6.0 Water Surface Profile

6.1 Introduction/Background

The data in this report were collected as part of the Channel Capacity Management Study, Water-Surface Elevations.

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

6.2 Methods

Water surface profiles were obtained using a survey-grade GPS (3D quality of 0.1 foot) to record the WSEs along the river. The horizontal datum used was the California Coordinate System Zone 3, U.S. Survey Feet, based on the NAD 83, Epoch 2007.0. The vertical datum used was the NAVD 88. Orthometric heights were derived from RTK observations and application of GEOID03 to the RTK values. RTK observations were received from either the Fresno State or Tranquility base stations via a cell phone modem attached to the GPS receiver. Existing control points were used to validate the accuracy of the data. Near the California Department of Fish and Game (DFG) hatchery in Friant, thick vegetation prohibited the use of the GPS equipment. Control was set in an open area using GPS, and a Total Station was used to record the water level.

Table A-6-1 shows when each reach was surveyed. The releases out of Friant during the surveys can be found in the Discharge Measurements report.

Table A-6-1.
Dates of Surveyed Reaches

Date	Reach	Start	End	Data Points
5-Jan	1A	Road 206	Highway 41	111
6-Jan	1A	Highway 41	Highway 99	107
7-Jan	1B	Highway 99	Gravelly Ford	100
8-Jan	2A	Gravelly Ford	CBCS	68
9-Jan	C[1]	CBCS	Avenue 14	48
10-Jan	3	Mendota Dam	Firebaugh Park	31
11-Jan	3	Firebaugh Park	Sack Dam	53
29-Mar	1A	Road 206	Highway 41	124
30-Mar	1A	Highway 41	Highway 99	97
31-Mar	1B	Highway 99	Gravelly Ford	97
1-Apr	2A	Gravelly Ford	CBCS	55
4-Apr	3	Mendota Dam	Firebaugh Park	41
5-Apr	3	Firebaugh Park	Sack Dam	52
6-Apr	C[1, 3] & E[2]	Avenue 14	Road 4	66
7-Apr	E[2]	Road 4	Washington Road	39
12-Apr	4A	Sack Dam	Washington Road	61
2-May	1A	Road 206	D7	45
3-May	1A	D7	Highway 41	56
4-May	1A	Highway 41	Highway 99	87
5-May	1B	Highway 99	Gravelly Ford	105
6-May	2A	Gravelly Ford	CBCS	65
6-Jun	1A	Road 206	D7	56
7-Jun	1A	D7	Highway 41	47
8-Jun	1A	Highway 41	Highway 99	87
9-Jun	1B	Highway 99	Gravelly Ford	99
10-Jun	2A	Gravelly Ford	CBCS	70
11-Oct	1B	Highway 99	Gravelly Ford	98

Notes:
[1] Chowchilla Bypass
[2] Eastside Bypass
[3] Chowchilla Bypass ends about 2.4 miles downstream from Avenue 14.

Key:
Apr = April
CBCS = Chowchilla Canal Bypass Control Structure
Jan = January
Jun = June
Mar = March
Oct = October

WSEs were obtained along Reaches 1A through 4A and along the Chowchilla and Eastside bypasses from the Chowchilla Bifurcation Structure to Washington Road. Survey locations were placed at the top and bottom of hydraulic controls, at the top and bottom end of long pools, and about 500 feet upstream, at and 500 feet downstream from discharge measurement cross sections. An attempt was made to limit the drop between points to no more than half a foot.

6.3 Results

Water surface profile data tables containing all of the survey point locations and elevations are available in electronic format and can be acquired by contacting the SJRRP. Please refer to Table A-6-1 for the number of data points collected for each reach.

6.4 Discussion

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 1-D HEC-RAS model indicates the majority of significant hydraulic controls were sufficiently characterized by the survey data, and 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.

The preliminary review of the data also indicates that, in general, no significant anomalies exist. However, an occasional subtle rise in WSE in the downstream direction does exist, but the average magnitude of these instances is only approximately 0.1 foot 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.

6.5 Conclusions and Recommendations

Comparisons between predicted WSEs in the one-dimensional (1D) model and measured WSEs have improved the model’s performance, and will provide more certainty in predicted inundation levels, channel capacities, and other channel responses to the restoration releases.

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7.0 Discharge Measurements

7.1 Introduction/Background

The data in this report were collected as part of the Channel Capacity Management Study, Surface Water Profile Surveys, and Discharge Measurements Study (SJRRP, 2011a), which is based on the measurement plan from Mussetter Engineering (2008). Discharge data are collected to evaluate discharge at specific split flow locations and at a 5-mile maximum increments along the river to correlate with the continuous record of WSEs. The discharge measurements are being used to calibrate and validate hydraulic models that are used to assess channel capacity, channel stability, fishery habitat, and other aspects of restoration planning and design.

7.2 Methods

An Acoustic Doppler Current Profiler (ADCP) was towed behind an inflatable kayak or in front of a raft, to measure velocities and flow area along a path between banks to determine the discharge at a site. The sites were located at existing sites from D4 (Discharge 4) in Reach 1A-1 through D32 in Reach 3. Maps locating these sites can be found in the 2011 Annual Technical Report. Sites were added for Chowchilla Bypass and Eastside Bypass channels. Specific dates for 2011 measurements by reach are indicated in Table A-7-1 along with the scheduled release discharge for Friant reported on California Data Exchange Center (CDEC) for station Millerton Lake (MIL).

Table A-7-1.
Discharge Measurement Date by Reach and Friant Scheduled Release in Cubic Feet per Second, Reported from CDEC

Reach	Date	Scheduled Release (cfs)
1A-1	1/5/11	6,000
1A-2	1/6/11	6,000
1B	1/7/11	6,000/5,500/5,000/4,500
2A	1/8/11	4,500
3-1	1/10/11	4,500
3-2	1/11/11	4,500/4,000/3,500/3,000
Chowchilla Bypass	1/9/11	4500
1A-1	3/28/11	6,000/6,500/7,000
1A-1	3/29/11	7,000
1A-2	3/29/11	7,000
1A-2	3/30/11	7,000
1B	3/31/11	7,000/7,500
2A	4/1/11	7,500
3-1	4/4/11	7,500/7,250
3-2	4/5/11	7,250
Chowchilla Bypass	4/6/11	7,250
Eastside Bypass	4/7/11	7,250
1A-1	5/2/11	4,500
1A-1	5/3/11	4,500
1A-2	5/4/11	4,500
1B	5/5/11	4,500/4,300
2A	5/6/11	4,300/4,100
1A-1	6/6/11	2,500/2,400
1A-1	6/7/11	2,400
1A-2	6/8/11	2,400/2,900
1B	6/9/11	2,900
2A	6/10/11	2,900
1B	10/18/11	700

Key:
CDEC = California Data Exchange Center
cfs = cubic foot per second

7.3 Results

Four measurement sets performed during spring 2011 and one set from fall 2011 are the subjects of this report. The sequence and quantity of sites measured was modified from previous runs due to the flows encountered during measurements. Summaries of the January, March, and May results are in the 2011 Draft ATR (SJRRP, 2011) and the June and October results in Data Appendix G are presented in Tables A-7-2 and A-7-3.

Table A-7-2.
Flow Measurement Data During June 2011, 2,500 cfs Friant Scheduled Release

Reach	Site	Location (RM)	Date/Time				Flow Measured (cfs)
Reach 1A	Discharge 4	263.6	6/6/11	12:00	-	12:21	2,670
	Discharge 6	261.5	6/6/11	13:46	-	14:09	2,610
	Discharge 7	260.8	6/6/11	15:03	-	15:17	2,540
	Discharge 8	260.5	6/7/11	8:58	-	9:52	2,560
	Discharge 8s		6/7/11	8:26	-	8:48	576
	Discharge 11	255.1	6/7/11	11:14	-	11:44	2,450
	Discharge 12	251.2	6/8/11	8:53	-	9:14	2,370
	Discharge12s		6/8/11	10:36	-	10:56	1,430
	Discharge 16	248.3	6/8/11	12:34	-	12:53	2,590
	Discharge 17	245.2	6/8/11	14:14	-	14:50	2,530
Reach 1B	Discharge 18	237.7	6/9/11	10:05	-	10:42	2,430
	Discharge 19	232.5	6/9/11	12:28	-	13:19	2,640
Reach 2A	Discharge 22	222	6/10/11	10:32	-	10:51	2,590
	Discharge 23	218.3	6/10/11	11:33	-	12:20	2,510

Key:
cfs = cubic foot per second
RM = River Mile

Table A-7-3.
Flow Measurement Data During October 2011, 700 cfs Friant Scheduled Release

Reach	Site	Location (RM)	Date/Time				Flow Measured (cfs)
Reach 1B	Discharge 18	237.7	10/18/11	11:27	-	11:40	571
	Discharge 19	232.5	10/18/11	13:59	-	14:11	562

Key:
cfs = cubic foot per second
RM = River Mile

7.4 Discussion

January discharge measurements at the scheduled release of 6,000 cfs were performed due to the uncertainty of a larger flow occurring within this report's duration. If the desired 8,000 cfs release could not be obtained, the 6,000 cfs release would make an acceptable calibration point. The 6,000 cfs point generally overtopped the low-flow banks, inundated the floodplains, but did not wet the bottom of the flood levees. At this flow, connectivity with many of the high-flow side channels and gravel pits was established. Some measurements of the 6,000 cfs Friant scheduled release are missing data from the lower portion of active flow in the transect. The measurement software automatically made assumptions for the velocities in the missing area in determining a discharge at the site. Cursory examination of the discharge measurements based on the transects' missing data appear consistent with other discharge measurements.

In March, a scheduled release was seen at 7,500 cfs, providing a much better fit for the 8,000 cfs calibration flow. At 7,500 cfs, the floodplain was fully inundated for most of the reaches and the bottom of the flood levees were wetted.

In May, scheduled releases from Friant included a 4,500 cfs bench to fill in the targeted 4,000 cfs desired flow for calibration. The 4,500 cfs flows overtopped the low-flow banks and wetted most of the floodplain. The 4,500 cfs flows also continued to wet most of the high-flow side channels and pits that were inundated at higher flows.

Scheduled releases in June provided the opportunity to measure a 2,500 cfs bench filling the data needs for the 2,500 cfs target. Fewer resources were allocated for this measurement set, resulting in a longer duration to measure all sites. A longer duration also allowed the sites to be measured in a more sequential order. At 2,500 cfs, islands were becoming more prevalent and split flows were distinguishable. Many of the floodplains had standing water without noticeable active flow.

October scheduled releases contained a 700 cfs bench, allowing measurements to be collected for the 700 cfs target in Reach 1B. Reaches 1A and 2 were collected in 2009 and 2010.

7.5 Conclusions and Recommendations

- Additional location data analysis needs to be performed to indicate the specific locations at which the measurements were taken and how some of the measurements relate to surrounding split-flow conditions. The split-flow conditions may best be analyzed in the models.

- Analyses of reaches and discharge collections need to be performed to determine which reaches require additional measurements and the flow events that measurements are required at.

- The applicability of measurements that have transects that contain missing bottom velocities needs to be determined through further analysis of the measurements and consideration of how they are applied in the models.

7.6 References

Mussetter Engineering, Incorporated, (2008). DRAFT San Joaquin River Data Collection and Monitoring Plan, prepared for California Department of Water Resources, August 27, 2008.

SJRRP. *See* San Joaquin River Restoration Program.

San Joaquin River Restoration Program (SJRRP). 2011a. 2011 Agency Plan. Section 10: Channel Capacity Management Study, Surface Water Profile Surveys, and Discharge Measurements Study. Available at <www.restoresjr.net>.

———. 2011b. 2011 Draft Annual Technical Report. Available at <www.restoresjr.net>.

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8.0 Topographic Surveys

8.1 Introduction/Background

Data collections discussed in this report are performed as a part of the Channel Capacity Management Study, Monitoring Cross Sections Resurveys (2011 Agency Plan, Section 11 (SJRRP, 2011)), which expands on the monitoring plan from Mussetter Engineering (2008) by establishing topographic patches to better describe the channel and increase the contrast between surveys. Topographic surveys make a record of the existing channel bed, bank, and feature elevations after potential bed-forming flows have occurred.

8.2 Methods

8.2.1 Topographic Surveys

Topographic surveys used a combination of equipment, including a Total Station and GPS base with two rovers to complete three-dimensional (3D) surveys of existing elevations of the channel. The survey method used multiple transects perpendicular to the channel, extending between the left and right levees. Transects were spaced longitudinally along the channel at approximately 15-foot increments to encompass an area covering approximately 60 feet of channel length. This was performed twice in 2011. The first survey in 2011 was performed in February after the Friant scheduled release of 6,000 cfs and before the Friant scheduled release of 7,500 cfs. The second survey occurred in August after releases diminished from 7,500 cfs to 350 cfs.

8.3 Results

The February and August surveys were conducted at each of the previously surveyed sites, as indicated in Table A-8-1. Processing and analysis of data is currently incomplete. Initial results from the February survey are in electronic format and are available by contacting the SJRRP. August survey results are planned to be reported on in the 2012 Annual Technical Report document.

**Table A-8-1.
Survey Site Statistics**

Site	River Mile	Point Count, February 2010	Point Count, August 2010
m1	234.7	231	342
m2	229.4	329	496
m3	228.3	299	400
m4	227.1	415	736
m5	226.1	454	770
m6	225.1	478	463
m6.5	223.8	278	442
m7	222.7	547	939
m8	221.8	237	556
m9	221.0	275	483
m10	220.0	332	397
m11	219.3	225	459
m12	218.5	277	490
m13	217.9	315	593
m14	212.1	410	749

8.4 Discussion

Survey results represent the topography of the ground at each site. The previous survey's bounds were used to refine the area required to collect the measurements. Measurements were generally taken at about a 15-foot interval and at significant grade breaks in between the 15-foot spacing to capture variations from and match similar point densities with the previous survey. The results of all surveys to date and the discharge history between surveys are expected to refine the estimated trigger conditions that determine the need for return surveys, and are planned to be addressed in the 2012 Annual Technical Report.

8.5 Conclusions and Recommendations

- Current survey data collected for this report require additional analysis for presentation and should be incorporated into the 2012 Annual Technical Report.
- The best approach to indicate channel changes needs to be determined. Comparisons between surveys can reduce to mean elevation, volume, or mass changes per unit area.
- Analyze contrasting all surveys for this report with a component relating the discharge volume and intensity required to cause significant alteration of the channel. This analysis should be used to aid in determining the trigger levels to resurvey for this report.

8.6 References

Mussetter Engineering, Incorporated, (2008). DRAFT San Joaquin River Data Collection and Monitoring Plan, prepared for California Department of Water Resources, August 27, 2008.

SJRRP. *See* San Joaquin River Restoration Program.

San Joaquin River Restoration Program (SJRRP). 2011. 2011 SJRRP Agency Plan. Available at: <http://restoresjr.net/flows/atr.html>.

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9.0 Bed Sampling

9.1 Introduction

Data discussed in this report were collected as a part of the Channel Capacity Management Study, Monitoring Cross Sections Resurveys (2011 Agency Plan Section 11 (SJRRP, 2011)), which expands on the monitoring plan from Mussetter Engineering (2008). This monitoring task includes collecting and analyzing river bed samples in the sand-bed reach of the San Joaquin River to improve understanding of the sediment transport behavior of the river.

9.2 Methods

9.2.1 Sampling Locations

The riverbed sampling sites were located between River Mile (RM) 212 and RM 235. The sampling locations were selected within the selected topographic monitoring sections (see Report: Topographic Surveys) designated as M1, M2, M3, M4, M5, M6, M6½, M7, M8, M9, M10, M11, M12, M13, and M14. The sampling locations are displayed in Figure A-9-1. Samples that had significant sediment size variation within one section were designated M#-# (for example; M5-2).

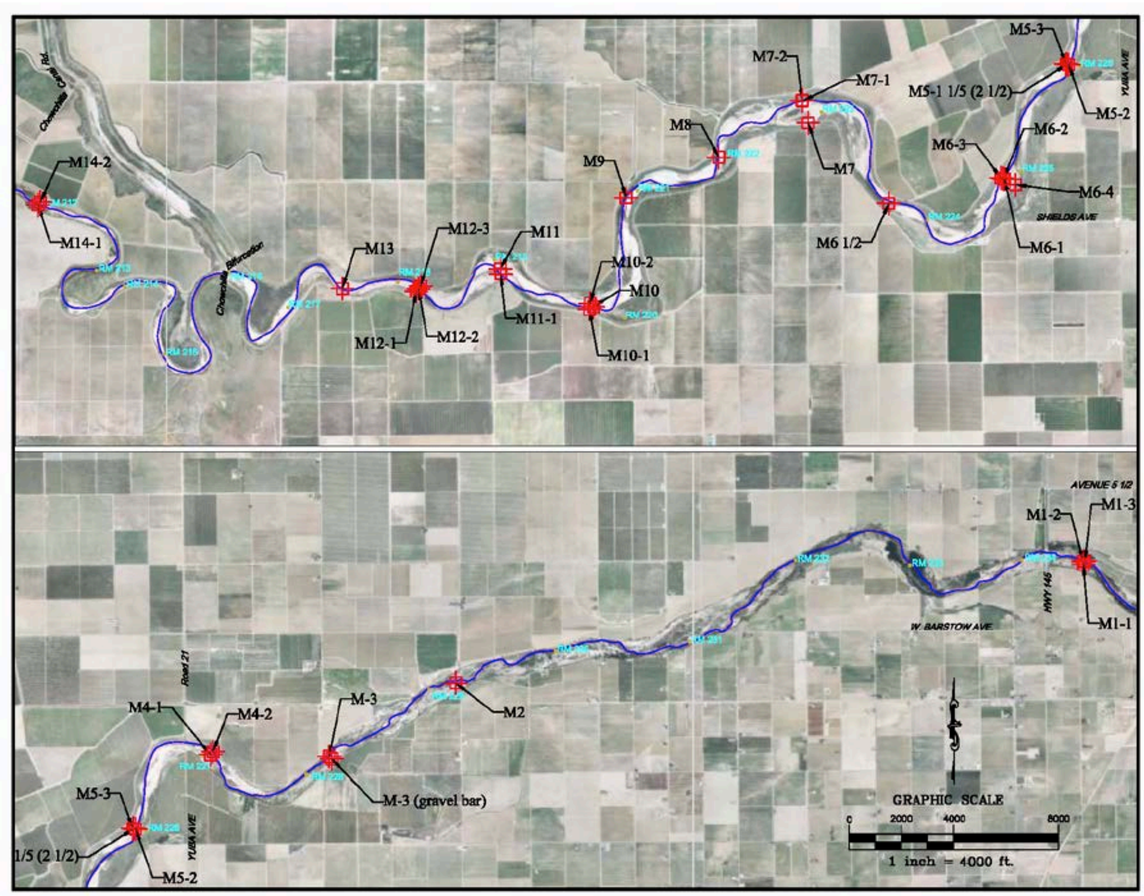

Figure A-9-1.
Sampling Location Map

9.2.2 Sample Collection

The bed samples were collected at a minimum of one location at each site during monitoring cross section surveys performed after each significant flow release from Friant Dam. During each sample collection set, the sampling locations were kept as close as possible to the initial locations using a Total Station.

The coordinates of the new sampling locations were recorded using a Total Station just before sampling. The bed samples were collected using a shovel and placed in either 1-gallon Ziploc bags for sandy material or a 5-gallon plastic bucket for coarser material. Only the top 6 inches of the surface were taken from each sample location. When the sizes were more variable, the sample locations were chosen to represent the variation. Multiple samples (four maximum) were obtained from each section.

9.2.3 Sample Analysis and Calculation – D_{84} and D_{50}

Analyses and necessary calculations were performed as described in the 2009 and 2010 ATRs (SJRRP, 2010 and 2011) for 84 mm and 50 mm size diameter samples (D_{84} and D_{50}, respectively).

9.3 Results

Channel bed samples from Reaches 1B, 2A, and 2B were collected three times in 2009 and 2010 at the topographic survey sites during the surveys to evaluate the changes in the substrate characteristics after each seasonal interim flow release from Friant Dam. Those samples were analyzed and the data were presented in the 2009 and 2010 ATRs (SJRRP, 2010 and 2011).

Bed samples were collected again during a topographic survey performed in February 2011 after the scheduled flood-flow release of 6,000 cfs from Friant Dam during the first week of January and before 7,500 cfs during the first week of April 2011. Another sample collection set was performed during the survey performed in August 2011 after the scheduled release was reduced from 7,500 cfs to 350 cfs. These bed samples were then analyzed in the California Department of Water Resources (DWR) laboratory and the data are presented in this report.

The D_{84} and D_{50} values of these samples were computed and compared with the data from previous sampling performed in fall 2010. The summary of the comparison is displayed in Table A-9-1.

Table A-9-1.
Sample Analyses Results

Reach	RM	Cross Section	After Spring 2010 Flow (October 2010)		After Winter 2010 High Flow (February 2011)		After Spring 2011 Floodflow (August 2011)	
			D_{84}, mm	D_{50}, mm	D_{84}, mm	D_{50}, mm	D_{84}, mm	D_{50}, mm
Reach 1B	234.4	M1-1	1.2	0.7	n/a	n/a	1.0	0.5
		M1-2	4.0	1.0	2.3	0.8	1.8	0.7
		M1-3	41.6	22.1	42.1*	18.8*	41.6*	24.5*
	229.2	M2	20.8	2.0	17.1	1.8	20.5	13.1
Reach 2A	228.1	M3 (gravel bar)	n/a	n/a	37.4	6.9	28.2	14.2
		M3	40.5	24.2	28.1	14.7	41.2	27.0
	227.0	M4-1	25.3	4.8	15.4	9.1	30.7	15.2
		M4-2	19.3	5.9	24.0	2.2	n/a	n/a
	226.0	M5-1.5	2.2	1.1	13.4	1.6	4.5	1.1
		M5-2	2.1	0.8	3.5	1.0	n/a	n/a
		M5-3	3.6	1.2	1.8	1.0	1.1	0.7
	224.9	M6-1	14.2	1.1	13.9	1.2	9.8	1.4
		M6-2	2.0	1.0	13.0	1.7	5.3	1.3
		M6-3	1.2	0.9	1.1	0.6	2.0	1.0
		M6-4	10.9	1.0	16.0	8.4	n/a	n/a
	223.8	M6½	13.7	1.2	1.4	0.8	1.1	0.7
	222.9	M7	1.1	0.7	0.9	0.5	1.2	0.8
		M7-1	1.9	0.9	2.5	1.1	n/a	n/a
		M7-2	1.5	0.8	2.1	1.0	n/a	n/a
	222.0	M8	1.8	0.9	1.0	0.5	1.2	0.7
	220.9	M9	1.9	0.9	2.0	0.9	n/a	n/a
	219.9	M10	1.7	1.0	1.0	0.6	n/a	n/a
		M10-1	1.7	1.0	1.2	0.9	1.8	1.0
		M10-2	2.6	0.9	1.2	0.8	1.1	0.7
	219.0	M11	1.0	0.5	0.7	0.4	1.7	0.7
		M11-1	1.3	0.8	1.1	0.6	n/a	n/a
	218.2	M12-1	2.9	1.3	0.6	0.4	n/a	n/a
		M12-2	1.6	0.7	2.9	0.8	1.6	0.9
		M12-3	1.1	0.6	1.9	1.0	1.1	0.7
	217.5	M13	1.5	0.8	1.4	0.7	n/a	n/a

Table A-9-1.
Sample Analyses Results (contd.)

Reach	RM	Cross Section	After Spring 2010 Flow (October 2010)		After Winter 2010 High Flow (February 2011)		After Spring 2011 Floodflow (August 2011)	
			D84, mm	D50, mm	D84, mm	D50, mm	D84, mm	D50, mm
Reach 2B	212.0	M14-1	1.7	0.6	3.2	0.9	2.3	0.7
		M14-2	2.1	0.7	1.1	0.6	1.3	0.7

Note:
* – Sampled at approximately 15 feet upstream from the original location.
Key:
D = diameter
mm = millimeter
RM = River Mile

9.4 Discussion

9.4.1 Reach 1B

There was no significant change in particle size observed in Site M1 while a significant increase in the amount of coarse material was observed in Site M2. The Site M1-1 sample was not collected in February 2011, and the M1-3 sampling location was moved approximately 15 feet upstream from the original location due to the high water level for February and August 2011 data collections.

9.4.2 Reach 2A

Analyses of samples collected in several sites in Reach 2A (M4-2, M5-2, M6-4, M7-1, M7-2, M9, M10, M11-1, M12-1, and M13) in August 2011 were not completed and the corresponding data will be reported in next the ATR.

Some significant changes in particle size were observed at a few sampling locations from Sites M3 through M6½, whereas the rest of the sites showed slight or no changes (see Table A-9-1). Sites M5-1.5 and M6-2 showed a significant increase in particle size in the samples collected in February 2011, after the winter 2010 flood-flow release, and these changes were found reversed in August 2011. Whereas, Sites M3 and M4-1 initially showed a decrease in particle size in February 2011 and these changes were also reversed later in August 2011. In addition, the particle size of the sample collected in Site M6½ considerably decreased after high floodflow releases.

9.4.3 Reach 2B

There was no significant change in particle size observed in Site M14, which is the only selected site in Reach 2B.

9.5 Conclusions and Recommendations

No significant changes in bed material size were observed before and after the series of scheduled flood-flow releases from Friant Dam in 2011(approximately up to 6,000 to 7,500 cfs) except at Site M6½.

At some sampling locations at Sites M3 through M6, the particle sizes of bed materials changed significantly after the scheduled flood-flow release in winter 2010, approximately up to 6,000 cfs. These changes were reversed after spring 2011 floodflow releases, approximately up to 7,500 cfs. Site M6½ showed a decrease in particle size after the series of flood and interim flow releases occurred in 2011. The reason for the changes in particle size may be either due to coarse/fine material movement from upper reaches or loss of fine material during high flows.

Sample collection should continue to be performed when topography surveys are conducted so that a more complete picture of changes at each location will be available for future analysis.

9.6 References

Mussetter Engineering, Incorporated, (2008). DRAFT San Joaquin River Data Collection and Monitoring Plan, prepared for California Department of Water Resources, August 27, 2008.

SJRRP. *See* San Joaquin River Restoration Program.

San Joaquin River Restoration Program (SJRRP). 2010. 2009 Final Annual Technical Report. Available at <www.restoresjr.net>.

———. 2011. 2010 Final Annual Technical Report. Available at <www.restoresjr.net>.

10.0 Bed Profile Surveys

10.1 Introduction

The data presented in this report are related to the study “Effects of Sand Mobilization on Water-Surface Elevation” that specifically addresses needs related to Problem Statement 5 in the 2011 Agency Plan, San Joaquin River Channel Capacity Management (SJRRP, 2011a). Resulting data are used to evaluate the changes in bed formation and to create stage-discharge rating curves to assess the extent to which potential bed mobilization affects channel capacity.

Two monitoring sites in Reach 2A were selected for this task and one cross section per each site was monumented. Cross-sectional and longitudinal profiles at the selected cross section sites were repeatedly surveyed during one release event in January 2011. During the survey, a discharge measurement along with multiple WSE measurements were also made.

10.2 Methods

10.2.1 Site Selection

The locations for the data collection sites were selected based on the previously established vegetation monitoring sites, M6.5 (RM 223.8) and M10 (RM 219.8), in Reach 2A. The locations of the selected cross sections are shown in Figure A-10-1.

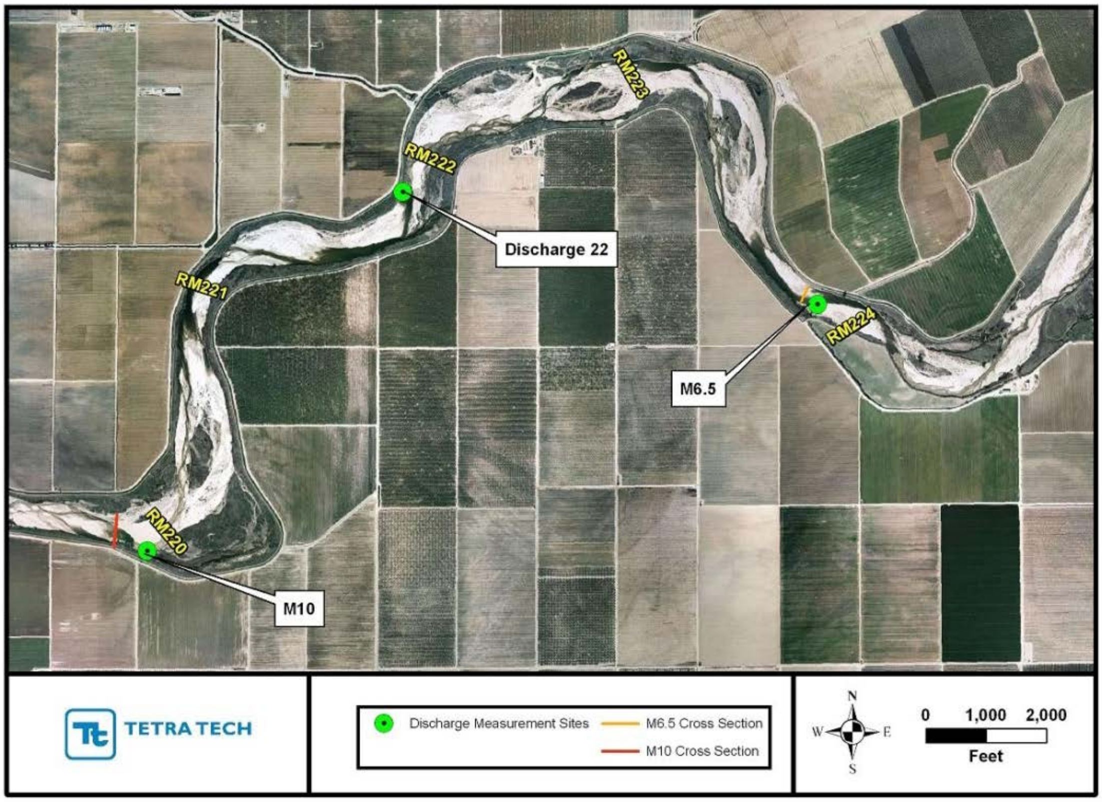

Figure A-10-1.
General Location of Monitoring Sites M6.5 and M10

10.2.2 Monitoring Activity

In January 2011, the bed profile survey was performed in M6.5 for the flood-flow release of 6,000 cfs from Friant Dam. The discharge was measured with DWR's TRDI Rio Grande ADCP, and the bed profile was measured using a cataraft-mounted echo sounder linked to a survey-grade GPS rover. Detailed methodologies of this monitoring task were described in the 2010 ATR (SJRRP, 2011b).

10.3 Results

Bed profile surveys were performed during five interim flow release benches from Friant Dam in 2010 that ranged from 800 cfs to 1,550 cfs, and the associated data were presented in the 2010 ATR (SJRRP, 2011b) Results of the survey performed in January 2011 are compared with previous data and presented below.

The comparisons of plan and profile views of thalwegs at Site M6.5 for various flow release benches that occurred in 2010 along with the Friant release of 6,000 cfs that occurred early in 2011 are presented in Figures A-10-2 and A-10-3. The measured discharge at Site M6.5 was 4,480 cfs on January 10, 2011. The comparisons of cross-sectional profiles and the respective plan views for Site M6.5 are shown in Figures A-10-4 and A-10-5.

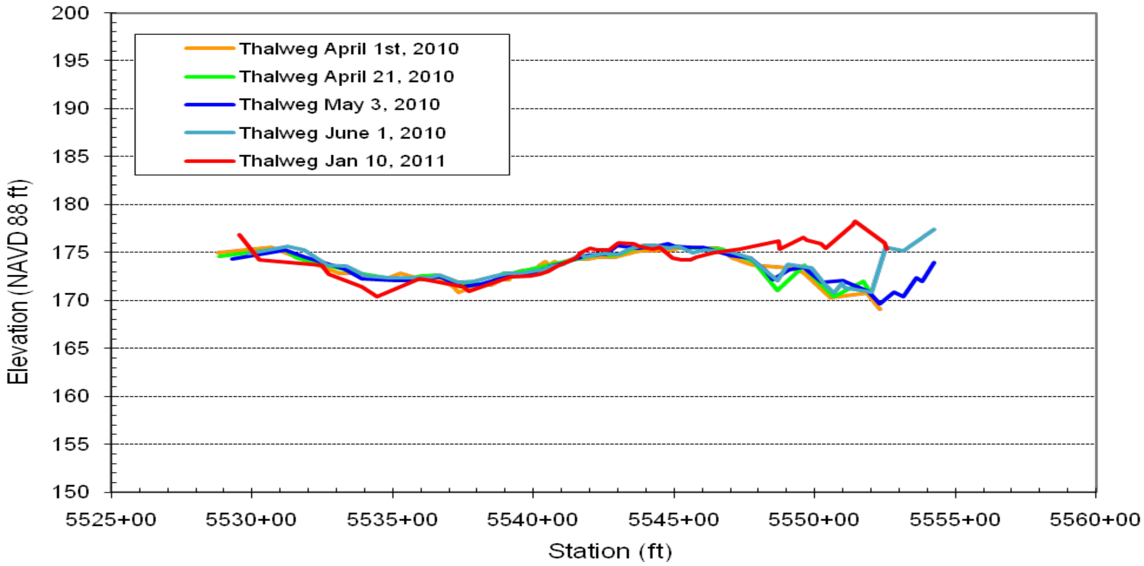

Figure A-10-2.
Profile View of the Thalweg During the Spring 2010 and 2011 Bathymetric Surveys at M6.5

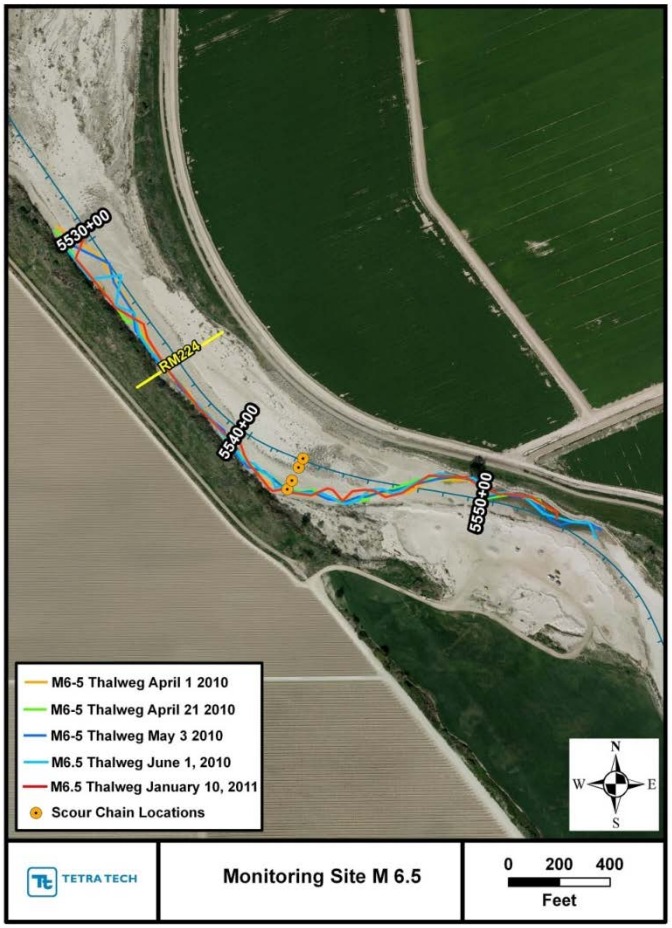

Figure A-10-3.
Plan View Showing the Location of the Thalweg During the Spring 2010 and 2011 Bathymetric Surveys at M6.5

Placeholder
Figure A-10-4.
M6.5 Comparative Section View

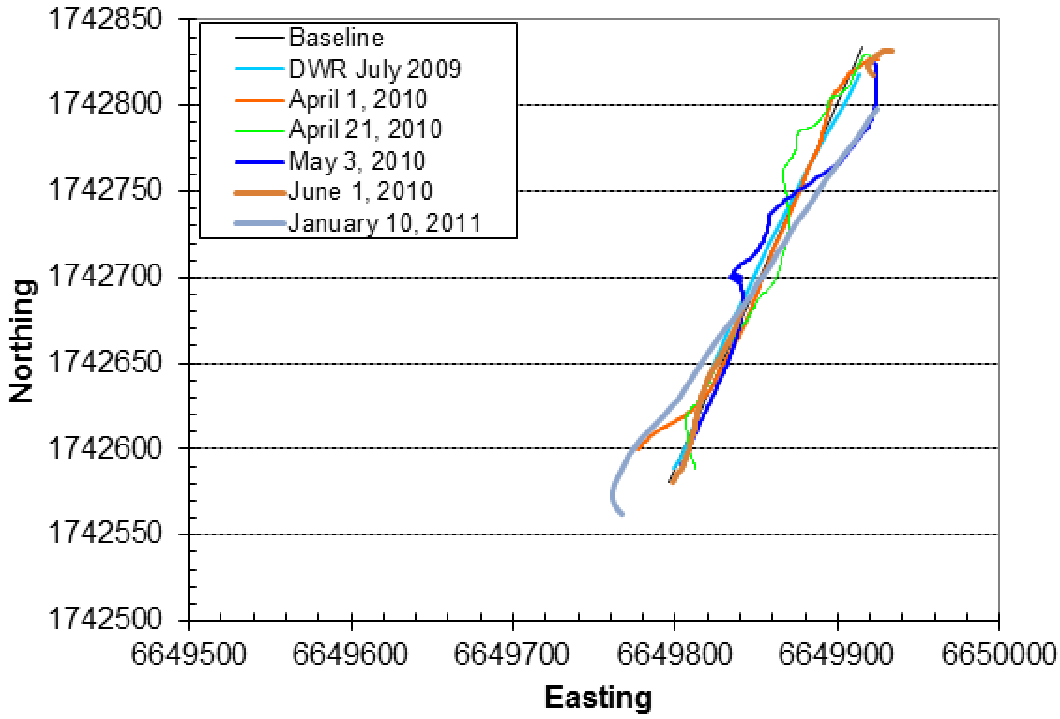

Figure A-10-5.
M6.5 Comparative Section Path

10.4 Discussion

In general, comparison of the longitudinal profiles at Site M6.5 shows very little change in the location of the thalweg over the entire reach, and only minor changes in bed elevation through most of the reach over the range of surveyed flows (Figures A-10-2 and A-10-3). Significant aggradation appears to have occurred in the pool on river right (north) at the upstream end of the site between River Stations 5552+52 and 5554+25 between the May 3, 2010, and June 1, 2010, surveys. The aggradational area appears to represent the downstream face (or possibly, top) of a shoal bar that pushed closer to the right bank as the high flows receded from about 1,300 cfs (Gravelly Ford) to about 625 cfs on June 1.

This depositional tendency continued to push downstream to about River Station 5547+34 by January 10, 2011. It is not known whether the formation of this sand bar in early spring 2010, before the beginning of the report, was due to natural behavior of the river or any possible human activities.

10.5 Conclusions and Recommendations

Based on the collected bed profile data, general scour was not observed over the range of surveyed flows (800 cfs to 6,000 cfs) in these selected sites. However, local scour and deposition were observed at the sites during the period of the report. Even though scour chains showed some significant localized degradation and aggradation, no general relationships with changing flows were found. In addition, human influences at Sites M6.5 and M10 may have an impact on the quality of the data collected.

Based on these data, the hypothesis that the water-surface elevation at high flows in the sand bed portions of the reach is lower than projected by the existing rigid-boundary hydraulic models due to scouring of the bed does not appear to have been validated in the selected sites. This concludes the current scope of this report, and no further data collection is planned at this time.

10.6 References

SJRRP. *See* San Joaquin River Restoration Program.

San Joaquin River Restoration Program (SJRRP). 2011a. 2011 Agency Plan. Available at <www.restoresjr.net>.

———. 2011b. 2011 Draft Annual Technical Report. Available at <www.restoresjr.net>.

11.0 Scour Chains

11.1 Introduction

The data reported in this section are related to the report "Effects of Sand Mobilization on Water-Surface Elevation." These data specifically address 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. The information from this monitoring task, associated with the data from bed profile surveys, is used to determine if bed mobilization in the sand bed reaches affects rigid boundary hydraulic modeling results and other river restoration aspects of San Joaquin River.

In all, eight scour chains were installed in two sites in Reach 2A that were selected for the report to quantify amounts of scour and deposition that take place during each seasonal Restoration Flow release.

11.2 Methods

11.2.1 Site Selection

See site selection in the Bed Profiling Surveys report (Section 11.0).

11.2.2 Installation

The detailed installation procedures of scour chains were described in the 2010 ATR (SJRRP, 2011) and some photos showing the process of installing the chains were displayed in the 2009 ATR (SJRRP, 2010).

11.3 Monitoring

Chain sites were revisited after each major Restoration Flow season for chain recovery, after the water level in the river returned to a safe working condition. Quantities of scour and deposition were measured as described in the 2010 ATR (SJRRP, 2011).

11.4 Results

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. At least one of the four chains in each cross section was placed in the low-flow channel. Based on the locally established control points referenced to NAD 83 California Zone III (U.S. Survey Feet) coordinate system, these chain locations were surveyed using a Total Station after installation. During chain recovery in fall 2010, it was found that Chain 1 at Site M10 was missing.

Chain sites were revisited in fall 2011 for further data collection after a few high flood-flow releases. A new chain was installed to replace Chain 1 at Site M10, and Chain 3 at Site M6.5 was extended by 1.96 feet for future measurements. Updated chain details and locations are presented in Table A-11-1.

Table A-11-1.
Scour Chain Information

Point Number	Longitude	Latitude	Date Installed	Total Length (feet)
1-XS6.5	W120°11'57.19"	N36°46'48.96"	8/11/2009	9.90
2-XS6.5	W120°11'56.96"	N36°46'49.30"	8/11/2009	9.90
3-XS6.5*	W120°11'56.64"	N36°46'49.80"	8/11/2009	11.45
4-XS6.5	W120°11'56.42"	N36°46'50.15"	8/11/2009	9.90
1-XS10`	W120°14’16.65”	N36°46’09.80”	12/20/2011	10.05
2-XS10	W120°14’16.35”	N36°46’10.62”	8/13/2009	14.05
3-XS10	W120°14’16.07”	N36°46’11.08”	8/13/2009	14.60
4-XS10	W120°14’15.78”	N36°46’11.51”	8/19/2009	13.45

Notes:
` - A new chain was installed.
* - Chain was extended.
Key:
XS = cross section

The data collected in December 2009 and fall 2010 were analyzed and presented in the 2009 and 2010 ATRs, respectively (SJRRP, 2010 and 2011). After each data collection, chains were reset and elevations of chain elbows and exposed lengths were recorded. The chain sites were revisited in September 14, 2011, and December 20, 2011, for another set of data collection after 2011 flood-flow releases. Results are shown below in Table A-11-2.

Table A-11-2.
Post-Flow Scour Chains Inspection Results

Date of visit		Site and Chain #								
		M 6.5					M 10			
		1	2	3*	4		1`	2	3	4
09/14/2011 & 12/20/2011	Initial exposed length (feet) (after resetting in fall 2010)	1.29	1.25	0.59	1.38		N/A	3.87	4.27	3.38
	Chain length to kink (feet)	1.89	2.92	0.67	2.38			5.67	6.92	4.57
	Depth to kink (feet)	0.50	1.86	0.64	0.99			1.28	2.05	2.12
	New exposed length (feet)	1.42	1.15	2.08	1.38		3.05	4.33	4.67	2.67
	Amount of scour (feet)	0.60	1.67	0.08	1.00			1.80	2.65	1.19
	Redeposit (feet)	0.50	1.86	0.64	0.99			1.28	2.05	2.12
	Net (-Scour, + Deposit) (feet)	(0.10)	0.19	0.56	(0.00)			(0.52)	(0.59)	0.93

Notes:
* - Chain 3 at Site M6.5 was extended by 1.96 feet.
` - Chain 1 at Site M10 was not found and replaced with a new one with a length of 10.05 feet.

11.5 Discussion

Based on the data presented in Table A-11-2, all chains showed significant scour in their vicinity during high flood-flow releases, except Chain 3 at Site M6.5, which indicated very little scour. Significant amounts of redeposition were also observed in the vicinity of all chains. In Site M6.5, net changes in the bed elevation at the vicinity of chains were very minor, except Chain 3. This chain is located close to the right bank of the low-flow channel and showed approximately a little more than 0.5 foot of net deposition. In Site M10, the right portion of the channel bed had experienced net deposition of about 1 foot, while the other areas experienced approximately 0.5 foot of net scour.

11.6 Conclusions and Recommendations

There were significant amounts of local scour observed at the vicinity of chains at both sites M6.5 and M10 during 2011 Restoration Flow and flood-flow releases (350 cfs to 7,500 cfs), except Chain 3 at Site M6.5, which showed very little scour. However, significant amounts of local redeposition also occurred in the vicinity of all chains in both sites.

These chains should continue to be monitored if the study continues.

11.7 References

SJRRP. *See* San Joaquin River Restoration Program.

San Joaquin River Restoration Program (SJRRP). 2010. 2009 Final Annual Technical Report. Available at <www.restoresjr.net>.

———. 2011. 2010 Final Annual Technical Report. Available at <www.restoresjr.net>.

12.0 2011 Reach 1A Sand Storage Surveys

12.1 Introduction/Background

Tetra Tech, Inc., dba Mussetter Engineering, Inc. (Tt-MEI) performed an assessment of sand storage in Reach 1 in 2010, which was reported in a draft technical memorandum (TM) in April 2011 (Tt-MEI, 2011). The report's purpose was to quantify the amount and location of sand storage in Reach 1; identify, to the extent possible, the sources of sand; and provide a basis for developing a longer term sand monitoring program to assess future changes in the availability of sand in Reach 1 that could affect both the quality of instream habitat and downstream sediment-transport balance. The TM is being revised and finalized, and is expected to be released in early 2012.

DWR directed Tt-MEI to follow up on the earlier study results by expanding the study based on those earlier results and recommendations. Additional work was conducted in late 2011. Specific additional data collection tasks included:

- Identify three channel reaches of approximately 1 mile each that best represent the entire Reach 1 for sand deposits, as reported from the 2010 study. Duplicate earlier field surveys in those reaches to determine changes due to 2011 high flows. Complete higher level surveys of approximately 5 percent of the sample reaches to validate reach-wide field survey methods. The higher level surveys were similar to that described in the Draft TM (Tt-MEI, 2011), Section 4, Page 8, and included a combined total of 37 surveyed transects at three sites with deposit depth measurements across each transect. Analyze results to show volume comparisons with earlier work, extrapolate to the rest of the reach, and correlate validation of select sites to the entire reach.

- Expand the study conducted by Reclamation (see Tt-MEI, 2011, for abbreviated discussion of Reclamation study) to cover selected sites within Reach 1 that will compare entrainment potential of normally vegetated deposits to those that are vegetated by red sesbania (*Sesbania punicea*) by establishing two sites each of native and invasive vegetation for short- and long-term monitoring. Longer term monitoring tasks (beyond 1 year) are not included in this scope. Techniques employed match those being used in the Reclamation study, and include both ground elevation and vegetation surveys of each transect as well as bed sample gradations. Baseline measurements were taken by Tt-MEI in November 2011, and a second set of data will be collected in 2012 after trigger flows of at least 4,500 cfs have been reached. Analysis of the data should contrast erosion at sites with different vegetation characteristics.

- Collect RTK GPS location and elevation bathymetry data of the four pits surveyed in the earlier study. Bathymetric surveys were completed in November 2011, after the 2011 high-flow period had subsided. A second survey may also be conducted after the 2012 spring high-flow period has subsided if Friant releases reach a minimum of 4,500 cfs for at least 2 weeks.

All data and results shown in this report are based on what is presented in an unpublished draft TM (Tt-MEI, 2011), and as such should be considered preliminary and subject to revision. A final TM will be published in early 2012.

12.2 Methods

12.2.1 Sand Surveys

Based on the distribution of sand from the 2010 survey, three approximately 1-mile-long reaches within Reach 1A (Friant Dam to Highway 99) were selected for sand measurements between November 14 and 18, 2011, when the releases from Friant Dam varied from between 120 and 63 cfs. Site locations are shown in Table A-12-1. As was done previously in 2010, sand depths were determined across the channel with a 10-foot-long piece of 0.25-inch-diameter rebar rod that was inserted into the bed until refusal, generally on underlying gravels and cobbles.

Table A-12-1.
Erosion Monitoring Sites

Vegetation Type (Site ID)	Site Location	Site Length (feet)
Red sesbania (RS1)	RM 247.3L	230
Red sesbania (RS2)	RM 247.2R	144
Grasses (G1)	RM 264.3R	103
Grasses (G2)	RM 264.2R	66

Key:
RM = River Mile

Site selection depended on previous observations of sand deposits. Site 1 was selected because the Ledger Island Bridge is located about mid-point on the reach and sand storage was observed both upstream and downstream from the bridge in 2010. Based on the presence of bank erosion within the reach and the fact that the bridge forms a hydraulic constriction at higher flows, it was expected that there would be significant sand deposits within the reach. Site 2 was selected because there was extensive sand storage at two locations within the reach in 2010. Site 3 was selected because there was extensive sand storage at three locations within the reach in 2010.

12.2.2 Channel Margin Surveys

Contrary to the original assumption, Reclamation researchers are not currently studying the effects of different types of vegetation on the erosion of channel margin deposits in Reach 1. Therefore, there were no existing methods to follow. Based on observations within Reach 1 since 1997, it appears that there is a difference in erodibility between sandy channel margin deposits that are grass-covered versus those covered by red sesbania. In an effort to test this hypothesis, four sites were located to evaluate the effects of the different vegetation types on sand erodibility (Table A-12-1). The sites were chosen on the basis of observed sand deposition and erosion following the 2011 high flows rather than on the basis of hydraulically based estimates from existing 1D and two-dimensional (2D) hydraulic models, as was originally envisaged.

At each of the sites, parallel transects were surveyed at roughly 6-foot intervals with RTK-GPS from the water’s edge to the high-water marks from the 2011 high flows. The surveyed data were then used to develop a topographic surface of the site in ArcGIS, which will represent the baseline condition for future surveys following high flows. Each of the sites was also extensively photographed. Bank-material samples were also collected from each site to characterize grain-size distribution of the substrate at each site.

12.2.3 Pit Bathymetry Resurveys

Four abandoned sand-and-gravel pits between Friant Dam and Donny Bridge (RM 240.5) were initially surveyed in April 2010 (Figure A-12-1). The pits were located at RM 252.5 (Sycamore Island), RM 246.5 (downstream from Milburn), RM 243.7 (above Highway 99) and RM 240.5 (above Donny Bridge). Following a 30-day period with flows of about 1,600 cfs, the four pits were resurveyed in June 2010. A third survey of each pit was conducted approximately 17 months later, between November 7 and 13, 2011. During the period between the second (June 2010) and third (November 2011) surveys, flows peaked near the 10-year recurrence interval level of 8,000 cfs several times, and flow levels of over 2,000 cfs were sustained for over 100 continuous days. Digital surfaces were created from the collected data and used to calculate depositional and scoured volumes between the June 2010 and November 2011 surveys.

12.3 Results

12.3.1 Sand Surveys

Summarized results for the sand surveys are shown in Table A-12-2. This data is currently from a draft TM by Tt-MEI to be published in early 2012.

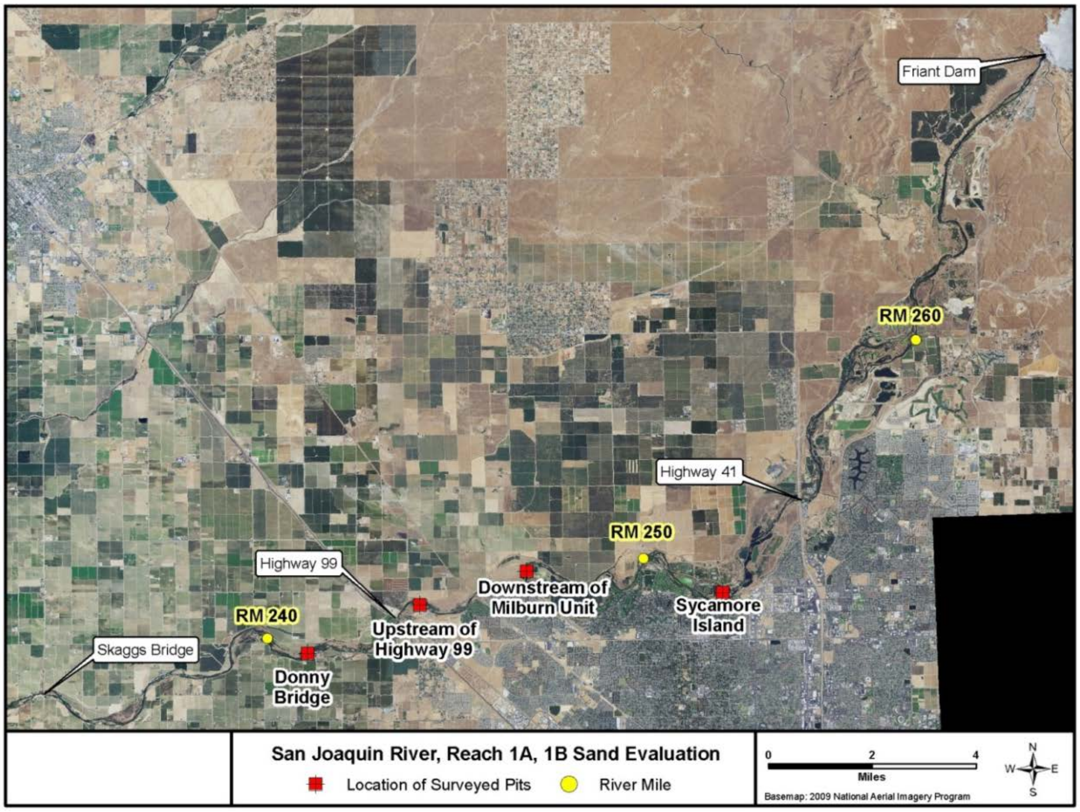

Figure A-12-1.
Map Showing Locations of the Four Surveyed Pits

Table A-12-2.
November 2011 Survey Reaches and 2010 Sites Included Within the Individual Survey Reaches

2011 Site No.	Site Boundaries	2010 Survey Sites (Refer to Table 3, Tt MEI, 2011)	2010 Average Sand Depth and Range (feet)	2011 Average Sand Depth and Range (feet)
1	RM 261.5 – RM 262.5	36 37	1.5 (1 – 2) 2.0 (1 – 3)	1.7 (0.1 – 7)
2	RM 248.8 – RM 249.8	25 26	2.5 (1 – 4) 1.5 (1 – 2)	2.2 (0.1 – 9)
3	RM 244.4 – RM 245.4	15 16 17	1.5 (1 – 2) 1 (1) 0.75 (0.5 – 1)	2.6 (0.1 – 9)

Key:
RM = River Mile

Site 1

The total volume of sand in storage within the 1-mile-long reach, based on end-area calculations from 11 surveyed transects, is 6,055 cubic yards (yd^3). Observations of the bed in the reach during the very low-flow conditions in 2011 support the general absence of sand deposits in the reach downstream from Ledger Island Bridge.

Site 2

The total volume of sand in storage within the 1-mile-long reach, based on end-area calculations from nine surveyed transects, is 8,783 yd^3. Observations of the bed in the reach in the vicinity of Site 25 during the very low-flow conditions in 2011 support the general absence of sand deposits in the site that was previously located upstream from the acute bend at RM 248.6. A considerable, but unquantified, volume of sand was observed in the bed between RM 247.8 and RM 248.2.

Site 3

The total volume of sand in storage within the 1-mile-long reach, based on end-area calculations from 17 surveyed transects, is 24,592 yd^3.

12.3.2 Channel Margin Surveys

Baseline surveys of the four sites will be presented in a TM. Surveys consist of geodetic survey points of the river bank within each study site, and will be presented as plan view topography.

The median (D_{50}) sizes of the samples at Red sesbania (RS)1 are 1.4 millimeters (mm) and 1 mm, respectively, which are in the very-coarse-sand range. At RS2, the D_{50}s are 0.5 and 0.4 mm, respectively, which are in the medium-sand range. At both the grass sites (G1, G2), the D_{50}s are in the fine-sand range (0.2 mm).

12.3.3 Pit Bathymetry Resurveys

Table A-12-3 below shows the resultant volume change calculated from differences in the surfaces generated by survey data collected in April 2010, June 2010, and November 2011.

Table A-12-3.
Measured Changes in Sediment Volume in the Surveyed Pits in Reaches 1A and 1B

Site	River Mile	Estimated Trap Efficiency (percent)	Change in Volume (yd^3)	
			April 2010 – June 2010	June 2010 – November 2011
Sycamore Island	252.5	60	+19,243	+17,329
Downstream from Milburn	246.5	97	+5,860	-8,703
Upstream from Highway 99	243.7	80	+3,718	-3,170
Donny Bridge	240.6	95	+1,668	-6,251

Key:
yd^3 = cubic yard

12.4 Discussion

A TM presenting complete methods, data, and analyses will be published separately for this report in early 2012.

12.5 Conclusions and Recommendations

A TM presenting conclusions and recommendations will be published separately for this report in early 2012.

12.6 References

Tt-MEI. *See* Tetra Tech, Inc., dba Mussetter Engineering, Inc.

Tetra Tech, Inc., dba Mussetter Engineering, Inc. (Tt-MEI). 2011. Evaluation of Sand Supply, Storage, and Transport in Reaches 1A and 1B. April.

13.0 Additional Water-Level Recorders

13.1 Introduction

The data reported in this section is related to the report "Additional Water Level Recorders" that specifically addresses needs related to Problem Statement 5 in the 2011 Agency Plan (SJRRP, 2011), San Joaquin River Channel Capacity Management, and indirectly addresses certain aspects of other problem statements by providing a continuous record of WSEs at key locations during Interim Flow releases to calibrate hydraulic models being used to assess channel capacity, fishery habitat, channel bed stability, and many other aspects of Restoration planning and design.

Five water-level recorders (WLR) (Recorders 1 through 5) were installed at Reach 1A before the start of the 2009 Interim Flow releases and another one (Recorder 6) was installed at Reach 1B before the start of the 2010 spring Interim Flow release. The stage data are continuously being collected from the dates of installations.

13.2 Methods

As shown in Figure A-13-1, this particular type of WLR, Global Water-WL16U, is an integrated unit consisting of a submersible pressure transducer (pressure sensor) connected to the data logger with a standard 25-foot cable (longer cable lengths are available). Refer to the 2009 ATR (SJRRP, 2010) for more detailed information about installation methods.

Figure A-13-1.
Water Level Recorder

The data from the WLRs were downloaded periodically and used to compute the WSE. The necessary calculation methods were described in detail in the 2010 ATR (Tt MEI, 2010).

13.3 Results

Coordinates of WLR locations and the recording dates for 2011 are summarized in Table A-13-1. The coordinates associated with each recorder refer to the position of the corresponding transducer located in the channel bed. Recorder 4 was replaced with a new one on February 2011 and the new coordinates were updated in the table displayed below in Table A-13-1.

Table A-13-1.
Location of Water Level Recorders

WLR No	Location	Reach	River Miles	Northing	Easting	Elevation	Date Recorded
1	Head Ledger Island	1A	263.4	1806574	6783091	289.21	01/01/2011 – 12/21/2011
2	Willow Unit Grade Control		261.5	1800801	6781533	284.93	
3	Rank Island Grade Control		260.4	1796241	6780278	274.85	
4	Sycamore Island Flow Split		251.1	1769841	6755774	245.35	
5	Milburn Unit		248.4	1769997	6747942	232.90	
6	R 1B-1_RM 237.7	1B	237.7	1760168	6704615	206.91	

Key:
WLR = Water Level Recorder

Stage data collected in 2011 were converted as elevation data, as described in the 2010 ATR (Tt MEI, 2010)and are presented in this report. The data collected before this period were reported in 2009 and 2010 ATRs (SJRRP, 2009 and 2010).

The data from the additional WLRs located in Reach 1A are presented in Figures A-13-2 and A-13-3. In addition, the data from US Geological Survey (USGS) gages located in the same reach are extracted on-line from the CDEC Web site and presented in Figure A-13-4 for comparison purposes.

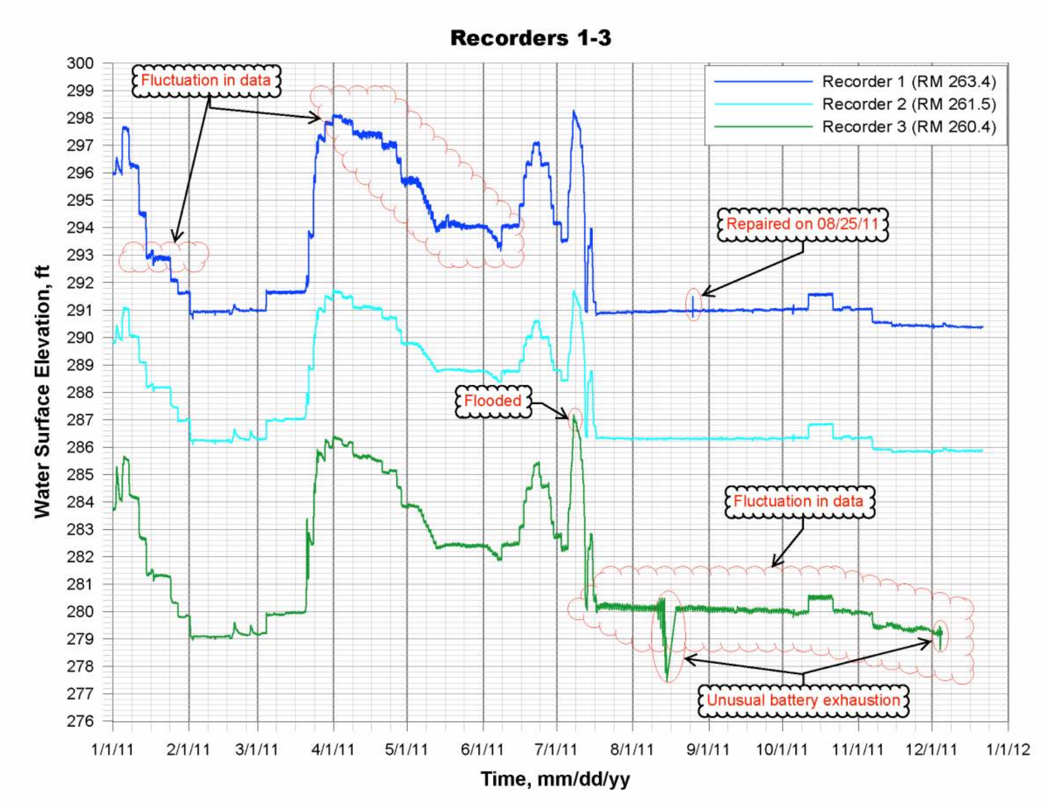

Figure A-13-2.
Water Level Recorders 1, 2, & 3 Elevation Data

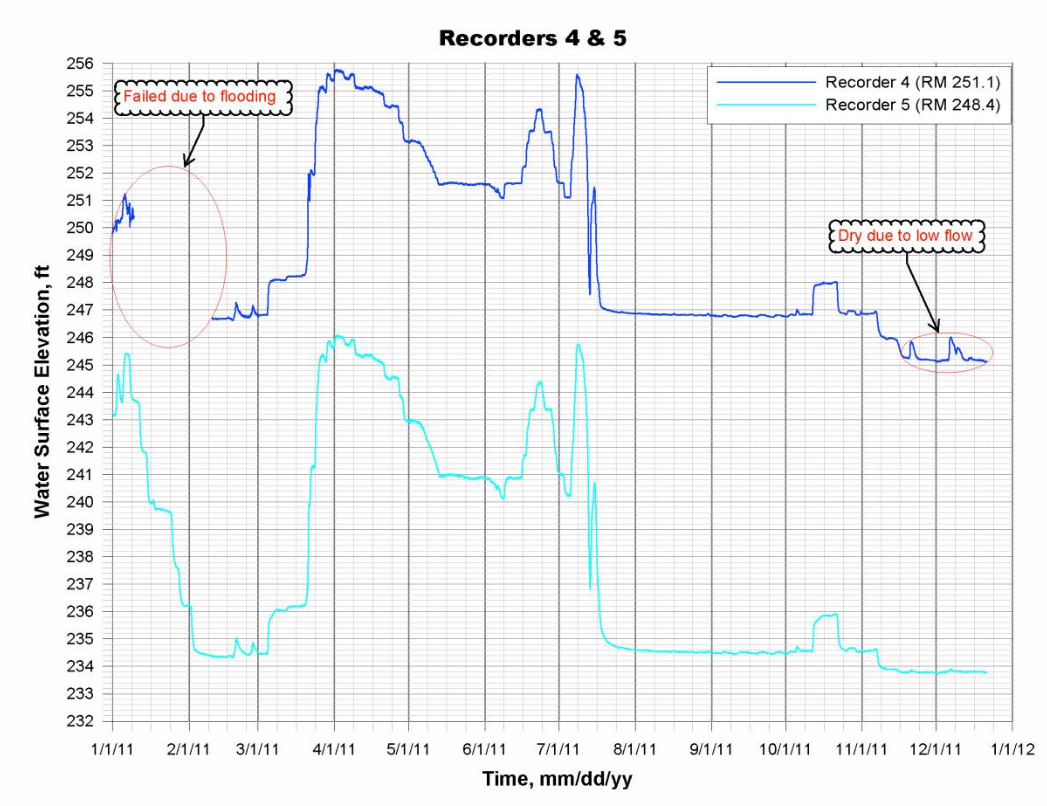

Figure A-13-3.
Water Level Recorders 4 & 5 Elevation Data

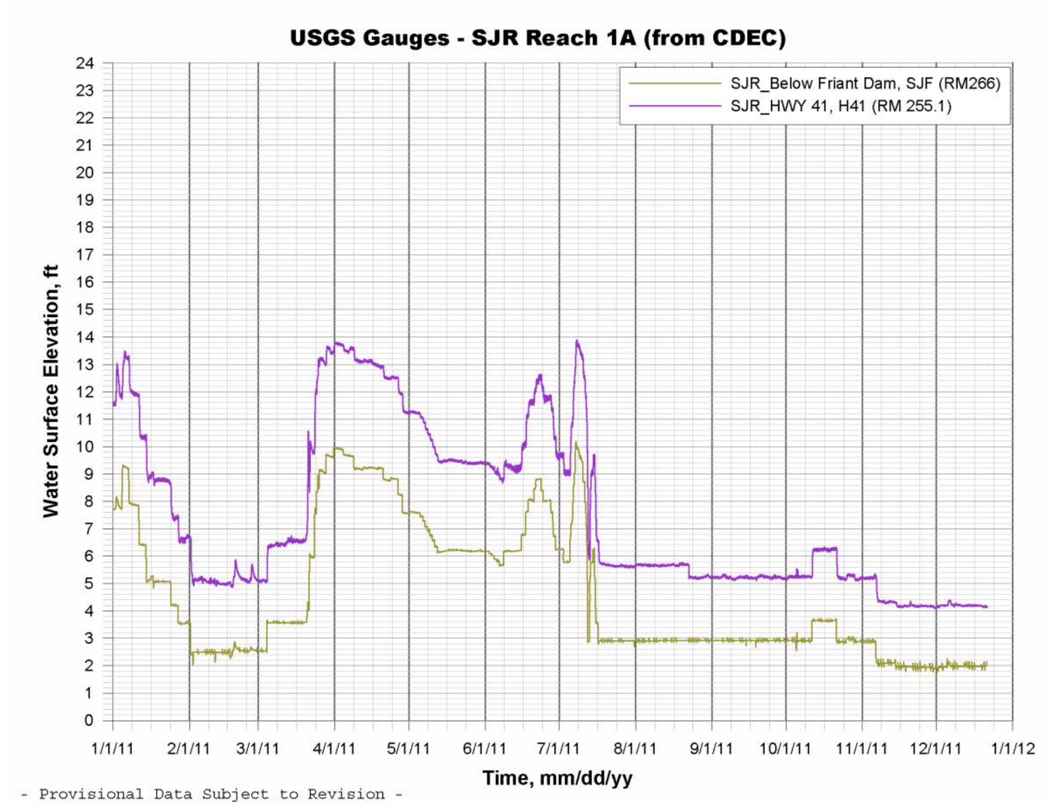

Figure A-13-4.
USGS Gage at Reach 1A Elevation Data

Similarly, the data from WLR 6 located in Reach 1B and the USGS gage located in the same reach at Donny Bridge are presented in Figures A-13-5 and A-13-6

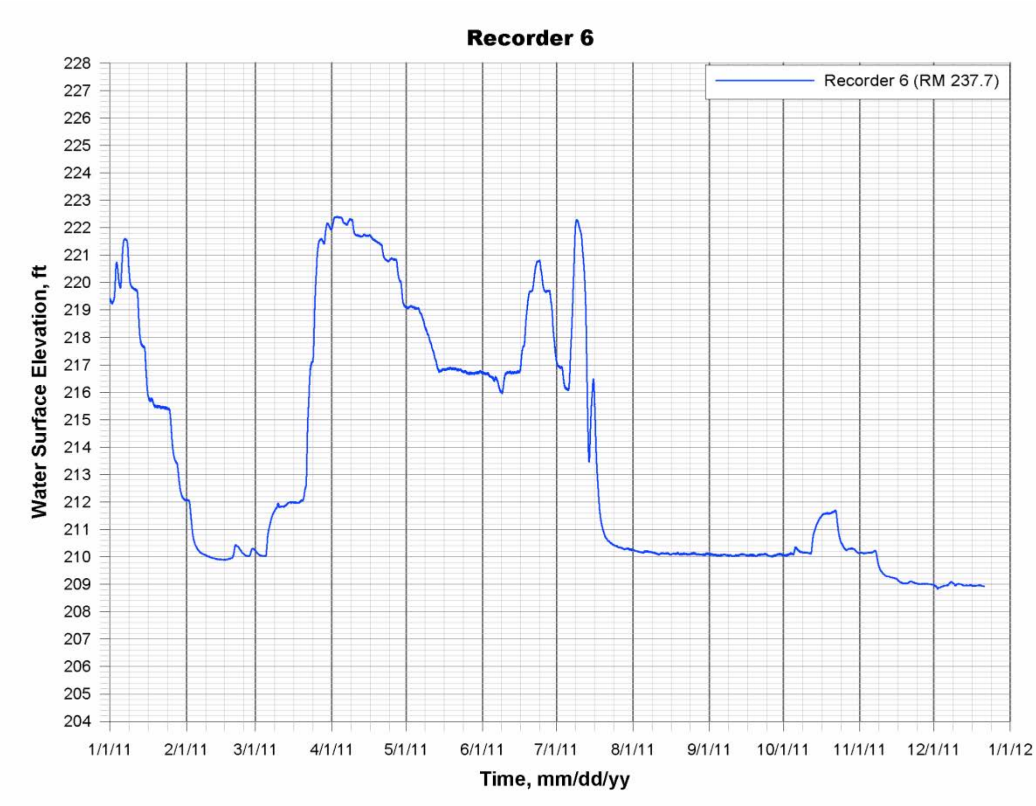

Figure A-13-5.
Water Level Recorder 6 Elevation Data

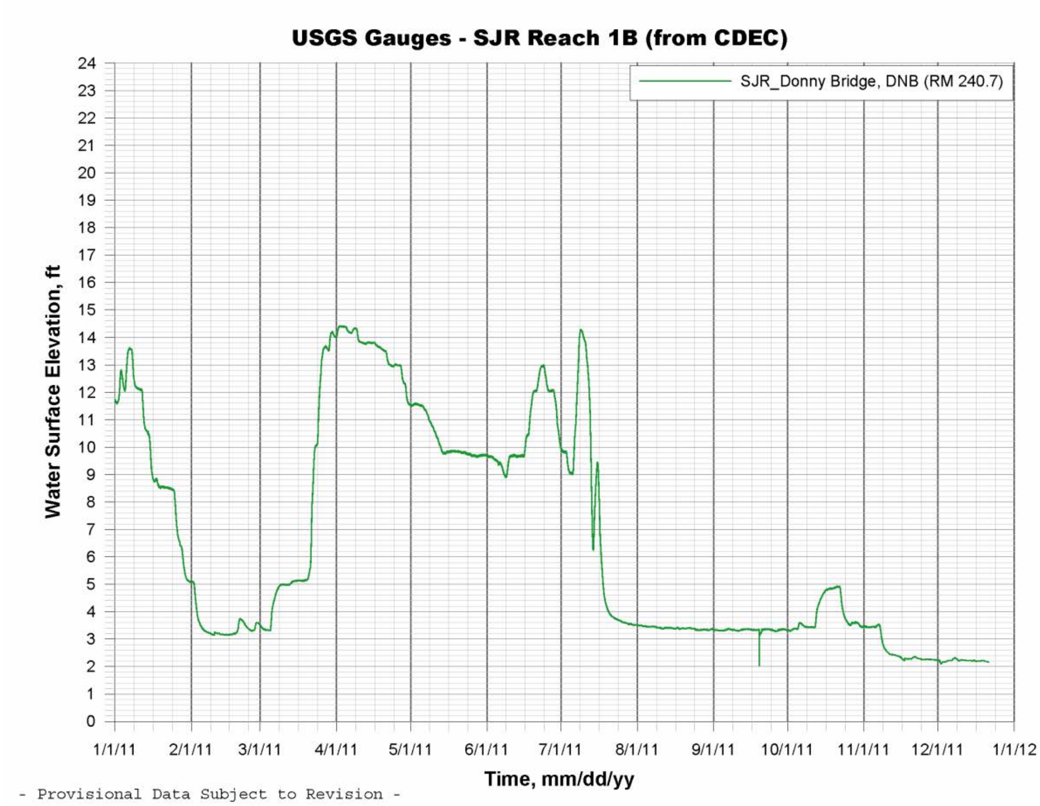

Figure A-13-6.
USGS Gage at Reach 1B Elevation Data

13.4 Discussion

According to Figure A-13-2, Recorder 1 indicates water-level fluctuations during the third week of January 2011 as well as in April and May (see red markups). However, Recorders 2 and 3 located downstream from Recorder 1 did not show any significant fluctuation in the data during the same period. As a result, the accuracy of the data for Recorder 1 during this period of time is suspect. A similar-type fluctuation in the data from the same recorder was observed in 2009. A field investigation performed on August 25, 2011, identified that accumulated debris loosened one of the anchors and made the end of the pipe, which contains the transducer, to fluctuate about 2 to 3 inches due to water force. This issue was rectified on the same day and a pulse in the data was observed during the repair work (see Figure A-13-2).

A sudden fluctuation in water level within a day was observed from Recorders 1 through 5 between March 20 and March 22, 2011. The amplitude of this fluctuation increased from Recorders 1 through 3, peaked at approximately 2 feet at Recorder 3, and then receded at Recorder 5 (see Figures A-13-2 and A-13-3). This sudden fluctuation was also observed in the USGS gages located in Reach 1A (see Figure A-13-4). The gage at Highway 41 showed approximately the same amplitude as Recorder 3, which is located about 5 miles upstream from Highway 41. The storm event that occurred right before and during this period is the likely explanation for the above phenomena. According to

National Oceanic and Atmospheric Administration Web site (www.noaa.gov), total precipitation in the Friant and Fresno areas for the 48-hour period ending at 4:00 p.m. Pacific Daylight Time March 21, 2011, ranged from 2.1 to 2.6 inches, and there were also some relatively smaller amount of precipitation (approximately 0.2 inch) accounted on the day before this period.

According to the WSE and the elevation of the data logger, the data logger of Recorder 3 was over-topped during the flood-flow release that occurred on July 7 and 8, 2011. Even though this recorder is currently functioning, an unusual battery exhaustion and significant fluctuation in the data were observed after flooding. This issue should be rectified before the spring 2012 flow releases start.

The data logger of Recorder 4 was also over-topped during the high flood-flow releases that occurred at the end of last year. It started collecting unusual data from December 29, 2010, and stopped functioning on January 9, 2011 (see Figure A-13-3). There was a sudden drop in the data of Recorder 4, when the WSE reached the approximate elevation of the data logger (253.3 feet). This recorder was replaced with a new one and was back on-line February 10, 2011. During the next site visit, this recorder was found dry during the recent low flows (approximately 100 cfs), since it is located in an area that is surrounded by sand/gravel bars. As a result, data from Recorder 3 during the low-flow period starting from November 7, 2011 (see red markups in Figure A-13-3), is unreliable.

The data from Recorder 6 matches with that of the USGS gage at Donny Bridge, which is about 3 miles upstream (see Figures A-13-5 and A-13-6).

13.5 Conclusions and Recommendations

Data from the transducers will be compared to model results, and adjustments will be made to the models, as necessary, to better match the data. This data will also be cross-checked with WSE data measured during the water surface profile survey for quality control.

The existing recorders should continuously be monitored and the data collection should be done periodically. Necessary action should be taken to investigate and rectify Recorder 3 about the fluctuation of readings and unusual battery exhaustion. All WLRs will be resurveyed to make sure that no movement occurred during high flood-flow releases.

It is recommended to evaluate the possibility of moving a recorder from Reach 1A or to install a few additional recorders in Reach 2 to provide wider spatial distribution of calibration data. We are currently reviewing possible options for relocation.

13.6 References

SJRRP. *See* San Joaquin River Restoration Program.

San Joaquin River Restoration Program (SJRRP). 2010. 2009 Final Annual Technical Report. Available at <www.restoresjr.net>.

———. 2011. 2011 Agency Plan. Available at <www.restoresjr.net>.

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14.0 Millerton Lake Temperatures 2005 – 2010

14.1 Introduction/Background

This report presents results of Temperature Monitoring for the Millerton Lake Cold Water Pool Study from 2005-2010 (refer to 2011 Agency Plan, Appendix A, section 14.0 (SJRRP, 2011)). Reclamation began collecting Millerton Lake temperature data in 2005 as background information in anticipation of the San Joaquin River Restoration Program. This monitoring investigated the effects of Friant Dam operations (with and without Interim Flows) on release temperatures to the San Joaquin River and the availability of the cold water pool to support recreational fisheries in Millerton Lake.

Water temperature exerts a substantial influence on the abundance, development, growth, and survival of fishes, including Chinook salmon (EPA, 1999, and Myrick and Cech, 2001). 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.

In 2005 Reclamation deployed temperature sensors for monitoring the Millerton Lake inflow and outflow temperatures, and evacuation of the cold water pool. The data are used to calibrate and validate the CE-QUAL-W2 model of Millerton Lake temperatures providing Friant Dam release temperature inputs for the HEC-5Q model of San Joaquin River temperatures. The data inform management of the cold water pool for downstream release temperatures.

14.2 Methods

Hourly inflow temperatures were collected in the San Joaquin River Channel where it enters Millerton Reservoir and at release points below Friant Dam using ONSET temperature loggers. Hourly outflow temperatures were measured at the three release points from Friant Dam and from the fish hatchery and worm farm. In Table A-14-1 and Figure A-14-1 they are as described as follows:

**Table A-14-1.
Millerton Lake Temperature Monitoring Locations**

Name	String ID	Location	Notes
San Joaquin River outlet works	TW Temp	N36.99930, W119.70597	
Friant Forebay Temperature String	MLSTRNG	N37.00553°, W119.69492°	In the old river channel upstream from Friant Dam, a full depth string located near the Dam with 15 temperature loggers irregularly spaced to capture the detail in the epilimnion and metalimnion and to a lesser extent the hypolimnion.
Friant-Kern Canal	FKCANAL	N36.99697, W119.70453	
Madera Canal	MCTemp	N37.00220 W119.70769	
Main Outflow From Fish Hatchery/Worm Farm	FHTEMP	N36.98485, W119.72133	
Secondary outflow from Worm Farm	FH2	N36.98563,W119.72028	
Millerton Inflows below Kerckhoff #2 PP	HW-TEMP	N37.06938, W119.56102	
Finegold Temperature String	FGSTRNG	N37.04277°, W119.63910°	In the old river channel uplake from Finegold Creek, a full depth string with 15 temperature loggers irregularly spaced to capture the detail in the epilimnion and metalimnion and to a lesser extent the hypolimnion. This string was lost in 2009 and not replaced.

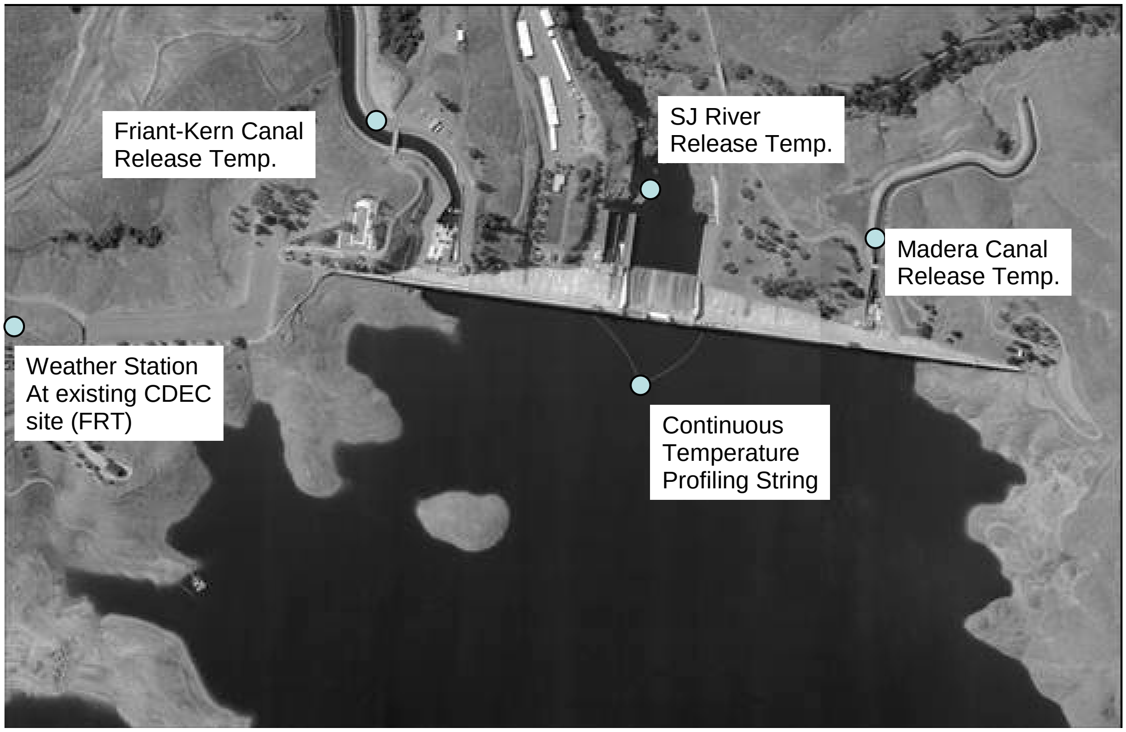
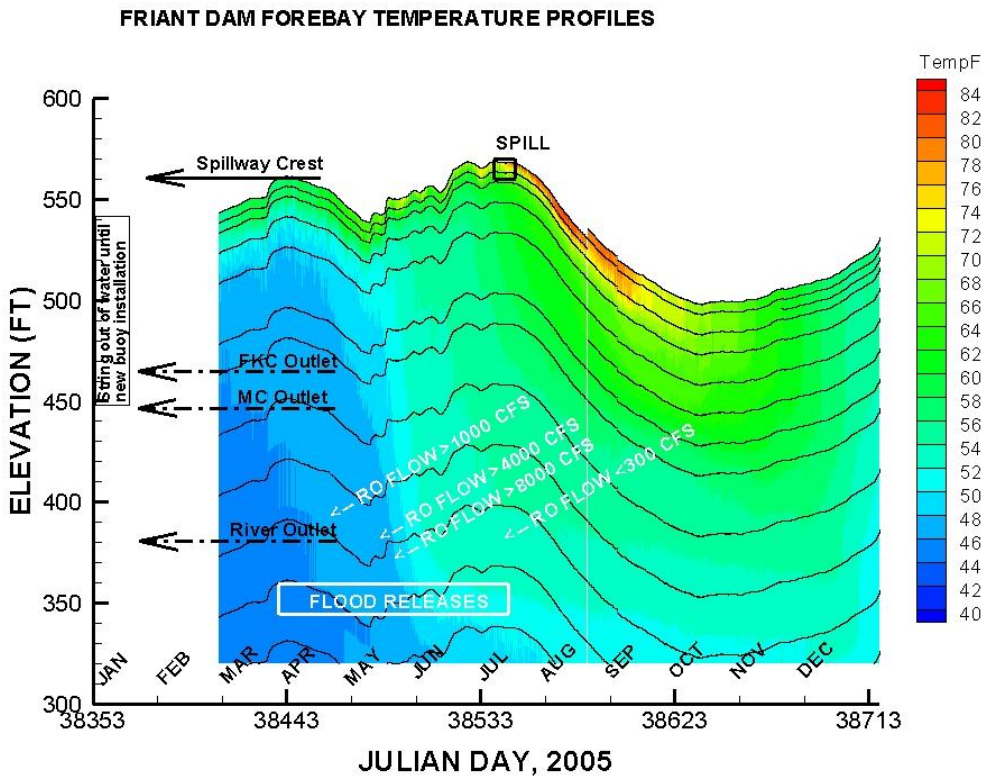


Figure A-14-1
Temperature Monitoring and Weather Station Locations near Friant Dam

14.3 Results

Temperature profiles for Friant Dam Forebay and Finegold Bay are presented below in Figures A-14-2 through A-14-8. Refer to the Temperature Atlas attached to this ATR for temperature results at other locations.



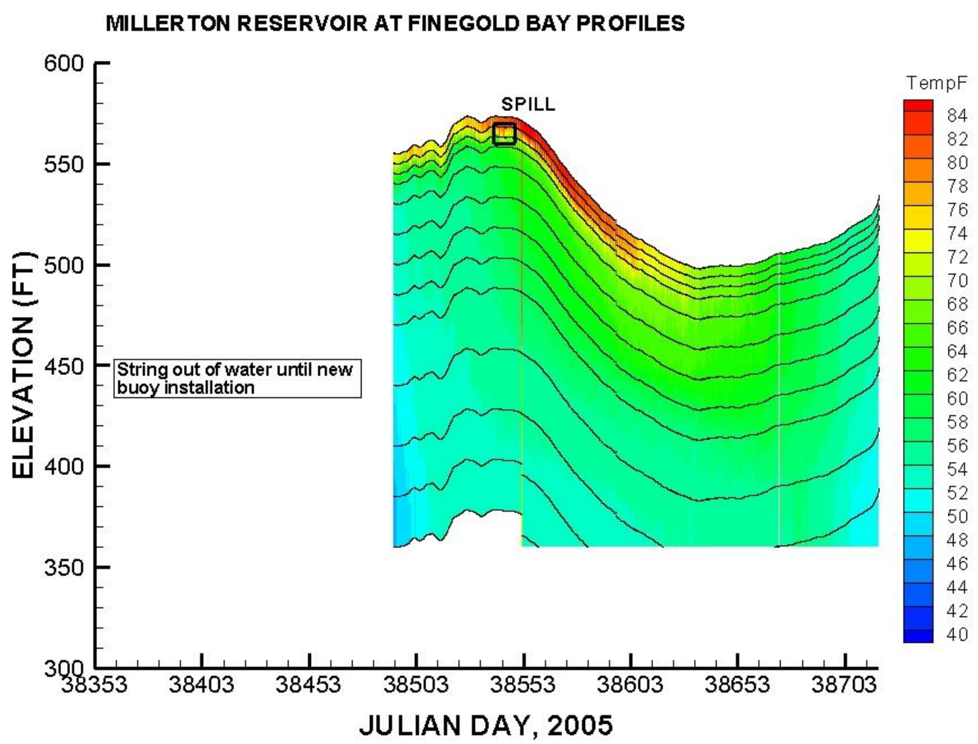
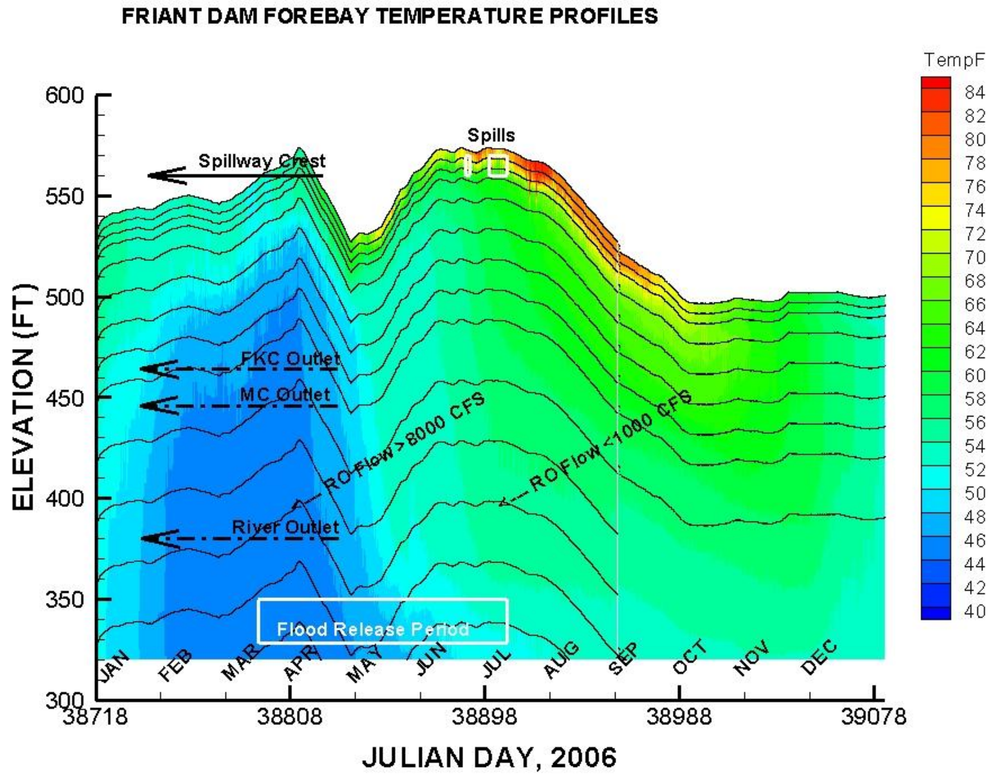


Figure A-14-2.
2005 Millerton Reservoir Temperature Profiles



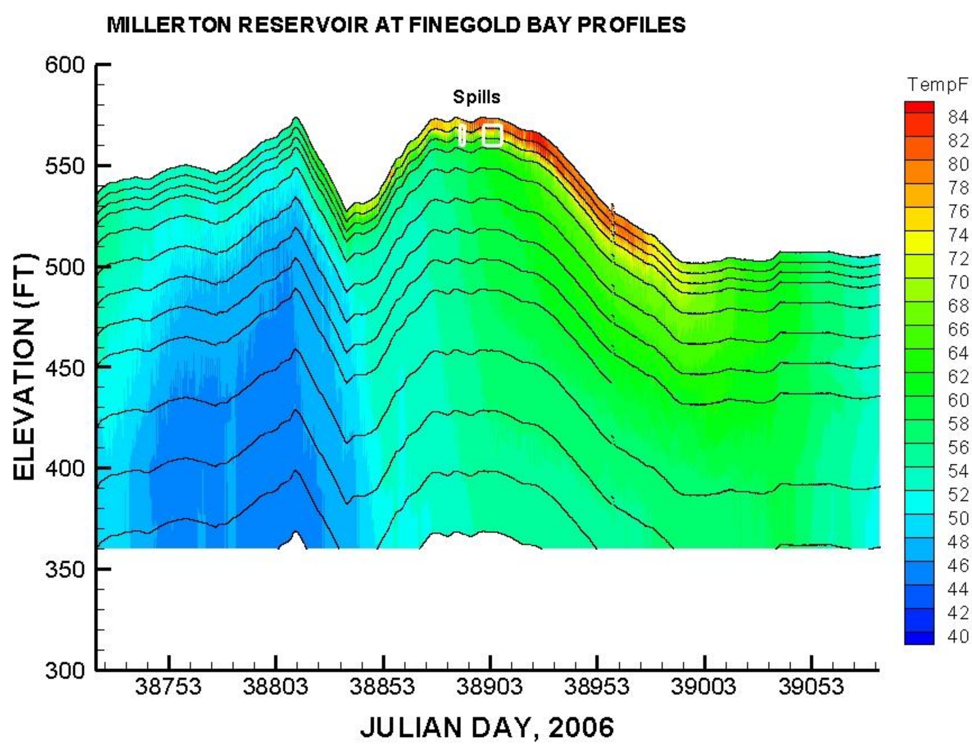
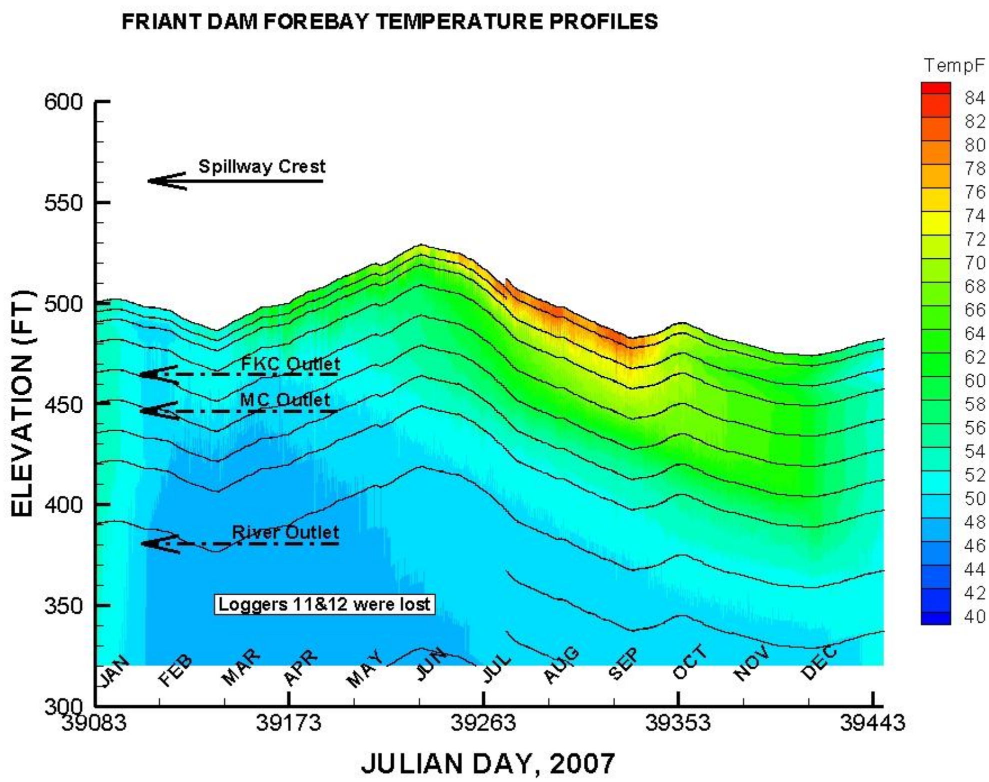


Figure A-14-3.
2006 Millerton Reservoir Temperature Profiles



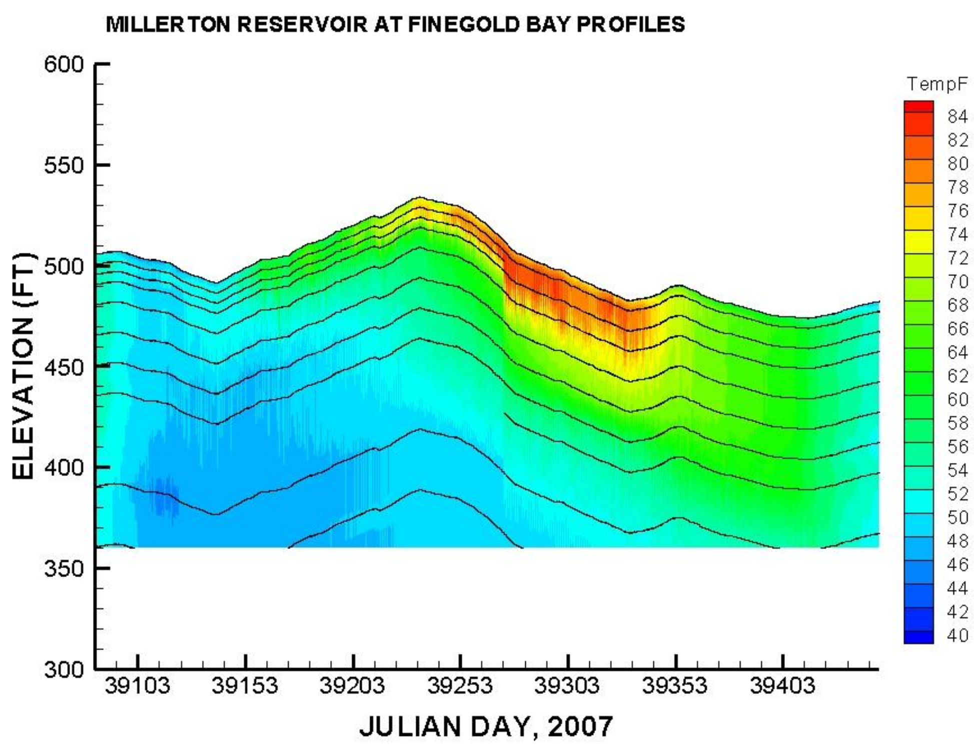
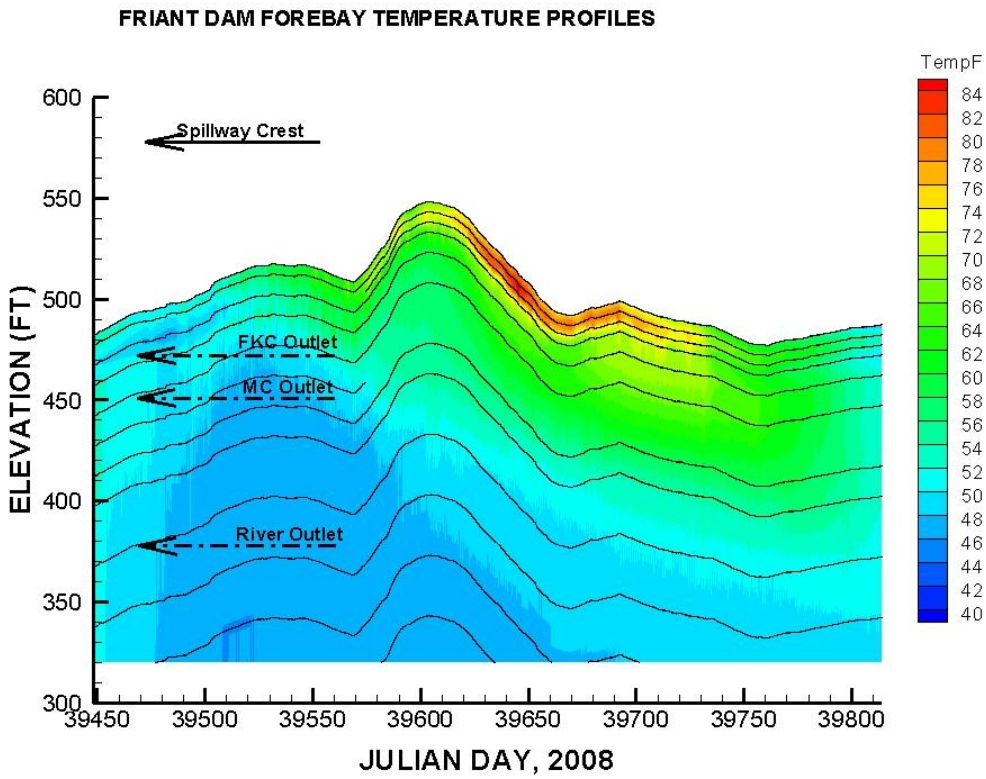


Figure A-14-4.
2007 Millerton Reservoir Temperature Profiles



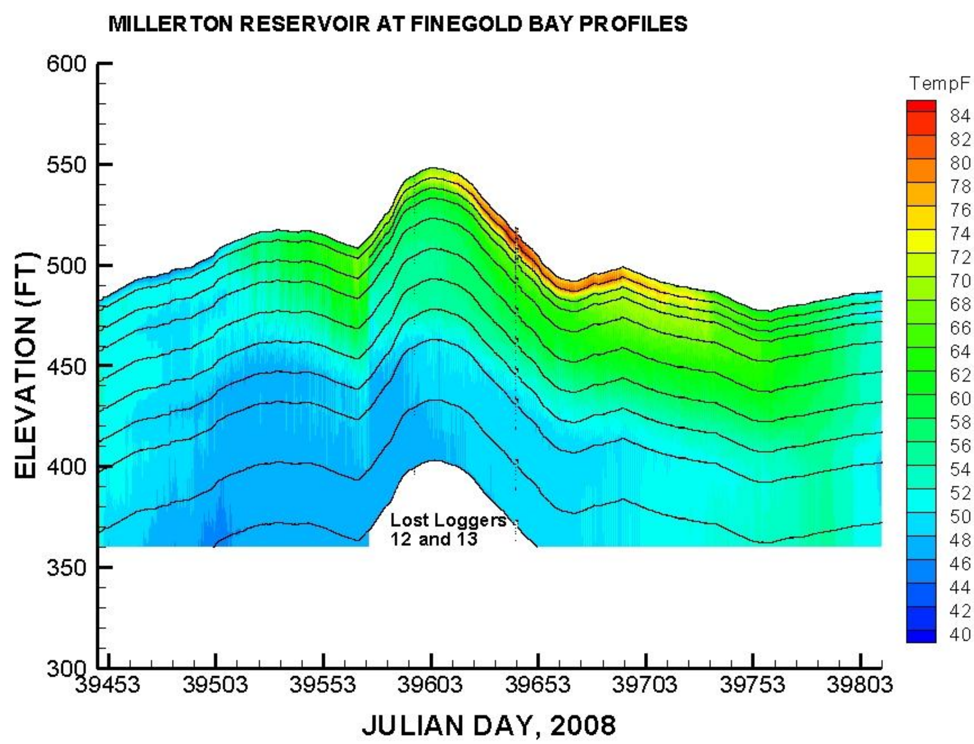
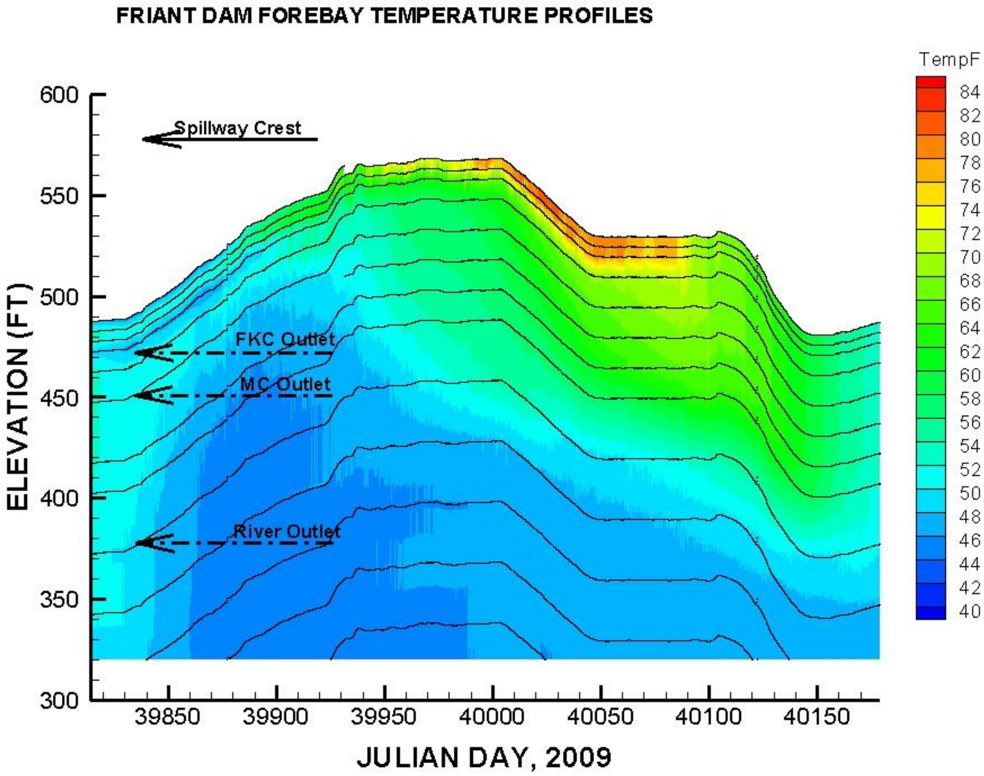


Figure A-14-5.
2008 Millerton Reservoir Temperature Profiles



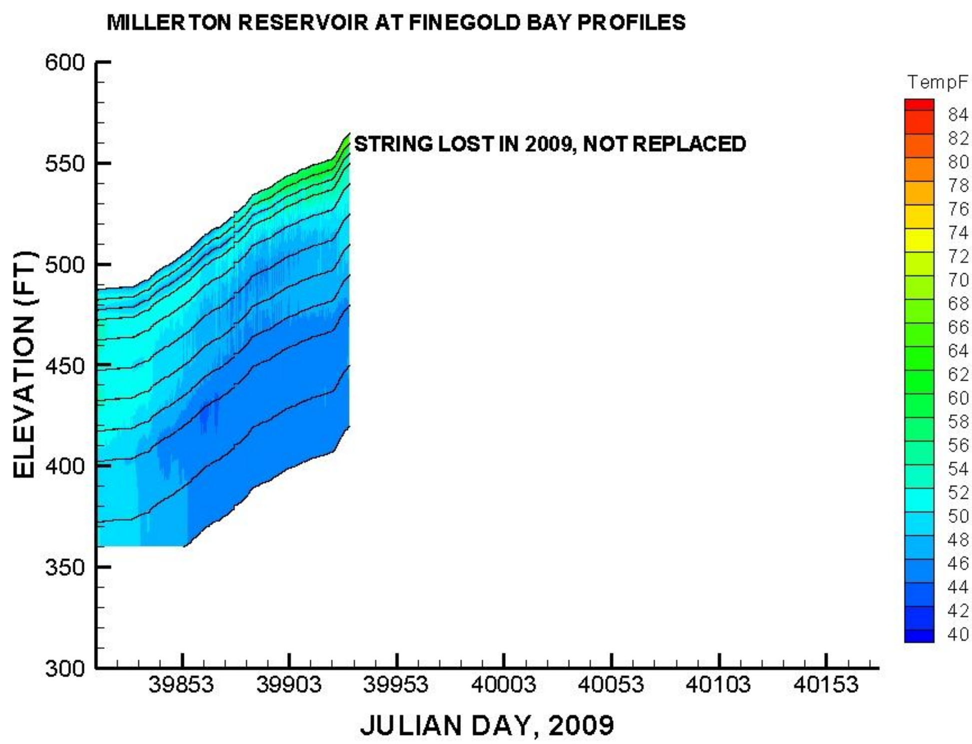


Figure A-14-6.
2009 Millerton Reservoir Temperature Profiles

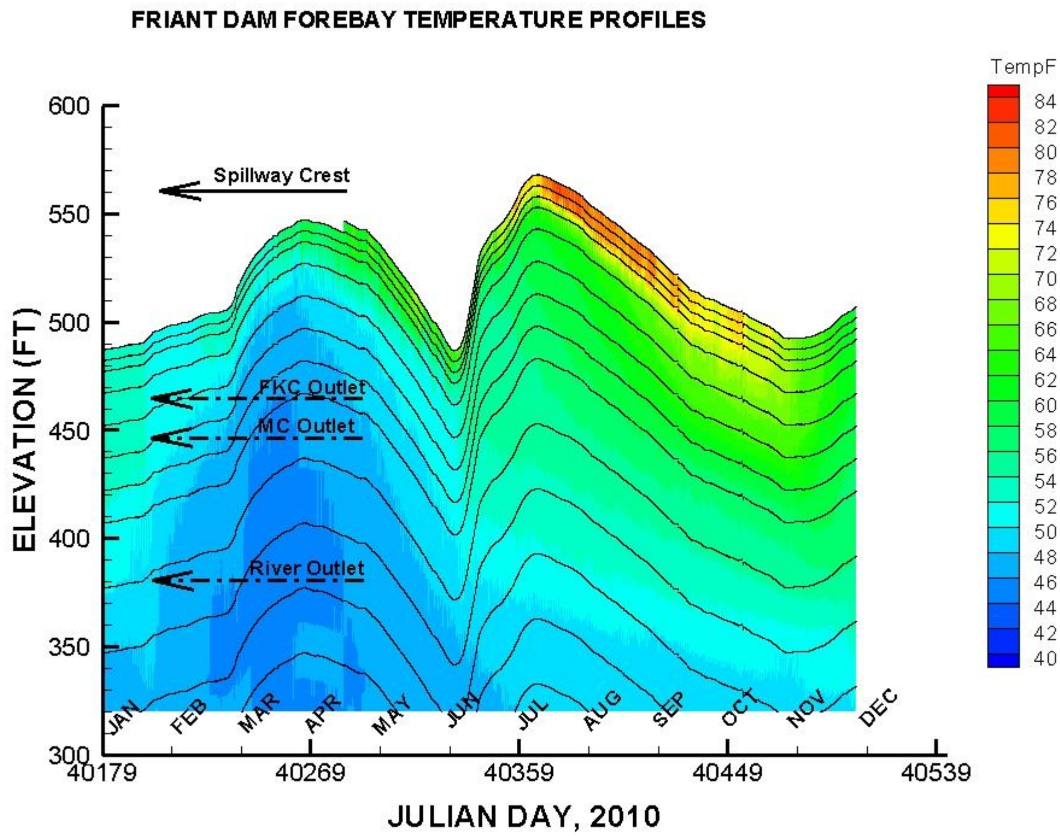


Figure A-14-7.
2010 Millerton Reservoir Temperature Profiles

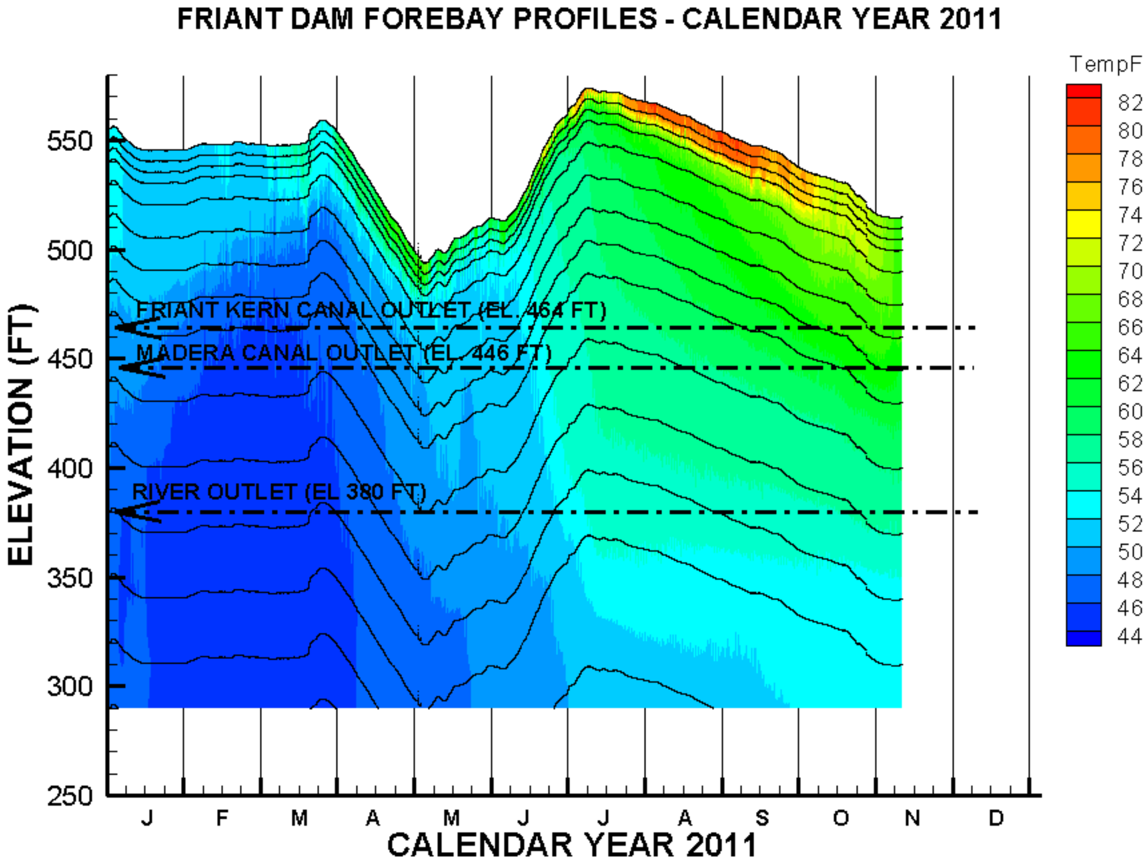


Figure A-14-8.
2011 Millerton Reservoir Temperature Profiles

14.4 Discussion and Conclusions

Temperature profile results indicate a relationship between high flow years (2005, 2006, 2010 Interim Flows) and the hypolimnetic temperatures in Millerton Reservoir. When flood releases are made through the river outlets (elevation 380 feet) the coldest water is released and it is replaced by San Joaquin River inflows to Millerton Reservoir. By late May and early June San Joaquin River inflows to Millerton Reservoir warm and cause warmer river outlet release temperatures. 2005 flood releases began in mid-April and river outlet releases temperatures exceeded 50 °F on May 25, 2006 flood releases began in early April and river outlet releases temperatures exceeded 50 °F on May 9, 2006. During 2010 Interim Flow releases the river outlet releases temperature exceeded 50 °F on June 8, 2010.

The cold water depletion timing differences between these high flow years corresponds to differences in river outlet release timing. When deliveries to the higher elevation Friant-Kern and Madera Canals outlets are insufficient to maintain flood control storage, Reclamation releases floodflows from the cold water pool through the river outlet. Flood releases over the spillway are much warmer because this water comes from the reservoir surface.

14.5 References

EPA. *See* U.S. Environmental Protection Agency.

Fry, F.E.J. 1971. The effects of environmental factors on the physiology of fish. Pp. 1–98 in W.S. Hoar and D.J. Randall, editors. Fish Physiology. Academic Press, New York.

Myrick, C. A., and J.J. Cech, Jr. 2001. Temperature effects on Chinook salmon and steelhead: a review focusing on California's Central Valley populations. Technical Publication 01-1. Published electronically by the Bay-Delta Modeling Forum at http://www.sfei.org/modelingforum/.

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U.S. Environmental Protection Agency (EPA). 1999. A review and synthesis of effects of alterations to the water temperature regime on freshwater life stages of salmonids, with special reference to Chinook salmon, EPA 910-R-99-010, 279 pp.

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

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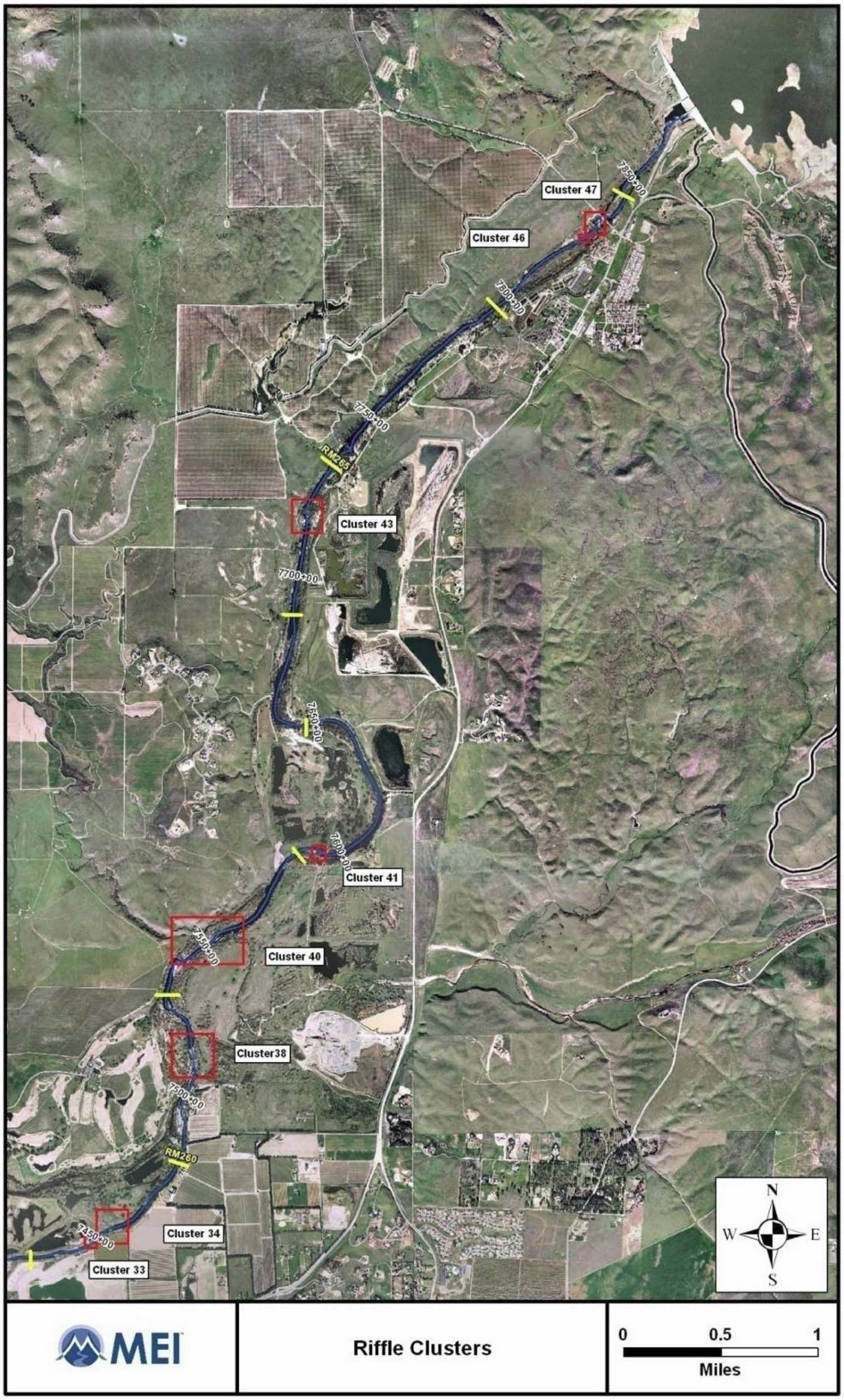
16.0 Bed Mobility: Channel Bathymetric Surveys

The data in this report were collected as part of the Reach 1A Spawning Area Mobility Study (2011 Agency Plan, Section 17 (SJRRP, 2011)). Channel topography was surveyed for building a topographic mesh for use with a flow-and-sediment transport model.

16.1 Methods

Two sites were selected for bed mobility measurements and monitoring activities (Figure A-16-1). They are located at RMs 260.7 and 261.6 and are denoted as Riffle Clusters (RC) 38 (RC38) and 40 (RC40), respectively (MEI, 2008). At each of these sites five channel-spanning cross sections were staked on both banks to stretch a tape measure across and define measurement locations. The cross sections were selected to monitor and assess the upstream pool tail (XSA), riffle head (XS1), middle riffle (XS2), riffle tail (XS3), downstream pool head (XS4), and middle pool (XS5) morphological zones (Figures A-16-2 and A-16-3).



Source: MEI 2008
Note: Sites Selected for this Study are Labeled Cluster 38 and Cluster 40.

Figure A-16-1.
Riffle Cluster Areas Where Gravel Mobilization Studies were Proposed

Figure A-16-2.
Riffle Cluster 38 Study Site's Staked Cross Sections XSA, XS1, XS2, XS3,XS4, and XS5

Figure A-16-3.
Riffle Cluster 40 Study Site's Staked Cross Sections XSA, XS1, XS2, XS3, and XS4

16.1.1 Channel Bathymetric Surveys

Ongoing surveys of the channel features were conducted to develop a topographic mesh of the study sites. The topographic mesh will be used to develop a flow-and-sediment transport model.

Topographic Surveys: The topography in and around the channel was surveyed using an RTK GPS as the primary method of horizontally and vertically surveying the site. In situations where riparian canopy cover was too dense to maintain a satisfactory signal with GPS satellites, a conventional Total Station and survey rod were used. All surveys are tied to the 2007 – 2008 established control points local to each study site. The horizontal datum used is the California Coordinate System Zone 3, U.S. Survey Feet, based on California Geodetic Coordinates of 1983, Epoch 2007.0. The vertical datum used is the NAVD 88. Existing control points are used to validate the accuracy of the data. At the beginning of a survey, several times per day, and at day’s end the accuracy of the survey readings are verified by positioning the rover on a control point to make certain that the horizontal and vertical locations are within 0.01 and 0.1 foot, respectively. Survey data presented with this report were collected from both study sites on September 2, 2010, December 2010, February 2011, and August 2011.

16.2 Results

Sufficient channel bathymetry data have been collected to develop a flow-and-sediment transport model at a resolution capable of quantifying the hydraulic parameters to the scale at which bed mobility measurements (e.g., tracer and force gaging patches) were accomplished. Future efforts at surveying the channel for this purpose are anticipated to be much more limited, if at all necessary.

16.3 References

Mussetter Engineering, Inc. (MEI). 2008. DRAFT San Joaquin River Data Collection and Monitoring Plan, prepared for California Department of Water Resources, August 27, 31 pp.

SJRRP. *See* San Joaquin River Restoration Program.

San Joaquin River Restoration Program (SJRRP). 2011a. 2011 Agency Plan. Available at <www.restoresjr.net>.

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17.0 Bed Mobility: Cross Section Surveys

The data in this report were collected as part of the Reach 1A Spawning Area Mobility Study (2011 Agency Plan Section 17 (SJRRP, 2011)). To validate a channel evolution model the channel geometry was monitored with repeat cross-sectional surveys of the channel.

17.1 Methods

See the report titled "Bed Mobility: Channel Bathymetric Surveys" (Section 16.0) for information about location and configuration of the study sites.

17.1.1 Channel Evolution Monitoring (Cross Section Surveys)

Repeated cross-sectional surveys were performed to monitor change in bed elevation and location of the banks. Each monitoring event followed a high-flow event such as the January 5, 2011, 7,080 cfs peak flow; and the July 7, 2011, 8,600 cfs peak flow. Topography along monumented, channel-spanning cross sections was surveyed using an RTK GPS and methodology described under "Channel Bathymetric Surveys: Topographic Surveys" (Figure A-17-1).

Note: The yellow tape is stretched between monument stakes on both banks and the rover rod is held plumb while placed tangential to the tape at each survey point.

Figure A-17-1.
RTK GPS Rover Used While Repeat Surveying XS1 at RC38

17.2 Results

17.2.1 Channel Evolution

Post-fall 2010, January 2011, and July 2011 peak flow topographic survey results are illustrated and compared with previous surveys in the Appendix D "Sediment." A brief summary of the observations are as follows:

- **RC38 XSA –** A minor (approximately 0.1 foot) decrease in the bed elevation is fairly consistently observed across the section after the spring and early summer 2011 high flows.

- **RC38 XS1 –** A minor (approximately 0.1 foot) decrease in the bed elevation is most noticeably observed along the thalweg and more sporadic within the bar chute after the spring and early summer 2011 high flows.

- **RC38 XS2 –** Significant bed elevation change (on the order of 1.5 feet) is observed along the thalweg and neighboring bank. The bank has eroded by 7 feet.

- **RC38 XS3 –** Approximately 2.5 feet of bank erosion along the right bank has been measured since monitoring began in summer 2009. The majority of this bank erosion occurred after the spring – summer 2011 high flows. The stream bed in this area has been more dynamic than other areas with up to 1 foot of deposition and up to 0.5 foot of erosion. The majority of this dynamism was observed following the fall 2010 event and toward the right side of the channel. Later erosion (approximately 0.25 foot) occurred resulting from the January 2011 flow and spring/summer 2011 events.

- **RC38 XS4 –** Approximately 0.25 foot of erosion occurred as a result of the spring/summer 2011 peak flows. This erosion occurred on the inside of the bend with only a slight amount (approximately 0.1 foot) occurring in the thalweg.

- **RC38 XS5 –** Monitoring began in October 2011.

- **RC40 XSA –** A slight (approximately 0.1 foot) to no erosion is observed after the spring/summer 2011 high flows.

- **RC40 XS1 –** Approximately 0.25 foot of erosion of the mid-channel bar following the fall 2010 flow event. No net change after the January 2011 event. The spring/summer 2011 high flows caused continued sporadic erosion of the mid-channel bar head and chute and significant erosion (approximately 1.0 foot) along the right side of the channel.

- **RC40 XS2 –** Minimal net change is observed with no apparent trend.

- **RC40 XS3 –** A minor amount of erosion in the main channel and along the mid-channel bar following the fall 2010 event. No net change after the January 2011 event.

- **RC40 XS4** – Observed minor (up to 0.2 foot) erosion has occurred since monitoring began in August 2010. The trend appears steady so far.

17.3 Discussion

17.3.1 Channel Evolution

The channel geometry was predominantly stable with up to 1 foot of horizontal change along small portions of the channel. Lateral movement was observed occasionally by as much as 7 feet. Typically, observed differences were on the order of a median-grain diameter and are, therefore, considered within the error of the measurement. A large amount of erosion (approximately 2.5 feet) was observed along XS3's right bank following the 700 cfs flow in fall 2010. This was likely the result of the large woody debris (LWD) upstream from XS3 deflecting flow and causing convergence in the vicinity of the right bank. However, subsequent to the removal of the LWD-heightened flows in the spring and summer of 2011 continued to erode this bank more-so than the LWD-induced erosion. In addition, the bed elevation in this area has continued to erode in this area after the LWD-induced deposition.

17.3.2 Hydraulic Change

One of the purposes of this monitoring is to evaluate the effect of interim flows on the channel geometry. But another purpose is to examine the feedback that channel change has on the hydraulics. By comparing the WSEs of similar flow levels before and after changes in the channel occurred from bed erosion and/or deposition, bank erosion, and/or removal of roughness elements (e.g., LWD, bed forms), we can begin to detect whether such changes to the hydraulics in fact occur. Several examples of hydraulic change are illuminated by doing this basic comparison (see Repeated Topographic Surveys in the Appendix D "Sediment"). For example, RC38 XS1 monitored a 264 cfs flow and a 416 cfs flow and found they had very similar WSEs. This may suggest an increase in flow velocity resulting from smoothing and/or the compensation cross-sectional area by increasing depth from bed erosion. Additional flow modeling is necessary to make a definitive conclusion on this matter. But monitoring the changes and observing such trends will assist in determining the effect of the flow alteration on aquatic habitat. As these monitored changes suggest, the development of a predictive model used to quantify channel evolution and hydraulic change under anticipated Restoration Flow scenarios should indeed be useful.

17.4 References

SJRRP. *See* San Joaquin River Restoration Program.

San Joaquin River Restoration Program (SJRRP). 2011a. 2011 Agency Plan. Available at <www.restoresjr.net>.

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18.0 Bed Mobility: Scour Chains

The data in this report were collected as part of the Reach 1A Spawning Area Mobility Study (2011 Agency Plan Section 17 (SJRRP, 2011)). To validate a channel evolution model, scour chains were installed to measure erosion and deposition associated with elevated flow events.

18.1 Methods

See the report titled “Bed Mobility: Channel Bathymetric Surveys” (Section 16.0) for information about the location and configuration of the study sites.

18.1.1 Channel Evolution Monitoring (Scour Chains)

Scour chains were installed to measure erosion and deposition that occurs during elevated flow events. Scour chains were installed within 30 feet upstream from RC38’s XS2 and XS3 in February 2011. Due to the limited time, only six chains were installed; three at both cross sections. These two cross sections were selected due to previously observed bed elevation changes. Later, in fall 2011, additional scour chains were installed at RC38’s XSA, XS1, XS4, and XS5. These were installed within 10 feet downstream from the associated cross sections. Each scour chain was hammered 2 to 2.5 feet into the substrate, clasped with a hog ring or zip-tie at the link closest to the bed surface, surveyed with an RTK GPS, measured from the left-bank-monumented stake, and the number of links exposed on the bed surface were counted. Locations of scour chains are illustrated in Figure A-18-1. Additionally, the scour chain locations are plotted on the repeated topographic survey cross sections for comparison of surveys with scour chain monitoring results (see Appendix D “Sediment”).

Figure A-18-1.
Scour Chain Locations at RC38 as of December 2011

18.2 Results

Chains at XS2 and XS3 have been monitored for scour and deposition resulting from the spring/summer 2011 high flows. Chains at other locations were installed in the fall of 2011 and therefore have not experienced scouring flow levels as of yet. The results for each scour chain are described briefly below. For further details, see the Scour Chain Monitoring Table in the Appendix D "Sediment."

- **RC38 XS2 –** Three scour chains are within the thalweg of the channel. The only chain that showed evidence of significant change is the middle of the three. It was buried with about 4 inches of sand and indicated 4 inches of gravel scour had occurred as well. The chain closest to the right bank experienced about 1 inch of gravel burial and no measureable scour. The chain closest to the bar exhibited no signs of deposition or scour.
- **RC38 XS3 –** Three scour chains are within the thalweg of the channel. The only chain that showed evidence of significant change is the one closest to the right bank. In this location the bed was scoured about 4 inches of coarse gravels. The middle chain experienced about 1 inch of gravel burial and no measureable scour. The left chain exhibited no signs of deposition or about 1 inch of scour.

18.3 Discussion

Scour chains indicate the channel geometry was predominantly stable with up to 4 inches (100 mm) of vertical change within the thalweg region. This depth corresponds well with the armor layer thickness, which is typically assumed to be approximately equal to the D_{90} of the surface grain size distribution. Therefore, the maximum depth of scour that occurred was able to mobilize the surface layer in limited areas. Interestingly, these areas exhibited greater net bed elevation changes after much lower flow levels than were experienced in the spring/summer of 2011. It is suspected that the presence of LWD during previous pulse flows was the cause of the enhanced bed erosion and deposition.

The results from the scour chains are difficult to compare with the net changes observed from the repeated topographic surveys collected after the corresponding spring/summer 2011 peak flows. The fact that the cross-sectional plots are skewed is due to the use of easting position measurements on the horizontal axis. This is because the scour chains are as much as 20 feet upstream from the cross section and the channel does not run truly north-south through the cross sections. Future efforts will be made to line up the chain’s location with a more comparable position along the cross section. However, there are also local differences in bed topography that likely affect the comparison of bed elevation changes. For example, XS2 and XS3 have scoured out areas immediately upstream from each of them. The scoured pit upstream from XS2 along the right bank is suspected to be the result of topographic steering causing flow convergence against this bank at bank full levels. Further flow modeling may shed light on this hypothesis. Additionally, in the vicinity of XS2 there is some backwater deposition of sand and small gravels at lower flows that may not be captured to the same degree using both the scour chain and repeated topographic survey methods due to the proximity to the deposition and its local nature. The scoured pit upstream from XS3 is a remnant of the LWD previously positioned there.

The placement of additional scour chains covering a longer stretch of the study site will provide further information on the channel dynamics during pulse flows. Therefore, we have installed 15 chains at 4 other cross sections at the RC38 study site. Measurements obtained from monitoring these chains should supply information on trends as well as the extent of scour and deposition with flow levels and/or resulting from debris or other flow perturbation. This information will be used to develop a predictive channel evolution model that can quantify changes in habitat parameters (e.g., flow depth and velocity) that will occur as a result of planned Restoration Flows.

18.4 References

SJRRP. *See* San Joaquin River Restoration Program.

San Joaquin River Restoration Program (SJRRP). 2011. 2011 Agency Plan. Available at <www.restoresjr.net>.