Technical Memorandum

Channel Capacity Report
2019 Restoration Year

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List of Abbreviations and Acronyms

CCAG	Channel Capacity Advisory Group
CCR	Channel Capacity Report
CFS	Cubic feet per second
CPT	Cone Penetration Test (Cone Penetrometer Test)
CVFPB	Central Valley Flood Protection Board
DWR	Department of Water Resources
GCR	Geotechnical Conditions Report
LMAs	Local Maintaining Agencies
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
NOD	Notice of Determination
O&M	Operations and Maintenance
PEIS/R	Program Environmental Impact Statement/Environmental Impact Report
Reclamation	Bureau of Reclamation
Restoration Area	San Joaquin River Restoration Program Restoration Area
RM	River mile
ROD	Record of Decision
SJLE Project	San Joaquin Levee Evaluation Project
SJRRP	San Joaquin River Restoration Program

Definitions

San Joaquin River Restoration Program (SJRRP): The SJRRP (also abbreviated as Program) 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 (CCAG): 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 Area that correspond to flows that would not significantly increase flood risk from Restoration Flows in the Restoration Area. This annual report will recommend updating then-existing channel capacity based on recently completed evaluations.

In-channel capacity: The channel capacity 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

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 Restoration Flows, which were initiated in 2014 and are specific volumes of water to be released from Friant Dam during different water year types, according to Exhibit B of the Settlement. Federal authorization for implementing the Settlement is provided in the San Joaquin River Restoration Settlement Act (Public Law 111-11). Reclamation signed the Record of Decision (ROD)/Notice of Determination (NOD) 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 Restoration Flows at or below estimates of then-existing channel capacities. Then-existing channel capacities in the Restoration Area (San Joaquin River between Friant Dam and the confluence of the Merced River) correspond to a Restoration Flow that would not significantly increase flood risk.

This Channel Capacity Report (CCR) for the 2019 Restoration Year (2019 CCR) is the sixth report in a series of annual reports required to fulfill the commitments in the ROD/NOD. The 2019 CCR will be an abbreviated version of previous reports because then-existing channel capacity will be the same as the 2018 CCR. A summary of the current and recommended then-existing channel capacity for the San Joaquin River and flood bypasses are described in Table ES-1. It should be noted that in addition to consideration of then-existing channel capacities, the release of Restoration Flows would also be limited by agricultural seepage. Details of how agricultural seepage limits are determined and limit Restoration Flows are in the *Seepage Management Plan*, which can be found at the SJRRP website under the following link:

Seepage Projects Page

A complete discussion of the data and analysis conducted for the then-existing channel capacities can be found in the 2018 CCR. New in the 2019 CCR is a summary of two studies completed in 2018 that relate to subsidence and sediment transport. The 2019 CCR also includes a summary of studies and monitoring that will be completed the following year.

Table ES-1.
Current and Recommended Then-existing Channel Capacity

Reach	Current and Recommended Then-existing Channel Capacity (cfs)[1]
Reach 2A	6,000[2]
Reach 2B	1,210
Reach 3	2,860[3]
Reach 4A	2,840[4]
Reach 4B1	Not Analyzed
Reach 4B2	930
Reach 5	2,350
Middle Eastside Bypass	580[5]
Lower Eastside Bypass	2,890
Mariposa Bypass	350

[1] Then-existing channel capacity shown in this table is based on levee stability only and does not consider Restoration Flow limitations related to agricultural seepage.

[2] Capacity not assessed for flows greater than 6,000 cfs. Restoration Flows are limited to approximately 2,140 cfs due to agricultural seepage.

[3] Restoration Flows are limited to approximately 650 cfs due to agricultural seepage.

[4] Restoration Flows are limited to approximately 300 cfs due to agricultural seepage, but may be increased in 2019 if seepage easements are obtained.

[5] The recommended then-existing channel capacity reflects the typical board setting at the weirs that allows for flow diversions within the Merced National Wildlife Refuge. If all of the boards are removed from the weirs, the capacity could increase to 1,070 cfs. If all of the boards are placed in the weirs, Restoration Flows could not be put into the bypass without exceeding USACE criteria.

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 Restoration Flows, which were initiated in 2014 and are specific volumes of water to be released from Friant Dam during different water year types, according to Exhibit B of the Settlement. 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)/Notice of Determination (NOD) on September 28, 2012. Both the PEIS/R and the ROD/NOD committed to establishing a Channel Capacity Advisory Group (CCAG) to determine and update estimates of then-existing channel capacities as needed and to maintain Restoration Flows at or below estimates of then-existing channel capacities. Then-existing channel capacities in the 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 Restoration Flows. Sections of the PEIS/R applicable to the CCAG are included in Appendix A of this report.

This Channel Capacity Report (CCR) for the 2019 Restoration Year (2019 CCR) is the sixth in the series of annual reports required to fulfill the commitments in the ROD/NOD. The 2014 CCR was the first report that was followed by five subsequent reports that based recommended then-existing channel capacities on new information regarding levee stability, subsidence or other SJRRP considerations. The reports also included information on the CCAG roles and responsibilities, technical factors when considering channel capacity, the criteria and evaluation process for determining capacity, as well as the data and analytical tools used to determine channel capacity. Previous Channel Capacity Reports can be found at the SJRRP website at the following link:

Levee Stability / Channel Capacity Page

The 2019 CCR then-existing channel capacity will be the same as last year's. The 2018 CCR recommended then-existing channel capacity is based on geotechnical data in portions of Reach 2A, Reach 4A, and the Middle Eastside Bypass and considers subsidence Reach 2A, Reach 2B, Reach 4A and the Middle Eastside Bypass. This year's CCR includes two new studies related to subsidence and capacity. The CCR also includes a summary of studies and monitoring that will be completed the following year. All other background information on channel capacity, including how then-existing channel capacity was developed, can be found in the 2018 CCR.

The 2019 CCR was available for a 60-day public review and comment period beginning on November 9, 2018 to January 8, 2019. No written comments were received.

3.0 Study Area

The study area starts from the Friant Dam and ends at the confluence of the San Joaquin River with the Merced River. The CCR 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 the Sand Slough Connector Channel to the confluence with the San Joaquin River and the Mariposa Bypass. The study area reaches are shown in Figure 3-1. Currently, Restoration Flows pass through Reaches 1 through 4A, the Sand Slough Connector Channel and the Eastside Bypass before entering Reach 5 of the San Joaquin River. Portions of the Study area are also within the Lower San Joaquin River Flood Control (LSJRFC) Project, which includes 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.

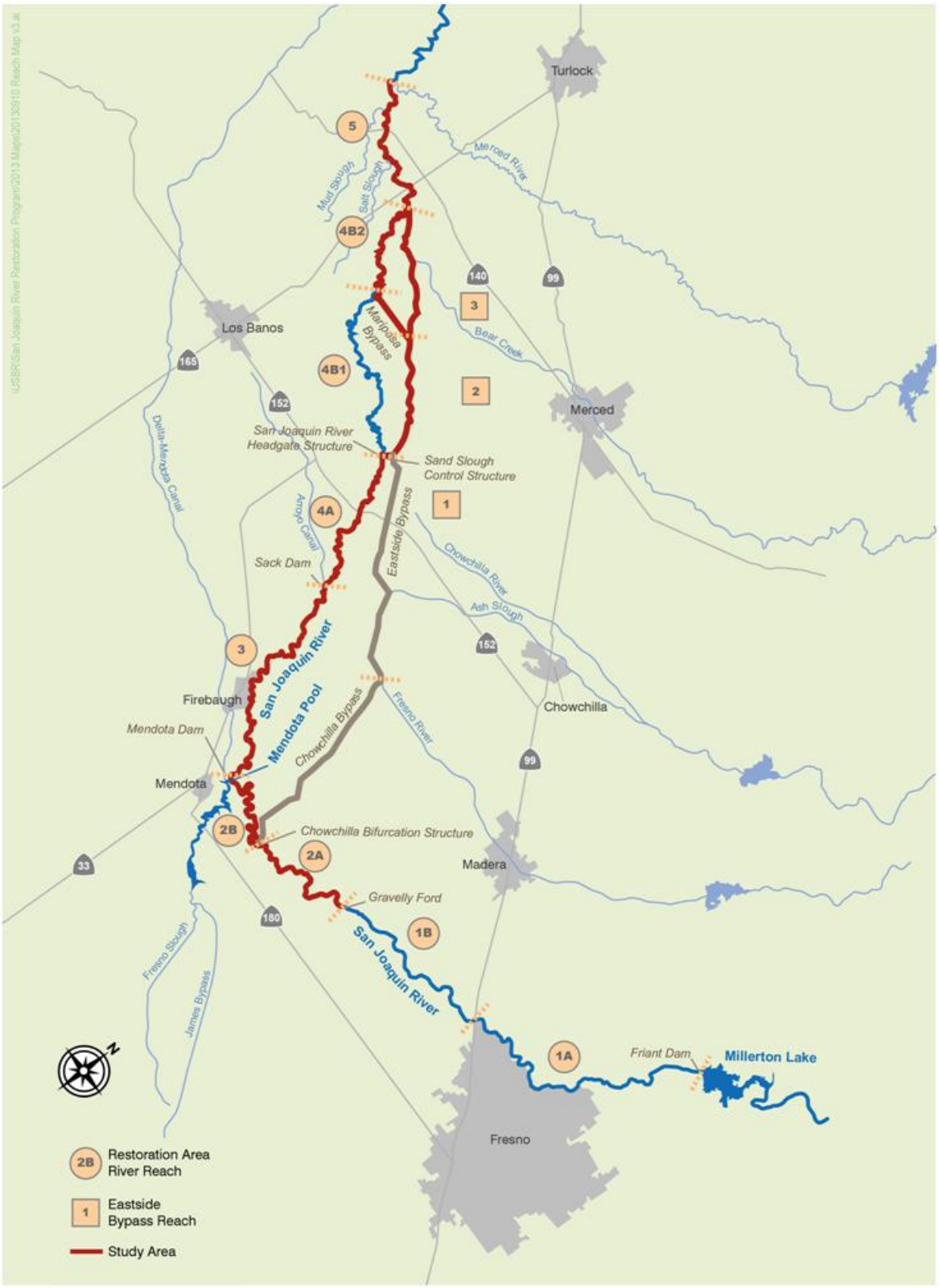

Figure 3-1.

San Joaquin River Reaches and Flood Bypass System

4.0 Completed Channel Capacity Studies and Related Work

The following sections summarize the new technical studies and related work that has been completed at the time of publication of this report that relate to channel capacity. This year's report includes two DWR studies that provide a general picture of flow capacity and the effect of subsidence and sediment transport on the ability of the system to convey flood flows.

The first study, *Evaluation of the Effect of Subsidence on Flow Capacity in the Chowchilla and Eastside Bypasses, and Reach 4A of the San Joaquin River*, presents the change in levee freeboard and flow capacity in the Chowchilla and Eastside bypasses and Reach 4A that has occurred between 2008 and 2016 and makes projections on potential future changes related to continuing subsidence through 2026. The second study, *Evaluation of the Effects of Subsidence and Sediment Transport on Channel Capacity in the Eastside Bypass and Reach 4A of the San Joaquin River*, evaluates the effects of subsidence and sediment transport on channel capacity in the Upper and Middle Eastside Bypass and Reach 4A, as well as looks at the effects of subsidence and Restoration Flows on design freeboard capacity to the year 2029. Both studies are described below.

4.1 Subsidence and Flow Capacity Study

DWR performed a hydraulic study that evaluates the potential impact of subsidence on flow capacity and freeboard in the Chowchilla and Eastside bypasses between the San Joaquin River at the Chowchilla Bifurcation Structure and the Mariposa Bypass and Reach 4A of the San Joaquin River. The study focuses on assessing the effects of ground subsidence between 2008 and 2016 and then estimates possible future effects to 2026. The study, *Evaluation of the Effect of Subsidence on Flow Capacity in the Chowchilla and Eastside Bypasses, and Reach 4A of the San Joaquin River,* dated May 2018, is included in Appendix B and is summarized below.

4.1.1 Study Topography and Tools

The study was conducted using validated 1-D steady state Hydrologic Engineering Center's River Analysis System (HEC-RAS) baseline models of the river and flood bypass with 2008 topography and where available 2010-2011 bathymetry. The model geometry was updated to 2016 based on the DWR top of levee surveys. In updating the model geometry, the 2008 cross-sections were adjusted based on the total subsidence measured between the 2008 LiDAR and the 2016 surveys (Figures 3, 4, and 5 of Appendix B). The model geometry was further modified to reflect future subsidence conditions in 2026. For the 2026 condition, the model was adjusted to reflect the amount of subsidence that is projected to occur between 2016 and 2026 using average annual rates from 2011 to 2017 determined by Reclamation in its bi-annual surveys. Figure 4-1 shows the average annual subsidence rates range from about 0.15 ft/year to 0.60 ft/year based on survey data collected from December 2011 to December 2017 (see also Table 2 of Appendix B).

4.1.2 Analysis and Results

The hydraulic study was completed as two separate evaluations. The first evaluation estimated the change in freeboard that has occurred from recent subsidence and may occur in the future as a result of ongoing subsidence. The second evaluation included translating those changes in freeboard into changes in flow capacity. The analyses focused on identifying the maximum (or limiting) discharge that can be conveyed through each reach associated with the water-surface elevation that does not exceed the design levee freeboard elevation at any location within the reach.

The design flow capacities for the study area were input into the models to evaluate water surface elevations and freeboard under 2016 and 2026 conditions. Because of subsidence, the results of the analysis showed that the modeled water surface elevations for 2016 and 2026 were lower than those of 2008. Generally, the total amount of subsidence that has occurred at each cross section were not the same as the total change in water surface elevation at each respective cross section. As shown in Figure 4-1, the ground has subsided at different rates along the study area and caused channel slopes to change. The slope in some segments of the reach has increased, which decreased the water depth and increased the freeboard. This increase in freeboard resulted in an increase in capacity. However, in the Eastside Bypass and Reach 4A, the slopes of other segments of the reach has decreased, which increased the water depth and decreased the freeboard. The decrease in freeboard resulted in a decrease in capacity. The design capacity is reduced as the water surface elevation encroaches upon the design freeboard.

The results of the hydraulic analysis that are summarized in Table 4-1 (also in Table 3 of Appendix B) show that portions of the bypasses and Reach 4A currently do not meet the reported flood design flow capacity. Subsidence documented since 2008 has changed the ability of the river and bypasses to convey flows, and in some locations, has significantly reduced capacities. If future subsidence occurs at the rate calculated from 2011 to 2017 (shown in Figure 4-1), capacities would be further reduced, which could change the way the flood system is operated. The channels within the Sand Slough area appear to be most significantly affected by subsidence. Considering backwater conditions, the 2016 capacity in the Upper Eastside Bypass is 5,700 cfs, a loss of as much as 70 percent of its design flow capacity. The loss in capacity may further increase by 2026 when the capacity is projected to be 3,400 cfs, a reduction of 80 percent from its design flow capacity.

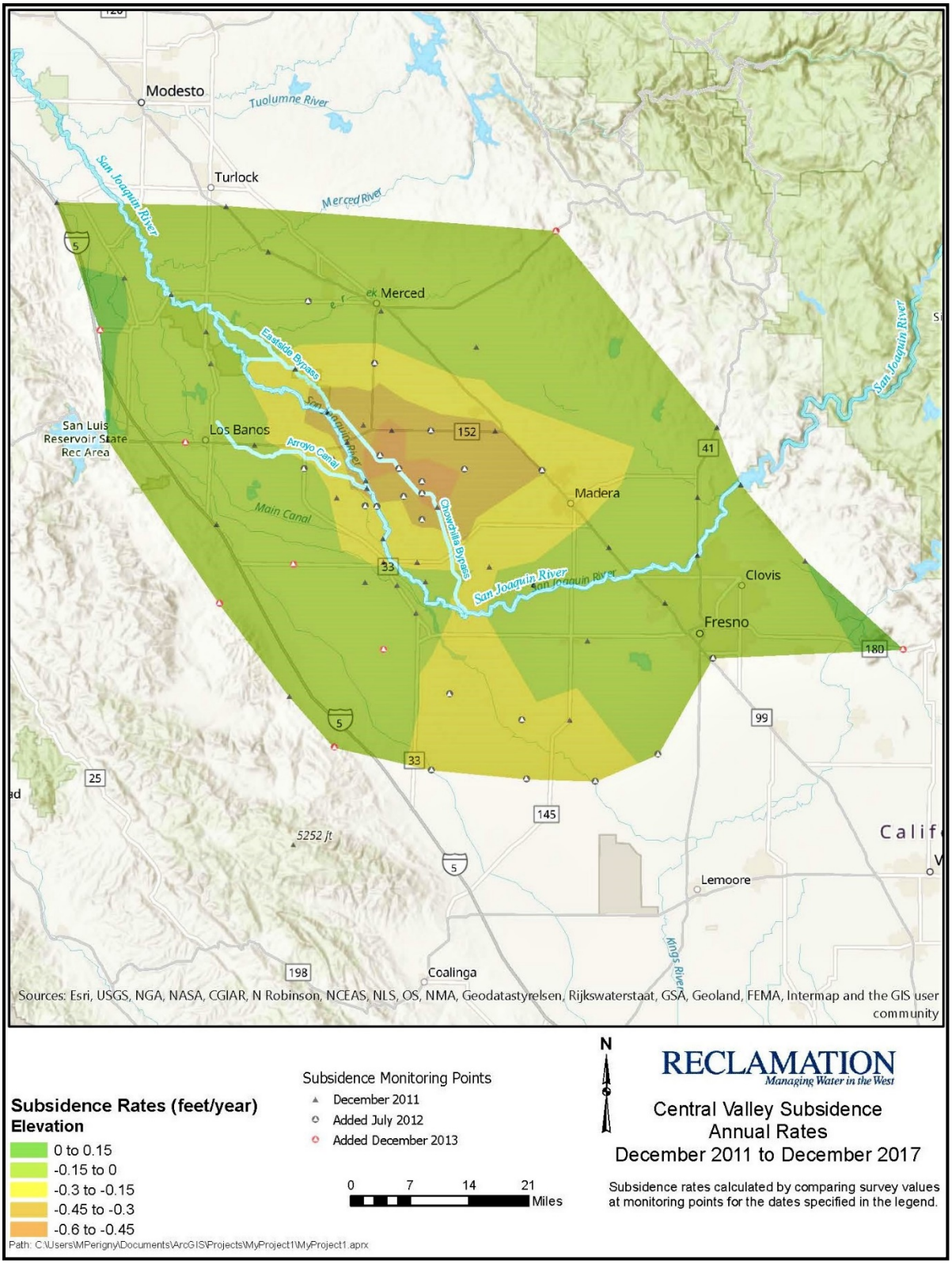

Figure 4-1.
Regional Subsidence Map

The same trend is seen in the Eastside Bypass from Sand Slough to the Mariposa Bypass and Reach 4A. In the Eastside Bypass from Sand Slough to the Mariposa Bypass, the capacity in 2016 is 12,500 cfs, a loss of 25 percent from its design flow capacity; in 2026, the capacity may be further reduced to 40 percent with a capacity of 9,800 cfs. Considering backwater conditions, Reach 4A has a capacity of 2,100 cfs in 2016, a reduction of 50 percent from its design flow capacity. Furthermore, the reach may not be able to convey any flows at its design freeboard by 2026 because of limitations at the Sand Slough Connector Channel.

Table 4-1
Estimated Flow Capacity based on Freeboard Criteria (in cfs)

Channel Segment	Flood Design Flow[1]	2008[2]	2011[2]	2016	2026
Chowchilla Bypass					
Bifurcation Structure to Fresno River	5,500	>5,500	>5,500	>5,500	>5,500
Eastside Bypass					
Fresno River to Berenda Slough	10,000	>10,000	>10,000	>10,000	>10,000
Berenda Slough to Ash Slough	12,000	>12,000	>12,000	>12,000	>12,000
Ash Slough to Sand Slough	17,500	9,500[3] – 12,500	7,500[3] – 11,500	5,700[3] – 9,500	3,400[3] - 7,500
Sand Slough to Mariposa Bypass[4]	16,500	16,000	14,500	12,500	9,800
San Joaquin River					
Reach 4A	4,500	ND[5]	ND	3,700[6] – 4,300	2,500[6] – 3,800
Sand Slough Connector Channel	ND	ND	ND	2,100[6] – > 4,500	0[6] – > 4,500

[1] Referenced from the Lower San Joaquin River Flood Control Project Operation and Maintenance Manual.
[2] Results obtained from a previous study done by DWR in 2013.
[3] Reduced capacity assumes contribution of 4,500 cfs from Reach 4A of the San Joaquin River (creating backwater conditions).
[4] Capacity assumes diversions into the Mariposa Bypass based on the O&M Manual operating rules.
[5] ND = not determined as part of this study.
[6] Reduced capacity assumes contribution of 12,000 cfs through the Bypass Channel (creating backwater conditions).

4.1.3 Conclusions

The reduced capacities in Table 4-1 are the result of flows exceeding the design freeboard at a single cross-section or small segments within each channel segment. Though these values are much lower than flood design flows, a majority of each reach may still be able to convey flood design flows within the design freeboard. It should also be noted that the Lower San Joaquin Levee District (LSJLD) will operate the system to reduce the risk of flood damages in the system. This may mean encroaching on freeboard during high-flow events to increase the conveyance in the channels. DWR and Reclamation will continue to conduct monitoring and

analysis that could provide a better understanding of the future rates of subsidence and the effect on future flow capacities.

4.2 Sediment Transport, Subsidence and Restoration Flow Capacity Study

DWR has also performed a preliminary study to evaluate the effects of sediment transport in addition to the subsidence on channel capacity in the Upper and Middle Eastside Bypass, and Reach 4A of the San Joaquin River. The evaluation looks at the effects of subsidence and Restoration Flows released from Friant Dam under the SJRRP on design freeboard capacity to the year 2029. The sediment-transport evaluation, *Evaluation of the Effects of Subsidence and Sediment Transport on Channel Capacity in the Eastside Bypass and Reach 4A of the San Joaquin River*, dated August 2018, is included in Appendix C and is summarized below.

4.2.1 Study Methodology

Hydraulic models were adjusted to incorporate subsidence and sediment transport within the study area to develop model geometries that represent current (2016) and future channel conditions based on the ongoing subsidence that is affecting the study reach. Sediment gradations along the Chowchilla and Eastside bypasses were developed from bed-material samples collected by Tetra Tech in 2013 and sediment gradations along Reach 4A were characterized based on bed-material samples collected by Reclamation. A mobile-bed sediment-transport model using HEC-RAS was developed based on the hydraulic model geometries and sediment gradations.

Four separate 13-year hydrologic periods were developed to represent dry and wet year periods under flow operations without Restoration Flows (referred to as existing conditions) and under Restoration Flow conditions. These scenarios are referred to as Existing-Dry, Restoration-Dry, Existing-Wet, and Restoration-Wet. It should be noted the only difference between the Existing and Restoration scenarios are the release of Restoration Flows. The HEC-RAS model was then executed using these four separate hydrologic periods to simulate the possible hydrology over the period between 2016 and 2029. These simulations were input into the mobile-bed sediment transport models to generate 2029 geometry for each hydrologic scenario. The five generated geometries were then used to determine the flood design flow capacity in each channel as describe below – 2016 baseline geometry and 2029 for the four separate hydrologic periods.

4.2.2 Analysis and Results

Channel capacities were evaluated for five different model geometries and four hydrological scenarios representing dry and wet periods for existing and Restoration Flow routing and are summarized in Table 4 of Appendix C. The capacity for each channel segment was then determined as the maximum flow (up to the flood design flow) that would not exceed the freeboard criteria at the most critical cross section. Like the results of the study described in Section 4.1 above, subsidence is a significant factor in the change in future capacity in the

channels within the Sand Slough area. This is largely due to the recent subsidence (whose epicenter is mostly upstream of the study reach), which has caused a reduction of channel slopes in each reach, reducing the channel capacity. Sediment can also play a factor in changing channel capacities as the change in flows from Restoration Flows also changes the sediment depositional and erosional patterns in a reach when compared to existing conditions. The dry conditions hydrology (with and without Restoration Flow) results in much lower sediment loads than the wet conditions in all of the subreaches, directly attributable to the magnitude of flows. This generally results in a slightly higher flow capacity in dry year scenarios for both existing and Restoration hydrology when compared to the wet scenarios. Compared to the Existing-Dry conditions hydrology, the Restoration-Dry hydrology results in much lower sediment loads from the Upper Eastside Bypass resulting in a lower channel capacity for dry year hydrology. The opposite occurs in Reach 4A, which when compared to Existing-Dry conditions hydrology, the Restoration-Dry hydrology results in higher sediment loads from Reach 4A resulting in a higher channel capacity. This occurs because a greater portion of the flows are routed through Reach 4A rather than the Upper Eastside Bypass under Restoration Flow conditions.

4.2.3 Conclusions

Previous capacity studies demonstrate that subsidence is responsible for a majority of the predicted reductions in capacity (DWR, 2013). Furthermore, though sediment transport is predicted to further reduce capacities beyond the impacts of subsidence alone, sediment transport associated with Restoration Flows will not likely change channel capacities significantly beyond the impacts of subsidence. Assuming that subsidence is likely to continue to occur, and that the hydrology is likely to be somewhere between the Dry and Wet extremes that were evaluated, the results indicate that the capacity of Reach 4A over the next 13 years is likely to decrease by about 12 percent regardless of existing or Restoration Flows; in the Middle Eastside Bypass, channel capacity is likely to decrease by about 34 percent for that same time period. The primary sedimentation issues that do occur in the Middle Eastside Bypass, are located in the upstream end of the reach near El Nido Road. This is an area that has a history of sedimentation and low-capacity issues.

5.0 Recommended Then-existing Channel Capacities

The purpose of this section is to present the recommended then-existing channel capacities based on results from the channel capacity studies summarized in this and previous reports. Then-existing channel capacities are defined as flows that would not significantly increase flood risk from Restoration Flows in the Restoration Area. To reduce this risk, the PEIS/R included levee design criteria for 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 4.0 -- Completed Channel Capacity Studies and Related Work were analyzed for determining then-existing channel capacity. Both of these studies are included as informational items and are intended to help decision makers for the SJRRP understand the potential need to reduce future Restoration Flows or implement sediment removal projects due to reduced channel capacity. These studies focused on future design flood flow capacity within the flood bypasses and river and not future Restoration Flows, therefore; they did not change then-existing channel capacities for the 2019 Restoration Year.

The studies that were summarized in the previous 2017 and 2018 CCRs were used to determine then-existing channel capacity for the 2018 Restoration Year and will continue to be the studies that will be used to recommend then-existing channel capacity for the 2019 Restoration Year. These include: the *San Joaquin River In-channel Capacity Analysis* (Tetra Tech, 2015b) (included in the 2017 CCR) with update included in Appendix B of the 2018 CCR and the Priority 1 Levee Assessment (included in the 2017 CCR) with an update included in Appendix C of the 2018 CCR. The results in these studies and subsequent updates continue to be used to inform recommended then-existing channel capacities. This information uses in-channel capacity as the best estimate of then-existing channel capacities for Reach 2B, Reach 3, portions of Reach 4A, Reach 4B2, Reach 5, Lower Eastside Bypass and Mariposa Bypass. For Reach 2A, the lower 2.5 miles of Reach 4A, and the Middle Eastside Bypass, adequate data was available to perform a geotechnical analysis and these results were used to determine then-existing channel capacity. The results summarized and detailed in the 2017 and 2018 CCRs are the 2019 CCR then-existing channel capacity for the San Joaquin River and flood bypasses.

Table 5-1 summarizes the current and recommended then-existing channel capacities for each reach of the San Joaquin River and the flood bypasses, as well as what study was used to determine then-existing channel capacity. Then-existing channel capacities recommended above do not consider limitations to Restoration Flows as it relates to agricultural seepage. For the 2019 Restoration Year, releases of Restoration Flows in Reach 2A, Reach 3, and Reach 4A are limited by agricultural seepage, and not levee stability. Table 5-1 also notes current limitations of Restoration Flows based on agricultural seepage. Details of how these seepage limits are determined and limit Restoration Flows are in the *Seepage Management Plan* described in Section 6.2.2 of this report**.**

Table 5-1.
Current and Recommended Then-existing Channel Capacity

Reach	Current and Recommended Then-existing Channel Capacity (cfs)[1]	Study that determines Then-existing Channel capacity
Reach 2A	6,000[2]	Geotechnical Assessment
Reach 2B	1,210	In-channel
Reach 3	2,860[3]	In-channel
Reach 4A	2,840[4]	Geotechnical Assessment and In-channel
Reach 4B1	Not Analyzed	--
Reach 4B2	930	In-channel
Reach 5	2,350	In-channel
Middle Eastside Bypass	580[5]	Geotechnical Assessment
Lower Eastside Bypass	2,890	In-channel
Mariposa Bypass	350	In-channel

[1] Then-existing channel capacity shown in this table is based on levee stability only and does not consider limitations to Restoration Flows related to agricultural seepage.

[2] Capacity not assessed for flows greater than 6,000 cfs. Restoration Flows are limited to approximately 2,140 cfs due to agricultural seepage.

[3] Restoration Flows are limited to approximately 650 cfs due to agricultural seepage.

[4] Restoration Flows are limited to approximately 300 cfs due to agricultural seepage, but may increase in 2019 if seepage easements are obtained.

5 The recommended then-existing channel capacity reflects the typical board setting at the weirs that allows for flow diversions within the Merced National Wildlife Refuge. If all of the boards are removed from the weirs, the capacity could increase to 1,070 cfs. If all of the boards are placed in the weirs, Restoration Flows could not be put into the bypass without exceeding USACE criteria.

6.0 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 capacity. As channel or structure modifications are completed with additional environmental compliance, corresponding maximum Restoration Flow releases would be increased in accordance with then-existing channel capacity and the release schedule. Consistent with the commitments made in the PEIS/R ROD, Restoration Flows would be reduced, as needed, to address material seepage and levee stability impacts, as identified in the *Physical Monitoring and Management Plan* in Appendix D of the PEIS/R. If the San Joaquin River within the Restoration Area contains water other than Restoration Flows, concurrent Restoration Flows may be reduced such that the total flow does not exceed then-existing channel capacity. If flood control releases from Friant or other flood control facilities in the San Joaquin River system 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 that could affect then-existing channel capacity due to changes in the physical conditions within the Restoration Area. The listed potential actions and projects is not a comprehensive list, but a list of actions that may be implemented. If any actions increase then-existing channel capacity, a new Channel Capacity Report will be prepared prior to Reclamation increasing Restoration Flows.

6.1 Immediate Actions

Immediate actions are described at a project-level in the PEIS/R including specific details in the *Physical Monitoring and Management Plan*. Potential immediate actions to a reduction in channel capacity continue to include removal of vegetation and debris and/or restrictions on Restoration Flows that would exceed channel capacity.

Since the start of Restoration Flows, the SJRRP has implemented flow limitations and immediate flow reductions to address issues related to capacity, mainly for agricultural seepage and will continue to do so on an as-needed basis during the release of Restoration Flows.

6.2 Near-Term Actions

In addition to immediate actions, the SJRRP is evaluating sediment, vegetation and operational and maintenance projects that are being considered for implementation in the next couple of years (near-term) to address the potential to maintain or increase then-existing channel capacities. The near-term actions are described in the previous year's 2018 CCR and are summarized in the *Physical Monitoring and Management Plan* (in Appendix D of the PEIS/R). Updates on some of these actions are described below.

6.2.1 Operations and Maintenance

Overall operation and maintenance including vegetation and sediment management, structure and gate operations, levee integrity of the San Joaquin River and flood bypasses can impact then-existing channel capacities. DWR is leading an effort to assist the LSJLD and the SJRRP to ensure the maintenance of the flood system is not adversely impacted by actions of the SJRRP. DWR is working with the LSJLD to better understand the maintenance that is being performed, identify any changes to that maintenance from actions of the SJRRP, and develop a plan to ensure the intended outcomes of that maintenance can be achieved. The results of this effort will be detailed in the 2020 CCR.

6.2.2 Seepage Management Plan

Reclamation has developed a *Seepage Management Plan* and *Seepage Project Handbook* to guide efforts related to groundwater seepage. It should be noted that the actions and findings of the *Seepage Management Plan*, although related to channel capacity, is being reported as it relates to agricultural seepage only. Anticipated Restoration Flow limitations for each reach due to agricultural seepage for the 2019 Restoration Year is shown in Table 6-1.

The *Seepage Management Plan* and *Seepage Project Handbook* can be found at the SJRRP website under the following link:

Seepage Projects Page

Table 6-1.
Restoration Flow Limitations as it Relates to Agricultural Seepage

Reach	Seepage Management Plan Approximate Restoration Flow Limitations[1] (cfs)
Reach 2A	2,140
Reach 2B	1,300
Reach 3	650[2]
Reach 4A	300[3]
Reach 4B1	Not Analyzed
Reach 4B2	--
Reach 5	--
Middle Eastside Bypass	--
Lower Eastside Bypass	--
Mariposa Bypass	--

[1] Subject to real time groundwater monitoring.
[2] Restoration Flow limitation due to agricultural seepage for Reach 3 has been updated based on real-time monitoring.
[3] Restoration Flow limitation due to agricultural seepage for Reach 4A may increase to above 300 cfs pending on-going seepage easement negotiations.

6.3 Long-Term Actions

Long-term actions by the SJRRP will be needed to achieve then-existing channel capacity in the San Joaquin River and flood bypasses that can convey maximum Restoration Flow releases. Potential long-term actions could include, but would not be limited to, the following: providing a larger floodplain between levees through the acquisition of land and construction of setback levees; re-grading of land between levees; construction of sediment traps; sediment removal; levee improvements; construction of grade control structures; and channel grading.

Long-term actions would require a determination of need, identification for funding, and site-specific environmental compliance documentation. These actions would be considered by the SJRRP to allow the continued increase of then-existing channel capacity to meet full Restoration Flows.

The SJRRP is continuing to work on several long-term projects related to increasing site-specific channel capacity as provided for in the Settlement paragraphs 11(a) and 11(b). A status update on progress of the long-term progress includes:

- Construct Mendota Pool Bypass. The Compact Bypass would route flows and fish around the Mendota Pool and would improve channel capacity to at least 4,500 cfs from Reach 2B to Reach 3. Additionally, the Mendota Pool Control Structure would allow for deliveries into Mendota Pool, as appropriate. Pool operations would continue at the same water surface elevation as it does now, and the project includes a fish screen to avoid fish

straying into Mendota Pool. Construction of this project is planned to begin in 2019. As construction proceeds and the river slope equilibrates through the new bypass channel, this reach will be an active site of erosion and deposition and may influence downstream sediment transport. Though sediment transport modeling indicates that much of the mobile sediment will move out the Restoration Area, monitoring stations are being established to track the effects of Mendota Pool Bypass to key infrastructure and channel capacity.

- Construct levee and fish passage improvements in the Middle Eastside Bypass (the Eastside Bypass between the Sand Slough Control Structure and Mariposa Bypass). The improvements that will impact channel capacity include reinforcing two miles of right levee along the Eastside Bypass to improve levee stability and reduce seepage. This improvement will increase Restoration Flows to at least 1,300 cfs in the reach. Another improvement includes removing two weirs located in the Eastside Bypass and operated by U.S. Fish and Wildlife Service to allow for fish passage. Removal of the weirs and construction of the levee improvements are planned to begin in 2019. Both projects will result in changes in then-existing channel capacity.

6.4 Framework for Implementation

The long-term actions identified above, with the exception of the Reach 4B Project, are included in the SJRRP's 2018 *Funding Constrained Framework for Implementation* (Constrained Framework). This is an update of the *2015 Revised Framework for Implementation* (Revised Framework), given a more limited future funding stream than previously anticipated. The first stage (termed Stage 1) has the primary goal of beginning the reestablishment of spring-run and fall-run Chinook salmon in the San Joaquin River between the Merced River and Friant Dam through the establishment of volitional fish passage, sufficient flows to manage temperatures, and provide for the basic habitat needs of the species. Both the current Constrained Framework and previous Revised Framework establish the following:

- Five-year visions to provide clear, realistic, and accomplishable steps towards meeting the Restoration Goal and Water Management Goal;

- Achievable schedules based upon realistic Federal and State of California appropriation levels, improving our ability to plan and be transparent on actions; and

- More clearly defined roles and responsibilities for each Implementing Agency, increasing each agency's ability to budget, plan, and approve construction actions.

This Constrained Framework provides a more realistic schedule and associated future funding needs for the SJRRP Implementing Agencies to focus on "core" actions identified in the 2012 Framework and Implementation of the Settlement and the Settlement Act. The Constrained Framework includes objectives to have 2,500 cubic feet per second of channel capacity throughout the San Joaquin River to Reach 4A, the Eastside Bypass and Reach 5 by the end of 2024. Channel capacity improvements include levee improvements identified by the remaining

reaches constrained by then-existing channel capacity, and groundwater seepage projects needed to release flows without causing crop yield impacts. Approximately $20 million of levee improvement projects and $72 million of seepage projects are included in the Constrained Framework.

The Constrained Framework can be found at the SJRRP website under the following link:

Framework Funding Constrained Final For Final Review Document

7.0 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; and increased roughness from vegetation. Other future conditions, such as climate change and operation and maintenance while not directly impacting channel capacity, could have long-term impacts on overall performance of the conveyance system. These factors, as well as others were considered in developing SJRRP studies and monitoring to determine then-existing channel capacity. The following sections summarize studies and data collection activities by the SJRRP to provide a better understanding of then-existing channel capacity or changes in in-channel capacity.

7.1 Technical Studies

The 2018 CCR described several future technical studies that will provide additional information necessary to identify future then-existing channel capacities. The following describes the activities that are ongoing or may be conducted during the following Restoration Year.

7.1.1 San Joaquin Levee Evaluation Project

The San Joaquin Levee Evaluation (SJLE) Project lead by DWR assists the SJRRP in assessing flood risks associated with the SJRRP with respect to levee seepage and stability. As part of the work, DWR identified three priorities for levee evaluations representing an increasing priority for the need to complete geotechnical evaluations and analyses. DWR has completed its evaluation of Priority 1 levees and as a result will be reinforcing approximately 2 miles of levee along the Eastside Bypass to improve levee stability and reduce seepage (same levee improvement project described in Section 6.3 above). DWR is also continuing the exploration of Priority 2 levees to inform the SJRRP of future remediation needs and costs. Priority 2 evaluations are currently being performed on about 30 miles of levees in Reach 4B2 and the Mariposa Bypass. The explorations, including 152 bore holes, CPTs, geophysical surveys, and testing of the soils data has been completed. The evaluations and determination of capacities for these reaches will continue into 2019. Then-existing channel capacity will likely change once the Priority 1 levee improvements, and the Priority 2 assessments are complete.

7.1.2 Subsidence Monitoring and Studies

Previous channel capacity reports include a description of the methods and results of the subsidence monitoring and levee surveys completed by Reclamation, Mid–Pacific Region, Division of Design and Construction, Surveys and Mapping Branch (MP-220) and the California Department of Water Resources, South Central Region Office (DWR-SCRO) for the SJRRP.

The results of the monitoring continue to be used to study subsidence within the Restoration Area and to support the various studies that will help the SJRRP determine changes in then-existing channel capacities because of subsidence. Bi-annual surveys by Reclamation will continue, but currently, no additional subsidence studies are planned for 2019.

7.2 Monitoring Activities

The SJRRP is continuing various monitoring activities for different studies and purposes. These activities are described in the *Physical Monitoring and Management Plan*, which is in Appendix D of the PEIS/R, the *Restoration Flow Guidelines,* and the *Seepage Management Plan.* Typical activities, including flow, sediment mobilization and erosion monitoring, and water surface profile surveys are also described in previous channel capacity reports and are conducted when needed. Updates on the ongoing monitoring activities are described below.

7.2.1 Aerial Photography and Topographic Surveys

The purpose of the aerial photography and topographic surveys is to obtain information about the river stage, hydraulic roughness, river width, and bed elevation to assist with scientific studies that would inform the SJRRP about how physical changes in the system are impacting then-existing channel capacities. Much of the Restoration Area uses topography based on 2008 LiDAR and 2010/2011 bathymetry. Due to continued subsidence, a new flight of aerial photography and LiDAR was flown in 2015 within 1 mile of all reaches of the San Joaquin River from Friant Dam to the Merced River confluence as well as the Chowchilla, Eastside, and Mariposa Bypasses. Bathymetric surveys were also completed in 2015 and 2016. The data has been reprocessed and new terrain surfaces will be completed this year. The data will then be used for site-specific designs and to update hydraulic models and studies which could be used to inform then-existing channel capacity.

7.2.2 Vegetation Surveys

The purpose of the previous and future vegetation surveys is to obtain information on the establishment and recruitment of vegetation. This information can be used by the SJRRP to determine if actions need to be taken to address capacity issues as a result of increased roughness from vegetation within the channel. Annual surveys have occurred since 2011 and future surveys will be conducted annually after flood events as part of baseline SJRRP monitoring. The extent and scope of the monitoring is discussed in Section 10.2.5 of the 2014 CCR.

7.2.3 Levee Monitoring Program

The SJRRP has committed to minimizing flood risk from Restoration Flows as outlined in the PEIS/R. This effort includes collecting levee performance data within the Restoration Area with a focus on levees most critical to limiting the release of restoration flows. Because levee

evaluations are limited to a seepage and stability analysis, and do not include assessment of other levee failure mechanisms, a field monitoring program was established to evaluate the levees during high-water events and during Restoration Flows, which allow early identification of potential problems.

The levee monitoring effort began in Water Year 2017 and included two rounds of visual levee inspections. Water Year 2017 was the second wettest year on record for the San Joaquin Basin. Because of required flood control releases from Friant Dam, many of the levees within the system conveyed high flows for at least six months of the water year. Target levees for monitoring as flood flows receded and Restoration Flows continued were the upstream half of Reach 2B, the lower end of Reach 4A, the Middle Eastside Bypass, the Mariposa Bypass, and the right bank levee of Reach 4B2. High flows over extended periods of time did reveal levee performance issues in the levee areas inspected. During two rounds of levee inspections, 16 sites were identified. However, the levees no longer appeared to have performance issues (no active boils or notable seepage) at the lower Restoration Flows. Most of the issues were observed were in the Middle Eastside Bypass. Future levee monitoring is expected to continue on an as-needed depending on flood and Restoration Flow releases as well as changes in channel capacity identified in future channel capacity reports.

8.0 References

Reclamation Board, 1967; amended 1978, revised 1985. Lower San Joaquin River Flood Control Project: Operation and Maintenance Manual for Levees, Irrigation and Drainage Structures, Channels, and Miscellaneous Facilities.

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