Chapter 6
Flooding, Sediment, and Erosion

6.1 Introduction

This chapter describes the environmental setting for flooding, sediment, and erosion conditions and the regulatory setting associated with flooding, sediment, and erosion. It also evaluates environmental impacts on river channel flooding, erosion, and sediment transport that could result from the Lower San Joaquin River (LSJR) alternatives and, if applicable, offers mitigation measures that would reduce significant impacts.

The plan area is evaluated in this chapter and consists of four rivers within the San Joaquin River (SJR) Basin portion of the Central Valley of California. The rivers are the LSJR (downstream of the Merced River confluence) including the SJR portion of the Sacramento–San Joaquin Delta (Delta), and three eastside tributaries. North to south, the three tributaries are the Stanislaus, Tuolumne, and Merced Rivers. The flow in these rivers is primarily controlled by the three rim dams on these three rivers—the New Melones, Don Pedro, and New Exchequer, respectively. Consequently, the rivers are only evaluated below these dams. These three eastside tributaries are generally steeper, confined gravel-bedded channels in their upper portion. They transition to low gradient, sand-bedded meandering channels in their middle to lower reaches. The LSJR is a very low gradient river throughout the plan area and generally has a meandering pattern. The three eastside tributaries and the LSJR are constrained by channel modifications, development encroachment, agricultural encroachment and levees that limit their ability to flood the adjacent landscape or to have excessive channel erosion. The LSJR is further constrained by the alluvial fan sediment deposition of all tributary streams from both the Sierra Nevada Mountains (Sierra Nevada) and the Coast Ranges.

The impacts of the LSJR alternatives are described in Table 6-1. The LSJR alternatives take into consideration the maximum channel capacities of the affected rivers. That is, the flows for each alternative would comply with the U.S. Army Corps of Engineers' maximum channel capacities. The impacts evaluated include altering the existing drainage pattern through the alteration of the course of a stream or river in a manner that would result in substantial erosion or siltation on or offsite; or, increase the rate of surface runoff in manner that would result in flooding on or offsite.

Any change in salinity in the southern Delta as a result of the southern Delta water quality (SDWQ) alternatives is expected to be similar to that of the historic range of salinity because the Vernalis salinity objective would be maintained under the SDWQ alternatives. Water quality does not have the ability to affect flooding, sedimentation, or erosion. Consequently, there would be no impact on flooding, erosion, or sedimentation associated with these alternatives. Therefore, the SDWQ alternatives are not analyzed in detail in this chapter.

Impacts related to LSJR Alternative 1 and SDWQ Alternative 1 (No Project) are presented in Chapter 15, *LSJR Alternative 1 and SDWQ Alternative 1 (No Project Alternative)*, and the supporting technical analysis is presented in Appendix D, *Evaluation of LSJR Alternative 1 and SDWQ Alternative 1 (No Project Alternative)*. Impacts related to methods of compliance are discussed in Appendix H, *Evaluation of Methods of Compliance*.

Table 6-1. Summary of Flooding, Sediment, and Erosion Impacts

Alternative	Summary of Impact(s)	Significance Determination
FLO-1: Substantially alter the existing drainage pattern through the alteration of the course of a stream or river in a manner that would result in substantial erosion or siltation on or offsite		
LSJR Alternative 1	See note.[1]	
LSJR Alternative 2	Flows are much lower than channel capacities so there would be no sediment transport, bank erosion or meander-bend migration issues and no contribution to levee instability. Therefore, substantial alterations of the existing drainage patterns would not occur and would not result in substantial erosion or siltation.	Less than significant
LSJR Alternative 3	Same as Alternative 2 although very occasional gravel transport and bank erosion would occur in the upper gravel-bedded reaches of the eastside tributaries. The amount of bank erosion is limited by flood action levels and existing bank armoring. Therefore, substantial alterations of the existing drainage patterns would not occur and would not result in substantial erosion or siltation.	Less than significant
LSJR Alternative 4	Same as Alternative 3 with occasional gravel transport and bank erosion in the upper gravel-bedded reaches of the eastside tributaries. The amount of bank erosion is limited by the action stage and existing bank armoring. Therefore, substantial alterations of the existing drainage patterns would not occur and would not result in substantial erosion or siltation.	Less than significant
FLO-2: Substantially alter the existing drainage pattern through the alteration of the course of a stream or river or substantially increase the rate of surface runoff in manner that would result in flooding on or offsite		
LSJR Alternative 1	See note.[1]	
LSJR Alternative 2	Flows would be much lower than channel capacities and no significant flooding impact would occur outside of floodway. Flow objectives would not change reservoir flood storage capacity and would not violate USACE flood reservation so there would	Less than significant

Alternative	Summary of Impact(s)	Significance Determination
	be no changes in flood-control releases during major flood events. On an annual basis flows greater than 1,500 cfs on the Stanislaus River would be likely less than under baseline. Therefore, substantial alterations of the existing drainage patterns would not occur and would not result in flooding.	
LSJR Alternative 3	Same as Alternative 2. Therefore, substantial alterations of the existing drainage patterns would not occur and would not result in flooding.	Less than significant
LSJR Alternative 4	Flows greater than 1,500 cfs on Stanislaus River would occur with greater frequency than baseline from April to June; however, the associated seepage would not have an effect on erosion due to the rate and volume of water and would not be surface inundating. Therefore, substantial alterations of the existing drainage patterns would not occur and would not result in flooding.	Less than significant

[1] The No Project Alternative would result in implementation of flow objectives and salinity objectives identified in the 2006 Bay-Delta Plan. See Chapter 15, *LSJR Alternative 1 and SDWQ Alternative 1 (No Project Alternative)*, for the No Project impact discussion and Appendix D, *Evaluation of LSJR Alternative 1 and SDWQ Alternative 1 (No Project Alternative)*, for the No Project Alternative technical analysis.

6.2 Environmental Setting

The geographic area considered is the plan area. The background information in this section provides context for the effects evaluation of the LSJR alternatives. The LSJR alternatives do not involve ground-disturbing activities nor do they impact the potential for high peak flows. Consequently, this section does not provide information on overall basin erosion and sedimentation.

6.2.1 Overview of the Bay-Delta and Central Valley Basin

Chapter 2, *Water Resources*, describes in detail the hydrology, dams, water diversions, operating agreements, and flow requirements of the plan area. The present chapter provides additional information on the channel geomorphology and channel capacities relevant to evaluating the potentials for flooding, and sediment, and erosion impacts as described in Sections 6.4.2 and 6.4.3.

The Central Valley is a low-lying basin that receives water and sediment from the surrounding highlands of the Sierra Nevada to the east and the Coast Ranges to the west. The Sacramento River drains the north end of the Central Valley while the SJR drains the south end. The Sacramento River and SJR flow along the lowest elevation portions of the Central Valley as low gradient rivers. The two rivers meet in the Delta and flow to the Pacific Ocean through Carquinez Strait and San Francisco Bay.

Streams entering the SJR from both the Sierra Nevada and the Coast Ranges have steeper gradients as they exit their respective mountain front and then become progressively lower gradient as they reach the lowermost SJR Basin and join the LSJR. In their upper portions, the Sierra Nevada tributaries are incised into bedrock, and the larger dams are placed in these bedrock reaches. Further downstream, the streams leave the bedrock and begin flowing within channels formed of the sediment they transport (i.e., they become alluvial channels). The upper river reaches are steeper and gravel dominated (and are considered transport reaches) while the lower reaches are lower gradient and sand dominated (and are considered response reaches, constantly adjusting their channel bed to the available sediment, and water supply).

The Sierra Nevada streams generally have more water discharge and are lower gradient than the streams that drain the Coast Range. The Sierra Nevada tributaries have also been modified by gold dredging in their upper gravel-bedded reaches as well as within-stream and stream adjacent gravel mining for aggregate (Kondolf et al. 1996, 2001; McBain and Trush 2000; Weissmann et al. 2005). The LSJR and its eastside tributaries are described in the following sections.

6.2.2 Lower San Joaquin River and Southern Delta and Tributaries

Reservoirs

Flood control operations for Lake McClure, New Don Pedro Reservoir, and New Melones Reservoir are developed as part of the Water Control Plans by the USACE Sacramento District, according to national flood control regulations (33 CFR, § 208.11). Based on hydrologic engineering studies of rainfall and snowmelt floods, standard project floods and reservoir design floods are identified for the reservoir. The seasonal rainfall and snowmelt flood control curves (i.e., empty storage space) are based on these design storms. For example, the rainfall flood control storage for Lake McClure increases linearly from 0 thousand acre-feet (TAF) at the end of August to 175 TAF at the end of September to 350 TAF at the end of October. The flood control space remains at 350 TAF until March 15, and is reduced linearly to 0 TAF on June 15. Flood-control releases are made whenever the reservoir storage increases to above the maximum flood control storage during rainfall runoff events, with a maximum flood-control release flow of 6,000 cubic feet per second (cfs) at Stevinson. Additional snowmelt space is reserved from the beginning of March until the end of July, if necessary, to allow the reservoir to fill without uncontrolled spilling. A constant supplemental river release is computed, based on snowpack and snowmelt forecasts. The maximum snowmelt storage space is 400 TAF from April 1 to May 15. Emergency spillway releases are regulated with a similar process that requires higher releases during very high inflow events once the Lake McClure elevation is above the spillway crest at 837 feet (30 feet spillway gates). New Don Pedro and New Melones Reservoirs have similar flood control and flood control operating rules.

Lower San Joaquin River and Delta

The SJR flows from high in the Sierra Nevada, drains west into the SJR Basin, turns north and drains to the Delta, a distance of approximately 180 miles below Friant Dam. Below Friant Dam, the river has deposited a wide alluvial fan that it now flows across (McBain and Trush 2002; Weissmann et al. 2005). At the bottom of this alluvial fan, the river turns north and flows towards the Delta. Figure 6-1 shows the SJR longitudinal profile from Friant Dam downstream to the Delta. Table 6-2 describes the eight LSJR channel reaches from the Merced River north. The SJR channel reaches are distinguished by differences in floodplain width, connectivity of the channel to the floodplain, and encroachment. The SJR is generally a meandering channel in its lower reach; however, the width of the meander belt is related to space constraints placed upon it by both the San Joaquin Valley width and its tributary river and creek alluvial fans (Weissmann et al. 2005). Upstream of the Merced River confluence the SJR meandering floodplain is several miles wide because the Valley itself is wide and the Sierra Nevada tributaries (Chowchilla and Kings Rivers) do not have sufficient water and sediment available to fill the central basin and constrain the SJR (Weissmann et al. 2005).

Near the Merced River (LSJR River Mile [RM] 119), the LSJR floodplain becomes narrower because the Valley itself narrows and the Merced River alluvial fan has sufficient sediment deposition to constrain the LSJR's ability to migrate east. At the Merced River confluence, the SJR floodplain narrows from more than three miles to less than one mile. The channel pattern and floodplain width is similar from this location for approximately 44 miles north, past the confluence with the Tuolumne River at RM 83.5 to the confluence with the Stanislaus River at RM 75. The LSJR floodplain is also constrained by stream alluvial fans from the Coast Ranges to the west. These alluvial fans include Orestimba Creek at RM 109 and Del Puerco Creek at RM 93. North of the Stanislaus River at RM 75, the Valley and LSJR floodplain again widens towards the southern Delta (Weissmann et al. 2005). The LSJR has a very low gradient along this entire reach ranging from 0.000036 to 0.000284 and is sand-bedded (USACE 2002).

The LSJR generally forms a meandering pattern throughout this reach. Meandering or sinuous river patterns are repetitive, although varying, sinusoidal patterns with several features (Figure 6-2a and 6-2b). Meanders form by water flow eroding the channel bottom, forming a deep pool that also undercuts and erodes the adjacent channel bank. That eroded sediment is transported downstream and deposited, forming a shallow spot or riffle in the channel, which is followed by another pool with an eroding channel bank and then another riffle. Sediment is also deposited on the inside bend in the vicinity of the pool forming a point bar. Point bar sediment is commonly deposited during high flows and often forms arcuate ridges (scroll ridges, scroll bars) along the point bar that are visible at lower flows.

This erosion-deposition pattern causes the river channel to progressively erode the banks and "migrate" downstream. As the channel configuration changes, individual meanders may be cut off producing an oxbow lake (Figure 6-2c. The cutoff may occur at the meander neck (neck cutoff) or by flows across the point bar surface that erode a sufficiently deep channel to capture stream flow (chute cutoff) (Figure 6-2c).

Erosion and sediment transport occur during higher or flood flows, which can mobilize the bed sediment and undercut stream banks; consequently, overall meander channel dimensions reflect the high flows associated with individual river systems (McBain and Trush 2002; Larsen et al. 2006; Michalkova et al. 2011). Many factors control the rate of meander movement. These factors include flood flows, bed sediment size, bank erosional resistance and meander geometry. Higher flows approaching channel capacity are needed to move sediment, and coarse sediment movement requires higher flows than finer sediment. Bank resistance is also impacted by numerous factors such as levee construction to contain flood flows, placement of large rocks or physical structures to prevent bank erosion, presence of bridge abutments, and local variations of natural bank materials (e.g., sediment size and the presence of bedrock or cohesive soils).

On the LSJR, dams and increased water use have reduced river flow, which reduces sediment transport (McBain and Trush 2002). Combined with the effects of levees that have been constructed to contain peak flows, the meander migration rates on the LSJR have been minimized (McBain and Trush 2002).

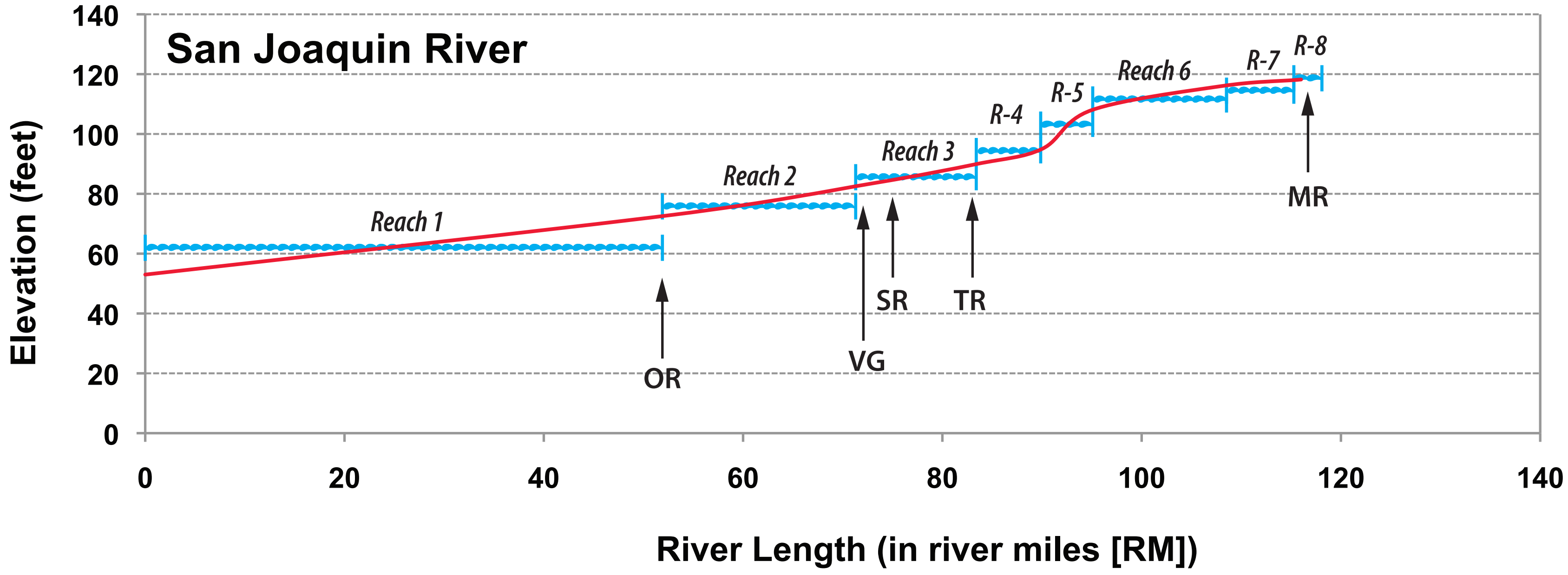
Figure 6-3 and Tables 6-3, 6-4, and 6-5 show the channel capacities, National Weather Service (NWS) flood categories, and observations of channel conditions and local inundation of the LSJR and the three eastside tributaries, respectively. The levee system shown in Figure 6-3 is part of the State Plan of Flood Control, which is part of the combined state-federal flood management system (DWR 2010). It has undergone a system-wide evaluation and update to improve flood control and management as part of the Central Valley Flood Protection Plan (DWR 2011, 2012). Private levees that are not part of the State Plan of Flood Control occur on the Stanislaus, Tuolumne, and Merced Rivers are not shown in Figure 6-3.

The designed LSJR channel capacity increases downstream from 26,000 cfs just above the Merced River confluence, to 45,000 cfs below that confluence and increases downstream of the Tuolumne and Stanislaus River confluences as well. Some flow is diverted at the Paradise Cut, and additional flow is diverted at Old River. Evaluations for the Central Valley Flood Protection Plan indicate that, in some cases, channel capacity may be higher or lower than the estimated or design capacities (Table 6-3). On the LSJR present channel capacities are uncertain downstream of the Merced River confluence, downstream of the Tuolumne River confluence, and from Old River to Burns Cutoff (Table 6-3). Additional evaluation is needed in these three reaches (DWR 2011).

The above capacities are mostly within the levee system, which protects the adjacent meander belt floodplain and agricultural land. The San Joaquin River National Wildlife Refuge is located approximately between the confluences of the Tuolumne and Stanislaus Rivers. The refuge can receive flood flows to reduce discharge downstream during floods (USFWS 2006; River Partners 2008).

The action stage for the SJR at Vernalis is 22,000 cfs, and the minor flooding level for the LSJR is 34,000 cfs (NWS undated website). The NWS (undated website) defines action stage as the point on a rising stream (i.e., the water discharge is increasing and expected to continue to increase) at which some type of mitigation action should be taken in preparation for possible significant hydrologic activity. Minor flooding has minimal or no property damage but possibly some public threat. Table 6-4 shows various action stages. Table 6-5 shows some local effects that occur at various discharge levels as well as reservoir flow limits.

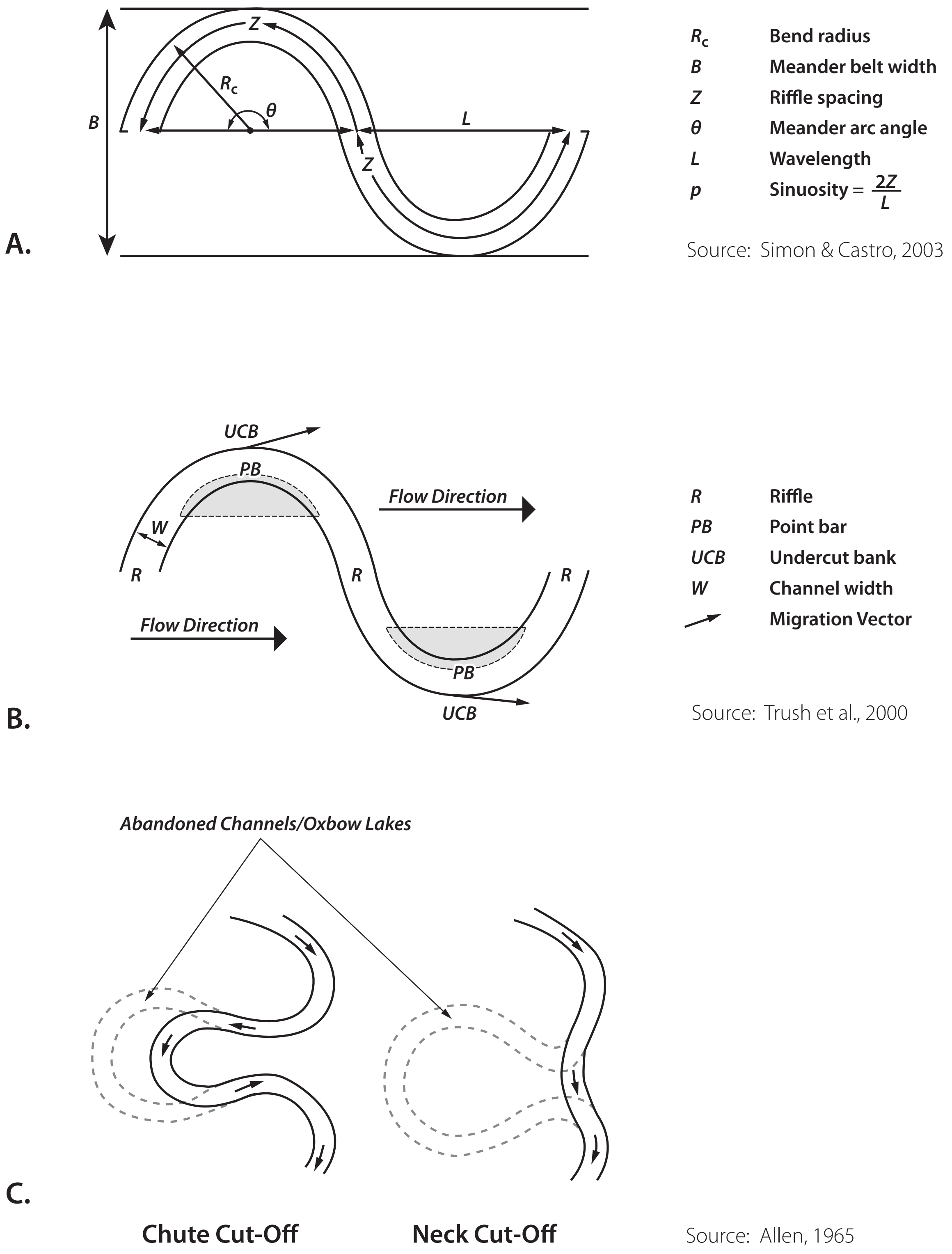
Recent floods were recorded in the region and on the LSJR in 1983, 1986, 1995, 1997, and 2006 (USACE 1999; Parrett and Hunrichs 2006). Generally these flood flows were contained by the LSJR levees, although there were several levee breaches during the 1997 flood (USACE 1999; DWR 2010, 2011, 2012). The 100-year floodplain is reflected in the meander belt floodplain described in Table 6-2 (USACE 1999, Figure 6-2f and 6-2g; DWR 2010, 2011, 2012).



MR	Merced River - RM 118
TR	Tuolumne River - RM 83
SR	Stanislaus River - RM 75
VG	Vernalis Gage - RM 72
OR	Old River Distributary - RM 53

Graphics...00427.11 SED (12-2011) JD

Figure 6-1
San Joaquin River Longitudinal Profile



R_c	**Bend radius**
B	**Meander belt width**
Z	**Riffle spacing**
θ	**Meander arc angle**
L	**Wavelength**
p	**Sinuosity** = $\frac{2Z}{L}$

Source: Simon & Castro, 2003

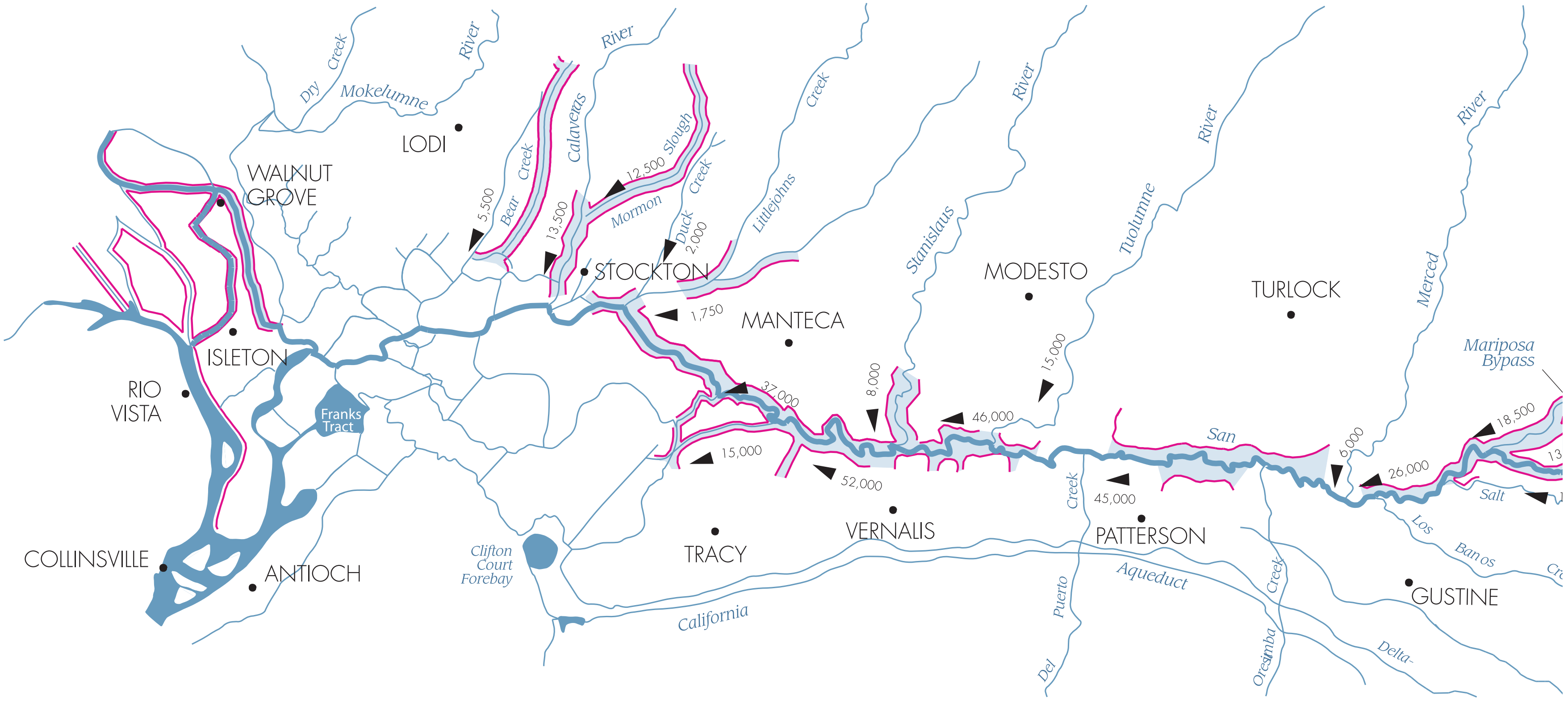
R	**Riffle**
PB	**Point bar**
UCB	**Undercut bank**
W	**Channel width**
↗	**Migration Vector**

Source: Trush et al., 2000

Source: Allen, 1965

Graphics...00427.11 SED (4-2011) JD

Figure 6-2
Meandering Channel Characteristics



— Project Levees Maintained by Reclamation, Levee, and Drainage Districts and Municipalities

◄ 45,000 Estimated Channel Capacity (in cubic feet per second)

Source: www.water.ca.gov/floodmgmt/docs/map_sac&sj_designflows.pdf

Graphics...00427.11 SED (4-2012) JD

Figure 6-3
Channel Capacities and Levees

Table 6-2. Lower San Joaquin River Channel Reaches

Reach	1	2	3	4	5	6	7	8
River Mile (RM)	0 – 53	53 – 73	73 – 83.5	83.5 – 90	90 – 95	95 – 108	108 – 116	116 – 118
Gradient	0.000036	0.000057	0.000234	0.000032	0.00011	0.000146	0.000284	0.000086
Description	Distributary channels downstream of Old River flowing towards junction with Sacramento River. Flow generally constrained between levees which protect adjacent Delta islands.	Floodplain continues to widen to Old River cutoff. Channel begins to become distributary at Paradise Cut and then Old River; main San Joaquin channel continues around east side of Delta. Vernalis stream gage at RM 72.	Floodplain 2 miles wide below Tuolumne confluence; continues to widen downstream. Tight meanders, then meander height increases with floodplain width. Main channel generally isolated from adjacent floodplain. Stanislaus enters at RM 75. SJR National Wildlife Refuge between Tuolumne and Stanislaus River confluences.	Floodplain widens to more than two miles. Laird Slough flows north from north side of river. Tuolumne River enters at approximately RM 83 and floodplain narrows.	Channel constrained with narrow floodplain less than 0.6 miles wide.	Floodplain and abandoned channels are adjacent to main channel but not generally connected. Floodplain up to 2 miles wide. Downstream end of reach terminates at Sewage Disposal Ponds southwest of Modesto.	Channel somewhat constrained with floodplain less than 1 mile wide. Channel less connected to floodplain than Reach 8. Ends at Crows Landing Bridge.	Meander Channels connected to main channel. Merced River enters at RM 118.

Source: McBain & Trush, Inc. 2000.

The composite condition for the LSJR levees is primarily "higher concern" (i.e., the levees display more performance problems than those of lower concern), with stretches of "medium concern" and short stretches of "lower concern" (DWR 2012, Figure 1-7), based on detailed levee evaluations along the LSJR conducted for the Central Valley Flood Protection Plan (DWR 2010, 2011, 2012). The evaluations included numerous criteria that affect levee integrity including seepage, slope stability, erosion, and animal burrows (DWR 2011, 2012). California Department of Water Resources (DWR) (2011) also includes individual rating maps for each assessment criteria.

Table 6-3. River Channel Capacity

River Channel Reach	Estimated Channel Capacity (cfs)[1]	Design Channel Capacity (cfs)[2]	Estimated Current Channel Capacity (cfs)[2]
Stanislaus River	8,000	12,000	23,000
Tuolumne River	15,000	15,000	No data
Merced River	6,000	No data	No data
San Joaquin River			
Upstream of Merced Confluence	26,000	No data	No data
Downstream of Merced Confluence	45,000	45,000	22,000–35,000[3]
Downstream of Tuolumne Confluence	46,000	46,000	25,000[3]
Downstream of Stanislaus Confluence to Paradise Cut	52,000	52,000	66,000
Paradise Cut to Old River	37,000	37,000	30,000–40,000[3]
Old River	15,000	No data	No data
Old River to Burns Cutoff	–	18,000	15,000–20,000[3]

Sources: [1] DWR. Undated. www.water.ca.gov/floodmgmt/docs/map_sac&sj_designflows.pdf; [2] DWR 2011; [3] Potential inadequacy, additional evaluation required (DWR 2011)

cfs = cubic feet per second

Table 6-4. National Weather Service Flood Category, Discharge and Elevation at Plan Area Stream Gages

	Action (cfs/feet)[1]	Minor (cfs/feet)	Moderate (cfs/feet)	Major (cfs/feet)
Stanislaus River at Orange Blossom Bridge (RM 41)	8,500 / 13.0	12,500 / 16.0	22,100 / 21.0	24,000 / 22.0
Tuolumne River at Modesto (RM 4)	6,600 / 50.5	10,400 / 55.0	36,900 / 66.0	40,000 / 67.0
Merced River at Stevinson (RM 5)	3,200 / 67.0	6,900 / 71.0	9,000 / 73.8	10,600 / 75.0
San Joaquin River at Vernalis	22,000 / 24.5	34,000 / 29.0	50,000 / 32.0	100,000 / 37.3

Source: National Weather Service (NWS) – Advanced Hydrologic Prediction Service. See “Scale to Flood Categories” dropdown box for flood levels (discharge cfs read from graph).

Stanislaus River: http://water.weather.gov/ahps2/hydrograph.php?wfo=sto&gage=obbc1&view=1,1,1,1,1,1,1,1&toggles=10,7,8,2,9,15,6&type=2

Tuolumne River: http://water.weather.gov/ahps2/hydrograph.php?wfo=sto&gage=mdsc1&view=1,1,1,1,1,1,1,1&toggles=10,7,8,2,9,15,6&type=2

Merced River: http://water.weather.gov/ahps2/hydrograph.php?wfo=hnx&gage=stvc1&view=1,1,1,1,1,1,1,1&toggles=10,7,8,2,9,15,6&type=2

San Joaquin River: http://water.weather.gov/ahps2/hydrograph.php?wfo=sto&gage=vnsc1&view=1,1,1,1,1,1,1,1&toggles=10,7,8,2,9,15,6&type=2

High Water Level Terminology: http://aprfc.arh.noaa.gov/resources/docs/floodterms.php

cfs = cubic feet per second

RM = river mile

[1] The NWS (undated web site) defines action stage as the point on a rising stream (i.e., the water discharge is increasing and expected to continue to increase) at which some type of action should be taken in preparation for possible significant hydrologic activity.

Table 6-5. Local Inundation Observations and Reservoir Flow Limits

Discharge cfs / Elevation feet	Observation / Impact
Stanislaus River	
5,000 / 10.5	Inundation of several campsites in Caswell State Park (below RM 9)
5,700 / 11.0	Orange Blossom Park (RM 47) and Caswell State Park flooding in lowest areas
6,000 / 11.5	Caswell State Park access roads and park areas flooded. Orange Blossom Park lower areas flooded.
7,500 / -	New Melones power generation maximum flow
8,300 / -	New Melones maximum capacity of outlet works
Tuolumne River	
5,500 / -	New Don Pedro power generation maximum flow
10,000 / 55.0	Channel capacity through downtown Modesto.
40,000- / 67.0	Extensive flooding occurs. Flow in excess of 40,000 cfs could cause extensive damage to residential, industrial and commercial development in Modesto
Merced River	
3,200/ -	New Exchequer power generation maximum flow
6,000/ -	Estimated channel capacity
San Joaquin River at Vernalis	
15,300 / 21.0	Seepage into crops behind levee
22,000 / 24.5	Action stage
25,500 / 26.0	Severe seepage outside levees
100,000 / 37.3	Top of levees. Above this height flooding outside of levees.

Source: National Weather Service – Advanced Hydrologic Prediction Service. See "Default Hydrograph" dropdown box for flood categories and flood impacts.

Stanislaus River:
http://water.weather.gov/ahps2/hydrograph.php?wfo=sto&gage=obbc1&view=1,1,1,1,1,1,1,1&toggles=10,7,8,2,9,15,6&type=2

Tuolumne River:
http://water.weather.gov/ahps2/hydrograph.php?wfo=sto&gage=mdsc1&view=1,1,1,1,1,1,1,1&toggles=10,7,8,2,9,15,6&type=2

Merced River:
http://water.weather.gov/ahps2/hydrograph.php?wfo=hnx&gage=stvc1&view=1,1,1,1,1,1,1,1&toggles=10,7,8,2,9,15,6&type=2

San Joaquin River:
http://water.weather.gov/ahps2/hydrograph.php?wfo=sto&gage=vnsc1&view=1,1,1,1,1,1,1,1&toggles=10,7,8,2,9,15,6&type=2

cfs = cubic feet per second
RM = River Mile

Stanislaus River

Similar to other Sierra Nevada tributaries, the Stanislaus River transitions from steeper, gravel-bedded reaches affected by gold dredging and aggregate mining, to areas where various activities encroached on the stream channel and then to a lower gradient predominantly sand-bedded reach. The upper gravel-bedded reach is confined within a bedrock canyon (Goodwin Canyon) and extends from RM 54.75 to RM 58.4. Below RM 54.75, the river exits the bedrock canyon, but the channel is incised below adjacent alluvial river terraces that constrain the channel. This reach is gravel-bedded and there are occasional dredger tailings and gravel mining on the adjacent floodplain. This reach continues downstream to Oakdale (RM 41) and Riverbank (RM 34). At Riverbank, the channel and floodplain begin to become less constrained, and channel meandering becomes prominent. Based on the reduced gradient and increased meandering, the channel is expected to become more sand dominated in this reach. The lower and upper reaches have gradients of approximately 0.0004 to 0.0047, respectively, and the lowermost channel is sand-bedded (USACE 2002). Figure 6-4 shows the Stanislaus River longitudinal profile and Table 6-6 describes the three channel reaches, based on characteristics of the river channel and floodplain morphology as well as alterations to the river channel and floodplain (Kondolf et al. 2001).

Table 6-6. Stanislaus River Channel Reaches

Reach	1	2	3
River Mile (RM)	0–34	34–54.75	54.75–58.4
Gradient	0.0004	0.0008	0.0047
Description	Reach below Riverbank composed of Holocene river deposits. Channel meandering begins and becomes more prominent downstream. Sand bedded conditions probably begin below Ripon based on the lower channel gradient and increased meandering. Levees extend from RM 0 to about RM 11 Gravel mining adjacent to river upstream of Ripon (RM 19).	Channel is inset below and confined by older and higher river terraces. Occasional gravel mining and dredger tailings indicating gravel bed conditions. Knights Ferry at RM 54. Oakdale at RM 41. Riverbank at RM 34.	Channel is incised into bedrock and very confined and non-meandering. Gravel bedded. Begins to emerge from bedrock canyon at RM 54.75.

Source: Kondolf et al. 2001

Under current conditions, gravel transport in the upper part of Reach 2 is estimated to begin in the range of 5,000 to 8,000 cfs based on observations and calculations in Kondolf et al. 2001. Kondolf et al. (2001) report a post dam high flow of 7,350 cfs in 1997. Figure 2-8 presents the monthly unimpaired and historical flows February–June for the Stanislaus River. This shows that flows of this level were not reached for water years 2000–2009.

The lower Stanislaus River is protected by levees to approximately RM 11 that allow a channel capacity of 8,000 cfs (Figure 6-3). These levees are not part of the State Plan of Flood Control but are called Stanislaus Local Interest Project Levees (DWR 2010, 2011, 2012). This channel capacity is the flood design flow for the entire river below Goodwin Dam (Kondolf et al. 2001). Evaluations for the Central Valley Flood Protection Plan indicate that the lower Stanislaus River channel capacity is higher than the values shown in Figure 6-3 and Table 6-3.

Table 6-4 shows that the action stage[1] for the Stanislaus River is 8,500 cfs, and that the minor flooding level for the Stanislaus River is 12,500 cfs (NWS undated website). Table 6-5 shows some local effects that occur at various discharge levels as well as reservoir flow limits for power generation.

Kondolf et al. (2001) also report active channel meandering and potential avulsion at Caswell State Park (approximately RM 4 to RM 9.5). Avulsion occurs when a stream channel leaves its initial channel, flows across the landscape and establishes a new channel position. Depending on landscape condition, the new channel may or may not reconnect with the original channel downstream. Avulsion only occurs during high flows.

There is not any increased rate in wetted surface area (approximately width) at flows of 100–10,000 cfs, based on a California Department of Fish and Game (DFG) (2010) evaluation of U.S. Army Corps of Engineers (USACE) cross sections with increasing flows on the Stanislaus River. This lack of increase suggests the Stanislaus River does not have a well-defined floodplain within this flow range.

Recent floods were recorded in the region and on the Stanislaus River in 1983, 1986, 1995, 1997, and 2006 (USACE 1999; Parrett and Hunrichs 2006). Generally these flood flows were contained by the channel and adjacent floodplain within the floodway (USACE 1999; DWR 2010, 2011, 2012). The 100-year floodplain is reflected in the channel reach descriptions in Table 6-6 (USACE 1999, Figures 6-2f and 6-2g).

Although the channel capacity is 8,000 cfs there is agriculture within the floodway that may be affected by seepage and high water tables at flows above 1,500 cfs (McAfee 2000; Kondolf et al. 2001). New Melones flow releases continue to operate in line with these limits (Clinton pers. comm.); however, flows on the Stanislaus are generally above 1,500 cfs. The 1,500 cfs restriction does not apply for flood-control releases.

The composite conditions (i.e., considering all the evaluated risk factors) for the evaluated Stanislaus River levees is "higher concern," i.e., the levees display more performance problems than those of lower concern (DWR 2012, Figure 1-7). Detailed levee evaluations for the Central Valley Flood Protection Plan only include the levees immediately upstream of the Stanislaus River–SJR confluence to about RM 2 (DWR 2010, 2011, 2012). The evaluations include numerous criteria that affect levee integrity including seepage, slope stability, erosion, and animal burrows (DWR 2011, 2012). DWR (2011) also includes individual rating maps for each assessment criteria.

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[1] The NWS (undated web site) defines action stage as the point on a rising stream (i.e., the water discharge is increasing and expected to continue to increase) at which some type of mitigation action should be taken in preparation for possible significant hydrologic activity. Minor flooding has minimal or no property damage but possibly some public threat.

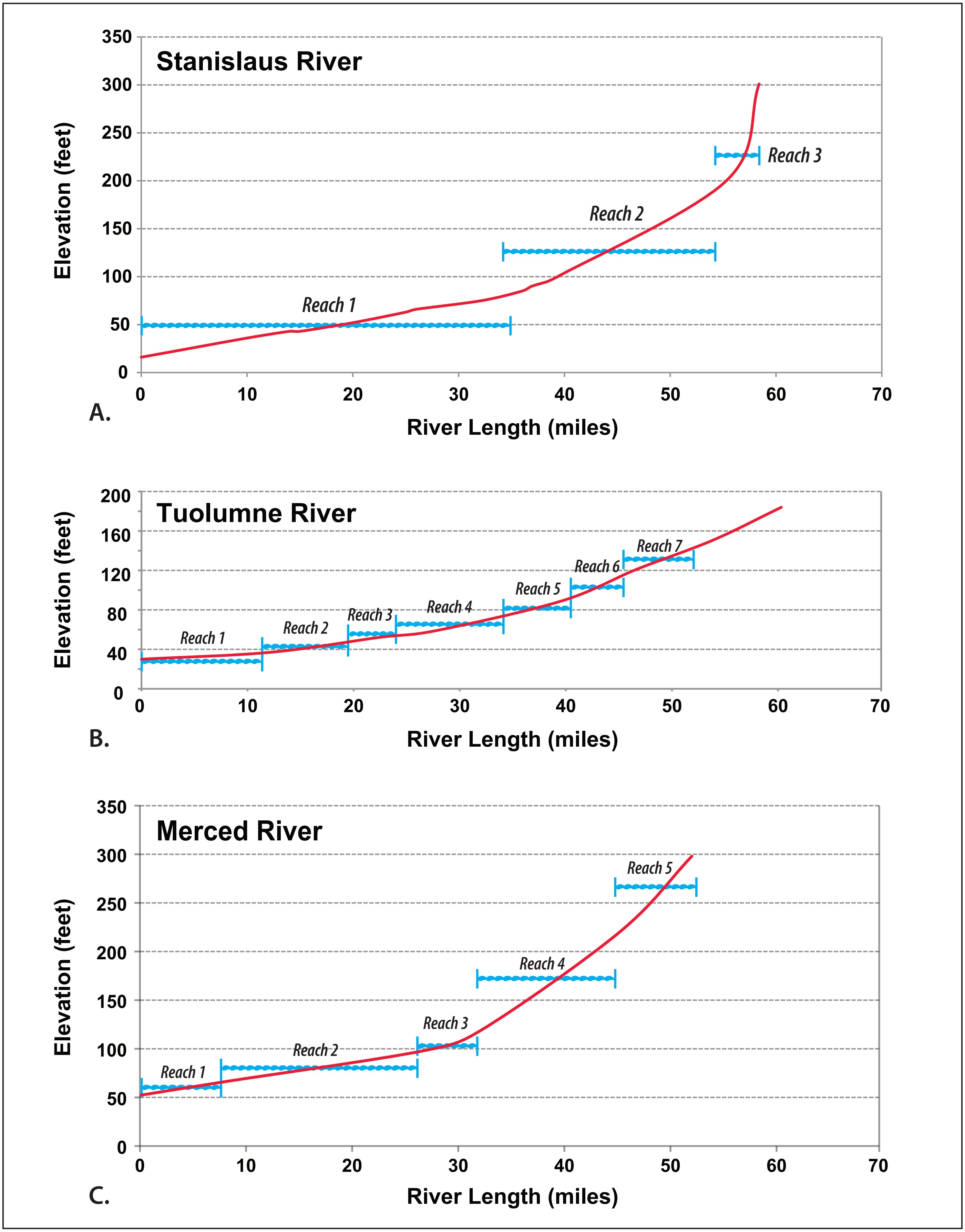

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Figure 6-4
Longitudinal Profiles for
Stanislaus, Tuolumne, and Merced Rivers

Tuolumne River

Similar to other Sierra Nevada tributaries, the Tuolumne River transitions from steeper, gravel-bedded reaches that have been affected by gold dredging and aggregate mining activities to areas where various activities have encroached on the stream channel, and then to a lower gradient sand-bedded reach. The upper gravel-bedded reaches are from RM 24 to RM 52 while the lower sand-bedded reaches are from RM 0 to RM 24. The lower and upper reaches have gradients of approximately 0.0003 to 0.0015, respectively and the lowermost channel is sand-bedded (USACE 2002). Figure 6-4 shows the Tuolumne River longitudinal profile and Table 6-7 describes the seven channel reach divisions, based on characteristics of the river channel and floodplain morphology as well as alterations to the river channel and floodplain (McBain and Trush 2000).

Under current conditions, gravel transport in the upper reaches are estimated to begin at flows of 7,050 cfs and as high as 9,800 cfs based on observations and calculations presented in McBain and Trush 2000. USFWS (2010) report 1995 Tuolumne River flow of 8,400 cfs. Figure 2-7 (*Monthly Unimpaired and Historical Tuolumne River Flows February–June*) shows that in water years 2000–2009, flows of this level were reached only in water year 2006.

Private levees occur intermittently along the lower ten miles of the Tuolumne River (DWR 2010, Appendix A, Figure 7).The lower Tuolumne River has an estimated channel capacity of approximately 15,000 cfs, which is also the design channel capacity for the entire river (Figure 6-3; Table 6-3).

Table 6-4 shows that the action stage for the Tuolumne River is 6,600 cfs and that the minor flooding level for the Tuolumne River is 10,400 cfs (NWS undated website). Table 6-5 shows some of the local effects that occur at various discharge levels as well as reservoir flow limits for power generation.

Overbank flow begins at river discharges of 1,100 cfs–3,200 cfs, based on a USFWS flow-overbank inundation evaluation of the Tuolumne River from RM 21.5 (just upstream of the Santa Fe Bridge near the town of Empire) to the La Grange Dam at RM 52 (USFWS 2010) using river channel aerial photographs from various years with river flows of 100–8,400 cfs, and then plotting river acres inundated versus river flow. These "overbank" flows are not flood flows that inundate the entire channel capacity; instead they are flows that inundate the adjacent point bars. The channel capacity for the Tuolumne River is approximately 15,000 cfs (Figure 6-3 and Table 6-3).

There is a greater rate of increase in wetted surface area (approximately width) at flows of 4,000–6,000 cfs (DFG 2010), based on a DFG evaluation of USACE cross sections with increasing flows on the Tuolumne River. This increasing area suggests that meander bar and floodplain inundation begins and increases within this flow range although additional work is needed to refine this preliminary observation.

Recent floods were recorded in the region and on the Tuolumne River in 1983, 1986, 1995, 1997, and 2006 (USACE 1999; Parrett and Hunrichs 2006). Generally these flood flows were contained by the channel and adjacent floodplain within the floodway (USACE 1999). However, the 1997 flood resulted in bank overtopping near Modesto, Waterford, La Grange, and Roberts Ferry (USACE 1999). The 100-year floodplain is reflected in the channel reach descriptions in Table 6-7 (USACE 1999, Figure 6-2f and 6-2g).

Table 6-7. Tuolumne River Channel Reaches

Reach	1	2	3	4	5	6	7
River Mile	0.0–10.5	10.5–19.3	19.3–24.0	24.0–34.2	34.2–40.3	20.3–46.6	46.6–52.0
Gradient	<0.0003	<0.0003	<0.0003	<0.0003 – 0.0015	0.0010 – 0.0015	0.0010 – 0.0015	0.0010 – 0.0015
Description	Sand-Bedded	Sand-Bedded	Sand-Bedded	Gravel-Bedded	Gravel-Bedded	Gravel-Bedded	Gravel-Bedded
	Agricultural encroachment. No valley confinement during high flow.	Agricultural and urban encroachment. Moderate valley confinement. City of Modesto is in reach center. Dry Creek enters about midway.	Agricultural and rural encroachment. Low valley confinement. Upstream end is transition to gravel-bedded channel.	In-channel gravel mining occurs with dike encroachments. Agricultural encroachment. Low valley confinement downstream of Waterford.	Extensive off-channel gravel mining pits. Dikes to isolate pits from river. Agricultural encroachment. Low valley confinement.	Remnant gold dredge tailings on floodplain. Fragmented channel with multiple backwaters. Low valley confinement during high flow.	Highest salmon spawning use. Agricultural land use. Low valley confinement during high flow. Single thread meandering low water channel with low bankfull confinement.

Source: McBain & Trush, Inc. 2000.

Merced River

Similar to other Sierra Nevada tributaries, the Merced River transitions from steeper, gravel-bedded reaches affected by gold dredging and aggregate mining, to areas where various activities have encroached on the stream channel, and then to a lower gradient sand-bedded reach. The lower and upper reaches have gradients of approximately 0.00002 to 0.0023, respectively, and the lowermost channel is sand-bedded (USACE 2002). Figure 6-4 shows the Merced River longitudinal profile, and Table 6-8 describes the five channel reach divisions (Stillwater Sciences 2001). These channel reach divisions are based on characteristics of the river channel and floodplain morphology as well as alterations to the river channel and floodplain.

Gravel transport (bed mobilization) in the upper dredger tailings reach was estimated to occur when flow conditions were greater than 4,800 cfs (Stillwater Sciences, 2001) which was similar to values in Kondolf et al. (1996) for similar sized material. Stillwater Sciences (2004) reports localized and short distance gravel movement (tens of feet) at flows of 1,870 cfs. Recent observations of gravel sediment movement in a restoration reach just above RM 43 (below Snelling , RM 48) show movement at similar discharges.

Harrison et al. (2011) measured discharge, flow characteristics and channel characteristics including changes in bed topography as an indicator of gravel mobility. They found that most of the gravel movement was in the upper 2,625 feet of the 6,645 foot restoration reach. This gravel movement primarily occurred at higher discharges of 4,255 cfs–5,015 cfs. Albertson et al. (2011) estimated more gravel mobility at lower discharges but that mobility does not reflect the observed gravel movement in the restoration reach (Harrison et al. 2011). Figure 2-6 (*Monthly Unimpaired and Historical Merced River Flows February–June*) shows that in water year 2000–water year 2009, flows of this level were reached in water years 2000, 2005, and 2006.

Bank erosion has decreased throughout the Merced River because of reduced peak flows and because of bank protection. About four percent of the channel banks show evidence of erosion, and these tend to alternate with bank protection sites (Stillwater Sciences 2001, Table 12). However, Harrison et al. (2011) evaluated ten meander bends in a restoration reach just above RM 43 and reported average bank erosion rates of 2.3 feet–8.5 feet per year for the periods of peak flow (water years 2005 and 2006). This bank erosion along the restored channel occurred in the broad dredger tailings area (Figure 6-4, Reach 5) and this bank-floodplain area was specifically anticipated to allow such bank erosion-channel migration.

Private levees locally reduce floodplain width in reaches 3 and 4, and reach 2 has levees along approximately 60 percent of its length (Stillwater Sciences 2001; DWR 2010, 2011). The Merced River has a channel capacity of approximately 6,000 cfs (Figure 6-3; Table 6-3; Stillwater Sciences 2001).

Table 6-4 shows that the action stage for the Merced River is 3,200 cfs, and that the minor flooding level for the Merced River is 6,900 cfs (NWS undated website). Table 6-5 shows the reservoir flow limits for power generation. DFG (2010) evaluated USACE cross sections and estimated the wetted surface area (approximately width) with increasing flows on the Merced River. Their analysis shows a greater rate of increase in wetted surface area at flows of 3,000–5,000 cfs. This increasing area suggests that meander bar and floodplain inundation begins and increases within this flow range although additional work is needed to refine this preliminary observation.

Recent floods were recorded in the region, with high flows on the Merced River in 1983, 1986, 1995, 1997, 2005, and 2006 (USACE 1999; Parrett and Hunrichs 2006; Albertson et al. 2011; Harrison et al. 2011). These flood flows were contained by the channel and adjacent floodplain within the floodway (USACE 1999). The 100-year floodplain is reflected in the channel reach descriptions in Table 6-8 (USACE 1999, Figures 6-2f and 6-2g).

Table 6-8. Merced River Channel Reaches

Reach	1	2	3	4	5
River Mile (RM)	0.0–8.0	8.0–26.8	26.8–32.5	32.5–45.2	45.2–52.0
Gradient	0.0002	0.0003	0.0008	0.0015	0.0023
Description	Confluence Reach	Encroached Reach	Gravel Mining Reach 2	Gravel Mining Reach 2	Dredger Tailings Reach
	Reach entirely sand bedded and subject to backwater effects from SJR. Some meanders are armored, others not.	Channel bed transitions from gravel to sand. The transition zone extends from RM 25.5 to 16.5. Agricultural development on former floodplain confines the river area between private levees. Channel migration eliminated and channel simplified.	Reach includes Dry Creek confluence. Channel bed of sand, gravel, and cobble. Channel is incised up to 5 feet. Aggregate mining in channel and on floodplain. Dry Creek contributes large amount of sand.	Cobble and gravel bedded but subsurface contains significant sand. Channel converted to single-thread channel with floodplain sloughs converted to irrigation ditches and drains. Some remnant off-channel meander channel features remain.	Channel and floodplain dredged for gold. Adjacent floodplain raised by dredge piles. Channel converted from complex multi-thread channel to single channel. Agricultural development on floodplain.

Source: Stillwater Sciences 2001.

6.3 Regulatory Setting

6.3.1 Federal

Relevant federal programs, policies, plans, or regulations related to flood control and geomorphic conditions are described below.

National Flood Insurance Program

The National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973 were intended to reduce the need for large, publicly funded flood control structures and disaster relief by restricting development on floodplains. The Federal Emergency Management Agency (FEMA) administers the National Flood Insurance Program (NFIP) to subsidize flood insurance to communities that comply with FEMA regulations limiting development in floodplains. FEMA issues Flood Insurance Rate Maps (FIRMs) for communities participating in the NFIP. These maps delineate flood hazard zones in the community. The maps designate lands likely to be inundated during a 100-year storm event and elevations of the base flood. They also depict areas between the limits affected by 100-year and 500-year events and areas of minimal flooding.

Requirements for Federal Emergency Management Agency Certification

Communities use and must abide by FEMA guidelines, as defined in 44 Code of Federal Regulations (CFR) 59–77. For FEMA to recognize a levee under the NFIP, the community must provide evidence demonstrating that adequate design and operation and maintenance systems are in place to provide reasonable assurance that protection from the base flood (1 percent or 100-year flood) exists. These specific requirements are outlined in 44 CFR Section 65.10, Mapping of Areas Protected by Levee Systems, and include requirements for levee height, closures, embankment protection, embankment foundation and stability, settlement, interior drainage, and operation and maintenance plans.

U.S. Army Corps of Engineers Levee Design Criteria

A majority of the levees included in the area affected by the alternatives are federally authorized and fall within the jurisdiction of USACE. The levee evaluation for the area affected by the alternatives conforms to the engineering criteria established by USACE for the assessment and repair of levees. The USACE provides technical criteria for issues such as overtopping of flood control levees and floodwalls, structural designs for closure structures for local flood protection projects, and design guidance on levees and conduits, culverts, and pipes.

U.S. Army Corps of Engineers Levee Safety Program

In 2006, the USACE implemented a new Levee Safety Program with a more comprehensive and rigorous levee inspection process to aid in communicating to local sponsors and the public the overall condition of levee systems and to recommend actions to reduce flood risk. The USACE Rehabilitation and Inspection Program provides for rehabilitation and/or repair of certain eligible (active status) levees that are damaged during flood events. This authority covers post flood repair of both federally authorized and/or constructed and non-federally constructed flood control works. Inspections of federal levees are funded and conducted under the Inspection of Completed Works (ICW) program. Inspection of non-federal levees are funded and conducted under the Rehabilitation and Inspection Program. As the subject levees in the LSJR and lowermost Stanislaus River are classified as federal levees, inspections are funded and conducted under the ICW program.

6.3.2 State

Relevant state programs, policies, plans, or regulations related to flood control and geomorphic conditions are described below.

Central Valley Flood Protection Board

The California Central Valley Flood Protection Board (CVFPB) (formerly the California Reclamation Board) provides flood management for the Central Valley, including the Sacramento River and SJR and their tributaries. The CVFPB has established standards that apply to encroachments and work that affect authorized flood control projects, floodways, and any adopted plan of flood control (23 Cal. Code Regs., §§ 111–138).

Central Valley Flood Protection Plan

The Central Valley Flood Protection Act of 2008 requires the DWR to prepare, and the CVFPB to adopt, the Central Valley Flood Protection Plan by 2012. The plan is intended to provide a system-wide approach to protecting areas currently protected by facilities of the State Plan of Flood Control. With 24 months of the plan's adoption, cities and counties within the Sacramento–San Joaquin Valley must update their general plans and zoning ordinances to include information in the plan, and goals and measures consistent with the plan, to reduce the risk of flood damage.

Safe, Clean, Reliable Water Supply Act

This act declares that among the basic goals of the state are to protect the integrity of the state's water supply system from catastrophic failure attributable to earthquakes and flooding.

6.3.3 Regional or Local

Local policies relevant to flood control and geomorphic condition within the three eastside tributaries, LSJR, and the Delta result from implementation of or compliance with federal and state requirements.

6.4 Impact Analysis

This section lists the thresholds used to define impacts related to flooding, sediment, and erosion. It describes the methods of analysis and the approach to determine the significance of impacts on flooding, sediment, and erosion. It also identifies impacts that are not evaluated further in the impact discussion. The impact discussion describes the changes to baseline resulting from the alternatives and incorporates the thresholds for determining whether those changes are significant. Measures to mitigate (i.e., avoid, minimize, rectify, reduce, eliminate, or compensate for) significant impacts accompany the impact discussion, where appropriate.

6.4.1 Thresholds of Significance

The thresholds for determining the significance of impacts for this analysis are based on the State Water Board's Environmental Checklist in Appendix A of the Board's CEQA regulations (23 Cal. Code Regs., §§ 3720–3781) and the Environmental Checklist in Appendix G of the State CEQA Guidelines. The thresholds derived from the checklist(s) have been modified, as appropriate, to meet the circumstances of the alternatives. (Cal. Code Regs., tit. 23, § 3777, subd. (a)(2).) Flooding, sediment, and erosion impacts were determined to be potentially significant (see Appendix B, *State Water Board's Environmental Checklist* in this SED) and, therefore, are discussed in the analysis. Impacts would be significant if the LSJR alternatives result in any of the following conditions.

- Substantially alter the existing drainage pattern, including alteration of the course of a stream or river, in a manner that would result in substantial erosion or siltation on or offsite.

- Substantially alter the existing drainage, including the alteration of the course of a stream or river, or a substantial increase in the rate or amount of surface runoff in a manner that would result in flooding on or offsite.

As described in Appendix B, *State Water Board's Environmental Checklist,* the LSJR and SDWQ alternatives would result in either no impact or less-than-significant impacts on the following related to flooding, sediment, and erosion, and, therefore, are not discussed within this chapter.

- Place housing within a 100-year flood hazard area as mapped on a federal Flood Hazard Boundary or Flood Insurance Rate Map or other flood hazard delineation map.
- Place within a 100-year flood hazard area structures that would impede or redirect flood flows.
- Expose people or structures to a significant risk of loss, injury or death involving flooding, including flooding as a result of the failure of a levee or dam.
- Be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in on or offsite landslide, lateral spreading, subsidence, liquefaction or collapse.
- Result in substantial soil erosion or the loss of topsoil.

In addition, as described in Appendix B, *State Water Board's Environmental Checklist,* the alternatives would result in either no impact or less-than-significant impacts in the following categories related to geology and soils, and, therefore, the following areas are not discussed within this chapter.

- Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving: rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault; strong seismic ground shaking; seismic-related ground failure, including liquefaction; or landslides.
- Be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial risks to life or property.
- Have soils incapable of adequately supporting the use of septic tanks or alternative waste water disposal systems where sewers are not available for the disposal of waste water.
- Inundation by seiche, tsunami, or mudflow.

6.4.2 Methods and Approach

LSJR Alternatives

The impact mechanisms under LSJR Alternatives 2, 3, and 4 for causing flooding, sediment transport, or erosion include (1) increasing flows such that they cause substantial bank erosion or sediment transport, and (2) increasing flows such that they exceed channel capacities.

The impact analysis uses results from the State Water Board's Water Supply Effects (WSE) model for flows (presented in Chapter 5, *Water Supply, Surface Hydrology, and Water Quality,* and Appendix F.1, *Hydrologic and Water Quality Modeling*, to qualitatively discuss if the LSJR alternatives would result in direct or indirect flooding, sediment transport, or erosion. The information presented below is based on the unimpaired flow estimates from water years 1999–2008. This time frame provides a representative range of flows (Chapter 5 and Appendix F.1). The modeling results are compared to the modeled baseline. The baseline information is based on the most recent available information regarding flooding, sediment, and erosion along the three eastside tributaries and the LSJR. The results of the modeling for water years 1999–2008 are presented below in the second column of Tables 6-9, 6-10, and 6-11. The impact assessment addresses the changes in flows compared to channel capacities (as identified in Table 6-3 with the comparison by alternative shown in Tables 6-9, 6-10, and 6-11) and inundation of the floodway along the eastside tributaries (Table 6-4), the LSJR, and southern Delta. This information is used to determine if flows under the alternatives would cause flooding, sediment transport, or erosion. Flooding is considered to occur at discharges greater than the channel capacities (Table 6-3), since flows greater than these would inundate areas outside the levees or floodway (DWR 2010, 2011, 2012). As described in Chapter 3, *Alternatives Description*, the percent of unimpaired flow requirement, as specified by a particular LSJR alternative, would cease to apply during high flows or flooding to preserve public health and safety. The State Water Board would coordinate with federal, state and local agencies to determine when it is appropriate to waive the requirements. The NOAA action stage of the rivers, or the point on a rising stream at which some type of mitigation action should be taken in preparation for possible significant hydrologic activity, is a reasonable proxy for the purposes of this SED analysis to describe when the unimpaired flow requirements might be waived as a result of public health and safety concerns. Action stages for each river are identified in Table 6-4. The WSE modeling performed for this chapter, and other chapters, uses monthly flow limits derived from observed flows above which the unimpaired flow requirement no longer applies. These model results are compared to those using the NOAA action stage in Appendix L, *Sensitivity Analyses.* The modeling and incorporation of the limits are also discussed in Appendix F.1.

Table 6-9. Stanislaus River Peak Monthly Flow Estimates and Percent of Channel Capacity by Alternative (Channel Capacity of 8,000 cfs)

Water Year	Peak Monthly Unimpaired Flow	LSJR Alternative 2 / % Channel Capacity	LSJR Alternative 3/ % Channel Capacity	LSJR Alternative 4 / % Channel Capacity
1999	4800	960 / 12	1920 / 24	2880 / 36
2000	3200	640 / 8	1280 / 16	1920 / 24
2001	3600	720 / 9	1440 / 18	2160 / 27
2002	5200	1040 / 13	2080 / 26	3120 / 39
2003	3000	600 / 8	1200 / 15	1800 / 23
2004	8800	1760 / 22	3520 / 44	5280 / 66
2005	8800	1760 / 22	3520 / 44	5280 / 66
2006	2000	400 / 5	800 / 10	1200 / 15
2007	3100	620 / 8	1240 / 16	1860 / 23
2008	4500	900 / 11	1800 / 23	2700 / 34

Note: Channel capacity from Table 6-3.

cfs = cubic feet per second

Table 6-10. Tuolumne River Peak Monthly Flow Estimates and Percent of Channel Capacity by Alternative (Channel Capacity of 15,000 cfs)

Water Year	Peak Monthly Unimpaired Flow	LSJR Alternative 2/ % Channel Capacity	LSJR Alternative 3/ % Channel Capacity	LSJR Alternative 4/ % Channel Capacity
1999	8900	1780 / 12	3560 / 24	5340 / 36
2000	6800	1360 / 9	2720 / 18	4080 / 27
2001	6100	1220 / 8	2440 / 16	3660 / 24
2002	8500	1700 / 11	3400 / 23	5100 / 34
2003	4100	820 / 5	1640 / 11	2460 / 16
2004	13800	2760 / 18	5520 / 37	8280 / 55
2005	13100	2620 / 17	5240 / 35	7860 / 52
2006	4100	820 / 5	1640 / 11	2460 / 16
2007	6000	1200 / 8	2400 / 16	3600 / 24
2008	9100	1820 / 12	3640 / 24	5460 / 36

Notes: Channel capacity from Table 6-3.

For all alternatives, Tuolumne River flows are still substantially below the 10,000 cfs channel capacity through downtown Modesto as indicated by NWS (Table 6-5).

cfs = cubic feet per second

Table 6-11. Merced River Peak Monthly Flow Estimates and Percent of Channel Capacity by Alternative (Channel Capacity of 6,000 cfs)

Water Year	Peak Monthly Unimpaired Flow	LSJR Alternative 2/ % Channel Capacity	LSJR Alternative 3/ % Channel Capacity	LSJR Alternative 4 / % Channel Capacity
1999	4500	900 / 15	1800 / 30	2700 / 45
2000	3600	720 / 12	1440 / 24	2160 / 36
2001	2000	400 / 7	800 / 13	1200 / 20
2002	4400	880 / 15	1760 / 29	2640 / 44
2003	2400	480 / 8	960 / 16	1440 / 24
2004	7700	1540 / 26	3080 / 51	4620 / 77
2005	8000	1600 / 27	3200 / 53	4800 / 80
2006	1900	380 / 6	760 / 13	1140 / 19
2007	3200	640 / 11	1280 / 21	1920 / 32
2008	4800	960 / 16	1920 / 32	2880 / 48

Notes: Channel capacity from Table 6-3.

cfs = cubic feet per second

The Stanislaus River has experienced seepage at flows greater than 1,500 cfs. Therefore, the WSE model was used to calculate the percentage of monthly flows greater than 1,500 cfs under baseline and compared to the LSJR alternatives. Tables 6-12 and 6-13 show that under baseline, flows greater than 1,500 cfs occur at Goodwin and Ripon 16 and 30 percent of the time, respectively, in March, 45 and 56 percent of the time, respectively, in April, and 46 and 50 percent of the time, respectively, in May.

Table 6-12. Percentage of Monthly Flows Greater than 1,500 cfs, Stanislaus River at Goodwin

Month/ Alternative	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual
Baseline	2%	2%	2%	5%	7%	16%	45%	46%	2%	1%	4%	5%	12%
LSJR Alternative 2	2%	2%	4%	7%	11%	7%	1%	6%	5%	7%	7%	6%	6%
LSJR Alternative 3	2%	2%	2%	5%	7%	7%	23%	59%	18%	2%	5%	5%	12%
LSJR Alternative 4	2%	2%	2%	5%	22%	21%	63%	78%	44%	2%	5%	6%	21%

cfs = cubic feet per second

Table 6-13. Percentage of Monthly Flows Greater Than 1,500 cfs, Stanislaus River at Ripon

Month/ Alternative	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Annual
Baseline	4%	2%	2%	6%	7%	30%	56%	50%	11%	2%	5%	6%	15%
LSJR Alternative 2	4%	2%	4%	9%	11%	9%	1%	10%	9%	9%	10%	11%	7%
LSJR Alternative 3	4%	2%	2%	6%	11%	13%	30%	62%	29%	4%	5%	6%	15%
LSJR Alternative 4	4%	2%	2%	6%	23%	27%	70%	84%	52%	4%	5%	6%	24%

cfs = cubic feet per second

Flood Control Operations at the Reservoirs

The same flood control curves and daily operations would be used for actual operations of the three reservoirs under the LSJR alternatives as under the baseline. Although the monthly reservoir operations during the February–June period would be slightly different under the LSJR alternatives, the same end of month flood control storage space would be maintained and the same daily flood-control releases would be made during major rainfall runoff events, with the same downstream maximum flood-control releases. Because the reservoir storages would often be at the monthly flood control levels in many of the years, the same monthly releases would be made. Some of the LSJR alternatives would release more water than the baseline, and the storage would be reduced so that flood-control releases would be delayed and/or reduced. The daily releases could vary between the LSJR alternatives, but the maximum flood-control release would not be increased. Therefore, periodic high flood flows during major storms on each of the three eastside tributaries would be nearly the same as the flood-control releases under baseline. These daily flood-control release flows are not simulated with the monthly reservoir operations model; however Appendix L, *Sensitivity Analyses*, presents an analysis for how the flow limits incorporated into the model compare to the action levels, which are based on daily flows.

SDWQ Alternatives

As discussed in Chapter 5, *Water Supply, Surface Hydrology, and Water Quality*, and Appendix B, *State Water Board's Environmental Checklist*, the baseline water quality in the southern Delta ranges from 0.2 dS/m and 1.2 dS/m during all months of the year. There is a strong relationship between salinity at Vernalis and salinity in the southern Delta, which increases by a maximum of 0.2 dS/m above the Vernalis salinity. Thus, when salinity at Vernalis is at the baseline salinity objective, the salinity in the southern Delta stays between 0.2 dS/m and 1.2 dS/m (based on the historical monthly salinity record). Any change in salinity in the southern Delta as a result of the SDWQ alternatives is expected to be similar to that of historic fluctuations because the salinity objective at Vernalis would be maintained under the SDWQ alternatives. Water quality does not have the ability to affect flooding, sedimentation, or erosion. Consequently, there would be no impact on flooding, erosion, or sedimentation associated with these alternatives. Therefore, they are not discussed further.

6.4.3 Impacts and Mitigation Measures

FLO-1: Substantially alter the existing drainage pattern through the alteration of the course of a stream or river in a manner that would result in substantial erosion or siltation on or offsite

LSJR Alternative 1: No Project

The No Project Alternative would result in implementation of flow objectives identified in the 2006 Bay-Delta Plan. See Chapter 15, *LSJR Alternative 1 and SDWQ Alternative 1 (No Project Alternative)*, for the No Project impact discussion and Appendix D, *Evaluation of LSJR Alternative 1 and SDWQ Alternative 1 (No Project Alternative)*, for the No Project technical analysis.

LSJR Alternative 2: 20% Unimpaired Flow (Less than significant)

For the LSJR and Delta, the flows associated with LSJR Alternative 2, even when cumulated downstream from each of the eastside tributaries, are substantially lower than the channel capacities in these river reaches and the Delta (Table 6-3 and Figure 6-3). Since these channels are capable of carrying much larger flows, no significant impact would occur with respect to sediment transport or bank erosion. Similarly, although there are a variety of levee stability issues identified along the LSJR and Delta (DWR 2010, 2011, 2012), the enhanced flows are not large enough to contribute to levee instability.

Tables 6-9, 6-10, and 6-11 show the expected range of peak flows for the eastside tributaries based on the unimpaired flow estimates for water years 1999–2008 (Figures 2-6, 2-7, and 2-8). These tables also show the percent of channel capacity for each flow based on Table 6-3 and Figure 6-3. The LSJR Alternative 2 flows in the eastside tributaries would be similar to baseline. Additionally, the flow objectives would be waived if flows reached the action stage (Table 6-4) which would further reduce sediment transport and erosion. Varying amounts of bank armoring also occur along the eastside tributaries which further limits the potential bank erosion (McBain and Trush 2000; Kondolf et al. 2001; Stillwater Sciences 2001). Sediment transport and bank erosion in the eastside tributaries would be similar to present rates. Consequently, impacts related to sediment transport or bank erosion would be less than significant.

LSJR Alternative 3: 40% Unimpaired Flow (Less than significant)

For the LSJR and Delta the flows associated LSJR Alternative 3, even when cumulated downstream from each of the eastside tributaries, are substantially lower than the channel capacities in these river reaches and the southern Delta (Table 6-3 and Figure 6-3). This result applies even considering the lower channel capacity estimates from DWR for some reaches (2011, Table 6-3). Since these channels are capable of carrying much larger flows, there would be no significant impact on sediment transport or bank erosion. Similarly, although there are a variety of levee stability issues identified along the LSJR and in the southern Delta (DWR 2010, 2011, 2012) the enhanced flows are not large enough to contribute to levee instability.

Tables 6-9, 6-10 and 6-11 show the percent of channel capacity for each flow based on Table 6-3 and Figure 6-3. The peak LSJR Alternative 3 flows in the eastside tributaries would seldom be sufficient to cause gravel transport in the upper gravel-bedded reaches (i.e., minimum flows in the range of 5,000–8,000 cfs [Stanislaus River], 7,000–9,800 cfs [Tuolumne River], and 4,800 cfs [Merced River]) and some in-stream bank erosion. Additionally, the action stage is lower than the gravel transport flow levels in the Tuolumne River (6,600 cfs) and Merced River (3,200 cfs), which would also limit potential gravel transport. For the Stanislaus River the action stage would allow gravel transport to occur. Varying amounts of bank armoring also occur along the eastside tributaries which further limits the potential bank erosion (McBain and Trush 2000; Kondolf et al. 2001; Stillwater Sciences 2001). Because these levels would only be associated with peak flows, they would generate a relatively small amount of stream bank erosion and the impact would be less than significant. Furthermore, the gravel movement that would likely occur is known to be beneficial for aquatic habitat enhancement (Chapter 7, *Aquatic Resources*; McBain and Trush 2000; Kondolf et al. 2001; Stillwater Sciences 2001, 2004).

In the mid- to lower sand-bedded portions of the eastside tributaries, flows greater than approximately 2,000–3,000 cfs would increase sand movement. Sand movement is generally associated with moderate to peak flows, and these flows would generate a small amount of sand movement, which would be considered less than significant. Furthermore, this movement is known to be a contributing factor to the amount and diversity of aquatic habitat in these reaches and would be considered an enhancement to the aquatic habitat environment. Accordingly, this impact would be less than significant (Chapter 7). The LSJR Alternative 3 enhanced peak flows are always less and generally much less than 53 percent of the channel capacities of the eastside tributaries. This level of flow would not cause excessive bank erosion, and the impact would be less than significant.

LSJR Alternative 4: 60% Unimpaired Flow (Less than significant)

For the LSJR and southern Delta, the flows associated with LSJR Alternative 4 unimpaired flow, even when cumulated downstream from each of the eastside tributaries, are substantially lower than the channel capacities in these river reaches and the southern Delta (Table 6-3 and Figure 6-3). This result applies even considering the lower channel capacity estimates from DWR for some reaches (2011, Table 6-3). Because these channels are capable of carrying much larger flows, significant impacts would not occur with respect to sediment transport or bank erosion. Similarly, although there are a variety of levee stability issues identified along the LSJR and southern Delta (DWR 2010, 2011, 2012), the enhanced flows are not large enough to contribute to levee instability.

Tables 6-9, 6-10 and 6-11 show the percent of channel capacity for each flow based on Table 6-3 and Figure 6-3. The peak flows in the eastside tributaries would occasionally be sufficient to cause gravel transport in the upper gravel-bedded reaches (i.e., minimum flows in the range of 5,000–8,000 cfs

[Stanislaus River], 7,000–9,800 cfs [Tuolumne River] and 4,800 cfs [Merced River]) and some in-stream bank erosion. Additionally, the flood stage action levels are lower than the gravel transport flow levels in the Tuolumne River (6,600 cfs) and Merced River (3,200 cfs) which would also limit potential gravel transport. For the Stanislaus River the action stage would allow gravel transport to occur. Varying amounts of bank armoring also occur along the eastside tributaries which further limits the potential bank erosion (McBain and Trush 2000; Kondolf et al. 2001; Stillwater Sciences 2001). Because these levels would only be associated with peak flows, they would generate a relatively small amount of stream bank erosion and the impact would be less than significant. Furthermore, the gravel movement that would likely occur is known to be beneficial for aquatic habitat enhancement (Chapter 7, *Aquatic Resources*; McBain and Trush 2000; Kondolf et al. 2001; Stillwater Sciences 2001, 2004).

In the mid- to lower sand-bedded portions of the eastside tributaries, flows greater than approximately 2,000–3,000 cfs would increase sand movement. Sand movement is generally associated with moderate to peak flows, and these flows would generate a small amount of sand movement which would be considered less than significant. Furthermore, this movement is known to be a contributing factor to the amount and diversity of aquatic habitat in these reaches and would be considered an enhancement to the aquatic habitat environment. This impact would be less than significant.

FLO-2: Substantially alter the existing drainage pattern through the alteration of the course of a stream or river or substantially increase the rate of surface runoff in a manner that would result in flooding on or offsite

LSJR Alternative 1: No Project

The No Project Alternative would result in implementation of flow objectives identified in the 2006 Bay-Delta Plan. See Chapter 15, *LSJR Alternative 1 and SDWQ Alternative 1 (No Project Alternative)*, for the No Project impact discussion and Appendix D, *Evaluation of LSJR Alternative 1 and SDWQ Alternative 1 (No Project Alternative)*, for the No Project technical analysis.

LSJR Alternative 2: 20% Unimpaired Flow (Less than significant)

For the LSJR, southern Delta, and eastside tributaries, the LSJR Alternative 2 flows are substantially lower than the channel capacities in these river reaches and the southern Delta (Table 6-3 and Figure 6-3, and Tables 6-9, 6-10, and 6-11). Since these channels are capable of carrying much larger flows, these flows would be contained within the existing floodway. Additionally, because the flow objectives would maintain flood storage capacity and would not violate the USACE flood reservation, as described above in Section 6.4.2 there would not be any changes in flood-control releases during major flood events. Under LSJR Alternative 2, monthly average flows for the Stanislaus, Tuolumne, and Merced Rivers and the LSJR (Tables F.1-10l, F.1-10h, F.1-10d, and F.1-10m, respectively) do not vary substantially from the modeled baseline average monthly flows (Tables F.1-9l, F.1-9i, F.1-9d, and F.1-9m, respectively). Additionally, the action stages for the rivers are lower than the channel capacities, which further limit any potential for flooding.

On the Stanislaus River, Tables 6-12 and 6-13 show small increases in flows greater than 1,500 cfs at Goodwin and Ripon. These increases are primarily in the winter (December through February) and in July and August. On an annual basis, flows greater than 1,500 cfs are less than baseline. These variations on the Stanislaus River represent impacts that would be less than significant.

LSJR Alternative 3: 40% Unimpaired Flow (Less than significant)

For the LSJR, Delta and eastside tributaries, the LSJR Alternative 3 flows are substantially lower than the channel capacities in these river reaches and the southern Delta (Table 6-3 and Figure 6-3, and Tables 6-9, 6-10, and 6-11), even when considering the lower channel capacity estimates from DWR for some reaches (2011, Table 6-3). Since these channels are capable of carrying much larger flows, these flows would be contained within the existing floodway, and no significant impact would occur with respect to flooding. Additionally, because the flow objectives would generally maintain baseline storage levels and would maintain the USACE flood reservation, there would not be any changes in flood-control releases during major flood events. Under LSJR Alternative 3, monthly average flows for the Stanislaus, Tuolumne, and Merced Rivers and the LSJR (Tables F.1-11l, F.1-11h, F.1-11d, and F.1-11m, respectively) do not vary substantially from the from the modeled baseline average monthly flows (Tables F.1-9l, F.1-9i, and F.1-9d, and F.1-9m, respectively). Additionally, the action stages for the rivers are lower than the channel capacities, which further limit any potential for flooding.

On the Stanislaus River, for flows greater than 1,500 cfs, Tables 6-12 and 6-13 show a similar early summer trend to those flows experienced under baseline, although the flows are slightly offset, with lower March and April flows, somewhat more May flows, and higher flows extending into June. Furthermore, on an annual basis, these flows are the same as baseline. These variations represent impacts that would be less than significant.

LSJR Alternative 4: 60% Unimpaired Flow (Less than significant)

For the LSJR, southern Delta and eastside tributaries, the LSJR Alternative 4 flows are substantially lower than the channel capacities in these river reaches and the southern Delta (Table 6-3, Figure 6-3, and Tables 6-9, 6-10, and 6-11), even considering the lower channel capacity estimates from DWR for some reaches (2011, Table 6-3). Since these channels are capable of carrying much larger flows, these flows would be contained within the existing floodway, and no significant impact would occur with respect to flooding. Additionally, because the flow objectives would cause minimal changes to storage, and would maintain the USACE flood reservation, there would not be any changes in flood-control releases during major flood events. Under LSJR Alternative 4, monthly average flows for the Stanislaus, Tuolumne, and Merced Rivers and the LSJR (Tables F.1-12l, F.1-12h, F.1-12d, and F.1-12m, respectively) do not vary substantially from the from the modeled baseline average monthly flows (Tables F.1-9l, F.1-9i, and F.1-9d, and F.1-9m, respectively). Additionally, the action stages for the rivers are lower than the channel capacities, which further limit any potential for flooding.

On the Stanislaus River for flows greater than 1,500 cfs, Tables 6-12 and 6-13 show a similar early summer trend to baseline, although slightly offset with similar March flows, higher April and May flows, and higher flows extending into June. On an annual basis, these flows are greater than baseline. These flows changes are a result of both flood releases and the unimpaired flow releases. Higher percentages flows greater than 1,500 cfs are expected to occur from April to July. These flows can cause localized underseepage to adjacent agricultural lands. The associated seepage would not have an effect on erosion because the volume and rate of water expected would not be sufficient to transport sediment or particles. Furthermore, the flows themselves are not sufficient to cause additional erosion (i.e., flows that cause erosion are known to occur above 3,000 or 4,000 cfs). Finally, the flows are not surface inundation flows. Accordingly, impacts would be less than significant.

The impacts associated with underseepage on agricultural production are addressed in Chapter 11, *Agricultural Resources*.

6.5 Cumulative Impacts

6.5.1 Definition

Cumulative impacts are defined in the State CEQA Guidelines (14 Cal. Code Regs., § 15355) as "two or more individual effects which, when considered together, are considerable or which compound or increase other environmental impacts." A cumulative impact occurs from "the change in the environment which results from the incremental impact of the project when added to other closely related past, present, and reasonably foreseeable future projects. Cumulative impacts can result from individually minor but collectively significant projects taking place over a period of time" (14 Cal. Code Regs., § 15355(b)).

Consistent with the State CEQA Guidelines (14 Cal. Code Regs., § 15130(a)), the discussion of cumulative impacts in this chapter focuses on significant and potentially significant cumulative impacts. The State CEQA Guidelines (14 Cal. Code Regs., § 15130(b)) state the following:

> The discussion of cumulative impacts shall reflect the severity of the impacts and their likelihood of occurrence, but the discussion need not provide as great detail as is provided for the effects attributable to the project alone. The discussion should be guided by the standards of practicality and reasonableness, and should focus on the cumulative impact to which the identified other projects contribute rather than the attributes of other projects which do not contribute to the cumulative impact.

6.5.2 Past, Present, and Reasonably Foreseeable Future Projects

Chapter 16, *Cumulative Impact Summary, Growth-Inducting Effects, and Irreversible Commitment of Resources*, includes a list of past, present, and reasonably foreseeable future projects considered for the cumulative analysis.

Present and reasonably foreseeable future projects are projects that are currently under construction, approved for construction, or in final stages of formal planning. These projects were identified by reviewing available information regarding planned projects and are summarized in Chapter 16. Past, present and reasonably foreseeable future projects related to flooding, sediment and erosion are listed in Chapter 16 and include the following.

- Bay-Delta Conservation Plan and Alternative Delta Conveyance Facilities
- Delta Risk Management Strategy
- Dos Rios Ranch
- Federal Energy Regulatory Commission (FERC) Relicensing of the Don Pedro Project (FERC Project No. 2299)
- FERC Relicensing of the Merced River Hydroelectric Project (FERC Project No. 2179)
- FloodSAFE California

- Gravel Mining Reach Floodway Restoration
- Grayson River Ranch Conservation Easement
- Habitat Management Preservation and Restoration Plan for Suisun Marsh
- Habitat Restoration Plan for the Lower Tuolumne River Corridor
- Jensen River Ranch Habitat Enhancement and Public Access Project
- Knights Ferry Floodplain and Side-channel restoration
- Knights Ferry Gravel Replenishment Project, Phase 2
- Levee Repair–Levee Evaluation Program
- Lower San Joaquin Flood Improvement Project
- Lower Sherman Island Wildlife Area (LSIWA) Land Management Plan (LMP)
- Lower Tuolumne River Big Bend Project
- Merced River Ranch Floodplain Restoration
- Merced Storm Water Group (MSWG) Storm Water Management Program
- New Exchequer Spillway Modification
- North Delta Flood Control and Ecosystem Restoration Project
- North-of-the-Delta Offstream Storage Investigation (Sites Reservoir)
- Restoration of the Ruddy Mining Reach
- San Joaquin County, Stockton, and Tracy Stormwater Management Programs
- San Joaquin River Flow Modifications
- South Delta Flood Bypass
- Spawning Gravel Supplementation (Stanislaus County, Tuolumne River)
- Special Run Pools 9 and 10 Reconstruction
- State Plan of Flood Control
- Tuolumne River Restoration Projects including Warner Deardorff Segment – Mining Reach Project No. 3
- Upper San Joaquin River Restoration Program
- Vernalis Adaptive Management Program (VAMP)
- Water Year 2010 Interim Flows Project

6.5.3 Significance Criteria

Two significance criteria must be met for an environmental consequence to have a significant cumulative impact: (1) the effect must make a cumulatively considerable incremental contribution to an overall cumulative impact, and (2) the overall cumulative impact (considering past, present, and reasonably foreseeable future projects) must be significant. (See Cal. Code Regs., tit. 14, §§

15064, 15065, 15130.). The cumulative analysis uses the impact threshold topics discussed in the impact analysis (i.e., result in substantial erosion or siltation or result in flooding).

6.5.4 Mitigation Measures for Significant Cumulative Impacts

As specified by Section 15130 of the State CEQA Guidelines (2012), the analysis of cumulative impacts will examine feasible options for mitigating or avoiding a project's contribution to any significant cumulative effects. With some projects, the only feasible mitigation for cumulative impacts may be the adoption of ordinances or regulations rather than the imposition of conditions on a project-by-project basis. Mitigation measures to reduce an alternative's contribution to significant cumulative effects are presented below where feasible and appropriate.

6.5.5 Cumulative Impact Analysis

Methodology

The cumulative impact methodology considers past, present and reasonably foreseeable actions first and whether they result in significant cumulative impacts. And then determines whether the alternatives would have an incremental contribution to the cumulative effect would not otherwise occur.

Geographic Scope

The geographic area considered is the plan area, but also the larger SJR Basin and projects that impact the flow and channel or levee stability.

Analysis

Cumulatively considerable impacts would not occur as a result of the LSJR alternatives. In all alternatives, flows would remain within existing flood channels and would not result in substantial bank erosion or mobilization of sediment.

The eastside tributaries and LSJR are controlled environments except during the highest flood flows and occasionally when levees are breached (Appendix C,*Technical Report on the Scientific Basis for Alternative San Joaquin River Flow and Southern Delta Salinity Objectives;* McBain and Trush 2002; DWR 2010, 2011, 2012). Dams, irrigation water use, river bank protection and levees maintain the rivers within their banks and reduce sediment transport and channel migration. While revised flows on the Tuolumne and Merced Rivers associated with hydroelectric relicensing (FERC 2011a, 2011b) may increase flows slightly, they would not have significant impacts on floods or sediment transport. The relicensing is focused on the upper gravel-bedded portions of these tributaries. Additionally, any new flows would be coordinated with the flows associated with the enhanced flows of the alternatives and they would not be substantially different from those analyzed above. Consequently, no additional cumulative impacts would occur with respect to flooding and sediment transport on the eastside tributaries.

The physical salmon habitat restoration activities that are ongoing on the eastside tributaries are also focused on the upper gravel-dominated reaches, especially where past in-channel and channel-adjacent gravel mining has simplified the channel and reduced gravel transport. The restoration activities include producing sinuous reaches similar to natural channels and adding gravel that can be moved by moderate to high flows. These gravels would move more often, particularly at the higher end of the LSJR alternatives (Tables 6-9, 6-10, and 6-11). However, the amount of gravel (upper reaches) and sand (mid- to lower reaches) movement and bank erosion would not be any greater than analyzed in Section 6.4 and there would not be a significant cumulative impact.

Similarly, the restoration flows on the SJR below Friant Dam combined with the enhanced flows on the three eastside tributaries would still be well below the channel capacities along the LSJR and in the southern Delta (Figure 6-3). Consequently, these combined flows would not significantly impact flood flows, channel stability, or levees even if expected levee improvements do not occur (DWR 2012). Consequently, there would not be a significant cumulative impact on the LSJR or Delta.

As the levee improvements described in the Central Valley Flood Protection Plan (DWR 2012) and other plans are implemented, the potential for levee instability or flooding would be further reduced. Consequently, no significant cumulative impacts would occur on the LSJR, Delta, or the lower portions of the Stanislaus and Merced Rivers where the levee improvements would be implemented.

LSJR Alternatives 2, 3, and 4 would not result in significant impacts on flooding, erosion, or sedimentation. Therefore, the incremental contribution of LSJR Alternatives 2, 3, and 4 would not be cumulatively considerable, and impacts would be less than significant.

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