Appendix A

Problem Statements and Studies

Draft 1
Annual Technical Report

SAN JOAQUIN RIVER RESTORATION PROGRAM

Draft 1
August 2010

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Abbreviations and Acronyms

Act	San Joaquin River Restoration Settlement Act
ADCP	Acoustic Doppler Current Profiler
ATR	Annual Technical Report
CDEC	California Data Exchange Center
cfs	cubic feet per second
CSUF	California State University, Fresno
CVP	Central Valley Project
CVRWQCB	Central Valley Regional Water Quality Control Board
CTK	Cottonwood Creek
Delta	Sacramento-San Joaquin Delta
DFG	California Department of Fish and Game
DO	dissolved oxygen
DPR	California Department of Pesticide Regulations
DWR	California Department of Water Resources
FMP	Fisheries Management Plan
FMWG	Fisheries Management Work Group
FWUA	Friant Water Users Authority
GBP	Grasslands Bypass Project
GIS	graphical information systems
GRF	Gravelly Ford
GPS	global positioning system
HEC-RAS	Hydrologic Engineering Centers River Analysis System
LDC	Little Dry Creek
mg	milligram
MIL	Millerton Lake gaging station
mm	millimeters
NAD	North American Datum
N/L	nitrogen per liter
NMFS	National Marine Fisheries Service
NRDC	Natural Resources Defense Council
Order	State Water Resources Control Board Order WR-2009-0058-DWR
PVC	polyvinyl chloride
QA/QC	quality assurance/quality control

RA	Restoration Administrator
Reclamation	U.S. Department of the Interior, Bureau of Reclamation
RFID	radio frequency identification
RM	river mile
RTK	real-time kinematic
Secretary	Secretary of the U.S. Department of the Interior
Settlement	Stipulation of Settlement in NRDC, et al., v. Kirk Rodgers, et al.
SJR	San Joaquin River
SJRRP	San Joaquin River Restoration Program
SWAMP	Surface Water Ambient Monitoring Program
TMDL	total maximum daily load
USGS	U.S. Geological Survey
USFWS	U.S. Fish and Wildlife Service
WLR	water level recorder
WSE	water surface elevation
WY	Water Year

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1.0 Introduction

This appendix presents a framework for developing studies to support the San Joaquin River Restoration Program (SJRRP). Problem statements describe monitoring and analysis requirements from the Stipulation of Settlement in *NRDC, et al., v. Kirk Rodgers, et al.* (Settlement), San Joaquin River Restoration Settlement Act (Act), and Draft Fisheries Management Plan (FMP), and are used to inform a long-term approach to address those needs through organized scientific studies and data collection. Problem statements presented in this appendix describe the current conceptual framework for how the SJRRP is currently approaching problems.

Studies link components with Settlement, Act, and FMP requirements, demonstrate applicability to SJRRP implementation, justify expenditures, aid prioritization, and potentially facilitate identification of alternative approaches. In the future, each study includes the following:

- Statement of Need: Identify part of problem statement that will be addressed by study.
- Background: Describe how the study changes the approach to the problem; includes literature review, as necessary.
    - Conceptual Models: Describes current or proposed understanding of physical, biological, and operational practices and proposed changes to the current conceptual framework based upon new monitoring information.
- Anticipated Outcomes: Describes potential changes in management decisions or constraints that would be informed by study results.
- Methods
    - Monitoring requirements
    - Analysis requirements
- Results: Summarizes key results and references to appropriate Annual Technical Report (ATR) data appendices.
- Discussion: Interpretation, applicability, and limitations of results.
- Conclusions and Recommendations: Evaluates anticipated outcomes based on discussion of results to recommend a management action, future reevaluation, or no further action.
- References: Lists sources used to compile the study.

Fisheries studies presented in this appendix may be applicable to multiple life stages. Table A-1 presents a summary of the different life stages, the physical monitoring parameters that may influence development and the ability for Chinook salmon to achieve the life stage outcome, and the studies that are related. Some studies are currently under development and not included in this appendix.

Table A-1. Fisheries Life Stages, Physical Monitoring Parameters, and Studies

Life Stage	Life Stage Outcome	Physical Monitoring Parameters	Biological Need or Impact	Study
Adult Holding	Mature Spawner	Water Temperature	Disease	Temperature Monitoring for Millerton Cold Water Pool
Adult Holding	Mature Spawner	Water Temperature	Disease, Habitat	*In-river water temperature monitoring*
Adult Holding	Mature Spawner	Holding Pool Habitat	Habitat	*TBD*
Adult Holding	Mature Spawner	Water Temperature	Disease, Prespawn mortality, in vitro egg mortality	Effect of Altered Flow Regime on Channel Morphology in Reach 1A
Adult Holding	Mature Spawner	Stream Flow	disease, meso-habitat	Meso-Habitat, *Stream Flow Monitoring*
Adult Holding	Mature Spawner	Harvest	number of spawners	Evaluation of Law Enforcement Needs and Regulatory Changes to Limit Harvest
Spawning and Incubation	Healthy Fry Production	Gravel Quantity	habitat, egg survival, emergence	Reach 1A Spawning Area Bed Mobility
Spawning and Incubation	Healthy Fry Production	Gravel Quantity	habitat, egg survival, emergence	Reach 1A Gravel Augmentation
Spawning and Incubation	Healthy Fry Production	Gravel Quantity	habitat, egg survival, emergence	Effect of Altered Flow Regime on Channel Morphology in Reach 1A
Spawning and Incubation	Healthy Fry Production	Gravel Quality	habitat, egg survival	Reach 1A Spawning Area Bed Mobility
Spawning and Incubation	Healthy Fry Production	Gravel Quality	habitat, egg survival, emergence	Reach 1A Mechanical Disturbance to Enhance Bed Mobility
Spawning and Incubation	Healthy Fry Production	Gravel Quality	habitat, egg survival, emergence, redd superimposition	Monitoring Spawning Gravel Quality and Quantity

Table A-1. Fisheries Life Stages, Physical Monitoring Parameters, and Studies (contd.)

Life Stage	Life Stage Outcome	Physical Monitoring Parameters	Biological Need or Impact	Study
Spawning and Incubation	Healthy Fry Production	Gravel Quality	egg survival, emergence	Effect of Scour and Deposition on Incubation Habitat in Reach 1A
Spawning and Incubation	Healthy Fry Production	Water Quality (dissolved oxygen)	egg survival, emergence	Water Quality Study
Spawning and Incubation	Healthy Fry Production	Gravel Quality	habitat	Effect of Altered Flow Regime on Channel Morphology in Reach 1A
Spawning and Incubation	Healthy Fry Production	Stream Flow	egg survival, emergence, redd superimposition	*Stream flow monitoring*
Spawning and Incubation	Healthy Fry Production	Intragravel Flow	Egg survival, emergence	*TBD*
Spawning and Incubation	Healthy Fry Production	Water Temperature	Egg survival, emergence	Temperature Monitoring for Millerton Cold Water Pool
Spawning and Incubation	Healthy Fry Production	Water Temperature	Egg survival, emergence	*In-river water temperature monitoring*
Juvenile Rearing	Smolt Outmigration	Water Temperature, Stream Flow, Meso-habitat	reach specific survival, migration timing, pathways	Juvenile Chinook Salmon Survival Study
Juvenile Rearing	Smolt Outmigration	Stream Flow, Structure Evaluation	migration delays, false pathways, physical harm	Entrainment
Juvenile Rearing	Smolt Outmigration	Floodplain Inundation	prey availability, predation	Floodplain Inundation
Juvenile Rearing	Smolt Outmigration	Water Quality (salts and toxins)	prey availability, disease	Water Quality Study

Table A-1. Fisheries Life Stages, Physical Monitoring Parameters, and Studies (contd.)

Life Stage	Life Stage Outcome	Physical Monitoring Parameters	Biological Need or Impact	Study
Juvenile Rearing	Smolt Outmigration		predation	Predatory Study
Juvenile Rearing	Smolt Outmigration	Gravel Quality	habitat availability	Effect of Altered Flow Regime on Channel Morphology in Reach 1A
Juvenile Rearing	Smolt Outmigration	Water Temperature	disease, habitat availability, predation, prey availability	Temperature Monitoring for Millerton Cold Water Pool
Juvenile Rearing	Smolt Outmigration	Water Temperature	disease, habitat availability, predation, prey availability	*In-river water temperature monitoring*
Smolt Migration	Smolt Survival	Water Temperature	disease, habitat availability, predation, prey availability	Temperature Monitoring for Millerton Cold Water Pool
Smolt Migration	Smolt Survival	Water Temperature	disease, habitat availability, predation, prey availability	*In-river water temperature monitoring*
Smolt Migration	Smolt Survival		migration delays, false pathways, physical harm	Entrainment
Smolt Migration	Smolt Survival	Floodplain Inundation	prey availability, predation	Floodplain Inundation
Smolt Migration	Smolt Survival	Water Quality (salts and toxins)	prey availability, disease	Water Quality Study
Smolt Migration	Smolt Survival	Delta Outflow	prey availability	No study proposed

Table A-1. Fisheries Life Stages, Physical Monitoring Parameters, and Studies (contd.)

Life Stage	Life Stage Outcome	Physical Monitoring Parameters	Biological Need or Impact	Study
Smolt Migration	Smolt Survival	Water Quality (salts and toxins)	prey availability, disease	Water Quality Study
Smolt Migration	Smolt Survival	Harvest	smolt survival	Evaluation of Law Enforcement Needs and Regulatory Changes to Limit Harvest
Adult Recruits	Ocean Survival	Ocean productivity	prey availability, predation, disease	No study proposed
Adult Migration	Adult Passage	Water Temperature	Migration delays	Temperature Monitoring for Adult Migration
Adult Migration	Adult Passage	Stream Flow	straying	*Stream flow monitoring*
Adult Migration	Adult Passage	Barriers	straying, blocked passage	Entrainment
Adult Migration	Adult Passage	Delta Outflow and Delta Water Quality	disease, delayed migration	No study proposed
Native Fish Assemblages	Healthy Communities	Water Temperature,Stream Flow, Meso-Habitat	Habitat availability to support native fish assemblages	Fish Community Assessment
All Life Stages	Successful Reintroduction		Genetics	Fall-run Chinook Experimental Captive Rearing Study
All Life Stages	Successful Reintroduction		Genetics	Natural Recolonization Study
All Life Stages	Successful Reintroduction		Genetics	Temperature Tolerance Study
All Life Stages	Successful Reintroduction		Genetics	Juvenile Chinook Predation Study
All Life Stages	Successful Reintroduction		Genetics	Positioning Central Valley Chinook single nucleotide polymorphisms onto the genetic map for Chinook salmon

Table A-1. Fisheries Life Stages, Physical Monitoring Parameters, and Studies (contd.)

Life Stage	Life Stage Outcome	Physical Monitoring Parameters	Biological Need or Impact	Study
All Life Stages	Successful Reintroduction		Genetics	Parentage based tagging (PBT)
All Life Stages	Successful Reintroduction		Genetics	Broodstock Genetic Diversity Study
All Life Stages	Successful Reintroduction		Genetics	Mating Matrix Development
All Life Stages	Successful Reintroduction		Genetics	Epigenetics Study: Comparison of Genetic Diversity and Methylation Diversity of Spring-run broodstock
All Life Stages	Successful Reintroduction		Genetics	Salmon Egg Survival Study
All Life Stages	Successful Reintroduction		Genetics	Juvenile Chinook Salmon Migration Survival

Compiling and prioritizing studies are necessary to develop an integrated monitoring and analysis approach, and assist with scheduling flow releases. The Restoration Flow Guidelines describe an annual process to develop plans, solicit feedback, implement monitoring plans, and report results. The process includes a planning period for the following spring and summer flows, a planning period for fall and winter flows, and periodic reporting. Figure A-1 summarizes the process.

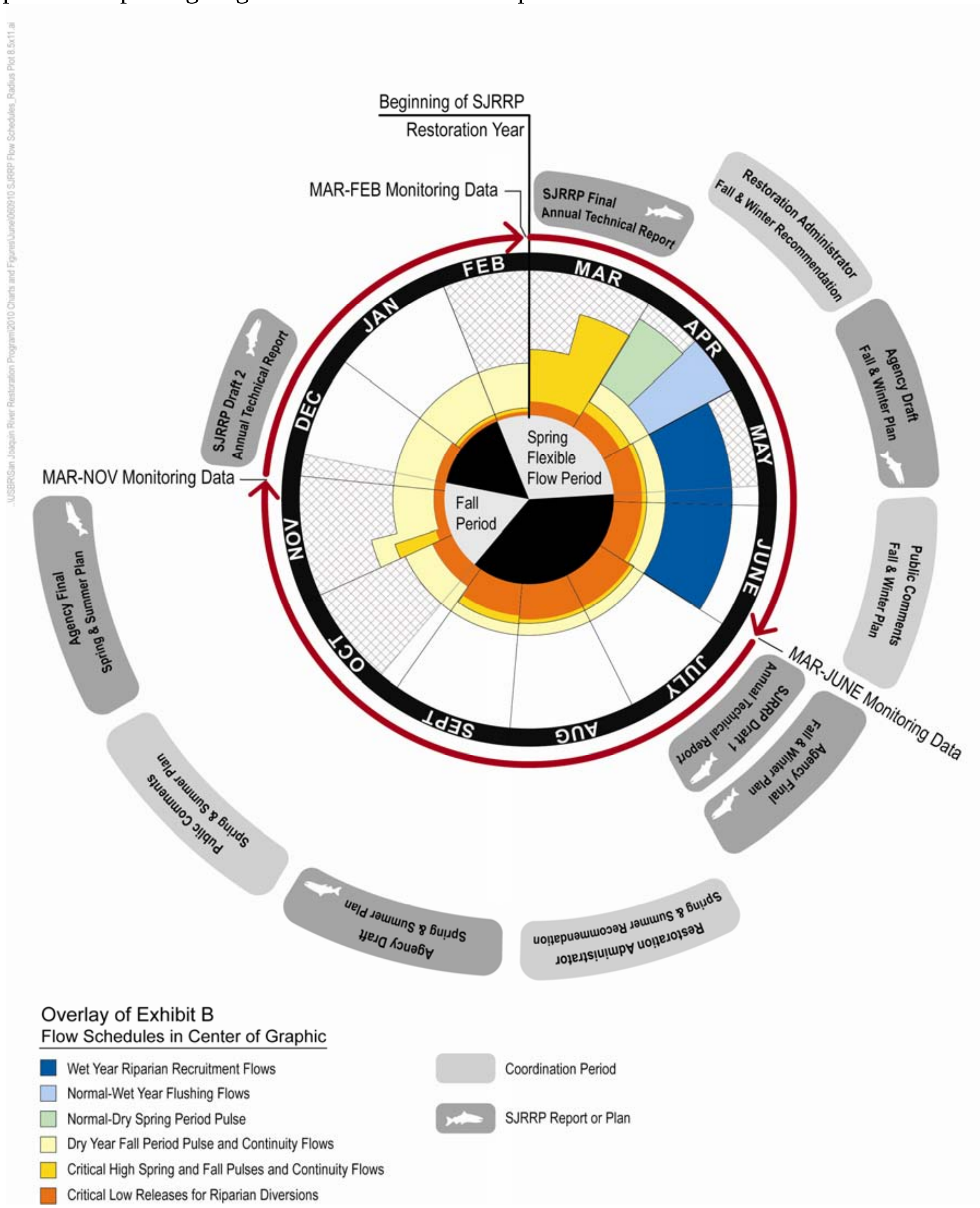


Figure A-1. Schedule of Monitoring and Reporting

2.0 Problem Statement – Gravelly Ford Flow Targets

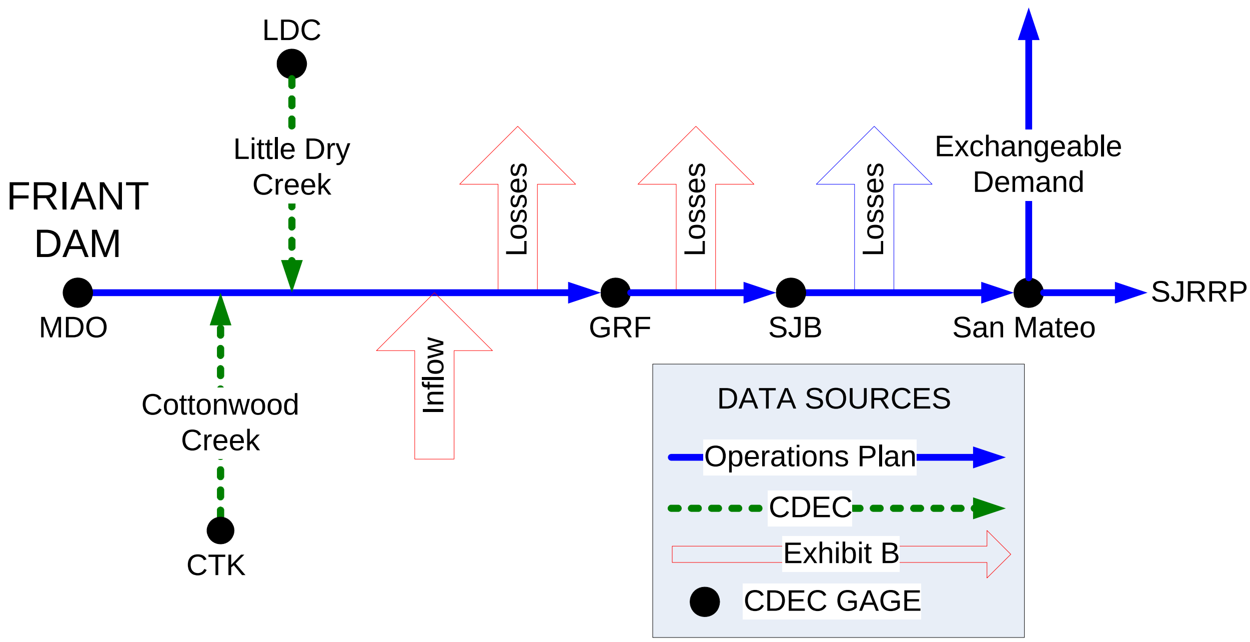
Account for riparian demands, tributary inflows and losses to identify the releases necessary to meet Gravelly Ford flow targets.

The Settlement requires releases from Millerton Reservoir to meet flow targets along the San Joaquin River from Friant Dam to the confluence with the Merced River, as described in Paragraph 13 and Exhibit B. Before the Settlement, Friant Dam released water to the San Joaquin River to meet Riparian Holding contracts by achieving 5 cubic feet per second (cfs) of flow past Gravelly Ford. The SJRRP target flow rates at the Gravelly Ford gage location to identify additional releases from the SJRRP as separate from historical obligations of the Central Valley Project (CVP) Friant division.

Gravelly Ford is located 40 miles downstream from Friant Dam. After release of water, travel time, attenuation, tributaries, infiltration, diversions, and return flows outside direct control by the SJRRP influence flow rates in the San Joaquin River. Determination of the appropriate release requires an estimate of typical losses and adjustments for daily conditions.

Friant Dam may be adjusted based on measured flows and other known watershed conditions in order to meet the Gravelly Ford flow target. Information to assist in determining a release includes tributary inflows, stage telemetry, and flow measurement. Figure A-2 displays components used to estimate releases for meeting Gravelly Ford flow targets.

Operations at Friant Dam begin with an assumption of typical losses. Table A-2 reports the loss assumptions by flow rate and time of year.



Note:
Inflows, losses, and exchangeable demand are measured in cubic feet per second (cfs)
Key:
CDEC – California Data Exchange Center
CTK = Cottonwood Creek
GRF = Gravelly Ford
LDC = Little Dry Creek
SJB = San Joaquin River below Chowchilla Bifurcation Structure

Figure A-2. Gravelly Ford Flow Target Analytical Framework

Table A-2. Typical Losses from Friant Dam to Gravelly Ford

Time of Year	Reach 2 Losses (Exhibit B)
October 1 – 31	80
November 1 – 10	100
November 11- December 31	80
January 1 – February 28	80
March 1 – 15	90
March 16 – 31	150
April 1 – 15	175
April 16 – 30	200
May 1 – June 30	80
July 1 – August 31	80
September 1 – September 30	80

Table A-2 will be updated based on analysis of Water Year (WY) 2010 flow gage records.

Limitations on measurement protocols inform the significance of a numerical values and the ability to enact and detect changes. Table A-3 includes factors taken into consideration when reevaluating the Friant release, and will be populated following analysis of WY 2010 flow gage records.

Table A-3. Gravelly Ford Daily Adjustment Factors

Friant Release Range (cfs)	MIL-GRF Travel Time (hours)	Tributary Travel Time (hours)	CDEC Accuracy (%)	Manual Streamflow Measurement Accuracy (%)

Key:
CDEC = California Data Exchange Center
MIL-GRF = Millerton Lake and Gravelly Ford gaging stations

Friant releases to meet Gravelly Ford flow targets must also be within the capacity limits of reaches farther downstream. Diversion points upstream from capacity-limiting reaches allow for greater releases from Friant when demands are exchanged for the portion of SJRRP flows in excess of downstream channel capacity. This operational flexibility results in conveyance of flows up to the current reach-specific capacity limits, and maximizes the flow range for which monitoring data are collected during Interim Flows.

2.1 Studies

The following section identifies studies associated with the Gravelly Ford flow targets problem statement.

2.1.1 2010 Flow Gage Record Analysis, Friant Dam to Gravelly Ford

Statement of Need

Typical losses for different flow rates and times of year inform decision-makers on flow releases from Friant Dam for meeting Gravelly Ford flow targets.

Background

Loss assumptions from Exhibit B informed decision-makers for flow releases at Friant Dam to achieve Gravelly Ford flow targets. This study synthesizes flow gage data gathered during WY 2010 releases.

Anticipated Outcomes

Flow gage record analysis will yield an updated Table A-2. Recently observed flows form the basis for making flow release decisions at Friant Dam.

Methods

Compare Millerton Lake gaging station (MIL) Daily Report flow values, less Little Dry Creek (LDC) and Cottonwood Creek (CTK) inflows, with Gravelly Ford (GRF) flows, with consideration of the U.S. Department of the Interior, Bureau of Reclamation (Reclamation) inventory of inflows/diversions in Reach 1.

2.1.2 Tributary Influence of Gravelly Ford Flows

Statement of Need

Tributary inflows change the loss assumptions from Friant Dam to Gravelly Ford.

Background

During precipitation events, tributaries to the San Joaquin River between Friant Dam and Gravelly Ford can produce large inflows of short duration. Reclamation's only mechanism to adjust flows reaching Gravelly Ford is the Friant Dam release. Existing California Data Exchange Center (CDEC) gages on Cottonwood Creek and Little Dry Creek provide real-time flow data from tributaries which contribute to Gravelly Ford flows.

Anticipated Outcomes

Table A-3 includes duration and magnitude estimates for tributary inflows. Operating rules for informing decisions to be made at Friant Dam are based on the influence of WY 2010 tributary inflows on Gravelly Ford flows.

Methods

Analyze magnitude and duration of LDC, CTK, and GRF Quality Assurance/Quality Control (QA/QC) records.

2.1.3 Stabilization at Gravelly Ford

Statement of Need

Identify when the effects of Friant Dam flow changes will be evident at Gravelly Ford.

Background

Friant Dam flow changes do not immediately affect flows at Gravelly Ford. Exhibit B reports all changes as occurring instantaneously.

Anticipated Outcomes

Include in Table A-3 travel time for Friant releases and tributary inflows to stabilize at Gravelly Ford and allow reevaluation of Friant releases.

Methods

Compare Millerton Daily Operations Report releases to GRF, CTK, and LDC QA/QC to determine when flow changes fully stabilize at Gravelly Ford.

2.1.4 Variability in Measurements

Statement of Need

Establish when measured flows at Gravelly Ford trigger a reevaluation of the Friant Dam release.

Background

Daily and weekly diversion practices in Reach 1, along with a measurement error, introduce a measure of uncertainty in attaining Gravelly Ford flow targets.

Anticipated Outcomes

Exceedence of a range of variability between measured and targeted flows at Gravelly Ford requires a reevaluation of the Friant Dam release.

Methods

Statistical analysis of available data.

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3.0 Problem Statement – Unexpected Seepage Losses Downstream from Gravelly Ford

Identify unexpected seepage losses downstream from Gravelly Ford that would be supplemented consistent with the guidelines in Settlement Paragraph 13(j), in accordance with Paragraphs 13 (c) (1) and 13(c) (2)The Settlement requires releases from Millerton Reservoir to meet flow targets along the San Joaquin River from Friant Dam to the confluence with the Merced River, as described in Paragraph 13 and Exhibit B. Exhibit B assumptions for flow targets downstream from Gravelly Ford include losses only in Reach 2A and accretions from Salt and Mud sloughs in Reach 5. If losses and diversions exceed Exhibit B assumptions, Paragraph 13(c) directs Reclamation to release water in accordance with the guidelines in Paragraph 13(j) such that the volume and timing of Restoration Flows are not impaired. Paragraph 13(c)(1) requires water to be acquired before commencement of full Restoration Flows, which the Secretary will use for additional releases. Paragraph13(j)(iv) requires a methodology to determine whether losses or diversions exceed the levels assumed in Exhibit B before full Restoration Flows are released.

Short- or long-term changes in shallow groundwater conditions may result in differences between Exhibit B assumptions and actual observations, which will inform decisions on acquisition of water from willing sellers and releases to meet flow targets.

Reclamation will update the Exhibit B assumptions in Table A-4 with measured loss values for comparison with Exhibit B losses to inform water acquisition decisions.

Table A-4. Exhibit B Normal-Wet Year Assumptions

Period of Time	Reach 2 Losses (cfs)	Salt and Mud Slough Accretions (cfs)
October 1 – 31	80	300
November 1 – 10	100	300
November 11 – December 31	80	400
January 1 – February 28	80	500
March 1 – 15	90	500
March 16 – 31	150	475
April 1 – 15	175	400
April 16 – 30	200	400
May 1 – June 30	80	400
July 1 – August 31	80	275
September 1 – September 30	80	275

Key:
cfs = cubic feet per second

3.1 Study

The following section identifies a study associated with the problem statement about unexpected seepage losses downstream from Gravelly Ford.

3.1.1 2010 Flow Gage Record Analysis, Below Gravelly Ford

Statement of Need

Decisions to acquire and release additional water according to the guidelines in Paragraph 13(j) require an updated Table A-4 of measured losses.

Background

Exhibit B specifies expected seepage losses below Gravelly Ford and includes provisions for Reclamation to acquire water from willing sellers if seepage below Gravelly Ford exceeds expectations, and to release water to meet flow targets downstream from Gravelly Ford.

Anticipated Outcomes

Decisions on flow requirements and the potential for purchased water to meet downstream targets would rely on updated loss tables downstream from Gravelly Ford based on WY 2010 gage records.

Methods

Compare QA/QC records at gages and groundwater model results to update Table A-4.

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4.0 Problem Statement – Seepage Management

Identify a relationship between San Joaquin River flow and groundwater levels to manage the potential for adverse impacts because of Restoration Flows, including both seepage and channel capacity limitations.

Increases in flow in the river may cause groundwater levels to rise along the San Joaquin River and potentially waterlog crop roots or change the soil salinity profile. Public Law 111-11, Section 10004.h(3) and State Water Resources Control Board Order WR-2009-0058-DWR (Order) Provision 8 require a Seepage Monitoring and Management Plan. The plan includes both installing groundwater monitoring wells and establishing groundwater elevation thresholds to reduce or avoid impacts to agricultural lands or levee stability.

Flow release decisions at Friant and Mendota Dams rely on coarse assumptions about relationships between river stage, monitoring well readings, and groundwater elevations below fields. Management evaluation of potential seepage impacts is triggered by exceedence of monitoring thresholds based on the most recent crop rooting depth, salinity tolerance, and terrain information.

Monitoring both surface water stage and groundwater level in wells at Gravelly Ford and downstream quantifies a relationship between river stage and groundwater. Predictions of groundwater rise from calculated stage-flow rating curves assume a conservative direct connection between river stage and groundwater levels (see Figure A-3).

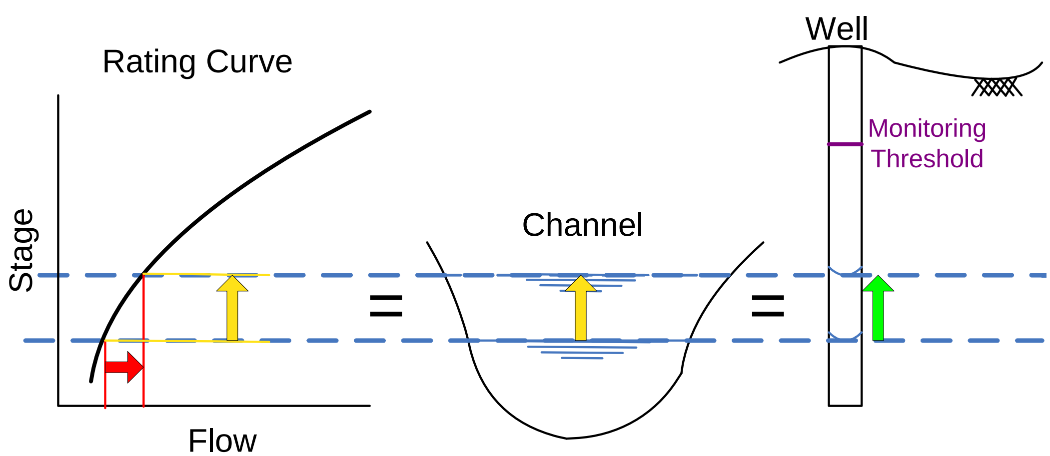

Figure A-3. Seepage Evaluation Conceptual Model

The flow bench evaluation process uses these groundwater predictions to determine the maximum allowable groundwater rise without encroachment into the buffer zone. When flows exceed 475 cfs in Reaches 2A and 3, daily evaluations consider conveyance thresholds, Mendota Pool operational concerns, real-time and manual groundwater monitoring, upstream conditions, and seepage hotline calls to determine if seepage problems are anticipated and if Interim Flows must diverge from the recommended schedule. The daily evaluation process receives key input from the hotline calls, which usually prompt a site evaluation by Reclamation staff. Information gathered during the evaluation informs the flow scheduling process.

Site evaluations during Interim Flows determine if in fact crop rooting depth and salinity tolerance are reflected by the established thresholds.

4.1 Studies

The following section identifies studies associated with the seepage management problem statement.

4.1.1 Lateral Gradient of Water Table

Statement of Need

It is necessary to understand the relationship between surface water flow in the San Joaquin River and the associated near-river, shallow groundwater response to inform water management decisions regarding the magnitude, duration, and routing of SJRRP Interim Flows in the study area.

Background

Groundwater and surface water monitoring is currently informs real-time management of Interim Flows. Management decisions regarding the magnitude, duration, and routing of SJRRP Interim Flows benefit from evaluations of potential impacts to farm lands, subsurface drainage systems, and levees adjacent to the San Joaquin River. Currently, the primary metric to evaluate impacts is depth to groundwater from the land surface for lands adjacent to the river. A better understanding of the relationship between flows in the San Joaquin River, and the associated response in the shallow groundwater system, will allow SJRRP management to make informed real-time management decisions, and informed decisions regarding seepage mitigation actions should they be required.

The current working hypothesis for Interim Flows management decisions is a 1:1 relationship between river stage changes and the response in the shallow groundwater system adjacent to the river. Implicit in this assumption is a direct hydraulic connection between the river and the near-river aquifer, the absence of a groundwater gradient (slope) near the river, and the river as the sole influence on shallow groundwater levels beneath the lands adjacent to the river.

Anticipated Outcomes

This investigation quantifies the response of the shallow groundwater to the Spring 2010 Interim Flows in the study area, evaluates the current working hypothesis used in the SJRRP flow bench evaluations, and informs future decisions regarding management of SJRRP Interim Flows and seepage mitigation actions should they be required.

Methods

The river stage – shallow groundwater relationship is evaluated based on surface water, groundwater, soil monitoring, and tile drain system flow data gathered during the Spring 2010 Interim Flow period. Surface water data consist of 15-minute river stage data and flow data from the stream gages located below Sack Dam (San Joaquin River (SJR) near Dos Palos, River Mile (RM) 181.5) and at the top of Reach 4B (SJR at Washington Road, RM 168.2). River stage information includes data from temporary staff gages at Highway 152 (RM 173.9) and the San Juan Ranch (RM 170). Groundwater level data from numerous monitoring wells and soil borings collected at frequencies ranging from hourly to weekly quantify shallow groundwater response. Flow data from existing subsurface tile drain systems indicate activation of shallow groundwater table.

4.1.2 Terrain Comparison Between Wells and Fields

Statement of Need

Current operations assume the location of a monitoring well represents water table depth below ground surface in adjacent lands. Consideration of topography in threshold elevations accounts for site-specific conditions where wells cannot be placed in critical locations.

Background

Specific buffer zones and thresholds trigger monitoring actions for each monitoring well. During 2010 Interim Flows, when groundwater exceeded a monitoring threshold, Reclamation conducted an evaluation of adjacent fields to determine if damage to crops was imminent, often at the request of landowners. Several thresholds proved to be non-representative of field conditions because of monitoring well placement on levee embankments. A refined approach allows Reclamation to more efficiently manage for seepage impacts.

Anticipated Outcomes

Monitoring thresholds for wells may be updated because of an elevation differential between fields and monitoring wells outside the fields to ensure appropriate thresholds for nearby crops and prevent unnecessary use of resources in areas where seepage impacts are not imminent.

Methods

Survey wells and adjacent fields all along the SJR. SJRRP has generally surveyed the well elevations, but fields require access and most still need surveying. After obtaining the surveyed elevations, the SJRRP will set new thresholds based on the difference between the ground surface elevation at the well and the ground surface elevation at the field.

4.1.3 Changes in Salinity Conditions Resulting from Interim Flows

Statement of Need

Establish baseline salinity levels for seepage prone areas to detect salinity changes resulting from Interim Flows. Quantify salinity changes over time from an established salinity baseline, rather than assuming by default, the presence of shallow groundwater during Interim Flows caused salinity impacts.

Background

The primary adverse seepage impact to crops is mobilization of salts upward into the root zone.

Anticipated Outcomes

Quantifying antecedent soil salinity conditions allows Reclamation to assess changes in salinity during Interim Flows. Repeated monitoring of soil salinity at locations with existing groundwater monitoring wells allows Reclamation to determine changes in soil salinity and potentially eliminate constraints to the release of flows when unnecessary.

Methods

The SJRRP conducted soil salinity surveys at over 50 sites. The data needs calibration before presentation of results.

4.1.4 Flow Restrictions Due to Seasonal Groundwater Conditions

Statement of Need

Identify flow constrictions due to potential seepage impacts and prioritize sites for capacity-increasing solutions in the interest of conveying Restoration flows.

Background

During WY 2010 Interim Flows, several locations experienced high groundwater levels and the potential for seepage impacts under higher flows. Per the seepage management goal to reduce or avoid seepage impacts, these locations restricted flow releases for a given reach.

Anticipated Outcome

This study refines assumptions about the river stage - seepage relationship, inventories known drainage infrastructure such as tile drains, develops conveyance solutions, and enables projection of capacity benefits following removal of each restriction.

Methods

The SJRRP will use geographical information systems (GIS) imagery of seepage hotline calls and observed high groundwater on the surface or in monitoring wells to identify locations with potential seepage impacts. Data collected on existing tile drains, landowner preferred mitigation methods, etc. will determine the methods chosen to alleviate seepage-related flow constraints.

4.1.5 Monitoring Well Network Optimization

Statement of Need

Monitoring wells provide the basis for implementing the seepage management plan.

Background

Groundwater data are needed to identify the gradient of the water table (i.e., Study 4.1) and to identify losses (Problem Statement 3). The existing well network has been expanded in response to landowner requests and to improve the data resolution available to inform decisions.

Anticipated Outcome

Develop an updated monitoring well table.

Methods

Site analysis and coordination provide information needed to site new monitoring wells.

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5.0 Problem Statement – San Joaquin River Channel Capacity Management

Identify nondamaging flow capacities of the San Joaquin River to convey appropriate Interim Flows.

Section 10004, Paragraph (h)(2)(B) of the Act authorizes the Secretary of the U.S. Department of the Interior (Secretary) to release Interim Flows to the extent that such flows do not exceed existing downstream channel capacities. Paragraph 13 of the Settlement states that releases of water from Friant Dam to the confluence of the Merced River shall be made to achieve the Restoration Goal, in accordance with hydrographs in Exhibit B ("Base Flows") plus releases of up to an additional 10 percent of the applicable hydrograph flows ("Buffer Flows"). Under Exhibit B, the Friant Dam release includes up to 4,000 cfs for Full Restoration Flows.

Friant Dam releases are based on conservative estimates of nondamaging channel capacity from studies and model runs, as shown in Table A-5, and conveyance requirements to deliver non-SJRRP water to satisfying existing contracts. Reach 3 is required to convey deliveries to San Luis Canal Company; this reduces the available capacity for Interim Flows. In addition, Reach 1 is required to convey deliveries for historical Riparian Holding Contracts of the Friant Division, although the large Reach 1 capacity means this is not a constraint on Interim Flow releases. Spring 2010 Interim Flow releases were designed conservatively to not surpass 8,000 cfs in Reach 2A, or 1,300 cfs in Reaches 2B or 3.

Table A-5. Capacities of San Joaquin River and Bypasses Within Restoration Area

	Reach	Upstream Extent	Downstream Extent	Design Capacity (cfs)	Approximate Nondamaging Flow Capacity (cfs)
San Joaquin River	Reach 1A	Friant Dam	State Route 99	8,000	NA
San Joaquin River	Reach 1B	State Route 99	Gravelly Ford	8,000	NA
San Joaquin River	Reach 2A	Gravelly Ford	Chowchilla Bypass Bifurcation Structure	8,000	8,000
San Joaquin River	Reach 2B	Chowchilla Bypass Bifurcation Structure	Mendota Dam	2,500	1,300
San Joaquin River	Reach 3	Mendota Dam	Sack Dam	4,500	1,300
San Joaquin River	Reach 4A	Sack Dam	Sand Slough Control Structure	4,500	3,300
San Joaquin River	Reach 4B1	Sand Slough Control Structure	Confluence with Mariposa Bypass	1,500	<100
San Joaquin River	Reach 4B2	Confluence with Mariposa Bypass	Confluence with Bear Creek and Eastside Bypass	10,000	NA
San Joaquin River	Reach 5	Confluence with Bear Creek and Eastside Bypass	Confluence with Merced River	26,000	NA
Chowchilla Bypass		Chowchilla Bypass Bifurcation Structure	Confluence with Fresno River and Eastside Bypass	5,500	NA
Eastside Bypass	Reach 1	Fresno River	Sand Slough Bypass	10,000 – 17,000	NA
Eastside Bypass	Reach 2	Sand Slough Bypass	Mariposa Bypass Bifurcation Structure/Eastside Bypass Bifurcation Structure	16,500	NA
Eastside Bypass	Reach 3	Mariposa Bypass Bifurcation Structure/Eastside Bypass Bifurcation Structure	Head of Reach 5	13,500 – 18,500	NA
Sand Slough Bypass		Sand Slough Control Structure	Eastside Bypass	3,000	
Mariposa Bypass		Mariposa Bypass Bifurcation Structure	Confluence with San Joaquin River	8,500	
Kings River North		Fresno Slough Bypass	Mendota Pool	4,750	

Key:
cfs = cubic feet per second
NA = not applicable

Planning and design of projects described in Paragraph 11 of the Settlement and implementation of Restoration Flows under Paragraph 13 of the Settlement require continued study of channel capacity.

Flows released according to capacity estimates greater than actual capacity could potentially exceed nondamaging channel capacity and impact adjacent lands. Flow schedules avoid potentially damaging conditions by relying on monitoring results from previous releases and refined hydraulic models.

5.1 Studies

The following section identifies studies associated with the San Joaquin River channel capacity management problem statement developed by the California Department of Water Resources (DWR).

5.1.1 Water Surface Profile Surveys and Discharge Measurements

Statement of Need

The data specifically address needs related to Problem Statement 5, San Joaquin River Channel Capacity Management, and indirectly address certain aspects of the other Problem Statements by providing a continuous record of water surface elevations (WSE) at key locations during Restoration releases to calibrate hydraulic models being used to assess channel capacity, fishery habitat, channel stability, and many other aspects of Restoration planning and design.

Background

Inundation levels, channel capacity, and channel response to Restoration releases require knowledge of WSEs and hydraulic conditions along the reach. Specific measurements of water surface elevations at approximately 0.5-mile intervals that can be correlated with concurrent discharge measurements at known, steady-state discharges provide a means of assessing water surface elevations and associated hydraulic conditions, and the extent of inundation along a reach. These data provide a direct means of calibrating hydraulic models to specific ranges of discharge.

Anticipated Outcomes

The water surface profiles and velocity and depth data from the discharge measurements will be compared to model results, and adjustments will be made to the models, as necessary, to better match the data. The data will also be evaluated with respect to the surrounding topography to understand inundation levels associated with the Interim (and, eventually, full) Restoration Flows. Improved model performance from these comparisons and resulting adjustments to the models will provide more certainty in predicted inundation levels, channel capacities, and other channel responses to the Restoration releases.

Methods

Methods used by DWR to collect water-surface profile surveys and measuring discharge are presented in Appendices F and B, respectively.

Results

Water surface profile data points are shown with recorded elevations on maps presented in Appendix F. Data tables containing all of the survey point locations and elevations are contained on a data disk available through DWR. Discharge location maps can be found in Appendix B, and raw discharge data files are available on the data disc available through DWR. Raw files can be viewed using WINRIVER II software, which can be found on the Teledyne RDI Web site: http://www.rdinstruments.com/rio.aspx#software.

Water Surface Profile Details

Timing. Table A-6 shows when each reach was surveyed and when Reclamation made changes to flow releases from Friant Dam. The 1A-2 survey was broken into two pieces because of heavy rains on April 20; the survey stopped at about RM 250 on April 20, and restarted at the same location the following day.

From Table A-6, it appears that for Reaches 1A through 1B, the flows were held constant at about 1,250 cfs. On April 24, they increased to approximately 1,550 cfs and held constant for the duration of the Reaches 2A, 2B, and 3 surveys.

Local flows for the surveys will be determined by correlating discharge measurement data. Additional measurement and gage data collected by other agencies at the time of surveys will also be used, as appropriate.

Table A-6. Friant Dam Releases During Water Surface Profile Surveys

Date	Time	Activity	Flows Released from Friant (cfs)
April 18	0:00	NA	1,130
April 18	11:00	Increase to	1,270
April 19	4:00	Decrease to	1,260
April 19	7:20	Start 1A-1 Survey	
April 19	16:00	Decrease to	1,250
April 19	18:17	End 1A-1 Survey	
April 20	7:24	Start 1A-2 Survey	
April 20	9:43	End 1A-2 Survey	
April 20	18:00	Decrease to	970
April 20	21:00	Increase to	1,240
April 21	8:46	Start 1A-2 Survey	
April 21	13:00	End 1A-2 Survey	
April 21	21:00	Increase to	1,250
April 21	22:00	Decrease to	1,260
April 22	6:41	Start 1B Survey	
April 22	13:53	End 1B Survey	
April 22	16:00	Increase to	1,270
April 23	9:30	Start Hatchery Survey	
April 23	10:30	End Hatcher Survey	
April 23	12:00	Decrease to	1,260
April 24	12:00	Increase to	1,560
April 25	18:00	Decrease to	1,550
April 26	8:00	Decrease to	1,540
April 26	9:31	Start 2A Survey	
April 26	16:00	End 2A Survey	
April 27	8:31	Start 2B Survey	
April 27	13:00	Decrease to	1,530
April 27	14:21	End 2B Survey	
April 28	9:02	Start 3-1 Survey	
April 28	14:09	End 3-1 Survey	
April 29	8:38	Start 3-2 Survey	
April 29	14:38	End 3-2 Survey	

Key:
cfs = cubic feet per second
NA = not applicable

Locations. WSEs were obtained along Reaches 1A through 3 (Friant Dam through Sack Dam). Please refer to the figures in Appendix F for locations and elevations. Survey locations were placed at the top and bottom of hydraulic controls (bridges, riffles, rock weirs) at the top and bottom end of long pools, about 500 feet upstream, at, and 500 feet downstream from pressure transducers and velocity profile cross sections, and at significant split flows. An attempt was made to limit the drop to 1 half-foot between two consecutive points. At Ledger Island, drop was limited to 0.25 feet between points, and points were gathered on both sides of the river.

Reach 1A. Approximately 194 survey points were collected. On April 19, travel time was approximately 11 hours from the Road 206 Bridge to Highway 41. The survey crew used a polyvinyl chloride (PVC) raft. Increasing the point density at Ledger Island added approximately 3 hours onto the survey time. The survey crew launched from Road 206 on the Madera side and pulled out at Wildwood Park.

On April 20, travel time took about 2.5 hours from Highway 41 to Scout Island. At Scout Island, the survey crew stopped because of rainy weather. They launched at Wildwood Park and pulled out on the Madera side of Scout Island (also owned by the Fresno County Department of Education).

On April 21, travel time took 4.25 hours from Scout Island to Highway 99. They launched at Scout Island (Madera side) and pulled out at Camp Pashayan. A possible arundo/wisteria strainer at RM 249.7 was a concern that was a hazard at 350 cfs and 700 cfs. However, at 1,250 cfs, the river was wide enough on the right-hand side for the hazard to be completely avoided.

Reach 1B. Approximately 82 data points were collected. Travel time was approximately 7 hours from Highway 99 to Gravelly Ford; a PVC raft was used. The survey was performed quickly, most likely because of a steady water surface gradient that meant minimal rowing. At Donny Bridge, there were only about 2.5 feet from the water surface to the bridge soffit. It would be best to portage around Donny Bridge when flows are higher than 1,250 cfs. The raft at Camp Pashayan was launched, and pulled out at River Cross, Inc. (Fresno side).

Reach 2A. Approximately 92 data points were collected. Travel time was approximately 6.5 hours from Gravelly Ford to the Bifurcation Structure. A PVC raft was used, which was launched from River Cross Inc., and pulled out at the Bifurcation Structure.

Reach 2B. Approximately 37 data points were collected. Travel time was about 6 hours to the Bifurcation Structure to the Mendota Pool. A cataraft was used with a 4-horsepower motor. At RM 211, thick vegetation was encountered. When approaching the area, the river appears to split, allowing a boater to either go right or left. On closer inspection, the middle and right side of the river is a large log/vegetation strainer while the river actually narrows quickly and makes a hard left. We got caught on a log in the middle and had to use the motor to travel back upstream and portage around the strainer.

We found a side channel on the right hand side to get around the vegetation. We launched at the Bifurcation Structure and pulled out on the Fresno side of the Mendota Pool.

Reach 3. Approximately 72 data points were collected. Travel time was 5 hours on April 28 from the Mendota Pool to the 13th Street Bridge in Firebaugh. Travel time was 6 hours on April 29 from the 13th Street Bridge to Sack Dam. A cataraft was used with a 4-horsepower motor. On April 28, the cataraft was launched at Mendota Dam on the Fresno side and pulled out at a gazebo on the north side of a Firebaugh park. On April 29, the cataraft was launched from the gazebo, and pulled out about 500 feet upstream from Sack Dam on the Fresno side of the river.

Discharge Measurement Details

Procedure Modifications. Communication difficulties between the Acoustic Doppler Current Profiler (ADCP) and laptop during the Spring 2010 Interim Flows measurements were common and resolved by either halting the craft on the transect until communications were restored, or abandoning the transect and starting a new transect to replace the faulty one. Location and travel of the ADCP were recorded from ADCP bed tracking data, and global positioning system (GPS) position and heading data. When a moving bed condition was observed, the GPS data were used to determine the distance traveled.

Timing. Discharge measurements were conducted following a week with Friant discharges ranging from 1,700 to 1,150 cfs before settling at 1,250 cfs. Reaches 1A and 1B were measured during Friant releases of approximately 1,250 cfs with a natural component from a spring storm producing 0.67 inches of precipitation on April 20 and 0.36 inches of precipitation on April 21 in Fresno (California Irrigation Management Information System (CIMIS) Station No. 80). Reaches 2A, 2B, and 3 were measured during Friant releases of about 1,550 cfs. Discharge measurements were conducted at the same time as the water surface profile survey.

Locations. Discharge measurements were taken near predetermined locations established in the field before the flow releases (see maps in Appendix B). Five locations were added in Reach 3 as access was determined before the scheduled release. Eleven sites were measured between Friant and Highway 99 during the 1,250 cfs release, including 2 split flows and two measurements at the Fwy 41 crossing to end 1 day and start the next. Eleven sites were measured during the 1,550 cfs release, with two in Reach 1B, two in Reach 2A, two in Reach 2B and five in Reach 3.

Observations and Resources. During many of the measurements, communications between the ADCP/GPS and laptop were discontinuous. When a pause in communications was noticed before the ADCP was moved significantly, the movement was halted until communications was restored. When more than a few minutes to restore communications were needed, or if the traveled distance without communications was excessive, the transect would be removed from the average and a new transect would be measured.

After extensive office checks, it was determined that the USB-to-RS232 adapters were intermittent and alternative adapters would be necessary for future data collection.

In Reach 1A, access to discharge sites 8 and 8 split require access through a golf course, which likely closes at or around 3:00 p.m. during adverse conditions. Because of potential precipitation, and other weather conditions and time requirements necessary to perform the discharge measurements, it was determined that one team would begin at this site and finish the day at discharge 4, upstream from this site.

With the variability of the weather, and unknown amount of flow that could stem from precipitation, this site was remeasured to start Day 2. Efforts to keep wind-driven rain from the laptop computer used for data recording were not successful, leading to the conclusion that a weatherproof laptop is required in adverse conditions.

A few sites were measured without using a tagline or bank-operated cableway. Discharge sites D4, D12 split, D25 were conducted by towing the ADCP behind an inflatable kayak, which was paddled across the river between visually identified targets on either bank.

Data Summary

Refer to Table A-7 for a summary of initial flow measurement results. Summary data sheets for each measurement are included in Appendix B, and full data files containing raw data and measurement notes are included on the data disk.

Table A-7. Flow Measurement Results

Scheduled Friant Release (cfs)	Measurement Site	Location (RM)	Date/Time	Flow Measured (cfs)	Equipment Used
Reach 1A					
1595	Discharge 4	263.6	04/19/2010 16:43-17:03	1,320	ADCP
1595	Discharge 6	261.5	04/19/2010 11:03-11:18	1,413	ADCP
1595	Discharge 7	260.8	04/19/2010 14:14-14:37	1,393	ADCP
1595	Discharge 8	260.5	04/19/2010 10:39-10:58	1,447	ADCP
1595	Discharge 8 split	260.4	04/19/2010 12:24-12:37	382	ADCP
1595	Discharge 11	255.1	04/19/2010 17:25-17:55	1,377	ADCP
1595	Discharge 11	255.1	04/20/2010 09:05-09:29	1,146	ADCP
1595	Discharge 12	251.2	04/20/2010 11:53-12:24	1,300	ADCP
1595	Discharge 12 split	251.1	04/20/2010 14:43-15:24	732	ADCP
1595	Discharge 16	248.3	04/21/2010 09:43-10:49	1,138	ADCP
1595	Discharge 17	245.2	04/21/2010 13:30-14:02	1,101	ADCP
Reach 1B					
1595	Discharge 18	237.7	04/22/2010 09:47-09:55	1,127	ADCP
1595	Discharge 19	232.5	04/22/2010 12:31-13:32	1,050	ADCP
Reach 2A					
1595	Discharge 22	222.0	04/26/2010 10:05-10:18	938	ADCP
1595	Discharge 23	218.3	04/26/2010 12:35-13:12	977	ADCP
Reach 2B					
1595	Discharge 24	214.0	04/27/2010 09:55-10:19	1,070	ADCP
1595	Discharge 25	212.2	04/27/2010 13:27-13:45	1,032	ADCP
Reach 3					
1595	Discharge 28	202.9	4/27/2010	595	ADCP
1595	Discharge 29	197.7	04/28/2010 12:27-13:01	574	ADCP
1595	Discharge 30	193.6	04/29/2010 09:40-10:06	848	ADCP
1595	Discharge 31	189.8	04/29/2010 11:32-12:11	837	ADCP
1595	Discharge 32	184.5	04/29/2010 14:59-15:16	826	ADCP

Key:
ADCP = Acoustic Doppler Current Profiler
cfs = cubic feet per second

Discharge measurements were conducted following a week with Friant discharges ranging from 1,700 to 1,150 cfs before settling at 1,250 cfs. Reaches 1A and 1B were measured during Friant releases of approximately 1,250 cfs with an unknown additive component from a spring storm. Reach 2A, 2B, and 3 were measured during Friant release around 1,550 cfs.

As shown in Table A-7, flow measurements generally indicate a decrease in total discharge in the downstream direction. However, as observed in the fall 2009 monitoring, measurements also indicated a slight increase in discharge between Ledger Island (Discharge 4) and Rank Island (Discharge 8). At the 1,250 cfs release, this increase was approximately 127 cfs (41 cfs/mile). The flow split into a secondary channel at Rank Island was also measured, indicating main channel flow was 1,447 cfs and the secondary channel flow was 382 cfs.

Discharge measurements below the 41 bridge were complicated by a spring storm producing 0.67 inches of precipitation on April 20 and 0.36 inches of precipitation on April 21 in Fresno (CIMIS Station No. 80 at California State University, Fresno (CSUF)). Runoff from the storm increased the flow between the 41 bridge and Sycamore island by 154 cfs. The timing of measurements allowed runoff approximately 3 hours more time to accumulate and flow down through the watershed at Sycamore Island than at Fwy 41. Because of difficulties caused by the weather, additional measurements after Sycamore Island were abandoned for the day. Between Discharge 16, near the Milburn unit, and Discharge 17 at the Highway 99 crossing, flow losses were 37 cfs (12 cfs/mile). In Reach 1B, at discharge 18, a 26 cfs gain was observed, probably from responses to a spring storm earlier in the week. A 51 cfs (4 cfs/mile) loss occurred between Discharge 18 and Discharge 19.

Measurements in Reaches 2A and 2B yield a loss of 112 cfs (11 cfs/mile) at Discharge 22 followed by gains at discharge 23 and 24 for a total of 132 cfs (17 cfs/mile). Gains at discharge 23 and 24 are likely measurements of the rising limb of the increase in Friant releases to 1,550 cfs. By discharge 25, flows had lost 38 cfs (20 cfs/mile), indicating the flow was stabilizing.

Five sites were added in Reach 3 for the 1,595 cfs scheduled release at Friant. The locations were selected similarly to the previous sites and with a better understanding of optimal requirements for using an ADCP. Specific locations are listed by river mile in Table A-7 and shown in Appendix B. Operations at the Mendota Pool caused a flow discontinuity between measurements upstream from the pool and downstream from the pool. This discontinuity limits comparisons of the upstream and downstream measurements from channel losses without understanding how operations at the Mendota Pool control the flow.

In Reach 3 flow loss at discharge 29 was 21 cfs (4 cfs/mile), and flow gain at discharge 30 of 274 cfs was contributed by Firebaugh Wasteway. Losses from Discharge 30 to 31 are 11 cfs (3 cfs/mile) and from Discharge 31 to 32 were 11 cfs (2 cfs/mile).

Because of the unsteady releases and weather events, Reaches 1 and 2 discharge measurements may not be usable for analysis of channel losses; however, they may provide insight into how the San Joaquin River watershed below Friant Dam responds as it flows through agricultural and urban land use areas. Additionally all of the discharges with the surface profile can be used as calibration for the model.

Reach 3 discharges were much more stable, with a defined inconsistency where the Firebaugh Wasteway joins the river. Measuring the flow or installation of a transducer on the Firebaugh Wasteway should be performed to better account for flow changes in the system.

Discussion

Water Surface Profiles. As established before the monitoring effort, the spacing of surveyed water surface points varied, as necessary, according to channel slope and local conditions. Longitudinal distances between survey points were often reduced significantly at specific locations to refine abrupt changes in the water surface profile by collecting data at the top and bottom of riffles and other hydraulic controls. Larger distances between points were used in the large pools and backwater areas without impacting the accuracy of the water surface profile.

A preliminary comparison of the surveyed and computed water-surface profiles based on the current one-dimensional (1-D) Hydrologic Engineering Centers River Analysis Systems (HEC-RAS) model indicates that the majority of significant hydraulic controls were sufficiently characterized by the survey data, and that no noticeable gaps in the data exist. Brief comparisons of the survey data and current model results also indicate that additional model calibration is necessary and can now be performed in numerous locations where previous calibration data did not exist.

Preliminary review of the data also indicates that generally no significant anomalies exist. However, an occasional subtle rise in water surface elevation in the downstream direction does exist, but the average magnitude of these instances is only approximately 0.1 feet and can be explained by a combination of error tolerance in the equipment and error in the exact placement of the survey rod. In some cases, it could also possibly be a hydraulic jump occurring after a steep riffle or weir.

Discharge Measurements. Data from the ADCP are organized into columns along the path of the transect that the ADCP travels. Raw data for each column include velocities at specific depths, bottom distance from the ADCP, and other miscellaneous data to interpret the ping for each column. Developed data from the ADCP include transect width, cross-sectional area, column-averaged velocity, average transect velocity, and distance traveled among the outputs. Data being used for model calibration are primarily discharge data that are used with the profile data to compare with the model. Discharge data may also be used to determine flow losses along the river. Knowing flow losses improves model performance through adjusting the amount of flow along the river for a given flow release at Friant.

Data can best be applied to a model when a one-to-one correlation between measured data and modeled values exist. This level of correlation is best obtained when flows in the river are near a steady state, or do not exhibit changes over the time when measurements are taken. Altering the Friant flow release schedule, weather events, urban discharges, and diversions can affect discharge over the course of measurements and ultimately make calibrating the model more difficult.

Several factors affect discharge measurement by an ADCP. Four regions, the top, bottom, and each end of the transect, are not directly measured, but rather are estimated by applying empirical relationships to measured values at the boundaries to extrapolate partial discharge data. Several methods exist for estimating each of the unmeasured areas and can be adjusted anytime, as necessary. The default method to estimate the top area uses a power fit curve based on the uppermost measured cells. The default method to estimate side areas, from the bank to the nearest point the ADCP can collect data, uses a shape- and area-dependant coefficient applied to the average of the nearest measured velocities at the ends of the transect. The default method to estimate the bottom area is similar to the top; only it uses the bottom-most measured cells. Additionally, false velocity readings from fish are filtered based on the perceived velocity.

Conclusions and Recommendations

Spring 2010 Interim Flows data have not been thoroughly reviewed or analyzed. As presented within this report, they are preliminary and subject to revision. The water surface profiles will be reviewed and data will be used, along with the discharge measurements, to calibrate SJRRP hydraulic models.

5.1.2 Monitoring Cross section Resurveys (MEI3.3)

Statement of Need

The study specifically addresses needs related to Problem Statement 5, San Joaquin River Channel Capacity Management, by providing data that can be used to assess mid- and long-term changes in channel geometry and substrate characteristics in the sand-bed portions of the reach in response to the Restoration releases. The information gained from this study will be used to determine whether Restoration releases are causing systematic changes in channel geometry that could lead to a reduction in channel capacity and stability.

Background

Under both Interim and full Restoration Flow conditions, the duration and magnitude of intermediate to high flows will increase substantially compared to historical, post-Friant Dam conditions. In the sand-bed portions of a reach (particularly Reaches 2, 3, and 4), the channel may respond to these higher flows by aggrading, degrading or increases in bank erosion. Detailed data on the resulting changes in channel geometry and substrate characteristics will help identify potential channel capacity and stability problems, and will be useful in calibrating sediment transport modeling being done to predict long-term channel response.

Anticipated Outcomes

Understanding will be improved of mid- and long-term channel response to Restoration releases that will inform future management decisions.

Methods

Methods used by DWR to conduct cross section surveys and collect bed samples are presented in Appendices F.

Results

Surveys. Baseline topographic surveys and bed samples were collected during the summer 2009, before the fall Interim Flows period. The baseline surveys will be used for comparison to show any changes in the channel during the Interim Flows period. Eleven of the sites were performed at the previously established sites in 1999 and 2000 pilot flow studies for the San Joaquin River Riparian Habitat Restoration Program. Sites were surveyed from top of bank to top of bank and along an approximately 50-foot length of longitudinal reach of the river. Individual measurements on each section were taken at grade breaks, low and high points, and approximately 15 feet apart. Topographic surveys collected channel and bed elevations at 15 sites during the Spring 2010 Interim Flows period. Three new sites were added to the existing twelve sites when access was allowed for all the proposed sites in Reaches 1B, 2A, and 2B. Topographic surveys were conducted during minimal discharges between peaks to record bed changes that occurred during peak discharges. Surveys consist of five to eight sections measured approximately 15 feet apart longitudinally along the river bed, extending across the area wetted by the peak discharge in active flow areas. The new sites were surveyed in the same manner as the summer 2009 surveys. The general method was similar to the original topographic patches performed during summer 2009. Analysis will require a comparison between surveys with consideration of the discharge that altered the bed between surveys. Using the previous survey as a benchmark, relative results from the next survey can indicate gross effects of scour or aggradation during flow.

Bed Samples. Sampling locations in Reach 2A are shown in Figure A-4. The D84 and D50 values of the samples collected before the 2009 Interim Flow releases were computed and displayed in a Summer 2009 Data Report. Samples collected after 2009 Interim Flow releases were analyzed and the data were compared to the prerelease data. The above comparison is summarized in Table A-8.

As the Table A-8, several sites show that gravel (coarse material) was present within that cross section (higher values) and the relatively higher change in grain size was observed at sites M4, M5, and M6 compared to other sites.

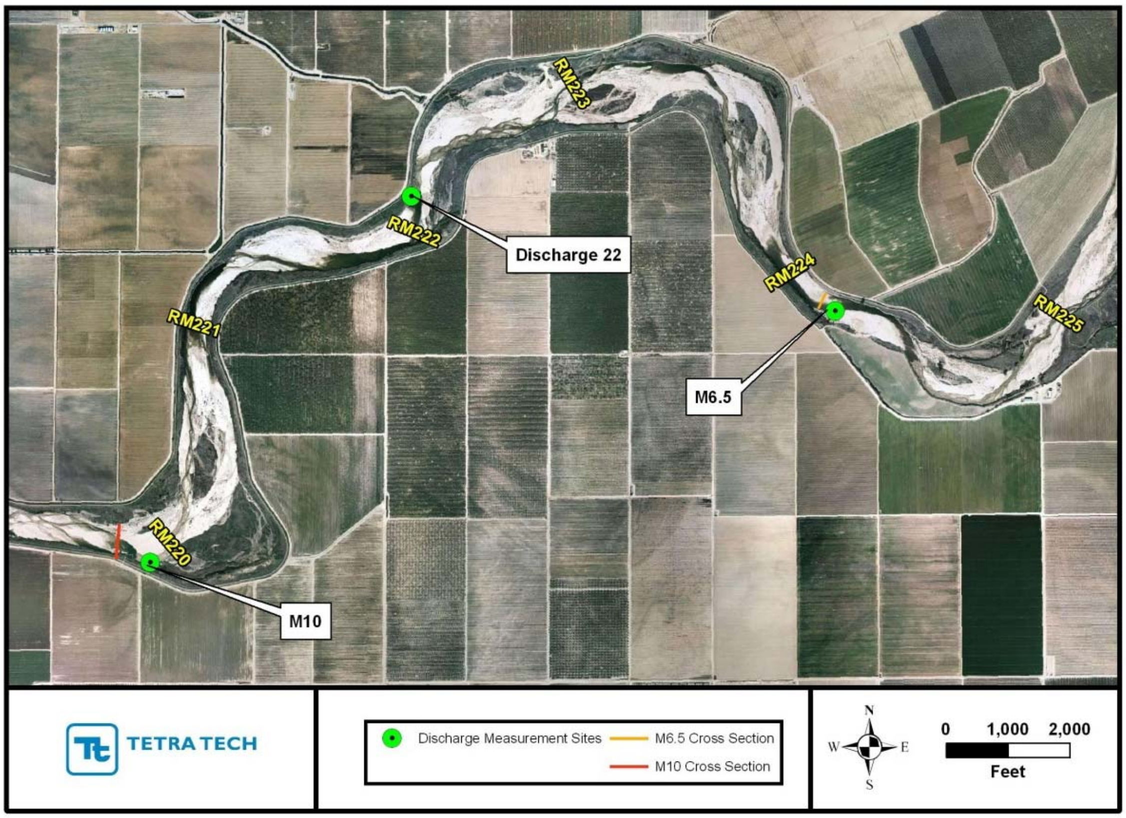

Figure A-4. Plan View Showing General Location of Monitoring Sites M6.5 and M10 in Reach 2A

Table A-8. Sample Analyses Results

RM	Cross Section	Before 2009 Interim Flow		After 2009 Interim Flow	
		D84 (mm)	D50 (mm)	D84 (mm)	D50 (mm)
228.1	M3 (gravel bar)	34.2	5.9	NA	NA
228.1	M3	1.7	0.8	1.5	0.9
227.0	M4-1	19.4	8.1	28.3	15.6
227.0	M4-2	1.8	1.0	NA	NA
226.0	M5-1.5	2.0	0.5	7.3	1.3
226.0	M5-2	6.3	1.1	2.1	1.0
226.0	M5-3	1.2	0.8	NA	NA
224.9	M6-1	14.3	2.3	NA	NA
224.9	M6-2	2.1	0.9	7.9	1.4
224.9	M6-3	1.3	0.9	NA	NA
224.9	M6-4	NA	NA	13.5	3.6
223.8	M6 1/2	10.8	0.6	1.9	0.9
222.9	M7	1.2	0.5	NA	NA
222.9	M7-1	NA	NA	2.1	1.1
222.9	M7-2	NA	NA	1.4	0.9
222.0	M8 (Samples 1 & 2)	1.3	0.7	1.2	0.7
222.0	M8 (Sample 3)	13.0	0.7	NA	NA
220.9	M9	1.1	0.7	1.2	0.7
219.8	M10	1.2	0.8	1.1	0.8
219.0	M11	1.2	0.6	1.4	0.8
218.2	M12-1	3.1	0.9	NA	NA
218.2	M12-2	1.7	0.9	NA	NA
217.5	M13	1.7	0.8	1.0	0.5

Key:
Mm = millimeter
NA = not available/applicable
RM = River Mile

Discussion

Refer to Appendix F for location and coverage of surveys. Point locations and elevations are contained on the data disk. Analysis can indicate lateral changes in the channel, gross effects of scour and aggregation at specific locations, and can estimate volumetric changes between the baseline survey and comparison survey would also be indicated.

Conclusions and Recommendations

References

5.1.3 Effects of Sand Mobilization on High-Flow Water-Surface Elevations (MEI3.6.1)

Statement of Need

Information from this study specifically addresses needs related to Problem Statement 5, San Joaquin River Channel Capacity Management, by providing data on the extent to which the bed scours during higher flows, and by providing stage-discharge rating curves that can be used to assess the extent to which bed scour affects channel capacity.

Background

Sand mobilization in sand bed portions of the river during high flows may have significant impacts on WSEs. Anecdotal reports indicate that water surface elevations for the same discharge can be significantly different during different portions of a given flood in Reach 2. Similar behavior has been observed in other sand bed streams, particularly where banks are relatively erosion-resistant because of cohesive bed material and/or because a stabilizing riparian corridor is present (……..). If the hypothesis is correct in at least portions of the Restoration reach, the channel capacity greater and the associated risk of flood damages during Restoration inflows may be less than is currently believed.

Anticipated Outcomes

Results from this study will provide information that can be used in conjunction with other information to assess channel capacity and potential flood risk in the sand bed portions of the Restoration reach.

Methods

Two monitoring sites were selected for this task and one cross section per each site was monumented. The locations of the selected cross sections are shown in Figure A-4.

Methods used by DWR to conduct discharge and WSE measurements and bed profile surveys are presented in Appendices B and D.

Results

Each data set was scheduled to occur after the Spring 2010 Interim Restoration Flows had stabilized for a given flow bench. General order of the monitoring activities performed at each site was as follows:

- Setting up base GPS station for real-time kinematic (RTK)
- Measuring WSE
- Measure discharge
- Measuring WSE
- Surveying bed profiles
- Measuring WSE

Measurements from scour chains were made before the beginning of Spring 2010 Interim Flow releases and should be revisited in summer 2010 for further data collection.

Monitoring activities listed above are described in detail, as follows:

- **Scour Chains** – Eight chains were installed at the selected cross sections in August 2009 to verify depth of scour and redeposition that takes place during particular flow releases. The buried depths of the chains vary from 8.20 and 9.10 feet, with the exception of one chain that was buried to a depth of 7.5 feet because of an obstacle at that depth that prevented the pipe from being driven deeper. At least one of the four chains in each cross section was placed in the low-flow channel.

  Table A-9 lists the GPS coordinates and total and buried lengths of the eight chains. Locations of the chains are shown in Figures A-5 and A-6.

  The data collected in December 2009 were analyzed and presented in the Summer 2009 Data Report. The chain sites need to be revisited in summer 2010 for the next set of data collection to determine further changes in bedforms.

Table A-9. Scour Chain Information

Point Number	Longitude	Latitude	Date Installed	Total Length (feet)	Buried Depth (feet)
1-XS6.5	W120°11'57.19"	N36°46'48.96"	8/11/2009	9.90	8.40
2-XS6.5	W120°11'56.96"	N36°46'49.30"	8/11/2009	9.90	7.50
3-XS6.5	W120°11'56.64"	N36°46'49.80"	8/11/2009	9.50	8.80
4-XS6.5	W120°11'56.42"	N36°46'50.15"	8/11/2009	9.90	8.40
1-XS10	W120°14'17.30"	N36°46'09.80"	8/13/2009	9.80	8.50
2-XS10	W120°14'16.35"	N36°46'10.62"	8/13/2009	9.10	8.20
3-XS10	W120°14'16.07"	N36°46'11.08"	8/13/2009	9.35	8.35
4-XS10	W120°14'15.78"	N36°46'11.51"	8/19/2009	9.90	9.10

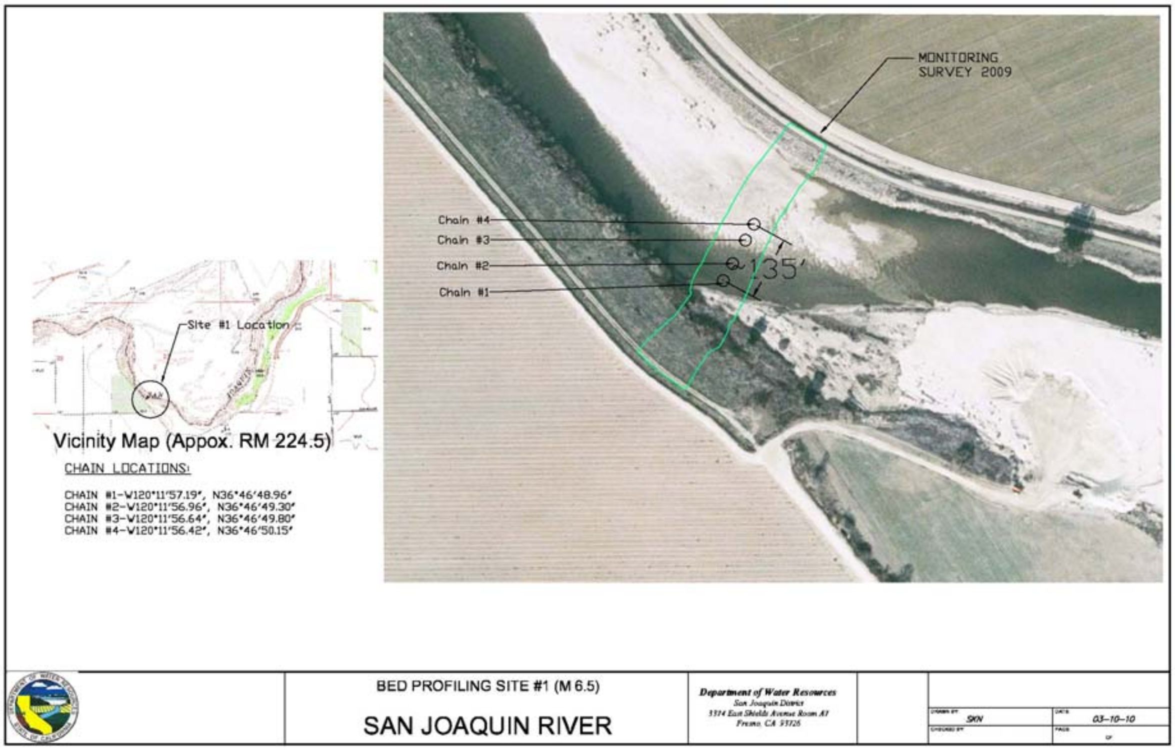

Figure A-5. Location of Scour Chains at Site M6.5 in Reach 2A

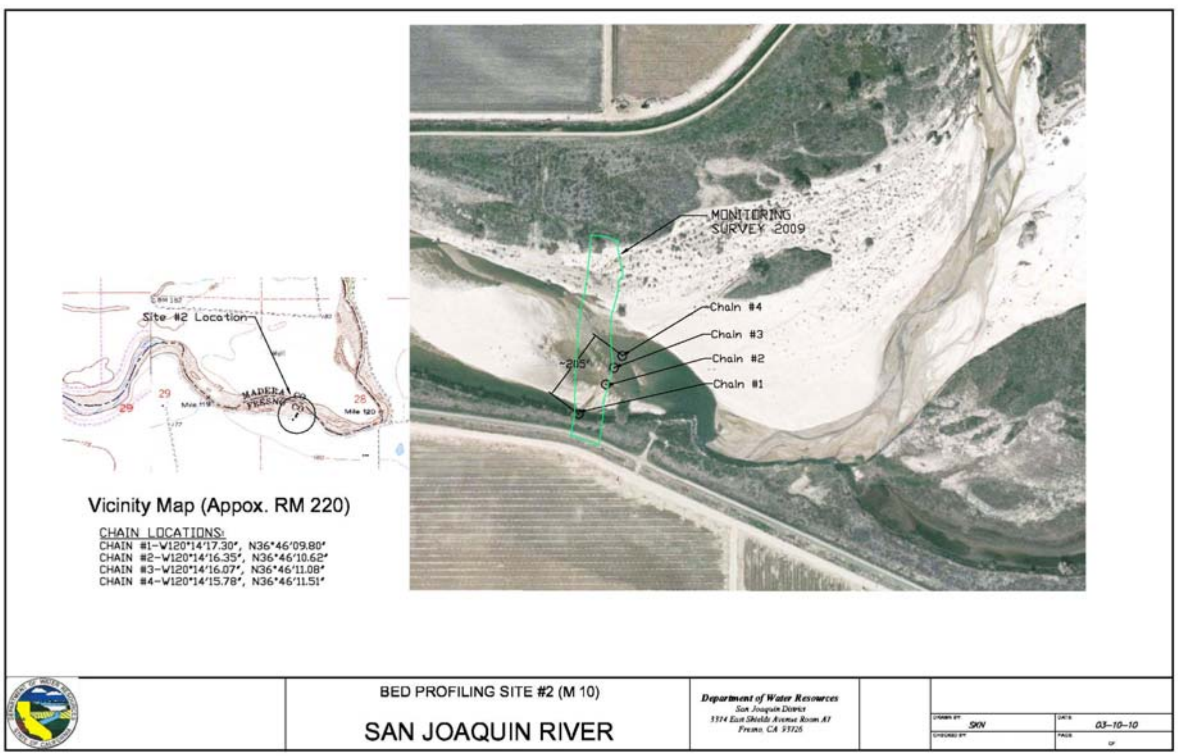

Figure A-6. Location of Scour Chains at Site M10 in Reach 2A

- **Discharge and Water Surface Elevation Measurement** –The discharge was measured with DWR's TRDI Rio Grande ADCP during the March 25 and 26 measurements. Subsequent flows were measured using the TRDI River Ray provided by Tetra Tech.

  WSEs were calculated from leveling data collected using Leica NA728 Auto Level before and after each flow measurement based on a North American Datum (NAD) 83 CA Zone III coordinate system. Discharge data collected during spring 2010 Interim Flow releases are presented in Appendix B.

- **Bed Profile Survey** – The results from bed profile surveys are presented in Appendix D – Sediment.

Discussion

Conclusions and Recommendations

DWR will further analyze data collected to date in late 2010 to consider future activities or modifications needed under this study.

References

5.1.4 Sand Storage in Reach 1 (3.6.2)

Statement of Need

Information from this study specifically addresses needs related to Problem Statement 5, San Joaquin River Channel Capacity Management, and Problem Statement 6, Healthy Fry Production, by quantifying the amount and location of sand currently stored in Reaches 1A and 1B. Transport of the stored sand through the reach may adversely affect the quality of spawning habitat and food base in Reach 1, but elimination or significant reduction in this transport may also cause downcutting in the downstream sand bed reaches because of the loss of sediment supply. Sand could also affect mobility of gravel in riffles along the reach, which could impact the stability and behavior of the hydraulic controls. A clear understanding of these issues will be important in identifying appropriate Restoration activities and the anticipated response of the river to those activities.

Background

Field observations indicate that a significant volume of sand and fine sediment is stored in the channel in Reach 1, but at the present time, understanding of the spatial distribution and volume and transport characteristics is limited. Storage could be the result of the relatively low sediment transport capacity of the river, exacerbated by reduced peak discharges because of the presence of Friant Dam, washing of fine sediment into the channel from mining overburden during high-flow releases, such as the 1997 flood, and/or an increase in fine sediment loading because of recent changes in land use.

Anticipated Outcomes

Results from this study will provide information that can be used to assess the potential for fine sediment intrusion into spawning riffles in Reach 1A and the effects of sand depletion on vertical stability of the sand bed portions of the Restoration reach.

Methods

1. Conduct a boat-based field reconnaissance of Reaches 1A and 1B to determine areas where data collection, sediment sampling, and field mapping are most likely to be required, and to identify access requirements for those areas.

2. Identify, map, and quantify potential overbank sand sources and the extent of inundation resulting from flows up to 8,000 cfs (the objective release from Friant Dam) through a combination of aerial photographic analysis (2007 aerial photography) and field inspection. Field inspection will involve determining sand deposit thicknesses through augering and sediment sampling to determine the gradation of the deposits. It is anticipated that between 10 and 20 samples (average sample weight about 20 pounds) will be collected and subsequently sieved. The footprint of the field investigation will be based on inundation mapping up to a flow of 8,000 cfs. Based on sediment gradations and output from one-dimensional hydraulic modeling, identified overbank sand deposits will be screened (i.e., is $\tau > \tau_c$) to determine potential availability. Where available, information on alluvial deposit thicknesses and characteristics (sand/gravel ratios)

in Reaches 1A and 1B will be assembled from sand and gravel mining companies and reviewed.

3. Field map the locations of bank erosion in Reaches 1A and 1B with a boat-based survey. At each identified location, the length of the site, height of the bank, and gradation of the bank materials will be determined. As appropriate to the site, bank material gradations will be determined either by direct sampling and subsequent sieving or by a combination of direct field measurement and sampling of the finer (sand) fraction. It is anticipated that up to 20 samples (average weight 20 pounds) will be collected for subsequent laboratory gradation analysis. Output from the SRH-2D model will be used to quantify bank shear, conduct incipient motion analyses of the bank materials, and rank erosion sites. Where possible, bankline comparisons using GIS will be conducted at each of the identified sites to provide gross estimates of the sediment volume and gradations contributed to the river over time. Bankline delineations by Reclamation will be used in this analysis, to the extent possible.

4. Use output from the SRH-2D model to identify reaches with sufficient energy to mobilize sand-sized bed material up to a flow of 8,000 cfs. Locations where energy is below critical will be eliminated from further consideration. For the remainder of the channel in Reaches 1A and 1B significant sand deposits will be visually identified at low flows during a boat reconnaissance. The volume of identified in-channel sand deposits in Reaches 1A and 1B will be quantified by field measurement of area (established by a grid) and thickness (by probing). About 15 samples (20 pounds per sample) will be collected for subsequent gradation analysis. Additionally, in Reach 1B, because of the high sand content in the bed material, bed material samples will be collected and field-sieved (about 20 samples at approximately 20 pound per sample) to determine sand content. Active bed thickness will be established by probing with a steel rod. Combination of data on bed area, bed thickness and sand content will provide a first approximation of the volume of sand in bed material storage in Reach 1B.

5. A number of active and inactive sand-and-gravel mining operations are located along the lengths of Reaches 1A and 1B. River capture of waste-product dumps in the 1997 flood may be responsible for a significant portion of the observed sand deposits in the reaches. Field inspection by boat will be used to identify, if any exist, locations where current and past mining operations may be actively or passively discharging sands to the river. If discharge sites are located, sampling of the bed material will be sampled upstream and downstream from the discharge location to quantify the impact of the sand discharge. It is estimated that up to five locations will be identified and two sediment samples (about 20 pounds per sample) will be recovered at each site for subsequent gradation analysis.

6. Two tributaries enter the river within Reach 1A, Cottonwood Creek and Little Dry Creek. Field inspection of the lower reaches of both tributaries will be conducted to determine whether they are supplying a significant quantity of sand to the river. If it is determined that sediment is being delivered to the river from

the tributaries, the bed material in the tributaries will be sampled (about five samples at about 20 pounds per sample) and the sand content will be determined. Estimates of sediment delivery to the river will be made based on evidence of sediment storage in the lower reaches of the tributaries. Irrigation return flows in Reaches 1A and 1B are also potential suppliers of sand to the river. Field inspection of all drain returns will be conducted to ascertain the characteristics of any sediments being delivered to the river. If field inspection indicates that sand is being delivered to the river, up to five samples (about 20 pounds per sample) will be collected to determine the sediment gradations. Estimates of return flows will be made and used to quantify sand input to the river.

7. Based on the results from Tasks 1–5, identify the key sediment source areas and develop a long-term monitoring program to establish the relationship between flows, the amount of storage, and the quantity and trends in sand transport downstream from these areas. The monitoring plan may include additional suspended sediment measurement sites that can be occupied during specific flow release periods. In developing the monitoring plan, the riffles at which gravel transport and sand infiltration studies were recommended under the Data Collection and Monitoring Plan developed for DWR by MEI (2008) will be reassessed, and recommendations will be made for relocating or enhancing those locations will be made.

Results

Because of storm activity during spring 2010, completion of field surveys was delayed until summer 2010. The high runoff caused turbid waters that made it difficult to accurately assess sand deposits in inundated areas. Data results and discussion will be included in a future ATR draft.

Discussion

Conclusions and Recommendations

References

5.1.5 Additional Water-Level Recorders (MEI3.1)

Statement of Need

The data specifically address needs related to Problem Statement 5, San Joaquin River Channel Capacity Management, and indirectly address certain aspects of other problem statements by providing a continuous record of water surface elevations at key locations during Restoration releases to calibrate hydraulic models being used to assess channel capacity, fishery habitat, channel stability and many other aspects of Restoration planning and design.

Background

There are currently 10 active stream gages on the main stem San Joaquin River within the Restoration reach. To provide additional data to calibrate the hydraulic and flow-routing models, up to six additional water-level recorders should be installed at key locations in Reaches 1 and 2 to supplement existing stream gages. With the additional six recorders, there will be a total of 12 locations in Reaches 1 and 2 where a continuous record of stage can be obtained. These stage readings can be used to assess hydrograph translation characteristics through the upstream reach and corresponding WSEs can be used to validate hydraulic models. Assuming that the stage-discharge relationship remains constant over time, rating curves can also be developed at the sites using opportunistic flow measurements and correlation with flows at the closest upstream and downstream gages to provide estimates of the local discharge.

Anticipated Outcomes

Data from the transducers will be compared to routing model results, and adjustments will be made to the models, as necessary, to better match the data. The data will also be evaluated with respect to the surrounding topography to understand inundation levels associated with the Interim (and, eventually, full) Restoration Flows. Improved model performance from these comparisons and resulting adjustments to the models will provide more certainty in predicted inundation levels, channel capacities, and other channel characteristics.

Methods

The methods used to collect WSE using a water level recorder (WLR) are presented in Appendix B.

Results

WLR location coordinates and recording dates are summarized in Table A-10. The coordinates associated with each recorder refer to the position of the corresponding transducer located in the channel bed. Water stage readings were downloaded from the data logger periodically using Global Logger v2.0.6 software. The WSE data are presented in Appendix B.

During the last data download on May 25, 2010, it was observed that Recorder 4 stopped functioning from March 3, 2010 because of unusual battery exhaustion; batteries were replaced. In addition, Recorder 3 was found off line and the data logger storage was empty. No reason was detected from this and Recorder 3 was brought back online.

Table A-10. Water Level Recorder Locations

Recorder	Location	River Miles	Northing	Easting	Elevation	Date Recorded
1	Head Ledger Island	263.4	1806574	6783091	289.21	12/04/09 – 05/25/10
2	Willow Unit Grade Control	261.5	1800801	6781533	284.93	12/04/09 – 05/25/10
3	Rank Island Grade Control	260.4	1796241	6780278	274.85	12/04/09 – 02/25/10
4	Sycamore Island Flow Split	251.1	1769843	6755779	245.70	12/04/09 – 03/03/10
5	Milburn Unit	248.4	1769997	6747942	232.90	12/04/09 – 05/25/10
6	R 1B-1_RM 237.7	237.7	1760168	6704615	206.91	01/28/10 – 05/25/10

The WSE data of each transducer from 12/04/2009 through 05/25/2010 are mapped and shown in Figures A-16 through A-18, whereas the data before this period were reported in the Summer 2009 Data Report. As stated above, a discontinuity can be observed in the data from Recorders 3 and 4 (data are presented in Appendix B, Figures B-4 and B-5) because of technical issues. These units were brought back in operation at the end of May 2010.

Recorder 1 showed inconsistent changes during and after the 700 cfs release in fall 2009 with respect to the other recorders (see Fall 2009 Data Report). Anchor movement was found as a possible reason for these inconsistent changes. The suspect anchors were reinforced and the data were continuously monitored. Based on results shown in Figure B-4, no significant fluctuations were observed afterwards.

Discussion

The existing WLRs will be monitored continuously and data collection will occur periodically.

Conclusions and Recommendations

References

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6.0 Problem Statement – Mature Spawners

Identify limiting factors to promote mature spawner development leading to a self-sustaining Chinook salmon population.

Following the construction of Friant Dam, spring-run Chinook salmon continued to use several holding pools immediately downstream from the dam, until their eventual extirpation. A key life stage for spring-run Chinook salmon is adult holding for several months in deep, cold pools at the headwaters of their spawning system (immediately downstream from Friant Dam). Adult spring-run start to spawn as fall-run Chinook are migrating upstream and starting their spawning activities.

Water temperature, meso-habitat, and illegal harvest are the key impacts, related to migrating, holding and spawning Chinook salmon that the SJRRP can monitor. Unsuitable water temperatures can lead to disease, prevent holding adults from developing into mature spawners, limit holding pool fish capacity, and increase vulnerability to illegal harvest (see Figure A-10). Meso-habitat corresponds to the quantity and variety of habitat units, the quantity and location of available holding pools, and the approximate total area of holding habitat encountered in Reach 1A (further analyses will be needed to address the quality of these habitats). FMWG believes law enforcement is the key to measuring impacts of illegal harvest of holding adults. Table A-1 lists the studies associated with Mature Spawners.

The conceptual models created by the FMWG for the FMP are more detailed than needed to define the monitoring programs that will be implemented by the SJRRP. Figure A-7 (and subsequent figures) are consistent with the conceptual models presented in the FMP, but are simplified to identify the physical parameters affecting mature spawners that can be monitored by the SJRRP.

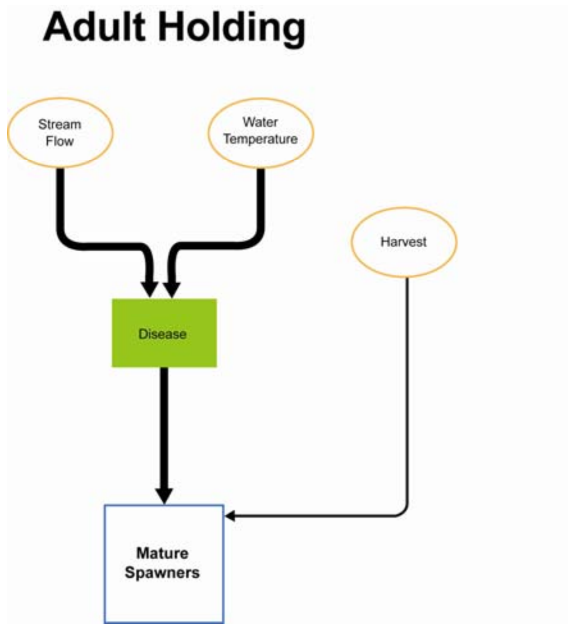


Figure A-7. Physical Monitoring Parameters and Biological Impacts that May Affect Mature Adult Spawning Spring-Run Chinook Salmon

A key limiting factor for holding adults in the San Joaquin River is water temperature. In general, water temperature is a function of release temperature, release rate, meteorological factors (viz., ambient air temperature, albedo, solar radiation, wind speed, etc.), and duration of heat exchange, although the effects of warm summer air temperatures are minimal in the holding pools immediately downstream of Friant Dam due to the short duration of exposure to the surrounding environment. Water temperature in holding habitat is influenced by the level of the cold water pool in Millerton Lake and discharge from Friant Dam, and the SJRRP has the greatest control over river water temperature in adult holding habitat through cold water pool management in Millerton Lake. Unsuitable water temperature can lead to an increase in disease in adult fish and inadequate flows can reduce the amount of available habitat. Another limiting factor for holding adults is exposure to illegal harvest which would directly reduce the number of potential spawners. An evaluation of law enforcement needs to limit poaching in spawning areas to facilitate meeting adult fish targets is not currently underway, but would be necessary to determine the potential impact of excessive harvest on development of mature spawners.

Temperature data, and modeling calibrated with existing data and verified by continued monitoring will inform the RA flow schedule recommendations.

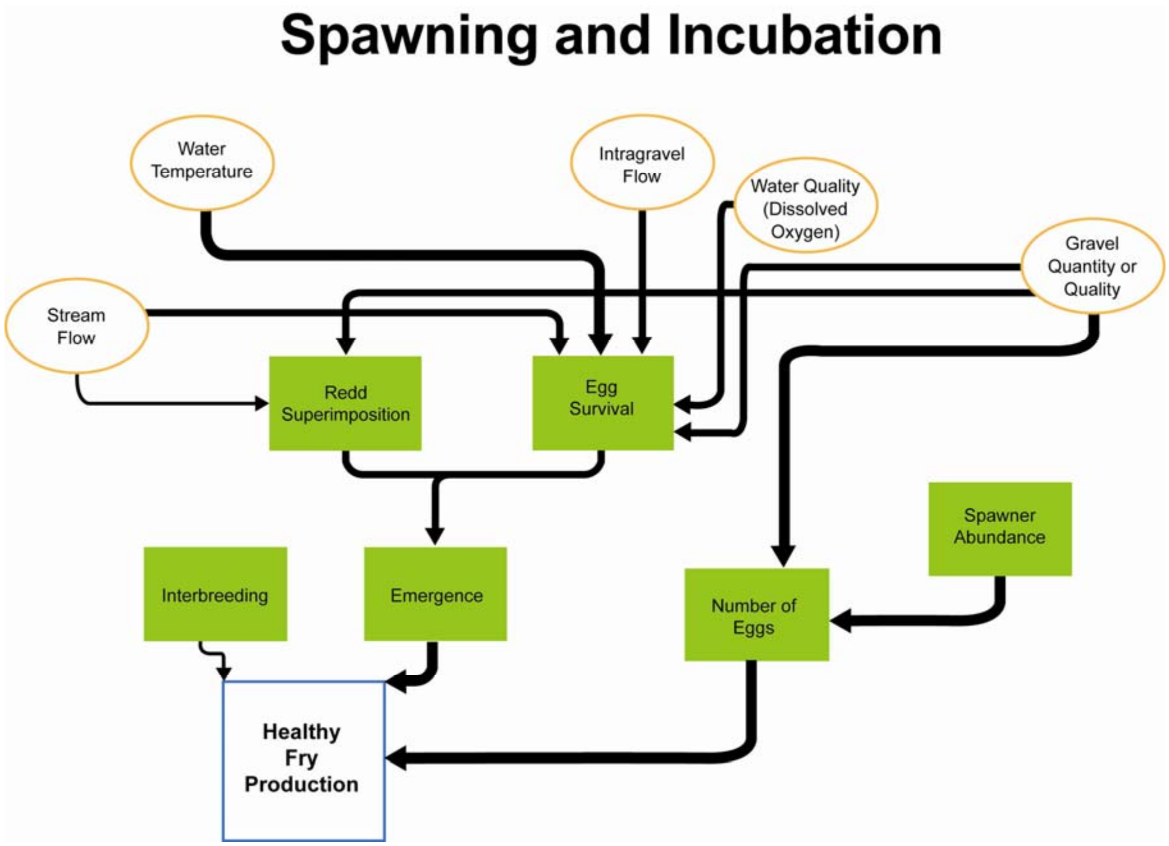
7.0 Problem Statement – Healthy Fry Production

Identify limiting factors to healthy fry production, leading to a self-sustaining Chinook salmon population.

To achieve the Restoration Goal, the SJRRP must reintroduce Chinook salmon that develop into a self-sustaining population. A key step to self-sufficiency is the production of fry from adults that spawn naturally in the river. The FMP identifies healthy fry production as the successful outcome of the spawning and incubation life stage. SJRRP believes that spawner abundance, number of eggs, egg survival, emergence, interbreeding between spring-run and fall-run Chinook salmon, and redd superimposition are biological impacts to healthy fry production. SJRRP does not recognize any measureable biological impacts before reintroduction that affect healthy fry production.

SJRRP classifies gravel quantity, intragravel flows, dissolved oxygen (DO), water temperature, and streamflow as measureable physical impacts affecting healthy fry production. These impacts are understood to control conditions in gravel and the hyporheic zone necessary to support a successful adult spawning and egg incubation life stage. SJRRP will make use of riverbed monitoring data and biological data following reintroduction to manage for conditions favoring healthy fry production.

The conceptual models created by the FMWG for the FMP are more detailed than is needed to define the monitoring programs that will be implemented by the SJRRP. Figure A-8 is consistent with the conceptual models presented in the FMP, but is simplified to identify the physical parameters affecting healthy fry production that may be monitored by the SJRRP. Table A-1 lists the studies associated with Healthy Fry Production.



Note: The width of the arrows indicates the relative importance of each mechanism.

Figure A-8. Physical Monitoring Parameters and Biological Impacts that May Affect Successful Spawning and Ultimately Healthy Fry Production of Spring-Run Chinook Salmon

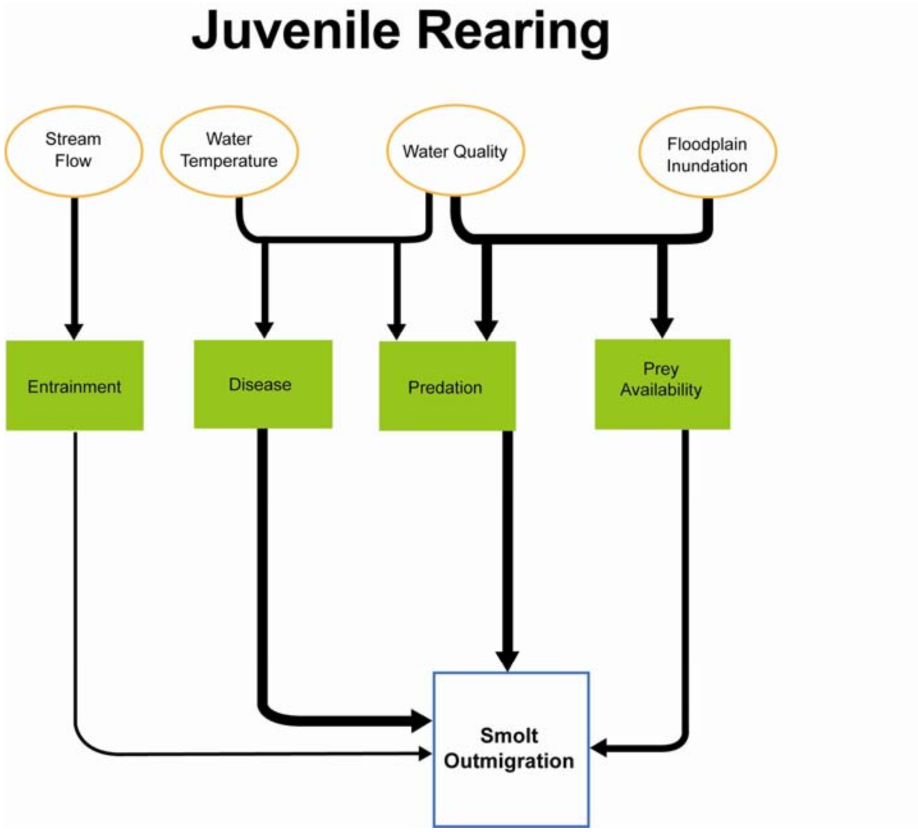
Successful spawning and incubation will lead to successful fry production in the San Joaquin River, which will help achieve a self-sustaining spring-run Chinook salmon population. Physical parameters that can be monitored that have the greatest effect on egg survival and development include spawning gravel quantity and quality (including DO and intragravel flow) and streamflow. Low gravel quantity could result in increased redd superimposition, reduced number of eggs (both because of reduced available spawning habitat), and thus reduced egg survival. Poor gravel quality (including high levels of embeddedness, which reduces intragravel flow) could result in decreased egg survival. Monitoring studies would begin upon reintroduction of spring-run Chinook salmon.

8.0 Problem Statement –Smolt Outmigration

Identify limiting factors influencing juvenile rearing and smolt outmigration that affect a self-sustaining Chinook salmon population.

A self-sustaining Chinook salmon population requires favorable habitat conditions in the upper reaches of the Restoration Area for rearing, smoltification, and outmigration before seasonal passage conditions deteriorate and prevent migration. Biological impacts that affect rearing and outmigration include entrainment, prey availability, predation, and disease. The SJRRP considers salinity, toxins, floodplain inundation, water quality, and water temperature as measurable, physical impacts, and prey availability as a measureable biological impact to development of smolt outmigrants. Monitoring data from these impacts informs decisions for managing conditions supporting rearing and smolt outmigrants. Table A-1 lists the studies associated with Smolt Outmigration.

Figure A-9 is consistent with the conceptual model for juvenile rearing presented in the FMP, but is simplified to identify the physical parameters affecting these life stages that will be monitored through the SJRRP. Some of the biological impacts (i.e., predation, prey availability and entrainment) can be monitored with the physical parameters, and are proposed by the FMWG for this life stage. Channel morphology, directly related to flow regimes, can affect the quantity and quality of available habitat for each life stage of Chinook salmon. Changes in channel morphology could have implications to the survival of each life stage.



Note: The width of the arrows indicates the relative importance of each mechanism.

Figure A-9. Physical Monitoring Parameters and Biological Impacts that May Affect Juvenile Spring-Run Chinook Salmon in San Joaquin River

Water temperature and degraded water quality can affect the level of disease exposure amount of available prey, and level of predation of juvenile fish. Often, predatory species are more active in warmer waters and can tolerate poorer water quality conditions; thus, having increased water temperatures and degraded water quality can create an environment more conducive to predation.

The use of floodplain habitat by juvenile Chinook salmon as they move downstream has been found to be extremely important for growth, development, and survival. Food resources tend to be much greater in newly inundated floodplains, particularly if the floodplain remains inundated for at least 2 weeks, and growth rates accelerated. Larger fish migrating downstream tend to have increased survival rates.

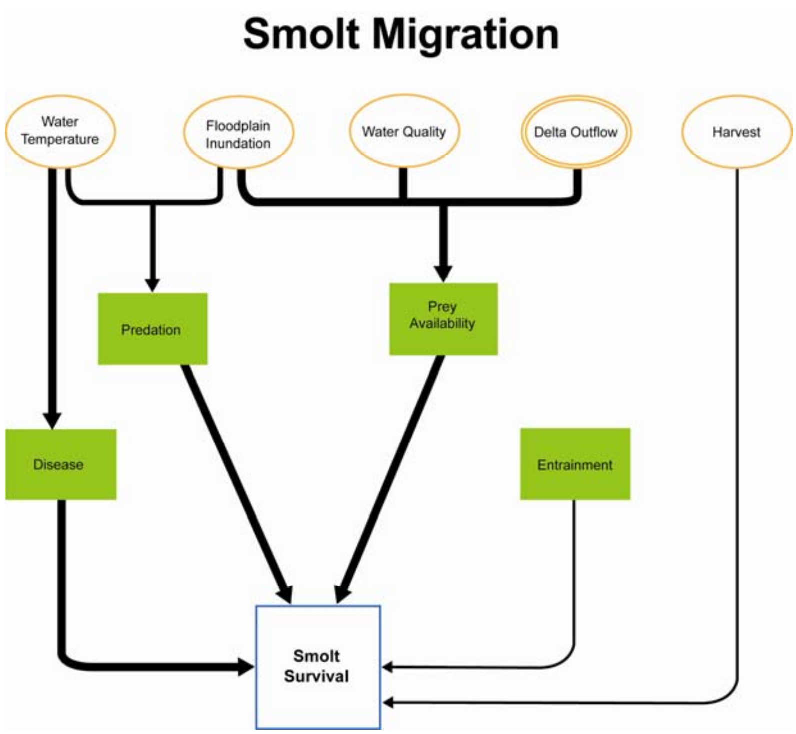
Determining invertebrate prey composition and abundance in the major rearing habitats (e.g., floodplain, edgewater, backwater) identified in Reach 1A is necessary to understand the potential for survival and growth of smolt outmigrants. Future surveys would need to be completed to evaluate floodplain and riparian habitats, and to determine invertebrate prey composition and abundance in rearing habitats. Entrainment at structures in the river can result in reduced juvenile survival. It is important to evaluated successfully the juveniles are able to pass the structures in order to determine if improvements need to be made.

9.0 Problem Statement – Smolt Survival

Identify limiting factors to smolt survival leading to a self-sustaining Chinook salmon population.

The FMP identifies smolt survival as the outcome of the Smolt Migration life stage. Juveniles that develop into smolt outmigrants must survive migration to the ocean. Biological impacts to smolt survival include predation, prey availability, entrainment, and disease. The SJRRP considers water temperature, water quality, floodplain inundation, salinity, and toxins to be measureable, physical impacts, and prey availability to be a measureable, biological impact to smolt survival. Delta outflow is a physical impact to smolt survival, but is not part of the SJRRP monitoring program. SJRRP monitoring data and data from outside sources regarding these impacts inform decisions to manage for conditions supporting smolt survival.

Figure A-10 is consistent with the conceptual model for smolt migration presented in the FMP, but is simplified to identify the physical parameters affecting these life stages that will be monitored through the SJRRP. Table A-1 lists the studies associated with Smolt Survival.



Note: The width of the arrows indicates the relative importance of each mechanism.

Figure A-10. Physical Monitoring Parameters and Biological Impacts that May Affect Survival of Migrating San Joaquin River Spring-Run Chinook Salmon Smolts

Successful rearing, smoltification, and outmigration will likely lead to a self-sustaining spring-run Chinook salmon population. Physical parameters that can be monitored having the greatest affect on outmigration include water temperature, water quality, and floodplain inundation. Delta outflow is also an important factor affecting rearing and outmigration; however, other programs are already monitoring Delta outflow. Therefore, the SJRRP would not conduct additional surveys, but would use existing data.

After reintroduction of Chinook salmon, monitoring the timing of smolt outmigration and smolt growth and physical condition would be related to ongoing monitoring of flow conditions, temperature, and food availability in Reaches 1 through 5 of the San Joaquin River. Management decisions related to Friant release schedules would consider the results from monitoring smolt outmigrants.

Monitoring the timing, growth, condition, and survival of smolt outmigrants will need to be related to the physiochemical environment. Determining the survival of smolts would be related to future adult return and straying rates, and is necessary for the permitting process.

Surveys to determine predator movements and feeding patterns would be related to ongoing monitoring of flow and water temperatures in Reaches 1 through 5 of the San Joaquin River. The information from these surveys would be used to determine smolt survival, and assist in efforts to increase survival, as necessary.

10.0 Problem Statement – Adult Recruits

Identify limiting factors to adult recruits leading to a self-sustaining Chinook salmon population.

The FMP identifies adult recruits as the outcome of the ocean survival life stage. Smolt that survive outmigration develop into adults in the ocean. Ocean productivity is determined by a complex set of ocean conditions and is the key impact to development of adult recruits. SJRRP cannot monitor or manage for any impacts to ocean survival, yet development of adult recruits is essential for the SJRRP to achieve the Restoration Goal. The SJRRP will rely on other studies for information, data, and trends of ocean productivity. Table A-1 lists the studies associated with Adult Recruits.

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11.0 Adult Passage

Identify limiting factors to adult passage leading to a self-sustaining Chinook salmon population.

The FMP identifies adult passage as the outcome of the adult migration life stage. Adult recruits migrate into the Delta, past the lower portion of the San Joaquin River, and through the Restoration Area to the holding pools and spawning areas below Friant Dam. SJRRP believes disease and straying are the key biological impacts to adult passage, and water temperature, Delta outflow, Delta water quality, and stream flow are the as the measureable, physical impacts controlling incidence of disease and straying. FMWG developed passage requirements (e.g., jump pool depth, velocity at screens, etc.) for adult salmon and other native fish which must be met at existing and future structures for successful adult passage.

Figure A-11 is consistent with the conceptual model for adult passage presented in the FMP, but is simplified to identify the physical parameters affecting this life stage that will be monitored through the SJRRP. Table A-1 lists the studies associated with Adult Passage.

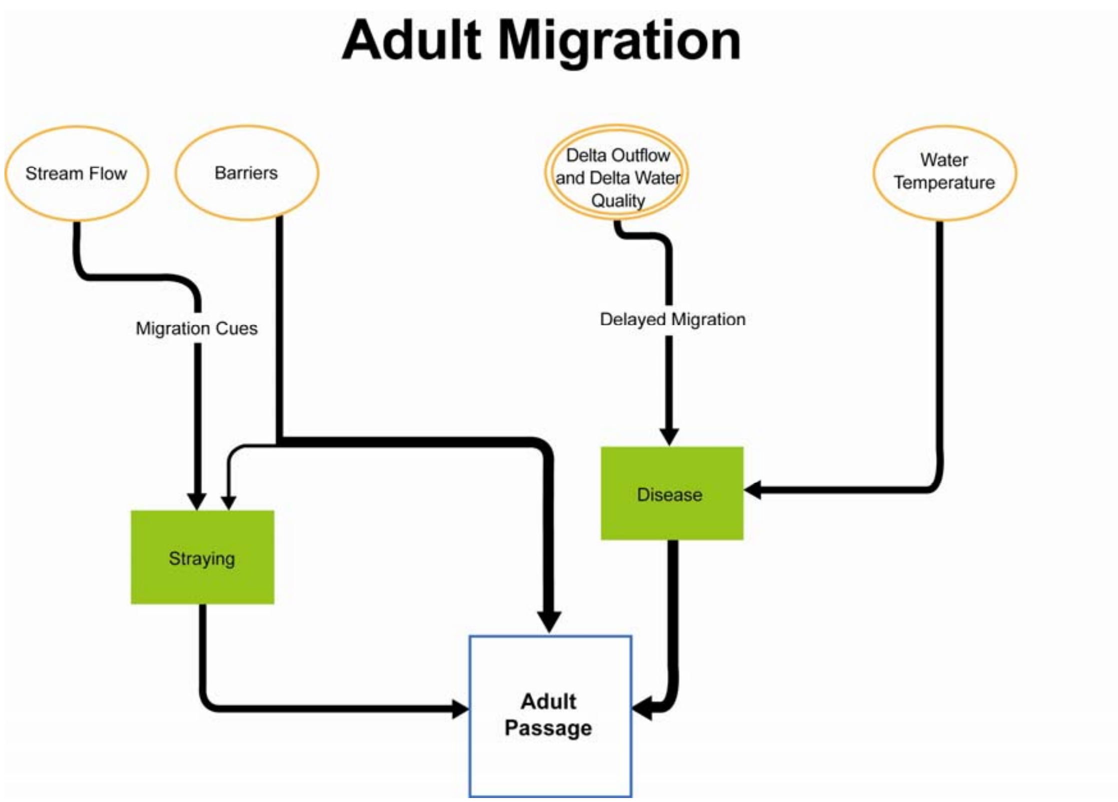

Figure A-11. Physical Monitoring Parameters and Biological Impacts that May Affect Survival of Migrating San Joaquin River Spring-Run Chinook Salmon Adults

Poorly timed Friant Dam releases may not deliver adequate water constituents to the Delta to serve as migration cues for fish to detect their natal stream. Delta water quality and outflow issues can also play a role in masking migration cues and result in delayed migration. Relationships between San Joaquin River streamflow, Delta water quality, Delta outflow, delayed migration, and migration cues are not well understood, but are believed to be an important part of successful adult passage. SJRRP may utilize monitoring data collected by other entities beyond the Restoration Area to evaluate physical impacts resulting in straying and disease during adult migration.

12.0 Temperature Monitoring for Millerton Cold Water Pool

12.1 Statement of Need

Water temperatures affect all life stages of Chinook salmon. Currently in the study area, the availability and the affect that the Millerton cold water pool has on instream river temperatures are not well understood. Water temperature needs to be monitored to evaluate how releases from Millerton Lake's cold water pool relate to instream river temperatures.

12.2 Background

Water temperature exerts a substantial influence on the abundance, development, growth, and survival of fishes, including Chinook salmon (EPA 1999; Myreck and Cech, 2004). Temperature is critical to the timing of life-history events, especially reproduction (Fry, 1971). High water temperatures result in physiological stress and increased metabolic demand, which may result in slower growth, increased susceptibility to disease, and lower survival rates. Understanding the longitudinal distribution of temperatures in relation to Restoration Flows on the San Joaquin River is critical to make flow schedule and stock selection recommendations.

12.3 Anticipated Outcomes

Analyses of temperature data will be used to evaluate the relative importance of the various factors that combine to produce observed stream temperatures, and to evaluate the impact of new flow schedules anticipated by the SJRRP on stream temperatures. Data can be used to inform decisions regarding methods for Chinook salmon reintroduction that could reduce thermal impacts. Water temperature monitoring evaluation will assist the SJRRP in making recommendations on specific actions relating to adaptive management of the SJRRP. Long-term monitoring is expected to allow informed decision-making to improve and/or offset adverse impacts as they may be determined by Interim Flow period monitoring and subsequent measurements of SJRRP success.

12.4 Methods

Temperature data collected at the base of Friant Dam from a temperature profile string and other locations within Millerton Reservoir will be compared to instream river temperatures.

12.5 References

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13.0 Evaluation of Law Enforcement Needs and Regulatory Changes to Limit Harvest

13.1 Statement of Need

Unlawful take of adult and, possibly, juvenile Chinook salmon may occur once they are established in the lower San Joaquin River. Potential sources of unlawful take (including physical disturbance), and extent that these factors could affect reaching and maintaining intended Restoration population goals, are unknown. Migrating adults and juveniles, adults holding over summer in pools, spawning, incubating eggs, and rearing juveniles could be affected.

Spring-run Chinook salmon are especially vulnerable because they hold for several months in confined locations and at high densities (FMWG, 2008), and thus have a longer exposure time to harvest than do fall-run. Illegal harvest may occur at fish ladders and other areas where adults congregate (McBain and Trush, 2002). Further, the portions of the river that will be used by salmon for holding and spawning support recreational and subsistence fishing, and many of these areas have public access (McBain and Trush, 2002). Public lands adjacent to the river and their recreational use have increased over the years, which may pose a problem for unintentional take. Sport anglers may catch yearling Chinook salmon while fishing for trout or other game fish, which could result in injury or mortality from hooking and handling (Conceptual Model, 2008). A Recreational Impact Study will be completed to identify recreational uses of the river that could affect juvenile Chinook salmon.

13.2 Background

Current State fishing regulations allow for legal catch throughout the year of one salmon in the San Joaquin River from Friant Dam downstream to the Highway 140 Bridge (DFG, 2007). From the Highway 140 Bridge downstream to the Highway 132 bridge, one salmon may be harvested from January 1 through October 31, and there is a zero bag limit from November 1 through December 31. These measures are designed to be protective for fall-run Chinook salmon and do not take into account the life-history requirements for spring-run Chinook. Size restrictions are not designated for salmon in any portion of the San Joaquin River (FMWG, 2008).

DFG wardens enforce State fishing regulations and the Fish and Game code. Currently, 11 wardens patrol areas in Fresno, Madera, and Merced counties (as of January 2009, it is anticipated that one additional warden will patrol these counties). The current number of wardens to enforce these areas is small. As of 2006, the State population was approximately 36 million, with192 wardens to patrol 1,100 miles of coast, 220,000 square miles of ocean, and 159,000 square miles of land (DFG, 2007). Allocating current wardens to patrol only the lower San Joaquin River may be difficult because of the large area a single warden has to cover. The creation of new warden jobs may be an option; however, there are approximately 40 unfilled warden positions currently statewide. With so many vacancies, it may be difficult to request new positions. DFG enforcement staff are currently working to address this problem.

13.3 Anticipated Outcomes

Data obtained from the Recreational Impact Study will assist FMWG and DFG in determining potential impacts to Chinook salmon. Evaluation of law enforcement needs will assist in protecting the resource by educating the public on new regulatory changes, therefore potentially minimizing the amount of harvest and/or take.

13.4 Methods

A Recreational Impact Study will be conducted to identify existing conditions on the San Joaquin River as they relate to recreational use within the river Restoration project area. During 2010 and 2011, DFG will draft special fishing regulations for the lower San Joaquin River that, if passed by the Regulation Review Committee and DFG Commission, will be in effect in early 2012. The DFG Commission has authority over fishing regulations, as per Fish and Game Code 205, to (a) establish, extend, shorten, or abolish open seasons and closed seasons, (b) establish, change, or abolish bag limits, possession limits, and size limits, (c) establish and change areas or territorial limits for their taking, and (d) prescribe the manner and means of taking. Future fishing regulations for the lower San Joaquin River may include, but are not limited to, the following: (a) zero bag limit for salmon from the Friant Bridge to Highway 140, may be seasonal; (b) gear restrictions, only artificial lures with barbless hooks;(c) closed fishing zones and seasons.

The DFG fishing regulations may be altered through the DFG Commission; however, any change to the Fish and Game code must be done through legislation. If DFG, at the local level, determines it is necessary to change the Fish and Game code, to further protect Restoration areas and the reintroduced spring-run Chinook salmon, DFG will elevate the concern to the State level. If DFG Headquarters (and Commission) agree, DFG Headquarters will seek sponsorship of the bill by a California Assembly or Senate member.

When the 2012 fishing regulations take effect, DFG will conduct a public outreach effort to inform the public of the introduction of sensitive resources, species protection laws, and new fishing regulations. Public outreach will include contacting city, county, other public agencies, local angling organizations and sportsmen’s clubs to inform them of new laws and regulations. Additionally, signs will be posted (in multiple languages) at appropriate locations with the new regulations and the CALTIP telephone number (the

DFG hotline for reporting illegal activity). During the first year of enforcement of new regulations, DFG typically increases education and issues a number of warnings before taking a strict enforcement philosophy. Full enforcement will include the use of existing warden staff to engage in general patrol activity. In addition to general patrol activity in these areas, wardens anticipate using other strategies, including the use of plainclothes officers to observe anglers and report illegal activity to uniformed officers who then take enforcement action, and the use of focused enforcement details such as bringing in several wardens from outside an area to patrol the area during high-use days. Data gathering and careful planning must occur to ensure proposed regulatory changes are appropriate and are in step with the State legislative process.

13.5 References

California Department of Fish and Game (DFG). 2008. 2008-2009 California freshwater sport fishing regulations. Available at http://www.dfg.ca.gov/regulations/08-09-inland-fish-regs.pdf.

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14.0 Reach 1A Spawning Area Bed Mobility (MEI3.4, UCSB)

14.1 Statement of Need

Results of this study will provide information on the ability to condition potential spawning bed material through heightened discharge events, ability of mature salmon to excavate a redd into the bed, and the quantity of suitable spawning gravel.

14.2 Background

Several studies have concluded that bed material mobilization required to maintain salmonid spawning habitat and create in-channel and channel-margin habitat in Reach 1A generally requires flows in the range of 12,000 to 16,000 cfs (MEI, 2002; JSA and MEI, 2002; McBain and Trush, 2002; Stillwater Sciences, 2003), well above the maximum Restoration releases called for in the Settlement. Hydraulic and sediment transport analysis by MEI (2002), however, showed that some local reworking of the bed occurs at flows in the 3,000 to 8,000 cfs range. The analysis, presented in Attachment A1 specifically indicated that bed mobilization would occur at flows of less than 3,500 cfs at riffle clusters 38 (RM 260.6), 40 (RM 261.4), 43 (RM 264.7), 46 (RM 266.6), and 47 (RM 266.7) (Figure 1 in Attachment A1 and Table 1 in Attachment A1). Grain size analysis of the San Joaquin River's bed near riffle crests indicates an armored condition (DWR, 2009). An armored bed effectively traps finer sediment beneath and between the stable surface particles. By entraining coarsened surface particles, protected fine material (sand, silt, and clay) can be flushed (Reiser et al., 1989). Theoretically, there are two beneficial outcomes of this process. The first is that by reducing the concentration of fine sediment, the survivability of salmonid embryos and emergence of hatching fry are increased (Kondolf, 2000). The second is that the armored surface is often in a locked pavement-like state, and by breaking it apart, a looser structure is then created that facilitates redd construction (Wilcock et al., 1996). A recent study suggests that spawnable area is linked to the excess shear stress available to assist in mobilizing bed material (Moir et al., 2009). Therefore, since the expectation is that the majority of the riffles exhibit a nonmobile condition in anticipated Restoration release scenarios, it is necessary to quantify the extent of those areas with an excess shear stress to refine the predicted existing level of spawnable stream bed.

14.3 Anticipated Outcomes

This study will provide the following information:

- Quantification of bed material characteristics proximal to existing riffles at higher resolution than is currently available.
- Data on the relative mobility of the existing bed material, including the extent and quantity transported in anticipated spawning areas.
- Hydraulic data information to quantify bed shear stresses over anticipated spawning areas during high flow releases.
- A refinement to the amount of anticipated Chinook salmon spawning beds.
- Field measurements to validate and calibrate the sediment transport, mobility, and flow models that can be extended to other locations.
- Data to calculate a friction angle and therefore the threshold transporting shear stress.
- Data that can be used to extrapolate to high-magnitude events that might be required to entrain the reinforced channel beds.
- Develop the requisite understanding for flow levels required for surface disruption for flushing fine sediment and whether high sand content affects the critical shear stress for movement.
- Predict bioenergetically relevant changes to channel form based on two-dimensional flow modeling.

14.4 Methods

Up to two monitoring sites will be selected proximal to riffles where analytical modeling suggests bed mobilization would occur at flows of less than 3,500 cfs (MEI, 2008). To assess bed mobility, several tasks will be performed such that their combination will provide sufficient information to understand mobility of the selected study areas. These tasks will include measurements of force required to mobilize bed surface gravel particles, bed material size characterization, marked gravel particle tracer studies, and flow hydraulic surveys. These tasks have been commenced at one riffle cluster (Riffle Cluster 38, MEI, 2008). The force gaging, bed material characterization, pilot tracer study, and flow hydraulic survey methods and preliminary results are presented in Attachment A1 – Bed Mobility Data Report. Bed material characterization methods and preliminary results were presented in the Fall 2009 ATR. Methods that will be extended beyond the existing study area are summarized below.

Gravel particles greater than 32 millimeters (mm) in intermediate diameter will be collected from riffles where they will later be placed as tracers. These particles will be transported back to the laboratory for measurement of size, mass, and roundness, and inserted with a passive radio frequency identification (RFID) tag. The RFID tag's unique identifier code will be recorded along with its measurements. Additionally, the tracer will be painted for ease of locating, especially when buried, after mobilizing events. Placement of the tracers will be along cross sections spanning the channel's width. Each tracer will be positioned on the bed such that it replaces a similar particle's size, shape, and relative position to surrounding particles. Tracers will be placed before high flow events, and their initial locations will be surveyed using GPS equipment. The surveyed latitude, longitude, and elevation will be recorded with other measurements and RFID code. During high flows, hydraulic properties proximal to the tracer lines will be surveyed using an ADCP with the primary intention of recording near-bed velocities. After flows return to safe levels for accessing the channel, the tracers will be relocated and their new position surveyed as before. The extent of bed material mobilization will then be compared to discharge levels as recorded from the nearby USGS Friant gaging station.

Force measurements and bed characterization surveys will be conducted at the onset of the study. Force gaging will be performed using submergible, spring-resisting, push-pull force measuring devices. Force gaging will be performed in areas delineated within approximately 20 feet of the tracer cross sections. Particles will be selected at random using a wandering and pointing-to-a-particle-without-looking method. All attempts will be made to test particles that have not been disturbed after the most recent high flow events. Additionally, roughly 20 particles of each size class (32 mm, 45 mm, 64 mm, 90 mm, 128 mm) will be gaged to determine a representative distribution of forces for each class for each channel-spanning area of the cross section.

Pebble counts will also be performed near the tracer cross sections, not to exceed 10 feet distance from the cross section. A pebble count will be performed at intervals of approximately every 10 feet of width parallel to the cross sections. This level of resolution should provide adequate information on trends in grain size with location along the cross section.

Photographs of the bed will be taken with the intention of producing a higher resolution grain size analysis that includes the sand-sized portion of the bed's surface. The photographs will be taken through a scope with a Plexiglas bottom straddling a stretched measuring tape to note the distance from the left bank's monument. Attempts will be made to photograph as much of the bed along the tracer cross sections as possible, with the main constraints of depth and velocity of flow.

14.5 Results

Preliminary results from the force gaging, bed material characterization, pilot tracer study, and flow hydraulic survey are presented in Attachment A1 – Bed Mobility Data Report. Results will be expected after implementation of this study and by December 2010. The start date for implementing the field experiments was January of 2010.

14.6 Discussion

Interpretation, applicability, and limitations of the results are anticipated to be presented after the tracers are surveyed following the first elevated flow event.

14.7 Conclusions and Recommendations

Conclusions and recommendations are expected after data analysis and comparison of two seasons of surveyed results. The anticipated schedule for these findings is after the Spring 2011 high flows.

14.8 References

California Department of Water Resources (DWR). 2009. Fall 2009 Interim Flows Monitoring Data Report for the San Joaquin River Restoration Program, Draft. March 26.

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15.0 Reach 1A Mechanical Disturbance to Enhance Bed Mobility (MEI3.4 and UCSB)

15.1 Statement of Need

Results of this study will specifically address needs related to Problem Statement 6, Mature Spawners, by providing information on a potential management alternative for increasing the quantity of spawnable area.

15.2 Background

Several studies have concluded that bed-material mobilization required to maintain salmonid spawning habitat and create in-channel and channel-margin habitat in Reach 1A generally requires flows in the range of 12,000 to 16,000 cfs (MEI, 2002; JSA and MEI, 2002; McBain and Trush, 2002; Stillwater Sciences, 2003), well above the maximum Restoration releases called for in the Settlement (Figure A-12 and Figures A-13, Table A-11). Grain size analysis of the San Joaquin River's bed near riffle crests indicates an armored condition (DWR, 2009). An armored bed effectively traps finer sediment beneath the stable surface particles. By entraining the coarsened surface particles, the protected fine material (sand, silt, and clay) can be flushed (Reiser et al., 1989). There are theoretically two beneficial outcomes of this process. The first is that by reducing the concentration of fine sediment, the survivability of salmonid embryos and emergence of hatching fry increase (Kondolf, 2000). The second is that the armored surface is often in a locked, pavement-like state and by breaking it apart, a looser structure is then created that facilitates redd construction (Wilcock et al., 1996). A recent study suggests that spawnable area is linked to the excess shear stress available to assist in mobilizing bed material (Moir et al., 2009). Furthermore, in the Merced River's Robinson reach, measurements with force gages, painted tracer rocks, and channel cross-section surveys immediately after the restoration indicated that mechanical disturbance of the bed is likely to significantly lower the shear stress required to mobilize the surface. However, the resulting distances of transport were short and the increase in surface mobility declined sharply once high flows had reestablished a more natural packing of the sediment.

Table A-11. Suggested Riffle Clusters for Gravel Mobilization Studies

Riffle Cluster Number	Distance Upstream from Merced River (feet)	River Mile	Surface Bed Material Size*		Critical Discharge (cfs)	
			D50 (mm)	D84 (mm)	Incipient Motion	Measureable Transport
38	751,140	260.6	48	84	500	1,600
40	755,440	261.4	78	112	275	1,800
43	771,790	264.7	65	115	3,600	2,900
46	782,550	266.6	42	90	1,450	>16400
47	783,090	266.7	42	90	4,200	>16400
Potential Gravel Fining and Ripping Study Sites						
17	696,380	249.8	48	73	5,800	>16400
18	696,660	249.9	48	73	>16400	>16400
19	697,740	250.1	48	73	>16400	>16400
21	702,490	251.1	48	73	5,900	13,800
33	744,890	259.4	65	101	8,300	>16400
34	745,490	259.5	65	101	9,700	16,300
41	759,360	262.1	57	94	>16400	>16400

Note:

*Based on collected by MEI in 1997

Key:
cfs = cubic feet per second
mm = millimeter

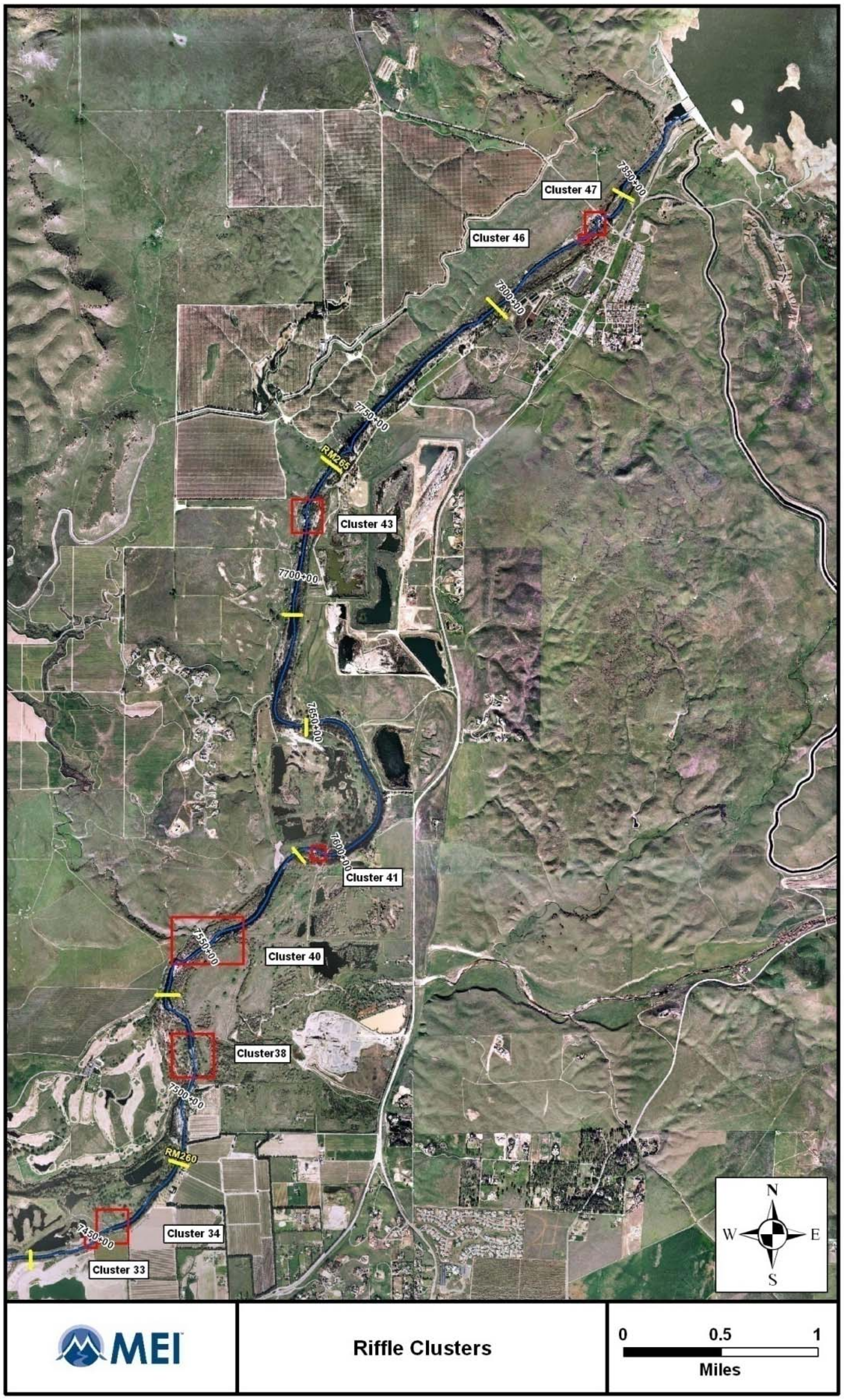

Figure A-12. Map Showing Proposed Locations of Riffle Clusters for Gravel Mobilization Studies

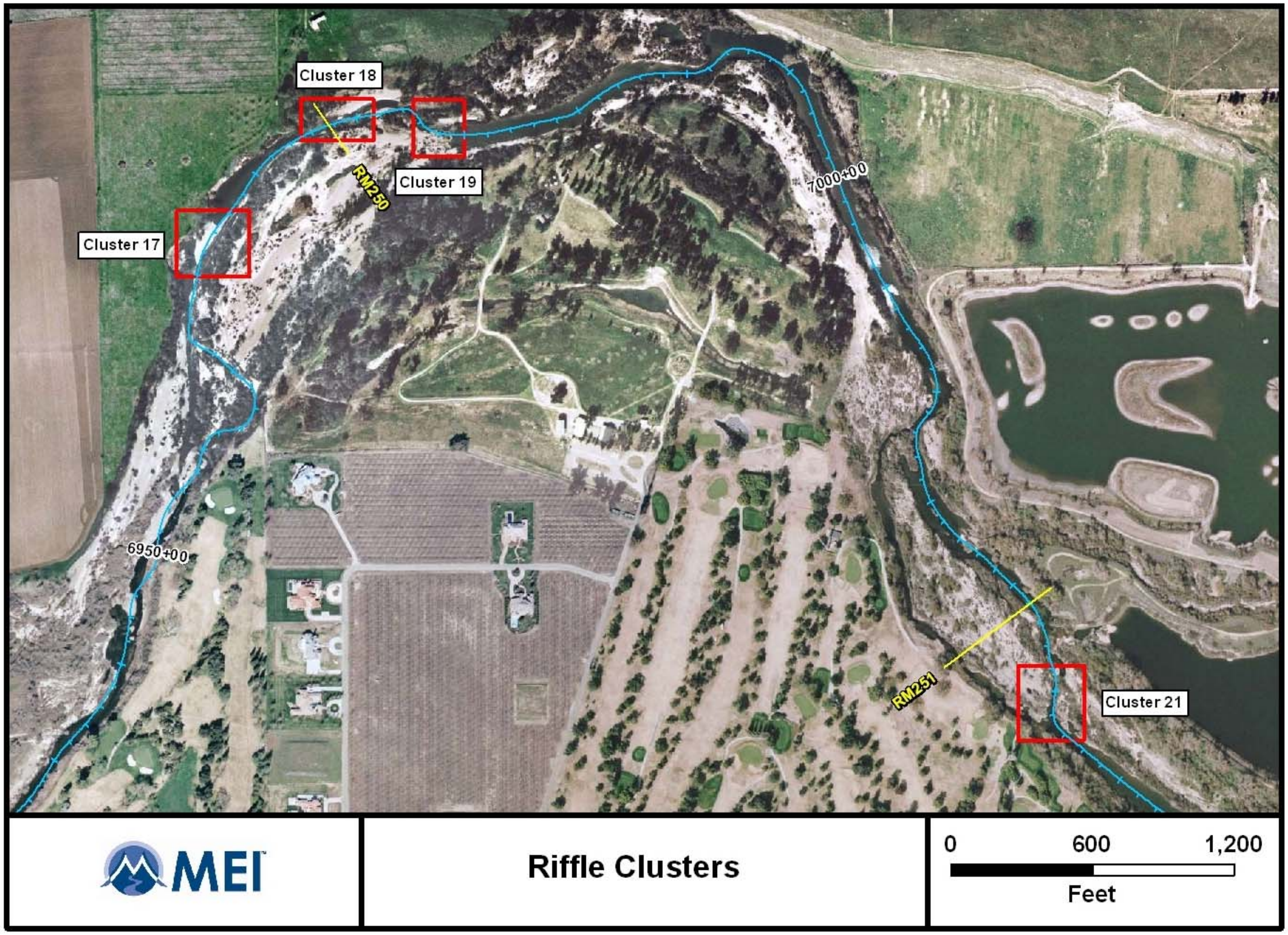

Figure A-13. Map Showing Proposed Locations of Riffle Clusters for Gravel Mobilization Studies

15.3 Anticipated Outcomes

This study will provide the following information:

- Quantification of bed material characteristics proximal to existing riffles at higher resolution than is currently available.
- Development of a quantitative model of the entrainment process to assess its relevance for Restoration design.
- Information with which compare the effectiveness of other options.
- Information on a potential Restoration option that may be better suited for certain scenarios.

15.4 Methods

This management alternative study will involve mechanically disturbing an immobile surface, thereby exposing the finer underlying material to mobilizing flows and loosening the surface structure. The mechanically disturbed areas would be compared to a local undisturbed area to note relative changes. Monitoring these study areas would include repeatable topographic surveys, tracer studies, flow hydraulic measurements, and force gage measurements. Detailed two-dimensional flow fields would be measured with an ADCP flow profiler at cross sections spanning the disturbed areas and cross sections at various distances immediately downstream in the anticipated zone of coarse-bed mobilization. Blocks of this targeted downstream riffle area could be tagged with paint of different colors so that when transported coarse particles are recovered, their locations could be identified to understand the flow conditions of entrainment and the distance of transport. The effect of the bed disturbance on the surface and subsurface texture of the riffle would also be measured by bulk sampling, photographic, and pebble count techniques. Once more, the intention is to build a quantitative model of the entrainment process to assess its relevance for Restoration design.

15.5 Results

Results will be expected after implementation of this study, and after approximately one season after the first flood flow cycle. The anticipated start date is summer 2011.

15.6 Discussion

Interpretation, applicability, and limitations of the results are anticipated to be presented after implementation of this method.

15.7 Conclusions and Recommendations

Conclusions and recommendations will be expected after post-implementation high-flow data collection and analysis. The anticipated schedule for these findings is after spring 2012 high flows.

15.8 References

California Department of Water Resources (DWR). 2009. Fall 2009 Interim Flows Monitoring Data Report for the San Joaquin River Restoration Program, Draft. March 26.

Jones & Stokes Associates and Mussetter Engineering, Inc. (JSA and MEI). 2002. Development of San Joaquin River Restoration Plan for Friant Water Users Authority and Natural Resources Defense Council. January.

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16.0 Reach 1A Gravel Augmentation (MEI3.4, UCSB)

16.1 Statement of Need

The results of this study will specifically address needs related to Problem Statement 6, Mature Spawners, by providing information on a potential management alternative for increasing the quantity of spawnable area.

16.2 Background

Several studies have concluded that bed-material mobilization required to maintain salmonid spawning habitat and create in-channel and channel-margin habitat in Reach 1A generally requires flows in the range of 12,000 to 16,000 cfs (MEI, 2002; JSA and MEI, 2002; McBain and Trush, 2002; Stillwater Sciences, 2003), well above the maximum Restoration releases called for in the Settlement (Table A-11, Figure A-12, and Figure A-13). Grain size analysis of the San Joaquin River's bed near riffle crests indicates an armored condition (DWR, 2009). An armored bed effectively traps finer sediment beneath the stable surface particles. By entraining the coarsened surface particles, the protected fine material (sand, silt, and clay) can be flushed (Reiser et al., 1989). There are theoretically two beneficial outcomes of this process. The first is that by reducing the concentration of fine sediment, the survivability of salmonid embryos and emergence of hatching fry is increased (Kondolf, 2000). The second is that the armored surface is often in a locked, pavement-like state and by breaking it apart, a looser structure is then created that facilitates redd construction (Wilcock et al., 1996). A recent study suggests that spawnable area is linked to the excess shear stress available to assist in mobilizing bed material (Moir et al., 2009). Furthermore, the effectiveness of introduced gravel one-quarter to one-half of the bed's median grain size to induce mobilization of otherwise immobile sediment has recently been demonstrated in a flume at the University of California, Berkeley (Sklar et al., 2009). However, although it is a promising idea, the relevance of the experiment at realistic river scale remains unknown. The flume bed, although immobile, was not embedded, and the distance of coarse-particle transport that can be maintained with realistic introduced sediment volumes in a large river is unknown. The degree to which the finer gravel and any passing sandy bedload would infiltrate the mobilized bed is also unknown. Therefore, it would be revealing and relevant to the Restoration effort to conduct an experiment in which a layer of fine gravel (the size of which should be determined after some sample calculations) would be added to a riffle and intensively monitored throughout the ensuing high flow.

16.3 Anticipated Outcomes

This study will provide the following information:

- Quantification of the bed material characteristics proximal to existing riffles at higher resolution than is currently available.
- Development of a quantitative model of the entrainment process to assess its relevance for Restoration design.
- Information with which to compare the effectiveness of other options.
- Information on a potential Restoration option that may be better suited for certain scenarios.

16.4 Methods

Detailed two-dimensional flow fields would be measured with an ADCP flow profiler at cross sections spanning the fine-gravel layer and cross sections at various distances immediately downstream in the anticipated zone of coarse-bed mobilization. Blocks of this targeted downstream riffle area could be marked with paint and/or RFID tags so that when transported coarse particles are recovered their locations could be identified to understand the flow conditions of entrainment and the distance of transport. The effect of the fine gravel on the surface and subsurface texture of the riffle would also be measured by bulk sampling. Once more, the intention would be to build a quantitative model of the entrainment process to assess its relevance for Restoration design.

16.5 Results

Results will be expected after implementation of this study and after approximately one season after the first flood flow cycle. The anticipated start date is summer 2011.

16.6 Discussion

Interpretation, applicability, and limitations of the results are anticipated to be presented after implementation of this method.

16.7 Conclusions and Recommendations

Conclusions and recommendations will be expected after post-implementation high-flow data collection and analysis. The anticipated schedule for these findings is after the Spring 2012 high flows.

16.8 References

California Department of Water Resources (DWR). 2009. Fall 2009 Interim Flows Monitoring Data Report for the San Joaquin River Restoration Program, Draft. March 26.

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17.0 Monitoring Spawning Gravel Quality and Quantity

Monitoring spawning gravel quantity and quality will help determine mean egg production and egg survival of spring-run Chinook salmon to assess production as related to production targets (egg survival studies should begin before reintroduction). This will help identify the success of the SJRRP.

17.1 Statement of Need

This study addresses several limiting factors (i.e., sedimentation, streamflow, water temperature, gravel quality and quantity) to the healthy fry production life stage (via egg survival) of Chinook salmon (FMWG, 2009a), and provides necessary information on existing conditions for reintroduction of Chinook salmon by 2012 by identifying factors that may contribute significant mortality to introduced Chinook salmon. This information will be a necessary component of the National Marine Fisheries Service (NMFS) 10(a)1(a) permit application.

17.2 Background

Incubating salmon eggs requires appropriate conditions (water temperature, spawning gravel size distribution, and water quality, including DO and pH) to survive and hatch successfully. Field studies indicate there may be a significant amount of sand and other fine sediments in the areas perceived to be adequate spawning habitats. Infiltration of these materials into the redd, in addition to poor water quality conditions (in the hyporheic environment) may result in decreased survival of eggs and prevent the SJRRP from meeting the targets identified in the FMP (FMWG, 2009a).

17.3 Anticipated Outcomes

The outcome of the study will be information required for the NMFS 10(a)1(a) permit application. Additionally, the study will provide the SJRRP with critical information on the suitability of spawning habitat for egg survival in the Restoration Area. This information will also help the FMWG make decisions on how to best manage perceived spawning areas in the Restoration Area.

17.4 Methods

This effort will be multiagency and multidisciplinary. The efforts proposed here will supplement efforts currently being undertaken by DWR and Reclamation. Constructing several artificial redds to include salmon eggs will allow monitors to document the effects of habitat conditions on the survival of the eggs.

Monitoring spawning gravel quantity and quality began in fall 2009, with a Pilot Tracer Study conducted by DWR. The monitoring activities provided a coarse evaluation of the longitudinal profile of larger sediments that could help answer questions about the size of gravel available for mobilization by fish that are building redds. Determining spawning gravel quantity, including the amount of appropriate sizes and accessibility to fish, should be evaluated as part of the ongoing study. Additional information collected during fall 2009 for finer sediments is on a spatial scale much coarser than fish operate. In addition, determining the spawning gravel quality, including DO, intragravel flow, intragravel water temperature, and water quality is necessary to evaluate the ability to meet egg/fry production targets. Results from the tracer studies will help to inform management about how flow decisions relate to coarse sediment mobilization.

17.5 Results

Portions of this study have been funded for 2010 (hyporheic conditions in a subset of spawning areas will be described – Reclamation, Denver), but will require future funding. Additionally, the egg survival portion (the direct biological link) has not been funded to date.

17.6 References

Fisheries Management Work Group (FMWG). 2009a. Conceptual models of stressors and limiting factors for San Joaquin River Chinook salmon. 178 pp. June.

18.0 Effect of Scour and Deposition on Incubation Habitat in Reach 1A (MEI3.6.3, UCSB)

18.1 Statement of Need

An understanding of the accumulation of fine sediment in a gravel framework of a salmon redd and its resultant influence on subsurface flow is a key factor in assessing the potential quality of available spawning habitat in Reach 1, and for designing measures to improve spawning habitat quality if fine sediment deposition is deemed to be a problem. Additionally, the potential for flows to scour the bed and thereby expose eggs to abrasive bed load transport should be assessed and used to refine suitable spawning areas estimates for given discharges. Additional uses of this study have been sited by the U.S. Fish and Wildlife Service (USFWS).

18.2 Background

Incubating salmon eggs and hatching fry require adequate DO delivery into the redd's egg pocket and, therefore, adequate hydraulic conductivity to allow its delivery (Cooper, 1965). During the redd building phase, bed material is mobilized by spawning salmon. This process removes a portion of the fine sediment from the local mix as it is transported further downstream, thereby increasing the vacant pore space within the lag material that remains to form the redd feature. This increased porosity induces greater hydraulic conductivity and increased delivery of DO from the surface flow (Kondolf, et al., 1993). After spawning is complete the eggs remain buried while incubating and benefit from this relatively higher hydraulic conductivity environment. During this time, fine sediment transported by the flowing water can deposit over or within the subsurface (Beschta and Jackson, 1979). Fine sediment depositing into the interstices of the redd or forming a seal at the surface is deemed one of the most detrimental factors to the survival of incubating eggs by reducing hydraulic conductivity and thereby reducing DO delivery and metabolic waste removal to and from the egg pocket, respectively (Shirazi and Seim, 1981; Chapman, 1988; Sear, 1993; Lapointe, et al., 2003).

Field observations indicate that there is a significant volume of sand and fine sediment stored in the channel in Reach 1. There is, therefore, potential for infiltration and accumulation of sand and finer material into the redds' gravel framework, which can significantly affect the quality of the spawning habitat (Kondolf, 2000). However, flow conditions that would have access to fine sediment supplies, have the ability transport fine sediment, and allow for it to accumulate on the bed and infiltrate the bed material are not known.

In addition, the bed surface will undergo changes through scour and later deposition as a result of sediment transport processes. These processes are known to present a risk to incubating embryos more typically found within bar and riffle subsurfaces. When scour occurs to the egg pocket depth, the eggs lose their protection from the effects of bed material transport. Additionally, subsequent deposition alters the texture of the material overlying the remaining egg pocket (Haschenburger, 1999; Lapointe, et al., 2000; May, et al., 2009). Understanding how redds will be transformed by the Restoration flows is necessary to assess the altered flow regime’s impact on adult and juvenile salmon habitat.

18.3 Anticipated Outcomes

Monitoring fine sediment infiltration into artificial redds will provide information on the magnitude of the sand infiltration issue and its relationship with flow regime, and proactively inform the project’s need for corrective actions to insure suitable spawning habitat.

18.4 Methods

Two sites (around Riffle Clusters 38 and 40) have been selected where studies on the influence of fine sediment infiltration into redds will be conducted. In the future, additional monitoring sites may be selected from those listed in Table A-12. The baseline task required to establish this monitoring program will include bed material characterization, artificial redd construction, monumentation, and surveying of monitoring cross sections where flow profile surveys will be performed. Upon completing each artificial redd a collapsed sediment retrieval bag will be inserted beneath the material that has reduced fine sediment from the redd building process. Additionally, a perforated tube will be inserted into each redd for subsequent hydraulic conductivity and DO measurements from within the redd (Lisle and Eads, 1991). The tube will allow these measurements with minimized disturbance of subsequently deposited fine sediment. After all, it is not only the amount but also the pattern in that the fine sediment accumulates which will influence those measurements.

Table A-12. Potential Riffle Clusters for Sand Infiltration Studies

Riffle Cluster Number	Distance Upstream from Merced River (feet)	River Mile	Surface Bed Material Size*		Critical Discharge (cfs)	
			D50 (mm)	D84 (mm)	Incipient Motion	Measureable Transport
47	783,090	266.7	42	90	4,200	>16400
46	782,550	266.6	42	90	1,450	>16400
43	771,790	264.7	65	115	3,600	2,900
41	759,360	262.1	57	94	>16,400	>16,400
40	755,440	261.4	78	112	275	1,800
38	751,140	260.6	48	84	500	1,600
34	745,490	259.5	65	101	9,700	16,300
33	744,890	259.4	65	101	8,300	>16,400
21	702,490	251.1	48	73	5,900	13,800
19	697,740	250.1	48	73	>16,400	>16,400
18	696,660	249.9	48	73	>16,400	>16,400
17	696,380	249.8	48	73	5,800	>16,400

Note:

*Based on collected by MEI in 1997.
Key:
cfs = cubic feet per second
mm = millimeter

The purpose of the artificial redd is to mimic a redd's fine sediment cleansed condition, and the infiltration process associated with hydrodynamic of its morphology as best as possible (e.g. Wu, 2000). These hydrodynamics in turn will affect fine sediment deposition because of the associated downwelling flow into the redd (Cooper, 1965; Thibodeaux and Boyle, 1987). Therefore, the artificial redd's morphology and sediment texture will more accurately reflect the processes that influence fine sediment infiltration and accumulation. The artificial redd will be constructed via a process that will be decided on based on conversations with biologists regarding the best method to create a feature resembling a redd both in surface expression and internal texture.

Artificial redds will be constructed in pairs, thereby allowing one to be sampled midway through an incubation period and the other at the end of the incubation period. Each will be sampled for the substrate interstice's hydraulic conductivity and DO concentrations using an inserted tube. Also, each will have its substrate sampled using a freeze-core method if collaborators with such expertise and equipment can be solicited (Lisle and Eads, 1991; Barnard and McBain, 1994). Otherwise, a less discrete method may be used such as employing a McNeil sampler (McNeil and Ahnell, 1964; Bunte and Abt, 2003).

Data from this task will be evaluated to assess fine sediment accumulation at the sites and the extent to which fine sediment infiltrates into an artificial redd. Data from the substrate measurements will provide a quantitative measure of fine sediment infiltration into cleansed gravels by fine sediment transported during flows that are likely to occur during the incubation period, and will provide insight into how long the biological benefits of cleaned gravel will last if upstream fine sediment sources are not reduced.

In two separate ATR Study Templates (Gravel Quantity and Quality, and Egg Survival) into USFWS has suggested collaboration by incorporating additional methods to this study so as to examine the influence of other water quality and biological influences on the survival of Chinook salmon embryos. The intention of this collaboration would be to examine the relative influences on embryo survival.

18.5 Results

Results will be expected after implementation of this study and after a length of time equal to one incubation cycle. The anticipated start date is mid- to late October 2010.

18.6 Discussion

Interpretation, applicability, and limitations of the results are anticipated to be presented after the first application of this method.

18.7 Conclusions and Recommendations

Conclusions and recommendations are expected after data analysis and comparison of two or more runs of this method with differing flow conditions. The anticipated schedule for these findings is after spring 2010 high flows.

18.8 References

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19.0 Juvenile Chinook Salmon Survival Study

This study identifies fish movement and habitat used in the study area.

19.1 Statement of Need

This study addresses two key components affecting juveniles: (1) identifying appropriate physical habitat and minimizing biological impacts for successful Chinook salmon reintroduction and to allow for development of smolt outmigrants, and (2) identifying physical habitat and minimizing biological impacts to establish appropriate conditions for Chinook salmon reintroduction and to allow for increased survival.

This study could provide a cursory assessment of potential entrainment areas, although additional studies would be necessary to accurately assess entrainment and quantify impacts to smolt outmigrants. Smolt migration timing, pathways, and survival, as they relate to flow and physiological conditions, can be determined with this study. Information from this study can be coupled with the predation study to determine the percentage of the population that may be lost to predation within reaches.

Overall, this study addresses the limiting factors of inadequate streamflows, degraded habitats (poor water quality, lack of floodplain and riparian habitat, predation by nonnative species, and diversions (entrainment)) (FMWG, 2009a), and provides the necessary information on existing conditions to inform 2012 salmon reintroduction by identifying “problem” areas that may contribute to salmon mortality.

19.2 Background

Fish habitat conditions in the San Joaquin River within the Restoration Area have been highly altered. Interim Flows, which are now underway, provide an opportunity to understand how the river may function under improved flow conditions, specifically, how Chinook salmon will use the river once they are reintroduced. Chinook salmon are scheduled for reintroduction in 2012, which will likely occur before completion of the larger site-specific physical habitat Restoration activities, and will expose the reintroduced fish to less than optimal habitat conditions. To successfully reintroduce both fall-run and spring-run Chinook salmon, and achieve the Settlement Goals, information must be gathered regarding potential sources of juvenile salmon mortality. The population goals set forth in the FMP (FMWG, 2009b) cannot be obtained unless juvenile survival rates through the system are first determined. Acoustic telemetry technology is currently relied on heavily in the Sacramento-San Joaquin River system to evaluate juvenile Chinook salmon survival (Perry et al., 2009; Vogel et al., 2008) and can allow investigators to evaluate reach-specific and through-project survival rates for juvenile Chinook salmon. In addition, data gathered from this acoustic telemetry study can determine the drivers for survival (i.e., which habitat conditions most affect successful migration). Initiating this study in the Interim Flows period allows for 2 years to investigate existing river conditions and how those habitat conditions may affect salmon survival, before reintroduction.

19.3 Anticipated Outcomes

Data will be used to determine areas that are contributing to Chinook salmon smolt mortality. This information will then inform the reach-specific habitat designs and fish passage designs, and identify entrainment areas that are in need of further study. In addition, these data will be used to estimate project-wide juvenile smolt survival rates, allowing for refinement of the stock selection decisions related to how many adults are needed from donor stocks, and the level of juvenile production necessary to meet the program population goals.

19.4 Products

Aid FMWG in study design development, provide recapture history dataset, determine appropriate mark-recapture model, fit recapture data to the model and estimate reach-specific and project survival rates, estimate travel time, identify areas of mortality, and relate them to habitat conditions.

19.5 Methods

Estimating reach-specific and project-level juvenile Chinook salmon survival will be the focus of this study. Stationary acoustic receivers will be placed in arrays above and below each reach, bypass, diversion, and major passage impediment, and at the downstream end of the Restoration Area. Juvenile hatchery fall-run Chinook salmon will have acoustic receivers surgically implanted, and will be released at strategic locations to evaluate survival by reach or in a suspected problem area. Receiver data will be downloaded and summarized to assess smolt migration timing and patterns, relationship to habitat, flow and water quality (primarily temperature), entrainment locations, and passage barriers/issues.

19.6 Conclusions and Recommendations

Not applicable. Study has not been funded to date.

19.7 References

Fisheries Management Work Group (FMWG). 2009a. Conceptual models of stressors and limiting factors for the San Joaquin River Chinook salmon. 178 pp. June.

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20.0 Entrainment

This study is intended to identify areas of entrainment and quantify impacts on smolt outmigrant numbers.

20.1 Statement of Need

Entrainment risk and false migration pathways need to be evaluated to ascertain if, and to what extent, adults, juveniles, smolts, and yearling salmon fail to access suitable habitat because of this limiting factor. The SJRRP needs to collect basic information on entrainment risk to assess the overall impacts of entrainment on meeting the Restoration Goal.

The FMP (FMWG, 2009b) identifies a number of potential actions to prevent entrainment including screening Arroyo Canal (Paragraph 11 project), construction of Mendota Pool Bypass (Paragraph 11 project), modification of Chowchilla Bypass (Paragraph 11), the filling and isolation of gravel pits (Paragraph 11, Phase II), consolidation of diversion locations, and an assessment of entrainment risk at other diversions (FMWG, 2009b). A preliminary assessment of entrainment risk, including adult and juvenile stranding opportunities, is needed to verify limiting factors analysis and identify future screening actions, if necessary. In addition, an evaluation of entrainment risk in the bypasses is needed to inform bifurcation design and engineering, and juvenile salmonid habitat potential in the bypasses. Effective entrainment prevention for salmon and other native fish is critical to the success of the SJRRP.

20.2 Background

Entrainment is defined as the " incidental trapping of fish and other aquatic organisms in the water, for example, used for cooling electrical power plants or in waters being diverted for irrigation or similar purposes" (http://dictionary.babylon.com), and generally applies to juvenile fish migration.

Potential impacts of juvenile entrainment might reduce the ability to meet the Restoration Goal; however, the level of entrainment is affected by diversion type and is highly variable. Although the Settlement requires specific diversions to be screened, an assessment of the effectiveness of the screen is needed so that modifications can be made to increase their effectiveness and apply the information to additional areas, as needed. Entrainment of migrating juveniles may occur if the design, operation, and maintenance at some facilities are not modified to reduce or eliminate incidental trapping of fishes. Entrainment may result in reduced escapement, increased stress, reduced fitness and injury to fish, and increased predation, thereby reducing survival of outmigrating smolts. Restoration measures are expected to take place in all five reaches to minimize entrainment losses at larger diversions; however, the SJRRP should make a preliminary assessment of the relative risk of entrainment at other diversions, including the Chowchilla Bypass.

The Settlement identifies the following entrainment features within the Restoration Area:

> (1) Paragraph 11(a)(6): "Screening the Arroyo Canal water diversion immediately upstream of Sack Dam to prevent entrainment of anadromous fish."

> (2) Paragraph 11(a)(10): "Modifications to enable the deployment of seasonal barriers to prevent adult anadromous fish from entering false migration pathways in the area of Salt and Mud Sloughs."

> (3) Paragraph 11(b)(2): "Modifications to the Chowchilla Bifurcation Structure to provide fish passage and prevent entrainment if the Secretary, in consultation with the Restoration Administrator and with the concurrence of the NMFS and the FWS, determines that such modifications are necessary to achieve the Restoration Goal."

Paragraph 11(a) items are Phase 1 improvements having the highest priority and scheduled for completion by December 31, 2013. Paragraph 11(b) items are Phase 2 improvements scheduled for completion by December 31, 2016.

In 2001, DFG (McBain and Trush, 2002) inventoried 95 diversions in the Restoration Area between RM 209 and RM 267 that were mostly unscreened pumps. The estimated maximum diversion capacity ranged between less than 1 cfs to 63 cfs. Three of these diversions are weir structures just downstream from Friant Dam. The Big Willow Unit Diversion (RM 261.3) is a cobble-type weir that diverts a small amount of water to the Fish Hatchery. The Rank Island Unit is a cobble weir located at RM 260. The Rank Island Unit diverts approximately 5 cfs to property on the north side of the river. The Milburn Unit Diversion is a small concrete-rubble weir located at RM 247.2. A small pump is located just upstream. In addition, Herren and Kawasaki (2001) found 298 and 2,209 diversions in the San Joaquin basin and Sacramento-San Joaquin Delta (Delta) respectively. More than 95 percent of 38 of these diversions were unscreened, and the impacts of these diversions on juvenile Chinook salmon are unknown. No studies have been conducted to determine the entrainment rates at the pumps and weirs in the Restoration Area or downstream in the Delta.

20.3 Anticipated Outcomes

Results from this study will help validate draft conceptual models of stressors and limiting factors for Chinook salmon (FMWG, 2009a), and build the ecosystem diagnosis and treatment model framework. In addition, this information will be critical to the decision-making loop of Adaptive Management, as described in the FMP (FMWG, 2009b).

The SJRRP should anticipate accomplishing the following study objectives: (1) identification of potential juvenile and adult entrainment features within the Restoration

Area, (2) documentation of potential entrainment features within the Restoration Area, describing each feature, including photographs and georeferenced data, (3) development of a GIS system that references the collected data, (4) development of a method to prioritize each feature based on its potential to impact migrating or rearing salmonids, and (5) providing information to assist in making Restoration or adaptive management recommendations to meet the Restoration Goals.

20.4 Methods

Potential entrainment features in the Restoration Area will be identified and evaluated qualitatively to determine juvenile fish entrainment risk. In addition, potential false pathways for adult migrants, and juvenile fish stranding locations in the Restoration Area, including the Chowchilla, Eastside, and Mariposa bypasses, should be evaluated by the SJRRP.

The entrainment study encompasses data collection for diversions within Reach 1 followed by the creation of a GIS database. Subsequently, the SJRRP will prioritize likely entrainment features for future modification and/or monitoring to ensure accomplishing the Restoration Goal.

Existing data on pumping diversions relative to equipment, configuration, and location of riparian pumps in the upper reaches of the San Joaquin River will be reviewed and compared to current conditions. Potential entrainment features within Reaches 2 through 5 and the bypasses will be measured during flowing conditions. Streamflow data, geomorphic information, and structural dimensions will be measured at each feature. In addition, location coordinates and photographs of each feature will be incorporated in a geodatabase.

The SJRRP will develop a prioritized list of potential entrainment features, indicating which anadromous fish life stages would most likely be impacted. This information will be reported to the FMWG and SJRRP for planning and prioritizing Restoration efforts.

The SJRRP should review DFG's existing pump diversion database to determine its relevance towards the purpose of this study, the thoroughness of the collected information, and if it is feasible to update with recent pumping installations, and to prepare worksheets for the field to confirm pump site locations, equipment, and configuration.

Inspection of potential entrainment features within Reaches 2 through 5 and the bypasses should occur during the Interim Flows period. When the river is flowing, flows should be measured in all gravity inflow and outflow features while cross sectional and longitudinal profile information is collected along with water depths in the inflow or outflow feature and the main channel. Staff will identify pumping facilities and collect information regarding pump size, pipe diameter, pumping depth, and perforations. Using handheld GPS units, staff will record coordinates for all identified structures and features. Also, staff will use photographs to identify important physical characteristics.

Riparian agricultural pumping diversions and continuously running pumps for mining operations spread throughout Reach 1. Staff should carefully survey these installations, compare them with the existing DFG database, attempt to link the installation with available landowner information, identify the acres and crops irrigated, and identify pump horsepower, pipe diameter, type of intake screen or perforations, and intake depth.

GIS staff will begin collating and organizing the field data as each reach is completed. The FMWG will review a report of assessment results along with a proposed prioritization method for the features identified in this study. Maps, photographs, and possibly some sketches can be included in the report along with a priority of features to be modified or addressed, and identification of those features requiring future monitoring once salmonids enter the system. This report, once finalized, can be used towards directing Restoration efforts.

20.5 References

Fisheries Management Work Group (FMWG). 2009a. Conceptual models of stressors and limiting factors for San Joaquin River Chinook salmon. 178 pp. June.

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21.0 Floodplain Inundation

Quantification of the amount of floodplain inundation related to discharge to determine food availability for smolt outmigrants is important in determining the success of smolt survival.

21.1 Statement of Need

This study addresses the limiting factor of floodplain and riparian habitat for juvenile Chinook salmon survival and outmigration and is a primary habitat goal in the FMP (2009a; 2009b). The Chinook salmon population objective recommended by the Restoration Administrator is a minimum annual target of 44,000 spring-run and 63,000 fall-run Chinook salmon subyearling smolts migrating from the Restoration Area, yet surveys are needed to establish the amount and quality of floodplain habitat available and necessary to achieve this goal. The need for Restoration of degraded floodplain habitat is articulated in Paragraph 12 of the Settlement and identified in Phase I Improvements at particular locations (*NRDC, et al., v. Kirk Rodgers, et al., 2006*).

21.2 Background

The Restoration Goal of achieving a self-sustaining population of Chinook salmon will not be possible without the availability of adequate rearing habitat. This is particularly true for spring-run Chinook salmon whose offspring may spend a significantly greater amount of time rearing in the San Joaquin River and migrate as yearlings. Inundated floodplain habitats have been reduced in the San Joaquin because of water management, yet they provide near-optimal rearing conditions for juvenile salmonids (Jeffres et al., 2008). The direct and indirect benefits of floodplains to salmon are significant and include higher growth rates (warmer water temperatures, greater prey abundance) and increased survivorship (Sommer et al., 2001).

Several factors can lower the value of floodplains for salmon such as water temperature and depth, and timing, duration, and magnitude of inundation. The amount of area and the number of juvenile salmon that can benefit from the habitat will therefore vary as a function of discharge. Monitoring of current floodplains and those associated with project Restoration areas is necessary to determine the extent to which they are providing quality rearing habitat.

21.3 Anticipated Outcomes

Results from this study will provide an assessment of the amount and quality of floodplain habitat for juvenile salmon in the Restoration Area as a function of discharge. This assessment will be based on a variety of factors, including water temperature, flows, depths, vegetation, and prey abundance to determine carrying capacity for the existing and proposed floodplains. This information can be used to identify the frequency, duration, and magnitude of inundation (related to discharge) to maximize the value of floodplains to outmigrating salmon. These results will be quantified and used to determine whether the available and proposed floodplains are likely to support the population abundances of outmigrating salmon in the Restoration plan.

21.4 Methods

Flow and depth have a major impact on water quality within the floodplain. Shallow floodplains may experience greater variation in temperature and low DO levels, and increase exposure of fish to avian predators. Therefore, temperature and depth monitoring/modeling need to be conducted for different discharge rates to ensure that temperatures and depths in floodplains are near optimal levels for salmonids to accelerate growth and reduce predation. Invertebrate sampling and vegetation survey data will be used to determine prey biomass, and vegetation on existing floodplains. In subsequent years, juvenile habitat use and growth rates attributable to existing and restored floodplains will be able to be monitored.

21.5 References

California Department of Fish and Game (DFG). San Joaquin Valley-Southern Sierra Region. 2007. San Joaquin River Fishery and Aquatic Resources Inventory. Cooperative Agreement 03FC203052.

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22.0 Water Quality Study

Water quality is of concern to the FMWG because it could affect juvenile Chinook salmon growth and survival.

22.1 Statement of Need

Degraded water quality is identified as a potential limiting factor for all life stages of Chinook salmon and other native fishes in the Restoration Area (FMWG, 2009). Urban and agricultural wastes may alter water quality parameters such as DO and turbidity, creating unsuitable habitat for Chinook salmon. It is unknown whether or not Interim Flows will improve water quality in the Restoration Area. Therefore, evaluation and management of water quality conditions are essential to successfully meet the Restoration Goal.

The SJRRP needs to monitor water quality conditions and identify water quality monitoring sites. Ideally, water quality monitoring should be coupled with sampling of sensitive aquatic biota, such as macroinvertebrates, the main food resource for rearing salmon.

To meet the Restoration Goal, the FMP states that water quality should meet minimum standards for protection of aquatic resources, including holding/spawning and rearing fish. The Central Valley Regional Water Quality Control Board (CVRWQCB) defines water quality objectives for beneficial uses that can be used to establish water quality goals for the protection of the San Joaquin River fishery (FMWG, 2009). Water quality monitoring contributes to the main beneficial uses for the enhancement of fisheries resources within the Restoration Area: (1) cold freshwater habitat, (2) fish migration, and (3) spawning, reproduction, and/or early development.

The SJRRP needs to coordinate with other water quality programs to monitor water quality at identified monitoring sites and ensure compliance with existing water quality objectives.

22.2 Background

McBain & Trush (2002) concluded that the historical water quality of the San Joaquin River likely provided suitable conditions for native fish, including anadromous salmonid populations. Moyle (2002) highlighted, however, that subsequent declines in water quality may be contributing to the decline of some native resident fish. While the capacity of Interim Flows to improve existing water quality conditions is unknown, a study by Henson and others (2007) showed that a pulse flow event similar to the Interim Flows could improve downstream fish and macroinvertebrate habitat quality.

Monitoring activities by the CVRWQCB suggest that the San Joaquin River above Friant Dam is not impaired and that water quality in the upper San Joaquin River is excellent. In contrast, water quality objectives for salinity have been routinely exceeded in downstream reaches (from Reaches 3 through 5), according to CVRWQCB reports. Furthermore, although most DO data are generally not indicative of water quality impairment, low DO levels have impaired the upstream end of the Stockton Deep Water Ship Channel since the 1970s.

Studies support that trace element concentrations in the San Joaquin River are a primary water quality concern. Saiki et al. (1992) found evidence of bioaccumulation of several trace elements from exposure to undiluted agricultural drainwater. Agricultural drainage water had been a source of selenium to Salt Slough, but selenium concentrations improved at this site after implementation of the Grasslands Bypass Project (GBP) in 1996. The GBP conveys agricultural drainwater to the San Joaquin River, which is still regarded as impaired because of selenium. A study by Saiki et al. did not detect any adverse effects to fish that could be attributed to GBP operations. However, Beckon (2007) found that juvenile fall-run Chinook salmon died in the laboratory after eating selenium-contaminated invertebrates and prey fish over a 90-day period that were collected from the San Joaquin River basin.

The 303(d) list, a list of impaired water bodies maintained by the CVRWQCB and revised by the U.S. Environmental Protection Agency, identifies pesticide impairment in Reaches 3, 4, and 5 of the Restoration Area. The 303(d) listing process guides the CVRWQCB, USGS, and State Department of Pesticide Regulation (DPR) to conduct cooperative synoptic and/or in-season sampling for pesticides, herbicides, and insecticides. Some of the sampling stations are within the Restoration Area.

When DO levels are below 5.0 milligrams per liter (mg/L), an oxygen barrier, also known as “oxygen block”, could impede upstream migration of adult Chinook salmon. Levels as low as 1.5 mg/L DO have been recorded in the lower San Joaquin River, and levels as low as 0 mg/L have been recorded in the Stockton Deep Water Ship Channel (FMWG, 2009). DO levels could be monitored in real-time at the same locations as water temperature: two locations in Reach 1, two locations in Reach 2, one location in Reach 3, two locations in Reach 4, and two locations in Reach 5. Additional sampling sites for DO may be added, if needed (FMWG, 2009).

Total ammonia nitrogen would be monitored weekly to every other week in two locations in cooperation with the GBP. Additional sampling sites for ammonia nitrogen may be added, as needed. Other water quality constituents of concern, such as turbidity, have not been extensively documented and need to be included in a water quality monitoring program to evaluate their potential effects on the San Joaquin River fishery.

22.3 Anticipated Outcomes

The SJRRP should coordinate with and expand on current water quality monitoring programs in the Restoration Area, where feasible, to meet SJRRP monitoring objectives (SJRRP, 2008). Such water quality monitoring programs are currently underway by Reclamation, USGS, DFG, DWR, and the Regional Water Quality Control Board (RWQCB) in the Restoration Area (SJRRP, 2008). The proposed monitoring plan would be implemented by Reclamation and resource agency staff.

The FMWG anticipates that monitoring for physical habitat parameters will yield information required for real-time decision making and help evaluate the success of the SJRRP in providing water of suitable quality for holding/spawning and rearing Chinook salmon. The proposed monitoring activities will inform real-time adjustments to SJRRP restoration releases to meet water quality needs for fisheries within some portions of the Restoration Area according to Settlement flow guidelines.

Monitoring is a critical component in the adaptive management process and will be used to assess the performance of the SJRRP (FMWG, 2009). To maximize their effect, monitoring activities should be complemented with public outreach and education. The FMP supports existing public outreach and education programs that incorporate education on best management practices. The FMWG recommends working with existing public outreach and education programs related to water quality, such as those implemented by the CVRWQCB and the Metropolitan Flood Control District.

22.4 Methods

Water quality monitoring methods include real-time and laboratory analyses of grab samples and composite samples (SJRRP, 2008). Continuous measurement of most physical conditions, including temperature, electrical conductivity (salinity), alkalinity, pH, DO, turbidity, and chlorophyll, would be recorded at identified stations using multiple parameter sondes connected to digital dataloggers. However, select constituents, including selenium, cannot be measured with field sensors and would require laboratory analysis, if necessary. A variety of cost-effective methods can be used to accomplish the following:

1. Determine water quality conditions (i.e., electrical conductivity, alkalinity, pH, DO, turbidity and chlorophyll) at holding pools to help provide or maintain a minimum of 30,000 square meters of high-quality spring-run Chinook salmon holding habitat.

2. Monitor selenium levels to ensure that they do not exceed 0.020 mg/L or a 4-day average of 0.005 mg/L in the Restoration Area.

3. Monitor DO levels to ensure that they remain above 5.0 mg/L when Chinook salmon are present.

4. Monitor total ammonia nitrogen to ensure that concentrations do not exceed the 30-day average of 2.43 milligrams (mg) of nitrogen per liter (N/L) when juvenile Chinook salmon are present or exceed a 1-hour average of 5.62 mg N/L when Chinook salmon are present."

To evaluate general water quality conditions in holding pools, a physical description of the habitat will be needed, including the location of holding pools in Reach 1. The task requires coordination with and expansion of current water quality monitoring programs. Field measurements should concentrate on the habitat features that were previously identified in habitat assessments.

Monitoring selenium levels in the lower reaches of the San Joaquin River requires laboratory analysis of grab samples and composite samples to determine selenium content. Selenium monitoring activities would be coordinated with the GBP, Reclamation, and the Regional Board. For instance, Reclamation measures selenium daily in the Delta-Mendota Canal and Mendota Pool to ensure that CVP water meets the 2 parts-per-billion monthly objective for the Grasslands wetlands water supply channels. In addition, the Regional Board collects weekly grab samples from these channels and the river below Fremont Ford to support the GBP.

Monitoring of DO requires real-time data collection and transmission to minimize response time in case of an emergency, such as an oxygen barrier to migration. Locations for oxygen monitoring with real-time sensors will be distributed along the river.

Monitoring total ammonia nitrogen can be conducted close to potential sources such as local wastewater treatment plants, septic leaching, and effluents from animal facilities. Targeted monitoring of such locations will help identify ammonia levels that may be acutely toxic to migrating subyearling smolts or rearing juveniles after exposures of short duration or levels that would significantly increase their susceptibility to disease.

The CVRWQCB currently measures nitrate as nitrogen, ammonia, and total Kjedahl nitrogen on a monthly basis and every 2 weeks during the irrigation season (March through August) at Mud Slough, the San Joaquin River at Fremont Ford, and San Joaquin River at Crows Landing.

22.5 Results

Ongoing water quality monitoring efforts for the SJRRP are being led by Reclamation in consultation with other Implementing Agencies.

22.6 Discussion

Monitoring activities should document the effects of Interim Flows on water quality indicators in the Restoration Area. Water quality monitoring is implicitly required to meet the goals of the Settlement (SJRRP, 2008). Specifically, water quality data are required to verify that Interim Flows are sufficient in condition to meet life-history requirements for holding/spawning and rearing Chinook salmon in the San Joaquin River. Hence, the proposed study responds to a need to measure select constituents in the Restoration Area.

22.7 References

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23.0 Predatory Study

Predation is often a key factor affecting the abundance of juvenile Chinook salmon, and given current conditions in the San Joaquin River, could impact juvenile survival.

23.1 Statement of Need

This study addresses the limiting factor of predation for the Smolt Outmigrants and Smolt Survival life stages of Chinook salmon (FMWG, 2009a); addresses the Phase II action of prioritizing mine pits for Restoration; and provides necessary information on existing conditions to inform the reintroduction of salmon by 2012 by identifying predator traps that may contribute significant mortality to introduced Chinook salmon.

23.2 Background

The San Joaquin River has been impacted historically by in-channel and floodplain sand and gravel mining leaving from both channel mine pits and captured mine pits in the channel. Many off-channel pits have been breached and allow the river to run through. Based on available data about 3.3 river miles have been directly impacted by mining actions (FWUA/NRDC, 2002). Studies on the Tuolumne River have shown instream and captured gravel pits and the lentic habitat they create favor largemouth bass, and predation losses in these habitats may be significant enough to affect populations of salmonids (TID/MID, 1992 as cited in Stillwater, 2003). Largemouth bass are adapted to high water temperatures and are commonly found in captured mine pits in the San Joaquin basin (FMWG, 2009a; DFG, 2007).

23.3 Anticipated Outcomes

Data can be used to inform decisions regarding methods for Chinook salmon reintroduction that would reduce predation impacts. Data can also provide information for prioritizing mine pits for Restoration by indicating where the most benefit can be achieved regarding smolt survival. The study will inform management actions for predator management, including predator removal efforts or flow management to reduce predator habitat value during key salmonid outmigration timing. Data can guide Restoration actions that may include filling mine pits, closing breaches, or reducing residence times of water and fish through these habitats.

23.4 Methods

Potential predator habitats will be the focus of this study based on fishery and aquatic resource assessments that have been conducted by DFG from 2003 through 2005 (2007), and during Interim Flows to date. Stationary acoustic receivers will be placed in arrays above, below, and within predator habitats, including captured mine pits. Predators will be captured in these habitats and have acoustic transmitters surgically implanted. Gastric lavage of captured predators will inform current diet composition, and will continue after the reintroduction to assess changes in diet with the presence of Chinook salmon. Receiver data will be downloaded and summarized to assess predator habitat use, movement patterns, and the relationship to flow and temperature. Additionally, while current temperature monitoring is being conducted by DFG and others (Guzman, 2009), more detailed profile monitoring of potential predator habitats, including mine pits, will be conducted to describe the suitability of the habitats to predators based on variable flow regimes and ambient conditions.

23.5 References

California Department of Fish and Game (CDFG). San Joaquin Valley-Southern Sierra Region. 2007. San Joaquin River Fishery and Aquatic Resources Inventory. Cooperative Agreement 03FC203052.

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24.0 Effect of Altered Flow Regime on Channel Morphology in Reach 1A (UCSB)

24.1 Statement of Need

Channel boundary features are critical to salmonids throughout their freshwater life cycles. The texture of the bed dictates successful incubation and emergence, flow complexity is beneficial to juvenile rearing, deep pools provide temperature refuge, and overhanging banks provide protection from predation. However, the effect of Restoration Flows on the existing channel is not known. Therefore, the early stages of Restoration Flows provide the opportunity to measure changes in pertinent channel boundary features from which trends can be observed and predictions made.

24.2 Background

SJRRP flows will be altered compared to the previous 60 year's hydraulic regime. Aspects of the channel boundary that are significant for salmon habitat quality, and that might change because of alteration of the flow regime, include pool depths, riffle/bar heights, bank erosion, and bed texture.

Channel form features such as pools and bars affect flow complexity that is bioenergetically favorable to both adult and juvenile salmon (Trush et al., 2000). Pools are important for the rearing of juvenile salmon and as resting places for adults returning to spawn. With current understanding of sediment mobility and flow stresses in Reach 1A, it is difficult to predict whether the increased duration of high flows will scour pools more deeply or make them shallower with sediment scoured from riffles immediately upstream.

In addition, the bed surface will undergo changes through scour and later deposition as a result of sediment transport processes. These processes are known to present a risk to incubating embryos more typically found within bar and riffle subsurfaces. When scour occurs to the egg pocket depth, the eggs lose their protection from the effects of bed material transport. Additionally, subsequent deposition alters the texture of the material overlying the remaining egg pocket (Haschenburger, 1999; Lapointe, et al., 2000; May, et al., 2009). Understanding how these features will be transformed by the Restoration flows is necessary for assessing the altered flow regime's impact on adult and juvenile salmon habitat.

24.3 Anticipated Outcomes

- Measure changes to bed texture, bar/riffle height, and pool depth that might occur as a result of the flow regime alteration.
- Model channel changes quantitatively in a way that will be useful for prediction of future behavior in Reach 1A.
- Evaluate the impact of changes on the habitat quality as best it can be assessed before salmon return to the reach.

24.4 Methods

If significant mobility of particles occurs on the riffles – as observed via the tracer studies – in the planned high-flow releases, survey cross sections will be topographically surveyed across riffles and pools after each high flow season or each extraordinary event. Comparisons of each cross section over time will determine the response to flow events. If the changes are large enough to be biologically significant, the response will be modeled through sediment transport calculations. Such mobile-bed modeling will require that higher-resolution bathymetry be obtained of one or more sample reaches and the calibration of the two-dimensional flow and sediment transport model, as was done in the Merced River, for which how flow and sediment supply affect the production of juvenile habitat quality was explained. In the Merced River case, collaboration with biologists occurred to model the bioenergetic quality of rearing habitat based on the definition of the two-dimensional flow fields. On the basis of a high-resolution bathymetric survey of one or more San Joaquin pools, the same technique can be applied to evaluating pool habitat and the potential for changes in it.

Sets of anchored scour chains will be installed at riffles to measure the occurrence and depth of scour and subsequent deposition during events for which we will be able to compute local shear stress from the calibrated and validated flow model. The location and depth of scour and deposition will not only be an indication of the process of how the bed responds to the limited number of high flows monitored, but will present an opportunity to test the ability to model such changes with a mobile bed simulation based on bed load transport modeling. Therefore, these results will provide information for validating and calibrating prediction models that can then be extended throughout the reach.

Enhanced bank erosion seems unlikely in Reach 1A because of the reinforcement of banks by dense riparian trees and shrubs. However, if banks become undermined below the rooting depth, changes will be monitored and the spatial extent of the changes in habitat quality (refugia) and in and the local sediment production will be evaluated, which would provide a small augmentation of the spawning gravel supply.

24.5 Results

Using data collected at Riffle Cluster 30 from topographic surveys performed in September 2009 and January 2010, methods and preliminary results of measured changes in the topographic profile are presented for three cross sections at this site. **(**See Attachment A1- Bed Mobility Data Report for this information.) Additional results will be expected after further implementation of this study and after a length of time equal to one flow-elevated flow season. The anticipated begin date for full implementation is mid- to late October 2010.

24.6 Discussion

Interpretation, applicability, and limitations of results are anticipated to be presented after Fall 2010.

24.7 Conclusions and Recommendations

Conclusions and recommendations are expected after data analysis and comparison of two or more elevated flow cycles with significantly differing flow conditions. The anticipated schedule for these findings is after spring 2011 high flows.

24.8 References

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25.0 Temperature Monitoring for Adult Migration

Water temperature is one of the environmental factors that can significantly affect adult migration. Because of this, monitoring water temperature when adults are typically moving upstream is critical in evaluating the success of the SJRRP.

25.1 Statement of Need

This study addresses the limiting factor of unsuitable water temperatures that may occur during migration for the adult life stage of Chinook salmon. Currently in the study area, thermal conditions in migration pathways and potential factors that influence temperature are not well understood. Temperature needs to be evaluated to identify potential thermal barriers and identify potential warm-water sources such as backwater areas, side channels, gravel pits associated with mining, wide/shallow areas, areas lacking riparian shading, tributaries, and Friant Dam operations.

25.2 Background

Water temperature exerts a substantial influence on the abundance, development, growth and survival of fishes, including Chinook salmon (EPA, 1999; Myreck and Cech, 2004). Temperature is critical to the timing of life-history events, especially reproduction (Fry, 1971). High temperatures result in physiological stress and increased metabolic demand on fishes, which may result in slower growth, susceptibility to disease, and lower survival rates. Understanding the longitudinal distribution of temperatures in relation to Restoration Flows on the San Joaquin River is critical to the ability to successfully prepare the system for reintroduction of Chinook salmon (i.e., evaluate site-specific alternatives, make recommendations on water allocations, make recommendations for stock selection).

25.3 Anticipated Outcomes

Analysis of river water temperature monitoring will be used to evaluate the relative importance of the various factors that combine to produce the observed stream temperatures, and to evaluate impact that changes in stream shade, channel morphology, flow may have on the stream temperature regime. Data can be used to inform decisions regarding methods for salmonid reintroduction that could reduce thermal impacts. Temperature monitoring evaluation will provide key information for the SJRRP in developing total maximum daily load (TMDL) standards and making recommendations on specific actions relating to adaptive management of the SJRRP. Data collection and monitoring activities are intended to support studies and data needs consistent with FMP and SJRRP recommendations. Long-term monitoring is expected to focus on enabling informed decision-making for recommendations to improve and/or offset adverse impacts, because they may be determined by Interim Flow period monitoring and subsequent measurements of SJRRP success.

25.4 Methods

Temperature data loggers (HOBO®, Onset Corporation, Bourne) will be placed at various locations beneath the water's surface, in a longitudinal array throughout the Restoration Area. Locations are dependent on an appropriate anchor point, the ability to conceal the loggers to reduce vandalism, and legal access. Loggers will record temperature hourly. Monitoring sites will be expanded to augment existing monitoring, as needed. Data loggers will be placed at predetermined intervals to best illustrate the temperature regime of the San Joaquin River. Loggers will be arrayed so that potential migration pathways may be evaluated. Loggers will be placed in areas that may provide an evaluation of potential warm-water sources, such as backwater areas, side channels, gravel pits associated with mining, wide/shallow areas, tributaries, and Friant Dam operations and areas lacking riparian shading.

25.5 References

California Department of Fish and Game (DFG). San Joaquin Valley-Southern Sierra Region. 2007. San Joaquin River Fishery and Aquatic Resources Inventory. Cooperative Agreement 03FC203052.

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26.0 Migration Cues

Streamflow affects how and when adult Chinook salmon begin their upstream migration. Flows that are too low will not provide the necessary cues to trigger upstream movement. Therefore, monitoring flows just before and during the typical adult migration period is proposed.

26.1 Statement of Need

This study addresses the limiting factor of inadequate water flows that prevent adult migration. One of the principle mechanisms that can determine migration routes for Chinook salmon are the volumes of water and constituents from natal source waters that salmon experience. The extent to which olfactory homing is disrupted during upstream migration can increase losses of reintroduced adults back to the Restoration Area, thereby compromising population goals for the program (*NRDC, et al., v. Kirk Rodgers, et al., 2006*).

26.2 Background

Adult Chinook salmon require adequate flows for upstream migration. The Settlement flow schedule aims to create "attraction flows" for spring-run adults (*NRDC, et al., v. Kirk Rodgers, et al., 2006*). These spring-time flows assist in providing migratory cues for fish to return to the Restoration Area to spawn. In addition, these flows help eliminate low-flow barriers, reduce water temperatures, and improve water quality. Chinook salmon have been found to respond to pulses in water flow to initiate upstream migration. Water operations can change the contribution of Sacramento River and San Joaquin River water at the confluence, which has been hypothesized to alter migratory route selection and cause fish to spawn in non-natal basins (NMFS Biological Opinion, 2009). In fact, during some months, more Sacramento River water is present in portions of the San Joaquin River than San Joaquin-origin water (DWR, 2010). Monitoring flows from the San Joaquin River at Friant Dam and from San Joaquin tributaries is necessary to assess the volume of water from each source. This will aid in determining the adequacy of Settlement flows in providing necessary cues for migrating adult salmon from the most downstream portion on the San Joaquin River to the Restoration Area.

26.3 Anticipated Outcomes

Results from this study will provide a quantitative assessment of the volume of water from Friant Dam, the Stanislaus River, Mokelumne River, Tuolumne River, and Merced River at different points on the San Joaquin River along the adult salmon migratory path during the migration period. Settlement flows can thereby be assessed for adequacy in promoting adult migratory cues.

26.4 Methods

DSM2 is a one-dimensional hydrodynamic and water quality simulation model used to simulate hydrodynamics, water quality, and particle tracking in the Delta (DWR, 2010). The QUAL module (Source Water Fingerprinting) identifies the proportion of water coming from different sources (Sacramento River, San Joaquin River, agricultural drainage, bays) for a set of locations in the Delta and along the San Joaquin River. The confluence of the Sacramento River and the San Joaquin is a significant point in route selection for Central Valley Chinook salmon adults. The confluence of the Sacramento and San Joaquin rivers will be used as the primary location to determine changes in the proportion of water coming from the Sacramento and San Joaquin rivers. Attraction flows in the lower San Joaquin River (e.g., Mossdale) can be used to assess the adequacy of Settlement flows for adult spring Chinook salmon migration. As salmon migrate upstream, the proportion of Mokelumne River, Stanislaus River, Tuolumne River, Merced River, and upper San Joaquin River water (from Friant Dam) will be assessed.

26.5 References

California Department of Water Resources (DWR) 2010. Modeled Volumetric and Constituent Fingerprinting. Available at http://www.water.ca.gov/waterquality/drinkingwater/modeled_data.cfm

National Marine Fisheries Service (NMFS) 2009. Biological opinion on the long-term operations of the Central Valley Project and State Water Project.

NRDC v. Rodgers. 2006. Stipulation of Settlement. 80 pp.

27.0 Adult Passage Study

Currently, the lower reaches of the study area cannot support adult fish passage. Many areas are too shallow or have impeding structures. FMWG proposed a fish passage study to help identify critical areas that will ultimately affect successful reintroduction.

27.1 Statement of Need

The SJRRP needs to determine if and to what extent adults, juveniles, smolts and yearling Chinook salmon fail to access suitable habitat because of physical or physiological barriers. To meet this need, the SJRRP will have to collect basic passage information that can help eliminate fish passage barriers and minimize migration delays and stranding of adult and juvenile Chinook salmon in the Restoration Area. Collection of passage information during the Interim Flows period will inform future passage needs.

Restoration measures are expected to take place, enabling passage in the Restoration Area; however, the SJRRP needs to conduct a preliminary inventory and qualitative assessment of the passage conditions in the Restoration Area.

27.2 Background

Barriers to migration for anadromous fish in the Restoration Area encompass a wide range of both adult and juvenile passage impediments. The term fish passage is commonly used to describe issues related to migrating adults. In this study, a fish passage barrier will include any natural channel restrictions and human-made crossings and structures over or through the San Joaquin River or bypasses designed to pass stream flow that will create a total, partial, or temporary barrier.

Passage for anadromous fishes in the San Joaquin River has been completely blocked in the Restoration Area since the 1950s, when the river was dewatered below Sack Dam except during uncontrolled flow releases in wet years. The 2002 San Joaquin River Restoration Study Background Report (McBain & Trush, 2002) identifies numerous potential barriers to fish migration in the Restoration Area. The Settlement prescribes that passage will be restored at a number of structures that may impede the passage of adult Chinook salmon through the Restoration Area, and requires that a number of currently unscreened diversions be screened; however, a preliminary assessment of additional passage impediments is needed. Passage may be impeded for migrating adults and juveniles if design, operation, and maintenance at some facilities and locations do not afford passage under a range of flows (FMWG, 2009a). In addition, passage can be impaired by lack of water, poor water quality, poor habitat, natural occurrences, waterfalls, boulder cascades, and other structures. Impacts of fish barriers may include impaired passage and injury to fish, resulting in reduced numbers of fish reaching suitable spawning areas and low survival for juvenile life stages.

The FMP identifies a number of potential actions to provide passage including modifications to the Sand Slough Control Structure and the Reach 4B headgate (Paragraph 11 projects), retrofit of Sack Dam (Paragraph 11 project), construction of the Mendota Pool Bypass (Paragraph 11 project), ensuring sufficient fish passage measures at all other structures and potential barriers, and the implementation of trap and haul if passage conditions are not suitable (FMWG, 2009).

Examples of potential fish passage barriers include crossings that are typically paved roads, unpaved roads, railroads, trails, and paths that can include culverts, bridges, and low-water crossings such as paved and unpaved fords; structures designed to store or pass flows that are typically dams, weirs, control structures, diversions, and canal or pipeline crossings; and natural channel barriers that typically include landslides, waterfalls and boulder cascades. Many of these types of human-made and natural barriers create temporary, partial, or complete barriers for fish passage during spawning migrations and juvenile salmonids during seasonal movements.

Several studies have documented existing known potential fish passage impediments on the San Joaquin River system. Studies include a Technical Memorandum (TM) on Potential Barriers to Migrating Steelhead and Chinook Salmon on the San Joaquin River by Jones & Stokes (2001), San Joaquin River Restoration Study Background Report by McBain & Trush (2002), and Bulletin 250 Fish Passage Improvement by DWR (2005) that have evaluated and listed passage problems within the Restoration Area.

In 2001, Jones & Stokes identified and measured potential barriers for movement of adult and juvenile steelhead and Chinook salmon based on criteria developed for all life stages of these organisms. They considered vertical, velocity, and depth criteria for identifying barriers on the San Joaquin River between Friant Dam and the Merced River, including the Eastside and Mariposa Bypasses. In addition, they developed passage solutions including modification of barriers or development of passage facilities such as fish ladders.

In 2002, McBain & Trush identified physical barriers for migrating fish as part of the San Joaquin River Restoration Study Background Report prepared for FWUA and NRDC. Fish resources were summarized as part of the study and physical barriers were identified when considering the habitat connectivity of the San Joaquin River. Only significant structures in the study area that are impediments to both upstream and downstream fish movement were illustrated in the study.

In 2005, DWR published Bulletin 250 that identified man-made structures in the Central Valley and Bay Area rivers and streams, particularly in the watersheds of the Sacramento and San Joaquin rivers. Bulletin 250 published an inventory of potential barriers based on data compiled from 395 sources. The list of barriers for Fresno, Merced, and Madera include several on the San Joaquin River. Bulletin 250 provided the report findings to the Fish Passage Decision Support System, USFWS. The Fish Passage Decision Support System, http://fpdss.fws.gov/, is an online application funded by the USFWS that makes information about barriers to fish passage in the U.S. available to policy makers and the public.

A total of 61 structures identified in the previous studies will be screened for inclusion in the SJRRP passage analysis.

27.3 Anticipated Outcomes

These data will help validate draft conceptual models of stressors and limiting factors for Chinook salmon (FMWG, 2009a), and build the ecosystem diagnosis and treatment model framework. In addition, these data will be critical to the decision-making loop of adaptive management as described in the FMP (FMWG, 2009b).

27.4 Methods

The passage study approach includes identification of potential structural and nonstructural barriers or impediments that may impede juvenile and adult fish passage in the Restoration Area. In addition, passage impairment should be qualitatively evaluated using common passage criteria (i.e., depth, velocity, discharge) under a variety of flow conditions. Identification and evaluation should be followed by the development of a prioritized list of structural and nonstructural barrier modifications.

Information from previous studies will be used to develop a complete list of structures that will be screened to determine those structures that are a barrier to fish passage in the river and flood bypasses. DWR created a geodatabase to input information on identified structures. The database will be used to incorporate the features of each structure against fish passage criteria to perform the initial screening of the structures.

This study will evaluate potential fish passage barriers on the main stem of the San Joaquin River and bypass system and will include an inventory of the types and location of structures on the system. Structural and nonstructural barriers to passage will be identified by name and location, along with a physical description. All passage obstacles should be evaluated at as many flows as possible, enabling a qualitative assessment of passage under a full range of flow for native species.

First Pass surveys will be performed by DWR on several of 68 structures identified as stream crossings in the San Joaquin River and flood bypasses. Some structures will not be surveyed if they cannot be accessed because of lack of entry permits or because of locked gates. Once the surveys are completed for each structure, the data will be included in an ArcGIS geodatabase and run through a set of filters based on passage criteria. This initial evaluation only focuses on individual factors that would affect fish passage.

27.5 References

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