Chapter 2
Water Resources

This chapter provides an overview of existing water resources and the management of those resources in the plan area. As described in Chapter 1 *Introduction*, the plan area generally includes those portions of the San Joaquin River (SJR) Basin that drain to, divert water from, or otherwise obtain beneficial use (e.g., surface water supplies) from the three eastside tributaries[1] of the Lower San Joaquin River (LSJR). These include the Stanislaus River from and including New Melones Dam and Reservoir to its confluence with the LSJR; the Tuolumne River from and including New Don Pedro Dam and Reservoir to its confluence with the LSJR; the Merced River from and including New Exchequer Dam and Lake McClure to its confluence with the LSJR; and, the SJR between the confluence of the Merced River to Vernalis (i.e., LSJR).

This chapter describes the following within the plan area and upstream of the plan area: operation of rim dams[2] for hydropower and water storage, existing water diversions, current flow requirements for fish protection, and hydrology, including the unimpaired and historical flow. The plan area also encompasses the southern Delta, which includes the SJR from Vernalis to Brandt Bridge; Middle River from Old River to Victoria Canal; and Old River/Grant Line Canal from the Head of Old River to West Canal. Therefore, this chapter also describes the existing salinity and water quality conditions and water management in the southern Delta that influences water quality. This includes operations of the Central Valley Project (CVP) and State Water Project (SWP), existing water diversions, and existing municipal and agricultural drainage discharges. The information in this chapter[3] provides context for the description of the LSJR alternatives and southern Delta water quality (SDWQ) alternatives in Chapter 3, *Alternatives Description*. Chapters 5–14 present additional existing setting information for each relevant resource area.

2.1 Overview of Central Valley Basin and Delta

2.1.1 Central Valley Basin

The Central Valley Basin of California is comprised of the 450 mile long Central Valley and the surrounding upland and mountain areas that drain into it. The Central Valley is entirely surrounded by mountains except for a narrow gap on its western edge at the Carquinez Strait. Stream flow in the Central Valley is chiefly derived from runoff from the Cascade and Sierra Nevada mountains, with minor amounts from the Coast Ranges. Precipitation varies, with about four-fifths of the total

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[1] In this document, the terms "three eastside tributaries", "eastside tributaries" and "major SJR tributaries" all refer to the Merced, Tuolumne, and Stanislaus Rivers.

[2] In this document, the general term rim dams is used when referencing the three major dams and reservoirs on each of the tributaries, New Melones Dam and Lake, New Don Pedro Dam and Lake, and New Exchequer Dam and Lake McClure.

[3] The majority of the information in this chapter is based on a few key 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 the above reports. Citations are provided for other information not based on the above reports.

occurring between the end of October and the beginning of April. Snowpack in the high Sierra delays runoff until the snow melts, typically in April, May, and June. Normally, about half of the annual runoff occurs in these months. The Central Valley Basin is divided into the Sacramento Valley to the north and the San Joaquin Valley to the south. The San Joaquin Valley spans two subbasins: the SJR Basin and the Tulare Lake Basin. 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 and Kings River to the south (Figure 2-1 shows the SJR Basin).

In the Central Valley Basin, water is used primarily for growing crops, and to a lesser extent to meet urban, industrial, and environmental (e.g., minimum streamflow) needs. Local irrigation districts, municipal utility districts, county agencies, private utility corporations, as well as state and federal agencies have developed surface water projects. Flood control, water storage, and water diversion facilities exist on the major streams in the basin, altering natural flow patterns. These projects also produce hydroelectric power, enhance recreation opportunities, and serve other purposes. More information about the water resources developments in the SJR Basin are described in Chapter 5, *Water Supply, Surface Hydrology, and Water Quality*.

Groundwater in the Central Valley is extracted from the multiple groundwater subbasins of the larger San Joaquin Valley Groundwater Basin, providing water for agricultural and municipal uses. Most San Joaquin Valley cities rely on groundwater either wholly or partially to meet municipal needs. The regional aquifer system in this area is contained in semi-consolidated to unconsolidated marine and continental deposits. Fresh water in these deposits extends to about 1,000 feet below land surface in the Sacramento Valley and to about 1,500 feet below land surface in the San Joaquin Valley. The northern part of the San Joaquin Valley Groundwater Basin includes the Turlock, Modesto, Merced, and Eastern San Joaquin Groundwater Subbasins (Figure 2-2). These subbasins are further described in Chapter 9, *Groundwater Resources*.

The California Department of Water Resources (DWR) has estimated the storage capacity of the regional aquifer system to be 64 MAF and the perennial (i.e., sustainable) yield to be 5.7 MAF. However, overdraft conditions exist in some portions of the southern and western San Joaquin Valley Groundwater Basin's aquifer system. Ground water pumping in the region continues to increase in response to growing urban demand and reduced surface water deliveries from north of the Delta.

Groundwater quality varies in all directions throughout the San Joaquin Valley Groundwater Basin and the subbasins. The water quality in the northwestern part of the San Joaquin Valley Groundwater Basin is variable, with better quality generally found in the northern and eastern parts of San Joaquin and Contra Costa Counties. Agricultural and industrial contaminants tend to be present in the more urban and southern portions of the San Joaquin Valley Groundwater Basin.

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 are caused by naturally occurring constituents, such as arsenic, molybdenum, iron, and uranium, as well as by agricultural and industrial contaminants. Each of these constituents can locally or regionally affect the beneficial uses of groundwater. In the San Joaquin Valley Groundwater Basin, salinity is one of the primary water quality issues. Total dissolved solids (TDS) or electrical conductivity (EC) are the most commonly reported constituents related to salinity for groundwater basins and these constituents are generally lower in the deeper aquifer on the eastern side than in the shallower aquifer on the western side.

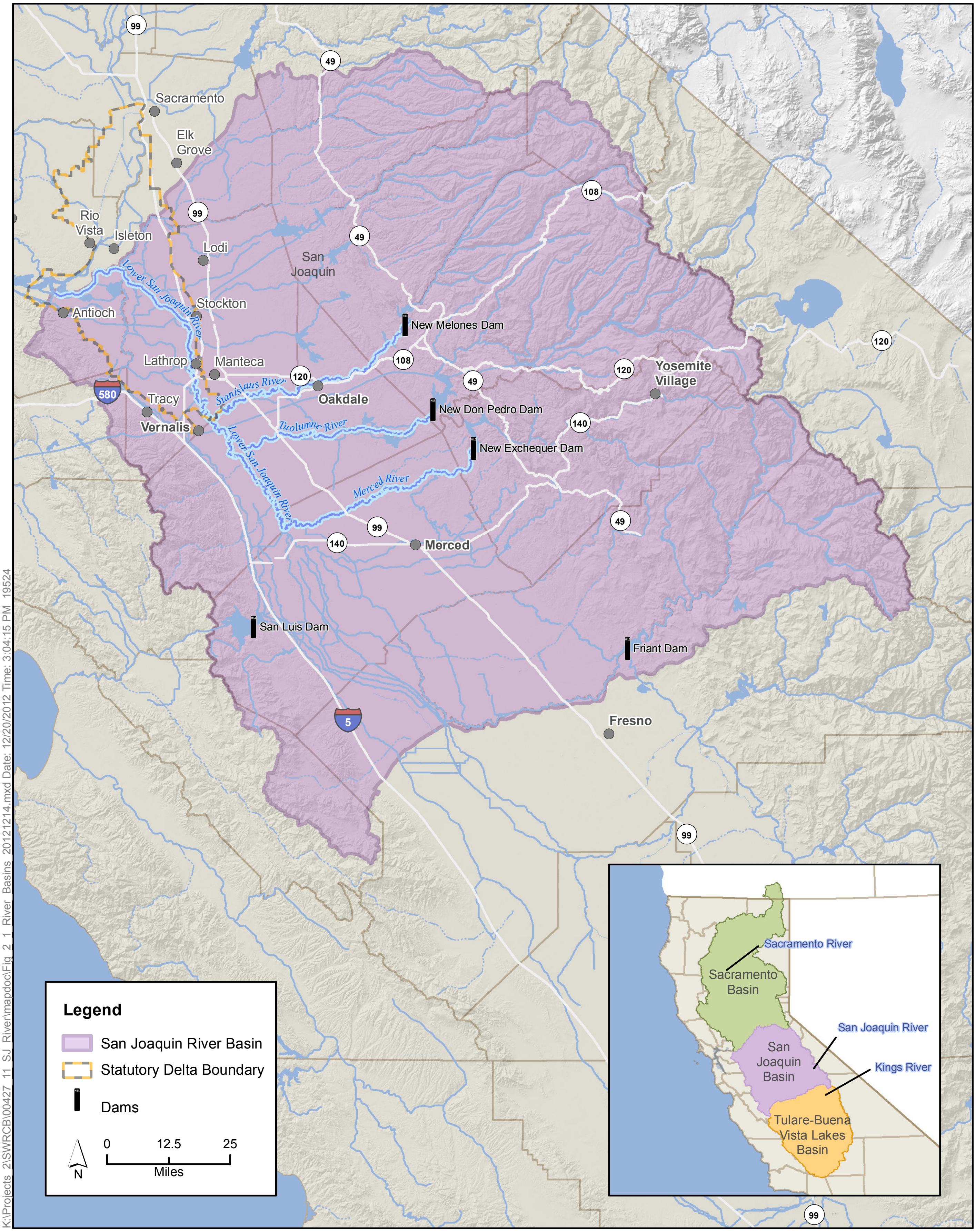

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Figure 2-1
Central Valley Basin and San Joaquin River Basin

2.1.2 Delta

The Delta, with legal boundaries established by California Water Code Section 12220, comprises a 738,000-acre area generally bordered by the cities of Sacramento, West Sacramento, Stockton, Tracy, Antioch, and Pittsburg (Figure 2-3). 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 about 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 bring in an average of 5.8 MAF, with Delta precipitation adding about another 1.0 MAF (DWR 2009, DWR 2012). During low-flow periods, the hydrodynamics of the channels within the Delta are influenced primarily by the tides, with secondary effects from inflows and exports (Burau et al. 1999; Kimmerer 2004). Tidal rise and fall varies with location, from less than 1 foot in the eastern Delta to more than 5 feet in the western Delta (DWR 2009). About 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 begin to diminish at locations further 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).

2.2 Overview of the San Joaquin River Basin

The SJR Basin drains about 15,550 square miles of the Sierra Nevada and the southern portion of the Central Valley of California. As mentioned above, the SJR Basin is separated from the Tulare Lake Basin by a low broad ridge that extends across the San Joaquin Valley between the San Joaquin and Kings Rivers (DWR 2009). The headwaters of the SJR are on the western slope of the Sierra Nevada Mountains at elevations in excess of 10,000 feet. At the foot of the mountains (in the foothills), the SJR is impounded by Friant Dam, which forms Millerton Lake. The SJR enters the valley floor near Fresno. Infrequent flood waters 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—the Merced, Tuolumne, and Stanislaus Rivers—enter it before it flows into the southern Delta at Vernalis.

Friant Dam diverts water into the Friant-Kern and Madera canals. Until the SJR Restoration Program began in 2009 (Section 2.3.3), 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 LSJR are the three eastside rivers that drain the western slope of the Sierra Nevada mountains. The three eastside tributaries contribute the majority of the flow at Vernalis. The Upper SJR (above the confluence of the LSJR and the Merced River) and the LSJR tributaries drain large areas of high elevation watersheds that supply snowmelt runoff during the late spring and early summer months. Smaller 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 from these smaller SJR tributaries results from rainfall, which is stored in reservoirs for irrigation purposes. There are no required fishery flow releases below these tributary reservoirs, although the streams are used to convey irrigation water to downstream diversions points. A few small tributaries to the west, with headwaters in the rain shadow of the Coast Ranges, contribute little flow to the LSJR.

The natural 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 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 or diverted to storage reservoirs for later beneficial uses, such as irrigation. Construction of storage reservoirs with hydropower diversions in the Sierra Nevada mountains 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). Table 2-1 summarizes the SJR Basin characteristics and existing reservoirs the tributaries.

The next sections describe the hydrology of the Upper SJR, the three eastside tributaries, and the SJR at Vernalis, including existing reservoirs and water development for hydropower and storage, existing diversions, current flow requirements for fish protection, and monthly unimpaired flows and the historical flows.

[4] Flows released from Friant Dam for fish protection or for flood control would contribute to the SJR flow at Vernalis, but they would not be modified under any of the alternatives.

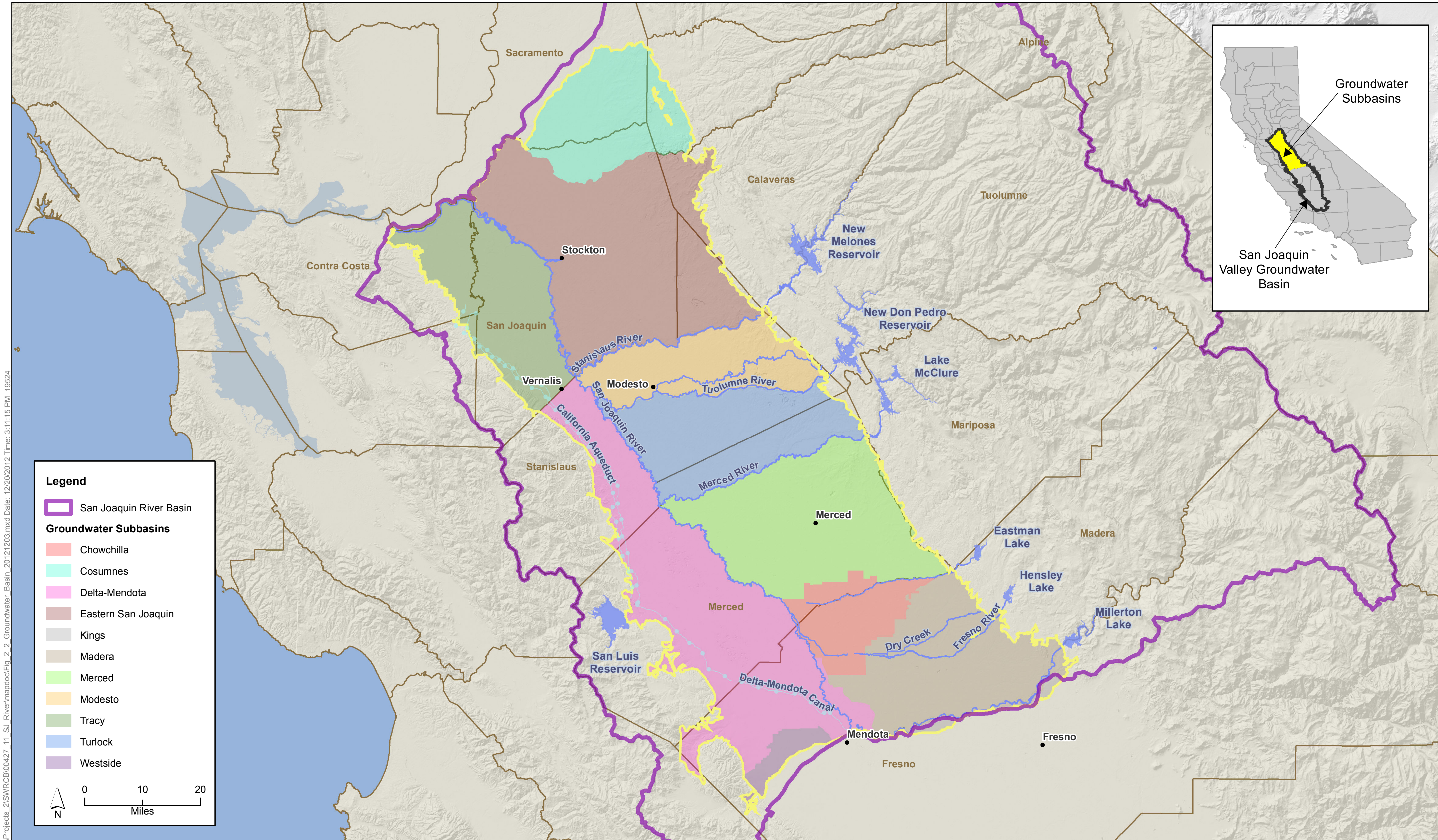

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Figure 2-2
San Joaquin Groundwater Basin and Subbasins

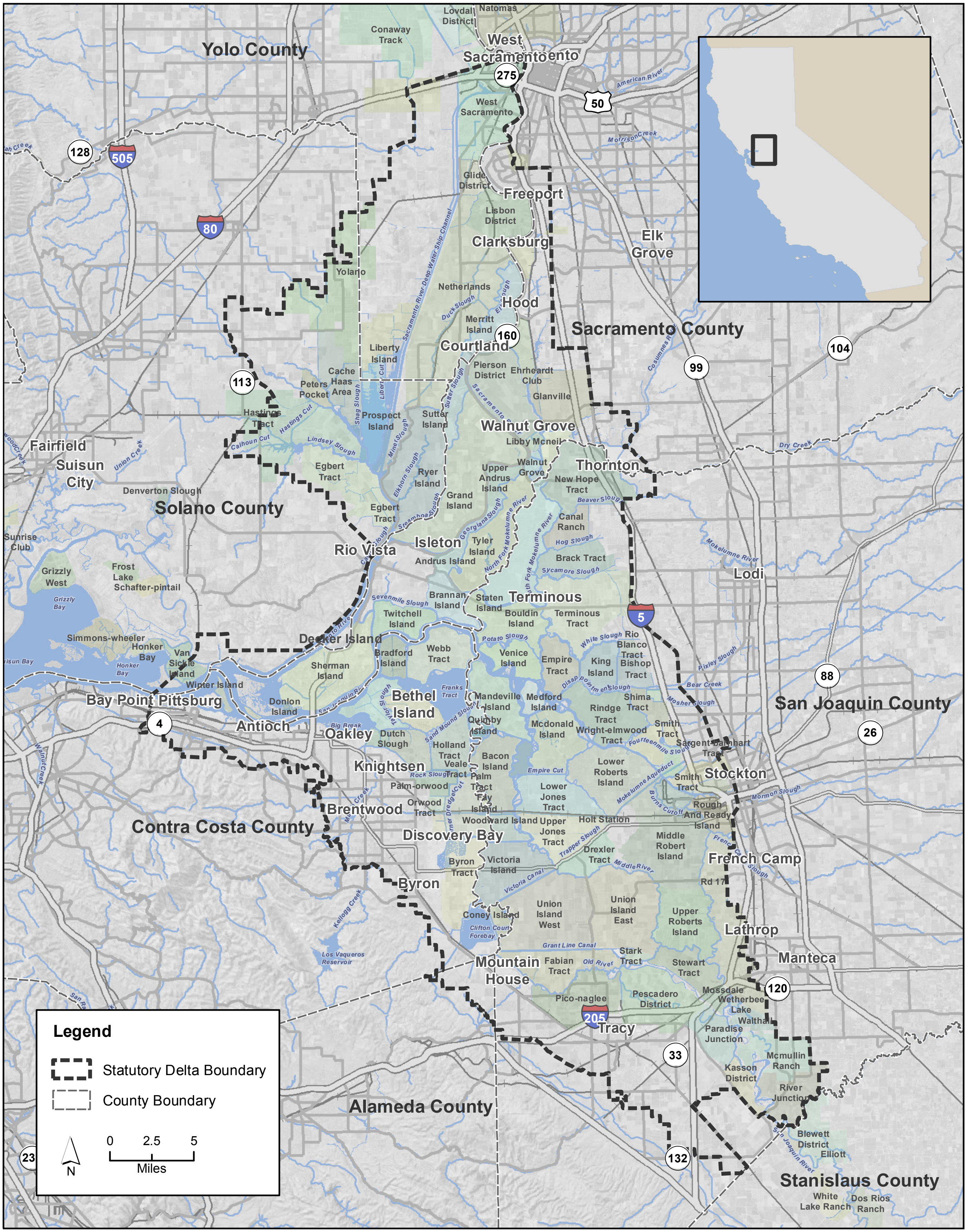

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Figure 2-3
The Sacramento–San Joaquin Delta

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

Characteristic	Lower San Joaquin River			Upper San Joaquin River
	Stanislaus River	Tuolumne River	Merced 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 with San Joaquin (and percent of tributary upstream of mouth)[1]	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[2]	28 DSOD[b]	27 DSOD	8 DSOD	19 DSOD
Total Reservoir Storage[2]	2.85 MAF	2.94 MAF	1.04 MAF	1.15 MAF
Most Downstream Dam (with year built and capacity)[3]	Goodwin, 59 miles upstream of SJR (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)[3]	New Melones (1978, 2.4 MAF) ; Tulloch, Beardsley, Donnells "Tri-dams project" (1958, 203 TAF)	New Don Pedro (1970, 2.03 MAF)	New Exchequer (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)	Hetch Hetchy (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)

Sources: Appendix C *Technical Report on the Scientific Basis for Alternative San Joaquin River Flow and Southern Delta Salinity Objectives*; [1]NRCS Watershed Boundary Dataset (2009) ; [2]Kondolf et al. 1996 (adapted from Kondolf et al. 1991) as cited by Cain et al. 2003; [3]Cain et al. 2003.

[a] Median annual unimpaired flow adjusted from Cain et al. 2003.

[b] DSOD dams are those greater than 50 ft in height and/or greater than 50 acre-feet of capacity, with some exceptions.

MAF = million acre-feet
RM = river mile
DSOD = Division of Safety of Dams
AF = acre feet
TAF = thousand acre-feet

2.3 Upper San Joaquin River

The Upper SJR is the river south (upstream) of the Merced River and LSJR confluence and includes the north, middle, and south forks.[5] The forks converge downstream and are impounded at the uppermost region of the Valley Floor by Friant Dam, about 25 miles northeast of Fresno, which is the location for measuring the unimpaired flow from the Upper SJR watershed. 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 of the plan area, it is drained by the SJR and enters the plan area at the Merced River confluence; and therefore is included in the description below.

2.3.1 Dams and Reservoirs

Several dams and reservoirs are located on the Upper SJR, which 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 is located about 25 miles northeast of Fresno. 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 provides diversions into the Madera and Friant-Kern Canals (discussed below). Friant Dam forms Millerton Lake and upstream reservoir operations affect inflows to Millerton Lake. Flood control storage space in Millerton Lake is limited, and additional flood control is provide by the upstream reservoirs.

2.3.2 Water Diversions

The Friant Water Authority delivers water to over 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 southerly into the Tulare Lake Basin and via the 36-mile Madera Canal northerly to the Madera and Chowchilla Irrigation Districts. The average annual water diversion at Friant Dam is about 1.1 MAF. Under their water contracts, irrigation districts receive Class I (reliable) and Class II (less dependable), as well as surplus water during flood-control operations.

2.3.3 Flow Requirements

Two requirements for flow exist below Friant Dam: 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 right users. These interim flows generally do not make it past the Mendota Pool on the Upper SJR and consequently water released from Friant Dam often does not make it to the LSJR and Merced River

[5] 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 only two small tributaries.

confluence. Because of this, USBR is undertaking a SJR Restoration Program[6] that would provide water throughout the year to re-connect the river upstream of the 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.[7]

2.3.4 Hydrology

The average annual unimpaired flow for the Upper SJR at Friant Dam from 1984 through 2009 was 1,702 TAF. This represents about 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), which was approximately 25 percent of the unimpaired flow.

As an example of these historical releases, Figure 2-4 shows the monthly unimpaired flow and the historical flow below Friant Dam for the recent 10-year period of water years 2000 through 2009[8]. 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.

[6] 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).

[7] 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. 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.

[8] A water year begins in October of the previous year, so water year 2000 begins in October 1999.

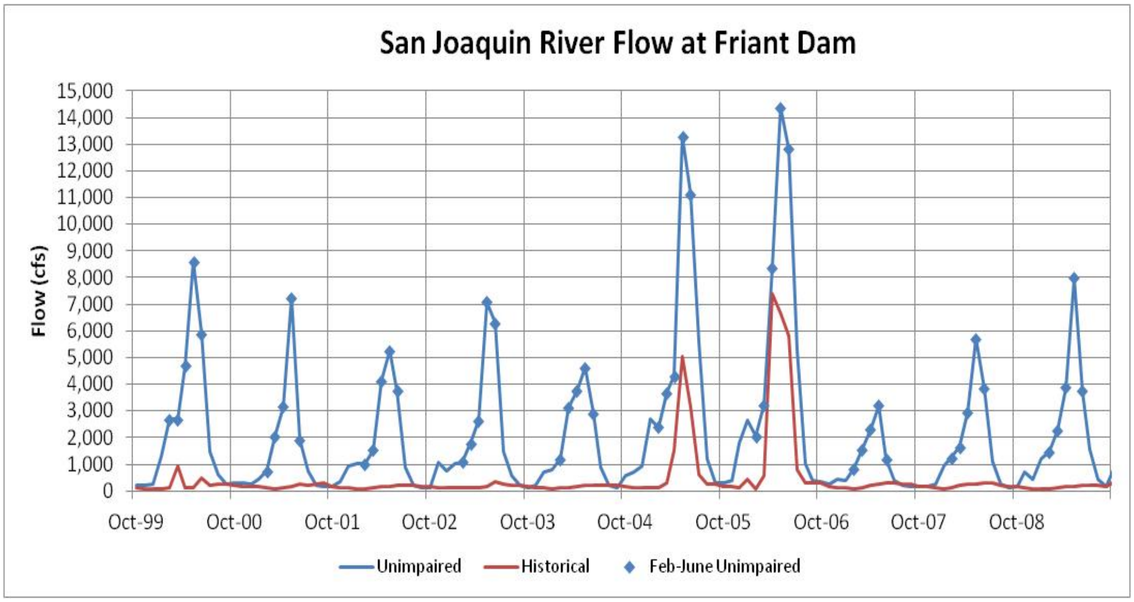

Figure 2-4. Monthly Unimpaired and Historical San Joaquin River Flows at Friant Dam for Water Years 2000–2009 (cfs = cubic feet per second)

2.4 Lower San Joaquin River Tributaries

In this document, the LSJR is defined as the portion of the SJR extending from the confluence of the Merced River downstream to Vernalis. It receives flow from the three eastside tributaries, the Stanislaus, Tuolumne, and Merced Rivers. 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 communities. Figure 2-1 shows the locations of the LSJR tributaries and Table 2-2 identifies the tributaries, rim dams, and localities.

Table 2-2. Location of LSJR Tributaries and Dams

River	Rim Dam	Downstream Dam(s)	County	Communities within General Proximity of the Rim Dams
Stanislaus	New Melones	Tulloch Goodwin	Calaveras Tuolumne	Angels Camp, Copperopolis, Columbia, Sonora, Jamestown, Copper Cove, Knights Ferry
Tuolumne	New Don Pedro	La Grange	Tuolumne	Blanchard, La Grange, Jamestown
Merced	New Exchequer	Crocker Huffman	Mariposa	Granite Springs, Snelling

Irrigation and water districts hold rights to divert surface waters from each of the three tributaries. In addition, these districts provide power to their service areas from hydropower generated by the rim dams. A summary of the diverters is presented in Table 2-3. Figure 2-5 shows their respective service areas.

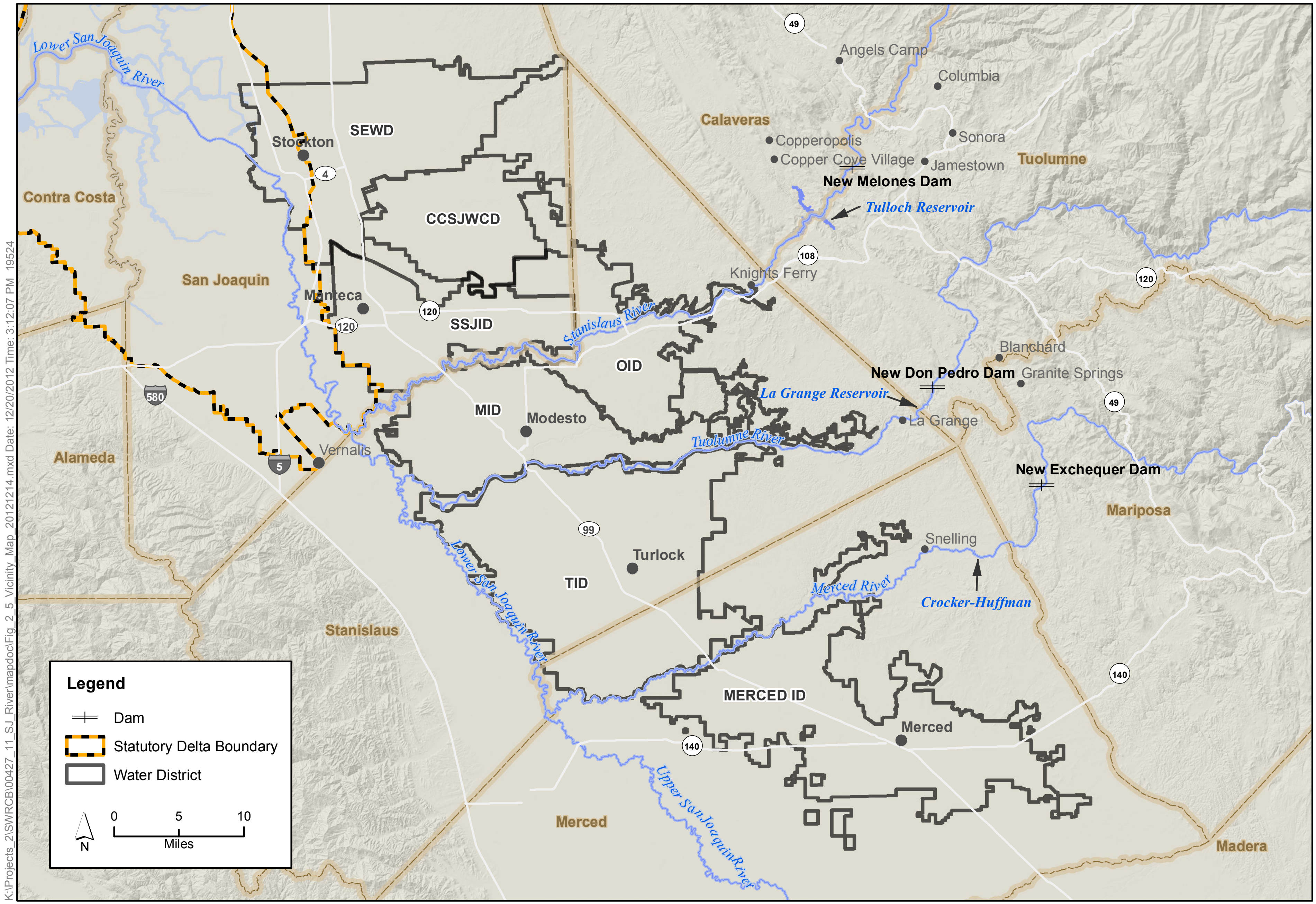

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Figure 2-5
Vicinity Map of Lower San Joaquin River and the Three Eastside Tributaries

Table 2-3. Summary of Major Surface Water Diverters

River	Rim Dam	Surface Water Diverters	Surface Water Diversion (AFY)[1]	Surface Water Users[2]
Stanislaus	New Melones	South San Joaquin Irrigation District (SSJID)	300,000	SSJID City of Lathrop City of Manteca City of Tracy City of Ripon SEWD
		Oakdale Irrigation District (OID)	300,000	OID SEWD
		Stockton East Water District (SEWD)	75,000 from USBR	City of Stockton CalWater San Joaquin County
		Central San Joaquin Water Conservation District (CSJWCD)	80,000 from USBR	CSJWCD
Tuolumne	New Don Pedro	Turlock Irrigation District (TID)	575,000	TID
		Modesto Irrigation District (MID)	310,000	MID City of Modesto
Merced	New Exchequer	Merced Irrigation District (Merced ID)	525,000	Merced ID City of Merced Stevinson Water District

1 These are assumed maximum diversions based on a review of documents and historical diversions for the irrigation districts. The diversions for SEWD and CSJWCD are from the USBR contract documents.

2 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.

Various flow requirements currently exist for the LSJR and the three eastside tributaries. These flow requirements were established by previous water rights decisions, agreements between diverters, biological opinions (BOs), and through the Federal Energy Regulatory Commission (FERC) licensing process. Additionally, the U.S. Army Corps of Engineers (USACE) has flood-control requirements for the reservoirs on the tributaries that affect the flow and releases from the rim dams. These various flow requirements influence the flows released or bypassed from the rim dams and the quantity of water users (also known as diverters) receive. A summary of the flow requirements is provided in Table 2-4 below.

Table 2-4. Flow Requirement Summary

River	Requirement	Description	Parties	Releases
Stanislaus	1987 Agreement	Provides instream flows as needed to maintain or enhance the fishery resource	USBR and DFG	Minimum of 98,300 AF; Maximum of 302,100 AF during wet years
	State Water Board D-1422	Provides flows for water quality control to maintain a mean monthly 500 ppm TDS concentration at Vernalis	USBR	Up to 70,000 AF in any one year
	Anadromous Fish Restoration Program	Provides pulse flows in the April–May period coordinated with VAMP[1]	USFWS, USBR	Allocation and scheduling of release flows are made annually
	NMFS BO	Provides minimum Stanislaus River flows according to a flow schedule as measured at Goodwin Dam and includes RPA 3.1.3	USBR and NMFS	Daily flow schedule (with several pulse flows)
	USACE	Establishes flood-control release limits	USACE, USBR	Releases are established by USACE for 12 months such that flows cannot exceed 1,970 TAF per month between October and February and can vary between March and September from 2,300 to 2,000 TAF per month
Tuolumne	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	DFG, 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 the USACE for 12 months such that releases cannot exceed 9,000 cfs on Tuolumne River below Dry Creek. per month
Merced	FERC License Project No. 2179	Provides minimum stream flows in the Merced River downstream from the project reservoirs	Merced ID and FERC	See Table 2-5 (FERC Project Number 2179 Stream Flow Requirements for the Merced River (cfs))

River	Requirement	Description	Parties	Releases
	Davis-Grunsky Contract	Provides minimum flow standards November–March from Crocker-Huffman Dam to Shaffer Bridge	DFG and Merced ID	No less than 180 to 200 cfs
	Cowell Agreement	Provides minimum flows downstream of Crocker-Huffman Dam during certain times of the year	Merced ID and Cowell Agreement Diverters[2]	50 cfs to 250 cfs during specified months
	USACE	Establishes flood-control release limits	USACE and Merced ID	Combination of flows from Dry Creek and Merced River must not exceed 6,000 cfs

[1] Vernalis Adaptive Management Program (VAMP) is a 12 year experimental pulse flow program, which was authorized to be conducted in Decision-1641 (D-1641) in lieu of implementing the pulse flow objectives in the 1995 Bay-Delta Plan for the SJR at Vernalis. The VAMP ended in 2011. Additional information regarding VAMP and flow requirements associated with the SJR at Vernalis is described in Section 2.5.2.

[2] The Cowell Agreement Diverters are downstream riparian and pre-1914 water users.

USBR = U.S. Bureau of Reclamation

DFG = California Department of Fish and Game

BO = Biological Opinion

RPA = Reasonable and Prudent Alternative

USFWS = United States Fish and Wildlife Service

NMFS = National Marine Fisheries Service

USACE = U.S. Army Corps of Engineers

FERC = Federal Energy Regulatory Commission

MID = Modesto Irrigation District

TID = Turlock Irrigation District

Merced ID = Merced Irrigation District

Additional information regarding the general characteristics, locations, major dams, water diversions, flow requirements, and unimpaired and historical hydrology of the three tributaries is provided below.

2.4.1 Merced River

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 other major tributaries to the LSJR, the Tuolumne and Stanislaus Rivers, reservoir operations have increased average monthly flows during the late summer and early fall and reduced the average monthly flows during the remainder of the year (Stillwater Sciences 2002).

Dams and Reservoirs

There are four mainstem dams and eight DSOD dams on the Merced River that regulate flow conditions in the Merced River. The four mainstem dams, which are known collectively as the Merced River Development Project, are owned by Merced ID and licensed by 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 to the Merced River upstream of New Exchequer Dam are regulated by the MacMahon, Green Valley, and Metzger Dams. 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 about 3,200 cfs. Water released for peaking power is regulated at the approximately 10 TAF McSwain Reservoir.

Water Diversions

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 district diverts approximately 100 cfs from the Merced Falls reservoir via the Northside Canal, irrigating roughly 10,000 acres of farmland. Merced ID diverts another 2,000 cfs of water from the Merced River via the Main Canal at the Crocker-Huffman Dam for municipal purposes. These diversions are approximately 525,000 AFY. In conjunction with the surface water diversions from the Merced River, Merced ID owns, operates and maintains 239 deep irrigation wells, of which 170 are currently active (Merced ID 2008b). These deep irrigation wells have historically produced a maximum of 182,900 AFY.

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).

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 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 required the licensee to provide minimum stream flows in the Merced River downstream from the project reservoirs.

Table 2-5. FERC Project Number 2179 Stream Flow 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. Streamflow 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.

In 1967, Merced ID executed a Davis-Grunsky Contract with the U.S. Department of Fish and Game (DFG). The contract provides minimum flow standards that require flows no less than 180 to 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. 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 Stream Flow 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

Hydrology

The unimpaired flow of the Merced River is the flow which 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 2-6 depicts both types of flows and shows the monthly unimpaired historical flow below Crocker-Huffman Dam for the recent 10-year period of water year 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.

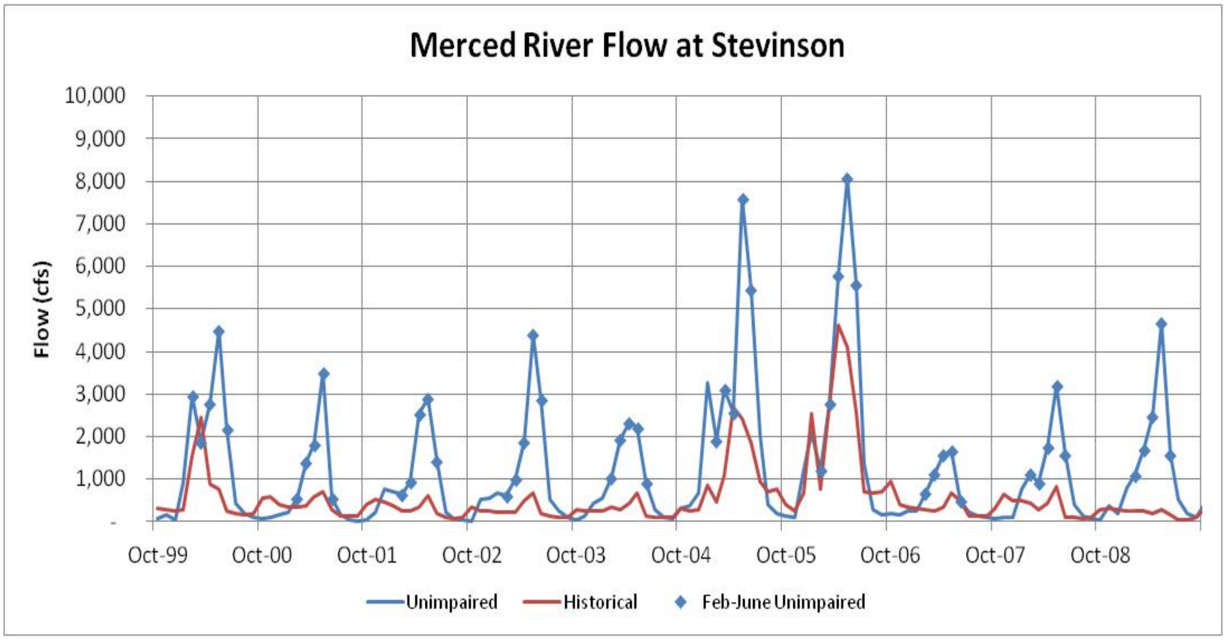

Figure 2-6. Monthly Unimpaired and Historical Merced River Flows February–June for Water Years 2000–2009 (cfs = cubic feet per second)

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 of 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 to 2,500	2,000 to 4,500
2001	250 to 750	500 to 3,500
2002	250 to 500	750 to 3,000
2003	250 to 750	500 to 4,500
2004	250 to 750	1,000 to 2,250
2005*	750 to 2,500	2,000 to 7,500
2006*	1,000 to 4,500	1,000 to 8,000
2007	250 to 750	750 to 1,750
2008	250 to 750	1,000 to 3,000
2009	250	1,000 to 5,000

* The high historical flows were in 2005 and 2006 because Lake McClure was nearly full, and releases for flood-control purposes were made in each of these months.

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 (10 percent value) to 1,746 TAF (90 percent value), with a median runoff of 721 TAF. The average unimpaired flow was 884 TAF/y, slightly more than the median runoff. This represents about 15 percent of the unimpaired flow at Vernalis.

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

	Unimpaired Flow												
Cumulative[9] (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

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 (10 percent value) to 1,167 TAF (90 percent value). The median historical annual river flow was 398 TAF. The average historical flow was 452 TAF/y for these years, slightly higher than the median. The average historical flow was about 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 tributary reservoirs and is generally filled and drawn down each year. Nevertheless, flood-control releases are not necessary each year and, as such, it is difficult to anticipate when reservoir releases for flood-control storage will be required.

[9] The cumulative distribution of a particular variable (e.g., flow, salinity, temperature) is determined by sorting the values from minimum to maximum and graphing them as the percentage of the total number of values. The lowest value is at the left of the graph (e.g., 0 percent) and the highest value is at the right of the graph (100 percent). The cumulative distribution indicates the probability of occurrence for the variable. 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 at the end of resource chapters (Chapters 5–14), Chapter 4, *Introduction to Analysis*, and Chapter 16, *Cumulative Impact Summary, 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)

	Observed Flow												
Cumulative	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

2.4.2 Tuolumne River

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 mountains and flows into the LSJR approximately 8 miles upstream of the Stanislaus River confluence. Like the other major tributaries to 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, which is the major dam on the Tuolumne River, provides water to TID and MID. The Hetch Hetchy Dam and other dams constructed on tributaries in the upper Tuolumne River watershed provide hydropower and water supply for the City and County of San Francisco (CCSF). While the upper Tuolumne River watershed is outside of the plan area, it is drained by the Tuolumne River and therefore is included in the description below.

Dams and Reservoirs

CCSF operates several water supply and hydroelectric facilities in the upper reaches of the Tuolumne above New Don Pedro. O'Shaughnessy Dam on the mainstem Tuolumne River impounds approximately 360 TAF to meet the water needs of the CCSF 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 about 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.

New Don Pedro Dam, the major dam located on the Tuolumne River, was constructed in 1971 to replace the original Don Pedro Dam. The hydroelectric powerplant 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 the 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, located 2.5 miles downstream of New Don Pedro Dam, is the diversion point for the TID and MID canals.

Water Diversions

On average, more than 60 percent of the annual flow of the Tuolumne River is diverted for agricultural or municipal and industrial use by the TID or MID. Each year, about 575 TAF of water is diverted to TID's canal into Turlock Lake and 310 TAF are diverted to MID's canal into the Modesto Reservoir for use in the service districts. Nearly all of the diverted surface water irrigates crops in the two districts.

City and County of San Francisco

The current CCSF demand for water is about 290 TAF, or about 15 percent of the 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 740 AFY in New Don Pedro Reservoir. (CCSF, TID, and MID 1966.)

Turlock Irrigation District

TID is has a service area of approximately 75,000 acres. It provides water and electric services to areas in Stanislaus and Merced Counties, as well as portions of Tuolumne and Mariposa Counties (TID 2010a and TID 2010b). TID uses primarily surface water diversions from the Tuolumne River and supplements them with groundwater to supply irrigation water (TID 2010c).

TID provides electrical service to an area encompassing approximately 600 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; TID 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 County around the New Don Pedro Dam. The water service area encompasses approximately 113,000 acres (MID 2012). 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 2012). It also provides approximately 30 million gallons of drinking water to the City of Modesto per day and is currently under expansion to increase delivery to 60 million gallons of water per day (MID 2012).

MID provides electrical service to approximately 560 square miles and over 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. 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 2012). 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 2012).

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. This license was issued on March 10, 1964; became effective on May 1, 1966; and has a term ending April 30, 2016. 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 to 400 cfs from October through March, with 100 cfs in April and 3 cfs from May through September. As shown in Table 2-10, the annual volume of required stream flows 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 2-10. FERC Project Number 2299 Stream Flow 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 feet per second

The settlement agreement with DFG 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 stream flows, and the annual volume of water required for stream flows was increased from about 95 TAF in the driest years to a maximum of about 300 TAF in years with greater-than-average runoff. Pulse flows are specified for salmonid attraction in October and outmigration in April and May.

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 2-7 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 year 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.

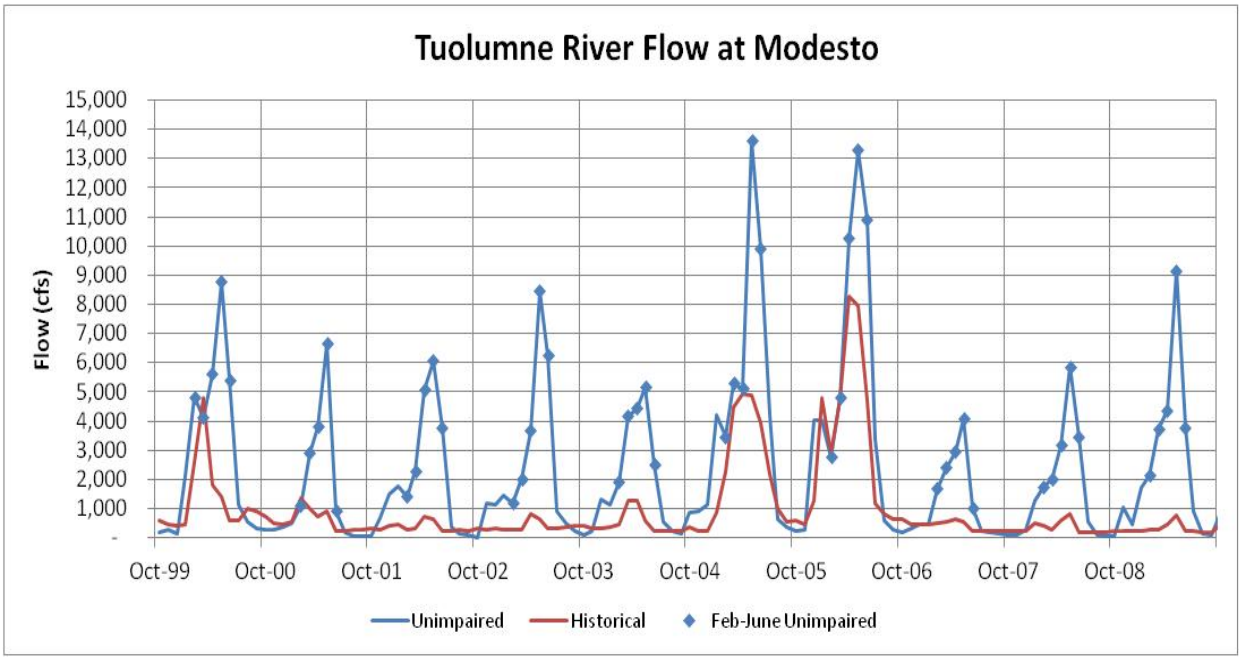

Figure 2-7. Monthly Unimpaired and Historical Tuolumne River Flows February–June for Water Years 2000–2009 (cfs = cubic feet per second)

LaGrange Dam released an average of about 40 percent of the unimpaired flow, but the releases were usually much less than 40 percent of the unimpaired, with flood-control releases providing the majority 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 2-11 summarizes the range of historical flows and unimpaired flows on the Tuolumne River February–June. The peak historical flows were in April and May of 2006 because New Don Pedro Reservoir was nearly full, and 8,000 cfs was released for flood-control purposes.

Table 2-11. 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*	2,000–5,000	3,500–13,500
2006*	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

* 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 2-12 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 characterize generally 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 (10 percent value) to 3,268 TAF (90 percent value), with a median runoff of 1,514 TAF. The average unimpaired flow was 1,851 TAF/y, slightly more than the median runoff. This represents about 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 about 85 percent of the Tuolumne River unimpaired flow[10].

[10] About 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 2-12. Monthly and Annual Unimpaired Flow in the Tuolumne River 1984–2009 (thousand acre-feet)

	Unimpaired Flow												
Cumulative	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 2-13 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 (10 percent value) to 2,249 TAF (90 percent value). The median historical annual river flow was 398 TAF. The average historical flow was 845 TAF/y, considerably greater than the median. The average historical flow was about 46 percent of the average unimpaired flow, but the majority 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 and, as such, it is difficult to anticipate when reservoir releases for flood-control storage will be required.

Table 2-13. Monthly and Annual Historical Flow in the Tuolumne River 1984–2009 (thousand acre-feet)

	Observed Flow												
Cumulative	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

2.4.3 Stanislaus River

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 mountains and flows into the LSJR approximately 3 miles upstream of Vernalis 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 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 to sell to their service areas. One municipal water district, Stockton East Water District (SEWD) and the Central San Joaquin Water Conservation District (CSJWCD) also divert water. Existing flow requirements include the 1987 Agreement, Decision 1422, U.S. Fish and Wildlife Service (USFWS) Anadromous Fish Restoration Program (AFRP), and 2009 National Marine Fisheries Service (NMFS) BO (NMFS 2009), specify flow releases on the Stanislaus River.

Dams and Reservoirs

The Stanislaus River has 28 dams within the California DWR Division of Safety of Dams' (DSOD) jurisdiction storing an approximate 2.8 MAF of water, including 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 located approximately 60 miles upstream from the confluence of the Stanislaus River and the LSJR and is operated by USBR. It has a storage capacity of about 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.

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; water quality improvement in the SJR at Vernalis; and dissolved oxygen requirements at Ripon. The reservoir and river corridor also provide recreation 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 in Tulloch Reservoir, which has a capacity of 67 TAF. Goodwin Dam is approximately two miles downstream of Tulloch Dam and 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 released to the lower Stanislaus River. Goodwin Dam also creates a reregulating reservoir for peaking power releases from Tulloch power plant. Water may also be pumped into the Goodwin Tunnel for deliveries to the CSJWCD and SEWD.

Water Diversions

SSJID and OID divert water from the Stanislaus River for use within their service districts. These districts also generate energy through hydropower for their service areas. SSJID and OID jointly hold rights to divert water through their 1988 agreement and stipulation with USBR, to 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 divert 1,816.6 cubic feet per second (cfs) of flow from the Stanislaus River (OID 2012). The location and general characteristic of three districts 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); 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. The 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 AFY based on monitored 1996 and 1997 data (EA EST 1999).

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). 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 AFY is pumped from these wells in dry years. OID also pumps approximately 1,500 AFY from four shallow wells to control water table levels. Over the last 10 years, these domestic wells have produced approximately 1,000 AFY (EA EST 1999).

Stockton East Water District

SEWD is an independent, publicly owned utility in the City of Stockton that provides surface water for both agricultural and urban uses. 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 AFY 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 combination of available water from these sources totals 90,099 AFY. SEWD has a contract with USBR to receive 75,000 AFY from the New Melones Reservoir through the CVP (SEWD 2011). SEWD has a water transfer agreement with OID and SSJID that allocates 8,000 to 30,000 AF annually through the New Melones Conveyance System specifically for municipal use.

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 AFY of surface water from the Stanislaus River (Northeastern San Joaquin County Groundwater Banking Authority 2004). Of this total, 49,000 AFY is a firm supply and 31,000 AFY is an interim supply subject to other user's requirements (Northeastern San Joaquin County Groundwater Banking Authority 2004). 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).

Flow Requirements

Various flow requirements 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.

1987 Agreement and Interim Operations Plan

USBR and DFG 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, as shown in Tables 2-14 and 2-15.

Table 2-14. Inflow Characterization for New Melones Reservoir (thousand acre-feet)

Annual Water Supply Category	March–September Forecast Inflow Pulse of February Storage
Low	0–1,400
Medium-Low	1,400–2,000
Medium	2,000–2,500
Medium-High	2,500–3,000
High	3,000–6,000

Table 2-15. Water Supply Allocations for New Melones Reservoir (thousand acre-feet)

Storage Pulse Inflow		Fishery		Vernalis Water Quality		Vernalis Flow		CVP Contractors	
From	To	From	To	From	To	From	To	From	To
1,400	2,000	98	125	70	80	0	0	0	0
2,000	2,500	125	345	80	175	0	0	0	59
2,500	3,000	345	467	175	250	75	75	90	90
3,000	6,000	467	467	250	250	75	75	90	90

State Water Board Water Right Decision 1422

State Water Board Decision 1422 specifies flow releases from New Melones Reservoir up to 70,000 AF in any one year for water quality control purposes in the LSJR. The flows must maintain a maximum mean monthly 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.

U.S. Fish and Wildlife Service AFRP

USFWS allocates water for fish flows below CVP reservoirs on the Stanislaus River. This program generally released pulse flows in the April–May period that were coordinated with the Vernalis Adaptive Management Program (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 BO

Reasonable and Prudent Alternative (RPA) Action 3.1.3 of the June 2009 NMFS BO for the long-term operation of the CVP and SWP (Operational Criteria and Plan [OCAP]) proposes 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 flows (volumes)[11]. Section 2.5.2 provides additional information regarding the 2009 NMFS BO as it relates to the flows measured on the SJR at Vernalis.

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 as described above. The hydrograph in Figure 2-8 depicts both types of flow over time. It shows the unimpaired flow at New Melones Dam averaged 1,100 TAF/y and the historical bypasses or releases averaged 611 TAF/y[12] below the Goodwin Dam for the recent 10-year period of water years 2000–2009.

[11] The monthly average flows (volumes) that were in the CALSIM model represent baseline.

[12] These releases including flood flows in 2000 and 2006.

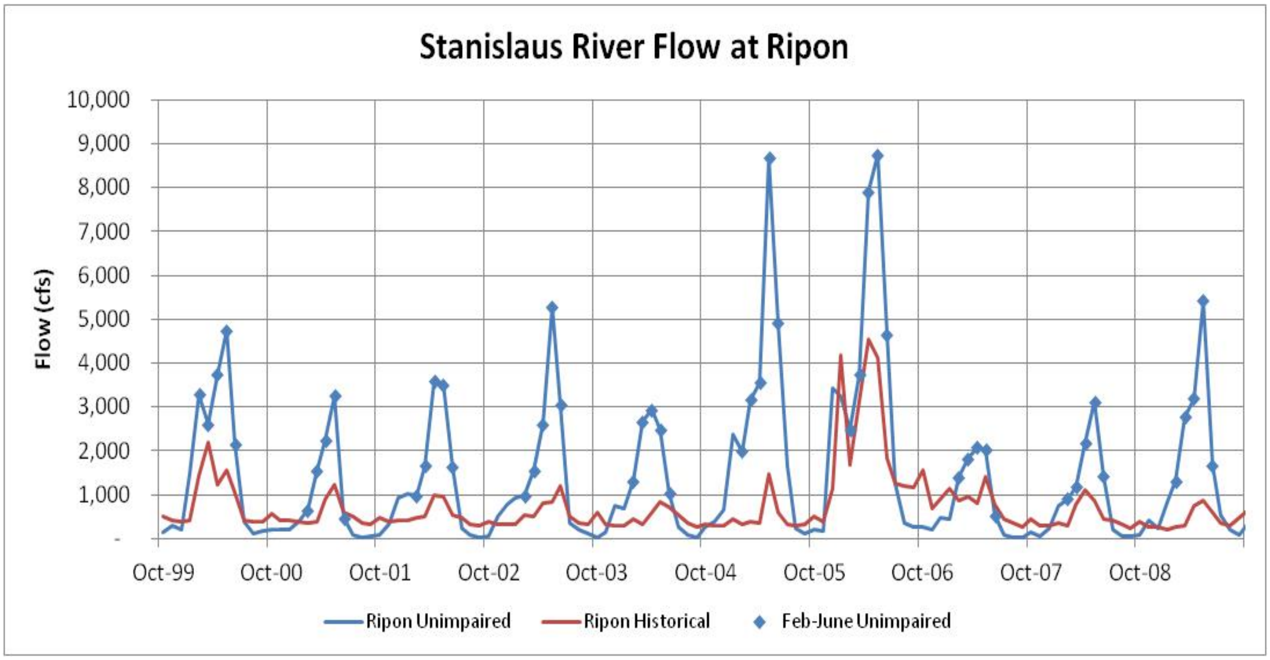

Figure 2-8. Monthly Unimpaired and Historical Stanislaus River Flows February–June for Water Years 2000–2009 (cfs = cubic feet per second)

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 the majority of the flow below Goodwin Dam. The historical monthly flows at Ripon are generally less than the unimpaired in the winter and spring months, and are often slightly higher than the unimpaired flows in the summer and fall months.

Table 2-16 summarizes the range of historical and unimpaired flows on the Stanislaus River to demonstrate the baseline hydrology of the river 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 cfs to 4,500 cfs were released for flood-control purposes.

Table 2-16. 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*	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

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

The Stanislaus River monthly unimpaired flows at New Melones Dam are summarized in Table 2-17 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 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 (10 percent value) to 2,015 TAF (90 percent value), with a median runoff of 922 TAF. The average unimpaired flow was 1,100 TAF/y, slightly more than the median runoff. This represents about 18 percent of the estimated unimpaired flow at Vernalis.

Table 2-17. Monthly and Annual Unimpaired Flow in the Stanislaus River 1984–2009 (thousand acre-feet)

	Unimpaired Flow												
Cumulative	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 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 and, as such, it is difficult to anticipate when reservoir releases for flood-control storage will be required. The monthly historical flows are summarized in Table 2-18 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 (10 percent value) to 1,249 TAF (90 percent value). The median historical annual river flow was 429 TAF. The average historical flow was 611 TAF/y, which is slightly more than the median. The average historical flow of 611 TAF was about 55 percent of the average unimpaired flow, but the majority of this flow was observed in the wet years with flood-control releases.

Table 2-18. Monthly and Annual Historical Flow in the Stanislaus River 1984–2009 (thousand acre-feet)

	Observed Flow												
Cumulative	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

2.5 Lower San Joaquin River

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 drainage area of the SJR above Vernalis includes approximately 12,250 square miles. All of the SJR flow from upstream of the Merced River (including the Friant Dam flood-control releases) and the tributary flows from the three major 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 streams are commonly referred to as the westside tributaries to the SJR, and are intermittent. However, at times of high rainfall, these streams contribute significant runoff to the LSJR.

2.5.1 Water Diversions

The water for irrigated agriculture in the San Joaquin Valley is supplied by the LSJR 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) also exports water from the southern Delta, supplying the SJR exchange contractors and several water districts along the DMC that have contracts for CVP water supplies.

2.5.2 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, San Joaquin River Agreement (SJRA), VAMP, Water Rights Decision D-1641 (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) members13 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.

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 the 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 2-19, 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 2-19. 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

2.5.3 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 historical (observed) flows in comparison to the unimpaired (natural) flows at Vernalis. Peak flows

[13] SJRGA members include: Modesto Irrigation District, Turlock Irrigation District, Merced Irrigation District, South San Joaquin Irrigation District, and Oakdale Irrigation District; the San Joaquin River Exchange Contractors Water Authority and its member agencies Central California Irrigation District, San Luis Canal Company, Firebaugh Canal Water District and Columbia Canal Company; the Friant Water Users Authority on behalf of its member agencies; and the City and County of San Francisco (CCSF).

currently occur earlier in the year during the months of February, March, April, and May, than in May and June as occurred under the unimpaired flow regime. Figure 2-9 shows the monthly unimpaired historical flow 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 releases (including flood flows in 2000, 2005, and 2006) average 2,915 TAF/y.

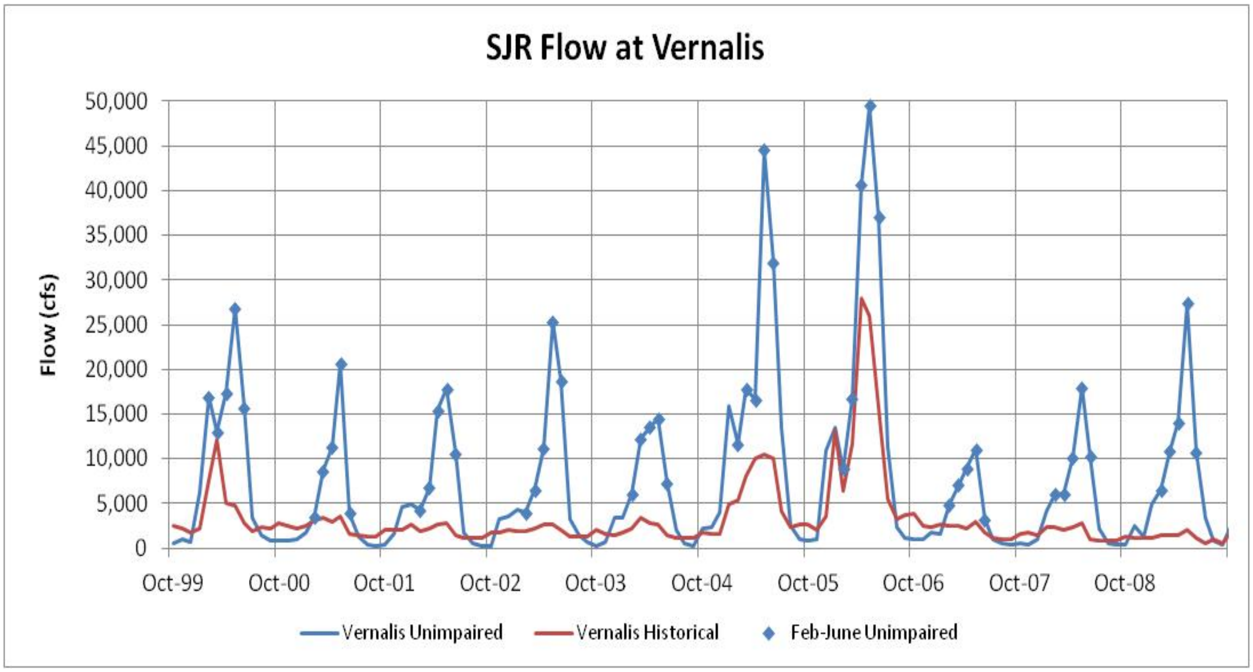

Figure 2-9. Monthly Unimpaired and Historical LSJR Flows at Vernalis February–June for Water Years 2000–2009 (cfs = cubic feet per second)

The historical (1930–2009) Vernalis flows average about 48 percent of the unimpaired flow, but the releases were usually much less than 40 percent of the unimpaired, 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 after completion and filling of New Melones in 1983. Tables 2-20 and 2-21 show the unimpaired monthly historical flows, respectively, for the SJR at Vernalis from 1984 through 2009. The natural hydrologic variability in the SJR Basin after 1983 has been further 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.

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.

Table 2-20. Monthly and Annual Unimpaired Flow in the San Joaquin River at Vernalis from 1984–2009 (thousand acre-feet)

Unimpaired Flow													
Cumulative	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 2-21. Monthly and Annual Historical Flow in the San Joaquin River at Vernalis from 1984–2009 (thousand acre-feet)

Observed Flow													
Cumulative	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

2.6 Southern Delta

The LSJR enters the southern Delta at Vernalis. About half of the LSJR flow is diverted west into Old River (which diverges from the LSJR downstream of Mossdale and connects with Middle River and the Grant Line Canal), and about half of the LSJR flow continues north toward Stockton. The majority of the lands located in the southern Delta are within the South Delta Water Agency (SDWA) in San Joaquin County. Figure 2-10 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 about 100,000 acres. The non-irrigated area includes urban lands, water courses, levees, farm homesteads, islands within channels, and levees. Just to the 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 Contra Cost Water District (CCWD) intakes. Figure 2-10 shows the location of these intakes, and the wastewater treatment plant facilities (WWTP) that discharge treated effluent into the southern Delta.

Southern Delta salinity concentrations are effected 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.

2.6.1 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. About 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 about 15,000 cfs at Vernalis, the Paradise Cut weir (elevation 12.5 feet) will divert 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 feet 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 the head to Victoria Canal. The surface area of Middle River is about 175 acres, with a volume of 750 AF at an elevation of 0 feet 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 Old River channel or the Middle River channel. About 60 percent of this Old and Middle River (OMR) flow is in the Old River channel and about 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 actually two parallel canals—the Fabian and Bell Canals. The Grant Line Canal is about 9 miles long, and the Fabian and Bell Canals begin near the Tracy Boulevard Bridge (across Grant Line Canal) and continue to the downstream end of Grant Line Canal where they rejoin the Old River channel just north of the Tracy fish facility. The surface area of Grant Line Canal is about 400 acres, with a volume of about 3,250 AF at an elevation of 0 feet MSL.

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

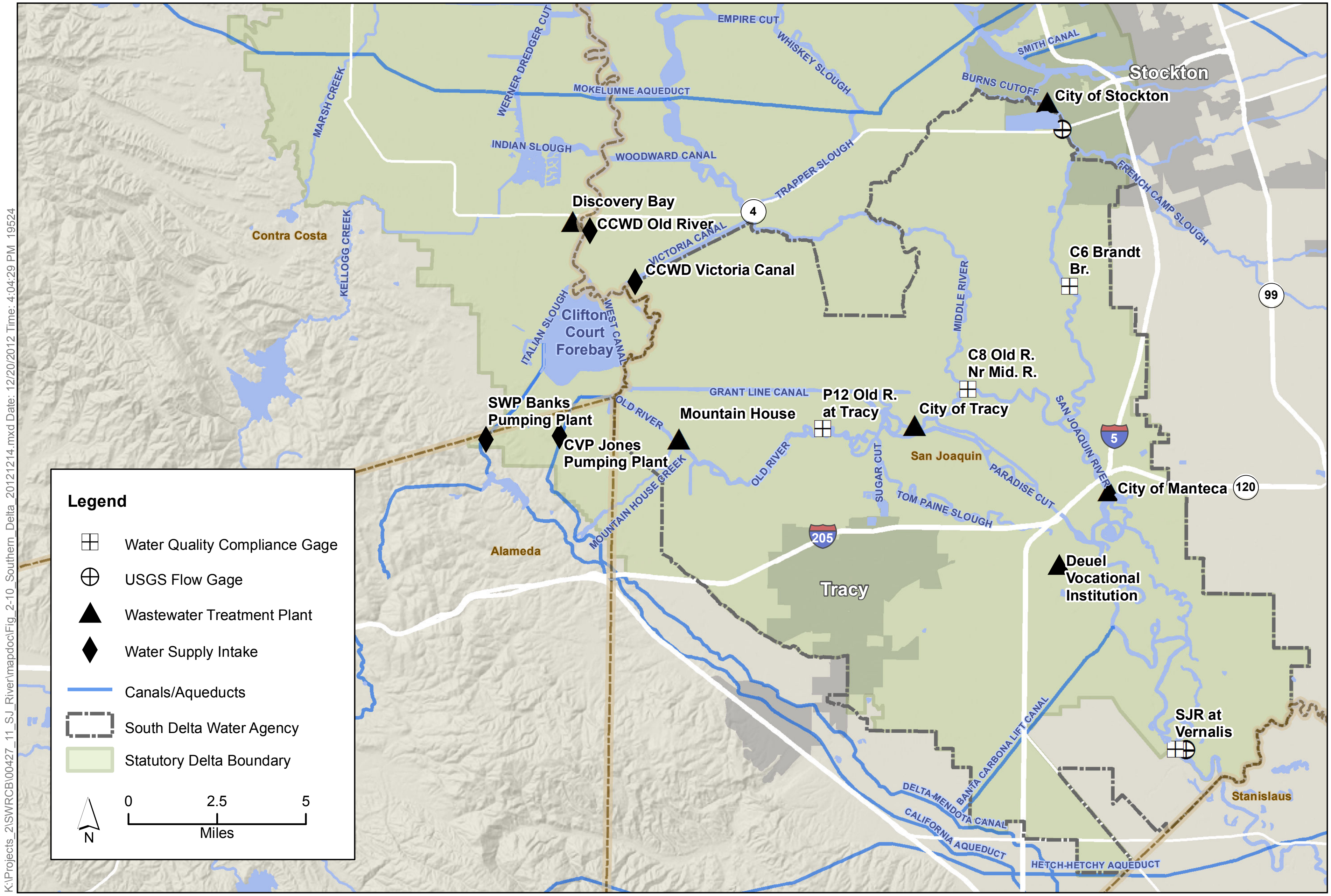

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Figure 2-10
Vicinity Map of Southern Delta

tide elevations. Sacramento River water moving towards the export pumps from the central Delta in 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 Head of Old River Barrier (HORB) is a temporary rock barrier (weir) that has often been installed 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.

2.6.2 Water Diversions

The two major water export facilities in the Delta are the CVP and SWP, which are both located in 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.

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 about 2.5 miles long. The Tracy Fish Collection Facility is located at the entrance to the intake channel on Old River. Water is pumped about 200 feet 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 for seasonal storage in San Luis Reservoir.

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 Section 10 Rivers and Harbor Act permit 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, or pumped further south in the California Aqueduct to Kern County Water Agency or pumped over the Coast Range in the Coastal Aqueduct or pumped over the 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

The 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) Old and Middle River (OMR) flows December–June. The BOs allow a range of reverse OMR limits to be imposed for delta smelt and salmonids protection, but the largest monthly average reverse OMR flows for December – June are a negative 5,000 cfs. This effectively limits the CVP and SWP exports to about 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 65percent 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 the CCWD's Rock Slough diversion.

The monthly cumulative distribution of CVP and SWP pumping for water years 1984 through 2009, which corresponds with 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 the months of April through 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 cfs to 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. The SWP pumping has been greatest in July through September with a median pumping of about 5,000 cfs because of the peak irrigation demand and because reduced pumping for fish protection is not usually required in these months.

CCWD Intake(s)

CCWD has four surface water intakes, Mallard Slough Intake, Rock Slough Pumping Plant #1, Old River Intake near State Route (SR) 4 and the Victoria Canal Intake. The Old River and Victoria Canal Intakes are located immediately north/northwest of the SDWA boundary (Figure 2-10). The Mallard Slough Intake and Rock Slough Intake are located further west and closer to the ocean. The Old River

Intake is the largest intake operated and accounts for the majority of surface water diverted to CCWD (CCWD and USBR 2006).

Generally, the 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 tell September. Additionally, periods with high agricultural drainage contributions in the summer from the LSJR 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 AFY) 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).

2.6.3 Return Flows

Return flows in the southern Delta consist of 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 the southern Delta salinity. There are six WWTPs with discharges 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 are set for a wide variety of constituents, including salt; they regulate the quality of the effluent discharged from the WWTPs. Chapter 13, *Service Providers*, provides additional information and specific characteristics about each WWTP. Table 2-22 lists these six WWTPs with discharges into the southern Delta, their receiving water bodies, and their total permitted discharge rate.

Table 2-22. 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	0.7
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
Discovery Bay WWTP	San Joaquin River	2

WWTP = Wastewater Treatment Plant

The City of Tracy WWTP discharge has limited effects on the salinity in the southern Delta as 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

Irrigation of the various crops in the southern Delta is done 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 evapotranspirated 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.

2.6.4 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, located upstream of the southern Delta Channels, is a focal point on the LSJR as the three eastside tributaries create the combined flow of the SJR at Vernalis. Flow at Vernalis is typical of the positive inflow that the LSJR contributes to the South Delta. The LSJR flow at

Vernalis has a large effect on the salinity at Vernalis and the South Delta. Higher flows generally reduce the salinity by diluting the LSJR agricultural drainage discharges. Higher flows generated by reservoir releases or less 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 have a large effect on southern Delta salinity as higher pumping brings more Sacramento River water across the Delta to the export pumps and results in lower salinity. 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 at 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 Vernalis measured salinity is below approximately 0.9 dS/m. (Chapter 5, *Water Supply, 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 2-10): 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 EC 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 objectives at Vernalis generally have been met. However, compliance with the southern Delta salinity objectives at the three interior stations (C-6, C-8, and P-12) has not always been achieved (Chapter 5, *Water Supply, Surface Hydrology, and Water Quality* 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.

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