion points below New Don Pedro Reservoir and La Grange Dam as described above and pumps groundwater to supplement surface water supplies for irrigation. It provides approximately 173,750 AF (20-year average) of irrigation water to approximately 58,000 irrigated acres within its service area (MID 2012b). It also provides up to 42 million gallons of drinking water to the City of Modesto per day and is expanding the Modesto Regional Water Treatment Plant to increase delivery to an average of 60 million gallons of water per day (MID 2012b, 2015).

Table 2-11 presents a summary of MID water supply and use values from the most recent AWMP. This plan was prepared by the irrigation district as required by Senate Bill X7-7, which was adopted by California in 2009. The AWMP does not provide one summary table for all the values incorporated in Table 2-11; rather it presents a wide array of values over multiple years or different time frames. Because the values represent different time frames, there may be inherent inconsistencies between the reported values in Table 2-11. This information is provided to illustrate estimated water supply and use of surface water diversions based on published irrigation district data.

Table 2-11. Modesto Irrigation District—Water Supply and Use

Water Supply/Use	Amount (thousand acre-feet)
Surface water supplies [a]	284.3
Applied surface water [a]	153.0
Irrigated acres [b]	66,517
Crop CUAW [a]	173.2
Pumped groundwater— district[a]	20.1
Municipal deliveries [a]	30.0
On farm recharge from irrigation[a]	58.1
Canal seepage [a]	8.0

Source: MID 2012a.
CUAW = Consumptive Use of Applied Water.
[a] Reported as year 2009.
[b] Reported as year 2012.

MID provides electrical service to approximately 560 square miles and more than 110,000 accounts in the following areas: the Greater Modesto Area (north of the Tuolumne River, Waterford, Salida, Mountain House [Northwest of Tracy], and parts of Ripon, Escalon, Oakdale and Riverbank). Pacific Gas and Electric Company (PG&E) also provides electric service in Riverbank, Oakdale, Ripon and Escalon in conjunction with MID. MID produces approximately 25 percent of its own electricity and purchases the remaining 75 percent (MID 2012b). MID owns approximately 64 MW of the power generated by New Don Pedro Reservoir, comprising approximately 9 percent of the power MID generates (TID 2010d; MID 2012b).

2.4.3 Flow Requirements

Flow requirements on the Tuolumne River include the original FERC license (1966) for the operation of New Don Pedro Reservoir and a 1995 settlement agreement that amended the FERC license. TID and MID jointly hold the initial FERC license (Project Number 2299) for the New Don Pedro Project. USACE also established flood control release limits. These requirements are summarized in Table 2-12.

Table 2-12. Tuolumne River Flow Requirement Summary

Requirement	Description	Parties	Releases
FERC License Project No. 2299	Provides specified releases from New Don Pedro to protect fall-run Chinook salmon spawning below La Grange Dam	TID, MID, and FERC	Annual volume for normal water years is 120 TAF; annual volume for dry water years is 65 TAF; specific flows identified during different months
Article 37 of FERC License Project No. 2299	Provides additional flows from original FERC License	CDFW, FERC, MID, and TID	Annual volume of water was increased to 95 TAF in dry water years and 300 TAF in normal water years
USACE	Establishes flood control release limits	USACE, MID, and TID	Releases are established by USACE for 12 months such that releases cannot exceed 9,000 cfs per month on Tuolumne River below Dry Creek

USBR = U.S. Bureau of Reclamation
CDFW = California Department of Fish and Wildlife
USACE = U.S. Army Corps of Engineers
FERC = Federal Energy Regulatory Commission
MID = Modesto Irrigation District
TID = Turlock Irrigation District

The original FERC license was issued on March 10, 1964; became effective on May 1, 1966; and has a term that expired April 30, 2016. The Project is currently undergoing relicensing with the Commission, and a Section 401 water quality certification issued by the State Water Board is required. (33 U.S.C. § 1341.) The FERC license is conditioned to require specified releases of water from New Don Pedro Reservoir for the protection of fall-run Chinook salmon, which spawn in the Tuolumne River below La Grange Dam. These required flows in most years (normal) were 200–400 cfs from October through March, with 100 cfs in April and 3 cfs from May through September. As shown in Table 2-13, the annual volume of required streamflows was almost 120 TAF. The dry year flows were approximately half of the normal year flows, with an annual volume of almost 65 TAF.

Table 2-13. FERC Project Number 2299 Streamflow Requirements for the Tuolumne River

Period	Normal Year (cfs)	Dry Year (cfs)
October 1–15	200	50
October 16–October 31	250	200
November	385	200
December 1–15	385	200
December 16–31	280	135
January	280	135
February	280	135
March	350	200
April	100	85
May–September	3	3
Annual (TAF)	118	64

cfs = cubic feet per second
TAF = thousand acre-feet

The settlement agreement with CDFW established in 1995 proposed that Article 37 of the FERC license be amended to increase flows released from the New Don Pedro Dam. Several different runoff conditions were associated with higher required streamflows, and the annual volume of water required for stream flows was increased from approximately 95 TAF in the driest years to a maximum of approximately 300 TAF in years with greater-than-average runoff. Pulse flows are specified for salmonid attraction in October and outmigration in April and May.

2.4.4 Hydrology

The unimpaired flow of the Tuolumne River is the flow that would occur without existing diversions. The historical flow of the Tuolumne River is influenced by the operation of the existing dams and diversions as described above. The hydrograph in Figure 2-9 depicts both types of flow over time. It shows the monthly unimpaired and historical flow below LaGrange Dam for the recent 10-year period of water years 2000 through 2009, reflects that the unimpaired flow at New Don Pedro Dam averaged 1,738 TAF/y, and that the historical releases (including flood flows in 2000, 2005, and 2006) averaged 695 TAF/y.

LaGrange Dam released an average of approximately 40 percent of the unimpaired flow, but the releases were usually much less than 40 percent of the unimpaired, with flood control releases providing most of the flow below LaGrange Dam. The historical monthly flows at Modesto (near the mouth of the Tuolumne River) were generally less than the unimpaired flows in the winter and spring months, and were often slightly higher than the unimpaired flows in the late summer and fall months.

Table 2-14 summarizes the range of historical and unimpaired flows on the Tuolumne River February–June. The peak historical flows were in April and May 2006 because New Don Pedro Reservoir was nearly full, and 8,000 cfs was released for flood control purposes.

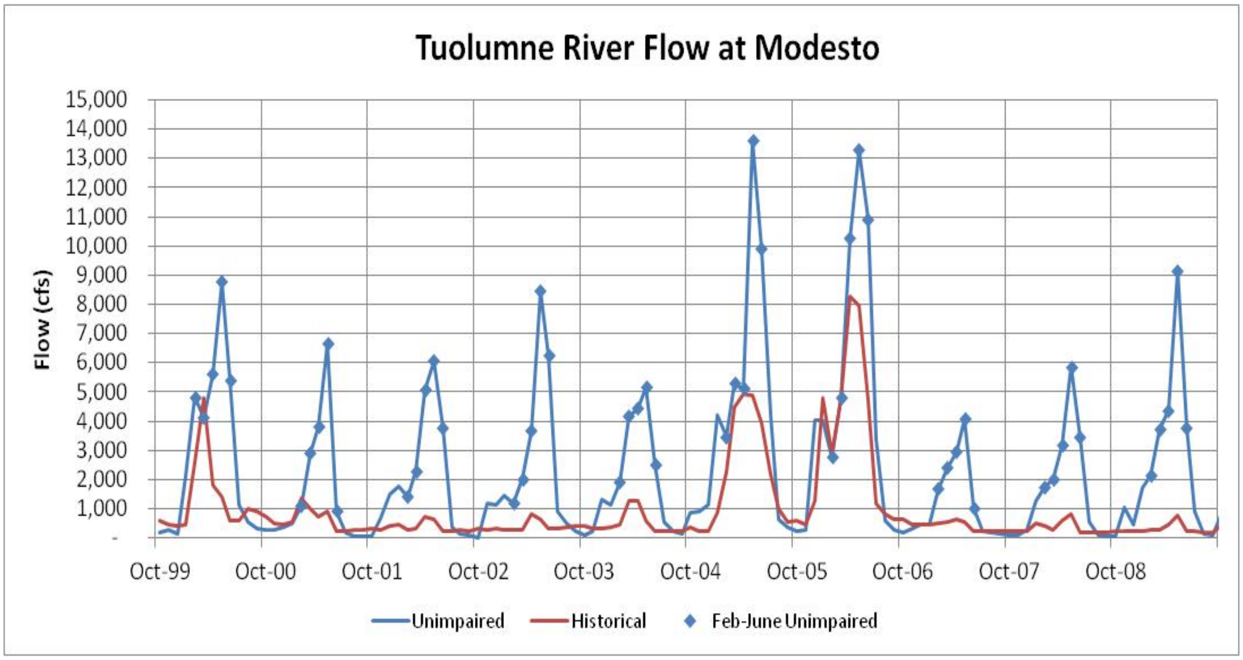

Figure 2-9. Monthly Unimpaired and Historical Tuolumne River Flows February–June for Water Years 2000–2009 (cfs = cubic feet per second)

Table 2-14. Historical and Unimpaired Flow February–June on the Tuolumne River (cubic feet per second)

Water Year	Historical Range	Unimpaired Range
2000	500–5,000	2,000–9,000
2001	250–1,000	1,000–7,000
2002	250–500	1,500–6,000
2003	250–750	1,000– 8,500
2004	250–1,250	2,000–5,000
2005[a]	2,000–5,000	3,500–13,500
2006[a]	3,000–8,000	3,000–13,000
2007	250–500	1,000–4,000
2008	250–750	2,000–6,000
2009	250–750	2,000–9,000

[a] In 2005 and 2006, the high historical flows occurred because New Don Pedro Reservoir was nearly full, and releases for flood control purposes were made in each month February–June.

The Tuolumne River monthly unimpaired flows (at New Don Pedro Dam) are summarized in Table 2-15 with the cumulative distributions of unimpaired flow (in 10 percent increments) for each month 1984–2009. Each month has a range of runoff depending on the rainfall and accumulated snowpack. The median flows (50 percent cumulative) can be used to generally characterize the seasonal runoff pattern. The peak runoff for the Tuolumne River is in May, and highest runoff (median monthly runoff greater than 180 TAF, or 3,000 cfs) is observed March–June. The minimum flows are observed in August, September, October, and November. The distribution of annual unimpaired flow ranges from 839 TAF (10th percentile) to 3,268 TAF (90th percentile), with a median runoff of 1,514 TAF. The average unimpaired flow was 1,851 TAF/y, 22 percent more than the median runoff. This represents approximately 30 percent of the unimpaired flow at Vernalis. Since 300 TAF/y are diverted upstream of New Don Pedro Reservoir, the average inflow to New Don Pedro Reservoir is approximately 85 percent of the Tuolumne River unimpaired flow.[14]

Table 2-15. Monthly and Annual Unimpaired Flow in the Tuolumne River 1984–2009 (thousand acre-feet)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
10	4	8	16	24	53	112	184	208	63	17	4	3	839
20	5	13	18	32	60	124	195	275	100	24	8	4	884
30	9	17	25	40	67	136	219	329	141	30	9	7	1,114
40	10	18	29	70	93	168	230	360	207	33	14	7	1,312
50	11	23	47	97	105	190	263	443	260	57	20	10	1,514
60	15	26	58	129	151	232	301	536	330	67	26	15	2,018
70	18	49	70	134	161	271	307	541	381	101	33	18	2,394
80	21	62	82	202	192	296	323	569	507	144	37	20	2,971
90	38	77	171	269	313	340	343	645	619	242	52	23	3,268

The Tuolumne River flows are subject to minimum flow requirements as described above. Table 2-16 provides a monthly summary of the historical flows in the Tuolumne River at Modesto. The majority of the historical monthly flows were between 10 TAF and 30 TAF (150 cfs and 500 cfs). The annual river flow volume ranged from 155 TAF (10th percentile) to 2,249 TAF (90th percentile). The median historical annual river flow was 398 TAF. The average historical flow was 845 TAF/y, considerably greater (112 percent) than the median. The average historical flow was approximately 46 percent of the average unimpaired flow, but most of this historical flow was observed in the wet years with flood control releases. New Don Pedro Reservoir is the second largest reservoir on the LSJR tributaries and allows considerable carryover storage from one year to the next. Therefore, flood control releases are not necessary each year; consequently, it is difficult to anticipate when reservoir releases for flood control storage will be required.

[14] Approximately 300 TAF of the unimpaired Tuolumne River flows are diverted each year to the San Francisco Hetch Hetchy aqueduct for municipal water supply purposes.

Table 2-16. Monthly and Annual Historical Flow in the Tuolumne River 1984–2009 (thousand acre-feet)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
10	10	12	12	13	14	16	22	17	7	7	7	7	155
20	15	14	15	18	15	18	23	26	9	8	9	10	213
30	16	16	16	25	24	19	34	31	13	13	12	11	265
40	21	18	20	28	26	23	43	38	15	15	15	14	316
50	27	21	25	35	28	46	46	42	17	16	17	16	398
60	36	27	27	41	76	79	56	52	20	20	21	23	593
70	42	29	28	54	144	209	102	79	28	21	27	30	1,236
80	46	30	78	96	236	291	180	170	47	30	30	38	1,560
90	74	51	129	231	302	338	324	275	251	103	61	58	2,249

2.5 Stanislaus River

2.5.1 Basin Overview

As shown in Table 2-1, the Stanislaus River is approximately 161 miles long and covers an area of approximately 1,195 square miles. The Stanislaus River originates in the high elevations of the Sierra Nevada and flows into the LSJR approximately 3 miles upstream of Vernalis near~~at~~ Ripon. The Stanislaus River receives most of its flow from late spring and early summer snowmelt; however, peak flows generally occur during winter rain events.

The New Melones Dam, the major CVP dam on the Stanislaus River, is located just downstream of the confluence of the river's three forks. There are two smaller dams downstream of New Melones: Tulloch Dam and Goodwin Dam. Two irrigation districts, South San Joaquin Irrigation District (SSJID) and Oakdale Irrigation District (OID) divert water from the Stanislaus River and generate hydropower, which they sell to the California Independent System Operator (CalISO). ~~One municipal water conservation district—~~Stockton East Water District (SEWD)— and the Central San Joaquin Water Conservation District (CSJWCD) also divert water.

The Stanislaus River has 28 dams under DSOD jurisdiction storing an approximate 2.8 MAF of water; these include the New Melones, Tulloch, and Goodwin Dams and several small dams both upstream and downstream of New Melones. The New Melones Reservoir was completed by USACE in 1979 and first filled in 1982. New Melones Reservoir is approximately 60 miles upstream of the confluence of the Stanislaus River and the LSJR and is operated by USBR. With a storage capacity of approximately 2.4 MAF, the dam has two hydroelectric generators with a combined capacity of 300 MW (USBR 2010) and a maximum flow of 8,000 cfs. Existing flow requirements in the 1987 Agreement, Decision 1422, U.S. Fish and Wildlife Service (USFWS) Anadromous Fish Restoration Program (AFRP), and National Marine Fisheries Service (NMFS) Biological Opinion (BO) and Conference Opinion on the Long-Term Operations of the Central Valley Project (CVP) and State Water Project (SWP) (NMFS BO), specify flow releases on the Stanislaus River.

New Melones Reservoir is a component of the CVP, but it is authorized to provide water supply benefits within the defined Stanislaus River Basin per the 1980 Record of Decision (ROD) before additional water supplies can be used outside of the defined basin. New Melones Reservoir is operated for the following purposes: water supply, maximum storage for flood control and maximum releases conducted in accordance with USACE's operational guidelines, power generation, fishery enhancement, improvement of SJR water quality at Vernalis, and dissolved oxygen requirements at Ripon. The reservoir and river corridor also provide recreational benefits.

Tulloch Dam and power plant are located approximately 6 miles downstream of New Melones Dam. Tulloch dam is part of the Tri-Dam Project, which is a power generation project that consists of two additional dams, Donnells and Beardsley Dams, located upstream of New Melones Reservoir. The water released from New Melones Dam (for peaking power) is regulated by Tulloch Reservoir, which has a capacity of 67 TAF. Goodwin Dam, approximately 2 miles downstream of Tulloch Dam, was constructed by OID and SSJID in 1912. Water released from Tulloch Dam flows into Goodwin Dam, which impounds water for diversion into the irrigation canals for OID and SSJID or release to the lower Stanislaus River. Goodwin Dam also creates a reregulating reservoir for peaking power releases from Tulloch power plant. Water may also be gravity fed into the Goodwin Tunnel for deliveries to the CSJWCD and SEWD.

2.5.2 Water Diversion and Use

The Stanislaus River has many diverters that apply the water to beneficial use, including SEWD/CCSJID, SSJID, and OID, discussed below. These districts also receive water diverted and released by USBR at New Melones Reservoir. These water diverters include appropriative water rights holders, pre-1914 users, and riparian claim users. In the Stanislaus River Watershed there are 160 post-1914 appropriative water rights with a combined face value of approximately 19.7 MAF. Of these 160 water rights, 139 are non-power water rights with a face value of approximately 4.2 MAF. Of the 139 water rights, 16 are non-power water rights held by OID, SSJID, USBR, McMullin Reclamation District #2075, and River Junction Reclamation District #2064. The face value of these 16 rights totals approximately 3.9 MAF, accounting for approximately 94 percent of the water authorized for diversion (based on face value) under non-power water rights in the Stanislaus River Watershed.

SSJID and OID hold pre-1914 water rights to divert water from the Stanislaus River for use within their service districts. These districts also generate hydropower, which they sell to CalISO. Delivery of water from New Melones Reservoir to SSJID and OID is described by the 1988 agreement and stipulation with USBR, which specifies that the districts receive 600,000 AF of water when the projected flow in the Stanislaus River is greater than 600,000 AF (OID 1988). OID and SSJID generally divide the water available to them under the 1988 agreement equally, each receiving approximately 300,000 AF. OID has an adjudicated pre-1914 water right held jointly with SSJID to directly divert 1,816.6 cfs of flow from the Stanislaus River (OID 2012). The location and general characteristics of the four districts that receive water from the Stanislaus River are provided below.

South San Joaquin Irrigation District

The SSJID service area covers approximately 70,000 acres in San Joaquin County. The predominant land use in SSJID is agricultural (approximately 60,000 acres, Table 2-17); however, SSJID currently provides some surface water to cities, including Lathrop, Manteca, Tracy, and Ripon. Stanislaus River surface water is diverted into the SSJID and OID Joint Main Canal at the Goodwin Dam and is channeled into Woodward Reservoir. SSJID releases water from Woodward Reservoir into a conveyance system of canals to provide irrigation water for agricultural customers. Unused surface water drains north to the French Camp Outlet Canal. A small portion of irrigation runoff drains south as surface water return flows to the Stanislaus River. Return flows to the Stanislaus River are estimated to be approximately 3,000 AF/y based on monitored 1996 and 1997 data (EA EST 1999).

Table 2-17. South San Joaquin Irrigation District—Water Supply and Use

Water Supply/Use	Amount (thousand acre-feet)
Total applied water [a]	222.5
Recharge activities [a]	97.0
Canal & reservoir seepage[a]	50.5
Irrigated acreage [a]	58,551
Pumped groundwater—district [a]	5.8
Pumped groundwater—private [a]	33.8
Crop CUAW [b]	142.6

Source: SSJID 2012.
CUAW = Consumptive Use of Applied Water.
[a] Reported as 1994-2008 average.
[b] Reported as year 2008.

Table 2-17 presents a summary of SSJID water supply and use values from the most recent AWMP. This plan was prepared by the irrigation district as required by Senate Bill X7-7, which was adopted by California in 2009. The AWMP does not provide one summary table for all of the values incorporated in Table 2-17; rather, it presents a wide array of values over multiple years or different time frames. Because the values represent different time frames, there may be inherent inconsistencies between the reported values in Table 2-17. This information is provided to illustrate estimated water supply and use of surface water diversions based on published irrigation district data.

Oakdale Irrigation District

The OID service area covers approximately 70,000 acres in San Joaquin and Stanislaus Counties. The predominant land use in OID is agricultural (approximately 60,000 acres, Table 2-18). More than 95 percent of the water served by OID is surface water diverted from the Stanislaus River at Goodwin Dam into the Joint Supply Canal and the South Main Canal.

Surface water is supplemented by groundwater pumping from 22 groundwater wells located throughout the district on both sides of the Stanislaus River, especially during dry periods when surface water supplies are limited. Approximately 8,000 AF/y is pumped from these wells in dry years. OID also pumps approximately 1,500 AF/y from four shallow wells to control water table levels. Over the last 10 years, these domestic wells have produced approximately 1,000 AF/y (EA EST 1999).

Table 2-18 presents a summary of OID water supply and use values from the most recent AWMP. This plan was prepared by the irrigation district as required by Senate Bill X7-7, which was adopted by California in 2009. The AWMP does not provide one summary table for all of the values incorporated in Table 2-18; rather, it presents a wide array of values over multiple years or different time frames. Because the values represent different time frames, there may be inherent inconsistencies between the reported values in Table 2-18. This information is provided to illustrate estimated water supply and use of surface water diversions based on published irrigation district data.

Table 2-18. Oakdale Irrigation District—Water Supply and Use

Water Supply/Use	Amount (thousand acre-feet)
Surface water supply [a]	232.0
Irrigated acres [b]	55,746
Farm deliveries [a]	186.7
Crop CUAW [a]	128.9
Pumped groundwater—district [a]	7.1
Pumped groundwater—private [a]	19.3
Recharge activities [c]	71.7
Canal seepage [a]	35.6
Deep percolation [a]	24.5

Source: OID 2012.
CUAW = Consumptive Use of Applied Water
[a] Reported as 2005-2011 average.
[b] Reported acreage for year 2010.
[c] Recharge activities include canal seepage, drain seepage, and deep percolation of applied water.

Stockton East Water District

SEWD is a water conservation district that provides surface water for both agricultural and urban uses and groundwater recharge. SEWD covers approximately 116,300 acres, of which approximately 47,600 acres are within the city of Stockton. SEWD supplies wholesale treated surface water, which is retailed to Stockton area customers, several different water districts, and retail suppliers. SEWD delivers a minimum of 20,000 AF/y to these water districts and retail suppliers. Currently, raw water sent to the SEWD Treatment Plant originates from either New Hogan Reservoir on the Calaveras River or New Melones Reservoir on the Stanislaus River.

The estimated average amount of water that SEWD receives from the Calaveras River during a wet year is 67 TAF/y (Northeastern San Joaquin County Groundwater Banking Authority 2004). On the Stanislaus River, SEWD partially owns Goodwin Dam and uses it for diverting water into Goodwin Tunnel, which is at the upstream end of the New Melones Conveyance System. SEWD has a contract with USBR to receive 75,000 AF/y from the New Melones Reservoir through the CVP (SEWD 2011). However, during dry years, water delivery amounts may vary depending upon USBR water allocations. In the past, SEWD contracted with SSJID and OID to receive up to 30,000 AF/y through the New Melones Conveyance System, specifically for municipal use. This agreement ended in 2009, but was extended beyond 2010 and may be renewed pending further studies (SEWD 2014).

Table 2-19 presents a summary of SEWD's water supply and use values from the most recent water management plan. The water management plan does not provide one summary table for all of the values incorporated in Table 2-19; rather it presents a wide array of values over multiple years or different time frames. Because the values represent different time frames, there may be inherent inconsistencies between the reported values in Table 2-19. This information is provided to illustrate estimated water supply and use of surface water diversions based on published data.

Table 2-19. Stockton East Water District—Water Supply and Use

Water Supply/Use	Amount (thousand acre-feet)
Total surface water supply [a]	118.2
Irrigated acres [b]	50,981
CUAW [b]	127.6
Municipal deliveries [b]	52.4
Deep percolation of applied water	13.0
Conveyance system evaporation [b]	4.7
Pumped groundwater—district [b]	0
Pumped groundwater—private [b]	117.4
Recharge activities [c]	53.2
System seepage [b]	29.4

Source: SEWD 2014.

CUAW = Consumptive Use of Applied Water

[a] Total water supply from the Calaveras and Stanislaus Rivers, year 2010, includes Federal Ag. Water, Federal non-Ag. Water, and water transfers.

[b] Reported total for year 2010.

[c] Recharge activities include Farmington GW Recharge Program ponds as well as natural creeks/rivers and canals.

Central San Joaquin Water Conservation District

The CSJWCD service area is approximately 65,000 acres. CSJWCD has contracted with USBR to receive a total of 80,000 AF/y of surface water from the Stanislaus River. Of this total, 49,000 AF/y is a firm supply and 31,000 AF/y is an interim supply subject to other users' requirements. CSJWCD water is diverted through the Goodwin Tunnel at Goodwin Dam. The total contracted amount has never been fully delivered. On occasion, SSJID and OID have also made water available to CSJWCD for irrigation (Northeastern San Joaquin County Groundwater Banking Authority 2004).

Approximately 48,000 acres of CSJWCD land is irrigated. Because the CSJWCD surface water supply has generally been relatively small (in 2009 it was 32 TAF), groundwater has been the primary source of water for meeting irrigation needs. CSJWCD does not pump and sell groundwater, but it charges irrigators for groundwater pumping volumes that are estimated on the basis of an assumed water application rate of 2.8 acre-feet/acre (CSJWCD 2013).

Tri-Dams Project

The Tri-Dam project is a partnership between OID and SSJID. Together they developed, operate, and maintain the Beardsley, Donnells, and Tulloch projects, including the dams, tunnels, penstocks, power houses, communications systems, and general offices. The Tri-Dam facilities are located on the Middle Fork of the Stanislaus River in Tuolumne County.

The project is responsible for providing irrigation water to 117,500 acres of land on farms in San Joaquin and Stanislaus Counties. The Beardsley, Donnells, and Tulloch facilities provide OID and SSJID with storage reservoirs necessary to meet this water obligation. Storage and power are carried out pursuant to the districts' water rights and the districts' license issued by FERC. The Tri-Dam project has 660,000 acre-feet of water rights on the Stanislaus River (Richardson & Company 2010). In 2005, the State Water Board issued a water quality certification for the Tri-Dam Project (Beardsley/Donnels Hydroelectric Project) and in 2006 for the Tulloch Hydroelectric Project. Both certifications contain a reopener provision "to implement any new or revised water quality standards and implementation plans adopted or approved pursuant to [Porter-Cologne] or section 303 of the Clean Water Act" (State Water Board 2005, 2006).

2.5.3 Flow Requirements

Various flow requirements on USBR established through agreements, BOs, and water rights decisions govern the flow released from the dams on the Stanislaus River. Four of these are discussed below: the 1987 Agreement, Decision 1422, USFWS AFRP, and 2009 NMFS BO. In recent drought years, low storage levels in New Melones Reservoir, limited projected inflows and the junior nature of USBR's water rights for New Melones Reservoir, limited supplies are available to USBR to meet its flow and other water quality requirements and maintain water in storage. USBR does not appear to have adequate water in New Melones Reservoir under its water right permits to meet the State Water Board's Water Right Decision D-1641 (D-1641) (revised March 15, 2000) spring base flow and spring pulse flow requirements in 2016 as well as other requirements without depleting storage in New Melones Reservoir to unreasonably low levels. OID's and SSJID's water rights and other SJR Basin water rights are not conditioned on meeting any of these requirements.

1987 Agreement and Interim Operations Plan

USBR and CDFW executed an agreement titled *Interim Instream Flows and Fishery Studies in the Stanislaus River Below New Melones Reservoir* on June 5, 1987 (1987 Agreement). The interim plan of operations (IPO) increased the fisheries release by changing 98,300 AF from the maximum to the minimum required release and allowed for releases as high as 302,100 AF in wetter years. The exact quantity to be released each year is determined based on a formulation involving storage, projected inflows, projected water demands, and target carryover storage.

State Water Board Water Right Decision 1422

State Water Board Water Right Decision 1422 to USBR specifies flow releases from New Melones Reservoir up to 70,000 AF in any 1 year for water quality control purposes in the LSJR. The flows must maintain a maximum mean monthly total dissolved solids (TDS) concentration below the mouth of the Stanislaus River at 500 parts per million (ppm). They must also maintain at least 5 ppm of dissolved oxygen in the river.

State Water Board Water Right Decision 1641

The State Water Board established flow objectives for the SJR at Vernalis for the period from February through June and the month of October. With the exception of a 31-day pulse flow period from approximately April 15 through May 15, the February through June flows are referred to as the spring base flow objectives. The objectives require a specified minimum monthly average flow rate based on the San Joaquin Valley Water Year Hydrologic Classification (at the 75 percent exceedance level) and include two levels. The higher flow level applies when the 2 parts per thousand (ppt) isohaline (X2[15]) is required to be at or west of Chipps Island pursuant to Table 4 of D-1641. The fall pulse objective in all years except a critical year following a critical year is required to be 1,000 cfs plus up to an additional 28 TAF limited to the amount necessary to provide a monthly average flow of 2,000 cfs. The additional 28 TAF is not required in a critical year following a critical year.

In D-1641, the State Water Board assigned responsibility to USBR for ensuring that all of the SJR flow objectives are met. As part of the San Joaquin River Agreement (SJRA), a voluntary agreement between parties in the SJR Watershed to implement provisions of the 1995 Bay-Delta Plan from 2000 through 2011, USBR and DWR purchased water from other water users in the SJR Watershed to meet some of the SJR flow requirements. Instead of meeting the 1995 Bay-Delta Plan pulse flow objectives (the current D-1641 requirements), the SJRA parties proposed and the State Water Board approved the conduct of the Vernalis Adaptive Management Plan (VAMP). The VAMP provided for generally lower flows and offramps in very dry conditions. The SJRA also provided for the purchase of flows to meet the D-1641 fall flow requirements. After the expiration of the SJRA in 2011, USBR purchased some water to help to meet the SJR flow requirements in 2012 and 2013, but did not fully achieve the requirements. Due to inadequate water supplies in New Melones Reservoir to meet all of USBR's various obligations and the lack of water releases from elsewhere in the SJR Watershed, USBR has repeatedly failed to comply with the SJR flow objectives since the SJRA expired.

U.S. Fish and Wildlife Service AFRP

~~USFWS requires USBR to provide water for fish flows below CVP reservoirs on the Stanislaus River in accordance with AFRP goals set by USFWS~~ USBR is required to operate the CVP reservoirs on the Stanislaus River in accordance with CVPIA which defines a limited volume of increased releases (and/or export restrictions) that may be made in an effort to reach the AFRP goals, but are at the discretion of USFWS. This program generally released pulse flows in the April–May period that were coordinated with the VAMP~~)~~. The AFRP is continuing, although the VAMP ended in 2011. The annual allocation and scheduling of release flows are made annually, but are supplemental to the basic IPO flows, described above.

2009 National Marine Fisheries Service Biological Opinion

Reasonable and Prudent Alternative (RPA) Action 3.1.3 of the June 2009 NMFS BO to USBR for the long-term operation of the CVP and SWP (Operational Criteria and Plan [OCAP])imposes minimum Stanislaus River flows according to a flow schedule as measured at Goodwin Dam. These daily flows are dictated by the lifecycles of species: the fall flow for attraction, spring pulse flow for outmigration cues in wet years, and sustained late-spring flows for outmigration. The flows range from approximately 500 to 1,500 cfs in the fall and approximately 800 to 4,800 cfs in the spring. The daily flow schedule (with several pulse flows) is equivalent to the monthly average RPA flow requirement simulated by the Water Supply Effects (WSE) model. Section 2.6.3 provides additional information regarding the 2009 NMFS BO as it relates to the flows measured on the SJR at Vernalis.

[15] X2 is the location of the 2 parts per thousand salinity contour (isohaline), 1 meter off the bottom of the estuary measured in kilometers upstream from the Golden Gate Bridge. The abundance of several estuarine species has been correlated with X2. In the 2006 Bay-Delta Plan, a salinity value—or electrical conductivity (EC) value—of 2.64 millimhos/centimeter (mmhos/cm) is used to represent the X2 location. Note, in this SED, EC is generally expressed in deciSiemens per meter (dS/m). The conversion is 1 mmhos/cm = 1 dS/cm.

2.5.4 Hydrology

The unimpaired flow of the Stanislaus River is the flow that would occur without existing diversions. The historical flow of the Stanislaus River is influenced by the operation of the existing dams and diversions described above. The hydrograph in Figure 2-10 depicts both types of flow over time. It shows that the unimpaired flow at New Melones Dam averaged 1,100 TAF/y and the historical bypasses or releases averaged 611 TAF/y below the Goodwin Dam for the recent 10-year period of water years 2000–2009.[16]

The Goodwin Dam bypasses or releases averaged approximately 55 percent of the unimpaired flow, but the historical flows were usually much less than 50 percent of the unimpaired flow, with flood control releases providing most of the flow below Goodwin Dam. The historical monthly flows at Ripon are generally less than the unimpaired flows in the winter and spring months, and are often slightly higher than the unimpaired flows in the summer and fall months.

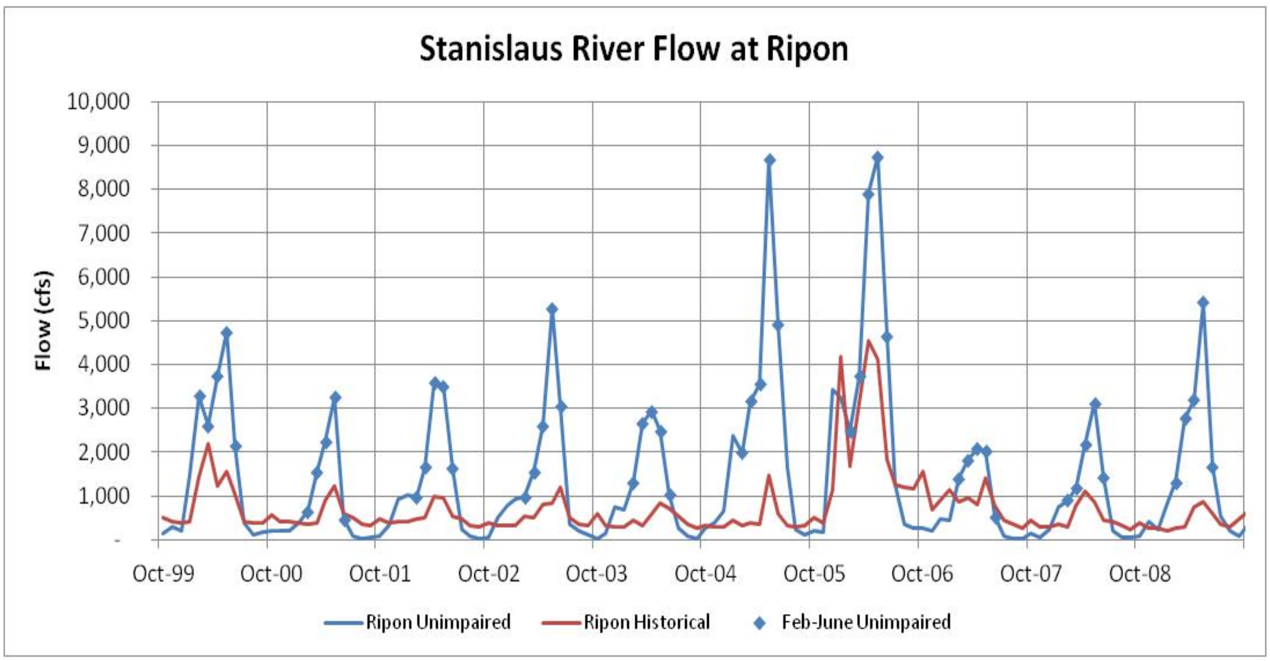

Figure 2-10. Monthly Unimpaired and Historical Stanislaus River Flows February–June for Water Years 2000–2009 (cfs = cubic feet per second)

Table 2-20 summarizes the range of historical and unimpaired flows on the Stanislaus River to demonstrate the baseline hydrology of the river in February–June. The peak historical flows during this period were in 2006 because New Melones Reservoir was nearly full, and relatively high flows ranging from 2,000 to 4,500 cfs were released for flood control purposes.

The Stanislaus River monthly unimpaired flows at New Melones Dam are summarized in Table 2-21, with the cumulative distributions of unimpaired flow (in 10 percent increments) for each month from 1984 through 2009. Each month has a range of runoff depending on the rainfall and

[16] These releases include flood flows in 2000 and 2006.

accumulated snowpack. The median flows (50 percent cumulative) can be used to generally characterize the seasonal runoff pattern. The peak runoff for the Stanislaus River is observed in May, and highest runoff (median monthly runoff greater than 90 TAF, or 1,500 cfs) is observed March–June. The minimum flows are observed in August, September, and October. The distribution of annual unimpaired flow ranged from 463 TAF (10th percentile) to 2,015 TAF (90th percentile), with a median runoff of 922 TAF. The average unimpaired flow was 1,100 TAF/y, 19 percent more than the median runoff. This represents approximately 18 percent of the estimated unimpaired flow at Vernalis.

Table 2-20. New Melones Reservoir Historical and Unimpaired Flow (cubic feet per second) February–June

Water Year	Historical Range	Unimpaired Range
2000	1,000–2,000	2,000–5,000
2001	250–1,000	500–3,000
2002	500–1,000	1,000–3,500
2003	500–1,000	1,000–5,000
2004	500–750	1,000–3,000
2005	250–1,250	2,000–9,000
2006[a]	2,000–4,500	2,500–9,000
2007	750–1,250	500–2,000
2008	250–1,000	1,000–3,000
2009	250–750	1,000–5,500

[a] New Melones Reservoir was nearly full, and flood control releases were made in each month February–June.

Table 2-21. Monthly and Annual Unimpaired Flow in the Stanislaus River 1984–2009 (thousand acre-feet)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
10	3	5	12	17	29	67	105	95	30	5	2	1	463
20	5	8	13	23	35	79	130	153	41	12	4	1	510
30	6	10	14	27	50	90	135	167	57	14	5	2	595
40	9	13	15	42	55	102	157	192	94	19	6	3	752
50	10	16	27	55	75	127	178	224	103	22	7	4	922
60	11	18	31	86	90	160	206	297	128	24	10	6	1,162
70	12	24	42	100	104	176	218	329	178	40	13	6	1,463
80	13	31	47	146	138	215	245	370	215	57	16	10	1,692
90	17	44	105	191	224	233	254	446	285	89	21	18	2,015

Compared to the other two eastside tributaries, the Tuolumne and Merced Rivers, the Stanislaus River historical flows are relatively high because of the minimum flow requirements for fish; additional releases for salinity control; AFRP flow releases for anadromous fish in April, May, and June; and the VAMP flow releases in April and May. The New Melones Reservoir is the largest reservoir on the SJR tributaries and has considerable carryover storage from one year to the next. Therefore, flood control releases are not necessary each year; consequently, it is difficult to anticipate when reservoir releases for flood control storage will be required. The monthly historical flows are summarized in Table 2-22 with the cumulative distributions (in 10 percent increments) from 1984 through 2009. The majority of the historical monthly flows were between 10 TAF and 40 TAF (150 cfs and 600 cfs). The annual river flow volume ranged from 310 TAF (10th percentile) to 1,249 TAF (90th percentile). The median historical annual river flow was 429 TAF. The average historical flow was 611 TAF/y, which is 42 percent more than the median. The average historical flow of 611 TAF was approximately 55 percent of the average unimpaired flow, but most of this flow was observed in the wet years with flood control releases.

Table 2-22. Monthly and Annual Historical (Observed) Flow in the Stanislaus River 1984–2009 (thousand acre-feet)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
10	20	17	14	12	13	19	30	33	28	21	19	16	310
20	21	19	17	15	17	24	36	47	33	25	20	18	333
30	24	19	19	20	18	31	45	51	35	27	22	19	351
40	27	19	20	24	20	43	49	54	36	29	23	19	386
50	30	22	22	25	26	53	53	63	41	31	25	23	429
60	32	24	25	29	41	67	57	77	49	34	27	25	532
70	35	25	28	40	65	77	66	87	58	39	33	28	624
80	43	27	55	69	91	135	75	92	70	45	39	33	967
90	74	43	65	182	150	181	109	98	77	65	74	57	1,249

2.6 Lower San Joaquin River

2.6.1 Basin Overview

The drainage area of the SJR above Vernalis encompasses approximately 12,250 square miles. All of the SJR flow from upstream of the Merced River (including the Friant Dam flood control releases) as well as the tributary flows from the three eastside tributaries are combined and measured at the Vernalis Bridge. On the west side of the LSJR, tributary streams include Hospital, Del Puerto, Orestimba, San Luis, and Los Banos Creeks. These intermittent streams are commonly referred to as the westside tributaries to the SJR. However, at times of high rainfall, these streams contribute significant runoff to the LSJR. Vernalis, an unincorporated community in San Joaquin County downstream of the Stanislaus River and upstream of tidal effects from the Delta, is where the LSJR enters the southern Delta.

The water for irrigated agriculture in the San Joaquin Valley is supplied by the LSJR and its tributaries and the Delta-Mendota Canal (DMC), which conveys water from the southern Delta to the Mendota Pool. The CVP Jones Pumping Plant (with seasonal storage in San Luis Reservoir) exports water from the southern Delta through the DMC, supplying the SJR exchange contractors and several water districts along the DMC that have contracts for CVP water supplies.

2.6.2 Water Diversion and Use

The LSJR within the plan area includes the confluences of the Stanislaus, Tuolumne, and Merced Rivers. The stretch of river from the Merced River confluence north to Vernalis has approximately

40 diversions. Of these diversions, approximately 15 are covered under appropriative water rights, and approximately 25 diversions are claimed under Statements of Water Use and Diversion. The major use of diverted water is for agricultural and domestic uses (State Water Board 2015).

2.6.3 Flow Requirements

Various flow requirements established through basin plans and agreements have governed the flow at Vernalis, including objectives in the 1995 and 2006 Bay-Delta Plans, SJRA, VAMP, D-1641, and 2009 NMFS BO.

The State Water Board first established LSJR flow objectives in the 1995 Bay-Delta Plan. The flow objectives were primarily intended to protect fall-run Chinook salmon and provide incidental benefits to Central Valley steelhead. The objectives were unaltered in the 2006 Bay-Delta Plan, but as authorized in D-1641, the 2006 Bay-Delta Plan allowed for the VAMP (discussed below) to be conducted instead of the plan's April 15–May 15 pulse flow requirements.

The SJRA signatory parties, including the California Resources Agency, U.S. Department of the Interior, San Joaquin River Group, CVP/SWP Export Interests, and two environmental groups, agreed that the San Joaquin River Group Authority (SJRGA) members would meet the experimental flows specified in the VAMP program in lieu of meeting the spring pulse flow objectives adopted in the 2006 Bay-Delta Plan. The VAMP, which ended in 2011, was a 12-year program designed to protect juvenile Chinook salmon migration from the LSJR through the Delta. It was also a scientific experiment with monitoring to determine how juvenile fall-run Chinook salmon survival rates change in response to alterations in LSJR flows and CVP and SWP exports as a result of the installation of the Head of Old River Barrier (HORB). The VAMP was designed to assess a combination of flows, varying between 3,200 cfs and 7,000 cfs, and exports varying between 1,500 cfs and 3,000 cfs.

The SJRA included flows for the October pulse flow objective. Supplemental water up to 28,000 AF was also released in October during all water year types. The amount of additional water was limited to that amount necessary to provide a monthly average flow of 2,000 cfs at Vernalis.

As discussed above in the Stanislaus River section, under D-1641, USBR is assigned responsibility for ensuring that all of the SJR flow objectives are met. Due to inadequate water supplies in New Melones Reservoir to meet all of USBR's various obligations and the lack of water releases from elsewhere in the SJR Watershed, USBR has repeatedly failed to comply with the SJR flow objectives since the SJRA expired.

The 2009 NMFS BO for the long-term OCAP included several RPAs related to New Melones Reservoir operations and the Stanislaus River that affect the flows at Vernalis. RPA action IV 2.1 requires a minimum LSJR inflow-to-export ratio and minimum flows at Vernalis based on SJR water year type during the 2-month pulse flow period of April and May. (USBR and DWR are required to seek a supplemental agreement with SJRGA to achieve these minimum long-term flows at Vernalis.) The LSJR inflow-to-export ratio is the inverse of the already established Delta Export/Inflow (E/I) ratio, which is calculated using the total Delta inflow. The LSJR inflow-to-export ratios are more restrictive and allow the exports to be 100 percent of the LSJR inflow in critical years, 50 percent of the LSJR inflow in dry years, 33 percent of the LSJR inflow in below normal years, and 25 percent of the LSJR inflow in above normal or wet years. As indicated in Table 2-23, these criteria effectively limit exports to 1,500 cfs during April and May unless the LSJR is higher than the minimum flow required in these months.

Table 2-23. Minimum April and May Vernalis Flows (cubic feet per second)

San Joaquin River (60-20-20) Index Year Types	Minimum Flow at Vernalis	Corresponding Exports
Critical	1,500	1,500
Dry	3,000	1,500
Below Normal	4,500	1,500
Above Normal	6,000	1,500
Wet	6,000	1,500

2.6.4 Hydrology

Construction and operation of the numerous water supply, hydroelectric, and flood control reservoirs during the twentieth century upstream of Vernalis have significantly modified the flows at Vernalis in comparison to the historical (observed) flows. Peak flows currently occur earlier in the year—during February, March, April, and May, rather than in May and June as occurred under the unimpaired flow regime. Figure 2-11 shows the monthly unimpaired and historical flows at Vernalis for the recent 10-year period of water years 2000 through 2009. The unimpaired flows at Vernalis average 6,056 TAF/y and the historical flows (including flood flows in 2000, 2005, and 2006) average 2,915 TAF/y.

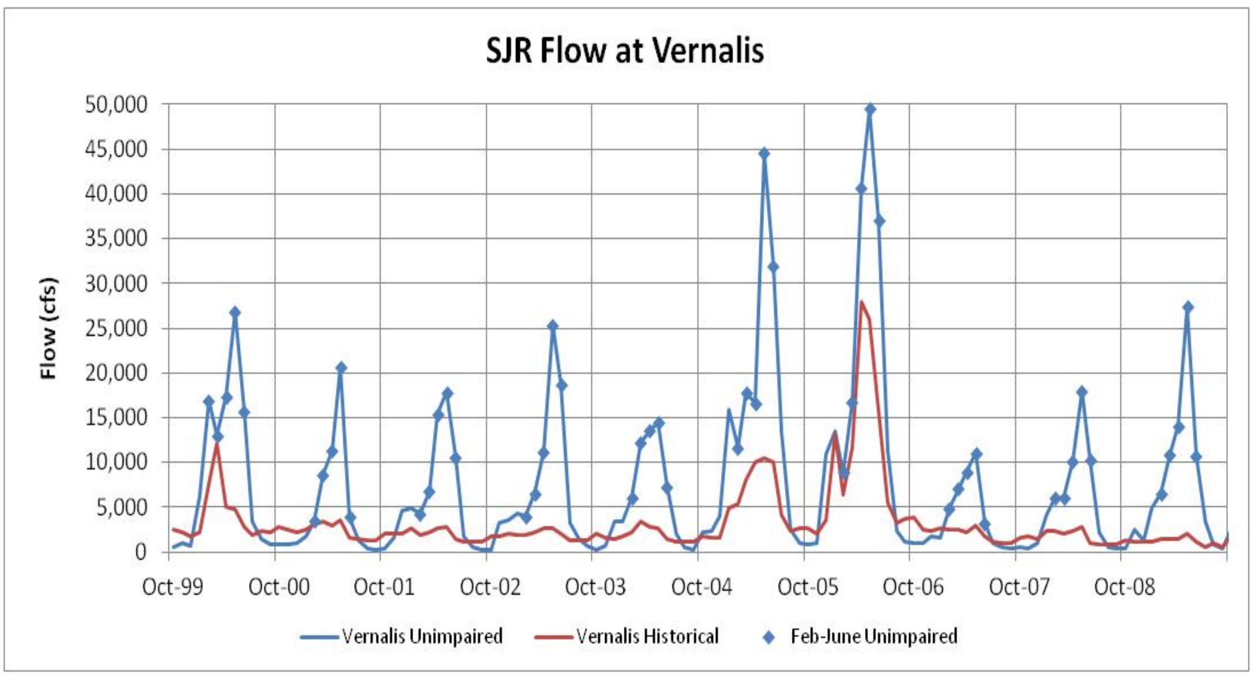

Figure 2-11. Monthly Unimpaired and Historical LSJR Flows at Vernalis February–June for Water Years 2000–2009 (cfs = cubic feet per second)

The historical (1930–2009) Vernalis flows average approximately 48 percent of the unimpaired flow, but the releases were usually much less than 40 percent of the unimpaired flow, with flood control releases providing the majority of the flow. The historical monthly flows at Vernalis were generally lower than the unimpaired flows in the winter and spring months, and were often slightly higher than the unimpaired flows in the fall months.

Observed flow at Vernalis after 1984 reflects conditions that existed following completion and filling of New Melones Reservoir in 1983. Tables 2-24 and 2-25 show the monthly unimpaired and historical flows, respectively, for the SJR at Vernalis from 1984 through 2009. The hydrologic variability in the SJR Basin after 1983 has been substantially altered, with greatly reduced monthly flows and annual runoff volumes. The median annual unimpaired flow in the SJR at Vernalis was 4,578 TAF, while the median annual historical runoff was 1,718 TAF, or approximately 38 percent of unimpaired flow.

Table 2-24. Monthly and Annual Unimpaired Flow in the San Joaquin River at Vernalis 1984–2009 (thousand acre-feet)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
10	15	35	49	77	148	326	557	631	238	84	29	15	2,555
20	22	41	62	97	169	380	645	820	337	105	34	18	2,681
30	33	50	70	121	226	412	672	981	447	111	38	20	3,468
40	39	55	102	208	275	490	714	1,095	630	145	44	28	3,753
50	49	70	125	284	339	587	892	1,424	773	208	55	37	4,578
60	57	76	160	378	482	719	926	1,600	874	232	94	44	6,102
70	62	145	211	387	553	802	984	1,763	1,122	324	108	52	7,868
80	75	156	225	773	726	998	1,144	1,941	1,643	478	139	61	10,082
90	100	209	491	948	1,071	1,099	1,421	2,307	2,141	833	169	82	11,242

Table 2-25. Monthly and Annual Historical (Observed) Flow in the San Joaquin River at Vernalis 1984–2009 (thousand acre-feet)

Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
10	65	67	65	72	78	109	87	94	63	45	45	52	891
20	84	77	80	91	104	130	114	121	66	70	62	56	1,168
30	91	95	89	114	114	135	138	133	88	73	69	68	1,300
40	108	102	97	131	127	157	155	163	102	81	79	81	1,396
50	125	110	113	146	155	187	167	174	111	89	98	91	1,718
60	161	121	130	159	180	211	204	217	137	108	121	121	2,108
70	170	136	138	252	361	504	290	295	161	123	129	134	3,678
80	230	151	216	291	486	744	446	518	222	157	160	165	5,227
90	293	168	280	590	655	913	1,176	872	714	298	212	223	6,539

Increased storage and water supply diversions have resulted in flow conditions that are more static with less seasonally variable flows throughout the year. There are now reduced flows in the winter and spring months, with increased flow in the fall, both of which combine to create managed flows that diverge significantly from what would occur under unimpaired conditions.

2.7 Southern Delta

The LSJR enters the southern Delta at Vernalis. When the Head of Old River Barrier is not in place, about half of the LSJR volume flows west into Old River (which diverges from the LSJR downstream of Mossdale and connects with Middle River and the Grant Line Canal) and is typically diverted by the CVP and SWP export pumps, and about half continues north toward Stockton. Most of the lands in the southern Delta are within the South Delta Water Agency (SDWA) in San Joaquin County. Figure 2-12 shows the outline of the SDWA relative to the San Joaquin County line and the legal boundary of the Delta. Of the nearly 150,000 acres within the southern Delta, irrigated lands comprise approximately 100,000 acres. The non-irrigated area includes urban lands, watercourses, levees, farm homesteads, islands within channels, and levees. Just west of the plan area in the southern Delta are the CVP and SWP pumping plant intakes. Just outside the plan area to the north and west are two CCWD intakes. Figure 2-12 shows the location of these intakes and of wastewater treatment plant (WWTP) facilities that discharge treated effluent into the southern Delta.

Southern Delta salinity concentrations are affected by numerous factors, including the amount and salinity concentration of SJR flow entering the southern Delta at Vernalis, daily tidal action, CVP and SWP pumping operations, agricultural return flows, municipal wastewater discharges, and other influences. These are discussed in more detail below.

2.7.1 Lower San Joaquin River and Tidal Conditions

Water enters the southern Delta channels along three major pathways: from the LSJR west through Old River and Grant Line Canal toward the CVP Jones and SWP Banks pumping facilities; from the central Delta through Middle River and Victoria Canal; and from the central Delta through Old River and West Canal to the Clifton Court Forebay (CCF) and the DMC. Approximately 50 percent of the LSJR flow splits into the Old River channel, and the other 50 percent continues down the LSJR channel toward Stockton. During storm flows of greater than approximately 15,000 cfs at Vernalis, the Paradise Cut weir (elevation 12.5 ft) diverts some of the flow at LSJR mile 60 into Paradise Cut toward Grant Line Canal, reducing the LSJR flow at Mossdale and the Head of Old River.

There are three major southern Delta channels: Old River channel, Middle River channel, and Grant Line Canal. The Old River channel flows west about 4 miles to the upstream end of Middle River and continues past Doughty Cut (which connects with the upstream end of Grant Line Canal) toward Tracy. The Old River channel in the vicinity of Tracy is the southernmost Delta channel. The Old River channel length between the Head of Old River and the CVP Tracy Facility (DMC and fish facility) is about 24 miles, with a surface area of about 550 acres and a volume of 3,500 AF at an elevation of 0 ft mean sea level (MSL). Most of the Old River flow moves through Doughty Cut to Grant Line Canal.

Middle River is a relatively narrow and shallow channel that extends 12 miles from its head to Victoria Canal. The surface area of Middle River is approximately 175 acres, with a volume of 750 AF at an elevation of 0 ft MSL. Export conditions (described further below) pull water from the Sacramento River and create cross-Delta water conditions. This cross-Delta water flows south (upstream) in the portions of Old and Middle Rivers that are north of the exports. Approximately 60 percent of this Old and Middle River (OMR) flow is in the Old River channel and approximately 40 percent is in the Middle River and Victoria Canal, because Victoria Canal is shallow and Old River is a larger conveyance channel.

The third major channel is the Grant Line Canal, which is about 7.5 miles long and extends from near Doughty Cut to the Old River channel just north of the Tracy fish facility. The surface area of the Grant Line Canal is approximately 400 acres, with a volume of approximately 3,250 AF at an elevation of 0 ft MSL. The Fabian and Bell Canal, which runs parallel to and is interconnected with Grant Line Canal for much of its length, is included in these measurements.

The total surface area of these three major southern Delta channels is approximately 1,125 acres with a volume of 7,500 AF at a water surface elevation of 0 ft MSL. As the tidal elevation fluctuates, the surface area and volume change. The average southern Delta tidal fluctuation is approximately 3 ft (i.e., from -1 to 2 ft), and the surface area increases from 1,000 acres at low tide to 1,250 acres at high tide (Delta Simulation Model 2 [DSM2]). The southern Delta channel volume increases from approximately 6,000 AF at low tide to approximately 9,500 AF at high tide, a change of approximately 3,500 AF. This tidal volume, also known as the tidal prism, moves into and out of the southern Delta channels twice each day, constituting an average tidal flow of approximately 3,500 cfs flowing into these channels during the flood tides (for about 12 hours each day) and approximately 3,500 cfs flowing out during the ebb tides.

The longitudinal movement of water between low tide and high tide depends on the cross-section of the channels but averages several miles in the southern Delta channels. This tidal movement provides considerable mixing and diluting of the agricultural drainage and wastewater discharges in the southern Delta channels. The CCF gates are usually operated to remain closed during flood tide periods to preserve as much upstream flow into the southern Delta channels as possible and to maintain the high tide elevations. Sacramento River water moving toward the export pumps from the central Delta through Old and Middle Rivers is tidally mixed with LSJR water in the vicinity of CCF and the DMC intake, with some Sacramento River water moving upstream in Old River and Grant Line Canal during flood tide, and some LSJR water moving downstream past CCF in West Canal, Old River, and Victoria Canal during ebb tide.

The HORB is a temporary rock barrier that has often been installed by DWR in the fall (late September through November). The barrier reduces the normal diversion of SJR flow into Old River. When the rock barrier is installed, the majority of the LSJR flows north to the Stockton Deep Water Ship Channel. However, some of the LSJR flow is drawn through Turner Cut and Middle River and Victoria Canal toward the CVP and SWP pumping facilities. The barrier is meant to increase flow in the Stockton DWSC and improve the migration of adult SJR Chinook salmon. The HORB was also installed in the spring during the VAMP pulse flow period to reduce the number of juvenile SJR Chinook salmon diverted into Old River and subsequently entrained (or salvaged) at the CVP and SWP fish collection facilities. The increased flow past Stockton was intended to improve the survival of SJR fish migrating through the Delta to Chipps Island.

2.7.2 Water Diversions

The two major water export facilities in the Delta are the CVP and SWP, which are both located west of Tracy just outside the western boarder of the SDWA boundary. The CCWD also diverts water from the southern Delta at Old River and Victoria Canal. These facilities and their influence on southern Delta circulation and salinity are described below.

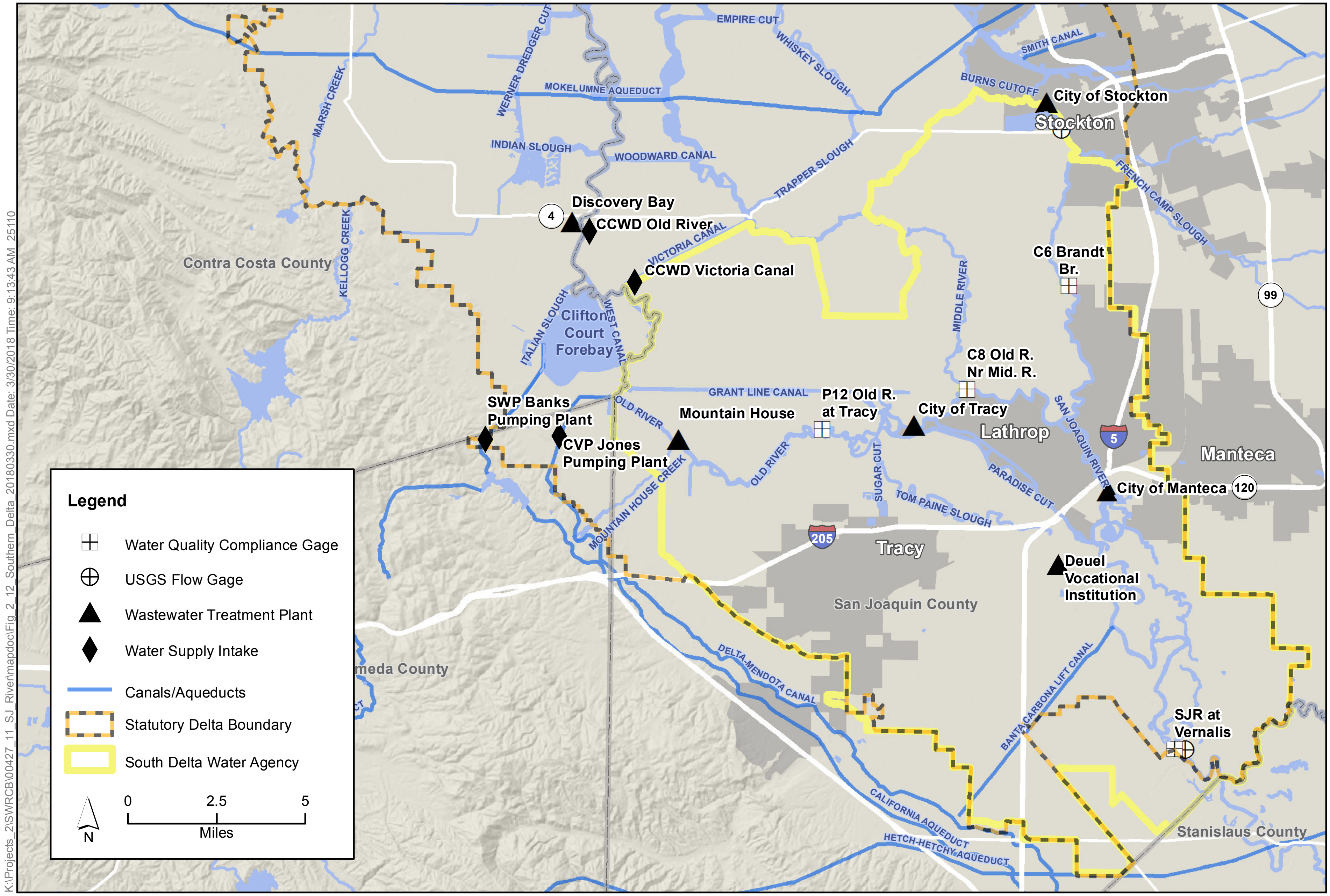

Figure 2-12
Vicinity Map of Southern Delta

Export Facilities

CVP Jones Pumping Plant

The CVP Jones Pumping Plant, formerly known as the Tracy Pumping Plant, is located about 5 miles northwest of Tracy. The Jones Pumping Plant consists of six pumps with a permitted diversion capacity of 4,600 cfs. It is located at the end of an earth-lined intake channel approximately 2.5 miles long. The Tracy Fish Collection Facility is located at the entrance to the intake channel on Old River. Water is pumped approximately 200 ft into the DMC, which, as mentioned earlier, delivers water to LSJR water rights holders at Mendota Pool (exchange contractors) and CVP contractors along the DMC and conveys water to San Luis Reservoir for seasonal storage.

The southern Delta CVP contractors are composed of three separate water demand types: CVP water service contractors, exchange contractors, and wildlife refuge contractors. Exchange contractors "exchanged" their senior rights to water in the LSJR for a CVP water supply from the Delta. USBR guaranteed the exchange contractors a firm water supply of 840 TAF/y, with a maximum reduction to 650 TAF/y. The exchange allowed USBR to build Friant Dam and to divert the LSJR water supply to the Friant-Kern and Madera Canals. Additional CVP contactors and wildlife refuge water supply contracts total almost 3,500 TAF/y of water supply demand for the Jones Pumping Plant.

SWP Banks Pumping Plant

The Harvey O. Banks Pumping Plant has a physical pumping capacity of 10,300 cfs. However, flow diverted from the Delta into CCF is limited by a USACE permit under Section 10 of the Rivers and Harbor Act to a maximum of 6,680 cfs during much of the year. SWP exports are diverted into CCF and then pumped at the Banks Pumping Plant into the California Aqueduct (State Water Board 1999). This exported water is pumped into the South Bay aqueduct, pumped into San Luis Reservoir for seasonal storage, pumped farther south in the California Aqueduct to Kern County Water Agency, pumped over the Coast Range in the Coastal Aqueduct, or pumped over Tehachapi Pass to southern California contractors. The total water supply demand for the Banks Pumping plant is approximately 4,000 TAF/y.

CVP and SWP Exports

CVP and SWP export pumping are subject to 2006 Bay-Delta Plan objectives, which are implemented through D-1641. Both the CVP and the SWP have maximum permitted pumping rates. Delta outflow requirements may limit export pumping if the combined Delta inflow is not enough to satisfy both the in-Delta agricultural diversions described earlier in this chapter and the CVP and SWP pumping. The coordinated operations agreement (COA) governs the CVP and SWP share in reservoir releases and Delta pumping.

Export rates are also limited by the 2008 USFWS and the 2009 NMFS BOs for the long-term OCAP of the CVP and SWP. These two BOs added limits on the reverse (negative) OMR flows December–June. The BOs allow a range of reverse OMR limits to be imposed for delta smelt and salmonid protection, but the largest monthly average reverse OMR flows for December–June are negative 5,000 cfs. This effectively limits the CVP and SWP exports to approximately 5,000 cfs plus one-half of the LSJR flow at Vernalis.

The 1995 Bay-Delta Plan introduced the E/I ratio, which limits the combined export to a specified monthly fraction of the combined Delta inflow. The E/I ratio is 35 percent February–June and

65 percent June–January. The February E/I can be increased to 45 percent under low-flow conditions. This E/I objective allows a maximum pumping that is often similar to the allowable exports under the Delta outflow objectives, but sometimes the E/I ratio is more limiting than the required outflow. At other times, the exports must be further reduced to increase the Delta outflow to satisfy the salinity requirements at Emmaton and Jersey Point or at CCWD's Rock Slough diversion.

The monthly cumulative distribution of CVP and SWP pumping for water years 1984 through 2009, which corresponds to the LSJR historical and unimpaired flows, suggests that the CVP pumping is uniform throughout most of the year. The largest reductions in pumping occur during April–June for fish protection. The median CVP pumping was greater than 3,500 cfs in all months except April, May, and June. The SWP pumping shows a greater range from year to year in most months. The median SWP pumping is 3,000–4,000 cfs from October to March, and approximately 2,000 cfs in April, 1,000 cfs in May, and 2,000 cfs in June. SWP pumping has been greatest in July–September with a median pumping of approximately 5,000 cfs because of the peak irrigation demand and because reduced pumping for fish protection is not usually required in these months.

CCWD Intakes

CCWD has four surface water intakes: Mallard Slough Intake, Rock Slough Pumping Plant #1, Old River Intake near State Route 4, and Victoria Canal Intake. The Old River and Victoria Canal Intakes are immediately north/northwest of the SDWA boundary (Figure 2-12). The Mallard Slough and Rock Slough Intakes are located farther west and closer to the ocean. The Old River Intake is the largest intake, accounting for the majority of surface water diverted by CCWD (CCWD and USBR 2006).

Generally, CCWD intakes are located where the effects of seawater intrusion are very pronounced. Therefore, salinity at CCWD intakes can vary substantially over the course of a year. CCWD's intakes typically experience relatively fresh conditions in the late winter and early spring, and salinity increases in summer and fall as conditions become drier and regulatory standards governing Delta operations shift. For example, in dry years, salinity begins to increase in July, while in wet years, an increase in salinity may not occur until September. Additionally, periods with high agricultural drainage contributions in the summer may increase salinity loads that CCWD diverts, as agricultural return flows tend to carry higher salt concentrations (CCWD and USBR 2006).

Use of the Mallard Slough Intake is generally restricted due to salinity concentrations because it experiences more tidal fluctuations as a result of its location. Water quality conditions have restricted diversions from Mallard Slough (an average of 3,100 AF/y) with no diversions available in dry years. When Mallard Slough supplies are used, CVP diversions at Rock Slough are reduced by an equivalent amount. The Victoria Canal Intake allows CCWD the flexibility to divert water with lower salinity and allows seasonal operations shifts between diversions. The seasonal variation in salinity between Old River/Rock Slough and Victoria Canal allows CCWD to divert predominantly in winter and spring from Old River and in the summer and fall from Victoria Canal (CCWD and USBR 2006).

2.7.3 Return Flows

Return flows in the southern Delta are those flows generated by different uses and then discharged (or returned) to the receiving waters of the southern Delta. There are two primary sources of return flows in the southern Delta: discharges from the existing WWTPs and agricultural discharges from irrigators in the southern Delta. These two sources are discussed below.

Wastewater Treatment Plants

Existing WWTPs are considered point sources and discharge salt into the southern Delta, thereby influencing southern Delta salinity. There are six WWTPs that discharge into the southern Delta, all of which are required to comply with effluent limitations established by National Pollution Discharge Elimination System (NPDES) permits. Effluent limitations that regulate the quality of the effluent discharged from the WWTPs are set for a wide variety of constituents, including salt. Chapter 13, *Service Providers*, provides additional information and specific characteristics for each WWTP. Table 2-26 lists these six WWTPs with discharges into the southern Delta, their receiving water bodies, and their total permitted discharge rate.

Table 2-26. Wastewater Treatment Plants with Discharges into the Southern Delta

Facility Name	Receiving Water	Current Permitted Discharge (million gallons per day)
City of Tracy WWTP	Old River	16
Deuel Vocational Institution	Paradise Cut and Old River	0.62
City of Manteca Wastewater Quality Control Facility	San Joaquin River	17.5
Stockton Regional Wastewater Control Facility	San Joaquin River	55
Mountain House Community Service District WWTP	Old River	5.4
Discovery Bay WWTP	San Joaquin River	2.1

WWTP = wastewater treatment plant

The City of Tracy WWTP discharge has limited effects on the salinity in the southern Delta compared to other sources of salinity, including drainage and runoff from agricultural activities and groundwater accretions. Salinity loads from the City of Tracy, Deuel Vocational Facility, and Mountain House CSD WWTPs are a small percentage of the salt load entering from upstream (Appendix C, *Technical Report on the Scientific Basis for Alternative San Joaquin River Flow and Southern Delta Salinity Objectives*).

Agricultural Discharges

Various crops in the southern Delta are irrigated primarily with surface water through numerous local agricultural diversions of existing surface waters. Many small agricultural diversions (siphons and pumps) move water throughout the Delta during the spring and summer irrigation season. All of the Delta islands and tracts use these drainage pumping stations to pump off stormwater runoff as well as seepage during the winter and discharge it into the Delta channels. Once the land has been irrigated, water not evapotranspired by the crops returns to the surface waters through either groundwater recharge (as a result of the high water table) or through runoff over the lands. As irrigation water is continually applied, salt infiltrates and builds up in the soil. Salt-leaching from the fields occurs naturally during the rainy season or may be managed by applying water in the fall or winter to maintain the soil salinity within acceptable bounds. Chapter 11, *Agricultural Resources*, and Appendix E, *Salt Tolerance of Crops in the Southern Sacramento–San Joaquin Delta*, provide specific information about the current crop mix and salinity tolerances of each crop.

2.7.4 Water Quality and Water Quality Objectives

The LSJR delivers water of relatively poor quality to the Delta, with agricultural drainage to the river being a major source of salts and pollutants (i.e., boron, selenium, pesticides). During periods of high flow, water quality generally improves. Because the southern Delta receives a substantial portion of its water from the LSJR, the influence of this relatively poor LSJR water quality is greatest in the southern Delta channels. Vernalis, upstream of the southern Delta Channels, is a focal point on the LSJR as the three eastside tributaries contribute to the combined flow of the SJR at Vernalis. Flow at Vernalis represents the positive inflow that the LSJR contributes to the southern Delta. The LSJR flow at Vernalis has a large effect on the salinity at Vernalis and the southern Delta. Higher flows generated by reservoir releases or decreased diversions generally reduce the salinity by diluting the LSJR, which tends to be higher in salt from agricultural return flows. Higher CVP and SWP pumping also results in reduced southern Delta salinity as higher pumping brings more Sacramento River water across the Delta to the export pumps. The State Water Board has conditioned the water right permits held by DWR and USBR on meeting salinity standards at compliance locations. ~~DWR and USBR meet the salinity standards by changing water project operations, particularly releases from New Melones on the Stanislaus River.~~ Historically, southern Delta water quality has generally ranged from 0.2 deciSiemens per meter (dS/m) to 1.2 dS/m. Salinity generally remains below 1.0 dS/m when salinity at Vernalis is less than approximately 0.9 dS/m (see Chapter 5, *Surface Hydrology and Water Quality*, and Appendix F.2, *Evaluation of Historical Flow and Salinity Measurements of the Lower San Joaquin River and Southern Delta*).

The four D-1641 water quality compliance stations in the southern Delta are at the following locations (shown in Figure 2-12): SJR at Airport Way Bridge near Vernalis (C-10), Old River at Tracy Road Bridge (C-6), Old River near Middle River (C-8), and SJR at Brandt Bridge (P-12). Currently, the salinity objective set for the southern Delta and measured at these four salinity (electrical conductivity [EC][17]) compliance stations is a maximum 30-day running average of mean daily EC of 0.7 dS/m from April 1 through August 30 and 1.0 dS/m from September 1 through March 31 for all types of water year. Since D-1641 was implemented in 2000, the objective at Vernalis have generally been met. However, compliance with the southern Delta salinity objective at the three interior stations (C-6, C-8, and P-12) has not always been achieved (see Chapter 5 and Appendix F.1, *Hydrologic and Water Quality Modeling*, for a description of exceedances). There is a strong relationship of increasing salinity from Vernalis to the interior stations under most conditions.

2.8 San Joaquin Valley Groundwater Basin

The plan area lies almost entirely within the boundaries of four subbasins on the east side of the San Joaquin Valley Groundwater Basin: Eastern San Joaquin, Modesto, Turlock, and Merced (Figure 2-3). Small portions of the plan area also lie within small parts of three additional subbasins: Tracy,

[17] In this document, EC is *electrical conductivity*, which is generally expressed in deciSiemens per meter (dS/m). Measurement of EC is a widely accepted indirect method to determine the salinity of water, which is the concentration of dissolved salts (often expressed in parts per thousand or parts per million). EC and salinity are therefore used interchangeably in this document.

Chowchilla, and Delta-Mendota (Figure 2-3). A summary of the subbasins and their associated irrigation districts is described in Sections 2.8.1 through 2.8.4 geographically from north to south. Further information regarding groundwater, and the subbasins, is in Chapter 9, *Groundwater Resources*.

Groundwater accounts for approximately 30 percent of the annual agricultural and municipal water supply within the SJR Hydrologic Region, and many cities in this area rely either wholly or partially on groundwater to meet municipal and community non-agricultural needs (DWR 2003a). More than half of all land within the subbasins is irrigated agriculture, and thus the largest use of groundwater is for agricultural purposes.

Although agricultural application of surface water provides significant contribution to groundwater recharge, groundwater levels in the San Joaquin Valley Groundwater Basin have generally declined as a result of extensive pumping. A USGS study of Central Valley groundwater shows that groundwater storage in the San Joaquin Valley Groundwater Basin has varied by plus or minus 5 million AF between 1962 and 2002, but the total storage of the San Joaquin Valley Groundwater Basin was about the same in 2002 as in 1962 (USGS 2009). DWR conducted a recent groundwater evaluation of all groundwater subbasins in California with potential water shortages and prioritized all of the subbasins to assess and rank them throughout the state (DWR 2014). The subbasin prioritization process is based on an evaluation of eight required data components specified by the California Water Code. All the subbasins within the plan area were identified as high priority by DWR and are considered to be at high risk of overdraft (DWR 2014). The Merced, Modesto, and Turlock subbasins experienced varying degrees of overdraft and recharge conditions between 1970 and 2000; however, each subbasin experienced a net overdraft condition during this period as indicated by average declines in groundwater elevation of approximately 30, 15, and 7.5 ft, respectively, with the eastern portion of the subbasins experiencing more severe overdraft (DWR 2003c, 2003d, 2003e). The Eastern San Joaquin subbasin has been in a consistent overdraft condition (approximately 1.7 ft/year) for the same time period. It is estimated that the overdraft has reduced storage in the basin by 2 million acre-feet over a 40-year period (DWR 2003e). Additional pumping in any of the subbasins would increase the drawdown, with a noticeable effect on groundwater levels over a number of years. Additional pumping and overdraft can also cause land subsidence. In the southern portion of the study area, increased dependence on groundwater during the recent drought resulted in groundwater levels approaching or surpassing historic lows, which caused aquifer-system compaction and land subsidence that most likely is permanent (Sneed and Brandt 2015). Further information regarding groundwater, and the subbasins, is in Chapter 9.

2.8.1 Eastern San Joaquin Groundwater Subbasin

The Eastern San Joaquin Subbasin is drained by the SJR and several of its major tributaries, mainly the Stanislaus, Calaveras, and Mokelumne Rivers. The subbasin is located under the urban centers of Manteca, Lathrop, Ripon, and Stockton, which use groundwater for a large portion of their drinking water supply.

The subbasin spans approximately 707,000 acres and includes several water and irrigation districts. SEWD, CSJWCD, SSJID, and a portion of OID fall within the subbasin boundaries. Water use within these districts is primarily for irrigation of approximately 200,000 acres. There are approximately 200,000 acres of irrigated land outside these irrigation districts but within the subbasin boundary (Table 9-5). These districts rely on surface water and groundwater to fulfill customer demand throughout the irrigation season. The agricultural areas outside these irrigation district lands are more dependent on groundwater, although some of these lands receive surface water from the Mokelumne River and SJR.

Historically, pumping from urban, rural, and agricultural wells has been above the safe yield of the subbasin (SSJID 2012). Groundwater levels have continuously declined over the past 40 years at an average rate of 1.7 ft/year and have dropped as much as 100 ft in some areas (USACE 2001 in DWR 2003b). Significant groundwater depressions are present under the city of Stockton, east of Stockton, and east of Lodi (SJCFC 1999 in DWR 2003b). However this cone of depression is not as severe as it once was; between 2005 and 2010, groundwater elevations within some portions of this area showed some signs of improvement.

Groundwater recharge is primarily from deep percolation of applied irrigation water, conveyance losses, and precipitation. Additional recharge also occurs as a result of lateral inflows from other subbasins and seepage from rivers, creeks, and reservoirs (Northeastern San Joaquin County Groundwater Banking Authority 2004). In recent years, multiple methods have been used to increase groundwater recharge in this subbasin. These methods include installation of check dams on waterways, increased use of surface water, creation of surface ponds, and flooding of fields (CSJWCD 2013; SEWD 2014). These recharge efforts have likely improved groundwater conditions in the subbasin. Between 2005 and 2010, some of the areas with the lowest groundwater levels in this subbasin experienced increases in groundwater levels at the same time that levels dropped in other subbasins (DWR 2015).

2.8.2 Modesto Groundwater Subbasin

The Modesto Subbasin is bordered by the Stanislaus River to the north and the Tuolumne River to the south. The subbasin is located under the urban centers of Modesto, Oakdale, and Riverbank, and under small areas of the southern boundary of Ripon. These cities use groundwater for a large portion of their drinking water supply.

The subbasin encompasses approximately 247,000 acres and includes MID and a portion of OID. These irrigation districts rely on surface water and groundwater to fulfill customer demand throughout the irrigation season. Approximately 116,000 acres are irrigated (Table 9-5), with approximately 77 percent of these acres being supplied with surface water from OID or MID.

Groundwater levels in this subbasin decreased at an estimated 0.5 foot/year during 1970–2000 (DWR 2003c), with groundwater declines coinciding with dry periods and stabilization and recovery coinciding with wet periods. Water level declines have been more severe in the eastern portion of the subbasin (DWR 2015).

Groundwater recharge is primarily from deep percolation of applied irrigation water and canal seepage from MID and OID facilities. Seepage from Modesto Reservoir is also significant (STRGBA 1995 in DWR 2003c). Lesser recharge occurs as a result of subsurface flows originating in the mountains and foothills along the east side of the subbasin, losses from minor streams and from percolation of direct precipitation.

2.8.3 Turlock Groundwater Subbasin

The Turlock Subbasin is bordered by the Tuolumne River to the north, the SJR to the west, and the Merced River to the south. The subbasin is located under the urban centers of Ceres, south Modesto, Turlock, and several smaller communities, which use groundwater for a large portion of their drinking water supply.

The subbasin encompasses approximately 349,000 acres. There are approximately 269,000 acres of irrigated land in the subbasin, with approximately 56 percent of these acres potentially being supplied with surface water from TID and a small portion from Merced ID (Table 9-5).

Groundwater levels in this subbasin decreased at approximately 0.25 foot/year during 1970–2000, with groundwater declines coinciding with dry periods and stabilization and recovery coinciding with wet periods. Since 1982, water level declines have been more severe in the eastern portion of the subbasin; however, from 1970 to 1982, water level declines were more severe in the western portion of the subbasin (DWR 2003d).

Groundwater recharge primarily comes from deep percolation of surface water used for irrigation. Additional recharge also occurs as a result of precipitation, seepage from Turlock Lake, lateral groundwater inflow from the east, and upward inflow from deep geologic fractures. The net effect of the groundwater interaction with the Tuolumne and Merced Rivers and the SJR was estimated to be negative, with more groundwater discharging to the rivers in the western portion of the subbasin than seeping from the upstream portions of the Tuolumne and Merced Rivers in the eastern portion of the subbasin (Turlock Groundwater Basin Association 2008).

2.8.4 Merced Groundwater Subbasin

The Merced Subbasin is bordered by the Merced River to the north, the SJR to the west, and partially by the Chowchilla River to the south. The subbasin is located under the urban centers of Atwater, Livingston, Merced, and several smaller communities, which use groundwater for a large portion of their drinking water supply.

The subbasin encompasses approximately 491,000 acres, and approximately 55 percent (approximately 269,000 acres) is irrigated. Approximately 32 percent of these acres (86,000 acres) are potentially supplied with surface water from Merced ID (Table 9-5). Merced ID relies primarily on surface water, but also on groundwater, to fulfill customer demand throughout the irrigation season. Agricultural land outside the Merced ID is more dependent on groundwater than the agricultural land within Merced ID service boundaries.

Groundwater levels in this subbasin decreased at approximately 1 foot/year during 1970–2000 (DWR 2003e), although some other estimates show different rates of decline. Determination of the rate is dependent on the span of years evaluated because groundwater levels rise and fall in response to hydrologic conditions. Water level declines have been more severe in the eastern part of the subbasin (DWR 2015).

Recharge from rivers and creeks tends to occur more in the eastern part of the subbasin where the Merced and Chowchilla Rivers are well above the water table. In contrast, groundwater tends to be discharged to the Merced River and the SJR at the western edge of the subbasin where the rivers are close to the water table. Merced ID has been increasing groundwater recharge by taking several actions to replace groundwater use with surface water use. These actions include providing surface water to land previously inaccessible to the Merced ID conveyance system, responding more quickly to requests for surface water delivery, and starting a direct recharge project at Cressey Basin (MAGPI 2008).

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