

Technical Memorandum

Channel Capacity Report 2014 Restoration Year



January 2014

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List of Abbreviations and Acronyms

CBBS	Chowchilla Bypass Bifurcation Structure
CCAG	Channel Capacity Advisory Group
CDEC	California Data Exchange Center
CFS	Cubic feet per second
CPT	Cone Penetration Test (Cone Penetrometer Test)
CVFPP	Central Valley Flood Protection Plan
CVFED	Central Valley Floodplain Evaluation and Delineation
CVFPB	Central Valley Flood Protection Board
Delta	Sacramento-San Joaquin Delta
DMC	Delta-Mendota Canal
DTM	Digital Terrain Model
DWR	Department of Water Resources
GAR	Geotechnical Assessment Report
GDR	Geotechnical Data Report
GOR	Geotechnical Overview Report
LSJLD	Lower San Joaquin Levee District
LSJRFC Project	Lower San Joaquin River Flood Control Project
MNWR	Merced National Wildlife Refuge
NRDC	Natural Resources Defense Council
NULE	Non-Urban Levee Evaluation
O&M	Operations and Maintenance
PEIS/R	Program Environmental Impact Statement/Environmental Impact Report
RACER	Remedial Alternatives and Cost Estimates Report
Reclamation	Bureau of Reclamation
Restoration Area	San Joaquin River Restoration Program Restoration Area
RFMP	Region Flood Management Plan
RM	River mile
ROD	Record of Decision
SJLE	San Joaquin Levee Evaluation
SJRRP	San Joaquin River Restoration Program
SPFC	State Plan of Flood Control
WSE	Water surface elevation
WSP	Water surface profile
ULE	Urban Levee Evaluation
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
USJR	Upper San Joaquin River

Definitions

San Joaquin River Restoration Program (SJRRP): The SJRRP was established in late 2006 to restore and maintain fish populations in good condition in the mainstem of the San Joaquin River (SJR) below Friant Dam to the confluence of the Merced River, while reducing or avoiding adverse water supply impacts.

Settlement: In 2006, the SJRRP was established to implement the Stipulation of Settlement in *NRDC, et al., v. Kirk Rodgers, et al.*

Program Environmental Impact Statement/Environmental Impact Report (PEIS/R): The Bureau of Reclamation (Reclamation), as the federal lead agency under the National Environmental Policy Act (NEPA) and the California Department of Water Resources (DWR), the state lead agency under the California Environmental Quality Act (CEQA), jointly prepared a Program Environmental Impact Statement/Report (PEIS/R) and signed a Record of Decision and Notice of Determination (ROD and NOD), respectively, in 2012 to implement the Settlement.

Channel Capacity Advisory Group: The Channel Capacity Advisory Group provides focused input to Reclamation's determination of "then-existing channel capacity" within the Restoration Area.

Then-existing channel capacity: The channel capacity within the Restoration Areas that correspond to flows that would not significantly increase flood risk from Restoration Flows in the Restoration Area. Then-existing channel capacities currently being followed were defined from an analysis included in the PEIS/R; this annual report will recommend updating then-existing channel capacity based on recently completed evaluations.

In-channel capacity: The flow at which the water surface elevation is maintained at or below the elevation of the outside ground (i.e., along the landside levee toe).

1.0 Executive Summary

2 Background

The San Joaquin River Restoration Program (SJRRP) was established in late 2006 to implement a Stipulation of Settlement (Settlement) in NRDC, et al., v. Kirk Rodgers, et al. The U.S. Department of the Interior, Bureau of Reclamation, the Federal lead agency under the National Environmental Policy Act, and the California Department of Water Resources (DWR), the State lead agency under the California Environmental Quality Act, prepared a joint Program Environmental Impact Statement/Report (PEIS/R) to support implementation of the Settlement.

The Settlement calls for releases of Interim and Restoration flows. Restoration Flows are specific volumes of water to be released from Friant Dam during different water year types, according to Exhibit B of the Settlement. Interim Flows are experimental flows that began in 2009 and will continue until Restoration Flows are initiated in 2014, with the purpose of collecting relevant data concerning flows, temperatures, fish needs, seepage losses, and the recirculation, recapture, and reuse of released water.

Federal authorization for implementing the Settlement is provided in the San Joaquin River Restoration Settlement Act (Act) (Public Law 111-11). Reclamation signed the Record of Decision (ROD) on September 28, 2012. Both the PEIS/R and the ROD committed to establishing a Channel Capacity Advisory Group (CCAG) to determine and update estimates of then-existing channel capacities as needed and to maintain Interim and Restoration flows at or below estimates of then-existing channel capacities. Then-existing channel capacities in the Restoration Area (leveed reaches within the San Joaquin River between Friant Dam and the confluence of the Merced River and the flood control bypass) correspond to flows that would not significantly increase flood risk from Restoration Flows. This Channel Capacity Report for the 2014 Restoration Year, prepared in coordination with the CCAG, fulfills the commitments in the ROD.

The primary objective of this report is to provide the CCAG and the public a summary of the prior Restoration Year's data, methods, and estimated channel capacities and recommendations for monitoring and management actions for the following year. Identifying then-existing channel capacity is critically important to ensure the release of Restoration Flows would not significantly increase flood risk in the Restoration Area. This report only considers flood risks associated with levee failure when estimating then-existing channel capacity; all other potential material impacts, including agricultural seepage, are addressed in other analyses.

33 CCAG Roles and Responsibilities

The CCAG is comprised of members from the Bureau of Reclamation (Convener), California Department of Water Resources (DWR, Co-convener), U.S. Army Corps of Engineers (USACE), Lower San Joaquin Levee District, and the Central Valley Flood Protection Board.

1 The role of the CCAG is to: (1) provide independent review of Reclamation’s estimates of then-
 2 existing channel capacity as needed; (2) provide independent review of Channel Capacity
 3 Reports; (3) participate in CCAG meetings; (4) provide independent and timely review of data;
 4 and (5) provide input and guidance on monitoring and management actions.

5 Study Area

6 This Channel Capacity Report focuses on the portion of the Restoration Area where levees exist
 7 along channels to control flows. The leveed reaches on the San Joaquin River start at Gravelly
 8 Ford (River Mile 226.9) and continue to the Merced River confluence (River Mile 118.2). The
 9 study area also includes the Eastside Bypass from Sand Slough Connector to the confluence with
 10 Bear Creek and the Mariposa Bypass.

11 Findings and Recommendations

12 Then-existing channel capacities are defined as flows that would correspond to the appropriate
 13 levee slope stability and underseepage Factors of Safety based on USACE criteria for levees.
 14 The application of the criteria requires the collection and evaluation of data at locations
 15 throughout the Restoration Area. Until adequate data are available to apply the USACE criteria,
 16 the release of Restoration Flows would be limited to those that would remain in-channel (the
 17 water surface elevation in the river remains below the levees). Based on the results of technical
 18 studies summarized in this Report and detailed in Appendices, the 2014 recommended then-
 19 existing channel capacities for the San Joaquin River and flood bypasses are described in Table
 20 ES-1 below.

21 **Table ES-1**
 22 **Current and Recommended Then-existing Channel Capacity**

Reach	Current Then-existing Channel Capacity (cfs)	2014 Recommended Then-existing Channel Capacity (cfs)
Reach 2A	1,060	1,630
Reach 2B	810	1,120
Reach 3	2,140	2,760
Reach 4A	630	970
Reach 4B1	Not Analyzed	Not Analyzed
Reach 4B2	990	930
Reach 5	1,690	1,940
Middle Eastside Bypass	600	370
Lower Eastside Bypass		2,890
Mariposa Bypass	Not Analyzed	350

23
 24 In general, the recommended then-existing channel capacity for most of the river reaches and
 25 bypasses have increased or stayed the same as the then-existing channel capacities identified in
 26 the PEIS/R as shown in table above. The changes to the then-existing channel capacities are
 27 mainly due to further refinement of the topographic data and updates to the hydraulic models.

1 **Current Channel Capacity Studies and Related Work Completed**

2 The following technical studies and related work were completed at the time of publication of
3 this report that relate to channel capacities and were specifically evaluated to determine the
4 recommended then-existing channel capacities in this report.

5 **In-channel Capacity Study**

6 The In-channel Capacity Study for the San Joaquin River and the Eastside and Mariposa
7 bypasses between Friant Dam and the confluence with the Merced River was conducted in 2013.
8 This study provides initial channel capacity estimates within leveed reaches that can inform then-
9 existing channel capacity prior to sufficient data becoming available to determine levee slope
10 stability and underseepage Factors of Safety.

11 Computed water-surface profiles were compared to the outside ground elevations adjacent to
12 both the left and right levees along the extent of each reach. The in-channel flow capacity of each
13 reach was determined to be the highest flow rate through the reach where the water-surface
14 elevation is at or below the outside ground elevation for any part of the reach. Results for each
15 reach are summarized in Table ES-2 below; these inform the 2014 recommended then-existing
16 channel capacity outlined in Table ES-1.

1
2

**Table ES-2.
Summary of In-channel Capacity for Each Side of Levee by River Reach**

Reach	Levee Side	In-channel Capacity ¹ (cfs)
Reach 2A	Left	2,430
Reach 2A	Right	1,630
Reach 2B (Entire Reach)	Left	0
Reach 2B (Entire Reach)	Right	0
Reach 2B (Excluding Mendota Pool) ²	Left	1,120
Reach 2B (Excluding Mendota Pool) ²	Right	1,550
Reach 3	Left	3,680
Reach 3	Right	2,760
Reach 4A	Left	970
Reach 4A	Right	1,340
Reach 4B2	Left	1,370
Reach 4B2	Right	930 ³
Reach 5 (All Levees)	Left	1,940
Reach 5 (All Levees)	Right	2,500
Reach 5 (Excluding Left Levee downstream of Mud Slough)	Left	2,350
Reach 5 (Excluding Left Levee downstream of Mud Slough)	Right	2,500
Middle Eastside Bypass (Eastside Bypass Reach 2)	Left	10
Middle Eastside Bypass (Eastside Bypass Reach 2)	Right	370
Lower Eastside Bypass (Eastside Bypass Reach 3)	Left	2,970
Lower Eastside Bypass (Eastside Bypass Reach 3)	Right	2,890
Mariposa Bypass	Left	650
Mariposa Bypass	Right	350

3 ¹ Capacity based on outside ground elevations.
 4 ² Portion of reach above influence of Mendota Pool (about River Mile 209.5).
 5 ³ Capacity excludes localized deep depressions, which would reduce capacity to 50 cfs.

6 Middle Eastside Bypass Geotechnical Assessment

7 As a preliminary component of the San Joaquin Levee Evaluation (SJLE) Project and to further
 8 investigate in-channel capacity results in the Middle Eastside Bypass relative to levee
 9 performance, preliminary levee seepage and stability analyses were completed at three sites with
 10 the lowest in-channel capacity along the left levee bank. The analysis was performed to better
 11 understand the potential levee seepage and stability impacts in the reach with high ground
 12 elevations along the landside levee toe resulting in unreasonably low in-channel capacity.

1 Table ES-3 summarizes the acceptable maximum water surface elevation, and approximate
 2 height of water on the waterside levee toe compared to the relative outside ground. The analysis
 3 results and recommendations summarized in Table ES-3 and in Appendix C are based on
 4 preliminary data. The results and recommendations should be refined once more detailed
 5 information becomes available.

6 **Table ES-3.**
 7 **Summary of Preliminary Analysis Results for Channel Capacity Assessment¹**

Site	Maximum Water Surface Elevation (feet, NAVD88)	Approximate Height of Water on the Levee ²
1	100.7	1.2
2	104.0	6.5
3	101.7	3.7

8 ¹ Height of water on the levee at a particular location does not necessarily translate directly to another site, i.e. if water were at
 9 a height of 1 foot on the levee at Site 1 then the height of water on the levee at a different location could be different.

10 ² Height of water relative to the typical outside ground elevation.

11 **Reach 2A Sedimentation Study**

12 The Reach 2A sedimentation study involved assessing the channel changes using topographic
 13 data and was performed as a response to concerns by the Lower San Joaquin Levee District that
 14 sediment accumulation near the Chowchilla Bypass Bifurcation Structure (CBBS) would affect
 15 operation of the CBBS and capacity of the reach. An initial assessment was completed in 2010,
 16 which then led to an expanded two-phase study in 2011 and 2012 and technical memorandums
 17 published for each phase. The results of this study suggest that the 4-year degradation trend in
 18 the majority of Reach 2A has tended to reduce the water-surface elevations by a small amount at
 19 high flows, and this trend can be expected to continue with continued degradation. In the reach
 20 just upstream of the CBBS, the slight increase in bed elevations showed only a minor increase in
 21 water surface elevations up to 4,000 cfs.

22 **Bypass Subsidence Study**

23 Subsidence along the Eastside Bypass has been identified in Madera and Merced Counties.
 24 Several studies and mapping efforts to determine the extent and magnitude of the subsidence
 25 have been completed by the USACE, DWR, Reclamation, and the U.S. Geological Survey. The
 26 results of modeling the design flow capacities in the bypasses indicate that freeboard in 2008 and
 27 2011 is generally above 3 to 5 feet along most of the bypass except between Sand Slough and
 28 West Washington Road, which is an area of recurring sediment deposition. From 2011 to 2016, it
 29 is expected that the continuing subsidence will reduce the freeboard in this area by about 0.5 feet.
 30 In the peak subsidence area between Road 4 and Avenue 21, ongoing subsidence is estimated to
 31 decrease the freeboard from 2011 to 2016 an additional 1.5 feet. For Highway 152, the projected
 32 decrease in freeboard is about 0.7 feet. The opposite is true within the proximity of Avenue 18 ½
 33 where the freeboard will actually increase from 2011 to 2016 by about 0.7 feet due to the
 34 increase of the channel slope as a result of the subsidence.

35 Subsidence is changing the amount of freeboard in the bypasses, and therefore is also affecting
 36 their ability to convey flows. Flow capacity in the bypasses has been reduced as a result of

1 subsidence by up to 2,500 cfs since 2008. If subsidence continues, it is estimated that an
2 additional loss in flow capacity up to 1,500 cfs from 2011 to 2016 depending on the segment of
3 bypass.

4 **Seepage Management Plan**

5 Reclamation has developed a Seepage Management Plan to guide efforts related to groundwater
6 seepage. It should be noted that the actions and findings of the Seepage Management Plan,
7 although related to channel capacity as it relates to agricultural seepage, will not be directly
8 considered in the determining then-existing channel capacities relating to levee seepage and
9 stability. However, data collection and seepage projects will be closely coordinated to determine
10 effect on channel capacities. The SJRRP will continue to limit Restoration Flows to levels that
11 do not result in material adverse impacts due to groundwater seepage, which may be more
12 limiting than levee seepage and stability.

13 Landowners farming adjacent to the San Joaquin River may experience impacts from Restoration
14 Flows via groundwater tables rising and waterlogging crops or bringing salts from groundwater
15 into the root zone, reducing crop yields. To address these potential impacts, Reclamation has
16 installed more than 180 shallow groundwater monitoring wells since 2009 and takes weekly
17 measurements in most of these, with monthly measurements in the rest.

18 Reclamation operates such that groundwater levels do not exceed thresholds due to Restoration
19 Flow releases. In most areas, the predicted rise in stage in the river is added to the most recent
20 groundwater level measurement to conservatively predict the new groundwater level. If this level
21 is above the threshold, the flow release is constricted.

22 Reclamation has also developed a Seepage Project Handbook, intended to guide a process of
23 implementing projects to release the full Restoration Flows over time while avoiding material
24 adverse groundwater seepage impacts. Potential projects include interceptor drains, slurry walls,
25 drainage ditches, shallow groundwater pumping, increasing the land surface through adding soil,
26 removing sediments from the river or bypass channel, seepage easements, license agreements,
27 and acquisition of property.

1 **Future Program Actions with the Potential to Impact Then-existing**
2 **Channel Capacity**

3 Throughout Settlement implementation, the maximum downstream extent and rate of
4 Restoration Flows to be released would be limited to then-existing channel capacities. As
5 channel or structure modifications are completed with additional environmental compliance,
6 Restoration Flow releases would be correspondingly increased in accordance with then-existing
7 channel capacities and with the release schedule. If release of water from Friant Dam is required
8 for flood control purposes, concurrent Restoration Flows would be reduced by an amount
9 equivalent to the required flood control release. If flood control releases from Friant exceed the
10 concurrent scheduled Restoration Flows, no additional releases above those required for flood
11 control would be made for SJRRP purposes. Until sufficient data are available to determine the
12 levee seepage and stability Factors of Safety, Reclamation would limit initial Restoration Flow
13 releases to those flows which would remain in-channel. When sufficient data are available to
14 determine the Factors of Safety, Reclamation would limit the release of Restoration Flows to
15 those flows which would maintain standard USACE levee performance criteria at all times.

16 This Report describes both the future Program studies and monitoring and non-program actions
17 with the potential to inform then-existing channel capacity. The future Program technical studies
18 include verification and monitoring of in-channel capacity, the implementation of the San
19 Joaquin Levee Evaluation Project (includes geotechnical exploration and analysis), continued
20 study and updates to the Reach 2A Morphology Study, continued subsidence monitoring and
21 study, as well as a vegetation study. The Program monitoring activities may include: gage
22 monitoring, water surface profile surveys, aerial and topographic surveys, erosion monitoring,
23 vegetation surveys, and suspended sediment monitoring.

24 There are other entities that are active in the Restoration Area and whose programs may help
25 inform or impact then-existing channel capacity. The SJRRP will need to closely coordinate and
26 collaborate with these entities by sharing data and coordinating specific actions along the river
27 that can inform or impact channel capacity. These entities and activities include the Lower San
28 Joaquin Levee District's periodic operation and maintenance of the bypass system and river
29 channel; the U.S. Fish & Wildlife Service operation of weirs within the boundaries of the
30 Merced National Wildlife Refuge along the Middle Eastside Bypass (Eastside Bypass Reach 2),
31 and DWR/FloodSAFE efforts such as the Non-Urban Levee Evaluations and the Regional Flood
32 Management Planning effort. The SJRRP will continue to coordinate with these non-Program
33 efforts and actions, and the CCAG will consider the effect of these actions in future Channel
34 Capacity Reports.

2.0 Introduction

The San Joaquin River Restoration Program (SJRRP) was established in late 2006 to implement a Stipulation of Settlement (Settlement) in *NRDC, et al., v. Kirk Rodgers, et al.* The U.S. Department of the Interior, Bureau of Reclamation (Reclamation), the Federal lead agency under the National Environmental Policy Act (NEPA), and the California Department of Water Resources (DWR), the State lead agency under the California Environmental Quality Act (CEQA), prepared a joint Program Environmental Impact Statement/Report (PEIS/R) to support implementation of the Settlement. The Settlement calls for releases of Interim and Restoration flows. Restoration Flows are specific volumes of water to be released from Friant Dam during different water year types, according to Exhibit B of the Settlement. Interim Flows are experimental flows that began in 2009 and will continue until Restoration Flows are initiated in 2014, with the purpose of collecting relevant data concerning flows, temperatures, fish needs, seepage losses, and the recirculation, recapture, and reuse of released water. Federal authorization for implementing the Settlement is provided in the San Joaquin River Restoration Settlement Act (Act) (Public Law 111-11). Reclamation signed the Record of Decision (ROD) on September 28, 2012. Both the PEIS/R and the ROD committed to establishing a Channel Capacity Advisory Group (CCAG) to determine and update estimates of then-existing channel capacities as needed and to maintain Interim and Restoration flows at or below estimates of then-existing channel capacities. Then-existing channel capacities in Restoration Area (the San Joaquin River between Friant Dam and the confluence of the Merced River) correspond to flows that would not significantly increase flood risk from Interim and Restoration flows. This Channel Capacity Report for the 2014 Restoration Year fulfills the commitments in the ROD. Sections of the PEIS/R applicable to the CCAG are included in Appendix A of this Report.

This Report was available for a 60-day public review and comment period beginning on September 27, 2013 to December 4, 2013. Written comments were received by the U.S. Army Corps of Engineers (USACE) and the Friant Water Authority. The comments and responses are summarized and included in Appendix H of this Report.

2.1 Objective

The primary objective of the report is to provide the CCAG and the public a summary of the prior year's data, methods, and estimated channel capacities and recommendations for monitoring and management actions for the following year.

This Channel Capacity Report is required by the San Joaquin River Restoration Program (SJRRP) PEIS/R and the corresponding ROD. In doing so, it will present data, evaluations, estimates of then-existing channel capacity, and management actions to address levee stability, hydraulics, and sediment transport within the system in accordance with levee performance standards. Identifying then-existing channel capacity is critically important to ensure the release of Restoration Flows in 2014 will not significantly increase flood risk in the Restoration Area. This report only considers flood risks associated with levee failure when estimating then-existing channel capacity. All other potential material impacts, including agricultural seepage, are addressed in other analyses.

1 This report shall be prepared annually in coordination with the CCAG. The purpose of the
2 CCAG is to provide independent review of estimated then-existing channel capacities,
3 monitoring results, and management actions to address vegetation and sediment transport within
4 the systems as identified by the Bureau of Reclamation (Reclamation).

5 **2.2 CCAG Roles and Responsibilities**

6 The CCAG is comprised of the following organizations and representatives:

- 7 • Bureau of Reclamation (Convener):
 - 8 - Pablo Arroyave, Deputy Regional Director (primary)
 - 9 - Alicia Forsythe, SJRRP Program Manager (alternate)
- 10 • CA Department of Water Resources (Co-convener):
 - 11 - Paula Landis, Chief, Division of Integrated Regional Water Management (primary)
 - 12 - Kevin Faulkenberry, Chief, South Central Region Office (alternate)
- 13 • U.S. Army Corps of Engineers:
 - 14 - Adam Riley, Project Manager (primary)
 - 15 - Christy Jones, Lead Water Manager (alternate)
- 16 • Lower San Joaquin Levee District:
 - 17 - Reggie Hill, General Manager (primary)
 - 18 - Robert Tull (alternate)
- 19 • Central Valley Flood Protection Board:
 - 20 - Len Marino, Chief Engineer (primary)
 - 21 - Ali Porbaha, Senior Engineer (alternate)

22 The roles and responsibilities of the CCAG members are as follows:

- 23 • **Provide independent review of Reclamation’s estimates of then-existing channel**
24 **capacity as needed:** Provide an independent review of Reclamation’s estimated then-
25 existing channel capacities, monitoring results, and management actions to address levee
26 stability, hydraulics, and sediment transport within the system estimated by Reclamation in
27 accordance with standard USACE levee performance criteria.
- 28 • **Provide independent review of Channel Capacity Reports:** Annually or in the event
29 Reclamation proposes increasing the upper limit of releases for Restoration Flows,
30 Reclamation will release a public report detailing the new upper limits of releases and data
31 and methods used to develop the new upper limits of releases. The CCAG provides input
32 during the development of these public reports.
- 33 • **Participate in Channel Capacity Advisory Group meetings:** Reclamation organizes
34 working meetings for the CCAG to review progress made in developing the annual reports.

1 These meetings are an opportunity for the CCAG to comment on content as it is developed.
2 CCAG members attend and participate in working meetings.

3 • **Provide independent and timely review of data:** The CCAG provides a timely review of
4 data, analytical methodology, and results used to estimate the then-existing channel
5 capacities.

6 • **Provide input and guidance on monitoring and management actions:** Reclamation
7 provides occasional updates on on-going erosion monitoring and management results –
8 including monitoring of potential erosion sites – to the CCAG. The CCAG provides
9 comments on information provided through these updates.

10 **2.3 Channel Capacity Technical Factors**

11 There are several factors that can impact and limit channel capacity. The following is a summary
12 of the factors that could be considered when evaluating and recommending then-existing channel
13 capacities, as well as determining potential future improvements and other management actions
14 of the SJRRP.

15 • **Levee Integrity** - Channel capacity may be limited if the levee is not constructed to design
16 criteria (e.g., insufficient slope stability Factor of Safety or underseepage Factor of Safety) or
17 if there is insufficient data to assess levee performance. In addition, observations (e.g., boils,
18 sloughing, seepage, etc.) made of the performance of a levee during historical flow releases
19 can also provide information on levee integrity and stability. Considering the observations, as
20 well as other factors may result in an increase or decrease channel capacity.

21 • **Erosion** - Stream bank erosion that encroaches on the levee prism or has a significant
22 potential to encroach on the levee prism increases the potential for levee failure. Therefore,
23 channel capacity may be limited if erosion is present that could result in levee failure during
24 a flow release.

25 • **Duration and Timing and Flow Releases** –The duration and timing of flow releases may
26 cause water to be against a levee for a period of time which could result in the levee
27 becoming saturated. As the levee becomes saturated, seepage through and sloughing of the
28 soil can occur, which could result in the loss of foundation stability and ultimately potential
29 levee failure.

30 • **Sediment Transport** - Sedimentation or scouring may change the geometry of the channel
31 and increase or decrease channel capacity.

32 • **Subsidence** - Ground subsidence may change the geometry of the channel and increase or
33 decrease channel capacity. Subsidence may also reduce freeboard, thus increasing the
34 potential for overtopping during flow releases.

35 • **Vegetation** - In-channel vegetation may impact flow and stage and is measured by channel
36 roughness in a hydraulic analysis. Changes in in-channel vegetation can increase or decrease
37 channel capacity.

38 • **Operation and Maintenance** - Levee operation and maintenance (O&M) programs are
39 necessary to assess changed conditions that could impact channel capacity and to provide

1 flood fight capability in case of levee failure. Channel capacity may be limited if there are
2 inadequate O&M resources to monitor conditions that could affect channel capacity.

3 • **Constructed Improvements** - Levee construction may improve levee integrity or channel
4 geometry and increase channel capacity.

5 • **Additional Factors** - Other future conditions (i.e. climate change, structures, land
6 encroachments, etc.) not listed above, or those recommended by the CCAG will also be a
7 consideration in evaluating channel capacity.

8 The above factors, as well as others are being considered as part of the current or future SJRRP
9 studies and monitoring to determine then-existing channel capacity.

10 **2.4 PEIS/R Summary and Approach**

11 As outlined in the PEIS/R, Reclamation will minimize flood risk from Restoration Flows
12 throughout the Settlement implementation process by undertaking three integrated measures: (1)
13 establish a CCAG and determine and update the estimates of then-existing channel capacities as
14 needed; (2) maintain Restoration flows below estimates of then-existing channel capacities; and
15 (3) closely monitor erosion and perform maintenance and/or reduce Interim and Restoration
16 flows as necessary to avoid erosion-related impacts. The CCAG was established in coordination
17 with Department of Water Resources (DWR) and prior to the release of Restoration Flows in
18 Water Year 2014.

19 Reclamation is to prepare an annual report, which would include data and methods used to
20 develop estimates of then-existing channel capacities. A draft report is provided to the CCAG for
21 its review and comment for a period of 60 days. In the event that comments or recommendations
22 are received from the Advisory Group within 60 days, Reclamation would be required to
23 consider and respond to such comments and prepare a final report for distribution to the CCAG
24 within 60 days of the close of the draft report review period. Reclamation will not increase
25 Restoration Flows above the previously determined then-existing channel capacities until 10
26 days after the final report is prepared and distributed to the CCAG. As described in the PEIS/R,
27 this first draft report is to be completed within 1 year of signing the PEIS/R ROD (September 28,
28 2013). Draft reports include the data, methods, and estimated channel capacities; flow limits and
29 any maintenance activities; and monitoring efforts and management actions. Draft and final
30 reports will be made available to the public concurrent with their distribution to the CCAG.

31 Reclamation will convene the CCAG as required until 2030, but may stop earlier, provided that
32 then-existing channel capacities are determined to equal or exceed the maximum proposed
33 Restoration Flows throughout the Restoration Area. If after 2030 then-existing channel capacities
34 decrease such that full Restoration Flows cannot be conveyed, the CCAG would be reconvened
35 and function as described above until such time that the then-existing channel capacities are
36 determined to equal or exceed the full Restoration Flows.

37 The 2014 Water Year Channel Capacity Report is the first in the series of annual reports. It will
38 focus on establishing the then-existing channel capacities and allow the CCAG to make
39 recommendations as to future data needs to determine then-existing channel capacities.

3.0 Study Area

The San Joaquin River originates from the Sierra Nevada Mountains and carries snowmelt from mountain meadows to the valley floor before turning north and becoming the backbone of tributaries draining into the San Joaquin Valley. It is California's second longest river and discharges to the Sacramento-San Joaquin Delta (Delta) and, ultimately, to the Pacific Ocean through San Francisco Bay.

In 1944, Reclamation completed construction of Friant Dam on the San Joaquin River. With the completion of Friant-Kern Canal in 1951 and Madera Canal in 1945, Friant Dam diverted San Joaquin River water supplies to over 1 million acres of highly productive farmland along the eastern portion of the San Joaquin Valley. In 1959, construction of the Lower San Joaquin River Flood Control Project (LSJRFC Project) began. The LSJRFC Project was completed in 1967 and provides flood protection along the San Joaquin River and tributaries in Merced, Madera, and Fresno Counties. The LSJRFC Project includes 108 river miles (RMs), 191 miles of levees, and protects over 300,000 acres. An additional 67 miles of non-Project levees also provide flood protection along the San Joaquin River.

The study area starts from the Friant Dam and ends at the confluence of the San Joaquin River with the Merced River. The Channel Capacity Report will focus on the portion of the study area where levees exist along channels to control flows. The leveed reaches on the San Joaquin River start at Gravelly Ford (RM 226.9) and continue to the Merced River confluence (RM 118.2). The study area also includes the Eastside Bypass from Sand Slough Connector to the confluence with Bear Creek and the Mariposa Bypass. The study area is shown in Figure 3-1.

The study area reaches are shown in Figure 3-2 and are describe below. Currently SJRRP flows pass through Reaches 1 through 4A, through the Sand Slough Connector Channel and into the Eastside Bypass, where they travel through Eastside Bypass before entering Reach 5 of the San Joaquin River. Since Reach 1 does not have levees, it is not the focus of the analyses included in this report and is not discussed further. Although the flood bypasses upstream of Sand Slough (Chowchilla Bypass and Eastside Bypass Reach 1) are not directly within the study area, they can inform then-existing channel capacities, and are therefore part of the study described in Section 7.2. The flood capacities of each of the reaches within the study area, as part of the overall flood control system are shown in Figure 3-3 (DWR, 1985).

3.1 Reach 2

Reach 2 marks the beginning of the LSJRFC Project levees and therefore the start of this Report's study area. Reach 2 begins at Gravelly Ford and extends approximately 24 miles downstream to the Mendota Pool, continuing the boundary between Fresno and Madera counties. This reach is a meandering, low-gradient channel. Reach 2 is subdivided at the Chowchilla Bypass Bifurcation Structure (CBBS) into two subreaches. Both Reach 2A and Reach 2B were dry in most months prior to the SJRRP. Reach 2A is subject to extensive seepage losses. Reach 2B is a sandy channel with limited conveyance capacity. Reach 2A has a flood design capacity of 8,000 cubic feet per second (cfs) while Reach 2B has a flood design capacity of 2,500 cfs. The levees in Reach 2B are not part of the LSJRFC Project. As part of the SJRRP, setback levees are anticipated to be constructed in Reach 2B to increase its capacity to at least 4,500 cfs.

1 **3.2 Reach 3**

2 Reach 3 begins at Mendota Dam and extends approximately 23 miles downstream to Sack Dam.
3 Reach 3 conveys flows of up to 800 cfs from the Mendota Pool for diversion to the Arroyo Canal
4 at Sack Dam, maintaining year-round flow in a meandering channel with a sandy bed. This reach
5 continues along the boundary between Fresno and Madera counties. The sandy channel
6 meanders through a predominantly agricultural area, and diversion structures are common in this
7 reach. Reach 3 has a flood design capacity of 4,500 cfs. The levees in Reach 3 are also not part
8 of the LSJRFC Project. Flood flows from the Kings River are conveyed to Reach 3 via Fresno
9 Slough and Mendota Dam.

10 **3.3 Reach 4**

11 Reach 4 is approximately 46 miles long, and is subdivided into three distinct subreaches. Reach
12 4A begins at Sack Dam and extends to the Sand Slough Control Structure. Other than short 1-2
13 mile levee segments at the downstream end, levees in Reach 4A are not part of the LSJRFC
14 Project. This subreach is dry in most months except under flood conditions and SJRRP flows.
15 Reach 4B1 begins at the Sand Slough Control Structure and continues to the confluence of the
16 San Joaquin River and the Mariposa Bypass. Only the lower 2 miles of Reach 4B1 levees just
17 upstream of the Mariposa Bypass are part of the LSJRFC Project. All flows reaching the Sand
18 Slough Control Structure are diverted to the flood bypass system via the Sand Slough Bypass,
19 leaving Reach 4B1 perennially dry for more than 40 years, with the exception of agricultural
20 return flows. Reach 4B2 begins at the confluence of the Mariposa Bypass, where flood flows in
21 the bypass system rejoin the mainstem San Joaquin River. Reach 4B2 extends to the confluence
22 of the Eastside Bypass. The levees in this reach are all part of the LSJRFC Project. Reach 4B1
23 has a flood design capacity of 1,500 cfs and Reach 4B2 has a capacity of 10,000 cfs. As part of
24 the SJRRP, setback levees may be constructed in Reach 4B1 to increase its capacity to at least
25 475 cfs and possibly up to 4,500 cfs, depending on the alternative.

26 **3.4 Reach 5**

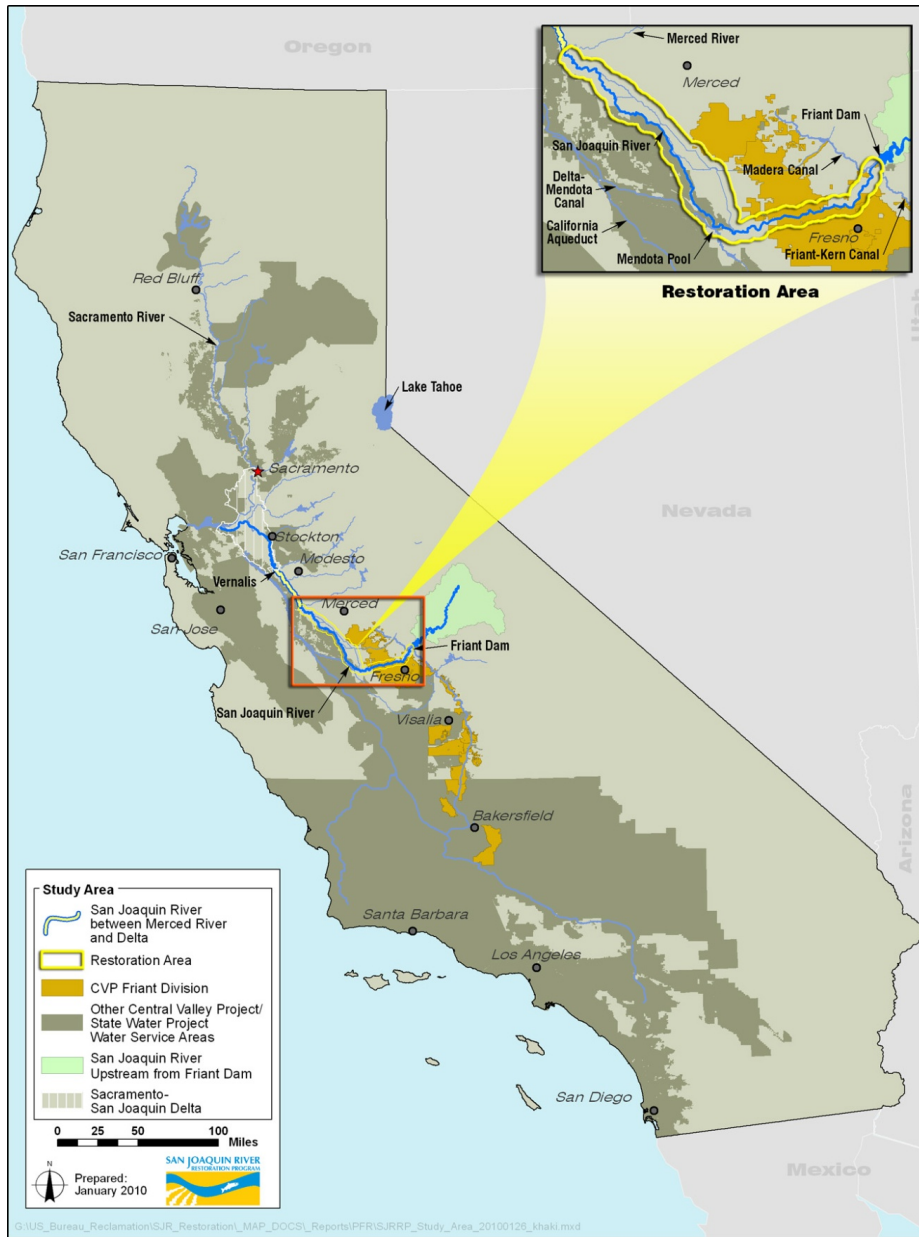
27 Reach 5 of the San Joaquin River extends approximately 18 miles from the confluence of the
28 Eastside Bypass downstream to the Merced River confluence. This reach receives flows from
29 Mud and Salt sloughs, and channels that run through both agricultural and wildlife management
30 areas. Much of Reach 5 includes levees that are within the LSJRFC Project. Reach 5 is the end of
31 the study area and has a flood design capacity of 26,000 cfs.

32 **3.5 Eastside Bypass and Mariposa Bypass**

33 The Middle Eastside Bypass (Reach 2) extends from Sand Slough Connector Channel to the
34 Eastside Bypass Control Structure. Flood flows from Reach 4A of the San Joaquin River and the
35 Upper Eastside Bypass (Reach 1) and the Chowchilla Bypass can be diverted into the bypass at
36 the head of this reach. The Merced Wildlife Refuge is in the middle of this reach of the bypass
37 and diverts some flows to its Refuge by using two weirs. The Lower Eastside Bypass (Reach 3)

San Joaquin River Restoration Program

1 extends from the head of the Mariposa Bypass to the head of Reach 5, and receives flows from
2 Deadman, Owens, and Bear creeks. The Mariposa Bypass extends from the Mariposa Bypass
3 Control Structure to the head of Reach 4B2. A drop structure is located near the downstream end
4 of the Mariposa Bypass that dissipates energy from flows before they enter the mainstem San
5 Joaquin River. The flood design flow for the Middle Eastside Bypass (Reach 2) is 16,500 cfs; the
6 Lower Eastside Bypass (Reach 3) is between 12,000 cfs at its upstream end and 18,500 cfs just
7 downstream of its confluence with Bear Creek; and 8,500 cfs for the Mariposa Bypass. As part
8 of the SJRRP, the Middle and Lower Eastside bypasses may be used for Restoration Flows, but
9 its overall design flood capacity will not be increased.



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Figure 3-1.

San Joaquin River Restoration Program Location

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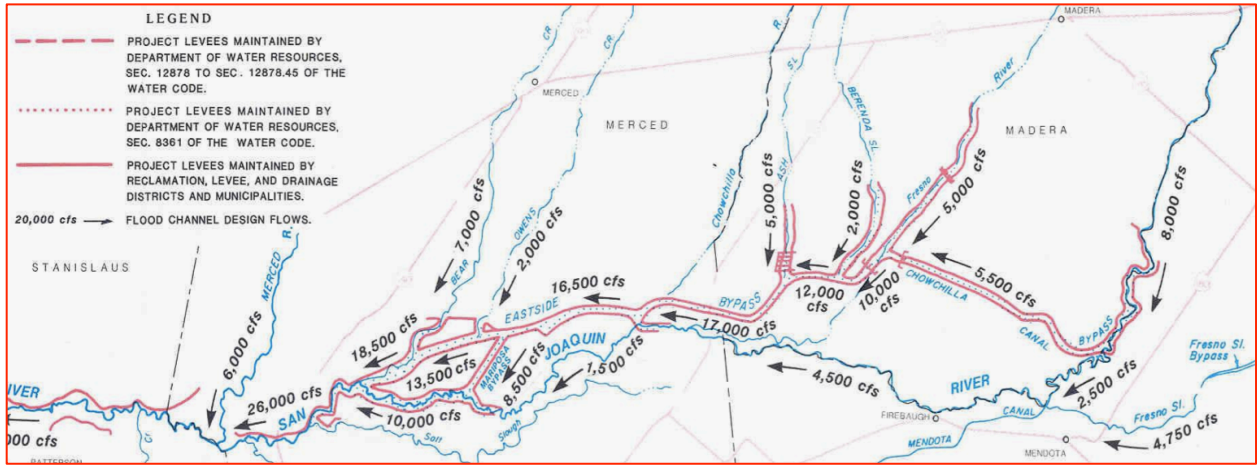
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Figure 3-2.

San Joaquin River Reaches and Flood Bypass System

San Joaquin River Restoration Program



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Figure 3-3.

Flood Channel Design Flows

1 **4.0 Then-existing Channel Capacity Criteria**

2 Then-existing channel capacities are defined by levee stability and seepage and not by other
3 factors like agricultural seepage. This section presents the levee evaluation criteria described in
4 the PEIS/R for determining then-existing channel capacity and briefly describes the process that
5 will be used to collect data and perform analyses to determine levee conditions to further refine
6 then-existing channel capacity estimates.

7 **4.1 PEIS/R Levee Criteria**

8 An objective of the SJRRP is to minimize increases in flood risk due to the release of Restoration
9 Flows. To achieve this objective, the PEIS/R included the levee design criteria developed by
10 USACE in Design and Construction of Levees Engineering and Design Manual (Manual No.
11 1110-2-1913) (USACE 2000) Engineering Manual: Slope Stability (Manual No. 1110-2-1902)
12 (USACE 2003), and Design Guidance for Levee Underseepage (Engineering Technical Letter
13 No. 1110-2-569) (USACE 2005). The levee design criteria and guidelines are to be applied
14 throughout the Restoration Area.

15 The levee criteria are included in the PEIS/R to reduce the risk of levee failure to less-than-
16 significant-levels by meeting levee slope stability and underseepage Factors of Safety. The
17 PEIS/R states that Restoration Flows should not cause the levee slope stability Factor of Safety
18 to be below 1.4, or the underseepage Factor of Safety to be reduced below the value
19 corresponding to an exit gradient at the (landside) toe of the levee of 0.5. The levee slope
20 stability Factor of Safety is defined as the ratio of available shear strength of the top stratum of
21 the levee slope to the necessary shear strength to keep the slope stable (USACE 2003). The
22 application of the levee slope stability Factor of Safety of 1.4 is required for federally authorized
23 flood control projects. The underseepage Factor of Safety is defined as a ratio of the critical
24 hydraulic gradient to the actual exit gradient of seepage on the levee. USACE design guidance
25 recommends that the allowable underseepage factor of safety used in evaluations and/or design
26 of seepage control measures should correspond to an exit gradient at the toe of the levee of 0.5
27 (in general this would provide a Factor of Safety of 1.6), but states that deviation from
28 recommended design guidance is acceptable when based and documented on sound engineering
29 judgment and experience (USACE 2005). The SJRRP will continue to coordinate with DWR,
30 CVFPB, and USACE to ensure appropriate methods and criteria are used in all levee evaluations
31 and design.

32 Until adequate data are available to determine these Factors of Safety, Reclamation would limit
33 the release of Restoration Flows to those that would remain in-channel. In-channel flows are
34 flows that maintain a water surface elevation at or below the elevation of the landside levee toe
35 (i.e., the base of the levee). When sufficient data is available to determine the levee slope
36 stability and underseepage Factors of Safety, Reclamation would limit Restoration Flows to
37 levels that would correspond to the appropriate levee slope stability Factor of Safety of 1.4 or
38 higher and an underseepage Factor of Safety corresponding to an exit gradient at the toe of the
39 levee of 0.5 or lower at all times. Implementing this measure would reduce the risk of levee
40 failure due to underseepage, through-seepage, and associated levee stability issues to less-than-
41 significant levels.

1 In addition, systematic levee condition monitoring would be implemented as described in more
2 detail in PEIS/R Appendix D, “Physical Monitoring and Management Plan.” Observation of
3 levee erosion, seepage, boils, impaired emergency levee access, or other indications of increased
4 flood risk identified through ongoing monitoring at potential erosion sites would indicate that the
5 minimum Factors of Safety are not met and would trigger immediate reductions in Restoration
6 Flows at the site. Such observations would supersede channel capacity estimates, and Restoration
7 Flows would be reduced in areas where these conditions occur.

8 **4.2 Future Evaluation Process**

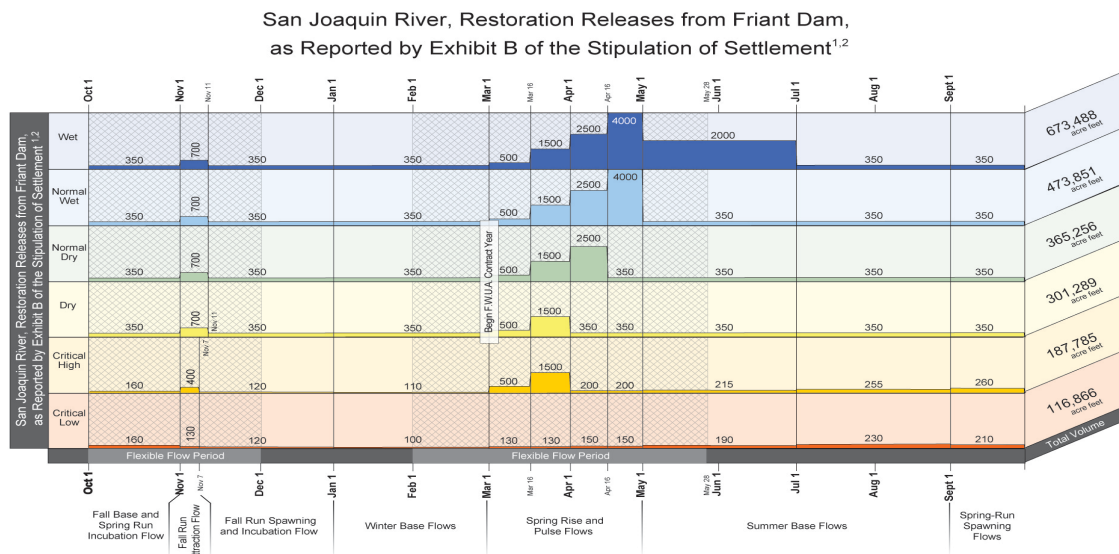
9 The SJRRP will continue to complete and update the studies necessary to determine then-
10 existing channel capacity. This includes, in part, collecting and assessing the necessary
11 geotechnical data to determine the appropriate levee slope stability and underseepage Factors of
12 Safety. To complete this task, the San Joaquin Levee Evaluation Project (SJLE Project) was
13 initiated by DWR. The SJLE Project includes collecting geotechnical data along the river and
14 flood bypasses, evaluating the levee geotechnical performance at various water surface
15 elevations, and identifying levees and appropriate actions to improve levee performance. The
16 goal of this evaluation is to gain adequate information on the levees to determine the levee slope
17 stability and underseepage Factors of Safety. This will provide Reclamation with the necessary
18 information to make decisions on Restoration Flow releases that will reduce the risk of levee
19 failure. Details regarding the process, geotechnical assessment, work completed thus far and
20 timeline for completion are summarized in the Section 10.1.2 - Future Program Studies and
21 Monitoring. A preliminary analysis of three low channel capacity sites along the Eastside Bypass
22 was also performed under the SJLE Project and is described in Section 7.2.

5.0 Data and Analytical Tools

The following sections describe the data and analytical tools used to determine then-existing channel capacity. The sections provide an overview of the restoration hydrograph and hydraulic, sediment transport modeling and levee assessment tools.

5.1 Restoration Hydrograph

The SJRRP flow hydrograph involves a spring and a fall pulse with base flow releases of 350 cfs from Friant Dam in the summer and winter months in most year types. These hydrographs are provided in Exhibit B of the Settlement and the Restoration Flow hydrograph at Friant Dam is summarized in Figure 5-1. Spring flow pulses range from 1,500 cfs maximum release in a critical-high year type, to a 4,000 cfs release in a wet year type. The Restoration Administrator, an independent individual called for in the Settlement, makes recommendations to the Secretary of the Interior on how best to shape the hydrograph to meet the Restoration Goal of the Settlement. The Restoration Administrator has the flexibility to adjust the hydrographs, consistent with the Settlement, including releasing buffer flows of up to 10 percent, mobilizing gravel with an up to 8,000 cfs pulse, and flexibly scheduling the spring pulse volume within a period defined as 28 days in advance of the Settlement Exhibit B hydrographs (i.e. beginning on February 1 with 500 cfs), and 28 days later than the Exhibit B hydrograph (May 28 at 4,000 cfs). The fall pulse volume may be flexibly scheduled from October 1 to November 30. In wet year types, an additional volume is available for riparian recruitment that can extend 60 to 90 days past the end of the spring pulse flow.



¹ - NRDC v Rodgers, Stipulation of Settlement, CIV NO. S-88-1658 - LKK/GGH, Exhibit B, September 13, 2006
² - Hydrographs reflect assumptions about seepage losses and tributary inflows which are specified in the settlement

Figure 5-1.

Restoration Flow Hydrograph at Friant Dam

1 Reclamation uses DWR forecasts to predict the unimpaired inflow to Millerton Lake. Then this
2 volume is allocated to the Friant Division long-term contractors and water users in Reach 1 per
3 Reclamation standard practice, and to the SJRRP using a calculation called Method 3.1 gamma.
4 Reclamation then submits an allocation and a default flow schedule to the Restoration
5 Administrator, with flow volumes by type (i.e., base flow, spring pulse, fall pulse, riparian
6 recruitment). The Restoration Administrator responds with a flow recommendation using the
7 flexibility as described above to change the flow schedule. Reclamation confirms that the
8 Restoration Administrator recommendation is consistent with all applicable regulation
9 (Settlement, Water Board Orders, channel capacity), accepts the recommendation, and then
10 implements the schedule.

11 Based on the schedule identified in the Settlement, Restoration Flows will begin on January 1,
12 2014. At present, the river system is not capable of passing the full Restoration Flows, and so
13 flows are released up to the then-existing channel capacity. This Report provides Reclamation's
14 analysis of then-existing channel capacities, and the CCAG was formed to provide a peer review
15 of that analysis in helping Reclamation determine the recommend flow rates for this river system
16 that can safely be passed. Preparation of this Report and review by the CCAG will continue until
17 such time as the full Restoration Flow hydrograph can be implemented.

18 The studies described in Section 7 of this report evaluate a maximum flow of 4,500 cfs in each of
19 the study reaches. This maximum flow is based on the Settlement required capacity in Reach 2B
20 and Reach 4B. Restoration Flows may be as high as 8,000 cfs in the upper reaches to perform
21 functions such as flushing spawning gravels, but are expected to attenuate so not to exceed
22 existing channel capacity in Reach 2B.

23 **5.2 Hydraulics**

24 One-dimensional (1-D) steady-state Hydrologic Engineering Centers River Analysis System
25 (HEC-RAS) hydraulic models of the 150-mile reach of the San Joaquin River and Bypass
26 System between Friant Dam RM 267.6 and the mouth of the Merced River (RM 118.2) were
27 developed and validated by Tetra Tech, Inc. (Tetra Tech) and DWR to support the SJRRP. Two-
28 dimensional (2-D) hydrodynamic models of all of the reaches except for Reach 5 were developed
29 by Reclamation. DWR developed a site specific model of a 2.5-mile segment of the downstream
30 portion of Reach 2A. The Reach 2A site specific 2-D model was also developed to facilitate the
31 development of the 2-D sediment-transport model that was used to evaluate erosion and
32 deposition in the vicinity of the CBBS that may be affected by the Restoration Flows.

33 **5.2.1 1-D Modeling**

34 The HEC-RAS hydraulic models provide a means of evaluating current 1-D hydraulic conditions
35 along the river and flood bypass system over a range of flows, including those specified in the
36 Settlement and flood events (Tetra Tech, 2013b). The 1-D models have been used to perform a
37 number of analyses, including:

- 38 • Assess channel capacities, including an evaluation of the degree to which sedimentation
39 would affect channel capacities in Reach 2A.
- 40 • Provide input to sediment-transport analyses, including an evaluation of the sediment-
41 transport behavior in Reaches 2A, 2B and 3.

- 1 • Assess potential effects of Restoration Flows on levee underseepage, levee erosion and
2 stability, channel stability and flood carrying capacity.

3 Model geometry for the in-channel and overbank elevations were derived from a Digital Terrain
4 Model (DTM) based on the 2008 LiDAR mapping and in-channel bathymetric data collected by
5 the DWR and Reclamation from 2009 to 2011. Friction losses were accounted for by inputting
6 horizontally and vertically varied Manning's n roughness values. The models were calibrated
7 using flow events in 2010 and 2011 ranging from 160 cfs in Reach 2B to 11,300 cfs in Reach 5.
8 The predicted water-surface profiles from the calibrated water-surface profiles are generally
9 within 0.5 feet of both the surveyed water-surface elevations and the published stage-discharge
10 rating curves at the stream gages throughout the reach over the range of discharges. Reach 4B1
11 cannot be calibrated as flow has not entered the reach since the 1960's.

12 **5.2.2 2-D Modeling**

13 Reclamation has developed 2-D hydrodynamic models for reaches 1B, 2A, 2B, 3, 4A, 4B1, 4B2
14 of the San Joaquin River and the Eastside Bypass. The 2-D models use the depth-averaged St.
15 Venant equations and an unstructured mesh to model water surface elevation, depth, and
16 velocities and report the above plus bed shear stress, critical sediment diameter, and sediment
17 transport capacity at each quadrilateral or triangular mesh cell. Applications of 2-D models for
18 channel capacity studies could include modeling of side channels, bank erosion, local flow
19 velocity and eddy patterns, as well as flow over in-channel bars and levees.

20 The geometry, in-channel and overbank elevations were derived from the same DTM used for
21 the 1-D model geometry. The SRH-2D model uses Manning's n-values to define boundary
22 friction losses associated with hydraulic roughness. Models were calibrated using the same flow
23 range as the 1-D hydraulic models. Similar to the 1-D hydraulic models, the predicted water-
24 surface elevations from the calibrated model are within 0.6 feet of the measured elevations at
25 calibration flows, with most reaches within 0.4 feet of measured elevations.

26 A site-specific 2-D hydrodynamic model was developed for the approximately 2.5-mile reach
27 immediately upstream from the CBBS to provide a basis for the 2-D sediment-transport
28 modeling (Tetra Tech, 2013d). The hydrodynamic portion of the 2.5 mile CBBS model was
29 primarily developed to provide input to the 2-D mobile boundary sediment-transport model
30 (Version 3 of SRH-2D). This model can be used to evaluate detailed hydraulic characteristics in
31 areas where cross-channel effects are important. The elevations of the in-channel and overbank
32 portions of the mesh were derived from the same DTM as the reach specific 2-D models. The
33 SRH-2D model uses Manning's n-values to define boundary friction losses associated with
34 hydraulic roughness and a parametric turbulence model was used to calculate the energy loss due
35 to internal turbulence.

36 **5.3 Sediment Transport**

37 Tetra Tech developed and calibrated a 2-D sediment-transport model for the approximately
38 2.5-mile reach immediately upstream from the CBBS. The model was developed to provide a
39 refined tool that can be used to predict the behavior of the downstream portion of Reach 2A and
40 to provide a more accurate estimate of sediment movement from Reach 2A through the San
41 Joaquin River Control Structure at the CBBS and into Reach 2B under various conditions (Tetra
42 Tech, 2013d). The mesh that was developed for the 2-D hydrodynamic model was adopted for

1 the sediment-transport model; however, adjustments were made to some of the deeper portions
2 of pools to adequately simulate observed sediment transport behavior through the bends. The
3 model was validated by comparing the results from a simulation of the 2010 hydrograph with
4 measured changes based on the change in volume between the 2008 LiDAR mapping and data
5 from 27 cross-sections that were surveyed in November 2010. Additional data collection may be
6 performed to allow continued model refinement and use in future evaluations.

7 **5.4 Geotechnical**

8 A preliminary seepage and stability analyses to evaluate levee impacts in the Middle Eastside
9 Bypass was performed using the 2-D finite element software program SEEP/W, developed by
10 GEO-SLOPE International, Ltd. The model uses topographic and geotechnical data to analyze
11 underseepage and excess pore-water pressure. This is to determine exit gradients and the
12 controlling water surface elevation that may result in failure due to underseepage. The levee
13 slope stability analysis was performed using SLOPE/W, a 2-D limit equilibrium stability analysis
14 software program developed by GEO-SLOPE International, Ltd. following the Spencer Method.
15 The same topography used for the seepage analysis was also used for the slope stability analysis.
16 Pore-water pressures calculated by the SEEP/W models are imported into SLOPE/W. The model
17 uses effective shear strengths for the different soil layers to determine the minimum factor of
18 safety for surfaces that affect the overall stability of the levee for different water surface
19 elevations. It is likely that the SEEP/W and SLOPE/W tools will also be used in the geotechnical
20 evaluations of the San Joaquin Levee Evaluation Project described in Section 10.1.2.

6.0 Current Then-existing Channel Capacity

The PEIS/R states that until adequate data is available to determine the levee slope stability and underseepage Factors of Safety, Reclamation would limit the release of Restoration Flows to those that would remain in-channel. In-channel flows are defined as flows that maintain a water surface elevation at or below the elevation of the landside levee toe (i.e., near the base of the levee). Appendix I of the Draft PEIS/R includes an estimate of the in-channel capacities as determined by DWR using one-dimensional HEC-RAS hydraulic modeling (see Table 6-1). Without having additional geotechnical information regarding the existing levee condition, Reclamation has considered these flows as then-existing channel capacities and has limited Interim Flows to these in-channel capacities to reduce the risk of levee failure due to underseepage and saturation adjacent to the levees. This report describes data collection and evaluations that were used to update these then-existing channel capacity estimates and recommend updated capacities.

Table 6-1
Current In-channel Flow Limits in PEIS/R

Reach	Channel Capacity (cfs)
1A/1B	None
2A	1,060
2B	810
3	2,140
4A	630
4B1	Not Analyzed
4B2	990
5	1,690
Eastside Bypass	600

7.0 Completed Channel Capacity Studies and Related Work

The following section summarizes the technical studies and related work that has been completed at the time of publication of this Report that relate to channel capacities. This includes the latest in-channel capacity study that identifies the in-channel capacities using outside ground elevations, a preliminary geotechnical analysis of the levees that have the lowest in-channel capacities within the Middle Eastside Bypass, a Reach 2A sediment transport study that takes a closer look at the potential sediment and capacities issues upstream of the CBBS, a freeboard capacity study in the bypass that considers subsidence, and a summary of the work associated with the Seepage Management Plan. With the exception of the Seepage Management Plan (which is located on the SJRRP website <http://restoresjr.net/flows/Groundwater/index.html#SMP>), the completed technical studies are included as appendices to this Report. These studies were specifically evaluated to determine the recommended then-existing channel capacities in this Report.

7.1 In-channel Capacity Study

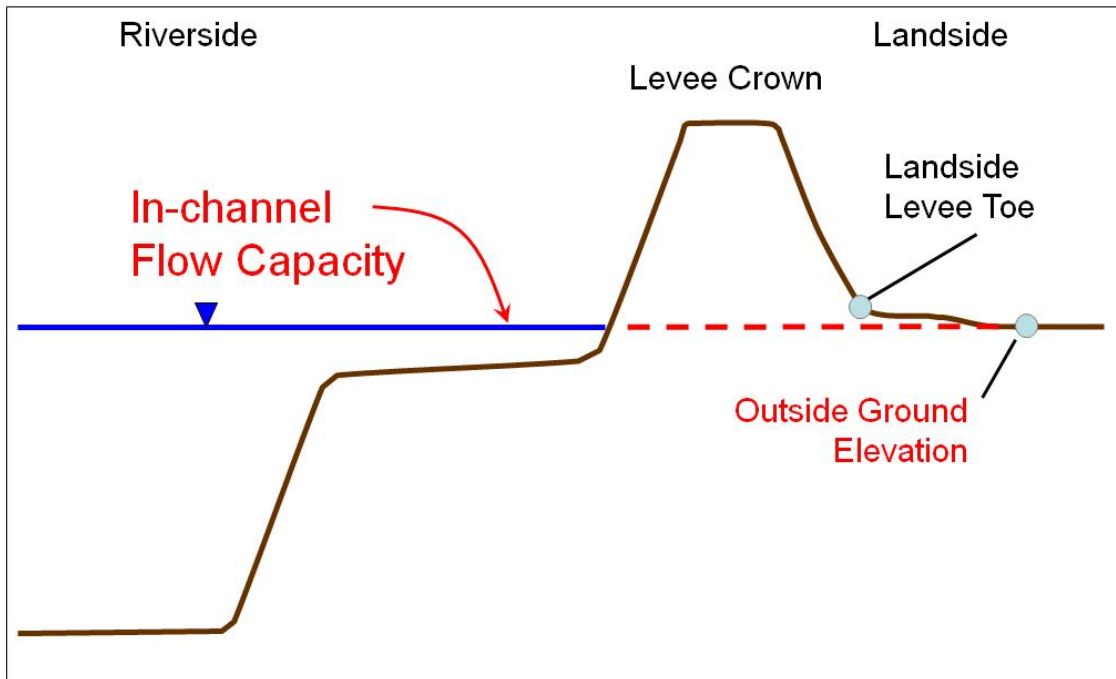
A channel capacity study of the San Joaquin River and the Eastside and Mariposa bypasses between Friant Dam and the confluence with the Merced River was conducted. That study, the *San Joaquin River In-channel Capacity Analysis* (Tetra Tech, 2013e), dated February 14, 2013, is included in Appendix B. This study provides initial channel capacity estimates within leveed reaches that can inform then-existing channel capacity prior to sufficient data becoming available to determine levee slope stability and underseepage Factors of Safety.

In general, the purpose of the study was to identify the flow in each reach at which the water-surface elevation would stay below the levees in each reach. Specific tasks included determining the channel capacity for each reach, as well as the approximate length of the left and right bank levee where the water surface elevation of 2,000 cfs and 4,500 cfs flows exceeded the outside ground elevation. The *Working Draft Framework For Implementation* (Reclamation, 2012), dated Jun 19, 2012, identifies a Restoration Flow release of up to 2,000 cfs as a necessary core action for successful implementation of the Settlement. Therefore, this study also determined the length of levee for the 2,000 cfs threshold. The following sections summarize the study.

7.1.1 Methodology and Assumptions

The in-channel capacity was evaluated for each subreach that is bounded by levees in Reaches 2A, 2B, 3, 4A, 4B2, 5, Middle Eastside Bypass, Lower Eastside Bypass, and the Mariposa Bypass. As part of the SJRRP, new setback levees are being evaluated for Reach 4B1 to safely convey Restoration Flows. Since the current capacity is assumed to be negligible, it is assumed that no Restoration Flows will be conveyed in this reach until channel capacity improvements are made. Therefore, Reach 4B1 was not included in this analysis. Setback levees are also anticipated to be constructed in Reach 2B, but because Restoration Flow releases will be routed through this reach prior to construction so in-channel capacity was evaluated for this reach. This analysis was completed for those levees upstream from the direct influence of the Mendota Pool. The 1-D HEC-RAS hydraulic models, discussed in Section 5.2 - Data and Analytical Tools were used for the analysis. As an initial step, the landside levee toe elevations were identified for each

1 reach. In this analysis, the outside ground elevation adjacent to the landside levee toe was
2 selected to represent the elevation of the landside levee toe. The elevations were identified at
3 each hydraulic model cross-section primarily through inspection of the cross-sectional
4 topography and were verified through review of the aerial photography and contour mapping.
5 The outside ground elevations were selected for both the left and right levees. In-channel
6 capacities reported in this analysis are based on water-surface profiles developed by running the
7 models over a series of local flows. Figure 7-1 is a conceptual figure of the outside ground
8 elevation location and the in-channel flow capacity.



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Figure 7-1.
Levee Schematic Defining Levee Features and In-channel Capacity

12 **7.1.2 Analysis and Results**

13 Computed water-surface profiles were compared to the outside ground elevations adjacent to
14 both the left and right levees along the extent of each reach. The in-channel flow capacity of each
15 reach was determined to be the highest flow rate through the reach where the water-surface
16 elevation is at or below the outside ground elevation for any part of the reach. Results for each
17 reach are described in the following sections and are summarized in Table 7-1.

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**Table 7-1.
Summary of In-channel Capacity for Each Side of Levee by River Reach**

Reach	Levee Side	In-channel Capacity ¹ (cfs)
Reach 2A	Left	2,430
Reach 2A	Right	1,630
Reach 2B (Entire Reach)	Left	0
Reach 2B (Entire Reach)	Right	0
Reach 2B (Excluding Mendota Pool) ²	Left	1,120
Reach 2B (Excluding Mendota Pool) ²	Right	1,550
Reach 3	Left	3,680
Reach 3	Right	2,760
Reach 4A	Left	970
Reach 4A	Right	1,340
Reach 4B2	Left	1,370
Reach 4B2	Right	930 ³
Reach 5 (All Levees)	Left	1,940
Reach 5 (All Levees)	Right	2,500
Reach 5 (Excluding Left Levee downstream of Mud Slough)	Left	2,350
Reach 5 (Excluding Left Levee downstream of Mud Slough)	Right	2,500
Middle Eastside Bypass (Eastside Bypass Reach 2)	Left	10
Middle Eastside Bypass (Eastside Bypass Reach 2)	Right	370
Lower Eastside Bypass (Eastside Bypass Reach 3)	Left	2,970
Lower Eastside Bypass (Eastside Bypass Reach 3)	Right	2,890
Mariposa Bypass	Left	650
Mariposa Bypass	Right	350

3 ¹ Capacity based on outside ground elevations.
 4 ² Portion of reach above influence of Mendota Pool (about RM 209.5).
 5 ³ Capacity excludes localized deep depressions, which would reduce capacity to 50 cfs.

6 In **Reach 2A**, along the right and left levees, the highest local flow for which the water-surface is
 7 at or below the outside ground elevation is 1,630 and 2,430 cfs, respectively (Figures 3 through 5
 8 in Appendix B). For about 3.3 miles of this reach, the water surface at Restoration Flows of
 9 4,500 cfs would be at or above the outside toe of the levee.

1 In **Reach 2B**, outside ground elevations along the lower portion of this reach are generally lower
2 than the normal pool elevation at Mendota Dam (Figures 6, 7, 8, and 9 in Appendix B). When
3 considering the entire reach, including Mendota Pool, the capacity along both sides of the
4 channel is 0 cfs. As a result, the existing flow capacity was evaluated for the entire reach as well
5 as only for the portion of the reach upstream from the influence of the pool. When only the
6 portion of the reach upstream from the influence of the pool is considered, the highest local flow
7 in which the water surface is at or below the outside ground elevation is about 1,120 cfs along
8 the left levee and 1,550 cfs along the right levee. For about 17.7 miles of this reach, the water
9 surface at Restoration Flows of 4,500 cfs would be at or above the outside toe of the levee
10 (includes the levees influenced by Mendota Pool).

11 In **Reach 3**, outside ground elevations are reasonably high along much of the reach except for an
12 area immediately upstream of Sack Dam (Figures 10 through 12 in Appendix B). Flow capacity
13 in this area is limited by a depression on the right side that has a capacity of 2,760 cfs. On the left
14 side of the channel, the capacity of the outside ground elevation is 3,680 cfs. For about 7.1 miles
15 of this reach, the water surface at Restoration Flows of 4,500 cfs would be at or above the
16 outside toe of the levee.

17 In **Reach 4A**, the maximum local flow for which the water-surface is at or below the outside
18 ground elevation is 1,340 cfs for the right levee and 970 cfs for the left levee (Figures 13 through
19 16 in Appendix B). The water surface elevation is above the outside ground for almost all of the
20 Reach at 4,500 cfs. For about 17.8 miles of this reach, the water surface at Restoration Flows of
21 4,500 cfs would be at or above the outside toe of the levee.

22 In **Reach 4B2**, the ground adjacent to the right levee in Reach 4B2 has many depressions, but
23 due to one localized and deep depression along the right levee, the in-channel capacity is limited
24 to about 50 cfs (Figures 17 through 20 in Appendix B). Aerial photographs and contour mapping
25 indicate that these depressions are relatively small, and can contain water even at low flows,
26 which would not make them a levee stability issue. If these local, right side depressions are
27 excluded from the analysis, the capacity along the right levee increases to 930 cfs. The outside
28 ground along the left levee is not as low, which results in an in-channel capacity of
29 approximately 1,370 cfs. For about 14.0 miles of this reach, the water surface at Restoration
30 Flows of 4,500 cfs would be at or above the outside toe of the levee.

31 In **Reach 5**, most of the areas with limited capacities occur along the mid- to upper- portion of
32 this reach, but one exception is a levee feature that exists along the left side of the channel near
33 the downstream end of the reach (Figures 21 through 24 in Appendix B). The highest local flow
34 for which the water-surface is at or below the outside ground elevation is 1,940 and 2,500 cfs
35 along the left and right levees, respectively. However, since much of the outside ground adjacent
36 to the left levee contains many local depressions, these results likely represent a conservative
37 estimate of the in-channel flow capacity in this reach. For about 3.7 miles of this reach, the water
38 surface at Restoration Flows of 4,500 cfs would be at or above the outside toe of the levee.

39 In the **Middle Eastside Bypass** (Eastside Bypass Reach 2), at the upstream end of this reach, the
40 channel bed is near the elevation of the ground outside of the levees on both the right and left
41 sides. The computed water-surface profiles indicate that the highest local flow for which the
42 water-surface is at or below the outside ground elevation along the left levee is about 10 cfs, and
43 along the right levee is 370 cfs. These low in-channel capacities are the result of the low outside
44 ground elevations compared to the channel bed. However, a low-flow channel keeps much of
45 these flows confined several hundred feet away from the levees. So, to better characterize the

1 potential levee impacts along the reach, sites with a capacity of less than 300 cfs were identified
2 and a preliminary geotechnical analysis was completed (see Section 7.2).

3 In the **Lower Eastside Bypass** (Eastside Bypass Reach 3), the computed water-surface profiles
4 indicate that the highest local flow for which the water-surface is at or below the outside ground
5 elevation along the left levee is 2,970 cfs and along the right levee is 2,890 cfs (Figures 29
6 through 31 in Appendix B). For about 3.6 miles of this reach, the water surface at Restoration
7 Flows of 4,500 cfs would be at or above the outside toe of the levee.

8 In the **Mariposa Bypass** along the left and right levees, the highest local flow for which the
9 water-surface is at or below the outside ground elevation is 650 and 350 cfs, respectively
10 (Figures 32 through 35 in Appendix B). As evident from the low in-channel capacity, the outside
11 ground elevations in this reach are relatively low when compared to the main flow channel, but
12 they are also relatively uniform throughout the entire reach. For about 6.6 miles of this reach, the
13 water surface at Restoration Flows of 4,500 cfs would be at or above the outside toe of the levee.

14 **7.2 Middle Eastside Bypass Geotechnical Assessment**

15 The In-channel Capacity Study (Section 7.1) identified three locations along the Eastside Bypass
16 with unusually low channel capacities ranging from 10 cfs to 240 cfs. As a preliminary
17 component of the SJLE Project, and to further investigate in-channel capacity results in the
18 Middle Eastside Bypass relative to levee performance, preliminary levee seepage and stability
19 analyses were completed at each of these three sites. Analyses of the remainder levees of the
20 Eastside Bypass will be performed under subsequent SJLE Project tasks. This preliminary
21 analysis was performed to better understand the potential levee seepage and stability impacts in
22 the reach with high ground elevations along the landside levee toe resulting in unreasonably low
23 in-channel capacity. That analysis, the *Middle Eastside Bypass Geotechnical Assessment* dated
24 August 30, 2013 (URS, 2013), is included in Appendix C. The analyses were conducted using
25 geotechnical exploration data collected as part of the SJLE Project, which will be documented in
26 subsequent SJLE Project data reports. Additional geotechnical analyses in this and other reaches
27 will be completed as part of the SJE Project (see Section 10.1) and documented in subsequent
28 SJLE Project analysis reports.

29 **7.2.1 Background and Past Levee Performance**

30 Until adequate data are available to determine levee performance, the SJRRP is limiting the
31 release of Restoration Flows to those that would remain in-channel. The purpose of this analysis
32 is to determine the amount of water that can be placed on the waterside levee slopes without
33 exceeding geotechnical criteria for stability and seepage at the three critical sites along the left
34 levee of the Middle Eastside Bypass (Figure 1, Appendix C). Site 1 occurs in the upper portion
35 of the reach with an in-channel capacity of 10 cfs. Site 2 is located adjacent to the Merced
36 Wildlife Refuge and has an in-channel capacity of 120 cfs. Site 3 occurs about 6,500 feet
37 downstream of Site 1 and has an in-channel capacity of 230 cfs.

38 Documented past performance events in the area of the Middle Eastside Bypass include seepage,
39 boils, sloughing, cracking, widespread erosion, and near overtopping. However, there have been
40 no documented reports of breaches. Based on the observations made by the Lower San Joaquin
41 Levee District (LSJLD) staff, the primary issues appear to be chronic seepage and inundation
42 once water gets on to the waterside levee slopes (i.e., not necessarily highwater events).

1 Underseepage may cause piping and internal erosion of material due to excessive pore water
2 pressure under the foundation blanket layers, and may negatively impact slope stability by
3 reducing effective stresses in both embankment and foundation soils. Underseepage conditions
4 are generally expressed by an average vertical exit gradient. Excessive gradients can result in the
5 formation of sand boils, piping and levee failure if left unrepaired.

6 **7.2.2 Geotechnical Approach and Criteria**

7 The analyses completed at the three sites were limited to levee seepage and stability. Due to the a
8 lack of exploration data along the levee toe, cross sections were developed at the sites using
9 available levee crest drilling data that was laterally extrapolated to capture the landside and
10 waterside toes. At each site, sensitivity cases were analyzed for four different water surface
11 elevations (WSE), which were used to interpolate the WSE corresponding to acceptable criteria
12 for seepage and stability.

13 For the seepage analysis, underseepage conditions are generally expressed by an average vertical
14 exit gradient. The average vertical exit gradient criteria used for the assessment are shown in
15 Table 4-1 of Appendix C. The allowable vertical gradients range from less than 0.5 for the
16 landside levee toe, and between 0.5 and 0.8 for landward locations up to 150 feet from the levee
17 toe.

18 For the slope stability analysis, the same stratigraphy and models used in the seepage analysis
19 were used to assess slope stability. A factor of safety number is typically used to characterize the
20 stability of a slope, which is the ratio of the available shear strength to the shear strength required
21 for equilibrium. A minimum factor of safety of 1.4 is required for slip surfaces that could affect
22 the overall stability of the levee (i.e. deeper seated failures that intersect with the levee crown
23 and impact the full height of the levee).

24 The three sites were analyzed for seepage and slope stability using a series of sensitivity models
25 to cover a range of possible field conditions. Soil strength and seepage parameters selected for
26 the analysis were determined using a combination of exploration data, engineering judgment, the
27 knowledge of the materials in the area and the recommendations of the DWR Levees and
28 Evaluations Program.

29 **7.2.3 Analysis and Results**

30 At **Site 1**, a 3 feet to 4 feet deep landside ditch is located approximately 30 feet from the landside
31 levee toe. Based on the exploration data available, the levee embankment is comprised of a
32 mixture of silty and clayey sand, silt and clay. Subsurface materials consist of silts and clays with
33 interbeds of silty sand and clayey sand. Due to variability of the landside blanket conditions and
34 the presence of the ditch, a sensitivity analysis was completed assuming varying blanket
35 thicknesses ranging from 1.5 feet to 10 feet thick. In general, the analysis shows that
36 underseepage is the controlling geotechnical failure mode for the Site 1 if the landside ditch is
37 empty and slope stability if the landside ditch is full. Approximately 1-foot (ditch empty) and
38 about 5 feet (ditch full) of water on the levee would be acceptable for this site.

39 At **Site 2**, where there is no landside ditch, available exploration data shows the levee
40 embankment is comprised of silts and clays. Subsurface materials are similar to those at Site 1,
41 but overall the landside blanket is thicker. A landside 12.5 foot-deep-blanket was assumed and
42 sensitivity analysis consisted of reducing the strength parameters for the top three soil layers and
43 increasing the permeability contrast between the blanket and the underlying aquifer layer. The

1 analysis shows that landside slope stability is the controlling geotechnical failure mode and
 2 approximately 6.5-foot of water on the levee would be acceptable for this site.

3 At **Site 3** there is also not a landside ditch, but there is a slight landside depression approximately
 4 30 feet landward of the landside levee toe. Based on the exploration data available, the levee
 5 embankment is similar to Site 2. Subsurface materials are comprised of silts and clays with
 6 interbeds of sand, silty sand and clayey sand. The landside blanket is variable in this area, but
 7 was assumed to be between 5- to 6-foot-thick. Two sensitivity analyses were completed that
 8 consisted of modifying the boundary conditions, and increasing the permeability contrast
 9 between the blanket and aquifer. In general, the analysis shows that underseepage is the
 10 controlling geotechnical failure mode and approximately 3.5-foot of water on the levee would be
 11 acceptable at this site.

12 Table 7-2 summarizes the acceptable maximum water surface elevation, and approximate height
 13 of water on the waterside levee toe compared to the relative outside ground elevation. The
 14 analysis results and recommendations summarized in Table 7-2 and in Appendix C are based on
 15 preliminary data and the results and recommendations should be refined once more detailed
 16 information becomes available.

17 **Table 7-2.**
 18 **Summary of Preliminary Analysis Results for Channel Capacity Assessment¹**

Site	Maximum Water Surface Elevation (feet, NAVD88)	Approximate Height of Water on the Levee ²
1	100.7	1.2
2	104.0	6.5
3	101.7	3.7

20 ¹ Height of water on the levee at a particular location does not necessarily translate directly to another site, i.e. if water were at
 21 a height of 1 foot on the levee at Site 1 then the height of water on the levee at a different location could be different.

22 ² Height of water relative to the typical outside ground elevation

23 After the acceptable WSEs were determined at the critical sites, the 1-D HEC-RAS hydraulic
 24 models were used to determine the corresponding flow at each site. For Site 1, the flow that
 25 corresponds to 100.7 feet (NAVD88) is about 520 cfs. For Site 2, the flow that corresponds to
 26 104.0 feet (NAVD88) is greater than 4,500 cfs. For Site 3, the flow that corresponds to 101.7 feet
 27 (NAVD88) is about 2,270 cfs. These flows are higher than the report in-channel capacity flows
 28 identified in Section 7.1 above. However, because the right levee in-channel critical site is
 29 370 cfs and was not part of the preliminary geotechnical assessment, the in-channel capacity of
 30 the Middle Eastside Bypass is 370 cfs.

31 **7.3 Reach 2A Sedimentation Study**

32 Two phases of a sedimentation study in Reach 2A were completed to evaluate the potential
 33 impacts of sediment deposition on channel capacity. The study was only carried out in the lower
 34 portion of Reach 2A due, in part, to visual evidence of sediment deposition upstream from the
 35 CBBS that may have been a result of the 2009 through 2011 Interim Flow releases and the 2010
 36 and 2011 flood flow releases.

1 **7.3.1 Background**

2 The sedimentation study involved assessing the channel changes using topographic data and was
3 performed as a response to concerns by the LSJLD that sediment accumulation near the CBBS
4 would affect operation of the CBBS and capacity of the reach. An initial assessment was
5 completed in 2010, which then led to an expanded two-phase study in 2011 and 2012 and
6 technical memorandums published for each phase (Tetra Tech 2012, 2013a). The *Reach 2A*
7 *Sedimentation Evaluation (2011)*, dated April 17, 2012, and *Reach 2A Sedimentation Evaluation*
8 *(2012)*, dated March 1, 2013, reports are included in Appendix D and E, respectively. This
9 section describes the work and results from the two-phase study.

10 **7.3.2 Methodology**

11 Twenty-seven cross-sections were surveyed in the downstream approximately 2.7 miles of Reach
12 2A in November 2010, when the flow was about 120 cfs. These cross-sections were located at
13 the existing HEC-RAS hydraulic model cross-sections in this part of the reach. The surveys were
14 repeated in November 2011 and June 2012 to assess ongoing effects of the Interim Flow
15 releases.

16 The cross-sectional survey data were analyzed by overlaying them onto the 2008 LiDAR-based
17 cross-sections to evaluate how the shape of the channel has changed since 2008. The
18 comparative data were also used to compute changes in minimum bed (i.e., thalweg) elevation
19 by developing thalweg profiles for each data set. While the thalweg analysis quantifies the
20 change in elevation of the deepest part of the channel, this is not necessarily a good indication of
21 the overall aggradation/degradation tendency at each location because other parts of a particular
22 cross-section can build or degrade in the opposite direction from the thalweg change. To provide
23 a more accurate assessment of the overall aggradation or degradation tendencies, the mean bed
24 elevation at each cross-section was computed by subtracting the hydraulic (or cross-sectionally
25 averaged) depth from a common reference elevation, and the resulting elevations compared
26 between the various surveys. Lastly, the overall aggradation/degradation response of the
27 surveyed reach was used to estimate the change in sediment volume based on the distances
28 between the cross-sections.

29 The cross-section survey data collected in November 2010, November 2011, and June 2012 were
30 also used to update cross-sectional geometry in the existing conditions HEC-RAS hydraulic
31 model, and the updated model was run over the range of Interim Flows to evaluate potential
32 changes in the water surface elevations during the 2008 to 2012 period. Calibration of the
33 updated model was checked by estimating the discharge associated with each measured point,
34 running the model for the range of flows in the reach during the survey period, and comparing
35 the estimated and measured water surface elevations. The predicted water surface profiles agree
36 very well with the measured data over the entire surveyed reach, indicating the model is well
37 calibrated.

38 **7.3.3 Results**

39 Analysis of the 2008 LiDAR and subsequent cross-section survey data resulted in some general
40 conclusions about trends in the lower few miles of Reach 2A. First, it appears that lower peak
41 flows, such as those experienced in 2009, 2010, and 2012, slightly degrade most of the study
42 reach with the exception of the 400 to 600 foot reach immediately upstream of the CBBS. The
43 reach near the CBBS tends to aggrade under those conditions. Second, it appears that during

1 relatively high peak flow seasons, such as that experienced in 2011, the reach immediately
2 upstream of the CBBS scours and the rest of the study reach experiences modest degradation.
3 Analysis of HEC-RAS output for each set of cross-section geometries showed consistent results.
4 For all years (2010 – 2012), the predicted water surface in the approximately 1,500-foot reach
5 just upstream from the CBBS is less than 0.35 feet higher than the 2008-based model results. For
6 the rest of the reach, the 1,000-cfs water surface is progressively lower with each set of survey
7 data. Similar trends occur at 2,000 and 4,000 cfs to a lesser extent. These results suggest that the
8 4-year degradation trend in the majority of Reach 2A has tended to reduce the water-surface
9 elevations by a small amount at high flows, and this trend can be expected to continue with
10 continued degradation. In the reach just upstream of the CBBS, the slight increase in bed
11 elevations showed only a minor increase in water surface elevations up to 4,000 cfs.

12 **7.4 Bypass Subsidence Study**

13 Subsidence along the Eastside Bypass has been identified in Madera and Merced Counties. The
14 USACE, DWR, Reclamation, and the U.S. Geological Survey (USGS) have completed several
15 studies and mapping efforts to determine the extent and magnitude of the subsidence. RBF
16 Consulting completed a quality control survey of the 2008 LiDAR data in 2010 under DWR's
17 Central Valley Floodplain Evaluation and Delineation (CVFED) Program that showed the major
18 locations of subsidence along the bypass and San Joaquin River. A contour map (Figure 7-2)
19 prepared by Reclamation that incorporates data from a variety of sources shows the primary
20 areas impacted by subsidence.

21 DWR has also performed a preliminary study of the potential impact of subsidence on flow
22 capacity and freeboard in the Chowchilla and Eastside bypasses between the San Joaquin River
23 at the CBBS and the Mariposa Bypass. Although the Chowchilla Bypass and Upper Eastside
24 Bypass are not included in the SJRRP project area, the capacity of these reaches of the bypass
25 could impact how flows are routed through the system for the SJRRP. That hydraulic evaluation
26 study, *Evaluation of the Effect of Subsidence on Flow Capacity in the Chowchilla and Eastside*
27 *Bypasses*, dated November 2013, is included in Appendix F (DWR-SCRO, 2013) and is
28 summarized below.

29 **7.4.1 Study Topography and Tools**

30 DWR collected topographic survey data in late 2012 to help further refine the estimated annual
31 subsidence rates along the flood bypasses. DWR then estimated subsidence rates based on
32 comparison of the levee profiles from the 2008 LiDAR and the surveyed 2012 levee profiles
33 (Figures 2 and 3 of Appendix F). The subsidence rates estimated by DWR match reasonably well
34 with other data sources, but a few differences in rates were noted and were likely the result of the
35 time frames that the data was taken, as well as the accuracy and geographical coverage of the
36 data.

37 The study was conducted using the calibrated 1-D steady state HEC-RAS models described in
38 the Section 5.2 -- Data and Analytical Tools. Using the annual estimated subsidence rates
39 determined by DWR, the model was developed to reflect 2011 by adjusting the topography to
40 reflect the subsidence between the date of the LiDAR survey and the target date of the analysis
41 (e.g., 2011). Using the annual subsidence rates, the 2011 model was adjusted again to simulate
42 2016 future conditions.

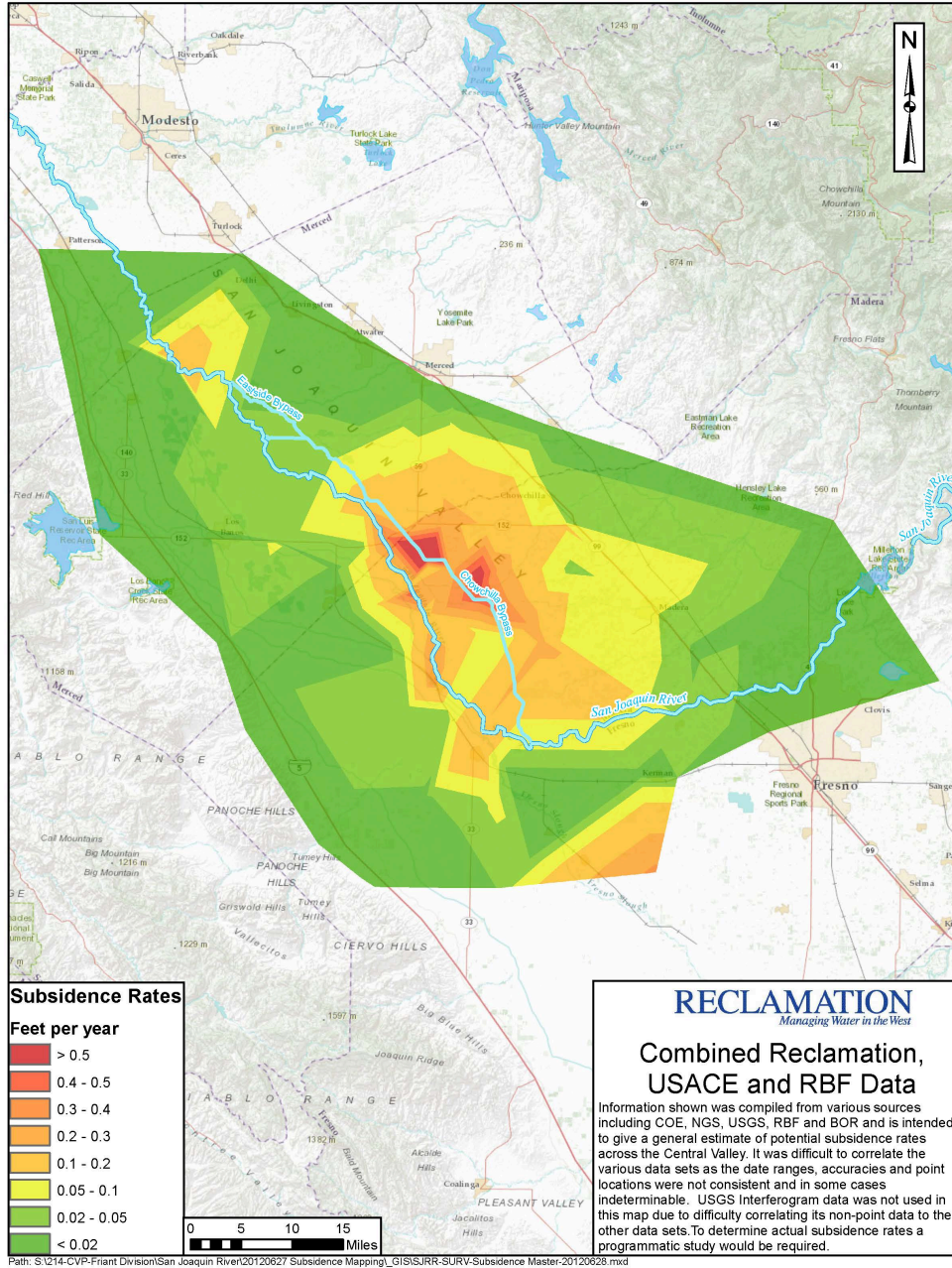
1 **7.4.2 Analysis and Results**

2 The hydraulic models were used to evaluate freeboard and flow capacity on the bypass levees
3 using flood design flow capacity rates published in the LSJRFC Project's O&M Manual. The
4 design flow capacities for the Chowchilla and Eastside bypasses were input into the models to
5 evaluate water surface elevations and evaluate freeboard under 2008, 2011, and estimated 2016
6 topography conditions. The results of the analysis showed that the modeled water surface
7 elevations for 2011 and 2016 are generally lower than those of 2008, corresponding to the
8 lowering of the ground due to subsidence. Because the ground is subsiding at different rates
9 along the reaches, the total amount of subsidence that has occurred at each cross section will not
10 be the same as the total amount of water surface elevation change at each cross section.
11 Furthermore, ground subsidence tends to steepen some segments of the reach that results in a
12 decrease in water depth and an increase in freeboard.

13 The results of modeling the design flow capacities in the bypasses indicate that freeboard in 2008
14 and 2011 is generally above 3 to 5 feet along most of the bypass except between Sand Slough
15 and West Washington Road, which is an area of recurring sediment deposition. From 2011 to
16 2016, it is expected that the continuing subsidence will reduce the freeboard in this area by about
17 0.5 feet. In the peak subsidence area between Road 4 and Avenue 21, ongoing subsidence is
18 estimated to decrease the freeboard from 2011 to 2016 an additional 1.5 feet. For Highway 152,
19 the projected decrease in freeboard is about 0.7 feet. The opposite is true within the proximity of
20 Avenue 18 ½ where the freeboard will actually increase from 2011 to 2016 by about 0.7 feet due
21 to the increase of the channel slope as a result of the subsidence.

22 Along the Eastside Bypass from Ash Slough to Sand Slough, flow capacity from 2008 to 2011
23 was reduced by 1,000 cfs and another 1,500 cfs in 2016 if subsidence continues at the same
24 assumed in the study. When flood inflows enter the Eastside Bypass from the San Joaquin River
25 upstream of Sand Slough (a typical routing situation as flooding on the Kings River generally
26 coincides with floods on the San Joaquin River) the backwater conditions inundates the upstream
27 area and further reduces the flow capacity in this segment of the Upper Eastside Bypass. Along
28 the Middle Eastside Bypass from Sand Slough to the Mariposa Bypass, the flow capacity at
29 4 feet of freeboard was reduced from 2008 to 2011 by about 2,500 cfs and by another 1,500 cfs
30 in 2016 if subsidence continues at the same assumed in the study.

31 Subsidence is changing the amount of freeboard in the bypasses, which affects their ability to
32 convey flows. Flow capacity in the bypasses has been reduced as a result of subsidence by up to
33 2,500 cfs since 2008. If subsidence continues, it is estimated that an additional loss in flow
34 capacity up to 1,500 cfs from 2011 to 2016 depending on the segment of bypass.



1
2
3

Figure 7-2.
Regional Subsidence Map

1 **7.5 Seepage Management Plan**

2 Reclamation has developed a Seepage Management Plan to guide efforts related to groundwater
3 seepage. It should be noted that the actions and findings of the Seepage Management Plan,
4 although related to channel capacity as it relates to agricultural seepage, would not be directly
5 considered in the determining then-existing channel capacities relating to levee seepage and
6 stability. However, data collection and seepage projects will be closely coordinated to determine
7 effect on channel capacities. The SJRRP will continue to limit Restoration Flows to levels that
8 do not result in material adverse impacts due to groundwater seepage, which may be more
9 limiting than levee seepage and stability.

10 Landowners farming adjacent to the San Joaquin River may experience impacts from Restoration
11 Flows via groundwater tables rising and waterlogging crops or bringing salts from groundwater
12 into the root zone, reducing crop yields. To address these potential impacts, Reclamation has
13 installed over 180 shallow groundwater monitoring wells since 2009 and takes weekly
14 measurements in most of these, with monthly measurements in the rest. Monitoring well
15 locations have been chosen initially in areas of public access where landowners were unwilling
16 to provide access to Reclamation, and then in areas chosen by landowners as likely to experience
17 surface ponding during flood flow. Reclamation has set thresholds in these monitoring wells
18 based on the root zone of the crop type grown in the adjacent field, plus a capillary fringe buffer.
19 In some areas, thresholds have been set based on the historical groundwater levels in the area, if
20 these are shallower than the ideal crop root zones published in literature.

21 Reclamation operates such that groundwater levels do not exceed thresholds due to Restoration
22 Flow releases. In most areas, the predicted rise in stage in the river is added to the most recent
23 groundwater level measurement to conservatively predict the new groundwater level. If this level
24 is above the threshold, the flow release is constricted. In areas with continual shallow
25 groundwater above thresholds, and not caused by river flows, a drainage method is used, such
26 that the water surface elevation in the river is kept below the elevation of the threshold in the
27 well. These thresholds currently constrict flows below Sack Dam to approximately 70 cfs.

28 Reclamation has also developed a Seepage Project Handbook, intended to guide a process of
29 implementing projects to release Restoration Flows over time while avoiding material adverse
30 groundwater seepage impacts. Potential projects include interceptor drains, slurry walls, drainage
31 ditches, shallow groundwater pumping, increasing the land surface through adding soil,
32 removing sediments from the river or bypass channel, seepage easements, license agreements,
33 and acquisition of property. There are 93 groups of assessor parcels that may need seepage
34 projects and will be evaluated for impacts. Reclamation will be gradually implementing seepage
35 projects by parcel group based on flow restriction. Reclamation plans to implement the first 3
36 projects in 2014. The Seepage Management Plan and Seepage Project Handbook can be found at
37 the SJRRP website under the following link:

38 <http://restoresjr.net/flows/Groundwater/index.html#SMP>.

8.0 Recommended Then-existing Channel Capacities

The purpose of this section is to recommend then-existing channel capacities based on results from the current channel capacity studies summarized in the previous sections of this report. Then-existing channel capacities are defined as flows that would correspond to the appropriate levee slope stability and underseepage Factors of Safety based on USACE criteria for levees. The application of the criteria requires the collection and evaluation of data at locations throughout the Restoration Area. Until adequate data are available to apply the USACE criteria, the release of Restoration Flows would be limited to those that would remain in-channel (the water surface elevation in the river remains below the levees).

The studies described in Section 7.0 -- Completed Channel Capacity Studies and Related Work were analyzed for determining then-existing channel capacity. Of the five studies analyzed, two of the studies, the Reach 2A Sediment Transport Study and the Bypass Subsidence Study, did not directly identify then-existing channel capacities for each reach. The Reach 2A Sediment Transport Study summarized in Section 7.3 showed that changes in the channel bed as a result of Interim and Restoration flows do not have a significant impact on water surface elevations in the lower portion of Reach 2A. The Bypass Subsidence Study summarized in Section 7.4 focused on capacity within the flood bypasses at higher design flood flows, and only considered flow capacity and levee freeboard, not levee integrity. The Seepage Management Plan described in Section 7.5 provides useful information regarding the impacts of flow on agricultural seepage, but this information does not directly relate to then-existing channel capacity with respect to levee stability.

Considering the above studies, the In-channel Capacity Study summarized in Section 7.1 and the Geotechnical Analysis of the Middle Eastside Bypass summarized in Section 7.2 provides the best information for determining then-existing channel capacities. The results in these two studies were used to recommend then-existing channel capacities in this report. Using in-channel capacity as the best estimate of then-existing channel capacities is consistent with information contained in the PEIS/R and what Reclamation used in the 2013 and previous water year to limit the release of Interim Flows for levee stability concerns. The only exception is the Middle Eastside Bypass, in which adequate data was available to perform a geotechnical evaluation to determine an acceptable depth of water on levees at three sites for the 2014 water year. Additional geotechnical analyses will be complete in other reaches as the data becomes available (Section 10.1.2).

Based on the results summarized in Sections 7.1 and 7.2 and detailed in Appendices B and C, the recommended then-existing channel capacities for the San Joaquin River and flood bypasses are described below.

- The recommended then-existing channel capacity for Reach 2A is 1,630 cfs based on a low point along the right levee approximately 1.6 miles upstream from the CBBS.
- The recommended then-existing channel capacity for Reach 2B is 1,120 cfs based on a low point along the left levee approximately 4.6 miles upstream of the Mendota Dam. The influence of the Mendota Pool was not considered because normal pool water surface elevations in the pool are already higher than some outside ground elevations adjacent to levees and Restoration Flows would not significantly change this water surface due to the requirements to operate Mendota Dam to maintain a relatively constant pool elevation.

- 1 • The recommended then-existing channel capacity for Reach 3 is 2,760 cfs based on a low
2 depression along the right levee about 11.4 miles upstream of Sack Dam.
- 3 • The recommended then-existing channel capacity for Reach 4A is 970 cfs based on a low
4 area along the left levee just upstream of Sand Slough.
- 5 • The recommended then-existing channel capacity for Reach 4B2 is 930 cfs based on the low
6 ground elevation along the right levee approximately one mile downstream of the confluence
7 of the Mariposa Bypass. The three major depressions were not considered in this or the
8 previous analysis, which would limit the flow to 50 cfs, since these depressions would likely
9 fill with water and not cause levee stability concerns.
- 10 • The recommended then-existing channel capacity for Reach 5 is 1,940 cfs, based on a low
11 point along the right levee near the downstream end of the reach.
- 12 • The recommended then-existing channel capacity for the Middle Eastside Bypass (Eastside
13 Bypass Reach 2) is 370 cfs. The left levee has an in-channel capacity of 10 cfs, but further
14 geotechnical analysis of the low areas below 300 cfs showed that the maximum acceptable
15 water surface elevation on the levee would correspond to a flow of over 500 cfs. However,
16 the next lowest capacity is 370 cfs, which is along the right levee.
- 17 • The recommended then-existing channel capacity for the Lower Eastside Bypass (Eastside
18 Bypass Reach 3) is 2,890 cfs based on the low point along the right levee just downstream of
19 the Eastside Bypass Control Structure.
- 20 • The recommended then-existing channel capacity for the Mariposa Bypass is 350 cfs based
21 on a low point along the right levee about 1.3 miles upstream of the drop structure.

22 Table 8-1 summarizes the current and recommended then-existing channel capacities for each
23 reach of the San Joaquin River and the flood bypasses.

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**Table 8-1.
Current and Recommended Then-existing Channel Capacity**

Reach	Current Then-existing Channel Capacity (cfs)	2014 Recommended Then-existing Channel Capacity (cfs)
Reach 2A	1,060	1,630
Reach 2B	810	1,120
Reach 3	2,140	2,760
Reach 4A	630	970
Reach 4B1	Not Analyzed	Not Analyzed
Reach 4B2	990	930
Reach 5	1,690	1,940
Middle Eastside Bypass	600	370
Lower Eastside Bypass		2,890
Mariposa Bypass	Not Analyzed	350

26 In general, the recommended then-existing channel capacity for most of the river reaches and
27 bypass have increased or stayed the same as the then-existing channel capacities identified in the
28 PEIS/R as shown in Table 8-1 above. For all of the reaches with the exception of the Middle

1 Eastside Bypass, the current then-existing channel capacities were defined using the same
2 methodology described in Section 7.1 – In-channel Capacity Study. The changes to the then-
3 existing channel capacities are mainly due to further refinement of the topographic data and
4 updates to the hydraulic models. In addition, the Mariposa Bypass was added to the analysis.
5 Although the Middle Eastside Bypass considered the preliminary geotechnical data for the
6 critical areas along the left levee up to 300 cfs, portions of the right levee are still below 370 cfs,
7 based on in-channel capacities.

9.0 Future Program Actions with the Potential to Improve Then-existing Channel Capacity

Throughout Settlement implementation, the maximum downstream extent and rate of Restoration Flows to be released would be limited to then-existing channel capacities. As channel or structure modifications are completed with additional environmental compliance, maximum Restoration Flow releases would be correspondingly increased in accordance with then-existing channel capacities and with the release schedule. Consistent with the commitments made in the PEIS/R ROD, Restoration Flows would be reduced, as needed, to address material seepage impacts, as identified in the Physical Monitoring and Management Plan in Appendix D of the PEIS/R. If releases of water from Friant Dam is required for flood control purposes, concurrent Restoration Flows would be reduced by an amount equivalent to the required flood control release. If flood control releases from Friant exceed the concurrent scheduled Restoration Flows, no additional releases above those required for flood control would be made for SJRRP purposes.

Until sufficient data are available to determine the levee seepage and stability Factors of Safety, Reclamation would limit Restoration flow releases to those flows, which would remain in-channel. When sufficient data are available to determine the Factors of Safety, Reclamation would limit the release of Restoration Flows to those flows which would maintain standard USACE levee performance criteria at all times.

The following sections identify potential immediate, near-term and long-term actions by the SJRRP to address changes in then-existing channel capacity due to changes in the channel or Settlement implementation. Seepage and channel capacity improvement actions could also include those described in the *Working Draft Framework For Implementation*. It is anticipated that the latest draft will likely indicate between 2015 and 2020, the SJRRP will work to engage in agricultural seepage projects and potential easements or license agreements to release flows of a minimum of 700 cfs past Sack Dam. In addition, the San Joaquin Levee Evaluation (SJLE) Project is assisting the SJRRP in assessing flood risks associated with the SJRRP based on geotechnical data. Therefore, the SJRRP will not know if the levee projects not described in the Settlement will be needed. Therefore, all potential actions and projects are not listed below and may change each year as additional information is provided. If any of these actions increase then-existing channel capacities, a new Channel Capacity Report will be prepared prior to Reclamation increasing Restoration Flows.

Environmental compliance for the specific projects and actions will vary depending on the action type. It is anticipated that the implementation measures and environmental compliance necessary would be identified during the planning phase of each project or action. Some projects and actions are already described in the PEIS/R or a project specific EIS/R. Therefore, specific compliance is not addressed further in this report.

9.1 Immediate Actions

Potential responses to a reduction in channel capacity include removal of vegetation and debris and/or restrictions on Restoration Flows that would exceed channel capacity. Vegetation removal would be conducted by mechanical or chemical means. Nonnative plant removal would receive

1 priority over removal of native species. These responses could include unplanned emergency
2 actions or actions taken within the water year. Immediate actions are described at a project-level
3 in the PEIS/R including specific details in Appendix D.

4 Since the start of Interim Flows, the SJRRP has implemented flow limitations and immediate
5 flow reductions to address issues related to then-existing channel capacity, mainly for
6 groundwater seepage and will continue to do so on an as-needed basis during the release of
7 Restoration Flows.

8 **9.2 Near-Term Actions**

9 In addition to immediate actions, the SJRRP is evaluating sediment, vegetation and operational
10 and maintenance projects that are being considered for implementation in the next couple of
11 years (near-term) to address the potential to maintain or increase then-existing channel
12 capacities. These projects and anticipated implementation schedules are described in the
13 following sections.

14 **9.2.1 Sediment Removal Projects**

15 Sediment deposition in the Eastside Bypass contributes to reduced channel capacities. At present,
16 there is one proposed project to remove sediment from the river system between the confluence
17 of the Eastside Bypass (Eastside Bypass Reach 2) and Reach 4B1 of the San Joaquin River.
18 Currently, sediment deposits between the river/bypass confluence and approximately 2,000 feet
19 downstream of El Nido Road in the Eastside Bypass. This deposition is caused by the difference
20 in river gradients upstream and downstream of the confluence. In the reach upstream of the
21 confluence, a steeper river gradient allows for sediment mobilization and suspension whenever
22 flows are present. In the reach immediately downstream of the confluence, a lower river gradient
23 causes the suspended sediment to fall out of the flow stream, and to deposit along the bypass
24 invert.

25 An Appraisal level study was conducted for this project in 2013, and a technical memorandum
26 was completed documenting the concepts and costs for this study. The proposed project will
27 excavate sediment from approximately 3,000 feet upstream to approximately 2,000 feet
28 downstream of El Nido Road. Following the sand removal, channel capacity will be re-evaluated
29 by updating bathymetry in hydraulic models. This project has the potential to increase the low
30 flow channel capacity in the Middle Eastside Bypass, which parallels Reach 4B1. However, the
31 project is not expected to have any significant effect on the flows above 2,000 cfs. It is expected
32 that this project will be completed in the summer of 2014.

33 **9.2.2 Vegetation Removal Projects**

34 Vegetation within the channel can reduce channel capacity by increasing channel roughness.
35 Vegetation management may be necessary to maintain then-existing channel capacities. The
36 amount of vegetation used to determine this year's then-existing channel capacity is based on the
37 vegetation polygons from 2011 aerial photography. However, localized changes in vegetation
38 could occur with the release of flows. Removal or monitoring of vegetation could be necessary to
39 improve or maintain channel capacities. Reclamation is currently working with a local non-
40 profit, the San Joaquin River Parkway and Conservation Trust, to identify, manage, and monitor
41 invasive aquatic and riparian species. The existing program, which is anticipated to continue into

1 the future, manages species such as giant reed (*Arundo donax*), sponge plant (*Limnobium*
2 *spongia*), Chinese tallow (*Sapium sebiferum*), red sesbania (*Sesbania punicea*), and salt cedar
3 (*Tamarix* sp.). The physical removal of plants occurs utilizing hand tools, herbicides, and
4 mechanized above-ground debris removal. Minor revegetation and erosion control measures are
5 also used. Spraying of plants occurs during the active growing season, April 1 through October
6 30, and is subject to all necessary local, state, and federal statutes. Though the focus of this
7 project is on invasive species, the removal of vegetation in the channel could have effects on
8 channel capacity.

9 **9.2.3 Operations and Maintenance Improvements**

10 Overall operation and maintenance including vegetation and sediment management, structure
11 and gate operations, levee stability and integrity of the San Joaquin River and flood bypasses can
12 impact then-existing channel capacity. The LSJLD operates and maintains several levees and
13 channels along the San Joaquin River and bypass system (details regarding the LSJLD are
14 summarized in the Non-Program Actions and Studies Section 11.1). Reclamation has been
15 actively pursuing a financial assistance agreement with the LSJLD to fund LSJLD's efforts to
16 adapt to changes in maintenance type and frequency and to make modifications to existing
17 operations to account for changes as a result of the release of SJRRP Interim and Restoration
18 flows, such as increases in vegetation growth or increased maintenance or operation of
19 structures.

20 **9.3 Long-Term Actions**

21 Long-term actions by the SJRRP will be needed to achieve then-existing channel capacities in
22 the San Joaquin River and flood bypasses that can convey maximum Restoration Flow releases.
23 Potential long-term actions could include, but would not be limited to, the following: providing a
24 larger floodplain between levees through the acquisition of land and construction of setback
25 levees; re-grading of land between levees; construction of sediment traps; sediment removal;
26 levee improvements; construction of grade control structures; and channel grading.
27 Long-term actions would require a determination of need, identification for funding, and site-
28 specific environmental compliance documentation. These actions would be considered by the
29 SJRRP to allow the continued increase of then-existing channel capacity to meet full Restoration
30 Flows.

31 The SJRRP is working on several long-term projects related to increasing site-specific channel
32 capacity as provided for in the Settlement paragraphs 11(a) and 11(b). These projects include the
33 following activities to be completed in future years:

- 34 • Construct Mendota Pool Bypass. Building a bypass around the Mendota Pool to convey at
35 least 4,500 cfs from Reach 2B to Reach 3. This could also include a fish screen or positive
36 fish barrier to avoid fish straying into Mendota Pool.
- 37 • Modify Reach 2B to convey at least 4,500 cfs. The channel would be modified to expand its
38 capacity to at least 4,500 cfs with integrated floodplain habitat. New levees would be
39 constructed to accommodate Restoration Flows.
- 40 • Modify Reach 4B1 to convey at least 475 cfs. Reach 4B would be modified to convey at least
41 475 cfs with integrated floodplain habitat. In addition to modifications of the Reach 4B1

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1 channel to convey at least 475 cfs, the Settlement and the San Joaquin River Restoration
2 Settlement Act, Public Law 111-11, Section 10009(f)(2)(B) also requires that a determination
3 be made on increasing the channel capacity to 4,500 cfs. Road crossings would require
4 modification and levees would need restructuring or construction anew. Modify San Joaquin
5 River Headgate Structure to Enable Fish Passage and Flow Routing. These modifications are
6 to be made consistent with the decision as to whether 4,500 cfs is routed through Reach 4B1.

10.0 Future Program Studies and Monitoring with the Potential to Inform Then-existing Channel Capacity

There are several factors that can impact and limit channel capacity. Potential factors could include overall levee construction or integrity (e.g., insufficient slope stability factor of safety or underseepage factor of safety); flow duration and timing that could saturate the levee and cause instability; erosion of the stream banks that could cause potential levee failure; sedimentation or scouring; ground subsidence, increased roughness from vegetation, as well as other future conditions, such as climate change and operation and maintenance. These factors, as well as others were considered in developing future SJRRP studies and monitoring to determine then-existing channel capacity. The following section summarizes the specific studies and data collection activities planned to allow a better understanding of then-existing channel capacity or changes in channel capacity.

10.1 Technical Studies

The following future technical studies either build on the studies described in Section 7.0 – Current Channel Capacity Studies and Related Work Completed or will provide additional information necessary to identify then-existing channel capacities.

10.1.1 Verification and Monitoring of In-channel Capacity

The following work will help inform the SJRRP on determining existing and future in-channel capacities by identifying potential capacity problem areas as a follow-up to the In-channel Capacity Study described in Section 7.1. The primary goal of the study is to develop a process to ensure that Restoration Flow releases avoid levee impacts by verifying that the flows identified in the Study are accurately “in-channel”. Another goal of the study is to develop a monitoring plan to ensure changes in the system are promptly detected. This work could include:

1. Evaluating the capacity studies conducted previously and other relevant ongoing work, including available data and assumptions, and refinement of the original analysis, if necessary. This includes evaluating the impacts on in-channel capacities from the operation of the Merced Wildlife Weirs in the Middle Eastside Bypass and from historical and future subsidence.
2. Developing a process so the “in-channel” flows in each reach can be defined from the stage at an existing real-time stage recorder or if necessary, a newly installed stage recorder.
3. Preparing a technical memorandum summarizing known and potential problem areas, including the flow conditions at which levee stability and seepage problems are likely to occur, and the process and recommendations to correlate flows at the potential problems sites with a real-time stage recorder.
4. Developing a monitoring plan to refine the modeling and correlations of gaged flows with water-surface elevations/stages at the critical locations, critical flows, and related water-

1 surface elevations, as well as to identify changes in the “in-channel” flows based on future
2 channel changes, including vegetation growth and sedimentation.

3 **10.1.2 San Joaquin Levee Evaluation Project**

4 The SJLE Project assists the SJRRP in assessing flood risks associated with the SJRRP with
5 respect to levee seepage and stability. Completion of this study will help determine and update
6 then-existing channel capacity based on geotechnical data. Under the SJLE Project, DWR is
7 performing geotechnical explorations, assessing the integrity of the existing levees within the
8 Restoration Area with respect to seepage and stability, and identifying potential remedies for
9 assessed deficiencies. As portions of SJLE Project study area overlap with DWR’s Non-Urban
10 Levee Evaluation (NULE) Project, which is summarized in Section 11.3.1, the SJLE Project will
11 be using some of the NULE Project data and processes.

12 The SJLE Project will evaluate levee seepage and stability within the Restoration Area
13 excluding: 1) Reaches 1A and 1B which have no levees or levee-related flood control features;
14 and 2) Reaches 2B and 4B1 (other than project levees segments in Reach 4B1 referenced earlier)
15 for which the Settlement has provided for flood control improvements to be designed and
16 implemented. Reaches 2B and 4B1 may be added to the SJLE Project if the SJRRP makes a
17 decision to use existing levees in these reaches for long-term conveyance of Restoration Flows.

18 The SJLE Project includes the following tasks:

- 19 • Review existing hydraulic and levee evaluation data and prioritize for further geotechnical
20 evaluation levees that would be stressed at select Restoration Flows.
- 21 • Conduct reconnaissance-level geotechnical evaluations consistent with USACE performance
22 criteria for the highest priority levee segments identified in Task 1.
- 23 • Prepare preliminary evaluation of, and discuss conceptual flood control improvements for,
24 identified deficiencies for the highest priority levee segments.

25 The levee prioritization work has been completed and DWR is currently collecting geotechnical
26 data and initiating the geotechnical analyses for the highest priority levees. Geotechnical
27 explorations and analyses of the remaining prioritized levee segments will be dependent upon
28 available funding and future Reclamation decisions regarding routing of Restoration Flows. The
29 following sections provide more detailed information concerning the scope and status of each
30 task.

31 ***Prioritization of Levee Segments for Exploration and Analyses***

32 The levee prioritization technical memorandum, *Identification and Prioritization of Levee*
33 *Segments for Geotechnical Exploration and Analyses*, dated March 2012, is included in
34 Appendix G (DWR-SCRO, 2013) and is summarized below. Initial prioritization of levees for
35 geotechnical evaluation were based on two criteria: 1) magnitude of flows at which water surface
36 elevations could impact levee performance; and 2) whether the levee segment would possibly be
37 used by the SJRRP to pass Restoration Flows prior to the implementation of the site-specific
38 projects.

39 Levee performance was considered impacted if the flow resulted in a water surface elevation
40 above the outside ground elevation along the landside levee toe. DWR performed this hydraulic
41 analysis for flows at 2,000 cfs and 4,500 cfs. Similar to the In-channel Capacity Study

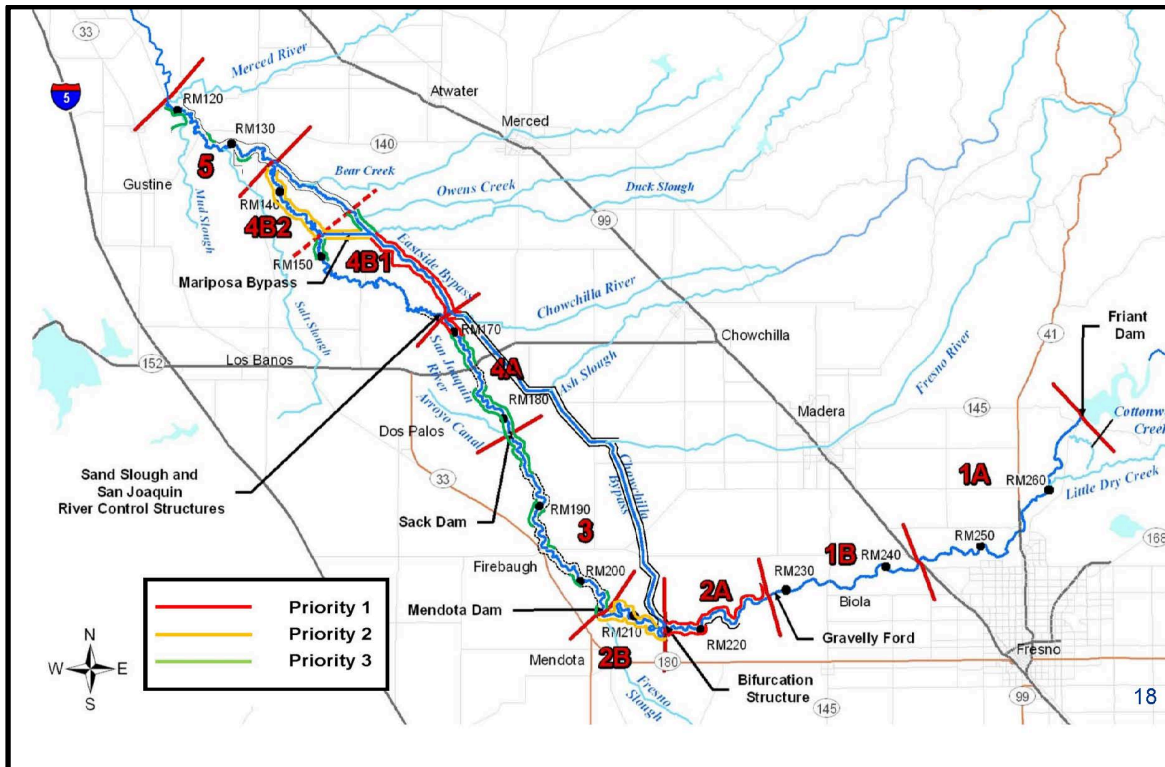
1 summarized in Section 7.1 above, the *Working Draft Framework For Implementation* identifies a
2 Friant flow release of 2,000 cfs as a core action for Program success.

3 DWR then classified levee segments in the study area to one of the following categories
4 representing an increasing priority for the need to complete geotechnical evaluation and
5 analyses. Reaches not identified under one of the three priority classifications did not have any
6 levees where the outside ground elevations were below the 4,500 cfs water surface elevation or
7 were excluded levee segments.

- 8 • Priority 1 – Levee segments, which may or are being used to transmit Restoration Flows
9 prior to the completion of the site-specific projects and along which flows of 2,000 cfs would
10 result in a water surface at or above the ground surface elevation at the landside levee toe.
- 11 • Priority 2 - Levee segments which will not be used for Restoration Flows until major site-
12 specific projects are completed that will allow Restoration Flows to be routed to the reach
13 and along which flows of 2,000 cfs would result in a water surface at or above the ground
14 surface elevation at the landside levee toe.
- 15 • Priority 3 – All remaining levee segments along which flows of 4,500 cfs would result in a
16 water surface at or above the ground surface elevation at the landside levee toe.

17 Figure 10-1 summarizes the results of the levee prioritization. Approximately 40 miles of levees
18 were classified as Priority 1, 37.5 miles were classified as Priority 2, and 50 miles were classified
19 as Priority 3. The remaining 140.5 miles of levees either had no potential impact to levee
20 performance at 4,500 cfs or were excluded from the study area as described earlier.

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Figure 10-1.

Levee Priorities within the San Joaquin Levee Evaluation Project Area

4 ***Geotechnical Explorations of Priority 1 Levees***

5 DWR initiated geotechnical explorations of Priority 1 levees in June of 2012 including Cone
 6 Penetrometer Tests (CPTs) every 1,000 feet and borings with sampling every 5,000 feet on the
 7 top of the levees. Toe borings are completed at select locations to provide additional lateral data
 8 to support geotechnical analyses. DWR also performed geomorphic studies of the study area,
 9 which were used to refine exploration locations. Exploration and analyses of Priority 2 and
 10 Priority 3 levee segments may be performed in the future.

11 The explorations are being phased. The initial phase, including explorations of levees along the
 12 Eastside Bypass between Sand Slough and the Mariposa Bypass were completed in December
 13 2012. The preliminary results from the geotechnical exploration of the Eastside Bypass were
 14 used in the geotechnical study described in Section 7.2 above. A second phase, including
 15 explorations along levees at the downstream end of Reach 4A and along the Eastside Bypass
 16 immediately upstream of Sand Slough were completed in June 2013. These efforts do not
 17 include explorations along the right bank of Reach 2A which were performed separately by
 18 DWR under its NULE Project in 2011. Combined during these two phases and including the
 19 Reach 2A work performed under NULE, DWR has drilled a total of 165 CPTs and 62 borings on
 20 the levee crest and 1 CPT and 13 borings at the levee toe. DWR is expecting to perform a final
 21 phase of explorations in these areas, which will be focused on landside data collection and other
 22 potential data gaps to support levee seepage and stability analyses. DWR is preparing a
 23 Geotechnical Data Report (GDR) summarizing the data from the completed data phases, which
 24 is scheduled to be complete in late 2013.

1 ***Preliminary Evaluation of Priority 1 Levees***

2 This task will include seepage and stability analyses of collected data and preparation of a
3 Geotechnical Overview Report (GOR) to assess the geotechnical integrity of existing Priority 1
4 levees with respect to seepage and landside slope stability for various water surface elevations
5 (WSEs). Under this task, DWR will also be developing criteria to be used in the geotechnical
6 analyses, implementing a pilot study of a subset of the Priority 1 levees to refine the process to
7 meet SJLE Project goals, and preparing the GOR upon complete geotechnical analyses of all
8 Priority 1 levees. Completion of the GOR is anticipated by the summer of 2014; however the
9 schedule is dependent on the completion of the final geotechnical exploration effort.

10 The outcome of this evaluation will be an assessment of levee performance against established
11 criteria for up to three water surface elevations (similar to what is described for the Middle
12 Eastside Bypass geotechnical study) and a conceptual summary of generally accepted remedial
13 alternatives for the geotechnical deficiencies identified in the analyses. This information will
14 inform the SJRRP of then-existing channel capacities and acceptable Restoration Flow releases
15 that will reduce the potential for flood management impacts to Priority 1 levees with respect to
16 levee seepage and stability. As the analyses is based on existing geotechnical data, DWR will
17 also prepare recommendations for monitoring levee performance under Restoration Flows which
18 may be used by levee maintaining agencies to monitor levee performance under future
19 conditions.

20 **10.1.3 Reach 2A Morphology Study**

21 The completion of the Reach 2A Morphology Study will help the SJRRP determine the short-
22 term and long-term channel response in Reach 2A and the CBBS and its potential impact on
23 then-existing channel capacity. This information can also be used to assess the potential need to
24 change then-existing channel capacity in Reach 2A or take immediate or long term-actions.
25 DWR plans to use the results and recommendations of the Reach 2A Sediment Studies described
26 in Section 7.3 of this report to formulate the next phase of morphologic investigation in this
27 reach. The goal will be to provide the SJRRP with a better understanding of expected long-term
28 Reach 2A channel capacity changes and Reach 2B and Chowchilla Bypass sediment supply
29 through the CBBS.

30 The 1-D and 2-D sediment transport models described in Sections 5.2 and 5.3 will be used to
31 predict long-term changes in Reach 2A morphology. Multiple flow and gate operation scenarios
32 will determine anticipated sediment movement through the CBBS under various conditions. Data
33 collection will be needed to improve topography and sediment gradation data in the reach so that
34 the models can be further calibrated. Short- and long-term efforts may include the following:

- 35 • Developing, calibrating and applying a 1-D sediment transport model of Reach 2A that can
36 be used to assess the long-term response of the reach to future restoration and flood flows
37 and the associated changes in upstream sediment supply. This effort will incorporate results
38 from the other SJRRP studies in Reach 1 and ongoing sediment transport measurements by
39 USGS and Reclamation.
- 40 • Collecting high-resolution topography of the channel bed in the approximately 1,500-foot
41 reach upstream of the CBBS and in the bends between the existing cross sections through the
42 remainder of the 2-D model reach.

- 1 • Photographing the area immediately upstream of the CBBS during and after high flow events
2 via field visits or stationary cameras installed at the structure to qualitatively monitor
3 sedimentation changes near the structure after each event.
- 4 • Identifying additional bed sediment sampling locations to improve representation of the
5 variability in surface and subsurface bed material gradations, and collect data after each
6 event.
- 7 • Refining the 2-D sediment model by adjusting the inflowing sediment load rating curve and
8 gradation based, in part, on results from the 1-D modeling, refining the spatial distribution of
9 the bed material gradations and adjusting the cross-sectional geometry in the bends to
10 improve agreement between the measured changes and model results.
- 11 • Performing additional calibration runs using the 2011 runoff hydrograph.
- 12 • Running the calibrated model for longer time periods and larger hydrographs for a range of
13 gate opening scenarios to assess the effects on aggradation/degradation trends in the lower
14 part of the reach and the amount and caliber of sediment delivered to Reach 2B and the
15 Chowchilla Bypass.

16 **10.1.4 Subsidence Monitoring and Studies**

17 In 2012, the SJRRP formed a subsidence coordination workgroup to 1) help address and study
18 the impacts of subsidence and 2) share information between landowners, local agencies, and the
19 SJRRP. The following sections briefly describe the ongoing and future monitoring and studies
20 that would be completed by Reclamation and DWR over the next year. The work described
21 below will help the SJRRP determine changes in then-existing channel capacities considering
22 geomorphic, sediment and hydraulic changes as a result of subsidence. The results of this
23 analysis will be part of updating and verifying the in-channel capacity described in
24 Section 10.1.1.

25 *Periodic Subsidence Surveys*

26 In 2010, Reclamation started conducting a series of investigations using both static GPS stations
27 and temporary GPS surveys to investigate the subsidence within the SJRRP study area. In
28 response to the study, Reclamation has conducted, and will continue conducting bi-annual
29 surveys of the established SJRRP Geodetic Control Network to monitor the rate of subsidence
30 over time. The network consists of approximately 61 control points, and establishes updated
31 elevations throughout the area of subsidence. These control points are used by the SJRRP to
32 study subsidence, as well as to provide control points for other studies. Historically, Reclamation
33 has collected data in July and December each year.

34 In addition to the surveys completed by Reclamation, in September/October 2012, DWR
35 completed surveys of the tops of approximately 65 miles of levees within the downstream
36 portion of Reach 2A; the Eastside Bypass from its confluence with the Fresno River to the
37 Eastside Bypass Control Structure; and the Mariposa Bypass. The processed survey data was
38 used to estimate annual subsidence rates by calculating the difference between the 2012 data and
39 the 2008 LiDAR elevations. The estimated annual rates were used to develop 1-D hydraulic
40 models of the bypasses to determine potential future impacts to capacity as a result of
41 subsidence. DWR completed another survey in late 2013 of the existing area. In addition, DWR
42 has initiated the a pilot survey study of Reach 4A to determine how the then-existing channel

1 capacity has been impacted by subsidence on the San Joaquin River, as well as how the
2 hydraulic models should be updated for future studies. The results of this analysis will guide
3 future analyses.

4 Results from the data collection efforts summarized above will be used to update the modeling
5 tools and inform and evaluate the impacts of subsidence on then-existing channel capacities
6 along the bypass and river.

7 ***Sediment Transport and Capacity Study***

8 To better understand the effects of continued subsidence on future flow capacities and sediment
9 transport in the bypass and how it will potentially affect the SJRRP and flood bypasses, DWR
10 and Reclamation may complete a sediment transport study. The study would be designed to
11 better understand and quantify how sedimentation will affect channel capacity and to provide
12 information on the amount of sediment removal that may be required to maintain necessary
13 design flow capacities. The data collected from the topographic surveys described in Section
14 10.1.4.1 will be used to confirm or update the previously calculated subsidence rates, and to
15 further develop the hydraulic and sediment modeling tools. Results from the sediment transport
16 study could provide information to further evaluate bypass flow capacities, as well as refine
17 certain aspects of the design for the Reach 4B, Eastside Bypass and Mariposa Bypass Channel
18 and Structural Improvements Project. In late 2013, DWR completed a field reconnaissance report
19 that summarizes the characteristics of the bypass and the results of bulk sample analyses. The
20 report makes recommendations on what tools and assumptions should be used to model the
21 sediment transport in the bypass. Based on these recommendations, DWR and Reclamation may
22 move forward with modeling and analysis.

23 ***SJRRP Site Specific Project Design***

24 The SJRRP is developing a technical memorandum *Subsidence Design Criteria for the San*
25 *Joaquin River Restoration Program (DRAFT), Technical Memorandum No. SUB-1*
26 (Reclamation, 2013) that documents subsidence within the SJRRP project area, and establishes
27 recommended subsidence criteria that will be applied to the designs for future site-specific
28 projects in Reach 2B, Reach 4B, and at the Arroyo Canal diversion in Reach 3. A draft of the
29 Technical Memorandum has been circulated for comment, and will be updated as the bi-annual
30 surveys are completed. This work will help determine with the designs of the projects that will
31 inform then-existing channel capacity.

32 **10.1.5 Vegetation Modeling**

33 Reclamation will use existing SRH-2D hydraulic models to quantify potential increases in river
34 stage given increases in riparian growth in reaches that convey the SJRRP Restoration Flows.
35 This study will help the SJRRP determine if action needs to be taken to maintain or reduce then-
36 existing channel capacities. It is expected that the analysis will be performed in Reaches 2A and
37 4A as they have the highest potential for vegetation recruitment as a result of rewetting. The
38 existing conditions Reclamation-built 2-D models, described briefly in Section 5.0 -- Data and
39 Analytical Tools, will be used as a starting condition. The potential increase in vegetation will be
40 estimated using analogs to surrounding reaches. Various methods will be used to predict the
41 increase in river stage due to increasing vegetation density. A technical report documenting the
42 effect of vegetation roughness in Reaches 2A and 4A is expected in 2014.

1 **10.2 Monitoring Activities**

2 The SJRRP is continuing various monitoring activities for different studies and purposes. The
3 monitoring described below will guide implementation of the Settlement for observing and
4 adjusting to changes in physical conditions within the Restoration Area including those changes
5 that may impact channel capacity. These monitoring activities are described in the *Physical*
6 *Monitoring and Management Plan*, which is in Appendix D of the PEIS/R. The following
7 sections describe the monitoring that may be undertaken on an as-needed basis.

8 **10.2.1 Flow monitoring**

9 The objective of continuing to monitor flow is to ensure compliance with the hydrograph
10 releases in Exhibit B of the Settlement and any other applicable flow releases without exceeding
11 then-existing channel capacity. Reclamation, DWR and the USGS currently maintain 23 flow
12 and staff gages along the San Joaquin River and tributaries between Friant Dam and the Merced
13 confluence. These gages are used to determine the flow in each reach of the river. All of the
14 gages shown in Figure 10-1 below are telemetered and available online at the California Data
15 Exchange Center (CDEC). Each of the operating agencies also conducts periodic flow
16 measurements in order to develop and adjust rating curves as necessary. Final daily average data
17 is determined monthly by Reclamation, as requested by DWR, and annually by the USGS. Flow
18 monitoring stations provide calibration data for hydraulic models and a key dataset for
19 comparison and evaluation. Monitoring of these stations would continue as needed to help ensure
20 Restoration Flows do not exceed then-existing channel capacities.

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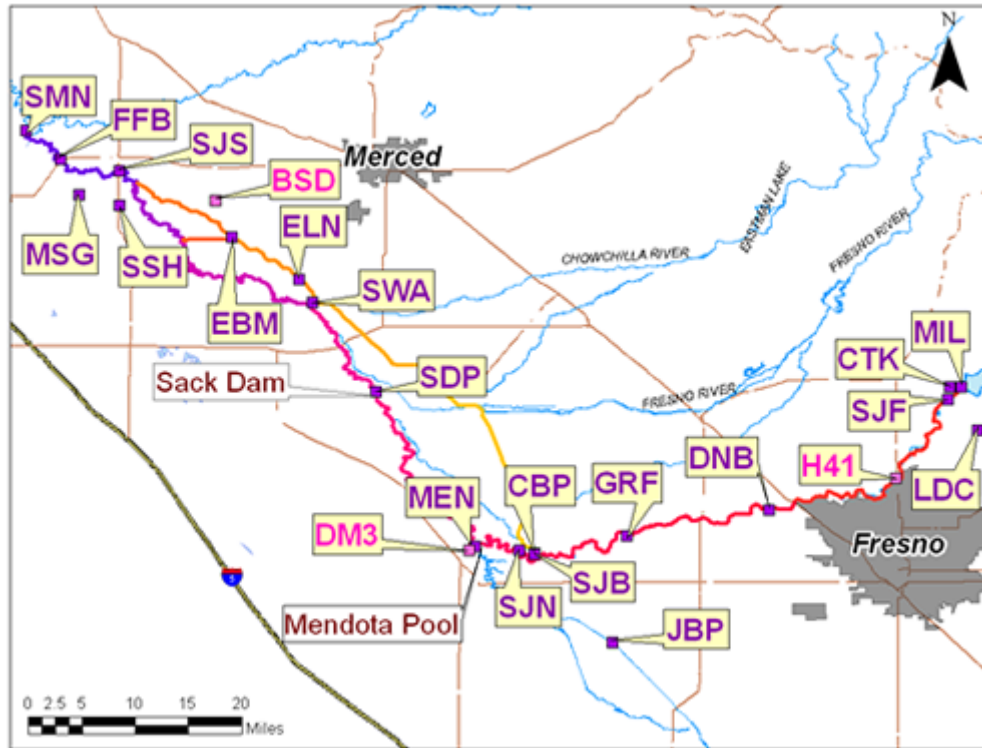


Figure 10-2.

Current flow gages (purple) and staff gages (pink) available on CDEC

10.2.2 Water surface profile surveys

Along with flow monitoring, water surface profile (WSP) surveys help inform the SJRRP of the potential changes in stage and channel capacity as a result of a change in specific or reach-wide conditions due to vegetation, channel work and sediment transport.

DWR and Reclamation conducts WSP surveys on the San Joaquin River and bypass system periodically. From 2009 to 2011, WSP surveys were collected primarily to calibrate the 1-D HEC-RAS models. Friant flow releases during those surveys ranged from about 350 cfs to about 7,000 cfs and for all the reaches with the exception of Reach 4B1 and the Mariposa Bypass, which lacked flow during the surveys.

Similar to the previous surveys, the WSP and water levels will be recorded at the top and bottom of hydraulic controls, upstream, at, and downstream of discharge sites, and systematically along the entire reach to characterize the overall hydraulics. The number, spacing, and exact location of the points would be prioritized based on hydraulic conditions, resources, access, and GPS coverage. Points would be measured with an accuracy of 0.1 feet or better. Discharge measurements would also be collected, as needed, during the WSP surveys so that the water surface elevation and discharge could be paired for model calibration.

Unless there is a change in reach-wide conditions that could impact water surface elevations or channel capacity, it is unlikely there will be future reach-wide WSP surveys with the same magnitude and frequency as the 2009 through 2011 surveys. Most future WSP surveys will be site and study specific.

1 **10.2.3 Aerial Photography and Topographic surveys**

2 The purpose of the aerial photography and topographic surveys is to obtain information about the
3 river stage, hydraulic roughness, river width, and bed elevation to assist with scientific studies
4 that would inform the SJRRP about how flows are impacting then-existing channel capacities. A
5 number of survey data sets have been collected in this region before and after the Settlement to
6 support the SJRRP.

7 ***LiDAR and Bathymetry***

8 The most current complete survey set was a combination of aerial LiDAR of the above water
9 portions completed in 2008 under the CVFED Program and bathymetric surveying for the below
10 water portions of the river channel that was completed in 2010/2011. Because of subsidence
11 experienced in the Restoration Area and the uncertainties on the rates of subsidence, additional
12 LiDAR surveys will likely need to be collected prior to final design of site-specific projects. The
13 updated topographic data will also be used to update the hydraulic models and studies, which
14 could be used to inform then-existing channel capacity. Additional LiDAR surveys are expected
15 to take place in 2014 or 2015. Bathymetry surveys may be completed, as needed.

16 ***Aerial Photography***

17 Aerial photos were flown in May 2009, five times during the spring pulse in 2010, and three
18 times during the flood releases in 2011. Both color infrared and natural color flights were flown,
19 with more color infrared flights in order to identify vegetation. Aerial photos allow observations
20 of vegetation recruitment and channel bank erosion, potentially affecting channel capacity in
21 rewetted reaches. Aerial photography may be completed, as needed.

22 ***Cross Sections***

23 DWR has over the period of 2008 and 2013 conducted multiple topographic surveys in Reaches
24 2A, and 2B. DWR will continue to periodically complete these surveys, as needed. The goal is
25 to monitor long-term changes so that potential impacts to channel capacity in these reaches can
26 be recognized based on trends identified. Each survey site covers approximately 150 feet of
27 channel distance from levee to levee, and they are intended to record changes in channel features
28 and geometry due to various flow events. The current phase of this study involves using the
29 survey data to estimate volume changes that have occurred. Initial results from the analysis of
30 channel changes with respect to flow magnitudes and durations do not indicate a clear set of
31 discharges that would correspond to a need for updated topography. Additional surveys are likely
32 for 2014 to help develop trends in channel change and flow magnitude. This will help to inform
33 then-existing channel capacity in Reach 2A and Reach 2B.

34 **10.2.4 Erosion Monitoring**

35 Erosion monitoring of the channel and channel banks would be conducted by the SJRRP to
36 identify areas that may potentially compromise levee integrity for consideration of future
37 management actions and projects (flow reduction, revetment, armoring, etc.). Monitoring would
38 be completed using several standard methodologies and protocols commonly employed by
39 DWR, reclamation districts, and/or USACE to monitor levee erosion. These surveys would
40 assess the condition of potential erosion sites, and could include a variety of techniques such as
41 aerial photography and topographic surveys.

1 **10.2.5 Vegetation surveys**

2 The purpose of the previous and future vegetation surveys is to obtain information on the
3 establishment and recruitment of vegetation. This information can be used by the SJRRP to
4 determine if actions need to be taken to address capacity issues as a result of increased channel
5 roughness from vegetation.

6 The SJRRP expects to continue to conduct vegetation surveys, which will help inform channel
7 capacity. In 2011, twenty permanent vegetation transects were established within river reaches
8 1A, 1B, 2A, 2B, 3, 4A, 4B2 (*i.e.* San Luis National Wildlife Refuge), and the Eastside and
9 Mariposa Bypasses. In 2012, two additional permanent vegetation transects were established
10 within river Reach 5. Due to the large project area (over 150 river miles), it was only feasible to
11 locate and monitor two transects within each reach with the exception of the Eastside Bypass,
12 where four transects were placed, two of which were in the Merced National Wildlife Refuge
13 (MNWR). Transects were placed in areas adjacent to the river channel within the active
14 floodplain. These transects are not representative of vegetation types across entire reaches, but
15 are illustrative of vegetation change over time resulting from Interim Flows. Monitoring of all
16 transects for 2013 was completed in June. To inform future then-existing channel capacities,
17 future surveys are anticipated to continue in 2014.

18 **10.2.6 Suspended Sediment**

19 Reclamation continues to collect data to manage channel capacity through the development of an
20 annual sediment hydrograph for the Restoration Area. Each year, the USGS collects suspended-
21 sediment, bedload, bed gradation data, and stream discharge eight times at six locations. These
22 sampling sites, listed in the order of the downstream direction, are: Highway 41, Skaggs Bridge,
23 Gravelly Ford, 1.3 miles west of Napa Ave (above CBBS), below CBBS, and below Mendota
24 Dam. This information will be useful to DWR and Reclamation as they develop studies on the
25 sedimentation impacts on channel capacity in the San Joaquin River and flood bypasses.

11.0 Non-Program Actions and Studies that May Influence Future Channel Capacity

There are several other entities that are active in the Restoration Area and whose programs may help inform or impact then-existing channel capacity. The SJRRP will need to closely coordinate and collaborate with these entities by sharing information and data, as well as coordinating specific actions along the river that can inform or impact channel capacity. This section briefly discusses a few of the programs, actions, and studies of other agencies that could impact or allow a better understanding of future channel capacity within the SJRRP Restoration Area.

11.1 Lower San Joaquin Levee District

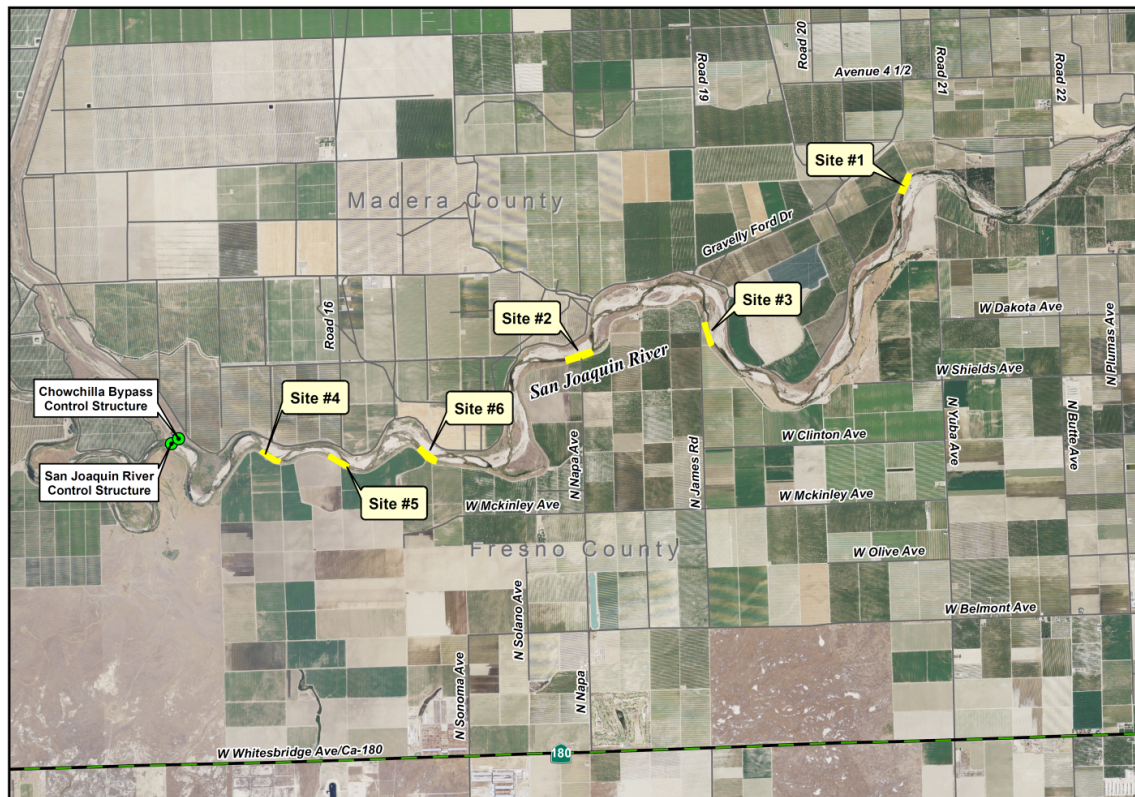
The LSJLD is a local agency that is responsible for operation, maintenance, and emergency management of the LSJRFC Project, which is part of the State Plan of Flood Control (SPFC) facilities within the SJRRP Restoration Area. The LSJLD operates and maintains levees, bypasses and other facilities built in connection with the SPFC and these actions directly impact the capacities of the reaches in the study area.

The LSJLD performs periodic standard operations and maintenance of the bypass system and river channel. Its activities may include the maintenance of the channels, levees, and related flood control facilities that will be used to pass Interim and Restoration flows. The LSJLD also conducts emergency flood watches, which requires 24-hour staffing when flows are at the inside toe of the levees. In addition, some of the specific current maintenance activities that could impact overall channel capacity include vegetation management, sediment management and removal, cleaning of screens and trash racks on facilities, opening and closing of gates and flap gates (in the bypass systems).

Changes in vegetation within the SPFC could impact channel capacities by increasing the channel roughness. To help manage vegetation within the flood control channel, some reaches are used for livestock grazing. In addition, the LSJLD also removes vegetation by spraying with herbicide.

After flow events to maintain channel capacity, the LSJLD may also remove sediment that has accumulated in the channels. These sediment removal activities are intended to return the channels back to their original LSJRFC Project condition before the next flow release. The primary location where sediment is removed includes the lower downstream portion of Reach 2A, the area just downstream of the CBBS within the Chowchilla Bypass, and the Sand Slough area within the Eastside Bypass.

Bank erosion at the inside toe of a levee could impact channel capacity by compromising the integrity of the levee. The LSJLD identified six erosion sites along Reach 2A of the San Joaquin River experiencing increased levels of bank erosion that threaten the flood control levee system as shown in Figure 11-1. To reduce this potential and maintain channel capacity, bank stabilization efforts currently underway consist of lining the banks with erosion-resistant materials such as rock, concrete rubble and local hard-pan. Sites 1, 4, 5 and 6 have been repaired. The LSJLD may commence work in 2013 on Site 3. If initiated, the work is estimated to take one year to complete.



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Figure 11-1.

Reach 2A Levee Erosion Sites

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For the last remaining site (Site 2), Reclamation teamed up with the LSJLD to propose a bank stabilization alternative that also provides in-channel fish habitat. The plan included placing nine cobble jetties/groins along the bank and into the river channel. Reclamation completed the plans, specifications and estimates to about 90 percent and then suspended the project due to funding constraints. The LSJLD plans to meet with the CVFPB, Reclamation, and DWR to discuss completing improvements for the remaining erosion site.

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11.2 Merced National Wildlife Refuge

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The U.S. Fish & Wildlife Service (USFWS) currently operates a pair of weirs within the boundaries of the MNWR along the Middle Eastside Bypass (Eastside Bypass Reach 2) that could have an impact on channel capacity. These weirs are referred to as the upper and lower wildlife refuge weirs, since they are located at the upstream and downstream intersections of the MNWR and the bypass. These structures have the ability to check water both upstream of the MNWR and within its boundaries for diversion to the various wetlands operated by USFWS. When the boards are placed into the weirs, they can have an impact on water surface elevation and capacity of the bypass. At higher flood flows, the USFWS works with the LSJLD to remove the stoplogs to allow for unimpeded passage of flood flows. No mechanical system is in place for the automatic setting or removal of these stoplogs. In 2013, Reclamation placed a

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1 water level sensor and staff gage at the lower weir to better understand the water levels and
2 hydraulics at this structure.

3 **11.3 DWR**

4 In implementation of its FloodSAFE initiative, DWR is leading two specific efforts within the
5 SJRRP Restoration Area that may affect channel capacity.

6 **11.3.1 Non-Urban Levee Evaluations**

7 As a component of its FloodSAFE initiative, DWR has been performing geotechnical
8 evaluations of over 1,800 miles of levees throughout the Central Valley. The evaluations are
9 divided into the Urban Levee Evaluations (ULE) Project for levees protecting populations
10 greater than 10,000 and the NULE Project for remaining levees including a portion of the levee
11 features within the Restoration Area. The evaluations are limited to Project levees and
12 appurtenant Non-Project levees, which protect part of a basin partially, protected by Project
13 levees or may impact the performance of Project levees. Figure 10-1 identifies the levees
14 assessed under the NULE Project, which includes the entire Restoration Area levee features with
15 the exception of:

- 16 • Reach 1 and the portion of the left bank of Reach 2A which are not leveed, and
- 17 • The majority of Reach 4B1 and portions of the left bank at the downstream end of Reach 5
18 where existing levee features are not appurtenant to Project levees.

19 The NULE Project scope is limited to levee geotechnical integrity and is not assessing existing
20 interior drainage issues landward of study area levees or investigating levee penetrations and
21 discontinuities (i.e., roads and bridges).

22 *NULE Overview*

23 The NULE Project is being performed in two phases. Phase 1, a largely screening effort
24 incorporating existing data and non-intrusive studies, was completed in 2011 with the
25 publication of the Geotechnical Assessment Report (GAR) and the Remedial Alternatives and
26 Cost Estimates Report (RACER). Phase 2 incorporates geotechnical explorations along select
27 levee segments protecting populations exceeding 1,000 followed by detailed geotechnical
28 seepage and stability analysis, evaluation of remedial alternatives, and preparation of conceptual
29 cost estimates. Phase 2 field work is complete and DWR is currently completing the data reports
30 and geotechnical analyses. A more detailed description of each of these phases, with a summary
31 of current status with respect to assessed levees within the Restoration Area, is provided below.

32 *NULE Phase 1 Assessment*

33 Phase 1 assessment, covering all NULE levees, was completed in June 2011 and was based on
34 non-intrusive studies and readily available data. Phase 1 tasks included:

- 35 • Collecting and cataloging existing data about the levees, levee systems, and historical levee
36 performance into a document database, the Levee Evaluations Database.

- 1 • Noting specific points of interest, including locations of performance problems,
2 improvements, repairs, or other items of note in discrete database entries.
- 3 • Performing geomorphic studies.
- 4 • Performing levee segment assessments using available data, tools, and methods developed
5 during this assessment project.
- 6 • Preparing conceptual remedial alternatives and associated cost estimates.

7 DWR has prepared a GAR and a RACER summarizing these data. The GAR included an
8 assessment of levee hazard indicators with a comparison to past levee performance from which
9 each levee segment was assigned one of the following hazard categories.

- 10 • **Hazard Level A.** When water reaches the assessment WSE, there is a low likelihood of
11 either levee failure or the need to flood-fight to prevent levee failure.
- 12 • **Hazard Level B.** When water reaches the assessment WSE, there is a moderate likelihood of
13 either levee failure or the need to flood-fight to prevent levee failure.
- 14 • **Hazard Level C.** When water reaches the assessment WSE, there is a high likelihood of
15 either levee failure or the need to flood-fight to prevent levee failure.
- 16 • **Lacking Sufficient Data (Category LD).** The segment is currently lacking sufficient data
17 about past performance or hazard indicators to be able to assign a hazard level, or there is
18 poor correlation between past performance and hazard indicators.

19 The findings of this assessment of levee hazard indicators have been vetted by levee maintenance
20 personnel and local experts and were publicly released in the *Flood Control System Status*
21 *Report* in December 2011. As used in these definitions, the term flood-fight refers to actions
22 associated with geotechnical failure modes, not flood-fighting to prevent levee overtopping.
23 Category LD indicates that available data do not resolve potential discrepancies between a
24 segment's expected performance and actual recorded performance, or that existing data are
25 contradictory or ambiguous.

26 The assessed overall hazard categories of levees within the SJRRP are summarized in Figure 11-
27 2. The majority of Restoration Area levee segments assessed under the NULE Project were
28 categorized as Hazard Level C (high likelihood of levee failure or need to flood fight) or as
29 Lacking Sufficient Data. The primary factor leading to this assessment was the potential for
30 levee underseepage due to the coarse-grained foundation materials. This is confirmed by past
31 performance as local agency representatives and landowners commonly report chronic boils and
32 seepage during high water events. A more detailed discussion of Phase 1 results specific to
33 Restoration Area levees can be found in the Geotechnical Assessment Report, South NULE
34 Study Area (DWR, 2011).

35 ***NULE Phase 2 Assessment***

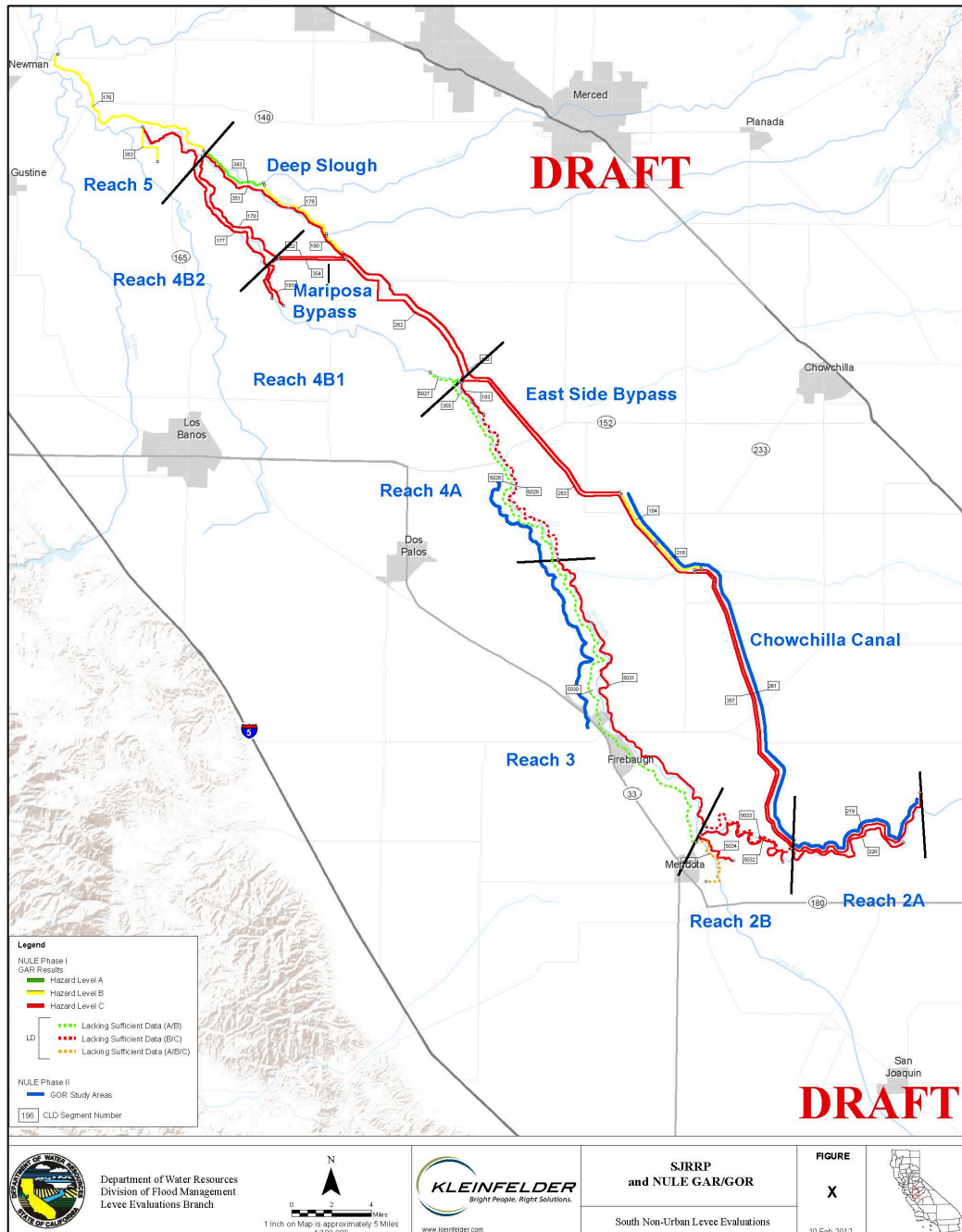
36 Phase 2 assessment builds on Phase 1 results by adding targeted field exploration, laboratory
37 testing, and analyses to identify levee areas not meeting criteria established for the NULE
38 Project. Remedial alternatives are being developed for levees not meeting these criteria.
39 Data and analyses for Phase 2 are presented in two separate reports. Field exploration and
40 laboratory testing program results for each study area are presented in a GDR. Analyses are

1 presented in a two-volume GOR. Analyses results for segments under existing conditions are
2 presented in Volume 1, Existing Conditions. Remedial alternatives, cost estimates, and analyses
3 of segments under remediated conditions are presented in Volume 2, Remedial Alternatives.

4 The study area for Phase 2 is a subset of the NULE study area and limited to those levees
5 protecting a population of more than 1000 people, which is consistent with the key objective of
6 the Central Valley Flood Protection Plan to provide flood protection to small communities. The
7 Phase 2 study area is significantly reduced from that of the initial phase and includes the
8 following portions of the Restoration Area, which are identified as GOR study areas on Figure
9 11-2:

- 10 • **Reach 2A** – San Joaquin River right bank – entire 10 mile segment
- 11 • **Reach 3** – San Joaquin River left bank – 12 miles segment downstream of the town of
12 Firebaugh
- 13 • **Reach 4A** – **San Joaquin River left bank – 7 mile segment at upstream end**
- 14 • **Bypass System**
 - 15 - Chowchilla Bypass Canal - right bank – entire 35 mile segment
 - 16 - Eastside Bypass right bank – 6 mile segment downstream of confluence with
17 Chowchilla Bypass Canal

18 The subsurface exploration program was completed in 2012 and consisted of approximately 5
19 Cone Penetration Tests (CPT) and 1 exploratory boring on the levee crest per mile with
20 occasional explorations on the levee toe. A total of 164 CPTs and 40 borings were drilled on or
21 along levees in Reaches 2A, 3, and 4A. A total of 125 CPTs and 46 borings were drilled along
22 the Eastside Bypass and Chowchilla Bypass Canal. The GDR for this effort will be completed by
23 late summer 2013. NULE GOR analysis is being performed currently and seepage and stability
24 results will be presented in the GOR for existing and remediated conditions which is expected to
25 be completed by the end of 2013 or early 2014. The NULE assessments and SJLE Project will
26 coordinate data collection efforts and findings, which will be used to inform next year's then-
27 existing channel capacity.



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Figure 11-2.
NULE Study Area

4 11.3.2 Regional Flood Management Planning

5 As part of its FloodSAFE initiative, DWR is also coordinating a Regional Flood Management
 6 Planning effort for the Central Valley. The regional planning effort will support locally-
 7 developed Region Flood Management Plans (RFMP) and is an important step in refining and
 8 implementing the Central Valley Flood Protection Plan (CVFPP). The main goal of the RFMP is

1 to identify high priority regional flood risk reduction solutions that are both economically viable
2 and implementable.

3 The CVFPP calls for DWR to work with local flood management agencies within six flood
4 inundation regions within the Central Valley to prepare a RFMP. The RFMP would identify
5 flood management challenges and deficiencies, potential projects and solutions, and financial
6 strategies that identify benefits of the projects, and sources of the funding for implementation of
7 the projects and actions. As part of the regional planning effort, the Upper San Joaquin River
8 (USJR) Region was created. The USJR Region lies within the counties of Fresno, Madera, and
9 Merced and encompasses the areas that are protected by the SPFC along the San Joaquin River
10 from Gravelly Ford to the confluence of the Merced River (see Fig 11-2). The USJR Region is
11 within the Restoration Area (Figure 1-2). The USJR Region's RFMP is expected to be completed
12 by February 2015.

13 The USJR RFMP is expected to include several management actions and projects that will
14 reduce flood risk in the Restoration Area. Management actions explored may include enhancing
15 flood emergency response and operation and maintenance of flood management facilities.
16 Projects addressing channel capacity issues will be a key element in this planning effort as the
17 SPFC facilities in the region are aging and were originally sized for less than the 100-year flood
18 event. Currently, channel capacity is decreasing due to ground subsidence, sedimentation,
19 seepage, vegetation and erosion. These challenges and deficiencies will most likely be high
20 ranked priorities on the regional plan.

21 Addressing these issues may lead to projects that could increase channel capacities along the San
22 Joaquin River and flood bypasses. As the plan progresses, the SJRRP will coordinate with the
23 USJR Region on potential projects that could increase then-existing channel capacities in the
24 SJRRP Restoration Area.

12.0 References

- 1
- 2 Bureau of Reclamation, 2010. SRH-2D version 2: Theory and User's Manual: Sedimentation and
3 River Hydraulics—Two-Dimensional River Flow Modeling. Technical Service Center,
4 Denver, CO, 2010.
- 5 _____, 2012). San Joaquin River Restoration Daily Flow Model (SJRRP) Documentation for the
6 Reach 4B Study, Technical Report No. 86-68210-2012-04, Prepared for the San Joaquin
7 River Restoration Program, Technical Service Center, Denver, CO, 2012.
- 8 _____, 2013. Subsidence Design Criteria for the San Joaquin River Restoration (DRAFT).
9 Technical Memorandum No. SUB-1, USBR Mid-Pacific Region, June 2013.
- 10 CA Department of Water Resources, 1985. Flood Channel Design Flows (Modified) May 1985.
11
- 12 _____, Division of Flood Management, 2012. Identification and Prioritization of Levee
13 Segments for Geotechnical Exploration and Analyses, August 30.
14
- 15 _____, South Central Region Office, 2013. Evaluation of the Effect of Subsidence on Flow
16 Capacity in the Chowchilla and Eastside Bypasses, 2013.
- 17 Provost & Pritchard Consulting Group, 2012a. Chowchilla Bypass and Reach 2A Topographic
18 Survey Results (DRAFT). Prepared for California Dept. of Water Resources, November
19 2012.
- 20 _____, 2012b. Eastside Bypass Topographic Survey Results (DRAFT). Prepared for California
21 Dept. of Water Resources, October 2012.
- 22 Reclamation Board, 1967; amended 1978, revised 1985. Lower San Joaquin River Flood Control
23 Project: Operation and Maintenance Manual for Levees, Irrigation and Drainage
24 Structures, Channels, and Miscellaneous Facilities.
- 25 Tetra Tech, Inc, 2012a. Draft Reach 2A Sedimentation Evaluation (2011). Prepared for the
26 California Dept. of Water Resources, April 2012.
- 27 _____, 2013b. Draft San Joaquin River and Bypass System 1-D Steady State HEC-RAS Model
28 Documentation, Prepared for California Department of Water Resources, May 2013.
- 29 _____, 2013c. Draft Reach 2A Sedimentation Evaluation (2012). Prepared for the California
30 Dept. of Water Resources, March 2013.
- 31 _____, 2013d. San Joaquin River, Reach 2B, Two-dimensional Sediment-transport Modeling to
32 Evaluate Sediment Budget through the San Joaquin River Bypass Structure, Prepared for
33 California Department of Water Resources, April 2013.

San Joaquin River Restoration Program

1 _____ . 2013e. San Joaquin River In-channel Capacity Analysis, Prepared for California
2 Department of Water Resources, September 2013.

3 Towill, Inc., 2009. Topographic and Bathymetric Mapping of the San Joaquin River from Friant
4 Dam to Highway 99 (Reach 1A). Letter of Transmittal submitted with mapping to Tetra
5 Tech-MEI for California Department of Water Resources, Fresno, California, April 24.

6 URS, 2013. Channel Capacity Assessment Based on Geotechnical Considerations. Prepared for
7 the California Dept. of Water Resources, August 30.

8 U.S. Army Corps of Engineers. 2000. Design and Construction of Levees Engineering and
9 Design Manual. Manual No. 1110-2-1913. April 2000. Table 6-1b, page 6-5.

10 _____ . 2003. Engineering and Design – Slope Stability. Manual No. 1110-2-1902. October
11 2003.

12 _____ . 2005. Design Guidance for Levee Underseepage Engineering Technical Letter. ETL
13 1110-2-569. May 2005.
14

1 **13.0 Appendices**

- 2 A. PEIS/R Text Related to Channel Capacity, 2012
- 3 B. San Joaquin River In-channel Capacity Analysis, 2013
- 4 C. Middle Eastside Bypass Geotechnical Assessment, 2013
- 5 D. Reach 2A Sediment Evaluation, 2011
- 6 E. Reach 2A Sediment Evaluation, 2012
- 7 F. Evaluation of the Effect of Subsidence on Flow Capacity in the Chowchilla and Eastside
- 8 Bypasses, 2013
- 9 G. Identification and Prioritization of Levee Segments for Geotechnical Exploration and
- 10 Analyses, 2012
- 11 H. Response to Comments, 2014