Chapter 6
Flooding, Sediment, and Erosion

6.1 Introduction

This chapter describes the environmental setting for flooding, sediment (including gravel, sand, and silt), and erosion and the regulatory background 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, the significance of any impacts, and, if applicable, proposes mitigation measures that would reduce significant impacts.

As described in Chapter 1, *Introduction*, the plan area generally includes those portions of the San Joaquin River (SJR) Basin that divert water from or otherwise support beneficial use (e.g., surface water supplies) from the three eastside tributaries[1] of the 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 its confluence with the Merced River and downstream to Vernalis (i.e., LSJR). The flow in the three eastside tributaries is primarily controlled by the three rim dams[2]; consequently, in this chapter, the rivers are only evaluated below these dams.

The extended plan area, also described in Chapter 1, *Introduction,* generally includes the area upstream of the rim dams. The area of potential effects for this area is similar to that of the plan area and includes the zone of fluctuation around the numerous reservoirs that store water on the Stanislaus and Tuolumne Rivers. (Merced River does not have substantial upstream reservoirs that would be affected.) It also includes the upper reaches of the Stanislaus, Tuolumne, and Merced Rivers. Unless otherwise noted, all discussion in this chapter refers to the plan area. Where appropriate, the extended plan area is specifically identified.

In Appendix B, *State Water Board's Environmental Checklist*, the State Water Board determined whether the plan amendment would cause any adverse impact for each environmental category in the checklist and provided a brief explanation for its determination. Impacts that are listed as "Potentially Significant Impacts" are discussed in detail in this chapter. Appendix B, Section IX, identified the LSJR alternatives as having a potentially significant impact by (1) substantially altering the existing drainage pattern, including through the alteration of the course of a stream or river, in a manner that would result in substantial erosion or siltation on- or off-site, and (2) substantially altering the existing drainage pattern, including through the alteration of the course of a stream or river, or substantially increasing the rate or amount of surface runoff in a manner that would result in flooding on- or offsite. In addition, whether or not people or structures

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

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

are exposed to a significant risk of loss, injury or death involving flooding is addressed. Accordingly, this chapter evaluates these potential impacts of the LSJR alternatives on the alteration of the existing streams or rivers in the plan area. Impacts were assessed using results from the State Water Board's Water Supply Effects (WSE) monthly model to compare the changes in flows to channel capacities for each alternative and, specifically, to assess how frequently the channel capacities were exceeded, which could result in flooding, sediment, and erosion.

Table 6-1 summarizes the potential impacts of the LSJR alternatives. As described in Chapter 3, *Alternatives Description*, LSJR Alternatives 2, 3, and 4 each include four methods of adaptive implementation. The substitute environmental document (SED) provides an analysis with and without adaptive implementation because the frequency, duration, and extent to which each adaptive implementation method would be used, if at all, within a year or between years under each LSJR alternative is unknown. The analysis, therefore, discloses the full range of impacts that could occur under an LSJR alternative, from no adaptive implementation to full adaptive implementation. As such, Table 6-1 summarizes impact determinations with and without adaptive implementation.

Any change in salinity in the southern Delta as a result of southern Delta water quality (SDWQ) Alternatives 2 or 3 is expected to be similar to that of the historic range of salinity because Vernalis water quality would be maintained under the SDWQ alternatives through the program of implementation. Furthermore, change in water quality does not affect flooding, sedimentation, or erosion. Therefore, the SDWQ alternatives are not discussed in this chapter. To comply with specific water quality objectives or the program of implementation under SDWQ Alternatives 2 or 3, construction and operation of different facilities in the southern Delta could occur, which could involve impacts on flooding, sediment, and erosion. These impacts are evaluated in Chapter 16, *Evaluation of Other Indirect and Additional Actions.*

Impacts related to the No Project Alternative (LSJR Alternative 1 and SDWQ Alternative 1) are presented in Chapter 15, *No Project Alternative (LSJR Alternative 1 and SDWQ Alternative 1),* and the supporting technical analysis is presented in Appendix D, *Evaluation of the No Project Alternative (LSJR Alternative 1 and SDWQ Alternative 1).* Chapter 16, *Evaluation of Other Indirect and Additional Actions,* includes discussion of impacts related to actions and methods of compliance.

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

Alternative	Summary of Impact(s)	Impact Determination without Adaptive Implementation	Impact Determination with Adaptive Implementation[a]
Impact FLO-1: Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, in a manner that would result in substantial erosion or siltation on- or off-site			
No Project Alternative (LSJR/SDWQ Alternative 1)	See note.[b]	Less than significant	NA
LSJR Alternative 2	Substantial erosion is caused by high flow events resulting from flood control releases of peak flows. These flows would not increase under LSJR Alternative 2. On average, the occurrence of monthly flows greater than	Less than significant	Less than significant

Alternative	Summary of Impact(s)	Impact Determination without Adaptive Implementation	Impact Determination with Adaptive Implementation[a]
	1,500 cfs on the Stanislaus River would be similar to baseline and would not influence stream bank erosion. Therefore, substantial alterations of the existing drainage patterns would not occur and would not result in an increase in substantial erosion or siltation.		
LSJR Alternative 3	Very occasional gravel transport and bank erosion would occur in the upper gravel-bedded reaches of the three eastside tributaries. The amount of bank erosion is limited by flood stage action levels, which is the river stage at which actions are presumed to occur to reduce flood risk, and existing bank armoring. Flows greater than 1,500 cfs on the Stanislaus River would occur with greater frequency than baseline, particularly during April to June; however, these flows are not sufficiently high to increase stream bank erosion. Therefore, substantial alterations of the existing drainage patterns would not occur and would not result in an increase in substantial erosion or siltation.	Less than significant	Less than significant
LSJR Alternative 4	Similar to Alternative 3, there would be occasional gravel transport and bank erosion in the upper gravel-bedded reaches of the three eastside tributaries. The amount of bank erosion is limited by the action stage, which is the river stage at which actions are presumed to occur to reduce flood risk, and existing bank armoring. Flows greater than 1,500 cfs on Stanislaus River would occur with greater frequency than baseline, particularly during April to June; however, these flows are not sufficiently high to increase stream bank erosion. Therefore, substantial alterations of the existing drainage patterns would not occur and would not result in an increase in substantial erosion or siltation.	Less than significant	Less than significant
Impact FLO-2: Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, or substantially increase the rate or amount of surface runoff in a manner that would result in flooding on- or offsite			
No Project Alternative (LSJR/SDWQ Alternative 1)	See note.[b]	Less than significant	NA

Alternative	Summary of Impact(s)	Impact Determination without Adaptive Implementation	Impact Determination with Adaptive Implementation[a]
LSJR Alternative 2	Controlled reservoir releases would be much lower than channel capacities and no significant flooding would occur outside of floodway. LSJR Alternative 2 would not change reservoir flood storage capacity and would not violate USACE flood reservation so there would be no changes in flood control operation procedures during major flood events. Therefore, substantial alterations of the existing drainage patterns would not occur and would not result in flooding. Consequently, people or structures would not be exposed to a significant risk of loss, injury or death involving flooding.	Less than significant	Less than significant
LSJR Alternative 3	Similar to Alternative 2 with respect to flood control operations. Substantial alterations of the existing drainage patterns would not occur and would not result in flooding. Consequently, people or structures would not be exposed to a significant risk of loss, injury or death involving flooding.	Less than significant	Less than significant
LSJR Alternative 4	Similar to Alternative 2, with respect to flood control operations. Substantial alterations of the existing drainage patterns would not occur and would not result in flooding. Consequently, people or structures would not be exposed to a significant risk of loss, injury or death involving flooding.	Less than significant	Less than significant

cfs = cubic feet per second

[a] Four adaptive implementation methods could occur under the LSJR alternatives, as described in Chapter 3, *Alternatives Description* and summarized in Section 6.4.2, *Methods and Approach*, of this chapter.

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

6.2 Environmental Setting

The information in this section provides context for the impacts evaluation of the LSJR alternatives within the plan area. The LSJR alternatives neither involve ground-disturbing activities nor do they increase the potential for high peak flows that could result in substantial sediment transport of gravels and sands that would cause substantial erosion of stream banks or stream levees. The LSJR alternatives would alter the timing of flows in the three eastside tributaries and the LSJR but would not significantly change peak flow rates or the rates of bank erosion or sedimentation within the plan area. Potential impacts associated with sediment transport that are expected to occur under the

LSJR alternatives in relation to fisheries habitat are discussed in Chapter 7, *Aquatic Biological Resources*. 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 sedimentation, and erosion impacts as described in Sections 6.4.2, *Methods and Approach*, and 6.4.3, *Impacts and Mitigation Measures*, of this chapter.

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 the three eastside tributaries are described in the following sections.

6.2.2 Lower San Joaquin River, Delta, and Tributaries

The LSJR is a very low gradient river throughout the plan area and generally has a meandering pattern. The three eastside tributaries are generally steeper, confined gravel-bedded channels in their upper portion. The reservoirs on the tributaries control and maintain flows in the rivers. They transition to low gradient, sand-bedded meandering channels in their middle to lower reaches. 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 and the Coast Ranges.

Reservoirs

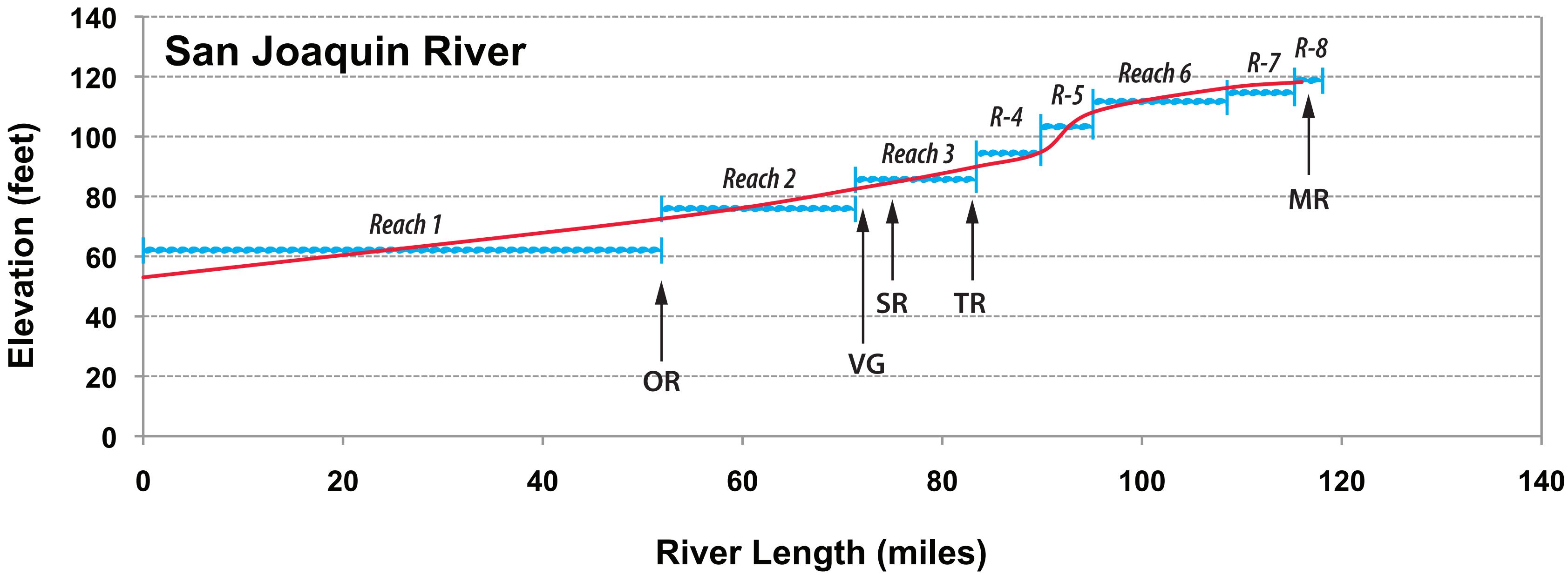
Flood control operations for Lake McClure, New Don Pedro Reservoir, and New Melones Reservoir are developed as part of the Water Control Plans by the USACE Sacramento District, according to national flood control regulations. (33 C.F.R. § 208.11.) Based on hydrologic engineering studies of rainfall and 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 goes 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. If necessary, additional storage space is reserved from the beginning of March to the end of July to prevent 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 (ft) (30-ft 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 divided based on 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).

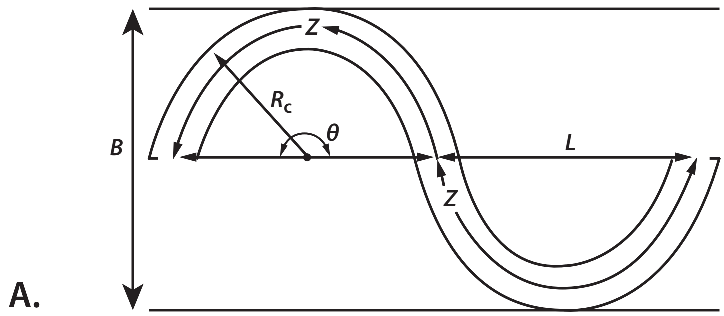
Near the Merced River (LSJR River Mile [RM] 119), the LSJR floodplain becomes narrower because the Valley itself narrows and the Merced River alluvial fan has sufficient sediment deposition to constrain the LSJR's ability to migrate east. At the Merced River confluence, the SJR floodplain narrows from more than 3 miles to less than 1 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 with features shown in Figures 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



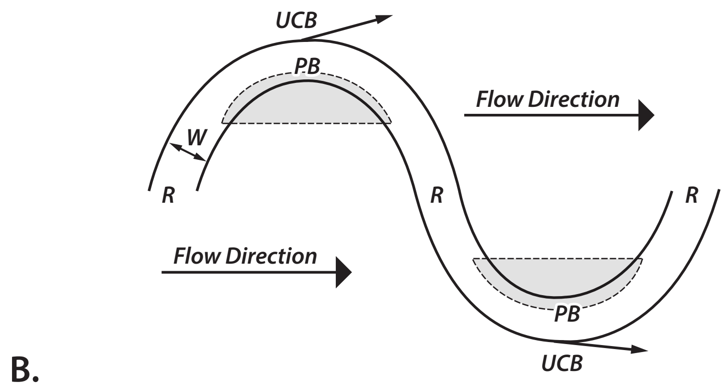
MR Merced River - RM 118
TR Tuolumne River - RM 83
SR Stanislaus River - RM 75
VG Vernalis Gage - RM 72
OR Old River Distributary - RM 53

Figure 6-1
San Joaquin River Longitudinal Profile



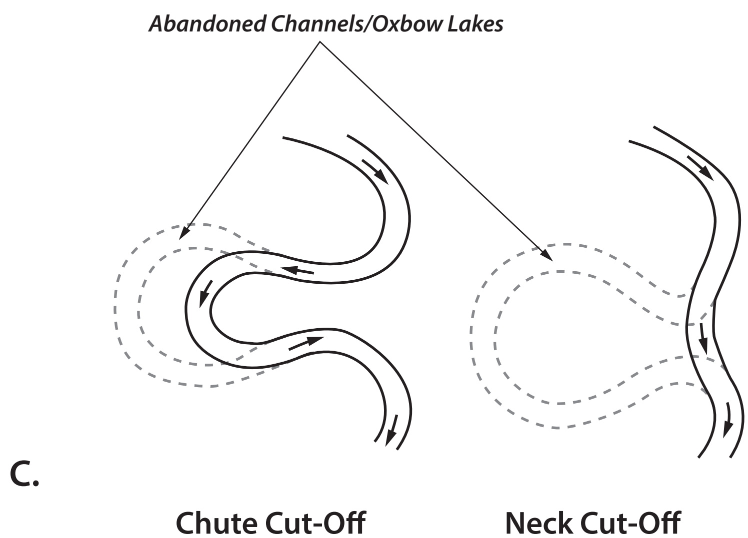
R_c	Bend radius
B	Meander belt width
Z	Riffle spacing
θ	Meander arc angle
L	Wavelength
p	Sinuosity = $\frac{2Z}{L}$

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

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Figure 6-2
Meandering Channel Characteristics

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 magnitude of the flow, bed sediment size, bank erosional resistance and meander geometry. Higher flows, often approaching channel capacity, are required to move larger amounts of coarser sediment. Bank resistance can be influenced 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).

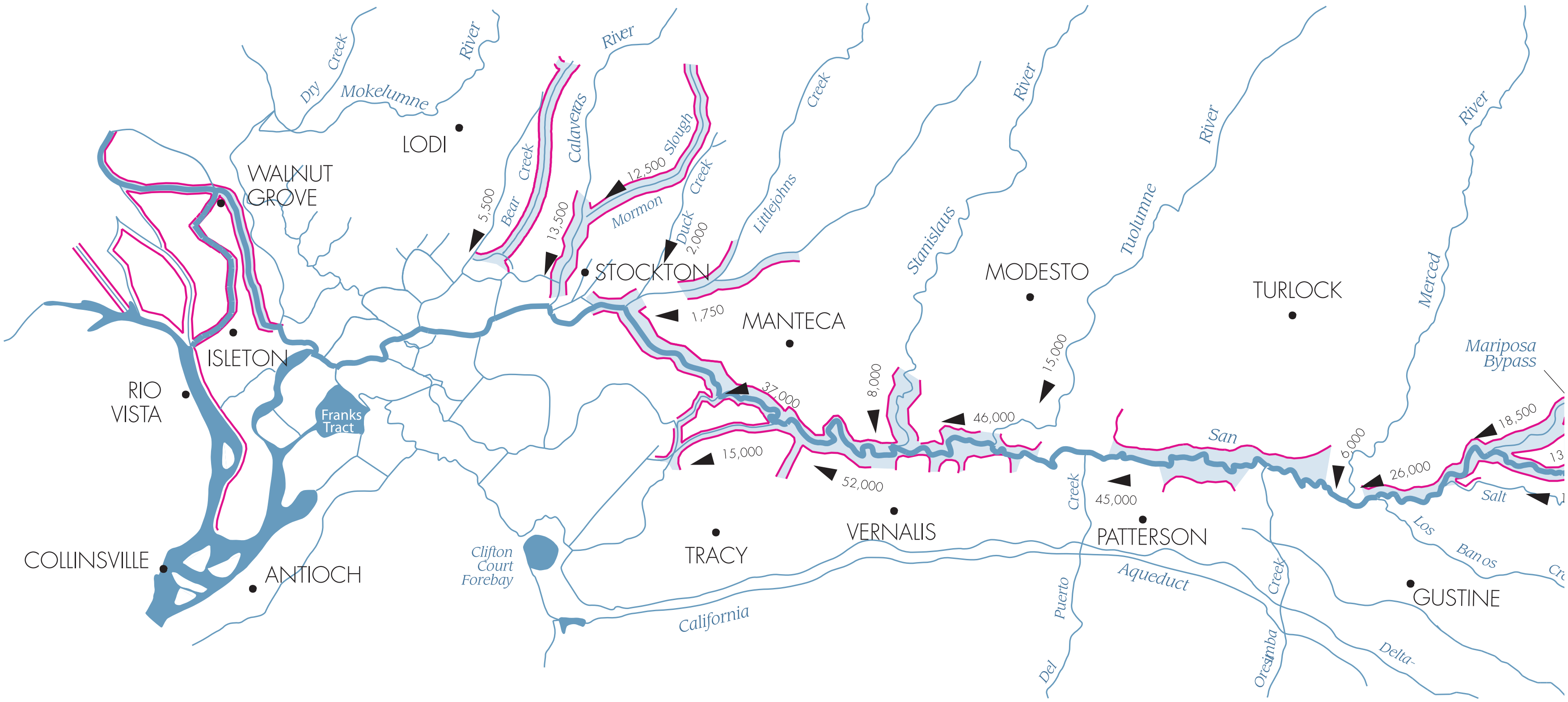
Finer sediment (fine sand, silt, and clay) is transported in suspension and is a major source of water turbidity. The amount of suspended sediment transported at a given time is generally related to discharge; that is, higher discharges can carry larger amounts of suspended sediment (Wright and Schoellhamer 2005; Saleh et al. 2007; Figure 19D for the SJR at Vernalis). However, the amount of fine sediment that a given discharge can possibly carry varies widely. For example, Kratzer and Shelton (1998: Figure 33) show that at 10,000 cfs suspended sediment concentrations in the SJR at Vernalis can vary from approximately 60 to more than 540 milligrams per liter. 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.

Table 6-2. Lower San Joaquin River Channel Reaches

Reach	1	2	3	4	5	6	7	8
River Mile	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 down-stream. 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 2 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 mile 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.
RM = River Mile



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

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Figure 6-3
Channel Capacities and Levees

The LSJR channel capacity increases downstream from an estimated 26,000 cfs just above the Merced River confluence, to a designed capacity of 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, located approximately between the confluences of the Tuolumne and Stanislaus Rivers, 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 n.d.). Action stage is 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 (NWS n.d.). 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.

Table 6-3. River Channel Capacity

River Channel Reach	Estimated Channel Capacity (cfs)[a]	Design Channel Capacity (cfs)[b]	Estimated Current Channel Capacity (cfs)[c]
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[d]
Downstream of Tuolumne Confluence	46,000	46,000	25,000[d]
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[d]
Old River	15,000	No data	No data
Old River to Burns Cutoff	–	18,000	15,000–20,000[d]

cfs = cubic feet per second

[a] Estimated channel capacity is estimated based on general channel characteristics (DWR n.d.).

[b] Design channel capacity is based on engineering design of the channels (DWR 2011).

[c] Current Channel capacity is estimated based on updated information (DWR 2011).

[d] There are potential inadequacies with estimated current channel capacity data and additional evaluation may be required by the agency (DWR 2011).

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

	Action[a] (cfs/feet)[b]	Minor[a] (cfs/feet)	Moderate[a] (cfs/feet)	Major[a] (cfs/feet)
Stanislaus River at	8,500 / 13.0	12,500 / 16.0	22,100 / 21.0	24,000 / 22.0
Orange Blossom Bridge (RM 41)				
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: NWS 2016a, 2016b, 2016c, 2016d.

Note: Data from the NWS Advanced Hydrologic Prediction Service. See "Scale to Flood Categories" dropdown box for flood levels (discharge cfs read from graph).

cfs = cubic feet per second

RM = River Mile

[a] High water level terminology based on the National Oceanic and Atmospheric Administration's National Weather Service Alaska-Pacific River Forecast Center: http://www.weather.gov/aprfc/.

[b] The NWS 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: NWS 2016a, 2016b, 2016c, 2016d.

Note: Data from the NWS Advanced Hydrologic Prediction Service. See “Default Hydrograph” dropdown box for flood categories and flood impacts.

cfs = cubic feet per second

RM = River Mile

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 composite condition (i.e., considering all the evaluated risk factors) 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). Individual rating maps for each assessment criteria are also included (DWR 2011).

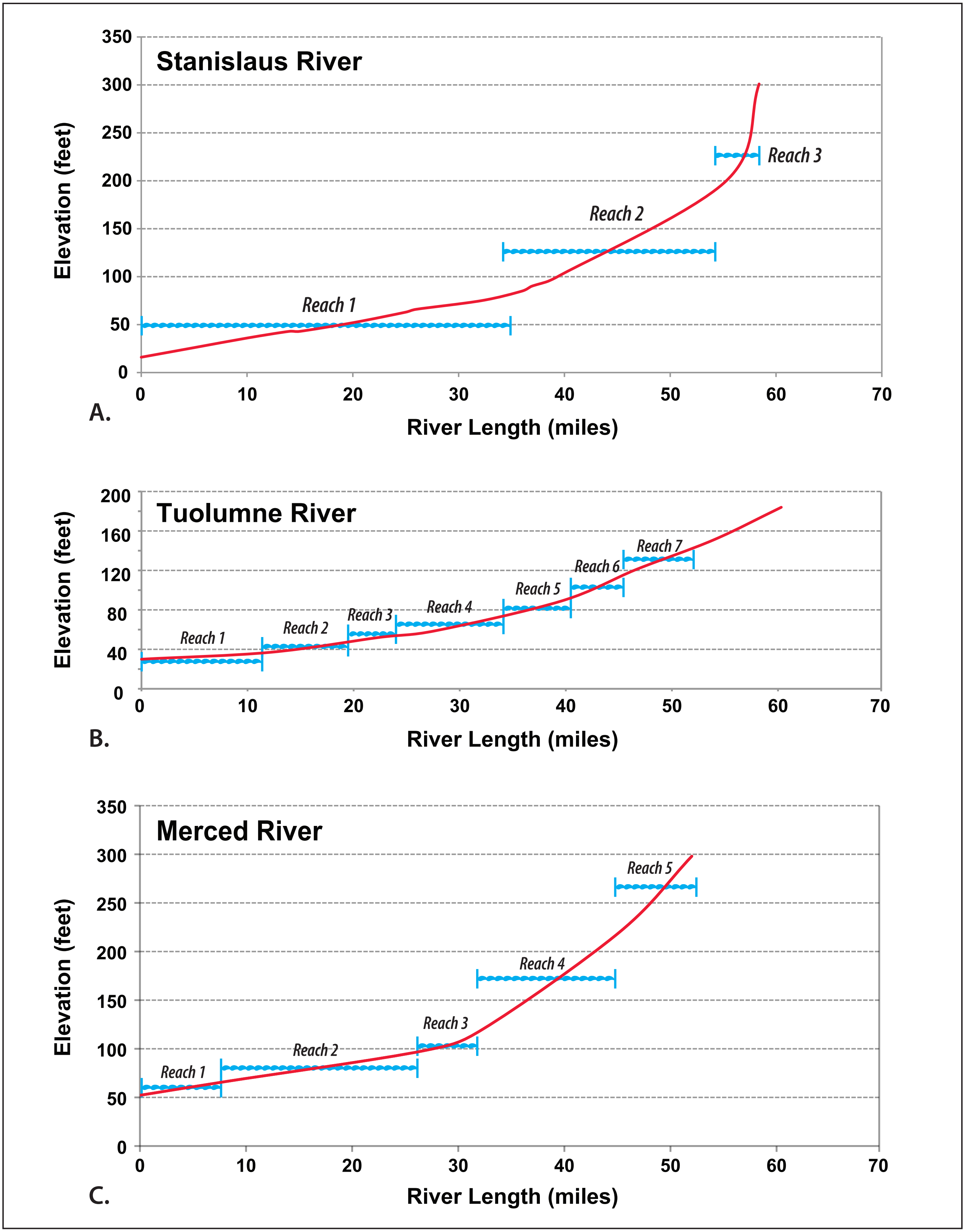
Stanislaus River

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. As its gradient reduces and meandering increases, the channel becomes more sand dominated in this reach. The lower and upper reaches have gradients of approximately 0.0004 to 0.0047, and the lowermost channel is sand-bedded (USACE 2002). Figure 6-4 shows the Stanislaus River longitudinal profile. Table 6-6 describes the three channel reaches, divided based on characteristics of the river channel, floodplain morphology and alterations to the river channel and floodplain (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) reports a post New Melones Dam high flow of 7,350 cfs in 1997. Figure 2-10 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 for the Stanislaus River is 8,500 cfs, and that the minor flooding level for the Stanislaus River is 12,500 cfs (NWS n.d.). Table 6-5 shows some local effects that occur at various discharge levels as well as reservoir flow limits for power generation.



Graphics...00427.11 (8-13-2014)

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

Table 6-6. Stanislaus River Channel Reaches

Reach	1	2	3
River Mile	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
RM = River Mile

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.

The U. S. Fish and Wildlife Service (2012, 2013) is evaluating floodplain fish habitat in relationship to discharge in the Stanislaus River (see detailed discussion in Chapter 19, *Analysis of Benefits to Native Fish Populations from Increased Flow Between February 1 and June 30*, Section 19.3, *Floodplain Inundation*). Current USFWS results indicate that floodplain inundation began at 1,250 cfs in both the Ripon to Jacob Meyers and the Orange Blossom Bridge to Knight's Ferry reaches.

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).

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). Concerns about seepage involve potentially adverse impacts that may occur to agricultural crops such as damage to the root systems of tree crops when the groundwater level rises due to high river flows. NMFS Biological Opinion RPA (NMFS 2011) limits spring pulse flow events to <10 days to reduce potential impacts of seepage to orchard crops. The RPA also includes channel forming and maintenance flows in the 3,000- to 5,000-cfs range in above normal and wet years to maintain spawning and rearing habitat quality. These flows are scheduled to occur after March 1 to protect incubating eggs and provide outmigration flow cues. These flows are high intensity, but limited in duration to avoid potential seepage issues that have been alleged under extended periods of flow greater than 1,500 cfs. New Melones flow releases continue to operate in line with these limits (Clinton pers. comm.); however, flows on the Stanislaus are often above 1,500 cfs. The 1,500 cfs restriction does not apply for flood control releases.

The composite condition for the 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.

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, 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 reaches, divided based on characteristics of the river channel, floodplain morphology and 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 discharges of 7,050 cfs to 9,800 cfs based on observations and calculations presented in McBain and Trush 2000. USFWS (2010) reports a 1995 Tuolumne River flow of 8,400 cfs. Figure 2-9 (*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 n.d.). 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 to 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 floodway capacity; instead they are flows that inundate the adjacent point bars and varying portions of the floodplain (see discussion in Chapter 19, *Analysis of Benefits to Native Fish Populations from Increased Flow Between February 1 and June 30*, Section 19.3, *Floodplain Inundation*). The channel capacity for the Tuolumne River is approximately 15,000 cfs (Figure 6-3 and Table 6-3).

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 Agricultural encroachment. No valley confinement during high flow.	Sand-Bedded Agricultural and urban encroachment. Moderate valley confinement. City of Modesto is in reach center. Dry Creek enters about midway.	Sand-Bedded Agricultural and rural encroachment. Low valley confinement. Upstream end is transition to gravel-bedded channel.	Gravel-Bedded In-channel gravel mining occurs with dike encroachments. Agricultural encroachment. Low valley confinement downstream of Waterford.	Gravel-Bedded Extensive off-channel gravel mining pits. Dikes to isolate pits from river. Agricultural encroachment. Low valley confinement.	Gravel-Bedded Remnant gold dredge tailings on floodplain. Fragmented channel with multiple backwaters. Low valley confinement during high flow.	Gravel-Bedded 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.

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).

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, 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, floodplain morphology and alterations to the river channel and floodplain.

Table 6-8. Merced River Channel Reaches

Reach	1	2	3	4	5
River Mile	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.
RM = River Mile

Gravel transport (or 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 ft) 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 ft of the 6,645-ft 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 2-8 (*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 ft to 8.5 ft 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 designed 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 an estimated 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 n.d.). Table 6-5 shows the reservoir flow limits for power generation. Floodplain inundation on the Merced River is assumed to start at 1,000 cfs (see discussion in Chapter 19, *Analysis of Benefits to Native Fish Populations from Increased Flow Between February 1 and June 30*, Section 19.3, *Floodplain Inundation*).

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).

6.2.3 Extended Plan Area

The Stanislaus, Tuolumne, and Merced rivers originate in the uppermost Sierra Nevada Mountains. The uppermost reaches have been scoured by glaciations so there is abundant exposed bedrock (California Geological Survey 2002). Above the rim dams the rivers generally flow through confined bedrock valleys or steep bedrock gorges (Kondolf et al. 2001; California Geological Survey 2002; Stillwater Sciences 2002). The stream channels are commonly very coarse-grained, especially downstream of dams on the Stanislaus and Tuolumne rivers (e.g., Kondolf et al. 2001). The stream channels also tend to be relatively steep, although the Yosemite Valley floor is very flat (Minear and Wright 2013).

6.3 Regulatory Background

6.3.1 Federal

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

U.S. Army Corps of Engineers Flood Operations

USACE is responsible for prescribing regulations for the use of storage allocated for flood control at certain reservoirs in the plan area. USACE maintains flood operations plans and operating criteria for these reservoirs. Flow criteria are described in Chapter 2, *Water Resources*, in Section 2.4.3, *Flow Requirements*. As described in that section combined Merced River and Dry Creek flows must not exceed 6,000 cfs and Tuolumne River flood control releases cannot exceed 9,000 cfs below Dry Creek. The Stanislaus River cannot exceed 8,000 cfs and the LSJR flow at Vernalis cannot exceed 50,000 cfs.

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 that are within the plan area, 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 and Central Valley Flood Protection Plan

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. (Cal. Code Regs., tit. 23, §§ 111–138.)

The Central Valley Flood Protection Act of 2008 requires the California Department of Water Resources (DWR) to prepare, and the CVFPB to adopt, the Central Valley Flood Protection Plan (CVFPP) by 2012. The plan, which was adopted in June 2012, is intended to provide a system-wide approach to protecting areas currently protected by facilities of the State Plan of Flood Control. The regional and system improvements considered in the CVFPP are intended to address a number of potential physical threats to the existing flood management system. As described in the CVFPP, cities and counties within the Sacramento–San Joaquin Valley must update their general plans and zoning ordinances within 24 months to include information in the plan, and goals and measures consistent with the plan, to reduce the risk of flood damage.

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 identifies the thresholds or significance criteria used to evaluate the potential impacts on flooding, sediment, and erosion. It further describes the methods of analysis used to determine significance. If any significant impacts are identified, measures to mitigate (i.e., avoid, minimize, rectify, reduce, eliminate, or compensate for) them are included in the impact discussion.

6.4.1 Thresholds of Significance

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

- Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, in a manner that would result in substantial erosion or siltation on- or off-site.
- Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, or substantially increase the rate or amount of surface runoff in a manner that would result in flooding on- or off-site.

In addition, if flooding on- or off-site would occur, the analysis identifies if people or structures would be exposed to a significant risk of loss, injury or death involving flooding. Where appropriate, specific quantitative or qualitative criteria are described in Section 6.4.2, *Methods and Approach*, for evaluating these thresholds.

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 result of the failure of dam.
- Inundation by seiche, tsunami, or mudflow.

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.
- 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 an on- or off-site landslide, lateral spreading, subsidence, liquefaction or collapse.
- Result in substantial soil erosion or the loss of topsoil.

6.4.2 Methods and Approach

LSJR Alternatives

This chapter evaluates the potential flooding, sediment, and erosion impacts associated with the LSJR alternatives. Each LSJR alternative includes a February–June unimpaired flow[3] requirement (i.e., 20, 40, or 60 percent) and methods for adaptive implementation to reasonably protect fish and wildlife beneficial uses, as described in Chapter 3, *Alternatives Description*. In addition, a minimum base flow is required at Vernalis at all times during this period. The base flow may be adaptively implemented as described below and in Chapter 3. State Water Board approval is required before any method can be implemented, as described in Appendix K, *Revised Water Quality Control Plan*. All

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

methods may be implemented individually or in combination with other methods, may be applied differently to each tributary, and could be in effect for varying lengths of time, so long as the flows are coordinated to achieve beneficial results in the LSJR related to the protection of fish and wildlife beneficial uses.

The Stanislaus, Tuolumne, and Merced Working Group (STM Working Group) will assist with implementation, monitoring, and assessment activities for the flow objectives and with developing biological goals to help evaluate the effectiveness of the flow requirements and adaptive implementation actions. Further details describing the methods, the STM Working Group, and the approval process are included in Chapter 3 and Appendix K. Without adaptive implementation, flow must be managed such that it tracks the daily unimpaired flow percentage based on a running average of no more than 7 days. The four methods of adaptive implementation are described briefly below.

1. Based on best available scientific information indicating that more flow is needed or less flow is adequate to reasonably protect fish and wildlife beneficial uses, the specified annual February–June minimum unimpaired flow requirement may be increased or decreased to a percentage within the ranges listed below. For LSJR Alternative 2 (20 percent unimpaired flow), the percent of unimpaired flow may be increased to a maximum of 30 percent. For LSJR Alternative 3 (40 percent unimpaired flow), the percent of unimpaired flow may be decreased to a minimum of 30 percent or increased to a maximum of 50 percent. For LSJR Alternative 4 (60 percent unimpaired flow), the percent of unimpaired flow may be decreased to a minimum of 50 percent.

2. Based on best available scientific information indicating a flow pattern different from that which would occur by tracking the unimpaired flow percentage would better protect fish and wildlife beneficial uses, water may be released at varying rates during February–June. The total volume of water released under this adaptive method must be at least equal to the volume of water that would be released by tracking the unimpaired flow percentage from February–June.

3. Based on best available scientific information, release of a portion of the February–June unimpaired flow may be delayed until after June to prevent adverse effects on fisheries, including temperature, which would otherwise result from implementation of the February–June flow requirements. The ability to delay release of flow until after June is only allowed when the unimpaired flow requirement is greater than 30 percent. If the requirement is greater than 30 percent but less than 40 percent, the amount of flow that may be released after June is limited to the portion of the unimpaired flow requirement over 30 percent. For example, if the flow requirement is 35 percent, 5 percent may be released after June. If the requirement is 40 percent or greater, then 25 percent of the total volume of the flow requirement may be released after June. As an example, if the requirement is 50 percent, at least 37.5 percent unimpaired flow must be released in February–June and up to 12.5 percent unimpaired flow may be released after June. If after June the STM Working Group determines that conditions have changed such that water held for release after June should not be released by the fall of that year, the water may be held until the following year. See Chapter 3 and Appendix K for further details.

4. Based on best available scientific information indicating that more flow is needed or less flow is adequate to reasonably protect fish and wildlife beneficial uses, the February–June Vernalis base flow requirement of 1,000 cfs may be modified to a rate between 800 and 1,200 cfs.

The operational changes made using the adaptive implementation methods above may take place on either a short-term (for example monthly or annually) or longer-term basis. Adaptive implementation is intended to optimize flows to achieve the narrative objective, while allowing for consideration of other beneficial uses, provided that these other considerations do not reduce intended benefits to fish and wildlife.

The impact mechanisms for causing sediment transport or erosion and flooding include (1) increasing flows such that they cause substantial additional sediment (gravel and sand) transport or siltation and stream bank erosion (Impact FLO-1), and (2) increasing flows such that they exceed channel capacities and cause flooding outside the levees or floodway (Impact FLO-2). The impact analysis uses results from the State Water Board's WSE monthly model (presented in Chapter 5, *Surface Hydrology and Water Quality*, and Appendix F.1, *Hydrologic and Water Quality Modeling)*, to assess whether the LSJR alternatives would result in flooding, sediment transport, or erosion. Impacts were assessed by comparing the baseline flow results with the results for LSJR Alternatives 2, 3, and 4. The quantitative results included in the figures, tables, and text of this chapter present WSE modeling of the specified unimpaired flow requirement for each LSJR alternative (i.e., 20, 40, or 60 percent). The impact assessment addresses the expected changes in flows for the LSJR alternatives compared to channel capacities (as identified in Table 6-3). The entire set of WSE results for 1922–2003 was used to assess how frequently the channel capacities were exceeded (Table 6-9). Because exceedances were very rare, the wettest years were examined more thoroughly (Tables 6-10, 6-11, and 6-12).

Table 6-9. Percent of Months with WSE Model Results Greater than Capacity

Alternative	Capacity	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Stanislaus River at Ripon													
Baseline	8,000	0.0	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LSJR Alternative 2	8,000	0.0	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LSJR Alternative 3	8,000	0.0	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LSJR Alternative 4	8,000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tuolumne River at Modesto													
Baseline	15,000	0.0	0.0	0.0	1.2	0.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0
LSJR Alternative 2	15,000	0.0	0.0	0.0	1.2	0.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0
LSJR Alternative 3	15,000	0.0	0.0	0.0	1.2	0.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0
LSJR Alternative 4	15,000	0.0	0.0	0.0	1.2	0.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0
Merced River at Stevinson													
Baseline	6,000	0.0	0.0	0.0	1.2	0.0	1.2	0.0	0.0	1.2	0.0	0.0	0.0
LSJR Alternative 2	6,000	0.0	0.0	0.0	1.2	0.0	1.2	0.0	0.0	1.2	0.0	0.0	0.0
LSJR Alternative 3	6,000	0.0	0.0	0.0	1.2	0.0	1.2	0.0	0.0	1.2	0.0	0.0	0.0
LSJR Alternative 4	6,000	0.0	0.0	0.0	1.2	0.0	1.2	0.0	0.0	1.2	0.0	0.0	0.0
San Joaquin River at Vernalis													
Baseline	52,000	0.0	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LSJR Alternative 2	52,000	0.0	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LSJR Alternative 3	52,000	0.0	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LSJR Alternative 4	52,000	0.0	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 6-10. Stanislaus River Peak Monthly Flow and Percent of Channel Capacity by Alternative (Channel Capacity of 8,000 cfs) During Wettest Years

Water Year[a]	Feb–Jun Peak Monthly Unimpaired Flow (cfs)	Baseline Flow (cfs)	Baseline Percent	LSJR Alternative 2 Flow (cfs)	LSJR Alternative 2 Percent	LSJR Alternative 3 Flow (cfs)	LSJR Alternative 3 Percent	LSJR Alternative 4 Flow (cfs)	LSJR Alternative 4 Percent
1938	8,803	1,945	24	2,329	29	3,357	42	5,166	65
1943	5,170	3,456	43	3,456	43	1,826	23	2,819	35
1952	9,595	2,089	26	2,089	26	3,668	46	5,529	69
1956	6,443	1,849	23	1,720	22	2,247	28	3,535	44
1958	9,233	2,023	25	2,023	25	3,481	44	5,329	67
1967	8,243	1,622	20	1,650	21	3,188	40	4,838	60
1969	9,675	2,088	26	2,088	26	3,752	47	5,687	71
1978	6,386	803	10	1,278	16	2,265	28	3,447	43
1980	5,212	2,040	26	2,040	26	2,024	25	2,934	37
1982	7,271	2,993	37	2,993	37	2,766	35	4,222	53
1983	10,627	6,223	78	6,223	78	6,223	78	6,313	79
1984	4,831	5,126	64	5,126	64	5,126	64	5,126	64
1986	9,580	2,960	37	1,916	24	3,832	48	5,747	72
1995	7,878	1,631	20	1,728	22	2,791	35	4,365	55
1997	3,755	10,555	132	10,555	132	10,555	132	6,009	75
1998	8,582	2,214	28	2,214	28	3,035	38	4,752	59

Note: Channel capacity from Table 6-3. Gray cells indicate values above capacity.

cfs = cubic feet per second

[a] These are water years with the highest monthly modeled flow and highest unimpaired annual flow.

Table 6-11. Tuolumne River Peak Monthly Flow and Percent of Channel Capacity by Alternative (Channel Capacity of 15,000 cfs) During Wettest Years

Water Year[a]	Feb–Jun Peak Monthly Unimpaired Flow (cfs)	Baseline		LSJR Alternative 2		LSJR Alternative 3		LSJR Alternative 4	
		Flow (cfs)	Percent	Flow (cfs)	Percent	Flow (cfs)	Percent	Flow (cfs)	Percent
1938	11,959	7,992	53	7,992	53	7,992	53	6,739	45
1943	8,043	6,406	43	6,406	43	6,406	43	6,406	43
1952	12,870	5,055	34	5,055	34	5,055	34	7,127	48
1956	9,778	7,146	48	5,679	38	4,963	33	6,985	47
1958	12,383	6,374	42	6,374	42	5,471	36	6,928	46
1967	12,495	6,352	42	6,352	42	6,352	42	6,843	46
1969	15,617	7,110	47	7,110	47	7,110	47	8,816	59
1978	11,143	4,876	33	5,421	36	4,876	33	5,947	40
1980	9,054	6,927	46	6,927	46	6,927	46	6,510	43
1982	11,272	9,332	62	9,332	62	9,332	62	9,332	62
1983	17,077	16,297	109	16,297	109	16,297	109	16,297	109
1984	8,713	7,479	50	7,479	50	7,479	50	7,479	50
1986	11,100	8,232	55	8,232	55	5,902	39	6,567	44
1995	13,627	9,474	63	9,474	63	9,474	63	8,333	56
1997	8,807	17,925	120	17,925	120	17,925	120	17,925	120
1998	14,368	7,440	50	7,010	47	6,614	44	7,976	53

Note: Channel capacity from Table 6-3. Gray cells indicate values above capacity. For all alternatives, no additional rows would be highlighted if a capacity of 10,000 cfs had been used instead of 15,000 cfs (10,000 cfs is the channel capacity through downtown Modesto as indicated by NWS [Table 6-5]).

cfs = cubic feet per second

[a] These are water years with the highest monthly modeled flow and highest unimpaired annual flow.

Table 6-12. Merced River Peak Monthly Flow and Percent of Channel Capacity by Alternative (Channel Capacity of 6,000 cfs) During Wettest Years

Water Year[a]	Feb–Jun Peak Monthly Unimpaired Flow (cfs)	Baseline		LSJR Alternative 2		LSJR Alternative 3		LSJR Alternative 4	
		Flow (cfs)	Percent	Flow (cfs)	Percent	Flow (cfs)	Percent	Flow (cfs)	Percent
1938	7,431	4,875	81	4,875	81	4,875	81	4,657	78
1943	4,750	3,022	50	3,022	50	3,022	50	3,022	50
1952	7,242	3,524	59	3,524	59	3,524	59	3,626	60
1956	5,181	2,288	38	3,440	57	3,859	64	4,319	72
1958	6,679	3,409	57	3,409	57	3,409	57	3,391	57
1967	7,191	4,079	68	4,079	68	4,079	68	3,807	63
1969	9,194	5,379	90	5,379	90	5,379	90	5,120	85
1978	6,846	3,832	64	3,589	60	3,140	52	3,381	56
1980	4,854	4,472	75	4,472	75	4,472	75	4,474	75
1982	7,206	4,845	81	4,845	81	4,845	81	4,845	81
1983	11,025	7,273	121	7,273	121	7,273	121	6,535	109
1984	4,304	3,495	58	3,495	58	3,495	58	3,495	58
1986	6,520	4,031	67	4,031	67	4,031	67	3,899	65
1995	7,914	5,050	84	5,050	84	5,050	84	4,726	79
1997	4,516	9,859	164	9,859	164	9,859	164	9,859	164
1998	8,038	5,151	86	5,092	85	4,631	77	4,038	67

Note: Channel capacity from Table 6-3. Gray cells indicate values above capacity.
cfs = cubic feet per second
[a] These are water years with the highest monthly modeled flow and highest unimpaired annual flow.

The LSJR alternatives do not involve physical changes to existing drainage patterns of the site or area, such as habitat restoration, dredging, or floodplain restoration, in a manner that would result in substantial erosion or siltation. The LSJR alternatives do not involve physical changes that substantially alter the existing drainage of the site or area, including through the alteration of the course of a stream or river, or substantially increase the rate or amount of surface runoff in a manner that would result in flooding on- or off-site. Accordingly, because the LSJR alternatives do not involve physical changes to the existing drainage or increases in surface runoff, there are no associated impacts and these issues are not addressed further.

This SED also evaluates whether the LSJR alternatives would substantially alter in-channel sediment transport (erosion) in a manner that would result in substantial erosion or siltation (FLO-1). The information in Tables 6-3 and 6-9 through 6-12 is used to determine if flows under the LSJR alternatives would cause excessive sediment transport and erosion. One intent of the LSJR alternatives is to increase within-channel sediment transport to enhance fish habitat, including spawning habitat. Consequently, some increased transport of gravel, sand and silt are likely to occur; the transport amount would be dependent on the expected flow under a specific alternative. Therefore, the analysis evaluates whether the LSJR alternatives are likely to have significant impacts by eroding stream banks and causing channel instability or levee collapse, or by moving so much sediment that excessive sedimentation (gravel and sand) or siltation (silt) is likely to occur (Impact

FLO-1). Excessive sedimentation is large amounts of sediment that contribute to channel instability or bury aquatic habitat.

This SED also evaluates whether the LSJR alternatives would substantially alter in-channel patterns and sediment transport in a manner that would result in flooding on- or off-site (FLO-2). Flooding is considered to occur at discharges greater than the channel capacities (Table 6-3), since flows greater than the channel capacities would inundate areas outside the levees or floodway (DWR 2010, 2011, 2012). As described in Chapter 3, *Alternatives Description*, the specified minimum unimpaired flow requirement for a particular LSJR alternative would cease to apply when flows would exceed levels that would cause or contribute to flooding or other related public safety concerns. The State Water Board would consult with appropriate federal, state and local agencies, including the reservoir operators, USBR, and USACE, in making its determination whether the specified minimum unimpaired flow requirements would apply. The NWS action stage of the rivers, i.e., the point on a rising stream at which some type of action should be taken in preparation for possible significant hydrologic activity (e.g., preventing access to or evacuating low-lying areas adjacent to a river), is a reasonable proxy for the purposes of this SED analysis to describe the flows above which the unimpaired flow requirements may not apply as a result of public safety concerns (Impact FLO-2). Action stages for each river are identified in Table 6-4, and are generally considerably lower than the estimated channel capacity.

This chapter also incorporates a qualitative discussion of adaptive implementation under each of the LSJR alternatives that includes the potential environmental effects associated with adaptive implementation. To inform the qualitative discussion and account for the variability allowed by adaptive implementation, modeling was performed to predict conditions at 30 percent and 50 percent of unimpaired flow (as reported in Appendix F.1). The modeling also allows some inflows to be retained in the reservoirs until after June, as could occur under method 3, to prevent adverse temperature effects. This variety of modeling scenarios provides information to support the analysis and evaluation of the effects of the alternatives and adaptive implementation. This chapter incorporates a qualitative discussion of the potential flooding, sediment, and erosion impacts of adaptive implementation under each of the LSJR alternatives. For more information regarding the modeling methodology and quantitative flow and temperature modeling results, see Appendix F.1, *Hydrologic and Water Quality Modeling*.

The Stanislaus River has experienced seepage in some locations where agricultural production occurs 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 6-13 and 6-14 show that under baseline, flows greater than 1,500 cfs occur at Goodwin and Ripon 27 and 28 percent of the time, respectively, in March; 46 and 52 percent of the time, respectively, in April; and 40 and 43 percent of the time, respectively, in May. This information is used to evaluate effects on stream bank erosion on the Stanislaus River in Impact FLO-1. Note that this seepage has not resulted in surface inundation (flooding). The impacts associated with underseepage on agricultural production are addressed in Chapter 11, *Agricultural Resources*.

Table 6-13. 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	Average Percent
Baseline	1	2	2	6	7	29	43	40	5	1	2	4	11
LSJR Alternative 2	1	2	4	7	10	33	34	33	2	1	5	5	11
LSJR Alternative 3	0	2	2	6	10	26	41	57	13	1	1	2	13
LSJR Alternative 4	0	1	1	4	21	29	65	76	39	1	0	1	19

cfs = cubic feet per second

Table 6-14. 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	Average Percent
Baseline	2	2	2	7	7	29	54	44	17	1	2	4	14
LSJR Alternative 2	2	2	4	7	10	33	50	40	12	1	5	6	14
LSJR Alternative 3	1	2	2	6	13	28	56	65	24	1	1	2	16
LSJR Alternative 4	1	1	1	4	22	29	73	83	51	2	1	1	22

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 rules would apply and the same need for daily flood control releases would apply during major rainfall runoff events. Some of the LSJR alternatives would release more water than the baseline earlier in the year, and the storage would be reduced so that flood control releases that might have occurred under baseline conditions would be delayed and/or reduced. The daily releases could vary between the LSJR alternatives, but in general 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.

Extended Plan Area

The analysis of the extended plan area generally identifies how the impacts may be similar to or different from the impacts in the plan area (i.e., downstream of the rim dams) depending on the similarity of the impact mechanism (e.g., changes in reservoir levels, reduced water diversions, and additional flow in the rivers) or location of potential impacts in the extended plan area. Where appropriate, the program of implementation is discussed to help contextualize the potential impacts in the extended plan area.

SDWQ Alternatives

As discussed in Chapter 5, *Surface Hydrology and Water Quality*, and Appendix B, *State Water Board's Environmental Checklist*, the baseline water quality in the southern Delta generally 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 generally increases by a maximum of 0.2 dS/m above the Vernalis salinity. Seasonal and inter-annual fluctuations in salinity in the southern Delta as a result of SDWQ Alternatives 2 or 3 are expected to be similar to historic fluctuations because the USBR's water rights would continue to be conditioned to meet the existing Vernalis electrical conductivity (EC)[4] requirement in through the program of implementation, thereby maintaining flows. Therefore, they are not discussed further in this chapter. To comply with specific water quality objectives or the program of implementation under SDWQ Alternatives 2 or 3, construction and operation of different facilities in the southern Delta could occur, which could involve impacts on biological resources. These impacts are evaluated in Chapter 16, *Evaluation of Other Indirect and Additional Actions.*

6.4.3 Impacts and Mitigation Measures

Impact FLO-1: Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, in a manner that would result in substantial erosion or siltation on- or off-site

No Project Alternative (LSJR/SDWQ Alternative 1)

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

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

LSJR Alternatives

Sediment (gravel and sand) transport can undermine stream banks or levees, thus potentially altering the existing drainage patterns. The transport of gravel and sand and the effect on stream bank or levee stability typically occur at higher flows generally either near channel capacities or exceeding channel capacities; therefore, they are discussed together in the impact analysis below. Silt materials are more easily transported than gravel and sand and silt transport does not influence stream bank or levee stability. However, excessive silt erosion and transport could alter the existing drainage pattern of a site by causing excessive siltation within fish spawning gravels or elsewhere; therefore, it is discussed separately from gravel and sand transport in the impact analysis below.

LSJR Alternative 2 (Less than significant/Less than significant with adaptive implementation)

Gravel and Sand Erosion

The amount of sediment transport and bank erosion under LSJR Alternative 2 would be similar to existing conditions. Sediment transport and erosion would be restricted by flood control activities, existing action stages, and existing bank armoring on the rivers. Consequently, no significant impact would occur with respect to the amount of sand and gravel transported, or bank erosion. Similarly, although there are identified levee stability issues along the LSJR and within the Delta (DWR 2010, 2011, 2012), the expected amount of gravel and sand transported under LSJR Alternative 2 would not be large enough to contribute to levee instability.

The existing stream channels transport the coarsest sediment at flows near channel capacities or exceeding channel capacities. The flows associated with LSJR Alternative 2, even when cumulated downstream from each of the eastside tributaries, are almost always substantially lower than the channel capacities in these river reaches and the Delta (Table 6-3 and Figure 6-3). Therefore, the amount of coarse sediment transported at higher flows would be limited under LSJR Alternative 2.

The range of flows associated with LSJR Alternative 2 is similar to flows that occur under baseline conditions. Only two of the water years simulated by the WSE model, 1983 and 1997, had monthly flows that exceeded channel capacities on the Stanislaus, Tuolumne, or Merced Rivers or the SJR (Table 6-9). These exceedances, which resulted from large storm events that led to flood control releases, also occurred under baseline conditions. Therefore, the amount of coarse sediment transported at higher flows under LSJR Alternative 2 is expected to be similar to baseline conditions.

Tables 6-10, 6-11, and 6-12 show the monthly peak flows from the WSE modeling results for the three eastside tributaries during the wettest years and the percent of channel capacity for each flow based on Table 6-3 and Figure 6-3. These peak flood control flows are the flows that are most likely to transport coarse sediment and cause substantial erosion. Under LSJR Alternative 2, peak monthly flows in the three eastside tributaries would be similar to baseline peak flows because they result from flood control actions. Therefore, the monthly releases simulated by the WSE model for meeting the unimpaired flow objectives generally equaled or remained below the baseline peak monthly flood control releases and would not transport any more gravel and sand than is currently transported. The cumulative flow additions from the three eastside tributaries to the LSJR are substantially below its channel capacity, which ranges between 37,000 cfs and 52,000 cfs (Figure 6-3; Tables 6-10, 6-11, 6-12). These small flow additions would not increase coarse sediment transport in the LSJR.

The monthly peak flows from the WSE model would not exceed the action stage, which is lower than the channel capacity (Table 6-4), further restricting sediment transport and erosion under LSJR Alternative 2. There may be circumstances in which the specified minimum unimpaired flow requirement would not apply when flows would exceed levels that would cause or contribute to flooding or other related public safety concerns; however, the decisions regarding these flow levels would vary by river and would involve consultation between the State Water Board and appropriate federal, state, and local agencies as described in Section 6.4.2, *Methods and Approach*.

Varying amounts of bank armoring to reduce stream bank erodibility also occur along the three eastside tributaries (McBain and Trush 2000; Kondolf et al. 2001; Stillwater Sciences 2001). This bank armoring further limits the potential bank erosion under higher baseline flows and flows under LSJR Alternative 2.

Excessive seepage could undermine the riverbank, which has the potential to cause localized stream bank erosion. However, this type of seepage would not result in surface inundation. There have been documented seepage concerns on the Stanislaus River. On the Stanislaus River for flows greater than 1,500 cfs, Tables 6-13 and 6-14 show little change under LSJR Alternative 2, both on a month-by-month and overall average basis. The volume and rate of the resulting seepage would not be sufficient to transport sediment or particles; hence, would not have any effect on stream bank erosion. 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).

Given the range of flows expected under LSJR Alternative 2, existing channel capacities, action stages, and bank armoring, impacts related to sediment transport or bank erosion would be less than significant.

Siltation

With respect to siltation (the deposition of suspended sediment or turbidity), the effects of LSJR Alternative 2 would be generally similar to those discussed above for gravel and sand erosion and be similar to baseline conditions. Higher flows, when they do occur, would transport larger amounts of fine sediment in suspension. Under LSJR Alternative 2, peak flows in the three eastside tributaries would be similar to baseline peak flows because those peak flows result from flood control actions. Therefore, LSJR Alternative 2 would not cause substantial siltation within the eastside tributaries or the LSJR. Consequently, impacts would be less than significant.

Adaptive Implementation

Based on best available scientific information indicating that a change in the percent of unimpaired flow is needed to reasonably protect fish and wildlife, adaptive implementation method 1 would allow an increase of up to 10 percent over the 20 percent February–June unimpaired flow requirement (to a maximum of 30 percent of unimpaired flow). A change to the percent of unimpaired flow would take place based on required evaluation of current scientific information and would need to be approved as described in Appendix K. Accordingly, the frequency and duration of any use of this adaptive implementation method cannot be determined at this time. However, an increase of up to 30 percent of unimpaired flow would potentially result in different effects as compared to 20 percent unimpaired flow, depending upon flow conditions and frequency of the adjustment. For example, an increase of up to 30 percent unimpaired flow would generally result in an increase in the volume of water in the rivers than would occur under 20 percent of unimpaired flow at those times of increased releases/flows. But as discussed above, peak flows are associated with flood control releases, not releases to meet LSJR Alternative 2 requirements, and are not expected to substantially change. In addition, it is expected flows would remain in channel capacities with a potential increase in the specified unimpaired flow requirement from 20 percent to 30 percent. Thus, adaptive implementation method 1 would not result in a substantial increase in erosion or siltation.

Based on best available scientific information indicating that a change in the timing or rate of unimpaired flow is needed to reasonably protect fish and wildlife, adaptive implementation method 2 would allow changing the timing of the release of the volume of water within the February–June time frame. While the total volume of water released February–June would be the same as LSJR Alternative 2 without adaptive implementation, the rate could vary from the actual (7-day running average) unimpaired flow rate. Method 2 would not authorize a reduction in flows required by other agencies or through other processes, which are incorporated in the modeling of baseline conditions. Changes in the timing of flows released from February–June adaptive implementation method 2 would not exceed peak flows experienced under baseline conditions, and therefore would not substantially result in increased erosion or siltation compared to baseline. In addition, during big storm events, the full specified percent unimpaired flow would not apply when projected flows under LSJR Alternative 2 would exceed levels that would cause or contribute to flooding or other related public safety concerns and therefore a substantial increase erosion or siltation would not occur relative to baseline.

Method 3 would not be authorized under LSJR Alternative 2 since the unimpaired flow percentage would not exceed 30 percent; therefore, adaptive implementation method 3 would not affect erosion or siltation.

Adaptive implementation method 4 would allow an adjustment of the Vernalis February–June flow requirement. The WSE model results show that under LSJR Alternative 2 the 1,200-cfs February–June base flow requirement at Vernalis would require a flow augmentation in the three eastside tributaries and LSJR only 2.7 percent of the time in the 82-year record analyzed. Similarly, flow augmentation would be required 0.7 percent of the time to meet a 1,000-cfs requirement and 0.5 percent of the time for an 800-cfs Vernalis base flow requirement. These results indicate that changes due to adaptive implementation method 4 under this alternative would rarely alter the flows in the three eastside tributaries or the LSJR.

Impacts associated with adaptive implementation method 1 may be slightly different from those associated with methods 2 and 3. With method 1, if the specified percent of unimpaired flow were changed from 20 percent to 30 percent on a long-term basis, the conditions and impacts could become more similar to those described under LSJR Alternative 3. It is anticipated that over time the unimpaired flow requirement could increase or not change at all within a year or between years, depending on fish and wildlife conditions and hydrology. If adaptive implementation method 2 is implemented, the total annual volume of water associated with LJSR Alternative 2 (i.e., 20 percent of the February–June unimpaired flow) would not change, but the timing or magnitude of flows might change. However, since monthly peak flows would not be substantially different than baseline, and flows would remain within channel capacities, the potential for additional erosion or siltation effects is similar to the results presented above for LSJR Alternative 2 without adaptive implementation. Implementing method 4 is expected to have little effect on conditions in the three eastside tributary rivers and LSJR because it rarely would cause a change in flow and the volume of water involved would be relatively small. Consequently the impact determination of LSJR Alternative 2 with adaptive implementation would be the same as described for LSJR Alternative 2 without adaptive implementation for erosion and siltation. Impacts would be less than significant.

LSJR Alternative 3 (Less than significant/Less than significant with adaptive implementation)

Gravel and Sand Erosion

The range of flows associated with LSJR Alternative 3 is similar to flows that occur under baseline conditions. Sediment transport and erosion would be restricted by flood control activities, existing action stages, and existing bank armoring on the rivers. Consequently, 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 expected amount of gravel and sand transported is not large enough to contribute to levee instability.

The existing stream channels transport the most coarse sediment) at higher flows. The flows associated with LSJR Alternative 3, even when cumulated downstream from each of the three eastside tributaries, are almost always 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). Therefore, the amount of coarse sediment transported at higher flows would generally be limited under LSJR Alternative 3.

The range of flows associated with LSJR Alternative 3 would be similar to flows that occur under baseline conditions. Only two of the water years simulated by the WSE model, 1983 and 1997, had monthly flows that exceeded channel capacities on the Stanislaus, Tuolumne, and Merced Rivers or the SJR (Table 6-9). These exceedances, which resulted from large storm events that led to flood control releases, also occurred under baseline conditions. Therefore, the amount of gravel transported at higher flows under LSJR Alternative 3 is expected to be similar to baseline conditions.

Tables 6-10, 6-11, and 6-12 show the monthly peak flows from the WSE model results for the three eastside tributaries during the wettest years and show the percent of channel capacity for each flow based on Table 6-3 and Figure 6-3. The cumulative flow additions from the three eastside tributaries to the LSJR are substantially below its channel capacity, which ranges between 37,000 cfs and 52,000 cfs (Figure 6-3; Tables 6-10, 6-11, 6-12). These small flow additions would not increase coarse sediment transport in the LSJR. Under LSJR Alternative 3 peak monthly flows in the three 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 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), thus actions to reduce flood risk under high flow conditions would also limit potential gravel transport. For the Stanislaus River the action stage coincides with flow levels that would allow gravel transport to occur. These high flow levels on the three eastside rivers would primarily be associated with peak flows during storm events under LSJR Alternative 3; therefore, they would generate a relatively small amount of stream bank erosion due to their low frequency of occurrence. Furthermore, any gravel movement that would occur is known to be beneficial for aquatic habitat enhancement (McBain and Trush 2000; Kondolf et al. 2001; Stillwater Sciences 2001, 2004). Chapter 7, *Aquatic Biological Resources*, includes a discussion of the importance of gravel transport for fish habitat maintenance.

As discussed under LSJR Alternative 2, varying amounts of bank armoring also occur along the three eastside tributaries. This further limits the potential for bank erosion to occur (McBain and Trush 2000; Kondolf et al. 2001; Stillwater Sciences 2001).

Sand transport begins at relatively low flows so that in the mid- to lower sand-bedded portions of the three eastside tributaries, flows greater than 2,000–3,000 cfs would increase sand movement (Hickin n.d.). However, the largest total amount of sand transport is associated with moderate to peak flows (Wolman and Leopold 1960), and the LSJR Alternative 3 flows would generate a small amount of total additional sand movement, which would be considered less than significant. Furthermore, any sand movement that would occur 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 (Chapter 7, *Aquatic Biological Resources*).

Excessive seepage could undermine the riverbank, which has the potential causing localized stream bank erosion. This type of seepage would not result in surface inundation. There have been documented seepage concerns on the Stanislaus River. On the Stanislaus River for flows greater than 1,500 cfs, Tables 6-13 and 6-14 show that under LSJR Alternative 3, some months would have decreases in the frequency of flows above 1,500 cfs and some would have increases compared to baseline, but on average there would be moderate increases. As simulated by the WSE model, the overall average percent of months with flow greater than 1,500 cfs would increase by 1 percent at Goodwin and 2 percent at Ripon under LSJR Alternative 3, with the largest increases occurring May–June. These flows may cause localized underseepage to adjacent agricultural lands based on historical accounts. The associated seepage would not have an effect on stream bank erosion because the expected volume and rate of the seepage 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).

Given the range of flows expected under LSJR Alternative 3, existing channel capacities, action stages, and bank armoring, impacts related to sediment transport or bank erosion would be less than significant.

Siltation

With respect to siltation (deposition of suspended sediment or turbidity) the effects of LSJR Alternative 3 would be generally similar to those discussed above for gravel and sand transport and erosion. Peak monthly flows are not expected to change significantly compared to baseline conditions. Infrequent high flows would transport larger amounts of fine sediment in suspension than under lower flows. Therefore, LSJR Alternative 3 would not result in substantial siltation within the three eastside tributaries or the SJR. Consequently, impacts would be less than significant.

Adaptive Implementation

Under LSJR Alternative 3, impacts associated with adaptive implementation method 1 may be slightly different from those associated with adaptive implementation methods 2 and 3.

Implementing method 1 would allow an increase or decrease of up to 10 percent in the February–June, 40 percent unimpaired flow requirement (with a minimum of 30 percent and maximum of 50 percent) to optimize implementation measures to meet the narrative objective, while considering other beneficial uses, provided that these other considerations do not reduce intended benefits to fish and wildlife. Adaptive implementation must be approved using the process described in Appendix K. Accordingly, the frequency and duration of any use of this adaptive implementation method cannot be determined at this time. Adaptive implementation method 1 could affect the amount of water available for water supply and the volume of water and level of flow in the LSJR and its tributaries. However, the frequency and duration of such a change is unknown. If the specified percent of unimpaired flow were changed from 40 percent to 30 percent or 40 percent to 50 percent on a long-term basis, the conditions and impacts could become more similar to LSJR Alternatives 2 or 4, respectively. It is anticipated that over time the unimpaired flow requirement could increase, decrease, or not change at all within a year or between years, depending on fish and wildlife conditions and hydrology. As described in LSJR Alternatives 2 and 3, a change to the percent of unimpaired flow could affect the volume of water and level of flow in the LSJR and its tributaries; however, peak flows and flood control actions are not expected to change substantially under this range of unimpaired flows.

Under adaptive implementation methods 2 or 3, the overall volume of water from the February–June time period or after June would be the same as LSJR Alternative 3 without adaptive implementation, but the volume within each month could vary. Impacts associated with the total volume of water would not be affected by method 2 or 3, but sediment and erosion, which can be dependent on the timing or magnitude of flow, could potentially be affected. Although, the volume of water would be substantially greater in the eastside tributary rivers when compared to baseline conditions, the peak monthly flows would not be substantially different compared to baseline. Similarly, the water volumes that might be shifted under adaptive implementation methods 2 and 3 are small in comparison to peak monthly flows and the effects on sediment and erosion would be small. In addition, adaptive implementation method 3, which allows flow shifting from the February–June time frame to other times of year is incorporated into the modeling; thus, the range of erosion and siltation effects is reflected in the results presented above for LSJR Alternative 3. Finally, given that these two methods would not allow flows to go below what is required by existing requirements on the three eastside tributaries and the SJR, impacts would be similar to those described for LSJR Alternative 3 without adaptive implementation.

Implementing method 4 is expected to have little effect on conditions in the three eastside tributary rivers. The WSE model results show that under Alternative 3 the 1,200-cfs February–June base flow requirement at Vernalis would require a flow augmentation in the three eastside tributaries and LSJR only 1.2 percent of the time in the 82-year record analyzed. Similarly, flow augmentation would be required only 0.2 percent of the time to meet either a 1,000-cfs or 800-cfs Vernalis base flow requirement. These results indicate that method 4 would rarely alter the flows in the three eastside tributaries or the LSJR under this alternative.

Consequently the impact determination of LSJR Alternative 3 with adaptive implementation would be the same as described for LSJR Alternative 3 without adaptive implementation, for erosion and siltation. Impacts would be less than significant.

LSJR Alternative 4 (Less than significant/Less than significant with adaptive implementation)

Gravel and Sand Erosion

The range of flows associated with LSJR Alternative 4 is similar to flows that occur under baseline conditions. Sediment transport and erosion would be restricted by flood control activities, existing action stages, and existing bank armoring on the rivers. Consequently, 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 expected amount of gravel transport is not large enough to contribute to levee instability.

The existing stream channels transport the coarsest sediment at higher flows. The flows associated with LSJR Alternative 4, even when cumulated downstream from each of the eastside tributaries, are almost always 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). Therefore, the amount of coarse sediment transported at higher flows would generally be limited under LSJR Alternative 4.

The range of flows associated with LSJR Alternative 4 would be similar to flows that occur under baseline conditions. Only two of the water years simulated by the WSE model, 1983 and 1997, had monthly peak flows that exceeded channel capacities on the Stanislaus, Tuolumne or Merced Rivers or the SJR (Table 6-9). These exceedances, which resulted from large storm events that led to flood control releases, also occurred under baseline conditions as well as under LSJR Alternative 4, with the exception of the January 1997 exceedance on the Stanislaus River. This exceedance occurred only in the baseline modeling results and not the LSJR Alternative 4 results, due to lower reservoir storage in LSJR Alternative 4, which led to lower required flow releases at the time.

Tables 6-10, 6-11, and 6-12 show the monthly peak flows from the WSE model results for the three eastside tributaries during the wettest years and show the percent of channel capacity for each flow based on Table 6-3 and Figure 6-3. The cumulative flow additions from the three eastside tributaries to the LSJR are substantially below its channel capacity, which ranges between 37,000 cfs and 52,000 cfs (Figure 6-3; Tables 6-10, 6-11, 6-12). These small flow additions would not increase coarse sediment transport in the LSJR. The peak flows in the three 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 stage actions are lower than the gravel transport flow levels in the Tuolumne River (6,600 cfs) and Merced River (3,200 cfs). Thus actions to reduce flood risk under high flow conditions would also limit potential gravel transport. For the Stanislaus River the action stage would allow gravel transport to occur. These high flow levels on the three eastside tributaries would primarily be associated with peak flows during storm events under LSJR Alternative 4; therefore, they would generate a relatively small amount of stream bank erosion due to their low frequency of occurrence. Furthermore, any gravel movement that would occur is known to be beneficial for aquatic habitat enhancement (Chapter 7, *Aquatic Biological Resources*; McBain and Trush 2000; Kondolf et al. 2001; Stillwater Sciences 2001, 2004).

As discussed under LSJR Alternative 2, varying amounts of bank armoring also occur along the three eastside tributaries. This further limits the potential for bank erosion to occur (McBain and Trush 2000; Kondolf et al. 2001; Stillwater Sciences 2001).

Sand transport begins at relatively low flows so that in the mid- to lower sand-bedded portions of the three eastside tributaries, flows greater than 2,000–3,000 cfs would increase sand movement (Hickin n.d.). However, the largest total amount of sand transport is associated with moderate to peak flows (Wolman and Miller 1960), and the LSJR Alternative 2 flows would generate a small amount of total additional 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 (Chapter 7, *Aquatic Biological Resources*).

Excessive seepage could undermine the riverbank, which has the potential causing localized stream bank erosion. This type of seepage does not result in surface inundation. There have been documented seepage concerns on the Stanislaus River. On the Stanislaus River for flows greater than 1,500 cfs, Tables 6-13 and 6-14 show that under LSJR Alternative 4, some months would have decreases in the frequency of flows above 1,500 cfs and some would have increases compared to baseline, but on average there would be moderate increases. As simulated by the WSE model, the overall average percent of months with flow greater than 1,500 cfs would increase by 7 percent at Goodwin and 8 percent at Ripon under LSJR Alternative 4, with the largest increases occurring April–June. These flows may cause localized underseepage to adjacent agricultural lands. The associated seepage would not have an effect on stream bank 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).

Given the range of flows expected under LSJR Alternative 4, existing channel capacities, action stages, and bank armoring, impacts related to sediment transport or bank erosion would be less than significant.

Siltation

With respect to siltation (desposition of suspended sediment or turbidity), the effects of LSJR Alternative 4 would be generally similar to those discussed above for gravel and sand transport or erosion Peak monthly flows are not expected to change significantly compared to baseline conditions. Infrequent high flows would transport larger amounts of fine sediment in suspension than under lower flow conditions. Therefore, LSJR Alternative 4 would not result in substantial siltation within the three eastside tributaries or the SJR. Consequently, impacts would be less than significant.

Adaptive Implementation

Under LSJR Alternative 4, impacts associated with adaptive implementation method 1 may be slightly different from those associated with methods 2 and 3. Adaptive implementation method 1 would allow a decrease of up to 10 percent in the annual February–June 60 percent unimpaired flow (to 50 percent) to optimize implementation measures to meet the narrative objective, while considering other beneficial uses, provided that these other considerations do not reduce intended benefits to fish and wildlife. Adaptive implementation must be approved using the process described in Appendix K. Accordingly, the frequency and duration of any use of this adaptive implementation method cannot be determined at this time. If the specified percent unimpaired flow were changed from 60 percent to 50 percent on a long-term basis, the conditions and impacts could become more similar to LSJR Alternative 3. It is anticipated that over time the unimpaired flow requirement could decrease or not change at all within a year or between years, depending on fish and wildlife conditions and hydrology.

Adaptive implementation method 2 or 3 would shift the timing of the river flows within the February–June time frame or after June. This adaptive implementation method would not affect the total volume of water, but as described above for LSJR Alternative 3, adjustments in the timing or magnitude of the flows could affect erosion and sedimentation. Although the volume of water would be substantially greater in the eastside tributary rivers when compared to baseline conditions, the peak monthly flows would not be substantially different compared to baseline. In addition, given that these two methods would not allow flows to go below what is required by existing requirements on the three eastside tributaries and the SJR, impacts would be similar to those described for LSJR Alternative 3 without adaptive implementation.

Implementing method 4 is expected to have little effect on conditions in the three eastside tributary rivers and LSJR. The WSE model results show that under Alternative 4 the 1,200-cfs February–June base flow requirement at Vernalis would require a flow augmentation in the three eastside tributaries and LSJR only 0.7 percent of the time in the 82-year record analyzed. Similarly, flow augmentation would be required only 0.2 percent of the time to meet a 1,000-cfs requirement and is not affected at all for an 800-cfs requirement. These results indicate that method 4 would rarely alter the flows in the three eastside tributaries or the LSJR under this alternative.

Consequently the impact determination of LSJR Alternative 4 with adaptive implementation would be the same as described for LSJR Alternative 4 without adaptive implementation for erosion and siltation. Impacts would be less than significant.

Impact FLO-2: Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, or substantially increase the rate or amount of surface runoff in a manner that would result in flooding on- or off-site

No Project Alternative (LSJR/SDWQ Alternative 1)

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

LSJR Alternatives

LSJR Alternative 2 (Less than significant/Less than significant with adaptive implementation)

LSJR Alternative 2 has the potential to affect the management of reservoir releases from the rim dams into the three eastside tributaries. Peak monthly flows are not expected to change substantially under LSJR Alternative 2. Only two of the water years simulated by the WSE model, 1983 and 1997, had monthly flows that exceeded channel capacities on the Stanislaus, Tuolumne or Merced Rivers or the LSJR (Table 6-9). These exceedances, which resulted from flood control releases due to large storm events, occurred under baseline conditions as well as under LSJR Alternative 2. Tables 6-10, 6-11, and 6-12 show the monthly peak flows from the WSE modeling results for the three eastside tributaries during the wettest years. These tables also show the percent of channel capacity for each flow based on Table 6-3 and Figure 6-3. Peak monthly flows under LSJR Alternative 2 are not expected to change, and generally remain within the channel capacity for the three eastside tributaries.

Since the flow objectives would generally not affect flood control storage capacity, as flood flow releases would still be made, and would not affect the USACE flood reservation, there would not be any changes in flood control operation procedures during major flood events. Under LSJR

Alternative 2, for most months, monthly median flows for the Stanislaus, Tuolumne, and Merced Rivers and the LSJR do not vary substantially from the modeled baseline median monthly flows (Tables 5-17a). Additionally, the peak monthly flow resulted from the WSE model would not exceed the action stage (Table 6-4) and would not apply when flows would exceed levels that would cause or contribute to flooding or other related public safety concerns as described in Section 6.4.2, *Methods and Approach*. This would further limit flooding under LSJR Alternative 2. LSJR Alternative 2 would not substantially alter existing drainage patterns or substantially increase the rate or amount of surface runoff in a manner that would result in flooding. Consequently, LSJR Alternative 2 would not expose people or structures to a significant risk of loss, injury or death involving flooding as noted in Section 6.4.1, *Thresholds of Significance*.

Adaptive Implementation

Adaptive implementation methods 1, 2, and 4 are not anticipated to substantially alter existing drainage patterns or substantially increase the rate or amount of surface runoff in a manner that would result in flooding. As described in Impact FLO-1, peak flows associated with flood control are not expected to substantially change. Thus, with a potential increase in the specified unimpaired flow requirement from 20 percent to 30 percent (i.e., method 1), it is expected flows would remain in channel capacities. A shift in timing or magnitude of flows under methods 2 is not expected to alter existing drainage patterns or substantially increase the rate or amount of surface runoff because the water volumes that might be shifted under these methods are small in comparison to peak monthly flows and the effects on sediment and erosion would be small. Therefore, impacts would be less than significant.

LSJR Alternative 3 (Less than significant/Less than significant with adaptive implementation)

LSJR Alternative 3 has the potential to affect management of reservoir releases from the rim dams into the three eastside tributaries. Peak monthly flows are not expected to change substantially under LSJR Alternative 3. Only two of the water years simulated by the WSE model, 1983 and 1997, had monthly flows that exceeded channel capacities on the Stanislaus, Tuolumne and Merced Rivers or the SJR (Table 6-9). These exceedances, which resulted from flood control releases due to large storm events, occurred under baseline conditions as well as under LSJR Alternative 3. Tables 6-10, 6-11, and 6-12 show the monthly peak flows from the WSE modeling results for the three eastside tributaries during the wettest years. These tables also show the percent of channel capacity for each flow based on Table 6-3 and Figure 6-3.

For the LSJR, the Delta, and the three eastside tributaries, the LSJR Alternative 3 flows are almost always substantially lower than the channel capacities in these river reaches and the southern Delta (Table 6-3 and Figure 6-3, and Tables 6-10, 6-11, and 6-12), 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 higher flows, these flows would be contained within the existing floodway, and no significant impact would occur with respect to flooding. Furthermore, because the flow objectives would generally not affect flood control storage capacity, since flood flow releases would still be made, and would not affect the USACE flood reservation, there would not be any changes in flood control operation procedures during major flood events. Additionally, the peak monthly flows would not exceed the action stage (Table 6-4)and would not apply when flows would exceed levels that would cause or contribute to flooding or other related public safety concerns, as described in Section 6.4.2, *Methods and Approach*. This would further limit flooding under LSJR Alternative 3.

LSJR Alternative 3 would not substantially alter existing drainage patterns or substantially increase the rate or amount of surface runoff in a manner that would result in flooding. Consequently, LSJR Alternative 3 would not expose people or structures to a significant risk of loss, injury or death involving flooding as noted in Section 6.4.1, *Thresholds of Significance*.

Adaptive Implementation

Adaptive implementation methods 1, 2, 3, and 4 are not anticipated to substantially alter the existing drainage pattern or increase the rate of surface runoff in a manner that would result in flooding. As described in Impact FLO-1, peak flows associated with flood control are not expected to substantially change. Thus, with a potential increase or decrease in the specified unimpaired flow requirement from 40 percent to either 30 percent or 50 percent (i.e., method 1), it is expected flows would remain in channel capacities. Similarly, a shift in timing or magnitude of flows under methods 2 or 3 is not expected to alter existing drainage patterns or substantially increase the rate or amount of surface runoff because the water volumes that might be shifted under these methods are small in comparison to peak monthly flows and the effects on sediment and erosion would be small. Therefore, impacts would be less than significant.

LSJR Alternative 4 (Less than significant/Less than significant with adaptive implementation)

LSJR Alternative 4 has the potential to affect management of reservoir releases from the rim dams into the three eastside tributaries. Peak monthly flows are not expected to change under LSJR Alternative 4. Only two of the water years simulated by the WSE model, 1983 and 1997, had monthly flows that exceeded channel capacities on the Stanislaus, Tuolumne or Merced Rivers or the SJR (Table 6-9). These exceedances, which resulted from flood control releases during large storm events, occurred under baseline conditions as well as under LSJR Alternative 4, with the exception of the January 1997 exceedance on the Stanislaus River. This exceedance occurred only in the baseline modeling results and not the LSJR Alternative 4 results (due to lower reservoir storage in LSJR Alternative 4). Tables 6-10, 6-11, and 6-12 show the monthly peak flows from the WSE modeling results for the three eastside tributaries during the wettest years. These tables also show the percent of channel capacity for each flow based on Table 6-3 and Figure 6-3.

For the LSJR, the southern Delta, and the three eastside tributaries, the LSJR Alternative 4 flows are almost always substantially lower than the channel capacities in these river reaches and the southern Delta (Table 6-3, Figure 6-3, and Tables 6-10, 6-11, and 6-12), even considering the lower channel capacity estimates from DWR for some reaches (2011, Table 6-3). Since these channels are capable of carrying much higher flows, these flows would be contained within the existing floodway, and no significant impact would occur with respect to flooding. Furthermore, 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 operation procedures during major flood events. Additionally, the peak monthly flow resulted from the WSE model would not exceed the action stage (Table 6-4) and would not apply when flows would exceed levels that would cause or contribute to flooding or other related public safety concerns, as described in Section 6.4.2, *Methods and Approach*. This would further limit flooding under LSJR Alternative 4. LSJR Alternative 4 would not substantially alter existing drainage patterns or substantially increase the rate of surface runoff in a manner that would directly result in flooding. Consequently, LSJR Alternative 4 would not expose people or structures to a significant risk of loss, injury or death involving flooding as noted in Section 6.4.1, *Thresholds of Significance*.

Adaptive Implementation

Adaptive implementation methods 1, 2, 3, and 4 are not anticipated to result in flooding. As described in Impact FLO-1, peak flows associated with flood control are not expected to substantially change. Thus, with a potential decrease in the specified minimum unimpaired flow requirement from 60 percent to 50 percent (i.e., method 1), it is expected flows would remain in channel capacities. A shift in timing or magnitude of flows under methods 2 or 3 is not expected to alter existing drainage patterns or substantially increase the rate or amount of surface runoff because the water volumes that might be shifted under these methods are small in comparison to peak monthly flows and the effects on sediment and erosion would be small. Therefore, impacts would be less than significant.

6.4.4 Impacts and Mitigation Measures: Extended Plan Area

The types of impacts that could occur in the extended plan area with respect to flooding, sediment, and erosion are similar to those described and discussed for the plan area. In general, upstream reservoirs would have more storage capacity under LSJR Alternatives 2, 3, or 4 with or without adaptive implementation because flows would be bypassed so there would be no change in flooding, sediment, or erosion when compared to baseline conditions in the extended plan area for the Stanislaus and Tuolumne Rivers. Flood control releases from the upstream reservoirs on the Stanislaus and Tuolumne Rivers would not increase and peak flows would be similar to baseline because storage in the upstream reservoirs would generally remain the same or be lower than under baseline. Additionally, bypass flows would not be required if they would result in flood control releases from the rim reservoirs. Consequently, there would be no impacts on flooding, sediment, or erosion compared to baseline conditions due to an inability to store water.

The nature of the river channels (predominantly contained in bedrock with very coarse-grained sediment) in the extended plan area means there would be minimal potential for increased sediment transport, erosion, or flooding under LSJR Alternatives 2, 3, or 4 with or without adaptive implementation on the Stanislaus, Tuolumne, and Merced Rivers. Additionally, peak flows would be no higher than under baseline. While higher flows, particularly under LSJR Alternatives 3 and 4 with or without adaptive implementation, might cause more frequent inundation of shallow point bars and occasional low elevation areas along the river channels, this would not be significant because such inundation occurs under baseline conditions and the inundation would not cause channel changes. Consequently, impacts associated with flooding, sediment, and erosion would be less than significant in the extended plan area under LSJR Alternatives 2, 3, and 4 with or without adaptive implementation.

6.5 Cumulative Impacts

For the cumulative impact analysis, refer to Chapter 17, *Cumulative Impacts, Growth-Inducing Effects, and Irreversible Commitment of Resources.*

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