RECLAMATION

Managing Water in the West

Delta-Mendota Canal Recirculation

Final 2008 Pilot Study Report

U.S. Department of the Interior
Bureau of Reclamation
Mid-Pacific Region
Sacramento, California

California Department of Water Resources
Sacramento, California

September 2009

This page intentionally left blank

Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

The mission of the California Department of Water Resources is to manage the water resources of California in cooperation with other agencies, to benefit the State's people, and to protect, restore, and enhance the natural and human environments.

Delta-Mendota Canal Recirculation

Final 2008 Pilot Study Report

Prepared for the Bureau of Reclamation by URS Corporation under Contract No. 06CS204097A

U.S. Department of the Interior
Bureau of Reclamation
Mid-Pacific Region
Sacramento, California

September 2009

This page intentionally left blank

Contents

Tables

Figures

Appendices

Abbreviations and Acronyms

μg/L	microgram(s) per liter
cfs	cubic foot (feet) per second
mg/L	milligram(s) per liter
mL	milliliter(s)
ng/L	nanogram(s) per liter

AWQC	ambient water quality criteria
Banks Pumping Plant	Harvey O. Banks Pumping Plant
Basin Plan	*Water Quality Control Plan for the Sacramento and San Joaquin River Basins* (CVRWQCB 2007a)
BOD	biological oxygen demand
CALFED	CALFED Bay-Delta Program
CDEC	California Data Exchange Center
CVP	Central Valley Project
CVRWQCB	Central Valley Regional Water Quality Control Board
D-1641	State Water Resources Control Board Water Rights Decision 1641
Delta	Sacramento-San Joaquin River Delta
DMC	Delta-Mendota Canal
DO	dissolved oxygen
DWR	California Department of Water Resources
EC	electrical conductivity
EPA	U.S. Environmental Protection Agency
Hg	mercury
ID	Irrigation District
Jones Pumping Plant	C.W. “Bill” Jones Pumping Plant
LCS	laboratory control sample
MB	method blank
MCL	maximum contaminant level
MP	milepost
MPN	most probable number
MS	matrix spike
MSD	matrix spike duplicate
ng/L	nanogram(s) per liter
NTU	nephelometric turbidity unit(s)
NW DS	Newman Wasteway downstream
QA	quality assurance

QAPP	Quality Assurance Project Plan
QC	quality control
Reclamation	Bureau of Reclamation
RPD	relative percent difference
SCL	San Joaquin River at Crows Landing
SD	sample duplicate
SJR	San Joaquin River
SJR DS	San Joaquin River downstream
SJR US	San Joaquin River upstream
SWP	State Water Project
TKN	total Kjeldahl nitrogen
TMDL	total maximum daily load
TOC	total organic carbon
TSS	total suspended solids
URS	URS Corporation
Wasteway	Newman Wasteway
WQO	water quality objective

Chapter 1 Introduction

The U.S. Department of the Interior, Bureau of Reclamation (Reclamation) is evaluating the feasibility of using a recirculation strategy to reduce salinity and improve flows in the lower San Joaquin River (SJR). Specifically, Reclamation is evaluating the feasibility of the Delta-Mendota Canal (DMC) Recirculation Project, which involves recirculating water from the Sacramento-San Joaquin River Delta (Delta) through the Central Valley Project (CVP) pumping and conveyance facilities to the SJR, upstream from Vernalis, the point at which SJR enters the Delta. Newman Wasteway is a CVP conveyance pathway between the DMC and the SJR. The purpose of recirculation is to provide greater flexibility in meeting existing water quality standards and flow objectives while reducing water demands from New Melones Reservoir.

A recirculation pilot study was conducted from July 29 to September 15, 2008. The study was conducted by URS Corporation (URS) on behalf of Reclamation and in collaboration with the California Department of Water Resources (DWR) and local water agencies.

The purpose of the 2008 Pilot Study was to evaluate the local and downstream impacts and benefits of recirculation at SJR confluence with Newman Wasteway and to provide information about the potential for recirculation to serve Reclamation's commitment to improve water quality in the lower SJR, related to the State Water Resources Control Board's Water Rights Decision 1641 (D-1641).

The recirculation study was conducted in the late summer of 2008, a dry hydrologic time of year in the SJR. The study called for a small-scale (50 to 250 cubic feet per second [cfs] flow) and short-term (7 weeks duration) implementation of recirculation. The 2008 Pilot Study used continuous logging instrumentation to gather real-time data to track water quality changes during the course of the study. The additional flows to the SJR from recirculation were intended to increase flow and improve water quality at Vernalis.

1.1 Background

Recirculation is recognized in D-1641 as a potentially useful tool to help improve overall flow and water quality in the lower SJR basin. Recirculation entails pumping CVP water from the Delta into the DMC and releasing it back into the SJR. Once in the SJR, water proceeds downstream to the Delta where it is pumped back into the DMC for release to the SJR or delivery to water contractors. Water can be diverted from the DMC into Newman Wasteway through a radial gate and then discharged into the SJR immediately upstream of the confluence with the Merced River.

Public Law 108-361 directs the Secretary of the Interior, acting through Reclamation, to include, to the maximum extent feasible, certain measures to provide flow, reduce salinity concentrations in the SJR, and reduce the reliance on New Melones Reservoir for meeting the water quality and fishery flow objectives of D-1641. The measures include a recirculation program that uses excess capacity in export pumping and conveyance facilities to achieve program objectives.

D-1641 requires Reclamation to evaluate the feasibility and impacts of recirculating water from the DMC through the Wasteway. In addition, the CALFED Bay-Delta Program (CALFED) Record of Decision calls for Reclamation to study recirculation of export water to reduce salinity and improve dissolved oxygen (DO) in the SJR. Reclamation is currently conducting a feasibility study for recirculation, as required by Public Law 108-361, D-1641, and the CALFED Record of Decision. The results of the 2008 Pilot Study will be used in support of the feasibility study.

1.2 Related Studies

The related studies of recirculation are two previous pilot studies (2004 and 2007) and the current feasibility study.

1.2.1 2004 Pilot Study

Reclamation conducted the initial recirculation pilot study in August 2004 to help meet its regulatory obligations (see **Section 1.1)** (Reclamation 2005) and to evaluate possible toxicity from the Wasteway, because higher flows had not occurred in the channel for some time. A moderate recirculation flow of 250 cfs was released and maintained for approximately 12 days. Recirculation increased flow and reduced electrical conductivity (EC) in the SJR immediately downstream of the Wasteway; however, changes at Vernalis were minimal during recirculation.

The study indicated that recirculation increased concentrations in the SJR downstream of the Wasteway in comparison to upstream concentrations for a number of constituents. The increased parameters were aluminum, metolachlor, total Kjeldahl nitrogen (TKN), phosphorous, ammonia as nitrogen, total organic carbon (TOC), total suspended sediments (TSS), and turbidity. Of these parameters, only aluminum, TSS, and turbidity remained elevated after initial Wasteway flushing. DO was decreased as a result of recirculation.

The level of turbidity exceeded the water quality objective (WQO) in the *Water Quality Control Plan for the Sacramento and San Joaquin River Basins* (Basin Plan) (CVRWQCB 2007a). TSS and turbidity effects attributable to recirculation were expected to be controllable in the future through design, structural improvements, and/or operation of the Wasteway. The cause for elevated aluminum levels was not identified but could have been the result of analytical matrix problems. Total aluminum could have been elevated and variable because of changes in TSS concentrations.

The results of the 2004 study suggested the importance of coordinating future recirculation experiments with local water district actions within the SJR basin. SJR flow downstream of the Wasteway may have been reduced due to increased riparian irrigation diversions. Close coordination with the activities of the major west-side irrigation diverters would help provide a better forecast of improvements to Vernalis water quality and flow.

1.2.2 2007 Pilot Study

Reclamation conducted a second pilot study in August through September 2007, which was a critically dry year in the San Joaquin Valley. The study evaluated the local and downstream impacts and benefits of recirculation at SJR confluence with Newman Wasteway (Reclamation 2008a). The study also provided information on the potential for recirculation to meet Reclamation's commitment to improve water quality in the lower SJR consistent with D-1641.

The study was conducted from August 15 to September 17, 2007. The recirculation was small-scale (35 to 210 cfs) and short-term (28-days). The majority of the flows were at 35 cfs, with pulse flows up to 210 cfs to clean debris. The additional flow for the SJR was intended to improve Vernalis flow and possibly provide additional flow for circulation in the southern Delta.

The results of the study indicated that recirculation through the Wasteway was effective at increasing flow and reducing electrical conductivity (EC) in the SJR immediately downstream of the Wasteway. However, the EC at Crows Landing and Vernalis did not change significantly, possibly because the flow rate and duration of the recirculation were insufficient.

Similar to the 2004 study, recirculation increased TSS and turbidity in the SJR. The results of the 2004 study showed increased concentrations of a number of constituents from recirculation, but during the 2007 study, concentrations generally decreased for all parameters except aluminum, TSS, and turbidity.

The concentrations of aluminum, TSS, and turbidity were elevated; the elevations were associated with the initial flush of the Wasteway. The elevations may have been caused by the mobilization of accumulated agricultural drainage, channel bottom sediments, vegetation, and other debris in the Wasteway.

Because the aluminum data were highly variable, it was difficult to determine whether DMC and Wasteway inputs affected the aluminum concentrations in the SJR. TSS and turbidity concentrations remained elevated throughout the study, but it was not determined whether extended low flows had the potential to flush out accumulated sediment and reduce the TSS and turbidity impacts of recirculation.

The 2007 study provided an opportunity to investigate various water-quality control measures during the initiation of recirculation because of a buildup of vegetation and debris in the Wasteway. The 2007 study also conducted water column and sediment toxicity measurements. Potentially, TSS and turbidity impacts could be reduced through changes in operations.

1.2.3 Recirculation Feasibility Study

Reclamation is currently conducting a recirculation feasibility study in collaboration with DWR, U.S. Fish and Wildlife Service, National Oceanic Atmospheric Administration National Marine Service Fisheries (NOAA Fisheries), and the California Department of Fish and Game. The Initial Alternatives Information Report (IAIR) for the feasibility study has been completed (Reclamation 2007). It is not a decision document but presents a recommendation for further analysis of several alternatives. The Plan Formulation Report (PFR) for the feasibility study is currently being prepared and is scheduled for release in 2009 (Reclamation in press).

In 2008, the Fisheries Technical Working Group prepared a Fisheries Technical Memorandum (FTM) that contains information about the life history of species that would be affected by recirculation and a description of different approaches to evaluating the effects of recirculation on aquatic resources (ENTRIX 2008). Information from the FTM will assist Reclamation and DWR evaluate the potential recirculation impacts to aquatic resources during the pilot recirculation.

1.3 Purpose

The 2008 Pilot Study was designed to gain a better understanding of recirculation through the Wasteway and improve flow and water quality conditions at the Vernalis compliance monitoring station.

Secondary purposes of the study were to evaluate the utility of recirculation in conjunction with temporary barrier gate operations in the southern Delta and examine if the study could benefit irrigated agriculture. Given the unusually low flow conditions in the SJR in the late summer of 2008, recirculation was expected to improve flow conditions and water quality, as measured at the Vernalis compliance monitoring station, and in turn, have a beneficial impact in the southern Delta.

1.4 Pilot Study Objectives

The objectives of the 2008 Pilot Study were to:

- Calculate the loss of flow in the Wasteway between the DMC and the confluence with the SJR
- Assess any impact of the recirculated flow on SJR flow, as measured at the Vernalis compliance monitoring station
- Monitor the quality of the recirculated water as it is diverted from the DMC through the Wasteway and discharged into the SJR
- Evaluate the water quality impacts of recirculation at locations downstream of the Wasteway
- Evaluate the potential toxicity of sediments mobilized in the Wasteway as a result of recirculation flows if flushed into the SJR

1.5 Organization of the Pilot Study Report

The 2008 Pilot Study report is organized as follows:

- Chapter 1 describes the purpose and objectives of the Pilot Study; highlights relevant studies; and describes the organization of the report.
- Chapter 2 describes the study design and data quality assurance.
- Chapter 3 describes the monitoring results; including field observations and continuous monitoring, discrete sample, and toxicity results.
- Chapter 4 provides an analysis of the SJR and south Delta response to recirculation and describes the geological/structural and habitat evaluation of the Wasteway.
- Chapter 5 summarizes the findings of the Pilot Study.
- Chapter 6 provides a list of references.

Supporting data and other relevant information is provided in the following appendices:

- **Appendix A**: Quality Assurance Project Plan
- **Appendix B**: Quality Assurance Summary Reports
- **Appendix C**: Laboratory Reports
- **Appendix D**: Flow Calibration
- **Appendix E**: Bathymetry Study
- **Appendix F**: Turbidity Transects Study
- **Appendix G**: Additional Water Quality Tables and Figures
- **Appendix H**: Geotechnical and Structural Report
- **Appendix I**: Biological Report

Chapter 2
Project Description

This section describes the study design, including the monitoring locations and the water quality parameters that were monitored, the flow release and monitoring schedules, and the quality assurance/quality control (QA/QC) procedures.

2.1 Study Design

The 2008 Pilot Study was conducted between July 29 and September 15, 2008. Water was diverted into the Wasteway from the DMC, which connects to the SJR. This water could potentially be recaptured at the C.W. “Bill” Jones Pumping Plant (Jones Pumping Plant), formerly Tracy Pumping Plant, for delivery via the DMC to contactors within the CVP.

To offset possible conveyance losses incurred by diverting DMC water into the Wasteway, CVP contract allocations south of the Delta were satisfied using the Joint Point of Diversion at the Harvey O. Banks Pumping Plant (Banks Pumping Plant).

2.1.1 Setting

The DMC is on the western side of California’s San Joaquin Valley. It runs for approximately 120 miles, beginning near Tracy at the southern edge of the Delta and terminating at the Mendota Pool on the SJR, at Mendota. The DMC is part of the CVP Delta export facilities, which also includes Jones Pumping Plant as well as Westley, Newman, Volta, and Firebaugh wasteways.

Newman Wasteway is a deep channel that connects the DMC to the SJR. It is designed to contain operational spills from the DMC during routine and emergency maintenance. The headgate of Newman Wasteway is located just upstream of Check 10 at milepost (MP) 54.38 of the DMC. The Wasteway flows from west to east and discharges to the SJR 1.24 miles upstream of the Merced River confluence.

The Wasteway is 8.2 miles long; the upper 1.5 miles is lined with concrete and the remainder is unlined. The design capacity of the Wasteway is 4,300 cfs to allow for emergency dewatering of the DMC; however, the typical average discharge from the Wasteway ranges from 20 to 75 cfs and is composed mostly of agricultural subsurface drainage. Twice a month, a pulse of water is discharged from the DMC into the Wasteway for 5 minutes to dislodge accumulated sediment from the headgate. See **Figure 2-1**.

2.1.2 Monitoring Locations

Sediment samples were collected at the Wasteway terminus in advance of the 2008 Pilot Study to obtain baseline toxicity data. Sediment samples were collected from the upper 2 inches of the bed of the Wasteway using a stainless steel scoop. Other sampling protocols followed those specified in DMC Recirculation's Quality Assurance Project Plan (QAPP), which is provided in **Appendix A**.

Six monitoring locations were used to track recirculation and upstream concentrations. Recirculation was tracked and sampled at five locations: one in the DMC, two in the Wasteway, and two in the SJR. Background concentrations for the SJR were also monitored upstream of the Wasteway. The monitoring locations are described in **Table 2-1**.

Flow, water quality, sediment toxicity, and water column toxicity were monitored to determine how these characteristics changed as water was released into the SJR from the DMC via the Wasteway. Water quality samples from the six monitoring locations were collected according to the schedule described in **Section 2.1.5**. When water was initially released into the Wasteway, water samples were collected in the DMC at the Wasteway headgate to measure background water quality before the quality was affected by the Wasteway. In addition, daily measurements were taken during the first 3 days of monitoring and weekly thereafter.

Physical water quality parameters (turbidity, water temperature, EC, and DO) were measured continuously using water quality meters at the Wasteway downstream (NW DS), SJR upstream (SJR US), and SJR downstream (SJR DS) locations. These parameters were used as indicators to determine when the first flush of recirculation water reached the Wasteway terminus and to track changes during the course of the study.

Flow rates were measured in the Wasteway to estimate the travel time from the DMC to the SJR. Continuous flow data were collected in the Wasteway throughout the pilot study at Wasteway MP 1.14 and/or MP 6.88. Additional flow information was gathered from the California Data Exchange Center (CDEC) for flow comparisons and are discussed in **Chapter 4**.

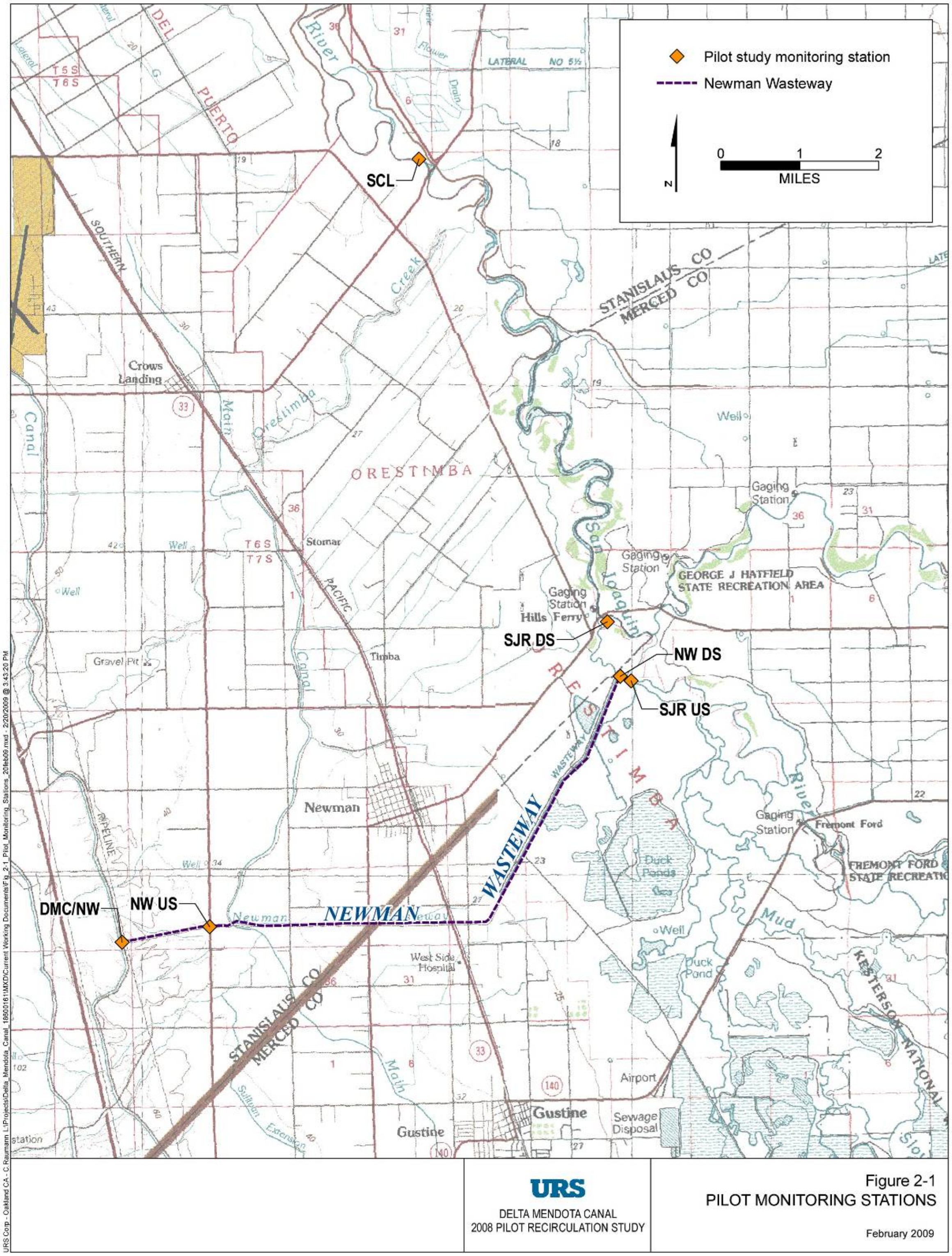


Figure 2-1. Pilot Monitoring Stations

Table 2-1. Monitoring Locations

Site Name	Abbreviation	Latitude	Longitude	Description
DMC at Newman Wasteway	DMC/NW	37.29082°N	121.08768°W	DMC above the Newman Wasteway headgate
Newman Wasteway upstream	NW US	37.29333°N	121.06757°W	Newman Wasteway 1.14 miles downstream of the headgate
Newman Wasteway downstream[1,2]	NW DS	37.33766°N	120.97234°W	Newman Wasteway approximately 100 yards upstream of discharge point to San Joaquin River
San Joaquin River upstream	SJR US	37.33678°N	120.96983°W	San Joaquin River 500 feet upstream of the confluence with Newman Wasteway
San Joaquin River downstream[3]	SJR DS	37.34772°N	120.97501°W	San Joaquin River approximately 1 mile downstream of the confluence with Newman Wasteway and before the confluence with Merced River
San Joaquin River at Crows Landing	SCL	37.43325°N	121.01595°W	San Joaquin River at Crows Landing Gauge

Note: Datum is World Geodetic System 1984

[1] The NW DS water quality monitoring station was located at approximately MP 8.16 (37.33766°N, 120.97234°W).

[2] The NW DS flow monitoring station was located at MP 6.88 (37.32048°N, 120.98289°W).

[3] The SJR DS location was relocated to 37.34753°N, 120.97536°W on September 3 because the California Department of Fish and Game installed a fish barrier at SJR DS. The YSI water quality meter stationed at SJR DS was relocated approximately 100 feet upstream of the barrier to avoid interference associated with the barrier or the barrier installation process.

DMC/NW = Delta-Mendota Canal / Newman Wasteway
NW DS = Newman Wasteway downstream
NW US = Newman Wasteway upstream
SCL = San Joaquin River at Crows Landing
SJR DS = San Joaquin River downstream
SJR US = San Joaquin River upstream

2.1.3 Monitoring Parameters

Table 2-2 lists the parameters that were monitored in the 2008 Pilot Study. Dates, times, and stations are described in the sections below.

The parameters that were monitored in the 2008 study differed from those of the two previous pilot studies; changes to the parameter list were reviewed and approved by the CVRWQCB. Analytes monitored in the 2004 and 2007 studies were similar with the exception of some semi-volatile organics. The parameters in the 2008 study excluded parameters that in the 2007 study were not detected, were below water quality criteria, did not have applicable thresholds, or were lower in the Wasteway than in the SJR. The concentrations of nitrate-nitrite, phosphorus as P, and chlorophyll a were lower in the Wasteway than in the SJR during the 2007 study and were therefore not monitored in the 2008 study. Volatile and semi-volatile organics were not included in the 2008 study. Butyl benzyl phthalate, naphthalene, and caffeine do not have an applicable water quality criterion and were therefore not monitored. Bis(2-ethylhexyl)phthalate and 2,4-D were detected at concentrations well below their maximum contaminant levels (MCLs). Metolachlor was detected at concentrations well below the human health advisory concentration. S-ethyl dipropylthiocarbamate (EPTC or eptam), dimethyl tetrachloroterephthalate (DCPA or dacthal), and diethyl phthalate were detected well below their water quality criterion.

A few parameters were substituted for similar parameters. Hardness was analyzed in lieu of calcium and magnesium. Total aluminum was analyzed instead of the dissolved fraction to allow for direct comparison to the water quality criterion. Mercury was analyzed as both a total and a dissolved parameter to provide additional information and allow comparison to the criterion.

Table 2-2. Monitored Parameters, 2008 Pilot Study

Group	Parameters
Physicals	Flow Temperature Electrical conductivity (EC) Dissolved oxygen (DO) pH Turbidity
Inorganics, Metals, and Nutrients	Total suspended solids (TSS) Total organic carbon (TOC) Biochemical oxygen demand (BOD) Hardness as calcium carbonate ($CaCO_3$) Total and dissolved mercury Total selenium Dissolved arsenic Dissolved copper Total aluminum Total boron Ammonia as nitrogen Total Kjeldahl nitrogen (TKN)
Biological	*Escherichia coli* (*E. coli*)
Water toxicity	*Selenastrum capricornutum* (green algae) growth *Ceriodaphnia dubia* (water flea) survival *Pimephales promelas* (fathead minnow) survival
Sediment toxicity	*Hyalella azteca* (freshwater amphipod) survival

2.1.4 Flow Release Schedule

The flow release schedule set by Reclamation and maintained by San Luis & Delta-Mendota Water Authority during the 2008 Pilot Study is shown in **Table 2-3** and on **Figure 2-2**.

Table 2-3. Flow Releases from the Delta-Mendota Canal to Newman Wasteway During Recirculation

Date	Time (24-hour)	Release rate (cfs)	Duration (hours)
Tuesday, July 29, 2008	6:01	36	1
Tuesday, July 29, 2008	7:00	56	1
Tuesday, July 29, 2008	8:00	100	0.4
Tuesday, July 29, 2008	8:25	129	1.6
Tuesday, July 29, 2008	10:00	154	2
Tuesday, July 29, 2008	12:00	219	2
Tuesday, July 29, 2008	14:00	232	0.5
Tuesday, July 29, 2008	14:30	250	39.5
Thursday, July 31, 2008	6:00	100	174
Thursday, August 07, 2008	12:00	250	931
Monday, September 15, 2008 (end date)	7:00	0	—

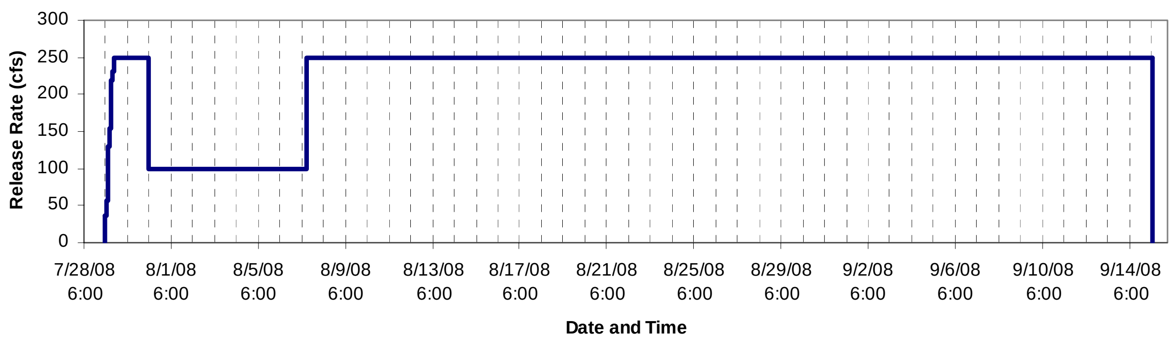


Figure 2-2. Plot of Recirculation Flow Release Schedule

2.1.5 Monitoring Schedule

An overview of the monitoring schedule for laboratory analytes is shown in **Table 2-4**, and a more detailed monitoring schedule is shown in **Table 2-5**.

Table 2-4. Overview of Monitoring Schedule for Laboratory Analytes

Time	Frequency	Number of Samples + Quality Control Samples
Days 1 to 3	• A minimum of 1 grab sample every 6 hours at NW US, NW DS, SJR US, and SJR DS, starting with time zero as background • Samples every 24 hours at DMC/NW and SCL starting with time zero • More frequently as turbidity changed significantly	73 + 8 duplicates, 4 blanks
Day 5 or 6	One sample at all six sites	6 + 0 duplicates, 0 blanks
Weeks 2, 3, 4, 5, 6, and 7	One sample each week at all six sites	36 + 4 duplicates, 3 blanks
	Total	115 + 12 duplicates, 7 blanks

DMC/NW = Delta-Mendota Canal / Newman Wasteway
NW DS = Newman Wasteway downstream
NW US = Newman Wasteway upstream
SCL = San Joaquin River at Crows Landing
SJR DS = San Joaquin River downstream
SJR US = San Joaquin River upstream

Table 2-5. Detailed Monitoring Schedule and Measured Parameters by Monitoring Location

Continuous Meters/ Grab Sampling	Day/ Week	Time (24-hour)	DMC/NW	NW US	NW DS	SJR US	SJR DS	SCL
Continuous meters	Entire study period	All day	—	Flow,[a] temperature, EC, DO, pH, turbidity[b]	Flow,[a] temperature, EC, DO, pH, turbidity[b]	Temperature, EC, DO, pH, turbidity	Temperature, EC, DO, pH, turbidity	Temperature, EC, DO, pH, turbidity
Grab sampling	7/29/08 (Day 1)[c]	6:00 (time zero)	Physicals, inorganics, *E. coli*	Turbidity, inorganics, *E. coli*	Turbidity, inorganics, *E. coli,* water toxicity, sediment toxicity[d]	Turbidity, inorganics, *E. coli*	Turbidity, inorganics, *E. coli,* water toxicity	Turbidity, inorganics[e]
		12:00	—	Turbidity, inorganics	Turbidity, inorganics	Turbidity, inorganics	Turbidity, inorganics	—
		18:00	—	Turbidity, inorganics	Turbidity, inorganics	Turbidity, inorganics	Turbidity, inorganics	—

Table 2-5. Detailed Monitoring Schedule and Measured Parameters by Monitoring Location

Continuous Meters/ Grab Sampling	Day/ Week	Time (24-hour)	DMC/NW	NW US	NW DS	SJR US	SJR DS	SCL
Grab sampling (cont.)	7/29/08 (Day 1) [c] (cont.)	22:00	—	Turbidity, inorganics	Turbidity, inorganics, water toxicity	Turbidity, inorganics	Turbidity, inorganics, water toxicity	—
	7/30/08 (Day 2)[c]	0:00	—	Turbidity, inorganics	Turbidity, inorganics, water toxicity	Turbidity, inorganics	—[f]	—
		2:00	—	—	Turbidity, inorganics	Turbidity, inorganics	Turbidity, inorganics, water toxicity	—
		6:00	Physicals, inorganics, *E. coli*	Turbidity, inorganics, *E. coli*	Turbidity, inorganics, *E. coli*	Turbidity, inorganics, *E. coli*	Turbidity, inorganics[g]	Turbidity, inorganics[h]
		9:00	—	Turbidity, inorganics	Turbidity, inorganics	Turbidity, inorganics	Turbidity, inorganics	—
		12:00	—	Turbidity, inorganics	Turbidity, inorganics	Turbidity, inorganics	Turbidity, inorganics	—
		16:00	—	Turbidity, inorganics	Turbidity, inorganics	Turbidity, inorganics	—[f]	—
		18:00	—	Turbidity, inorganics	Turbidity, inorganics	Turbidity, inorganics	Turbidity, inorganics	—
	7/31/08 (Day 3)	0:00	—	Turbidity, inorganics	Turbidity, inorganics	Turbidity, inorganics	Turbidity, inorganics	—
		6:00	Physicals, inorganics, *E. coli*	Turbidity, inorganics, *E. coli*	Turbidity, inorganics, water toxicity	Turbidity, inorganics	Turbidity, inorganics, *E. coli*, water toxicity	Turbidity, inorganics
		12:00	—	Turbidity, inorganics	Turbidity, inorganics	Turbidity, inorganics	Turbidity, inorganics	—
		18:00	—	Turbidity, inorganics	Turbidity, inorganics	Turbidity, inorganics	Turbidity, inorganics	—

Table 2-5. Detailed Monitoring Schedule and Measured Parameters by Monitoring Location

Continuous Meters/ Grab Sampling	Day/ Week	Time (24-hour)	DMC/NW	NW US	NW DS	SJR US	SJR DS	SCL
Grab sampling (cont.)	7/31/08 (Day 3) (cont.)	24:00	—	Turbidity, inorganics	Turbidity, inorganics	Turbidity, inorganics	Turbidity, inorganics	—
	8/1/08 (Day 4)	No specific time of day	Physicals, inorganics	Turbidity, inorganics	Turbidity, inorganics	Turbidity, inorganics	Turbidity, inorganics	Turbidity, inorganics
	8/4/08 (Day 7)	No specific time of day	Physicals, inorganics	Turbidity, inorganics	Turbidity, inorganics	Turbidity, inorganics	Turbidity, inorganics	Turbidity, inorganics
	Weeks 2, 3, 4, 5, 6, and 7	No specific time of day	Physicals, inorganics	Turbidity, inorganics	Turbidity, inorganics	Turbidity, inorganics	Turbidity, inorganics	Turbidity, inorganics

For physical, inorganic, water toxicity and sediment toxicity parameters, see **Table 2-2**.

[a] Flow at NW US station (MP 1.14) was determined by measurement from a 15 psig in-situ Aqua Troll from August 4 to August 11. Flow at the NW DS flow station (MP 6.88) was determined by measurement from a Marsh McBirney FloDar from July 24 to August 11 and an in-situ Aqua Troll from August 11 to September 15. Due to issues with debris, the 5 psig In-Situ Troll pressure sensor deployed at the NW US location during the entire 2008 pilot study did not record trustworthy data (see **Appendix D**).

[b] Temperature, EC, DO, pH, and turbidity were recorded by a YSI 6920 sonde at the NW US station (MP 1.14) as discrete samples at the time grab samples were collected and continuously at the NW DS water quality station (approximately MP 8.16).

[c] Grab sample were collected more frequently than every 6 hours as a result of adaptive management.

[d] Sediment sample for sediment toxicity testing was collected on 7/28/08, before recirculation.

[e] The samples were collected at approximately 12:00, prior to the influence of recirculation.

[f] The scheduled samples were not collected due to time restraints.

[g] *E. coli* sample not collected because of missing bottles at field location.

[h] The samples were collected at approximately 16:00.

DMC/NW = Delta-Mendota Canal / Newman Wasteway

NW DS = Newman Wasteway downstream

NW US = Newman Wasteway upstream

SCL = San Joaquin River at Crows Landing

SJR DS = San Joaquin River downstream

SJR US = San Joaquin River upstream

Continuous logging meters (YSI 6920) were installed at four locations (NW DS, SJR US, SJR DS, and SCL) and used to collect data on temperature, EC, pH, DO, and turbidity. Data were uploaded onto laptop computers at every sampling event during the initial 3-day period and weekly thereafter. During the initial 3-day sampling, these data were monitored to determine whether additional discrete samples needed to be taken, based on turbidity.

Meters were calibrated before installation and every 12 hours during the first 3 days, when accessible. Meters were calibrated at every site visit thereafter, when accessible. (Access to the NW DS meter was limited because of excess soft sediments on the channel bed during the initial weeks of recirculation.) All calibrations were performed in accordance with manufacturer's instructions and as described in the QAPP (see **Appendix A**).

2.2 Quality Assurance/Quality Control

The Quality Assurance Project Plan (QAPP) (**Appendix A**) for this study was prepared by URS and submitted to the Central Valley Regional Water Quality Control Board (CVRWQCB) on July 28, 2008. The QAPP contains information on the following.

- Sample collection methods
- External quality assurance (QA) incorporation methods (blank, duplicate, spike, and reference samples)
- Sample handling and custody requirements
- Analytical methods and reporting limits
- QA acceptance criteria for precision, accuracy, and contamination
- Outlier criterion

Chemical laboratory analyses were performed by Caltest Analytical Laboratory in Napa, California. Acute and chronic toxicity tests were performed by Pacific EcoRisk in Fairfield, California. Caltest is a Reclamation-approved contract laboratory that have passed an extensive QA audit and evaluation process. Pacific EcoRisk is a National Environmental Laboratory Accreditation Program certified laboratory and has gone through an extensive QA audits but has not been audited by Reclamation.

Most analytical results included in this report meet contract laboratory internal quality control (QC) and external QA requirements for precision, accuracy, and contamination. In selected cases, data not meeting QA requirements were flagged and accepted with qualification.

The following elements related to analytical laboratory data were reviewed and are discussed below.

- Sample holding time
- Method blank (MB)
- Laboratory control sample (LCS) spike
- Sample duplicate (SD)
- Matrix spike (MS) and matrix spike duplicate (MSD)
- Field duplicate
- Field blank
- Equipment blank
- Laboratory qualifiers
- Other qualifiers

An explanation of each control element and its purpose are in the quality assurance summary reports contained in **Appendix B**. Analytical laboratory reports are in **Appendix C**. Detailed quality assurance reports are included in **Appendix B**.

2.2.1 Sample Holding Times

Several turbidity samples were analyzed outside of the holding time because of a miscommunication with the laboratory regarding the sample delivery schedule. One sample for total mercury was analyzed outside of the holding time because of laboratory oversight. These results were qualified as estimated and flagged “J” to indicate uncertainty. All other samples were prepared and analyzed within recommended holding times. Compliance with sample holding times was achieved at the 99% level.

2.2.2 Method Blanks

One MB for TOC was detected above the reporting limit. All associated samples had TOC concentrations that were more than 5 times the concentration detected in the MB, and qualification was therefore unnecessary. All other MBs were nondetect with respect to the corresponding reporting limit. Compliance with MBs was achieved above the 99% level.

2.2.3 Laboratory Control Sample Spikes

The LCS recovery for biological oxygen demand (BOD) was 0% for one QC batch; this QC batch included six parent samples collected on September 8, a duplicate sample, and a field blank. Because of the short holding time (48 hours) and the test duration (5 days), it was not possible to reanalyze sample for this constituent. These results were not reported. All other LCS recoveries were within control limits for a compliance rate of more than 99%.

2.2.4 Sample Duplicates

All SD results associated with the project samples were within control limits, and a 100% level of compliance was achieved.

2.2.5 Matrix Spikes and Matrix Spike Duplicates

MS/MSD recoveries for TKN were slightly elevated relative to control limits in one QC batch. This difference was minimal and was not believed to require qualification. All other MS/MSD results associated with these samples were within control limits or had parent sample concentrations more than four times the spike concentrations, rendering the resulting recoveries not meaningful in accordance with EPA guidelines. Compliance with this metric was above 99%.

2.2.6 Field Duplicates

Twelve sets of field duplicates were collected, and relative percent differences (RPDs) were calculated to evaluate overall precision. Field duplicate results were generally in agreement with project criteria. The results that did not meet the QA acceptance criteria are presented in **Table 2-6**.

2.2.7 Field Blanks

Four field blanks were collected with grab samples during the study. The field blank results were compared to the parent sample results. In a few cases, there were detections above the reporting limit, but in all but one case the parent sample result was more than 5 times the concentration in the field blank. For the one case where the field blank was at a higher concentration than the parent sample, the result was qualified as undetected and flagged “U.” All other field blank concentrations were well below the concentrations detected in the parent samples.

Table 2-6. Qualified Field Duplicates

Sample ID	Analyte	Unit	Result	Duplicate	RPD	Comment
NWUS-006	Aluminum	μg/L	210	520	85%	Results presented in this table are qualified as estimated and flagged "J" to indicate uncertainty in data tables. It is not appropriate to qualify associated sample results.
SJRDS-005	TSS	mg/L	220	120	59%	
SJRDS-005	Turbidity	NTU	200	63	104%	
SJRDS-007	Turbidity	NTU	120	170	34%	
SJRDS-007	Ammonia	mg/L	0.65	0.24	92%	
SJRDS-007	Total Hg	μg/L	0.085	0.12	34%	
SJRUS-009	Ammonia	mg/L	0.077	0.33	107%	
NWUS-013	Total Hg	μg/L	0.0038	0.0026	38%	
NWUS-013	TKN	mg/L	0.35	0.11	104%	
SJRUS-019	TSS	mg/L	34	15	78%	
NWUS-023	Aluminum	μg/L	160	370	79%	
NWUS-023	Total Hg	μg/L	0.0014	0.0047	108%	

$$RPD = \frac{|Original - Duplicate|}{(Original + Duplicate)/2} * 100$$

μg/L = microgram(s) per liter
mg/L = milligram(s) per liter
Hg = mercury
NTU = nephelometric turbidity unit(s)
RPD = relative percent difference
TKN = total Kjeldahl nitrogen
TSS = total suspended solids

2.2.8 Equipment Blanks

Three equipment blanks were collected with grab samples during the study. One of the equipment blanks was not included on the chain-of-custody form and was not analyzed. In a few cases, there were detections above the reporting limit, but in all but one case the parent sample result was more than 5 times the concentration in the equipment blank. For two parameters, the equipment blank associated with one sample was at a higher concentration relative to the parent sample, and the results were qualified as undetected and flagged "U." All other equipment blank concentrations were well below the concentrations detected in the parent samples.

2.2.9 Laboratory Qualifiers

The laboratory reported all data to the method detection limit. For the detections between the reporting limit and the method detection limit, the laboratory flagged the results with a "J" to indicate uncertainty associated with the results.

2.2.10 Other Qualifiers

One dissolved mercury sample had a pH higher than 2. This result was qualified as estimated and flagged "J" to indicate uncertainty.

2.2.11 Toxicity Tests

Survival was acceptable (90% or above in the controls) for all reference toxicity tests. Reference toxicants were within ± 2 standard deviations of the previous 20 reference tests conducted by the laboratory for all species. Water quality elements were also within QC limits for all toxicity tests performed. The toxicity test results were acceptable without qualification.

Chapter 3
Monitoring Results

3.1 Field Observations

Field observations were made several times daily at each monitoring station during the first 3 days of the pilot study and weekly thereafter. Newman Wasteway accepts drainage from nearby agricultural properties, which were observed to be intermittently draining into the Wasteway throughout the study.

Flow releases increased the stage of the water, which inundated the vegetated banks along the Wasteway. The increased flow displaced large amounts of vegetation from the banks and bed, built-up debris throughout the Wasteway, and existing beaver dams. The increased flows also transported sediments as visibly noted by very turbid water. Photographs of the Wasteway are provided in **Appendices H and I**.

Early flow increases resulted in as much as 1 foot of accumulated soft sediments being flushed out at the NW DS site where the continuous data logging meter (YSI) was deployed, near the confluence with the SJR. However, additional soft sediments (8 to 10 inches) began to be re-deposited in the area near the completion of the study.

Suspended sediments were carried downstream of the confluence of the Wasteway and the SJR. Water clarity in the SJR changed markedly between SJR US and SJR DS, becoming very turbid after the confluence with the Wasteway where dense plumes of sediments were consistently observed. However, water clarity improved quickly, and no changes in turbidity were noticed farther downstream at SCL.

Throughout the study, large mats of vegetation were dislodged in the Wasteway and floated down the SJR. The vegetation mats were observed at the beginning of the study when flows began increasing in the Wasteway and continued throughout the study. There were also observations of vegetation mats upstream of the confluence of the Wasteway in the SJR.

Debris was physically removed from water quality meters and associated mounting structures at SJR DS and SJR US and from the in-situ Aqua Troll at NW DS during each sampling period. The water quality meters may have been obstructed by debris, resulting in high turbidity measurements that did not coincide with the visual observation that the turbidity was low.

A Marsh McBirney FloDar was set up at MP 6.88 on July 24 and remained there until August 11. (A gap in the flow data exists between August 3 and August 6 because the instrument was vandalized, necessitating its replacement.) After August 11, the replacement FloDar was removed for fear of further vandalism, and the in-situ Aqua Troll from MP 1.14 was moved to MP 6.88 and used for water level measurement, rated to FloDar flow. The Aqua Troll is less susceptible to vandalism because it is underwater.

On August 18, the debris mats that accumulated on the in-situ Aqua Troll at NW DS caused the Troll mounting pole to bend. On August 20, the deformed mounting pole was discovered, and the debris was removed. As a result, the Troll mounting pole was inspected weekly, and debris was removed as needed.

In September, the California Department of Fish and Game began installing a fish barrier at SJR DS. The physical barrier was constructed across the entire width of the river at SJR DS. The barrier allowed water and small debris to flow through. However, large debris built up along the upstream portion of the fish barrier. The debris was physically removed by personnel from the California Department of Fish and Game. On September 3 the YSI water quality meter stationed at SJR DS was relocated approximately 100 feet upstream of the barrier, before the completion of the barrier, to avoid any interference associated with the barrier or the barrier installation process.

On September 8, the SJR DS YSI meter was discovered to be tipped over, and the sonde was slightly buried in the sediment, which may have affected the instrument readings from the prior week. The YSI monitoring stations in the waterways were modified on September 8 to minimize the buildup of debris and to prevent tipping over.

3.2 Flow and Continuous Water Quality Measurements

Continuous metered data collected for the pilot study are presented in this section. Results include flow, turbidity, temperature, EC, pH, and DO.

3.2.1 Newman Wasteway Flow Contributions to the San Joaquin River

Continuous flow data collected at both Newman Wasteway monitoring locations are shown on **Figure 3-1**. Flow data at MP 1.14 are available for August 4 through August 11 and at MP 6.88 for July 24 through September 15. Flow data for MP 1.14 are not available after August 11 because the sensor at this location was relocated to MP 6.88 as described above and was not replaced.[1] A detailed discussion of the flow data and the flow data calibration are presented in **Appendix D**.

The flow at MP 1.14 reached approximately 300 cfs and farther downstream, it reached approximately 230 cfs. Flows at MP 6.88 were typically lower than at MP 1.14 (**Figure 3-1**). During steady-state flow (as seen after August 11), approximately 50 cfs of recirculation may have been lost in the Wasteway from infiltration. In the 2007 Pilot Study, infiltration was minimal when recirculation flow was approximately 50 cfs (Reclamation 2008a).

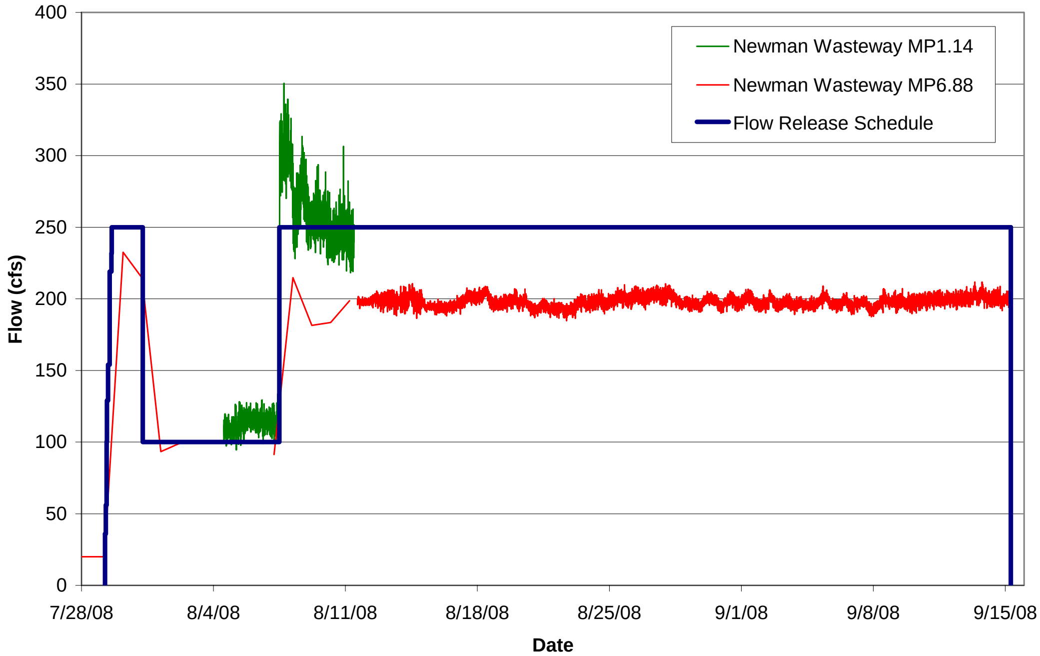


Figure 3-1. Measured Flow in Newman Wasteway Compared to Flow Release Schedule

The determination of how much time it took for water to travel from MP 1.14 to MP 6.88 was based on how long it took the increase in flow on August 7 to propagate from the upstream site to the downstream site. On August 7, flow monitoring instruments at both sites were functioning properly, making the determination possible.[2]

[1] The 5 pounds per square inch (psig) in-situ Aqua Troll pressure sensor deployed at MP 1.14 during the entire 2008 pilot study did not record reliable data because of debris. A 15-psig in-situ Aqua Troll was deployed at the site from August 4 to August 11. The data recorded by this instrument was reliable.

[2] During the other changes in water release between July 29 and August 1, the instrument at MP 1.14 was not operating correctly, so those data cannot be used to calculate travel time, leaving only the August 7 release change available for use in calculating time of travel.

The first substantial increase in flow (first flush or breakthrough flow) occurred at approximately 16 hours after the start of recirculation; before this, there was substantial pooling behind debris and beaver dams. By August 7, existing beaver dams were broken through or submerged by the water, and pooling was minimized.

On August 7, the flow monitor at MP 1.14 showed an increase at 12:10 from approximately 100 cfs to approximately 300 cfs (**Figure 3-2**). At 18:00 on the same day, the flow monitor at MP 6.88 began to show an increase in stage, representing a gradual increase from approximately 100 cfs to approximately 200 cfs (**Figure 3-3**),[3] indicating that the travel time from MP 1.14 to MP 6.88 was 6 to 9 hours under these conditions.

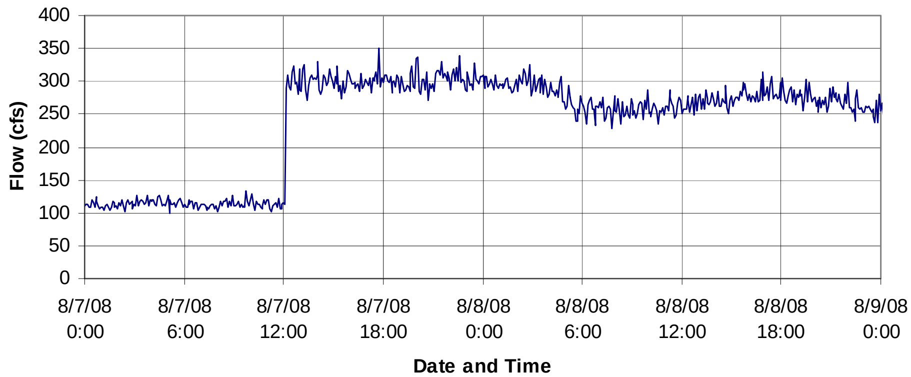


Figure 3-2. Flow at Newman Wasteway MP 1.14, 8/7/08 to 8/9/08

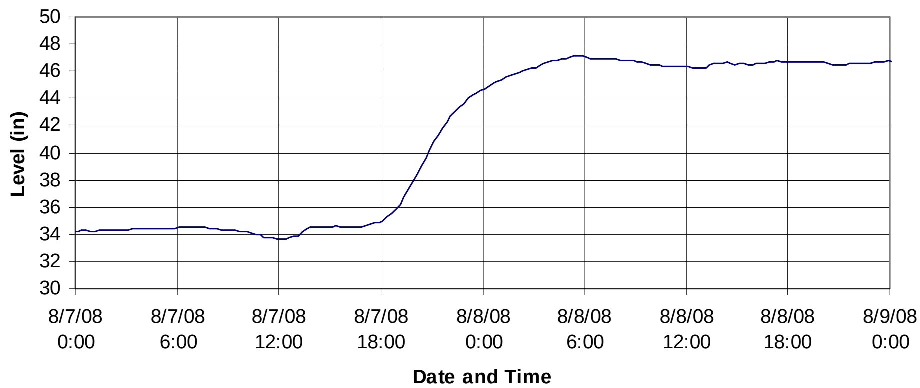


Figure 3-3. Flow at MP 6.88, 8/7/08 to 8/9/08

[3] Note that for the FloDar data, only level data (not velocity or flow data) are presented here at the original 15-minute interval sampling rate. This is because velocity data (and thus flow data) were biased by diurnal winds so that reliable flow data were available only as daily averages. Level data, however, were not biased so can be used at their original 15-minute rate, as is done here for time of travel estimation.

Continuous flow measurements at MP 1.14 and MP 6.88 recorded the response to flow in Newman Wasteway due to operational changes. Newman Wasteway bathymetry was evaluated before and after the 2008 study to investigate changes in the Wasteway bed due to recirculation flow. A detailed discussion of the investigation is provided in **Appendix E.**

3.2.2 Continuous Turbidity in the Wasteway and SJR

Continuous turbidity data were collected at SJR US, SJR DS,[4] NW DS, and SCL. These locations are shown on **Figure 2-1**.

Turbidity levels at SJR US were typically less than 75 nephelometric turbidity units (NTU) (**Figure 3-4**). Turbidity levels at SJR DS and NW DS varied substantially and reached approximately 1,300 and 1,400 NTU, respectively (**Figures 3-4** and **3-5**). Turbidity at SCL was similar to that at SJR US and ranged from about 20 to 50 NTU (**Figure 3-5**).

Turbidity exhibited a baseline diurnal cycle of about 15 to 35 NTU at the monitoring locations (**Figures 3-4** and **3-5**). At NW DS and SJR DS, the diurnal cycles were most visible after the majority of the sediment had moved through the Wasteway. The diurnal pattern for turbidity may be due to algae rising and falling in the water column on a daily basis.

Trends in turbidity are more apparent when the instantaneous data are averaged over a 6-hour period (**Figure 3-6**). Higher turbidity at NW DS and SJR DS occurred during the majority of recirculation. Turbidity measured at NW DS and SJR DS may be due to mobilized sediments in Newman Wasteway. Some sediment appears to have settled relatively quickly, as seen by fewer turbidity spikes at SJR DS compared to NW DS. Elevated turbidity was not measured at SCL.

The continuous turbidity monitoring in the Wasteway and at SJR recorded changes in turbidity due to recirculation flow. Greater increases in turbidity were observed near the SJR confluence with the Wasteway, but the downstream extent of the turbidity plume was limited as it was not observed at SCL.

Turbidity transects were conducted downstream of the Wasteway during the study to investigate the turbidity profile across the SJR and the influence of Merced River flow during recirculation. A detailed discussion of this investigation is provided in **Appendix F.**

[4]The YSI meter at SJR DS was discovered to be tipped over on September 8, and the sonde was slightly buried in the sediment, which may have affected the instrument readings from the prior week.

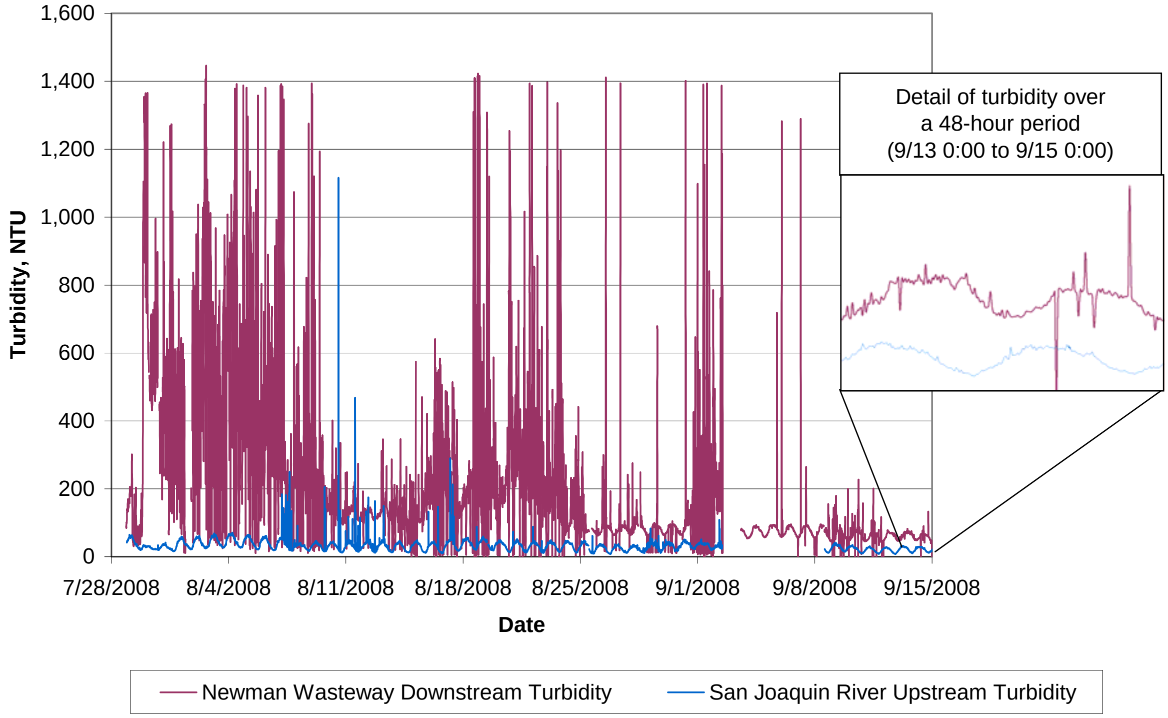


Figure 3-4. Turbidity in the San Joaquin River Upstream of Newman Wasteway and in Newman Wasteway

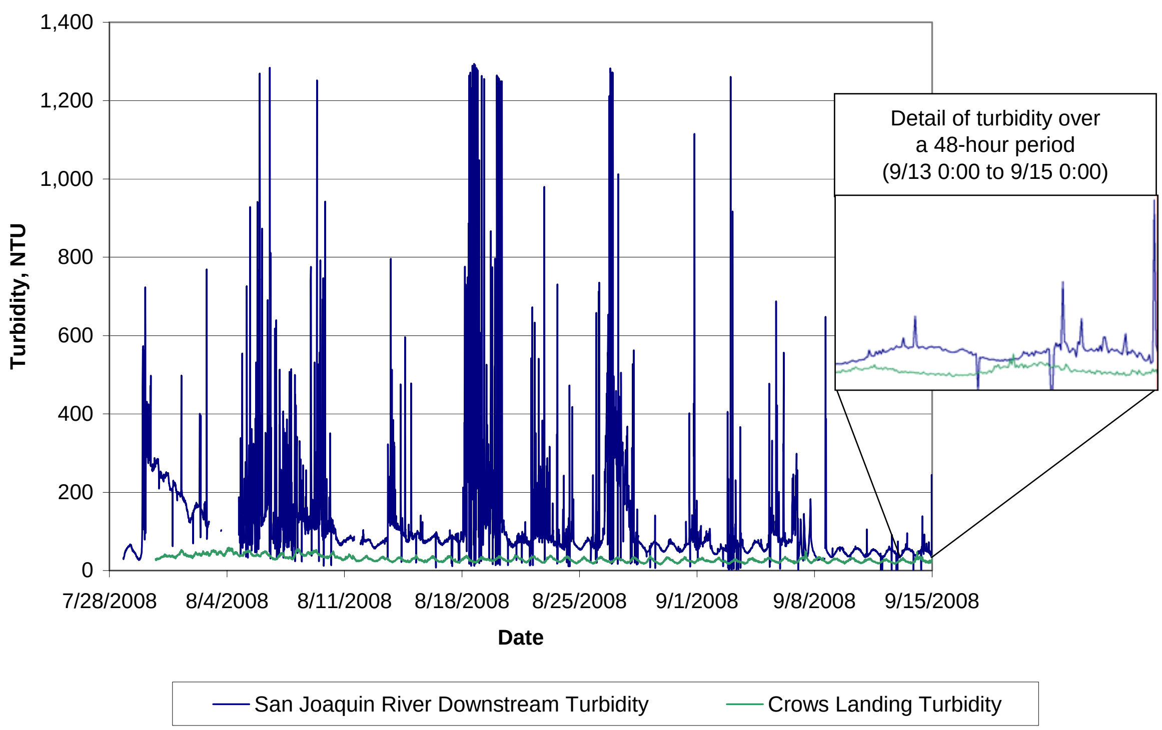
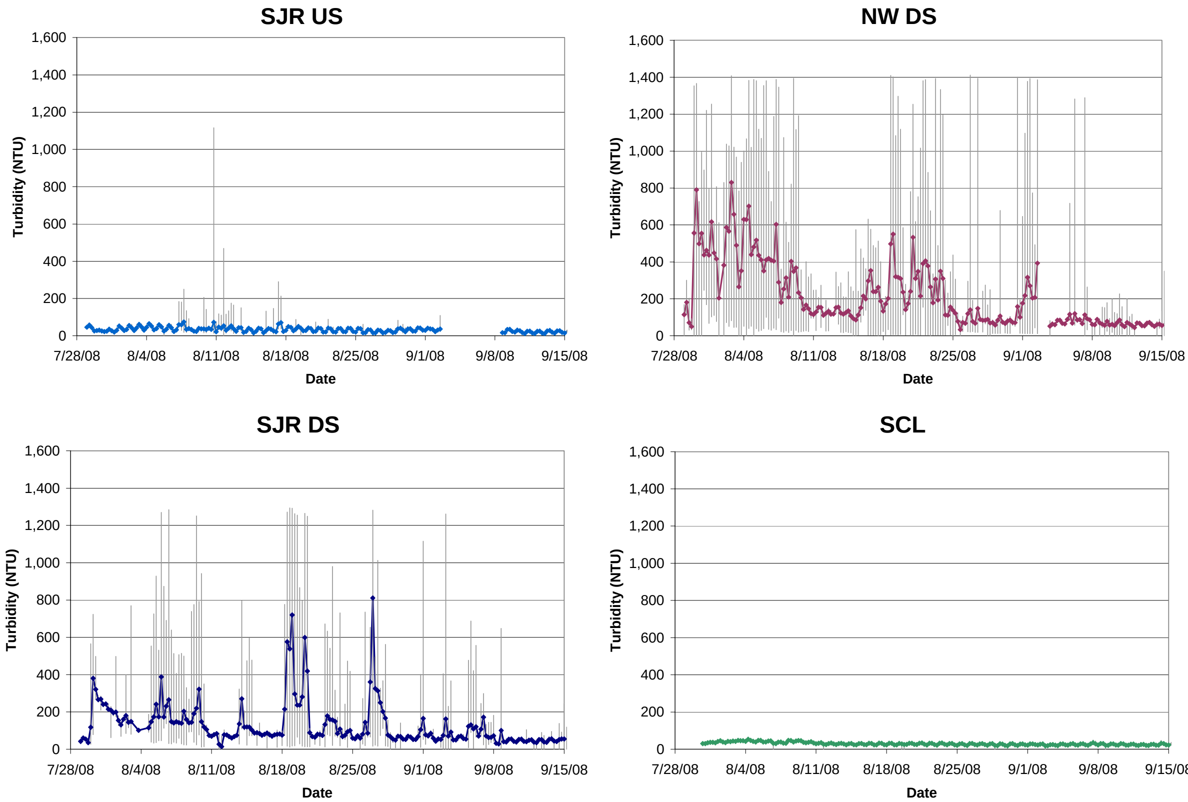


Figure 3-5. Measured Turbidity in the San Joaquin River Downstream of Newman Wasteway and at Crows Landing



Note: Error bars represent the minimum and the maximum of the measured turbidity in the 6-hour interval

Figure 3-6. Six-hour Averaged Turbidity at SJR US, NW DS, SJR DS and SCL

3.2.3 Temperatures in Newman Wasteway and San Joaquin River

Continuous temperature data measured at SJR US, NW DS, SJR DS, and SCL are presented on **Figure 3-7**. Data from SJR US were missing during the first week of September because of instrument damage.

Higher temperatures at NW DS occurred during July 29 and July 30 and may represent the temperature of the resident water in the Wasteway, which could be highly influenced by air temperature. The high temperatures could also be due to instrument malfunction or initially improper calibration (**Figure 3-7)**. A drop in temperature was recorded for all gauges on September 1. The decrease may be due to changes in weather. Water temperature recorded at SJR at Stevinson and air temperature at recorded at Mossdale Bridge also decreased during this time (CDEC 2009, data not shown).

After the first 2 days of recirculation, water temperature measured at NW DS was lower than the temperatures at the SJR monitoring locations. Temperatures at SJR DS and SCL were typically lower than temperatures at SJR US. The decrease in the SJR may be due to lower temperatures in the recirculation water.

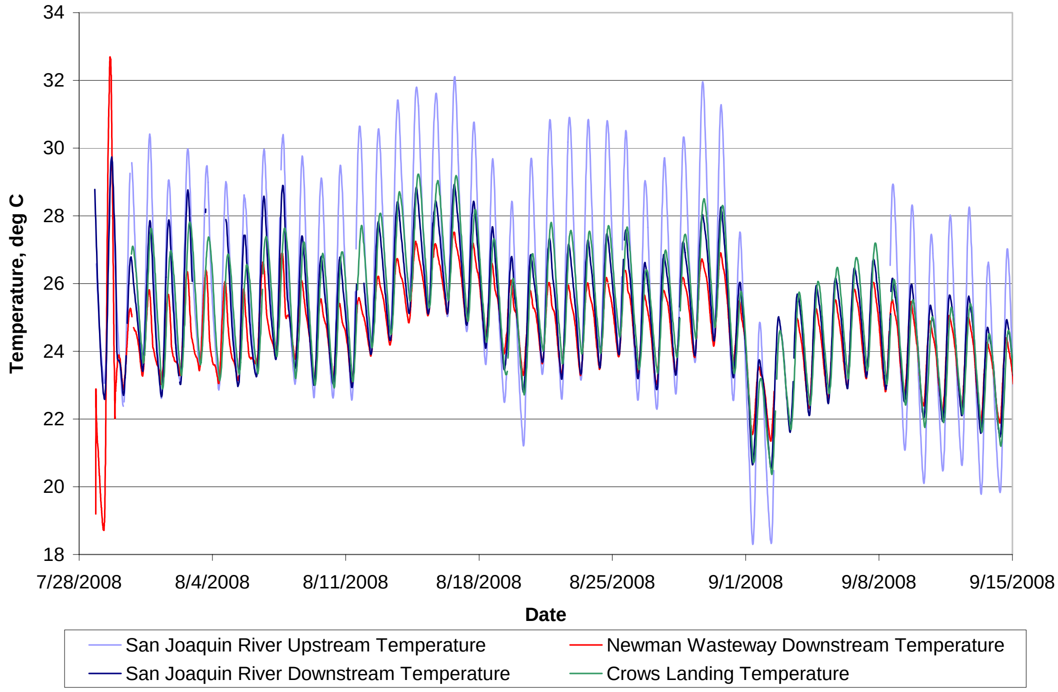


Figure 3-7. Temperatures in Newman Wasteway and San Joaquin River

The temperature at SJR US is typically warmer and more variable than at other SJR monitoring locations, possibly because of a lower flow rate. With a lower flow rate, there can be more heating during the day and more cooling at night. NW DS shows the least variability of the monitoring locations, possibly because of the continuous release of water from the DMC, which may be more constant in temperature than the SJR due to the flow rate in the DMC.

The continuous temperature monitoring in the Wasteway and the SJR recorded changes in temperature due to recirculation flow. During the study, temperature in the SJR immediately downstream of the Wasteway tended to decrease in diurnal variability as a result of recirculation.

3.2.4 Continuous Electrical Conductivity in the Wasteway and San Joaquin River

Continuous EC data measured at SJR US, NW DS, SJR DS, and SCL are presented on **Figure 3-8**. The YSI meter at SJR DS was discovered to be tipped over on September 8, and the sonde was slightly buried in the sediment, which may have affected the instrument readings from the prior week.

EC at NW DS was lower than at SJR US throughout the study (**Figure 3-8)**. The EC at NW DS during the first 2 days may reflect the quality of the water

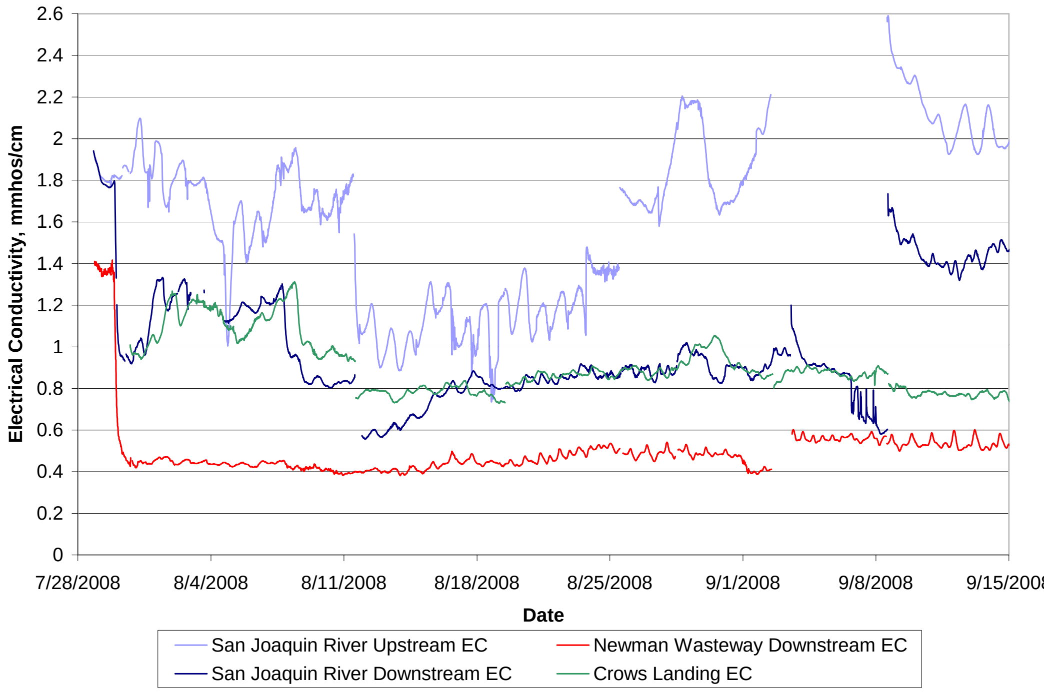


Figure 3-8. Measured Electrical Conductivity in the San Joaquin River and Newman Wasteway

resident in the Wasteway or may be due to the influence of the SJR until there was sufficient flow to flush the Wasteway. Thereafter, EC at SJR DS was lower than at SJR US. EC at SJR DS and at SCL were similar, with the exception of the last week of the study.

The continuous EC measurements in the Wasteway and the SJR recorded changes in EC due to recirculation flow. As a result of recirculation, EC tended to decrease in the SJR immediately downstream of the Wasteway during the study, which is consistent with the 2004 and 2007 Pilot Studies (Reclamation 2005, 2008).

3.2.5 Continuous pH Measurements in the Wasteway and San Joaquin River

The continuous pH data at SJR US, NW DS, SJR DS, and SCL are presented on **Figure 3-9**. Data from SJR US were missing during the first week of September because of damage to the instrument. The YSI meter at SJR DS was discovered to be tipped over on September 8, and the sonde was slightly buried in the sediment, which may have affected the instrument readings from the prior week. The pH measured at NW DS during the week of August 25 through September 2 was not consistent with the concentrations before and after that week; these changes occurred after maintenance and may have been a result of instrument re-calibration.

Recirculation tended to reduce pH in the SJR after the first 2 days, as seen by lower pH measured at SJR DS compared to SJR US (**Figure 3-9)**. The water from the DMC may have had lower pH than the water in the SJR during the study. Measured pH at SJR DS was less than pH 8.5 for almost all of the study as a result of recirculation. The diurnal variation in pH seen at the SJR monitoring locations may have been due to photosynthesis.

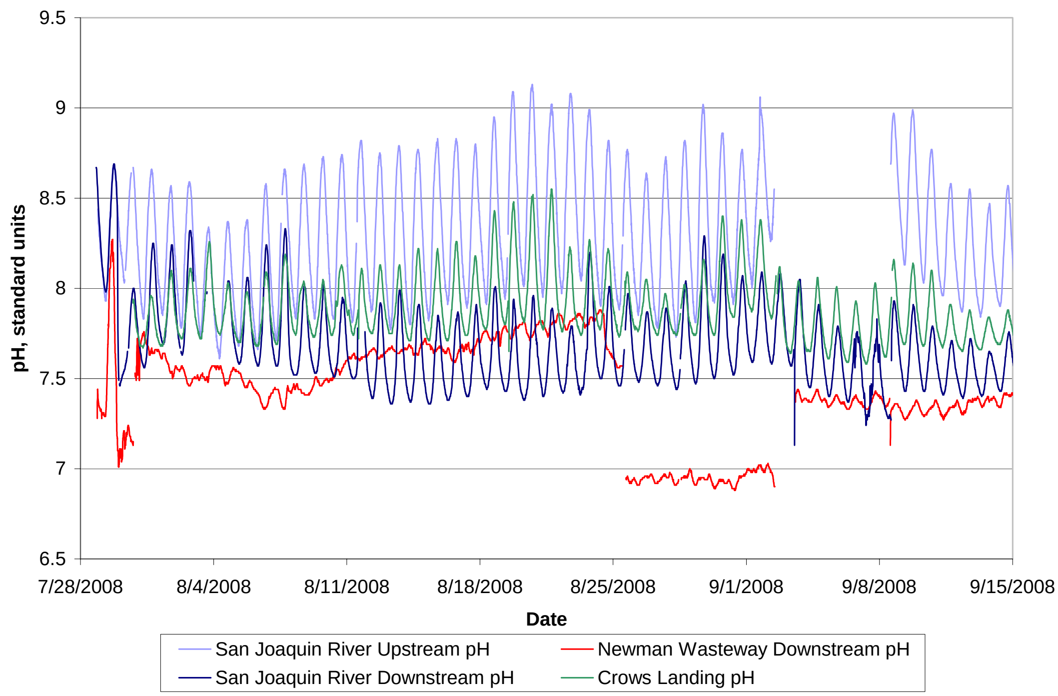


Figure 3-9. Measured pH in the San Joaquin River and Newman Wasteway

3.2.6 Continuous Dissolved Oxygen Measurements in the Newman Wasteway and the San Joaquin River

Continuous DO data measured at SJR US, NW DS, SJR DS, and SCL are presented on **Figure 3-10**. Data from SJR US were missing during the first week of September because of damage to the instrument. DO at NW DS before August 25 is not consistent with DO concentrations measured after August 25 and may be a result of instrument malfunction. The YSI meter at SJR DS was discovered to be tipped over on September 8, and the sonde was slightly buried in the sediment; this affected the instrument readings from the prior week.

Recirculation tended to reduce DO concentrations immediately downstream of the Wasteway, as seen by lower concentrations at SJR DS compared to SJR US (**Figure 3-10**). DO concentrations at SJR US were often above saturation. DO saturation at temperatures from 22 to 29 degrees centigrade was between 8 and

9 mg/L. The higher values found at SJR US could be due to photosynthesis during the day.

During the study, DO concentrations tended to decrease in the SJR immediately downstream of the Wasteway but were rarely below 5 mg/L, a trend that is consistent with the 2004 and 2007 Pilot Studies (Reclamation 2005, 2008).

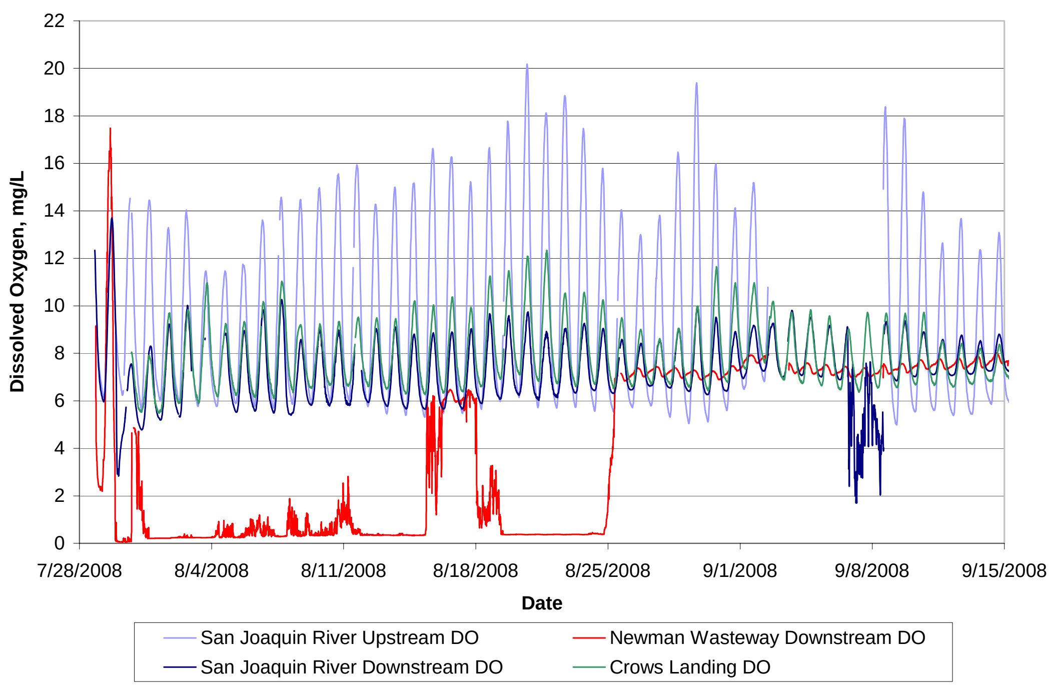


Figure 3-10. Measured Dissolved Oxygen in the San Joaquin River and Newman Wasteway

3.3 Discrete Water Quality Sample Results

Assessment of the water quality data focused on the results that exceeded the levels for protection of beneficial uses, as described in the Basin Plan (CVRWQCB 2007a) and the *Compilation of Water Quality Goals* (Marshack 2008), unless otherwise noted.

Inorganic, organic, and physical parameters were measured to assess the changes in water quality in the Wasteway and potential impacts to the SJR as a result of recirculation. The parameters that were assessed were metals, nutrients, suspended solids, turbidity, and biological and bacteriological indicators (see **Table 2-2**). Because individual constituent measurements do not take into account potential synergistic or additive effects, acute toxicity testing was also conducted.

Results of the water quality monitoring are summarized below; additional information is provided in **Appendix G.** Complete data are provided in **Appendix C**, and the results of the QA activities are reported in **Section 2.2** and the Quality Assurance Summary Report in **Appendix B**.

3.3.1 Total Suspended Solids and Turbidity

TSS can contribute directly to the physical and aesthetic degradation of water and may act as a transport mechanism for other pollutants, particularly nutrients and metals that are carried on the surfaces of sediments in suspension. However, there are no established numeric objectives for TSS in the Basin Plan but rather a narrative objective that states "waters shall not contain suspended material in concentrations that cause nuisance or adversely affect beneficial uses" (CVRWQCB 2007a).

At time zero,[5] the TSS concentration measured in the DMC was lower than in the Wasteway or at SJR monitoring locations (**Figure 3-11**). The concentration at SJR DS was higher than at SJR US. The concentration at NW DS was also higher than at SJR US.

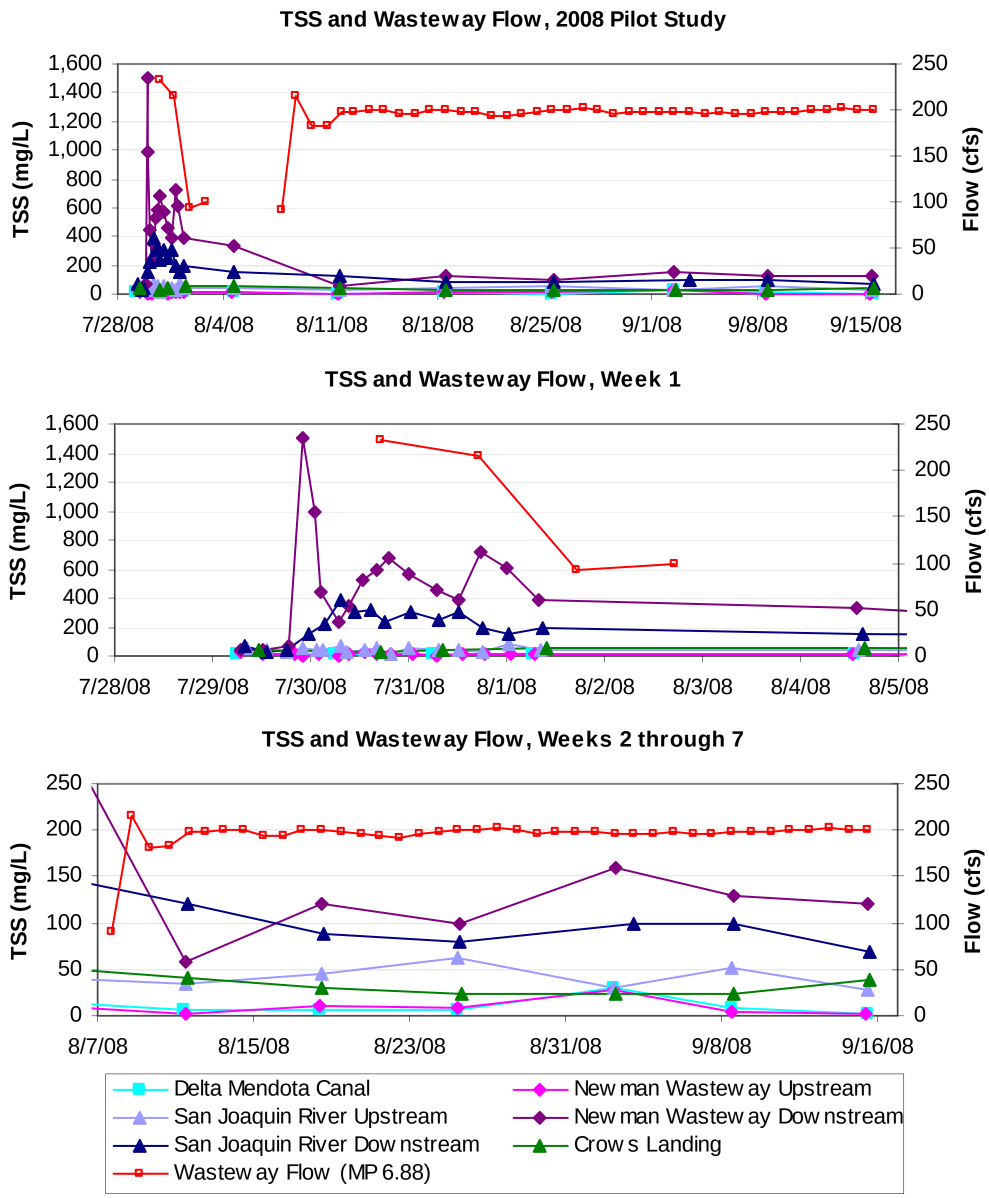
The flow at NW DS was monitored to identify the "first flush." A sample was collected of this first water at approximately 16 hours after being released from the DMC when it arrived at NW DS. After 16 hours of recirculation, the TSS concentration of the discrete samples measured at NW DS increased dramatically, reaching a maximum of 1,500 mg/L (**Figure 3-11)**. Thereafter, TSS concentrations generally decreased at NW DS, but concentrations remained elevated above the time zero background level. TSS concentrations at SJR DS also increased above the background time zero concentration during the first day of recirculation and remained above concentrations at SJR US throughout the recirculation.

Recirculation may have mobilized fine bottom sediment as well as algae that had accumulated within the Wasteway. The TSS increase during the first day of recirculation corresponds to an increase in flow (**Section 3.2.1**) and may have been caused by the breaking of several beaver dams along the Wasteway and the release of accumulated sediment.

Near the end of the study, TSS concentrations decreased (**Figure 3-11)**, which may be due to the looser sediments being washed out of the Wasteway and into the SJR.

[5] The first sample at each location was collected prior to the influence of recirculation, and the results represent time zero, baseline conditions.

Discrete samples measured at SCL remained similar to background concentrations throughout the recirculation, indicating that the geographical extent of the elevated TSS concentrations in the SJR may have been limited.



Note: For the purpose of display, non-detect data was assumed to have concentrations equal to the reporting limit (3 mg/L).

Figure 3-11. Discrete Samples for Total Suspended Solids

Turbidity is a measure of light penetration and can be related to TSS concentration. High turbidity can affect the reproduction, growth, and health of fish and other aquatic life. The Basin Plan (CVRWQCB 2007a) has numeric WQOs for turbidity that are based on turbidity increments above natural (background) levels when the turbidity increments can be attributable to controllable water quality factors. The turbidity WQO indicates that when natural turbidity is between 0 and 5 NTU, increases are not to be above 1 NTU; when natural turbidity is between 5 and 50 NTU, increases are not to be above 20% of natural turbidity; when natural turbidity is between 50 and 100 NTU, increases are not to be above 10 NTU; and when natural turbidity is greater than 100 NTU, increases are not to be above 10% of natural turbidity.

At time zero, turbidity measured at the DMC was less than in the Wasteway or at the SJR locations (**Figure 3-12**). Turbidity at SJR DS was greater than at SJR US, but the time zero sample for SJR DS may not be representative of background turbidity. The second and third sample collected at SJR DS before the recirculation water arrived were much lower in turbidity than the time zero concentration. The turbidity measured at NW DS and SJR DS were similar.

Similar to TSS, peak turbidity measured at NW DS occurred during the first day of recirculation. The turbidity increase at NW DS corresponded to a turbidity increase at SJR DS (**Figure 3-12**). Turbidity at NW DS was approximately one order of magnitude or greater than at NW US for the first 2 weeks; thereafter, it was approximately 5 times greater. Turbidity at SJR DS was generally higher than at SJR US for the duration of the recirculation (**Figure 3-12**).

Turbidity measured continuously by the sondes (**Section 3.2.2**) was compared to the discrete data for the same date and similar times. Continuous data were similar or slightly higher than the discrete data for turbidity data measured at SJR DS and SCL, and continuous data were typically higher than the discrete data for turbidity data at SJR DS and NW DS.

Turbidity measured at SJR US was between 5 and 50 NTU. Turbidity at SJR DS increased by more than 20% for all discrete samples subsequent to 16 hours of recirculation, with only one exception. The samples collected 27 days after the start of recirculation indicated decreasing turbidity based on measurements at SJR DS relative to SJR US. The Basin Plan (CVRWQCB 2007a) objectives were not met for the other turbidity grab samples collected after 16 hours of recirculation.

3.3.2 Ammonia as Nitrogen and Total Kjeldahl Nitrogen

In the presence of ammonia, fish have reduced growth, development, and reproductive rate. Injury can occur to gill, liver, and kidney tissues. At moderate ammonia levels, fish can suffer a loss of equilibrium and can become hyper-excited, which increases respiratory activity, oxygen uptake, and heart rate. High concentrations of ammonia can lead to convulsions, coma, and death (EPA 1999).

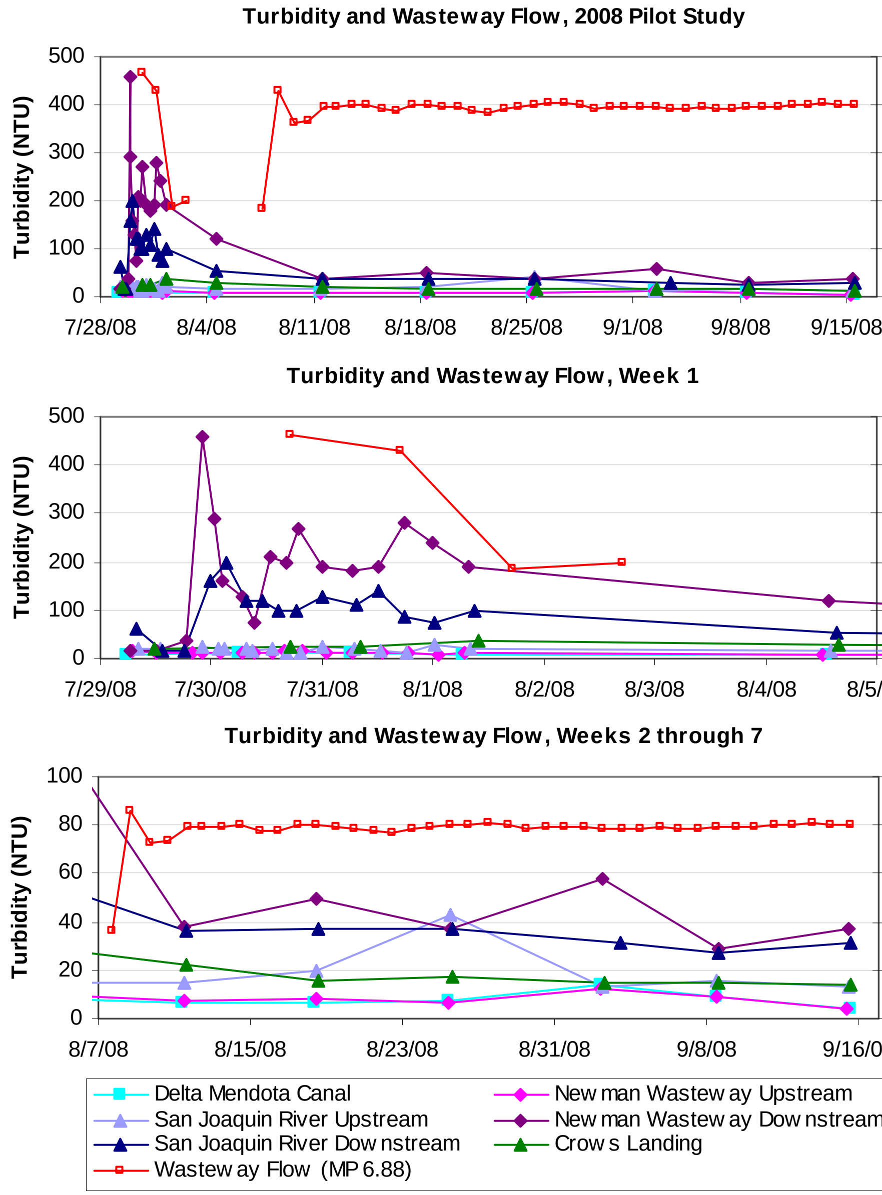


Figure 3-12. Discrete Samples for Turbidity

The U.S. Environmental Protection Agency (EPA) has recommended ambient water quality criteria (AWQC) for the protection of freshwater aquatic life that are pH- and temperature-dependent. The acute criterion is also dependent on the presence or absence of salmonids, which are particularly sensitive to ammonia. The chronic criterion is dependent both on temperature and on the presence or absence of fish in early life stages. An exact value for the acute and chronic criteria can be calculated for a specific set of conditions and are reported in total (un-ionized plus ionized) ammonia nitrogen.

Temperature and pH were recorded from the continuous monitoring probes at NW DS, SJR US, SJR DS, and SCL. The value of the chronic AWQC was calculated for each discrete sample with detected ammonia concentrations using the temperature and pH at the location and time the sample was collected. The chronic criterion was calculated for comparison because it was more conservative than the acute criterion. All detected concentrations were below the pH- and temperature-specific chronic AWQC. The reporting limit associated with the nondetect data (0.10 mg/L) was less than the lowest or most stringent temperature and pH corrected AWQC (0.179 mg/L).

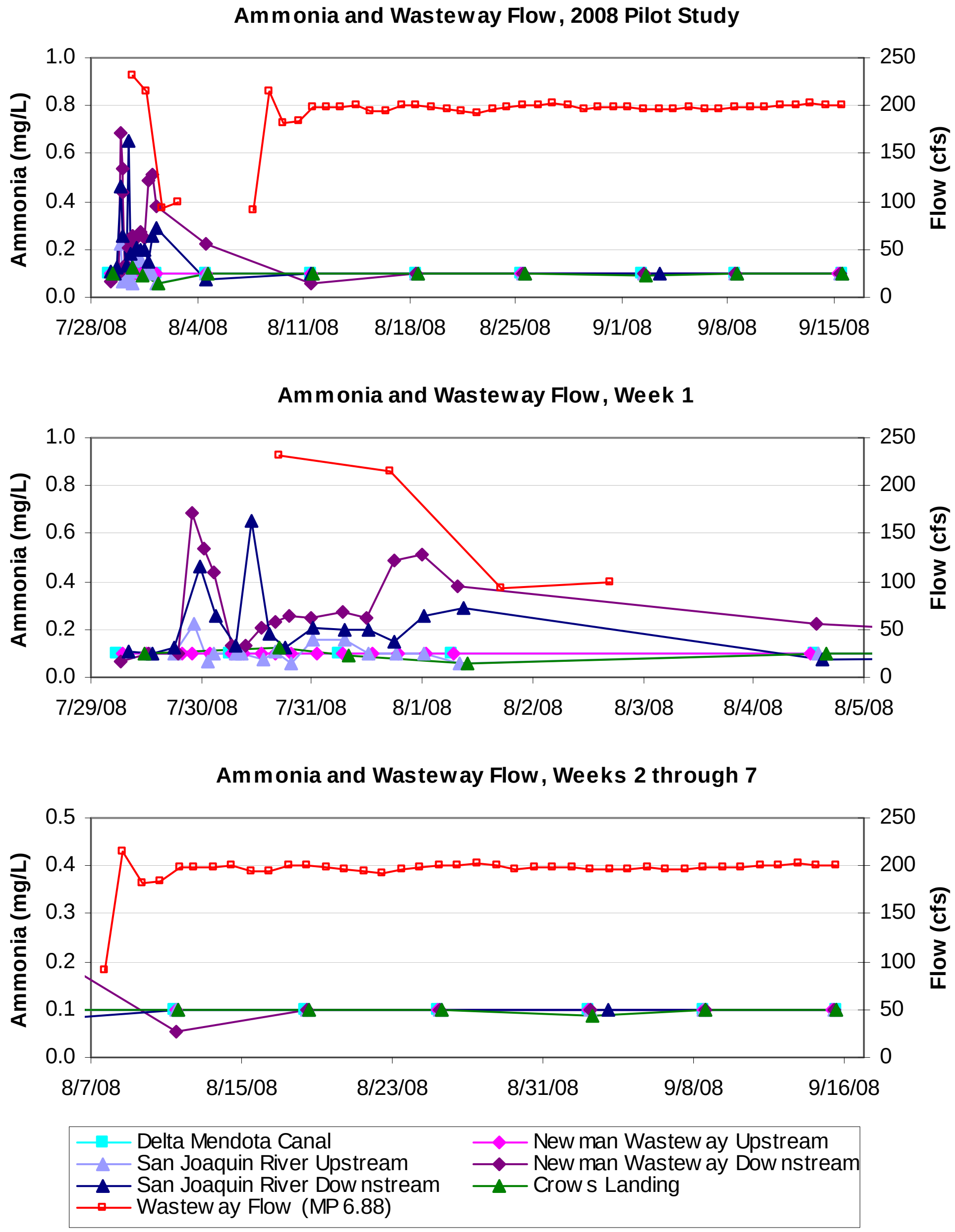
At time zero, the background ammonia concentration measured at the DMC, the SJR, and the Wasteway were similar (less than 0.10 to 0.11 mg/L, **Figure 3-13**).

Ammonia concentrations in the SJR and Wasteway during recirculation ranged from less than 0.1 to 0.7 mg/L (**Figure 3-13**). NW US had ammonia concentrations that were less than the reporting limit (< 0.10 mg/L) throughout the release event. Ammonia concentrations at SJR US had minor variation with concentrations typically near the reporting limit. Ammonia concentrations at NW DS and SJR DS did show an effect from recirculation. Although all samples at NW DS were below the pH- and temperature-corrected chronic AWQC, higher concentrations of ammonia occurred approximately 16 to 22 hours and 2.5 days after the beginning of the recirculation. At SJR DS, peak ammonia concentrations occurred at approximately 16 hours and 1.2 days after the beginning of the recirculation (**Figure 3-13**).

Elevated concentrations of ammonia could have resulted from remobilization of accumulated agricultural drainage or sediment within the Wasteway. The highest ammonia concentration measured at SJR DS during the study (0.65 mg/L) did not correspond with ammonia concentrations of similar magnitude at NW DS or SJR US and may have been due to concentrations of ammonia changing over relatively short periods (**Figure 3-13**).

TKN is a measurement of organic nitrogen and ammonia nitrogen. There are no WQOs for TKN.

At time zero, the TKN concentration measured in the DMC was slightly less than the TKN concentrations measured in the Wasteway and the SJR (**Figure 3-14**).



Note: For the purpose of display, non-detect data was assumed to have concentrations equal to the reporting limit (0.1 mg/L).

Figure 3-13. Discrete Samples for Ammonia as Nitrogen

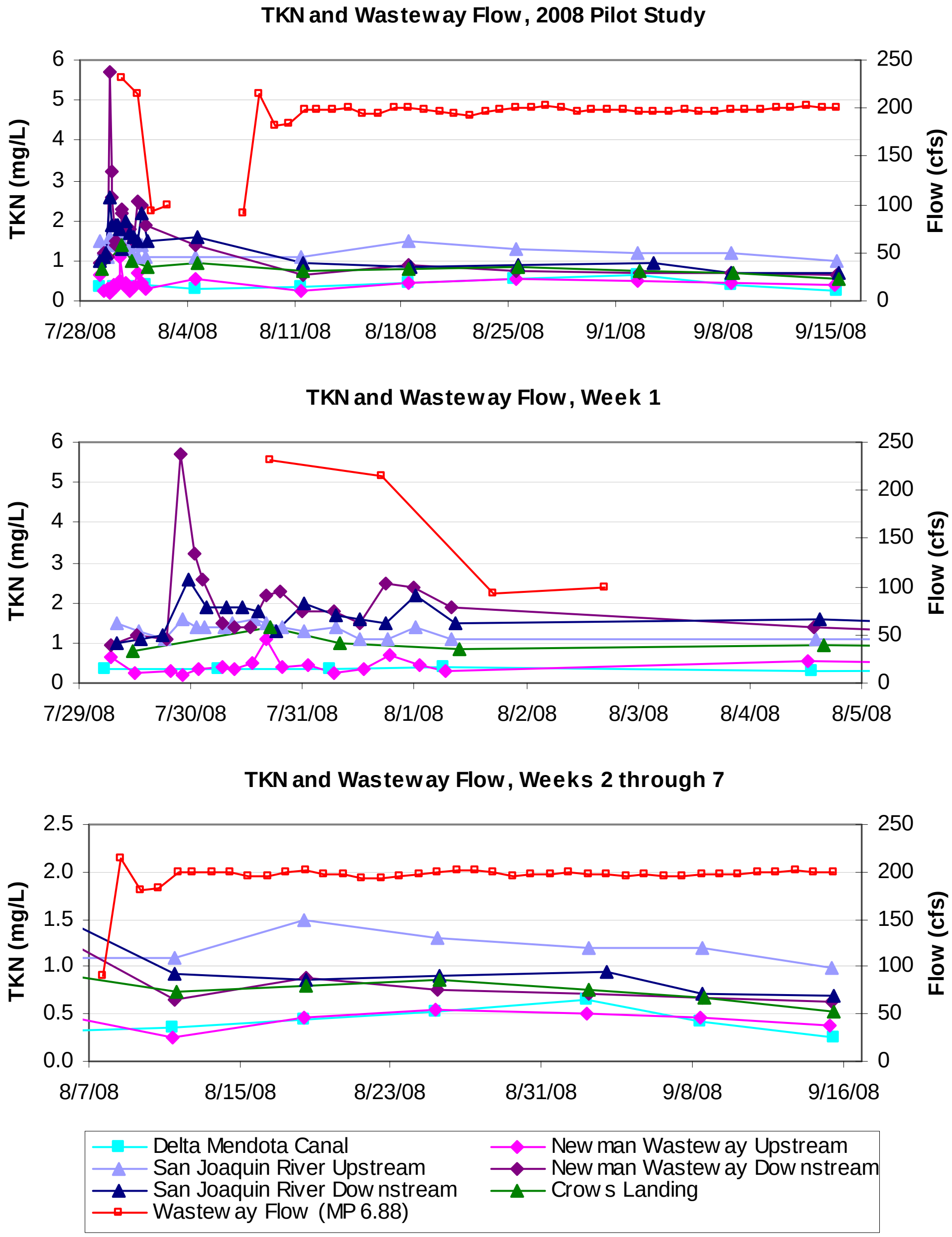


Figure 3-14. Discrete Samples for Total Kjeldahl Nitrogen

During the first 2 weeks, TKN concentrations at SJR DS and NW DS were typically higher than concentrations at the corresponding upstream locations (**Figure 3-14**), but the downstream concentrations decreased below their respective time zero background concentrations by the 13th day. Similar to ammonia, higher concentrations of TKN at NW DS occurred approximately 16 to 20 hours after the beginning of the recirculation. The highest concentration measured at SJR DS also occurred approximately 16 hours after the start of the recirculation.

Recirculation may have mobilized resident organic nitrogen in the Wasteway, but the readily mobilized sources of organic nitrogen may have been flushed from the Wasteway within the first 2 weeks.

3.3.3 Biological Oxygen Demand

Biological oxygen demand (BOD) is a measurement of the amount of oxygen consumed by biological processes that break down organic matter in water. BOD is an indicator of the amount of oxidizable and biodegradable organic matter in water. There are no WQOs for BOD.

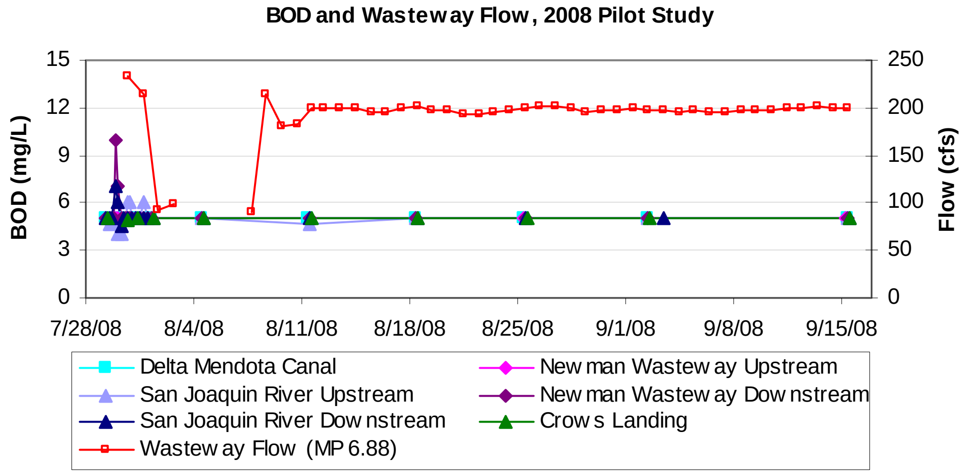
BOD was not typically detected at concentrations greater than the laboratory reporting limit; at time zero, none of the monitoring locations had detected concentrations of BOD. However, NW DS did have a peak concentration at approximately 16 hours after the start of recirculation (**Figure 3-15**), which may be additional evidence of a “first flush” of organic matter within the Wasteway.

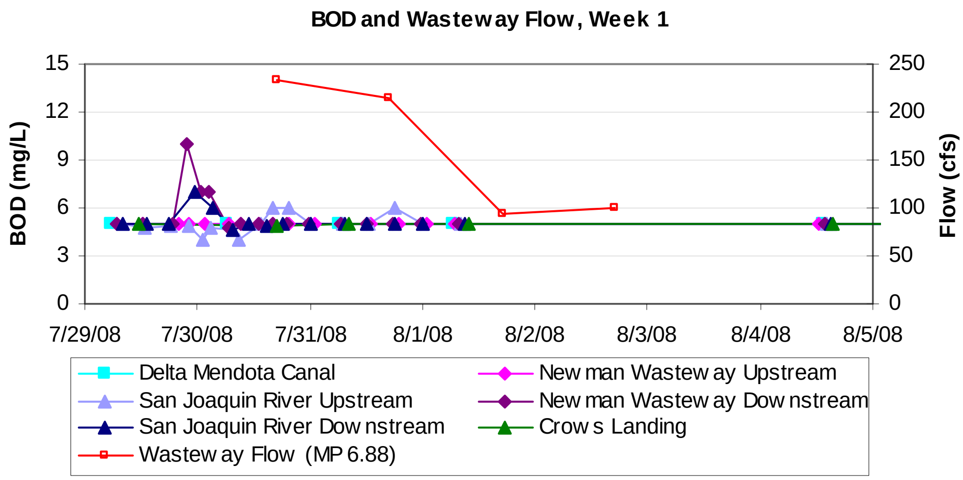
3.3.4 Total Organic Carbon

In additional to being a water quality indicator, TOC measurements may also indicate the potential presence of decaying natural organic matter. Organic carbon is itself not a harmful constituent; it may act as a source of food for aquatic organisms. However, problems can occur when water containing high levels of organic carbon is treated with chemical disinfectants. Some forms of organic carbon react with chlorine and produce potentially carcinogenic disinfection byproducts. There are no WQOs in the Basin Plan (CVRWQCB 2007a) for TOC.

At time zero, the TOC concentration measured at the DMC was similar to concentrations at NW US and less than concentrations at NW DS, SJR US, and SJR DS (**Figure 3-16**).

TOC concentrations at NW DS were typically higher than at NW US but similar to or less than at SJR US during recirculation (**Figure 3-16**). Notable exceptions were the measured concentrations approximately 16 to 22 hours after the





Note: For the purpose of display, non-detect data was assumed to have concentrations equal to the reporting limit (5 mg/L).

Figure 3-15. Discrete Samples for Biological Oxygen Demand

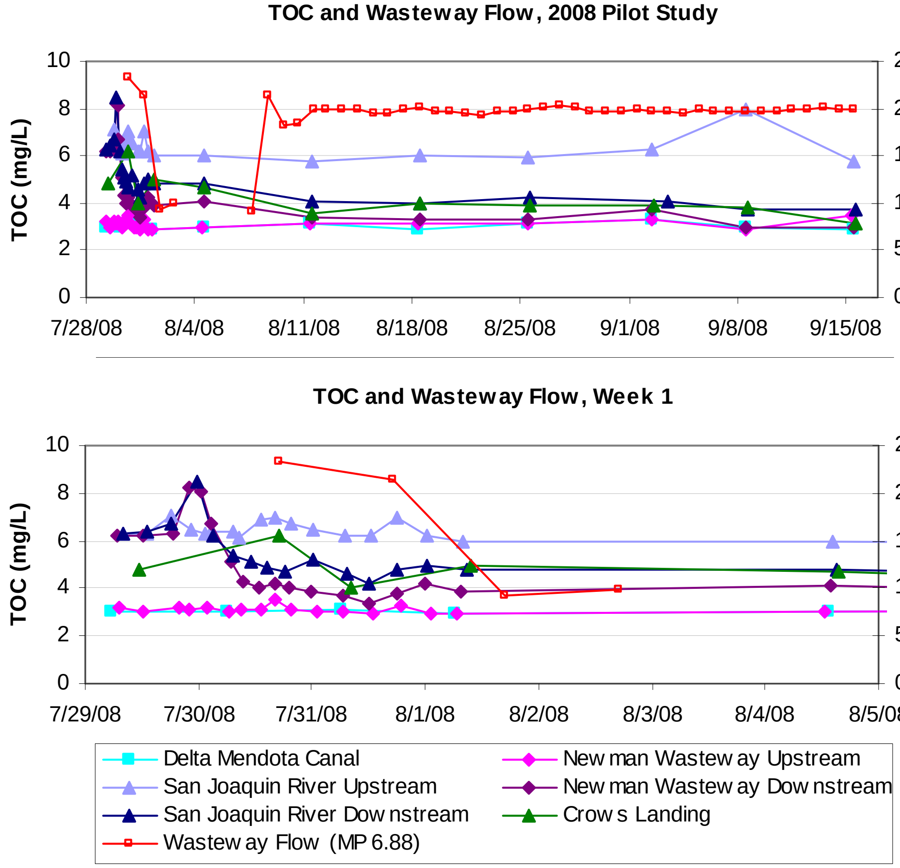


Figure 3-16. Discrete Samples for Total Organic Carbon

beginning of the recirculation (first flush samples). The TOC concentrations at NW DS were higher than at SJR US. Besides these exceptions, recirculation acted as a dilution flow for the SJR with respect to TOC, as evidenced by lower concentrations at SJR DS relative to those measured at SJR US.

The increases in concentrations between NW US and NW DS during the first 2 days indicate a first flush of TOC from the vegetation in the Wasteway. Downstream in the SJR concentrations reflect a mixture of SJR US and Wasteway flows.

3.3.5 *Escherichia coli* (*E. coli*)

The Basin Plan (CVRWQCB 2007a) contains numeric WQOs for fecal coliform but no numeric WQOs for *E. coli*. Coliform bacteria indicate the possible presence of pathogens that cause gastrointestinal infections. The Basin Plan states "All waters shall be maintained free of toxic substances in concentrations that produce detrimental physiological responses in human, plant, animal, or aquatic life" (CVRWQCB 2007a).

A proposed revision to the Basin Plan provides a numeric WQO for *E. coli* in waters designated for contact recreation (REC-1), such as the SJR. The proposed standards for *E. coli* are 126 most probable number per 100 milliliters (MPN/100 mL) when averaged over a 30-day period and 235 MPN/100 mL for a single sample (CVRWQCB 2002). Furthermore, the EPA freshwater recreational water quality criterion for *E. coli* is an average of 126 MPN/100 mL (EPA 1986).

E. coli was monitored at five locations: DMC, NW US, NW DS, SJR US, and SJR DS. At time zero, the *E. coli* concentration measured at the DMC was less than concentrations measured at the Wasteway and SJR locations (**Table 3-1**). *E. coli* concentrations measured at NW DS were greater than at NW US both before and after recirculation.

Table 3-1. Discrete Samples for *E. Coli*

Date	Time	*E. Coli* (MPN/100 mL) by Monitoring Location				
		DMC	NW US	NW DS	SJR US	SJR DS
7/29/2008	0540–0815	18	41	490	61	64
7/30/2008	0605–0727	8.6	7.3	550	200	—
7/31/2008	0600–0810	9.8	5.2	—	—	120

The first sample collected at each location represents concentrations prior to the influence of recirculation.

DMC = Delta-Mendota Canal
MPN = most probable number
NW DS = Newman Wasteway downstream
NW US = Newman Wasteway upstream
SJR DS = San Joaquin River downstream
SJR US = San Joaquin River upstream

There were only two samples collected at SJR US; measured concentrations were dissimilar. The one measured concentration at SJR DS during recirculation was less than the proposed criteria but greater than time zero background concentration. Concentrations measured at the SJR monitoring stations were below the proposed objective for an individual sample (235 MPN/100 mL).

Because of the limited data, it was difficult to draw any strong conclusions, but these data suggest that recirculation may have displaced resident water in the Wasteway that had higher levels of *E. coli*.

3.3.6 Metals

Water samples were analyzed for three dissolved metals (arsenic, copper, and mercury) and four total metals (mercury, aluminum, selenium, and boron). For each parameter, the most stringent regulatory water quality criteria were used for evaluation. Additional water quality criteria are included for some parameters for comparison.

Dissolved Arsenic

The Basin Plan (CVRWQCB 2007a) objective and the EPA primary maximum contaminant level (MCL) for arsenic in drinking water are the same (10 µg/L); levels above 10 µg/L may pose a risk to human health from the effects of chronic exposure to arsenic. The EPA human health AWQC for surface water not used as municipal supply is 0.14 µg/L. The EPA human health criterion is based on a 1:1,000,000 cancer risk from consumption of organisms and is not a regulatory value. (The EPA freshwater aquatic life criteria are higher than the human health criteria.) Health effects from chronic arsenic exposure above the MCL include skin damage, problems with circulatory systems, and increased cancer risk. Arsenic has been linked to cancer of the bladder, lungs, skin, kidney, nasal passages, liver, and prostate (EPA 2008a).

At time zero, the dissolved arsenic concentration measured at the DMC was similar to concentrations at the Wasteway monitoring locations but less than concentrations at the SJR monitoring locations (**Figure 3-17**).

Dissolved arsenic concentrations at NW US and NW DS were less than at SJR US during recirculation (**Figure 3-17**). Recirculation tended to act as a dilution flow for dissolved arsenic on SJR concentrations, as seen by lower concentrations at SJR DS relative to those at SJR US.

Dissolved arsenic concentrations at NW DS tended to be slightly lower than at NW US during the first few days of recirculation, starting with approximately the 16th hour of recirculation (**Figure 3-17**). Potentially, some of the dissolved arsenic was scavenged by sediments while in the Wasteway.

Dissolved arsenic concentrations at both the SJR and in the Wasteway were below the MCL for arsenic in drinking water (10 µg/L) and above the EPA non-regulatory, recommended human health criterion for arsenic in surface water from the consumption of organisms (0.14 µg/L).

Dissolved Copper

The primary cause of copper toxicity to aquatic organisms is through rapid binding to the gill membranes, which causes damage and interferes with osmoregulatory processes (EPA 2006). Copper toxicity is affected by the hardness of the receiving waters as well as the dissolved copper concentration. The EPA-recommended AWQC for the protection of freshwater aquatic life and the California Toxics Rule criteria vary depending on receiving water hardness. For the purpose of determining the WQO, the lowest and most conservative hardness value measured from surface water during the pilot study (88 mg/L,

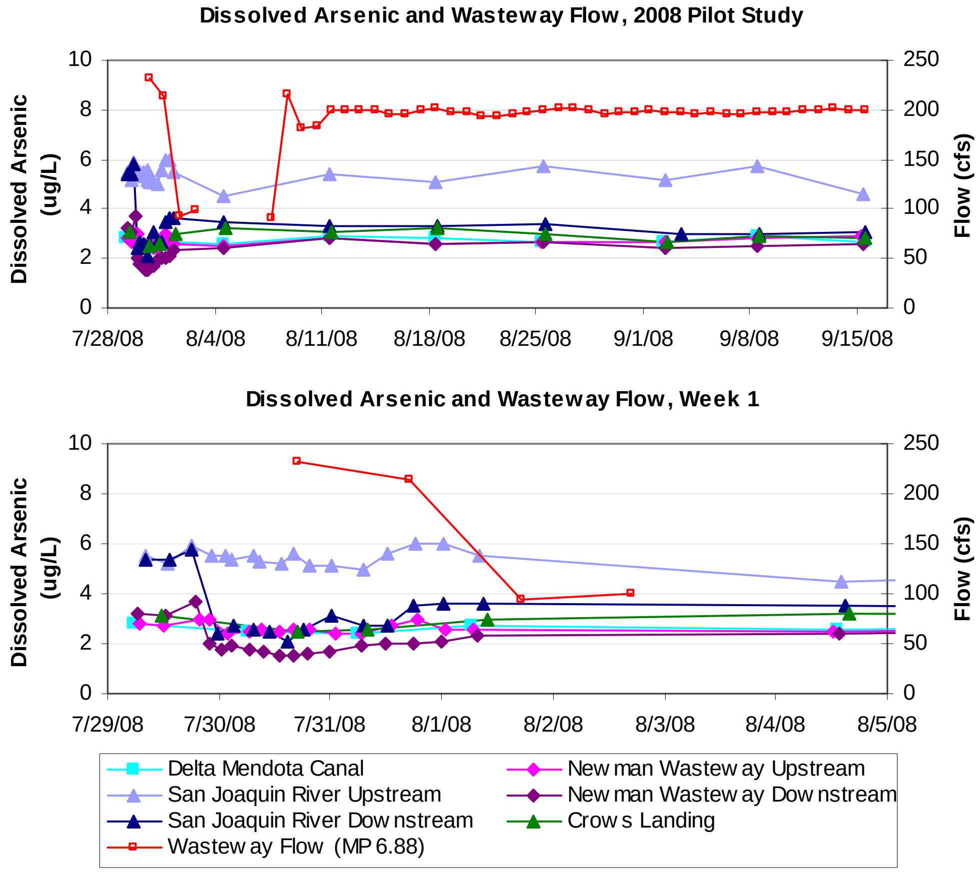


Figure 3-17. Discrete Samples for Dissolved Arsenic

see **Section 3.3.6.7**) was used for evaluation. The EPA-recommended AWQC to protect freshwater aquatic life is 8 µg/L 4-day average and 12 µg/L 1-hour average for dissolved copper, based on hardness of 88 mg/L. All of the dissolved copper concentrations measured in the study were below the AWQC based on the lowest observed hardness associated with these samples.

At time zero, the dissolved copper concentration measured at the DMC was similar to concentrations at the Wasteway monitoring locations and similar to or slightly less than concentrations measured at the SJR monitoring locations (**Figure 3-18**).

In general, dissolved copper concentrations measured at the Wasteway and the SJR were similar, at approximately 1-2 µg/L (**Figure 3-18**). Dissolved copper concentrations at NW US and NW DS were similar to or slightly less than concentrations at SJR US. Dissolved copper concentrations at SJR DS were similar or slightly less than concentrations measured at SJR US.

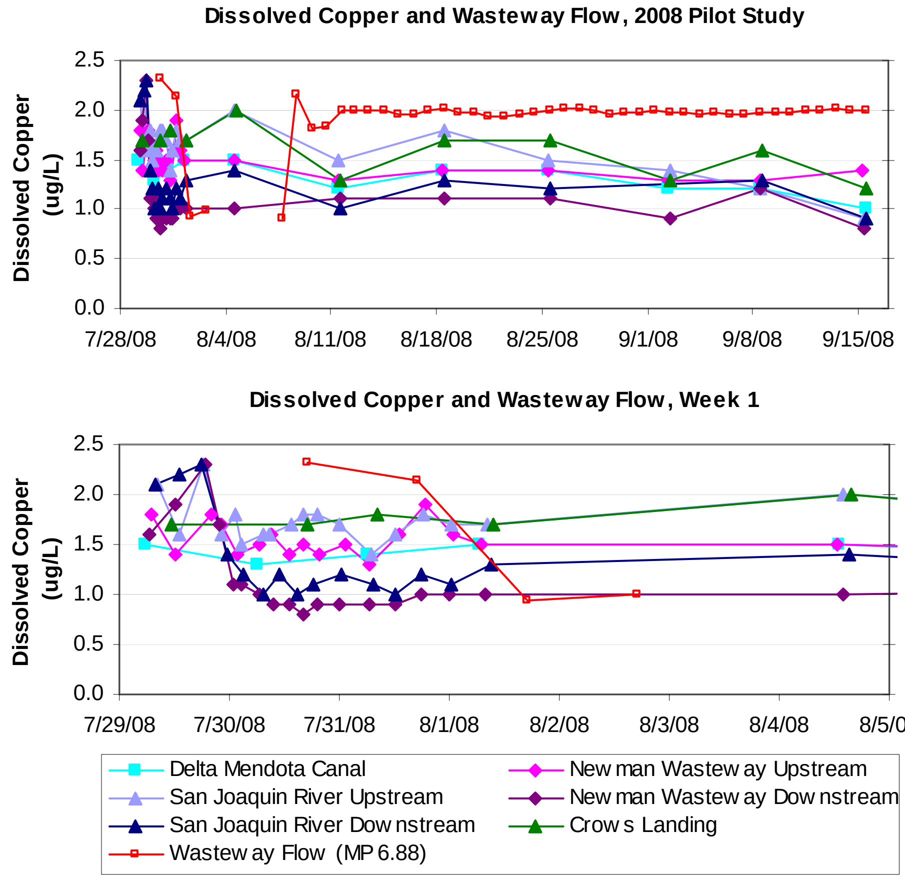


Figure 3-18. Discrete Samples for Dissolved Copper

Total and Dissolved Mercury

Mercury is found throughout California waterways as a result of air deposition or widespread historical mining activities. Although mercury in its natural form is usually not easily transmitted into living organisms, natural processes can encourage conversion to methylmercury, which is a powerful neurotoxin that accumulates in fish tissue and is harmful to animals and humans (DWR 2005).

The EPA AWQC for the protection of freshwater aquatic life are 770 nanograms per liter (ng/L) 4-day average and 1,400 ng/L 1-hour average for dissolved mercury. The California Toxics Rule criteria for protection of human health are 50 ng/L total mercury for drinking water sources (from the consumption of contaminated water and aquatic organisms) and 51 ng/L total mercury for other waters (from the consumption of aquatic organisms only) calculated as a 30-day average.

At time zero, the dissolved mercury concentration measured at the DMC was less than concentrations at NW DS and similar to or slightly less than at the other monitoring locations (**Figure 3-19**).

Dissolved mercury concentrations were similar at the Wasteway and the SJR after the first day of recirculation, at approximately 1-2 ng/L (**Figure 3-19**). Slightly higher dissolved mercury concentrations are found at NW DS during the first day when resident water was displaced in the Wasteway.

At time zero, the total mercury concentration measured at the DMC was lower than concentrations measured at the Wasteway and at the SJR (**Figure 3-20**).

Total mercury concentrations showed more variability than dissolved mercury concentrations (**Figure 3-20**). Concentrations at the downstream locations were generally higher than concentrations at the upstream locations for both the Wasteway and the SJR. The highest total mercury concentrations were found in samples from the downstream locations during the first week of recirculation.

Increased concentrations may be due to mercury sorbed onto the organic fraction of sediments suspended in the Wasteway. Variation may be due to variable suspended sediment concentration and/or mercury inhomogeneity within the sediments.

Dissolved mercury concentrations were below water quality criteria. Some of the samples collected during the first week of the study had total mercury concentrations greater than the California Toxic Rule human health criteria in surface water from the consumption of organisms (51 ng/L), but these concentrations did not persist through the remaining period of the pilot study. Furthermore, the average concentration during the first 30 days of the study was below 51 ng/L total mercury.

Total Aluminum

The EPA-recommended AWQC for the protection of freshwater aquatic life are 87 µg/L 4-day average and 750 µg/L 1-hour average for total aluminum when the pH is between 6.5 and 9.0 (EPA 2008c). The EPA secondary MCL for drinking water is between 50 and 200 µg/L total aluminum. Secondary MCLs are established only as guidelines to assist public water systems in managing their drinking water for aesthetic considerations; the guideline for total aluminum is established to prevent colored water. Fish tend to be more sensitive to aluminum than aquatic invertebrates. Aluminum toxicity has been linked to pH and hardness, but these effects are not well quantified. Aluminum toxicity in water may be related to the composition of the suspended particulate, such that aluminum associated with clay particles is less toxic than aluminum associated with aluminum hydroxide (EPA 2008b, c).

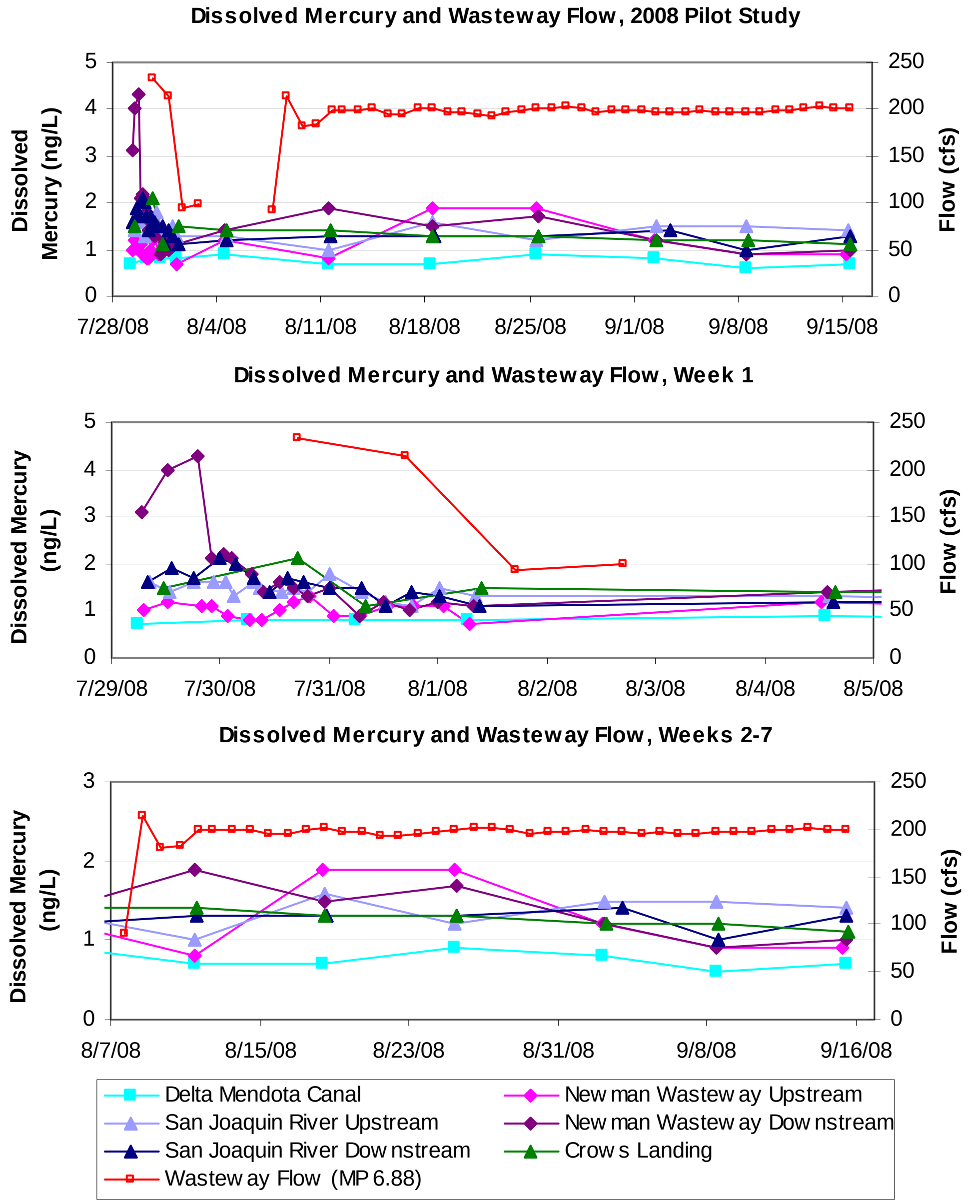


Figure 3-19. Discrete Samples for Dissolved Mercury

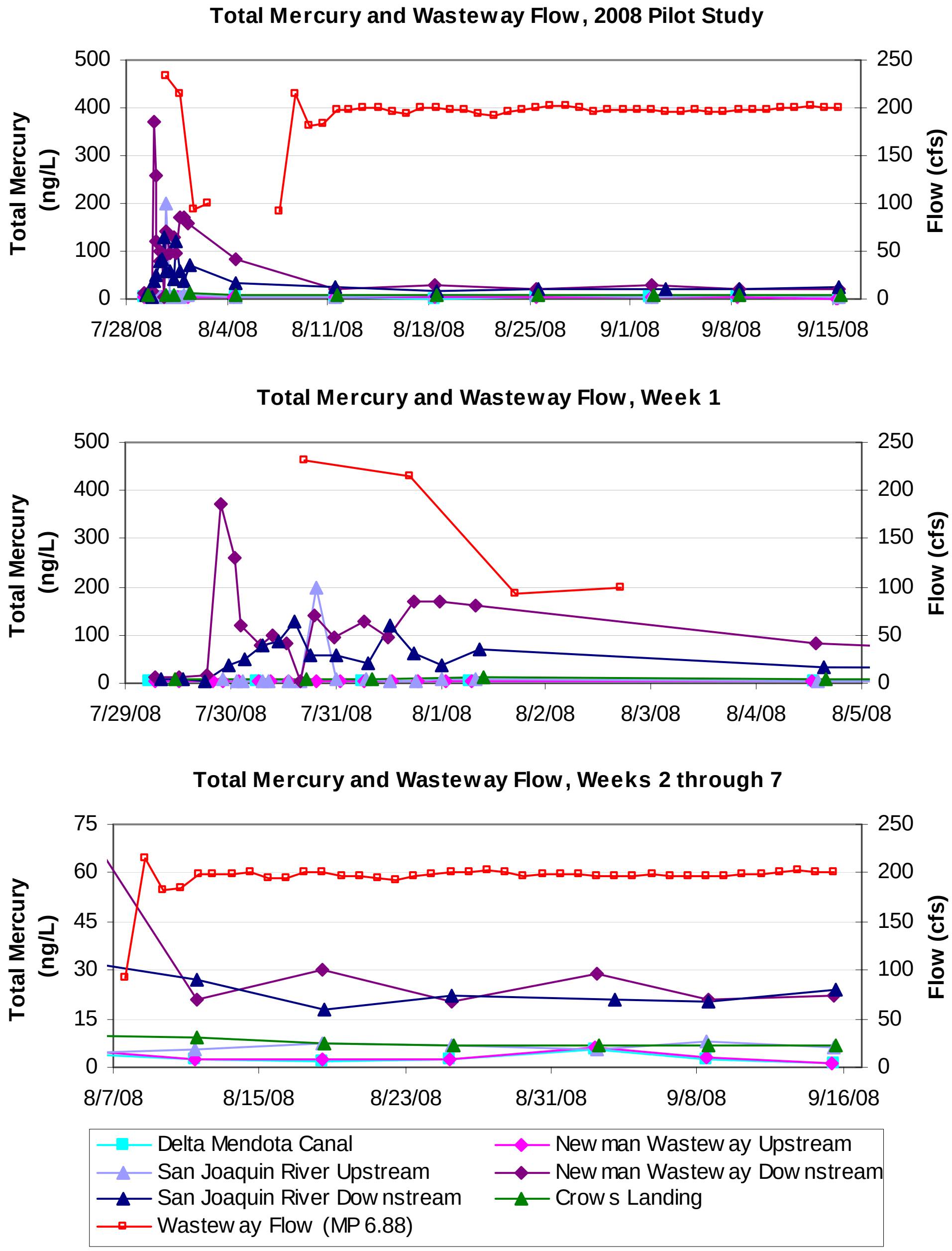


Figure 3-20. Discrete Samples for Total Mercury

At time zero, total aluminum concentrations measured at the DMC were less than concentrations measured at the Wasteway or SJR monitoring locations (**Figure 3-21**).

Concentrations at the downstream locations were generally higher than concentrations at the upstream locations for both the Wasteway and the SJR (**Figure 3-21**). The highest total aluminum concentrations were found in samples from NW DS during the first 3 days of recirculation. Increased concentrations may be due to aluminum from sediments suspended in the Wasteway, and variation may be due to suspended sediment concentration.

The pH was recorded from the continuous monitoring probes at NW DS, SJR US, SJR DS, and SCL. The pH associated with the discrete samples from these locations ranged from 6.9 to 8.7. Assuming that the pH concentrations were similar at the DMC and NW US locations, the aquatic life AWQC would apply to all of the measured aluminum concentrations.

Total aluminum was greater than the chronic aquatic life AWQC for all samples. Most concentrations measured at SJR US and SJR DS and all of the concentrations measured at NW DS and SCL were greater than the 1-hour average aquatic life AWQC. Concentrations measured at the DMC and the NW US locations were generally below the acute aquatic life AWQC. Measured aluminum concentrations at all of the monitoring locations were generally above the EPA secondary MCL (between 50 and 200 µg/L).

Total Selenium

Selenium effects on aquatic organisms can include the loss of equilibrium and other neurological disorders, liver damage, reproductive failure, reduced growth, reduced movement rate, chromosomal aberrations, reduced hemoglobin and increased white blood cell count, and necrosis of the ovaries (EPA 2008b). The Basin Plan (CVRWQCB 2007a) WQOs for the SJR from the Merced River to Vernalis are 5 µg/L 4-day average and 12 µg/L maximum selenium concentrations. The EPA AWQC and the California Toxics Rule criteria to protect freshwater aquatic life is also a 5 µg/L 4-day average for total selenium. All measured concentrations were below the WQOs (**Figure 3-22**).

At time zero, the measured total selenium concentration at the DMC was similar to the concentration at NW US, slightly less than at NW DS, and less than concentrations in the SJR (**Figure 3-22**).

Slightly higher total selenium concentrations were measured at NW DS relative to those at NW US, with measured concentrations at NW US and NW DS less than 1 µg/L (**Figure 3-22**). Similar or slightly decreasing total selenium

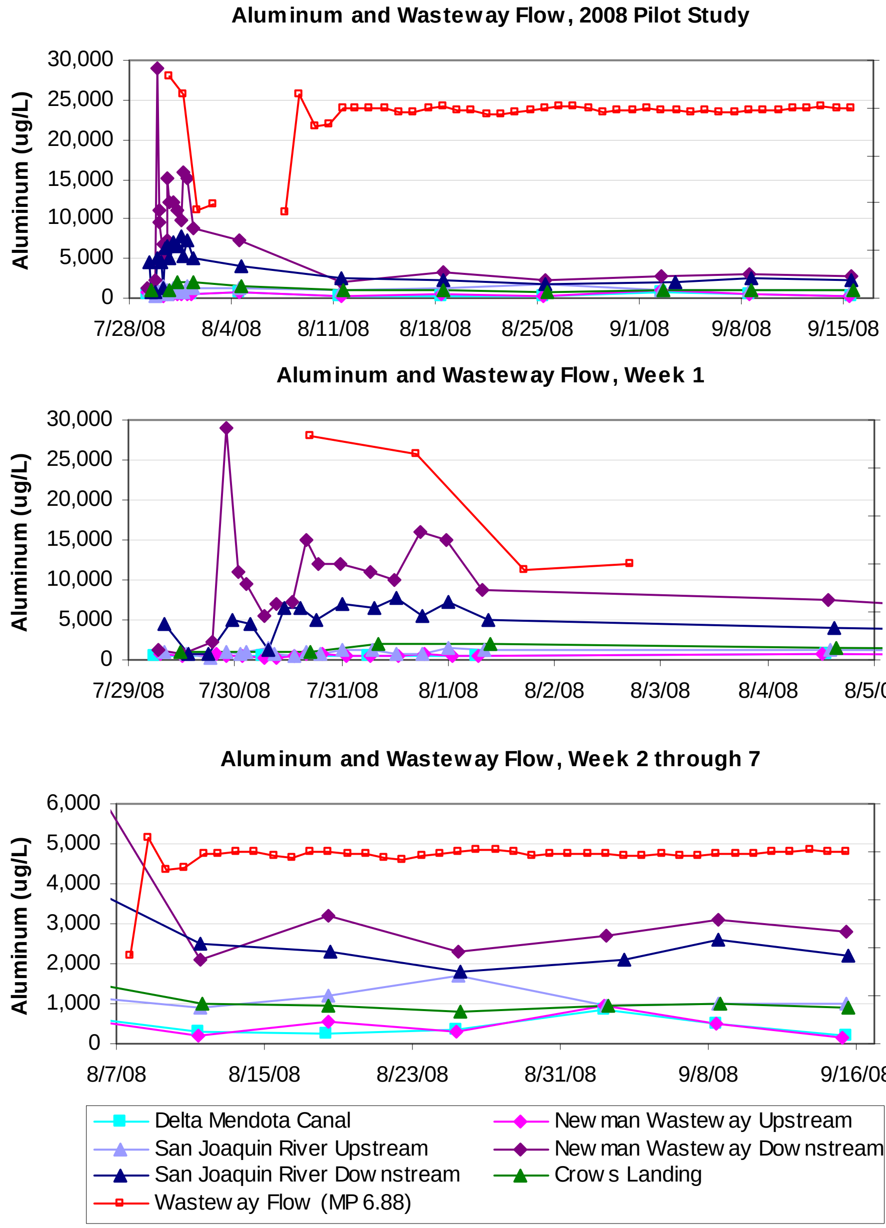


Figure 3-21. Discrete Samples for Total Aluminum

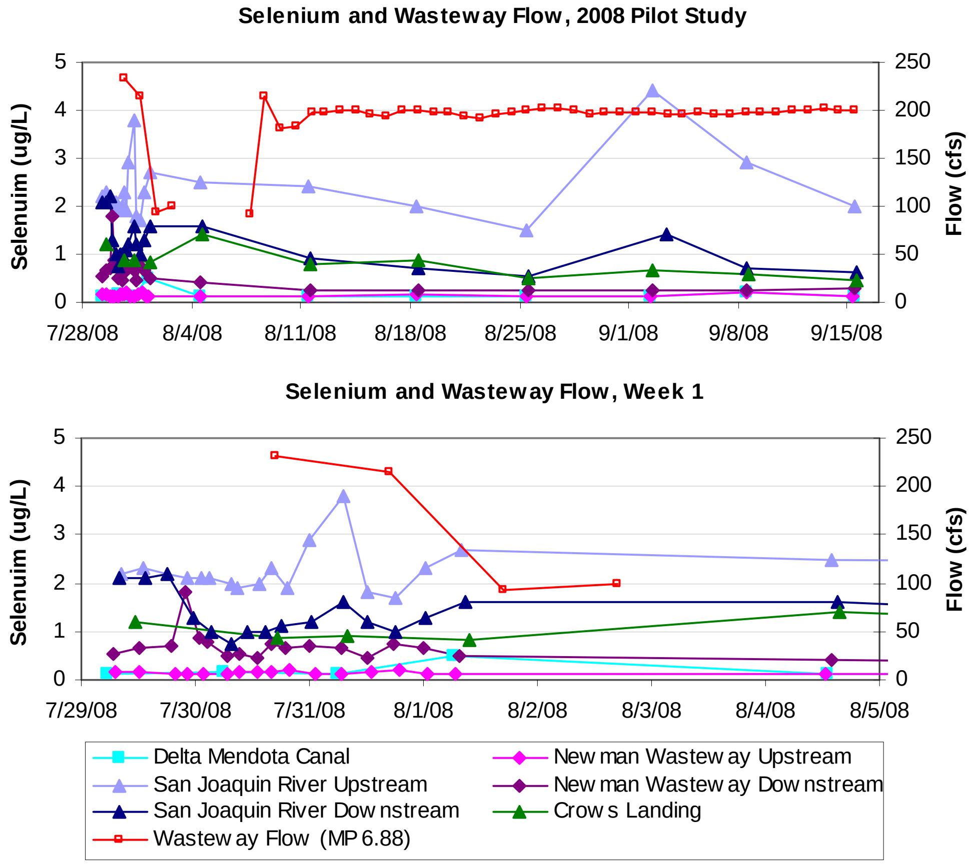


Figure 3-22. Discrete Samples for Total Selenium

concentrations were measured at SJR DS relative to those at SJR US, due to the lower level contributions from the Wasteway.

Total Boron

The Basin Plan (CVRWQCB 2007a) WQO for total boron stipulates an average monthly concentration of 800 µg/L from March 15 to September 15, 1,000 µg/L from September 16 to March 14, and 1,300 µg/L during critical year types for the SJR from the Merced River to Vernalis. The Basin Plan also stipulates a maximum concentration of 2,000 µg/L from March 15 to September 15 and 2,600 µg/L from September 16 to March 14 during noncritical year types for the SJR from the Merced River to Vernalis. These WQOs are established to be sufficiently protective of agriculture. The agricultural water quality goal for boron is 700 µg/L, which is the concentration reported by Ayers and Westcot (1985) that did not require restrictions for agricultural use (Marshack 2008). Boron toxicity in plants is characterized by leaf malformation such as thickened, curled, wilted, and chlorotic leaves (CVRWQCB 2004).

At time zero, the total boron concentration measured at the DMC was similar to the concentration at NW US and less than concentrations in the SJR (**Figure 3-23**).

Total boron concentrations measured at NW DS were generally higher than concentrations at NW US, but concentrations throughout the Wasteway were lower than concentrations at SJR US (**Figure 3-23**). Recirculation tended to act as a dilution flow for total boron on SJR concentrations, as seen by lower concentrations measured at SJR DS relative to those measured at SJR US.

Boron concentrations measured at NW DS were at or above time zero concentrations during approximately the first 12 hours, which may reflect concentrations of the resident water that was displaced in the Wasteway.

Boron concentrations measured at SCL were less than the Basin Plan objectives; the Basin Plan objectives for boron do not apply to other monitoring locations. Boron concentrations at SJR US did not meet the agricultural water quality limit, but concentrations at SJR DS that were influenced by the recirculation flow were generally below or near the agricultural limit.

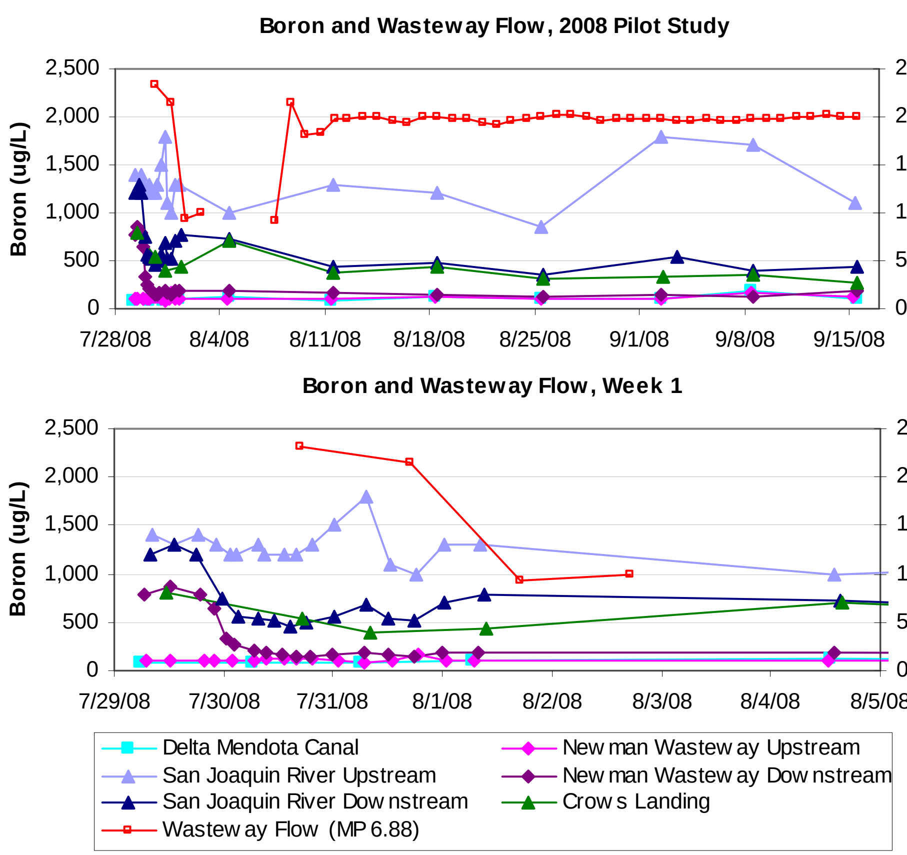


Figure 3-23. Discrete Samples for Total Boron

Hardness as Calcium Carbonate ($CaCO_3$)

Water hardness is a measurement of polyvalent metallic ions dissolved in water. For freshwater, it can be calculated as the sum of the calcium and magnesium concentrations and is expressed as the calcium carbonate equivalent concentration. The carbonate fraction of hardness is equal to the bicarbonate concentration in water, which is generally measured as alkalinity. In freshwater, hardness is often correlated with alkalinity and may give an indication the buffering capacity of the water.

The aquatic toxicity of various metals is often reduced with increasing hardness. For example, the EPA-recommended AWQC for the protection of freshwater aquatic life for copper is expressed as a function of hardness in the water column. There are no water quality criteria for hardness.

The hardness in the Wasteway was generally increasing between NW US and NW DS, but both locations were generally lower than concentrations at the SJR US (**Figure 3-24**). Measured hardness was generally less at SJR DS than at SJR US because of dilution from recirculation.

3.4 Toxicity Results

Water and sediment acute and chronic toxicity tests were conducted by Pacific EcoRisk in accordance with EPA guidelines. The full toxicity evaluation report is provided in **Appendix C**.

Based on the results of both the water and sediment toxicity tests, the addition of DMC and the Wasteway water to the SJR did not have any significant negative impacts on species growth and survival in the Wasteway or in the SJR downstream of the Wasteway.

3.4.1 Water Toxicity

Water for toxicity testing was collected from NW DS and SJR DS. Four samples at each location were collected between July 29 and July 31; a background sample was collected from both sites at time zero, a sample was collected from both sites once flow at NW DS exceeded 100 cfs, a sample was collected from both sites once flow at NW DS exceeded 200 cfs, and one sample was collected from both sites on the morning of the third day. The objective of toxicity testing is to evaluate the potential adverse effects of effluents on receiving waters by observing the survival and growth of the test organisms over a 96-hour exposure period. The sample exhibits toxicity if the survival is significantly different from the survival of the control test population (which must be greater than or equal to 90%), or the growth is significantly reduced from the growth control test population. The test species were

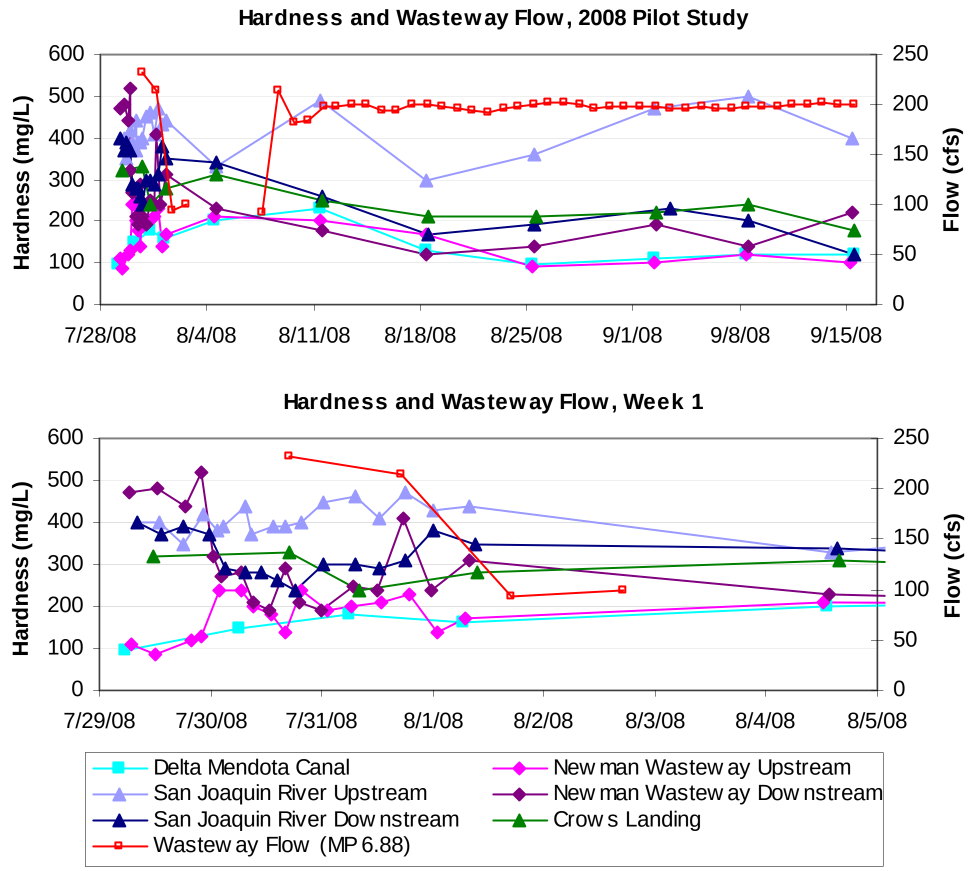


Figure 3-24. Discrete Samples for Hardness

Selenastrum capricornutum (green algae), *Ceriodaphnia dubia* (water flea), and *Pimephales promelas* (fathead minnow).

The sample collected at NW DS on the second day exhibited limited toxicity to *S. capricornutum*, which was insufficient to trigger a toxicity identification evaluation (50% mortality). There were no significant reductions in *S. capricornutum* growth in the water samples from any other samples. There were no significant reductions in *C. dubia* or *P. promelas* survival. The results are summarized in **Table 3-2**.

3.4.2 Sediment Toxicity

Sediment for background toxicity testing was collected from NW DS before the water releases. One sample was collected on July 28. The objective of sediment toxicity is to test for potential adverse effects of pollutants in the sediment by observing the survival of the test organisms over a 10-day exposure period. The sample exhibits toxicity if the survival is significantly different from the control survival. The test species was *Hyalella azteca* (freshwater amphipod), and results showed no significant reductions in survival.

Table 3-2. Summary of Water Toxicity Results

Sample	Water Toxicity Present Relative to Laboratory Control?		
	S. capricornutum **(green algae) Growth Test**	***C. dubia*** **(water flea) Survival Test**	***P. promelas*** **(fathead minnow) Survival Test**
NW DS Sample 1 (Background)	No	No	No
NW DS Sample 2	No	No	No
NW DS Sample 3	Yes[1]	No	No
NW DS Sample 4	No	No	No
SJR DS Sample 1 (Background)	No	No	No
SJR DS Sample 2	No	No	No
SJR DS Sample 3	No	No	No
SJR DS Sample 4	No	No	No

[1] Growth was inhibited; 50% of the population was growth inhibited (IC_{50}) at 19.4% ambient water.

DMC/NW = Delta-Mendota Canal / Newman Wasteway
NW DS = Newman Wasteway downstream
NW US = Newman Wasteway upstream
SCL = San Joaquin River at Crows Landing
SJR DS = San Joaquin River downstream
SJR US = San Joaquin River upstream

This page intentionally left blank

Chapter 4
Response to Recirculation

The DWR reports continuous EC, flow, stage, and DO data for various locations in the San Joaquin River basin and Delta using the CDEC (CDEC 2009). **Table 4-1** and **Figure 4-1** show the CDEC stations used to analyze the SJR and Delta response to recirculation.

4.1 San Joaquin River and Major Tributaries

The recirculation study period (July 29 to September 15) coincides with the end of the agriculture irrigation season. Irrigation applications tend to peak in July for most row crops and tail off in August and September, after the plants have reached maturity and are starting to senesce. Subsurface tile drainage and

Table 4-1. CDEC Stations Used to Analyze San Joaquin River and Delta Response to Recirculation

Site Name	CDEC Name	Latitude	Longitude	Parameters
SJR at Fremont Ford	FFB	37.3100°N	120.9300°W	Flow, EC
Mud Slough at Gustine	MSG	37.2625°N	120.9056°W	Flow, EC
Merced River near Stevinson	MST	37.3710°N	120.9310°W	Flow, EC
SJR at Crows Landing	SCL	37.4321°N	121.0122°W	Flow EC
Tuolumne River at Modesto	MOD	37.6500°N	121.0010°W	Flow, EC
SJR at Maze	MRB	37.6414°N	121.2276°W	Flow, EC
Stanislaus River at Ripon	RIP, RPN	37.7300°N	121.1090°W	Flow, EC
Goodwin Dam	GDW	37.8750°N	120.6030°W	Spillway discharge, full natural flow
SJR at Vernalis	VNS, VER	37.6670°N	121.2670°W	Flow, EC
Old River near Head	OH1	37.8080°N	121.3290°W	Flow
SJR at Brandt Bridge	BDT	37.8650°N	121.3231°W	Flow, stage, EC
Union Island	UNI	37.8240°N	121.3760°W	EC
Old River at Tracy Road Bridge	OLD	37.8050°N	121.4490°W	Stage, EC
Middle River at Howard Road	MHR	37.8770°N	121.3840°W	Stage, EC
Doughty Cut	DGL	37.8150°N	121.4250°W	Stage, EC
Rough and Ready Island	RRI	37.9630°N	121.3650°W	Flow, DO

CDEC = California Data Exchange Center
DO = dissolved oxygen
EC = electrical conductivity
SJR = San Joaquin River

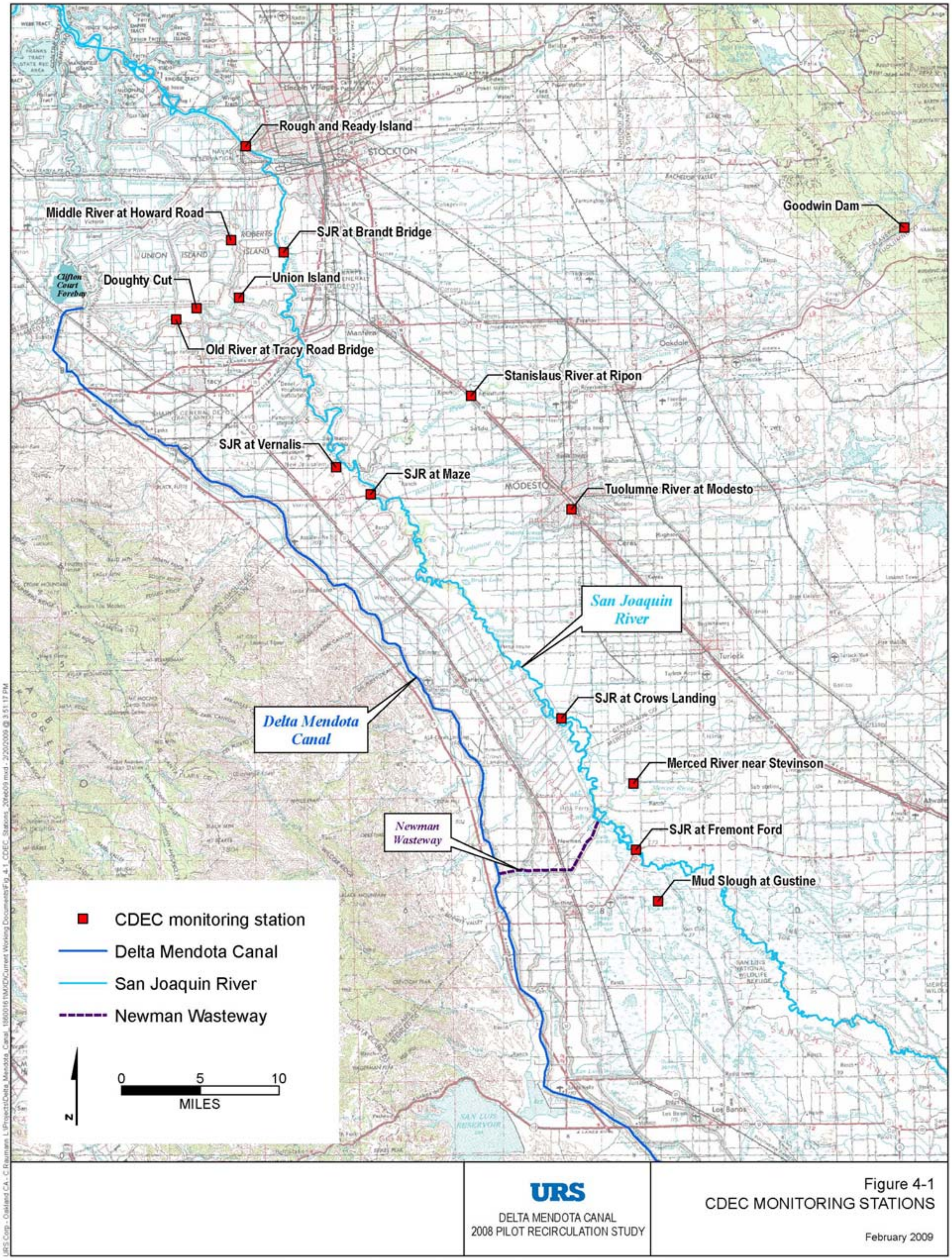


Figure 4-1. CDEC Monitoring Stations

surface water return flows (where not recaptured by the farmer or water district) are often associated with irrigation applications and thus also decline in volume at this time of year. There is a smaller combined surface and subsurface return flow to the SJR during this period. Seasonal releases to wetlands typically do not begin until September 1, and there may be a lag between the onset of wetland releases and the appearance of operational spills and wetland return flows. Wetland return flows at the beginning of this period can have a high salt content as water dissolves some of the effloresced salts that have accumulated in the dry wetland impoundments. The water can also become turbid with inert organic carbon from desiccated algae and wetland plant habitat. Wetland return flows tend to be mildly acidic; the first flush of return flows may contain a yellowish tinge of dissolved humic materials.

Water year 2008 was a critically dry hydrologic year for the San Joaquin River basin. During late summer 2008, flow in the SJR was influenced primarily by upstream releases, irrigation diversions, and return flows.

4.1.1 Fremont Ford

Two monitoring stations upstream of the Wasteway confluence with SJR can be used to describe the contributions to background flow and water quality seen at SJR US during the recirculation study. The two stations are the SJR at Fremont Ford and Mud Slough at Gustine.

The SJR at the Fremont Ford monitoring station is at the Highway 140 bridge northeast of Gustine between the confluence with Mud Slough and Salt Slough. Drainage discharges to this section of the SJR originate from Salt Slough and consist primarily of agricultural and wetland return flows. Water from Salt Slough comes from wetland discharges, runoff from farmland, and occasional flood flows and is composed of surface tailwater, operational spills, and wetland drainage from the surrounding area.

Flow and EC at the SJR at Fremont Ford (CDEC Station FFB) for the periods before, during, and after the pilot recirculation are shown on **Figure 4-2**. The Fremont Ford monitoring station is approximately 5.7 river miles upstream of the Wasteway confluence with the SJR. Assuming a velocity in the SJR of about 0.5 mile/hour (Reclamation 2008a), travel time from Fremont Ford to the confluence with the Wasteway is a little more than 11 hours.

4.1.2 Mud Slough

Mud Slough is the major carrier of agricultural drainage to the SJR. Drainage that originates from the Grassland Drainage Area is discharged directly into Mud Slough. Flow in Mud Slough upstream of the discharge point consists of wetland releases from northern and southern Grassland Water District, the Volta

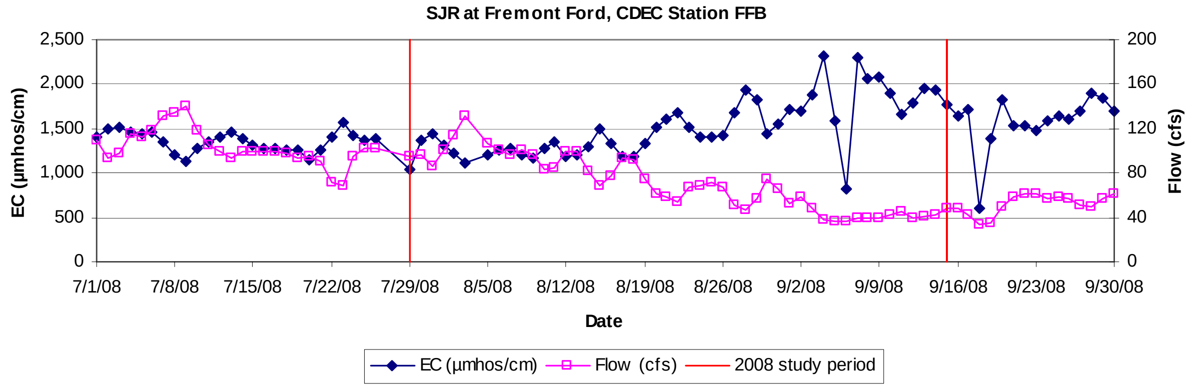


Figure 4-2. Flow and Electrical Conductivity at the San Joaquin River at Fremont Ford

Wildlife Management Area, operational spills from the DMC and Central California Irrigation District's (IDs) Main Canal, and flood flows from Los Banos Creek. Flow in Mud Slough downstream of the discharge point is often dominated by water originating from the Grassland Drainage Area.

Flow and EC at Mud Slough near Gustine (CDEC Station MSG) for the periods before, during, and after the pilot recirculation are shown on **Figure 4-3**.

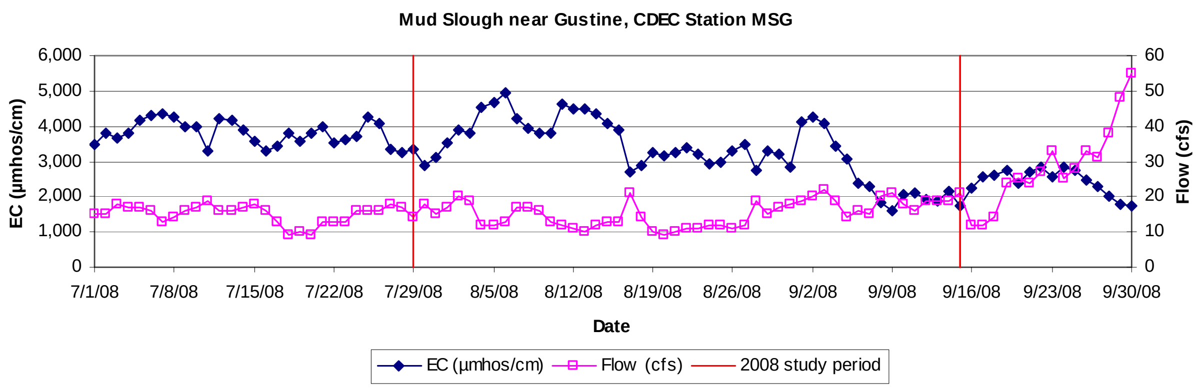


Figure 4-3. Flow and Electrical Conductivity at Mud Slough near Gustine

4.1.3 Newman Wasteway

Flow from upstream locations is compared to the pilot study monitoring data collected at MP 6.88 (**Figure 4-4)**. Recirculation contributed a significant amount of flow to the SJR at the confluence of the Wasteway. The flow in the SJR immediately after the confluence with the Wasteway was more than doubled due to the recirculation.

EC from the upstream locations is compared to data collected from SJR US, NW DS, and SJR DS (**Figure 4-5)**. EC measured at SJR US was similar in quality at the SJR at Fremont Ford. As discussed in **Section 3.2.4**, EC measured at SJR DS was lower than the upstream locations because of mixing with lower EC Wasteway water.

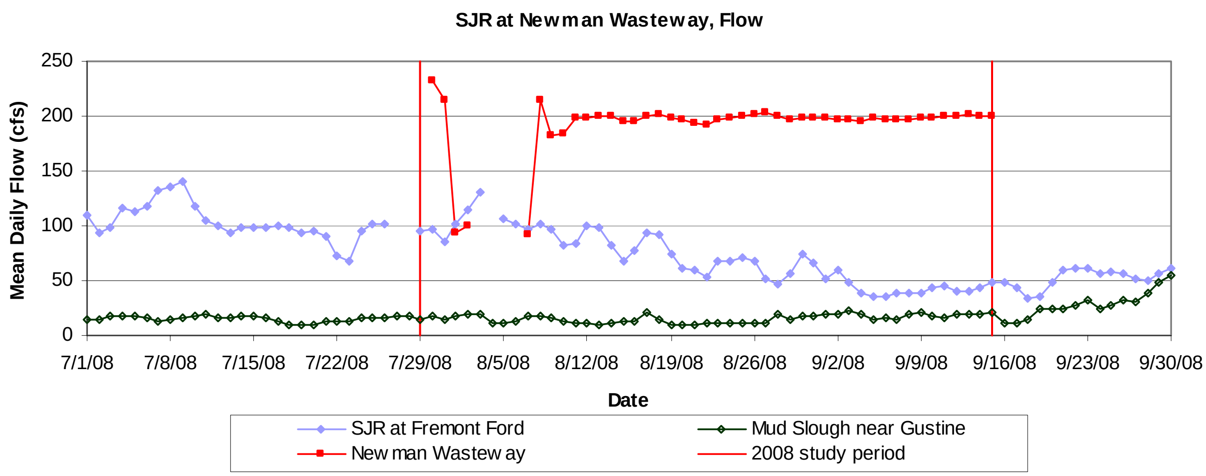


Figure 4-4. Flow Contributions at the San Joaquin River at Newman Wasteway

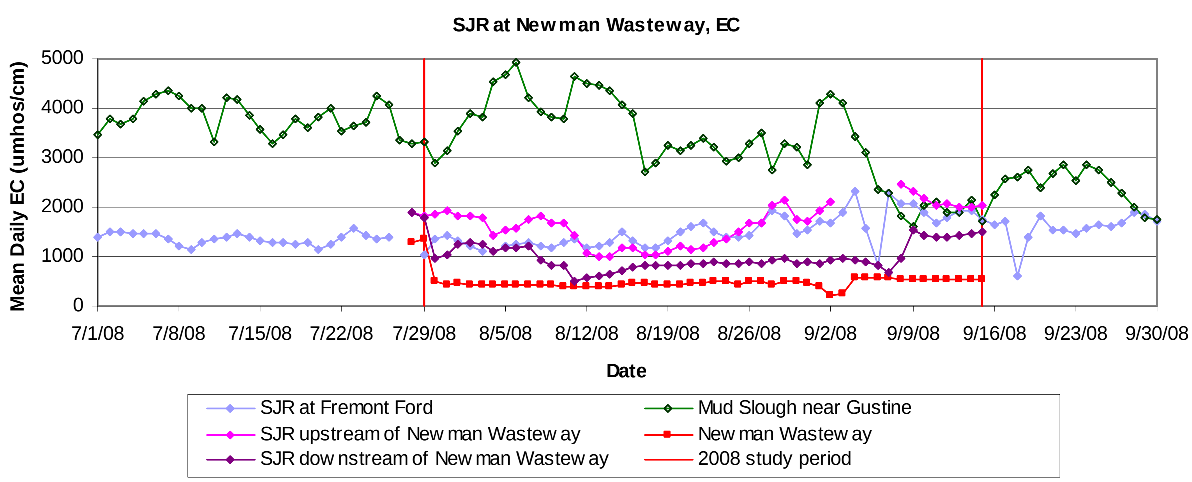


Figure 4-5. Electrical Conductivity at the San Joaquin River Confluence with Newman Wasteway

4.1.4 Merced River

The southern-most major eastside tributary to the lower SJR is the Merced River. The Merced River watershed covers approximately 883,000 acres and contributes approximately 15% of the flow in the lower SJR (CVRWQCB

2007b). Releases to the lower Merced River are regulated by New Exchequer Dam, which forms Lake McClure. New Exchequer Dam is owned and operated by the Merced ID for power production, irrigation, and flood control.

Flow and EC at the Merced River near Stevinson (CDEC Station MST) for the periods before, during, and after the pilot recirculation are shown on **Figure 4-6**. The Merced River typically lower in turbidity and EC, provides dilution to SJR.

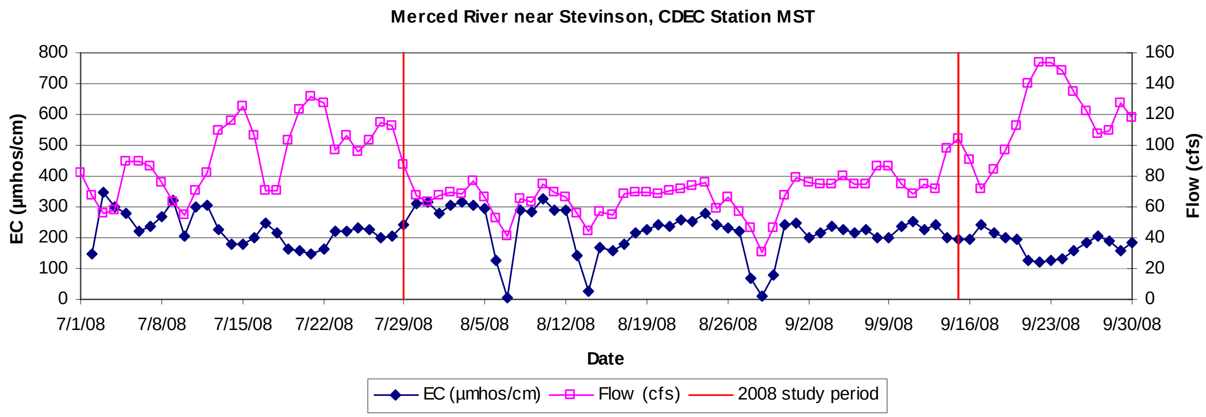


Figure 4-6. Flow and Electrical Conductivity at the Merced River near Stevinson

4.1.5 Crows Landing

Crows Landing bridge is at the SJR downstream of the Merced River confluence and upstream of the Tuolumne River confluence. The water quality at this site is better than it is at upstream stations because the Merced River drains to the SJR upstream of this station. Between the confluences with the Merced River and the Tuolumne River, water is diverted for agricultural use from small riparian areas on both the eastern and western banks of the SJR. Return flows enter the SJR between the town of Newman and Maze Road.

Flow and EC at the SJR at Crows Landing (CDEC Station SCL) for the periods before, during, and after the pilot recirculation are shown on **Figure 4-7**. The distance between the Wasteway confluence and the Crows Landing bridge is 12.3 river miles. Assuming a velocity in the SJR of about 0.5 mile/hour, the travel time from the SJR confluence with Newman Wasteway to the SJR at Crows Landing is about 25 hours.

The flow at the SJR at Crows Landing increased by approximately 150 cfs 2 days after the initial increases at the downstream section of the Wasteway (**Figure 4-8**). Flow at the SJR at Crows Landing remained elevated after steady-

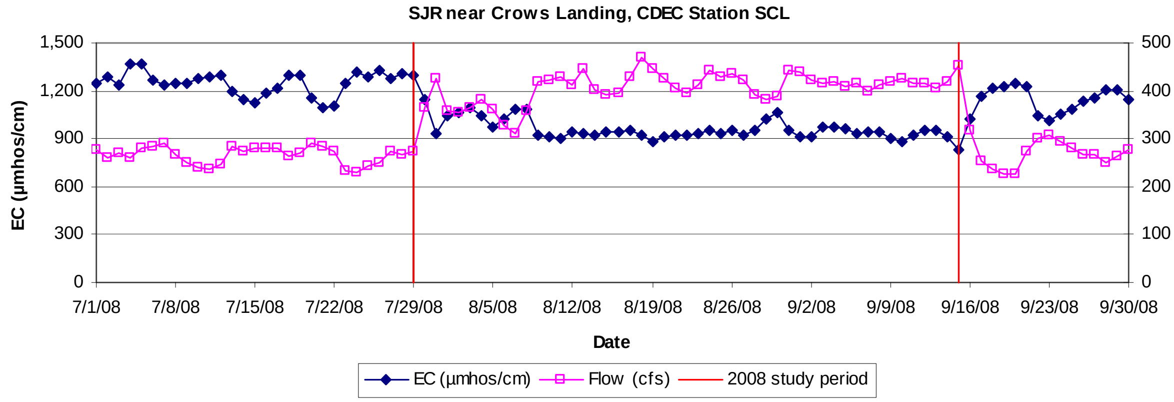


Figure 4-7. Flow and Electrical Conductivity at the San Joaquin River at Crows Landing

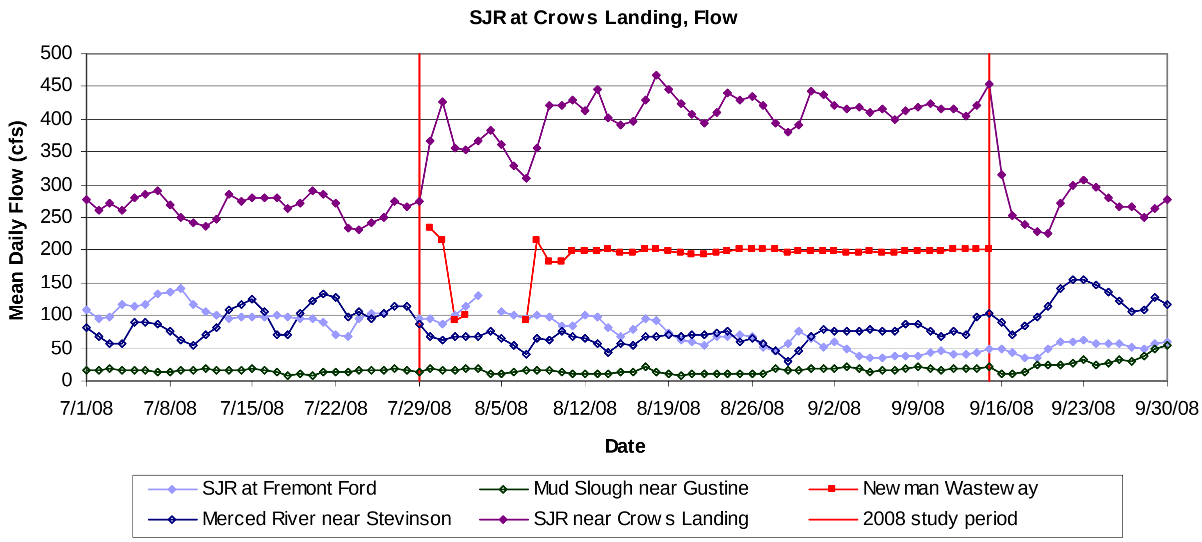


Figure 4-8. Flow Contributions at Crows Landing

state flow in the Wasteway had been achieved. During the increased flows, EC measurements decreased at Crows Landing by approximately 300 to 400 µmhos/cm (**Figure 4-9**). At the conclusion of the study, Crows Landing flows decreased and the EC measurements returned to pre-recirculation values.

4.1.6 Tuolumne River

The next major eastside tributary north of the Merced River is the Tuolumne River. The Tuolumne River watershed contains approximately 1.2 million acres and contributes approximately 27% of the flow in the lower SJR (CVRWQCB 2007b). Flows in the lower portion of the Tuolumne River are controlled primarily by the operation of New Don Pedro Dam, which was constructed in

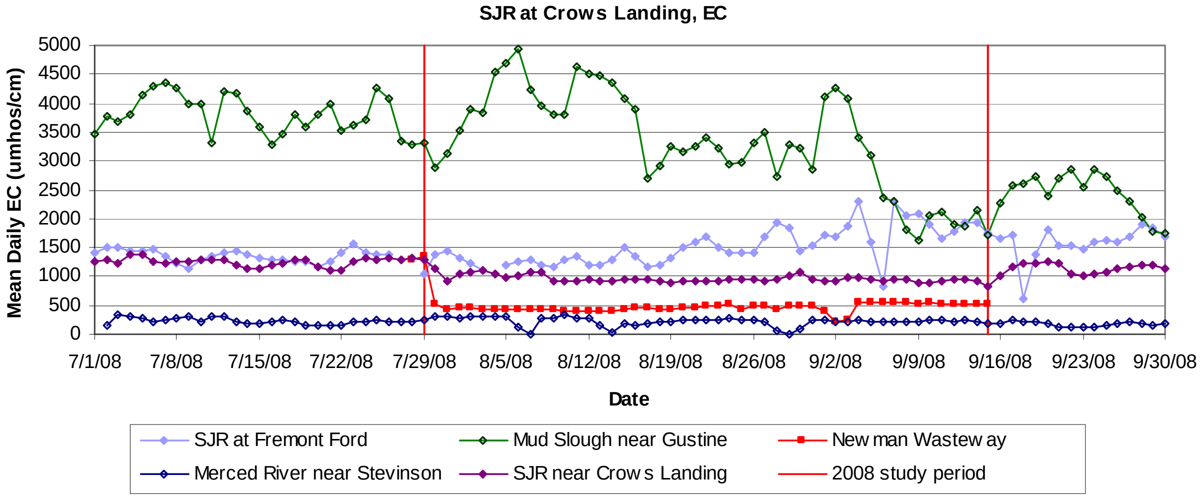


Figure 4-9. Electrical Conductivity Contributions at Crows Landing

1971 jointly by Turlock and Modesto IDs, with participation by the City and County of San Francisco.

Flow and EC at the Tuolumne River at Modesto (CDEC Station MOD) for the periods before, during, and after the pilot recirculation are presented in **Figure 4-10**. The Tuolumne River provides additional dilution to SJR EC.

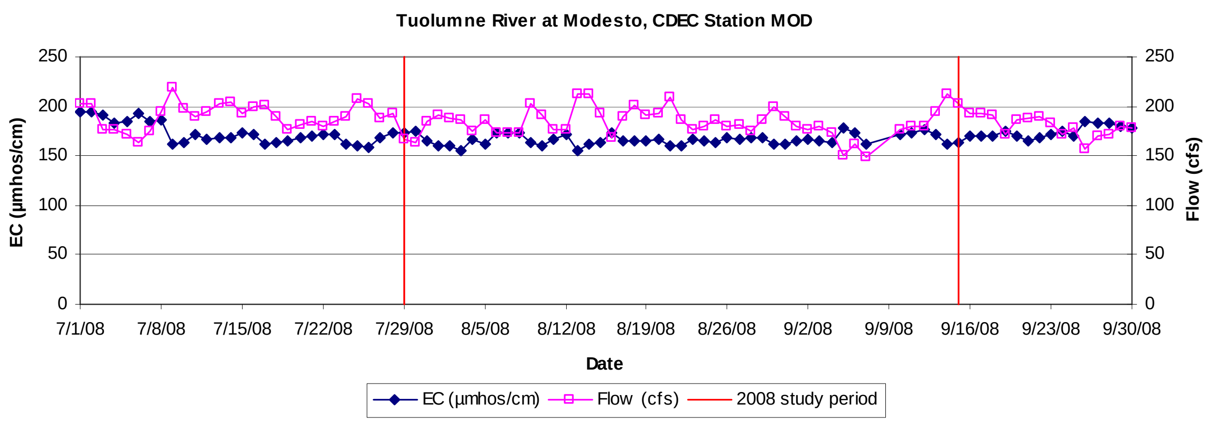


Figure 4-10. Flow and Electrical Conductivity at the Tuolumne River at Modesto

4.1.7 Riparian Irrigation Diversions

Estimates of flow diversions from some of the largest irrigators on the western side on the San Joaquin Valley were analyzed to determine whether there was a change in irrigation diversions from the SJR during the 2008 Pilot Study. Major SJR diverters between the Wasteway and Vernalis include Patterson Irrigation District (ID), West Stanislaus ID, and El Solyo Water District. Diversion data were available for Patterson ID and West Stanislaus ID but not from El Solyo Water District (N. Quinn, Water Resources Engineer, Reclamation, written communication, March 11, 2009).

During the 2004 study, irrigation diversions to Patterson ID were fairly consistent, but an increase in SJR diversions to West Stanislaus ID removed a portion of the recirculation flow from the SJR. During the 2007 study, diversion data were available only for West Stanislaus ID. Diversions were relatively consistent, but variations in diversions were often greater than the typical recirculation flow (50 cfs).

Flows at the Patterson ID and West Stanislaus ID main canals for the periods before, during, and after the 2008 Pilot Study are shown on **Figure 4-11**. The Patterson ID intake is just downstream of the Patterson Bridge and approximately 21 river miles downstream from the Wasteway. The West Stanislaus ID intake canal is upstream of the Maze Road bridge and approximately 40 river miles downstream of the Wasteway.

During the first four weeks of recirculation, diversions to Patterson and West Stanislaus IDs were fairly constant (**Figure 4-11**), and diversions therefore did not substantially contribute to changes in the pattern of the flow response at the Maze Road bridge. During the last three weeks of recirculation, diversions decreased approximately 20 to 70 cfs by each ID (**Figure 4-11**), but the flow pattern remained similar between Crows Landing and the Maze Road bridge (**Figure 4-12**).

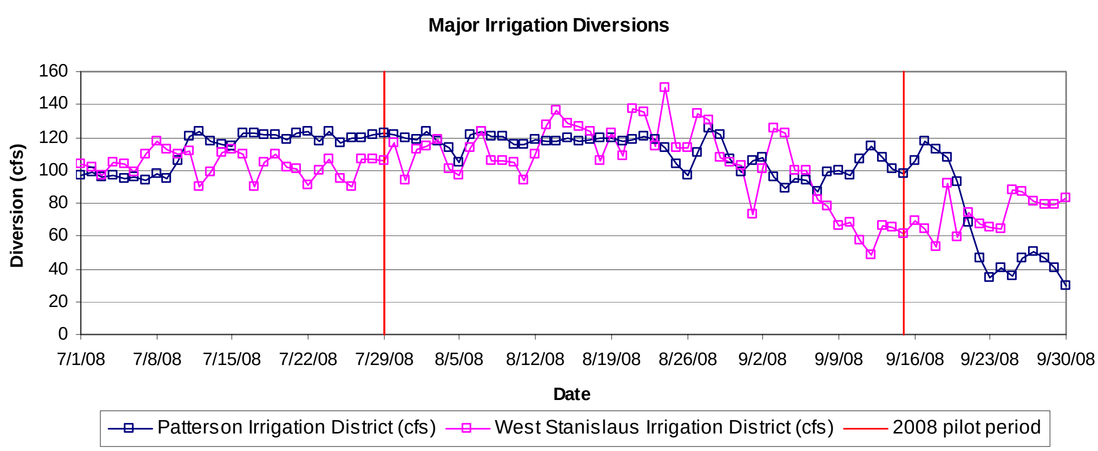


Figure 4-11. Patterson and West Stanislaus Irrigation Districts Irrigation Diversions from the San Joaquin River

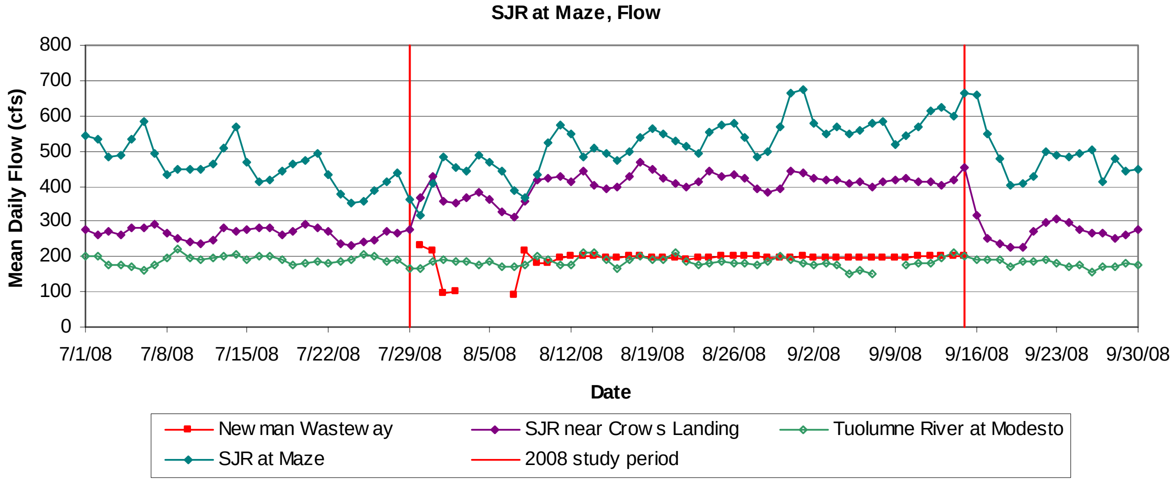


Figure 4-12. Flow Contributions at the San Joaquin River at Maze

4.1.8 Maze

Maze Road bridge is located at the SJR between the Tuolumne River confluence and the Stanislaus River confluence. Water is diverted for agricultural use from small riparian areas on both the eastern and western banks of the SJR between the two rivers. Return flows enter the SJR between Maze and Vernalis.

Flow and EC at the SJR at Maze (CDEC Station MRB) for the periods before, during, and after the pilot recirculation are shown on **Figure 4-12**. The SJR at Maze is approximately 41 river miles downstream of the Wasteway confluence. Assuming a velocity in the SJR of about 0.5 mile/hour, travel time from the confluence with Newman Wasteway to Maze is about 82 hours.

Flow in the Tuolumne River was approximately 200 cfs July through September; however, the difference in flow between the SJR at Maze and Crows Landing was rarely this high during August (**Figure 4-13**). Potentially, the rate of irrigation diversions was greater than return flows in this stretch of the SJR during July and August, as seen by the downward trend in flow at Maze before the recirculation period, when flow at the SJR at Crows Landing and the Tuolumne River was relatively stable. Despite this potential net withdrawal, flow in the SJR at Maze gradually increased during recirculation.

Changes in EC between Crows Landing and Maze are due to the influence of the Tuolumne River and irrigation return flow (**Figure 4-14**).

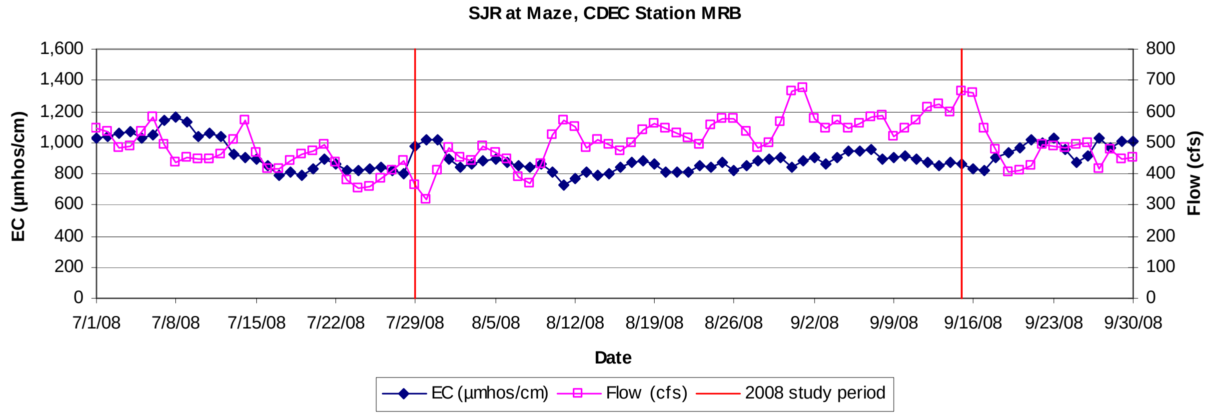


Figure 4-13. Flow and Electrical Conductivity at the San Joaquin River at Maze

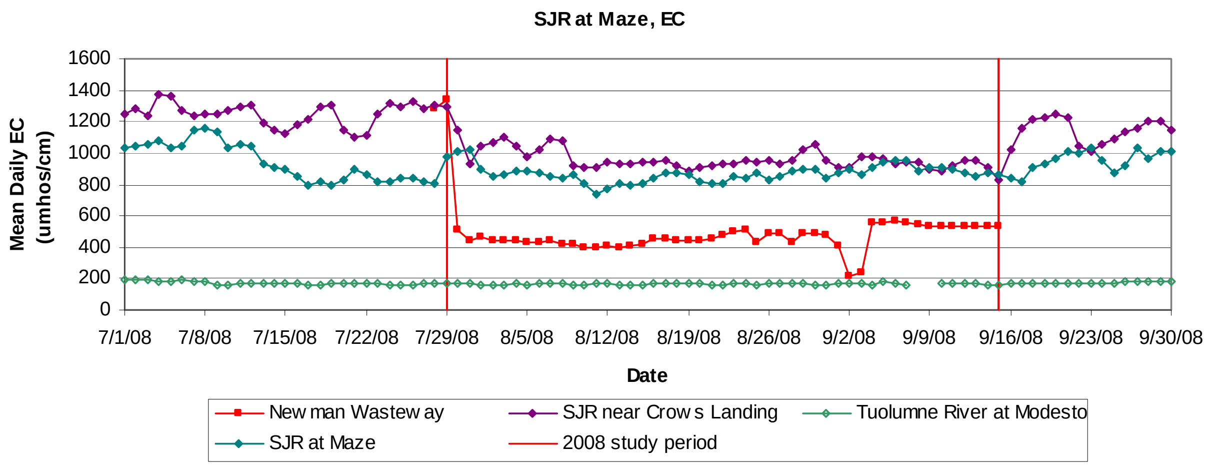


Figure 4-14. Electrical Conductivity Contributions at the San Joaquin River at Maze

4.1.9 Stanislaus River

The Stanislaus River is the northern-most eastside SJR tributary. The Stanislaus River watershed is approximately 737,000 acres and contributes approximately 18% of the flow in the lower SJR (CVRWQCB 2007b). Flow in the Stanislaus River during the late summer primarily consists of reservoir releases and agricultural return flows.

Flow and EC at the Stanislaus River at Ripon (CDEC Stations RPN and RIP) for the periods before, during, and after the pilot recirculation are shown on **Figure 4-15**.

The main water diversion point on the Stanislaus River is Goodwin Dam, which is approximately 1.9 miles downstream of Tulloch Dam. Goodwin Dam creates a re-regulating reservoir for releases from Tulloch Power Plant and provides for

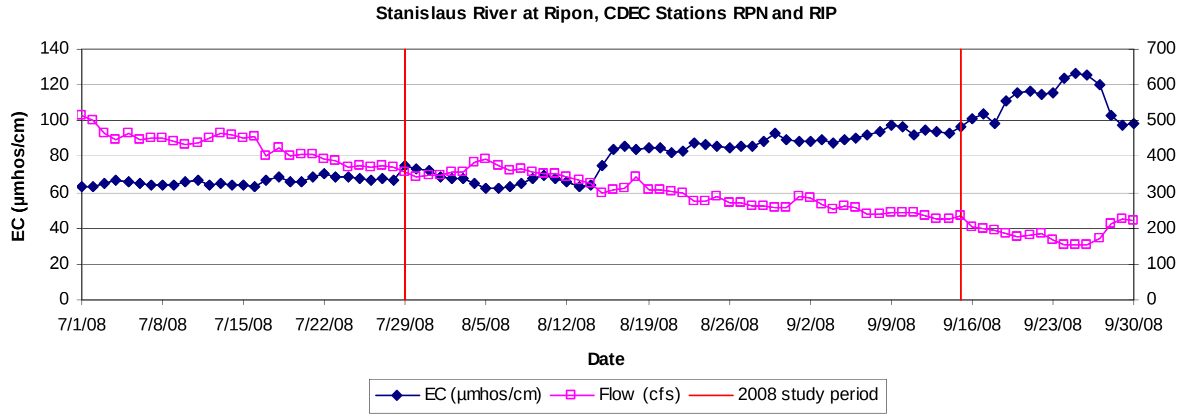


Figure 4-15. Flow and Electrical Conductivity at Stanislaus River at Ripon

diversions to canals north and south of the Stanislaus River for delivery to the Oakdale and South San Joaquin IDs.

Reclamation constructed New Melones Dam and Reservoir to assist with meeting the flow and salinity requirements at Vernalis. The intent of recirculation is to meet flow and salinity standards at Vernalis while reducing flow from New Melones Dam intended for the same purpose. Therefore, the reliability of meeting contract water services for CVP contractors along the Stanislaus River with water supplies derived from New Melones storage could increase in the long term.

Flow at Goodwin Dam (CDEC Station GDW) for the periods before, during, and after the pilot recirculation is shown on **Figure 4-16**. During the recirculation period (July 29 to September 15), spillway discharge from Goodwin Dam decreased approximately 200 cfs.

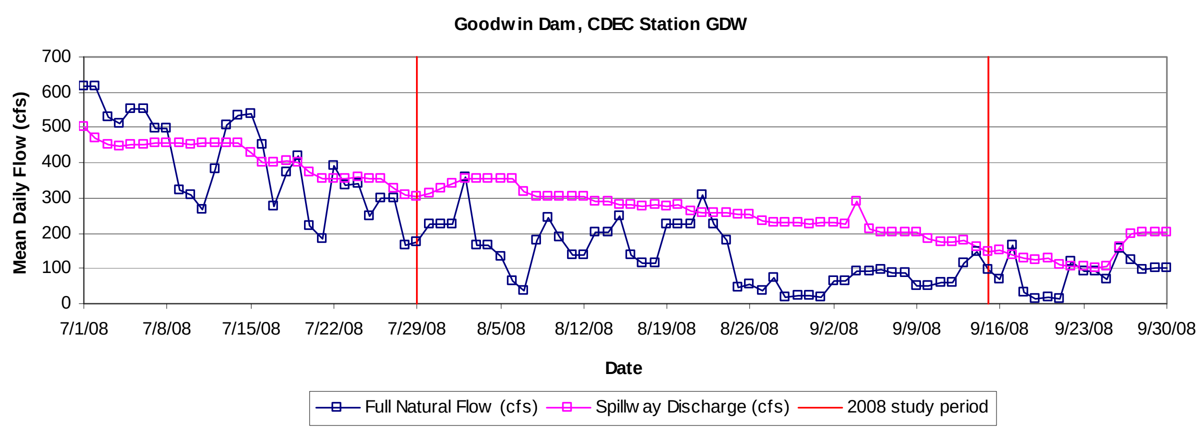


Figure 4-16. Flow at Goodwin Dam

4.1.10 Vernalis

Vernalis is a compliance site for EC, as stated in D-1641. Water quality at Vernalis is often better than at other SJR locations because Vernalis is just downstream of the SJR confluence with the Stanislaus River.

The distance between the Wasteway confluence and the Airport Way bridge, Vernalis, is about 47 river miles. Assuming a velocity in the SJR of about 0.5 mile/hour, the travel time from the SJR confluence with Newman Wasteway to Vernalis is about 94 hours. Assuming a residence time in the Newman Wasteway of 9 hours, DMC flow diversions would have been seen at Vernalis approximately 103 hours later.

Flow and EC at the SJR at Vernalis (CDEC Stations VER and VNS) for the periods before, during, and after the pilot recirculation are shown on **Figure 4-17**. No significant changes occurred in flow or EC at Vernalis during the recirculation period (July 29 to September 15). Flow at Vernalis decreased by approximately 300 cfs, and EC values increased by approximately 200 µmhos/cm at the end of September (**Figure 4-16**). This change in flow may be a result of operational decisions independent of recirculation.

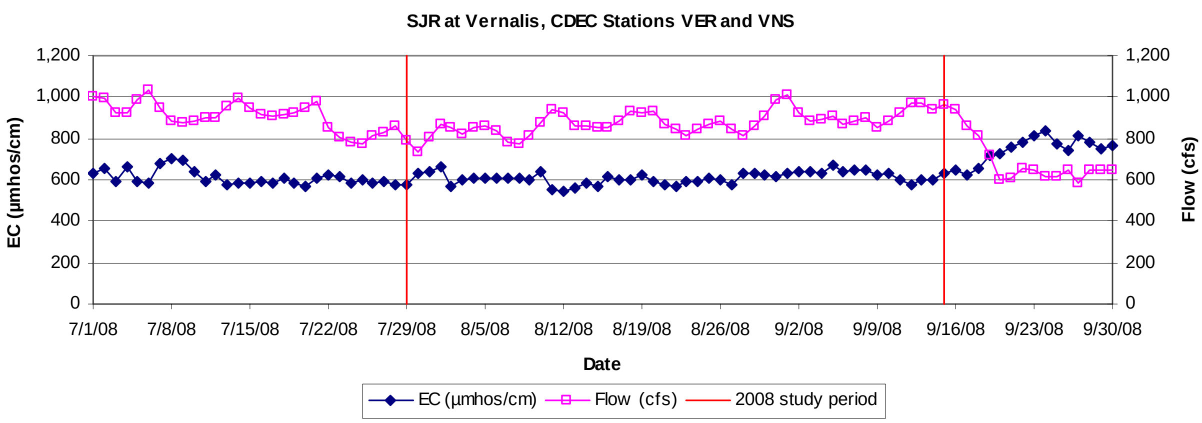


Figure 4-17. Flow and Electrical Conductivity at San Joaquin River at Vernalis

Before the recirculation study, the difference between the flow at Vernalis and the flow at Maze was approximately equal to releases from Goodwin Dam (**Figure 4-18**). During the recirculation study, releases from Goodwin Dam decreased while EC at Vernalis was maintained below the 700 µmhos/cm during July and August and below 1,000 µmhos/cm during September (**Figure 4-18**. At the end of the recirculation study, flow at Maze and Vernalis decreased and EC values increased (**Figures 4-18** and **4-19**).

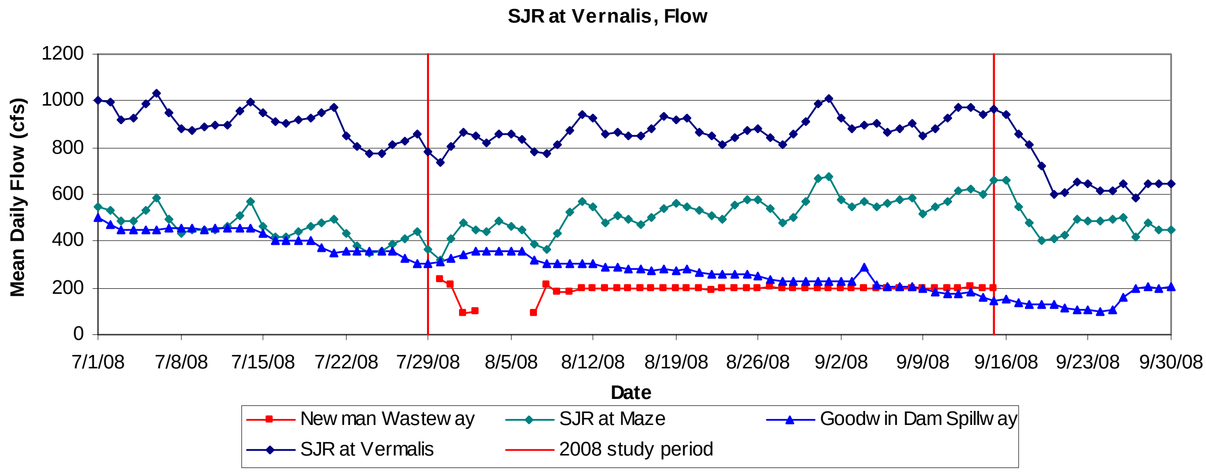


Figure 4-18. Flow Contributions at Vernalis

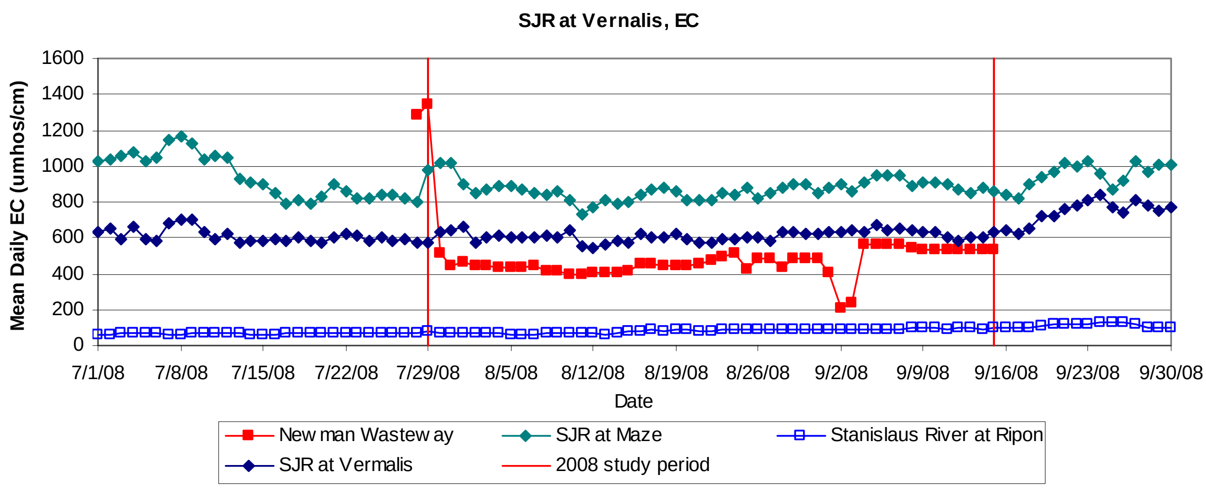


Figure 4-19. Electrical Conductivity Contributions at Vernalis

4.2 South Delta

The water quality in the south Delta downstream of Vernalis is influenced by river inflows, diversions of water by the State Water Project (SWP) and CVP, diversions by local users, return flows, urban runoff, wastewater discharges, tidal action, and channel capacity.

The SJR splits at the head of Old River in the south Delta, and under natural conditions, approximately half of the water flows down Old River. However, operations of the CVP and SWP can change Delta flow patterns (**Figure 4-20**). When low SJR flows combine with high export rates and low tides, south Delta water levels can become so low as to constrain diversions for Delta irrigation.

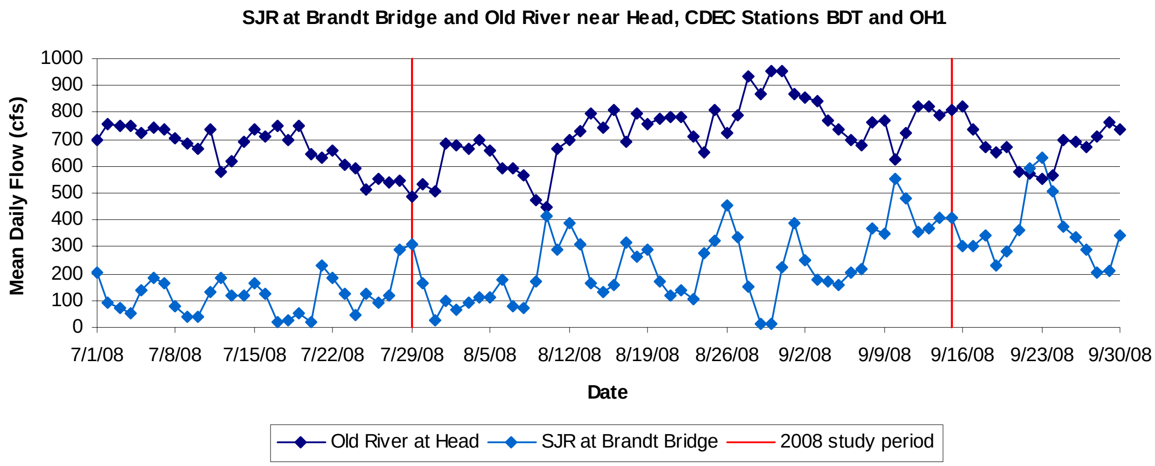


Figure 4-20. South Delta Flow, San Joaquin River, and Old River

4.2.1 Electrical Conductivity at Interior Delta Stations

The Basin Plan has established EC objectives for three sites in the south Delta: SJR at Brandt Bridge, Old River near Middle River, and Old River at Tracy Road bridge. EC for the periods before, during, and after the pilot recirculation are shown on **Figure 4-21** for locations at or near these three sites. The CDEC station for Union Island is near the head of Middle River. This station is assumed to have water quality similar to that of the D-1641 compliance site for the Old River near Middle River.

Before September 2008, the EC at these south Delta sites did not consistently meet the D-1641 and Basin Plan standard (**Figure 4-21**) as New Melones is not operated to meet south Delta standards. The EC measured at the south Delta sites during the recirculation study (July 29 to September 15) was generally within the background variation seen during the pre-recirculation period.

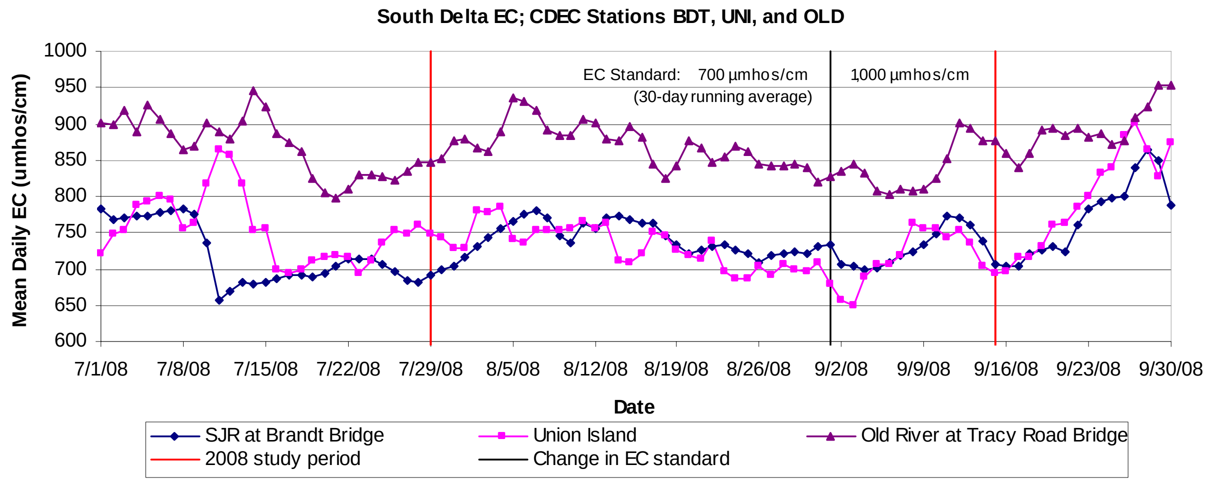


Figure 4-21. South Delta Electrical Conductivity

Therefore, during the study, the recirculation had very little effect on EC at these south Delta locations.

4.2.2 Temporary Barrier Gate Operations

The South Delta Temporary Barriers Project consists of four rock barriers across south Delta channels. The primary objectives of the program are to increase water levels, circulation patterns, and water quality in the south Delta area for local agricultural diversions and improve the operational flexibility of SWP to help reduce fishery impacts and improve fishery conditions (DWR n.d.).

The head of Old River barrier serves as a fish barrier and is intended primarily to benefit migrating SJR chinook salmon. The barrier installation in the fall usually occurs during late September but depends on the current and projected DO levels in the SJR near Stockton. The remaining three barriers serve as agricultural barriers, because they are intended to benefit agricultural water users in the south Delta. The barriers are usually in place between April 15 and September 30 (DWR n.d.). During the recirculation period, the three agricultural barriers were in operation, but the fall head of Old River barrier had yet to be installed. **Table 4-2** contains the 2008 operating schedule for the temporary barriers.

Normal barrier operation procedure includes more culvert flap gates tied open during the spring tides and fewer culvert flap gates tied open during the neap tides when improved south Delta circulation is needed to improve water quality. This procedure is followed as long as it does not cause water levels to drop below trigger levels. However, if water levels are sufficient, more culvert flap gates are tied opened than normal to improve water quality (DWR n.d.).

Table 4-2. Operating Schedule of Temporary Barriers

Barrier	Closure	Removal
Middle River	May 21, 2008	November 9, 2008
Old River near Tracy	June 4, 2008	November 25, 2008
Grantline Canal	June 26, 2008	November 24, 2008
Spring Head of Old River	Not installed, 2008	Not installed, 2008
Fall Head of Old River	October 16, 2008	November 9, 2008

In July, three of nine culvert flap gates were tied open on the Old River near the Tracy barrier. In early August, the number of open culvert flap gates on the Old River at Tracy barrier alternated between three and six. From the middle of August to the middle of September, six culvert flap gates were tied open continuously. Culvert flap gates at the Old River near Tracy barrier were untied in mid September due to the lowering of flows on the SJR and a less stringent water quality objective, along with continued south Delta demand for irrigation water (DWR n.d.).

Stage and EC for the periods before, during, and after the pilot recirculation are shown on **Figures 4-22** through **4-24** for Old River at Tracy Road Bridge, Middle River at Howard Road Bridge, and Doughty Cut (CDEC Stations OLD, MHR, and DGL, respectively). The water level at these stations directly benefits from the agricultural barriers.

The variation in minimum daily stage at these south Delta sites during the recirculation period was within the variation seen before the recirculation study (**Figures 4-22** through **4-24**), indicating recirculation did not increase minimum water levels at these stations.

4.2.3 Exports

Jones Pumping Plant is a federally owned facility used to move water from the Delta for transfer into the DMC. Banks Pumping Plant is a State-owned facility that is west of Jones Pumping Plant on a second canal off of Clifton Court Forebay. Banks Pumping Plant lifts water into the California Aqueduct for delivery to SWP contractors in the Central Valley and Southern California.

South Delta export information was obtained from the Central Valley Operations monthly water accounting reports (Reclamation 2008b). Daily exports at Jones Pumping Plant and Clifton Court Forebay for the months of July, August, and September 2008 are presented in **Figure 4-25**. The Jones Pumping Plant exports included approximately 5,000 acre-feet during July and

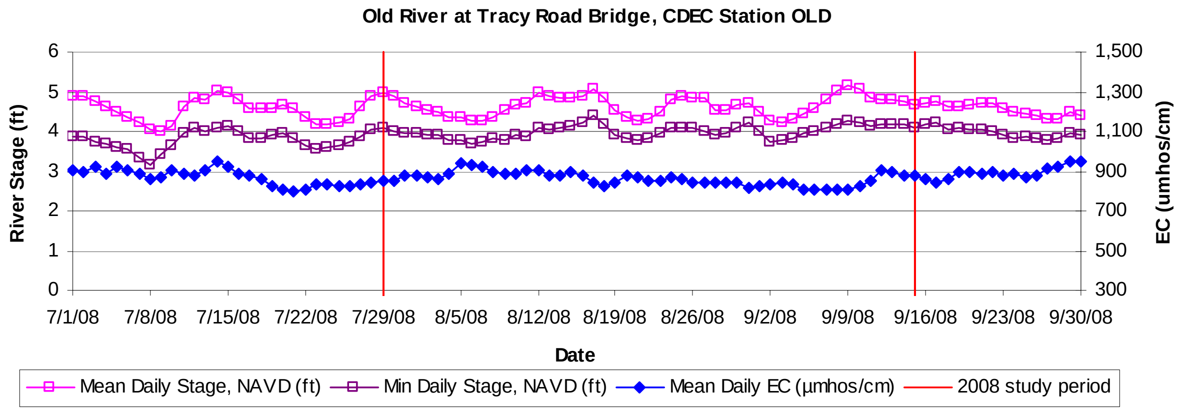


Figure 4-22. Stage and Electrical Conductivity at Old River at Tracy Road Bridge

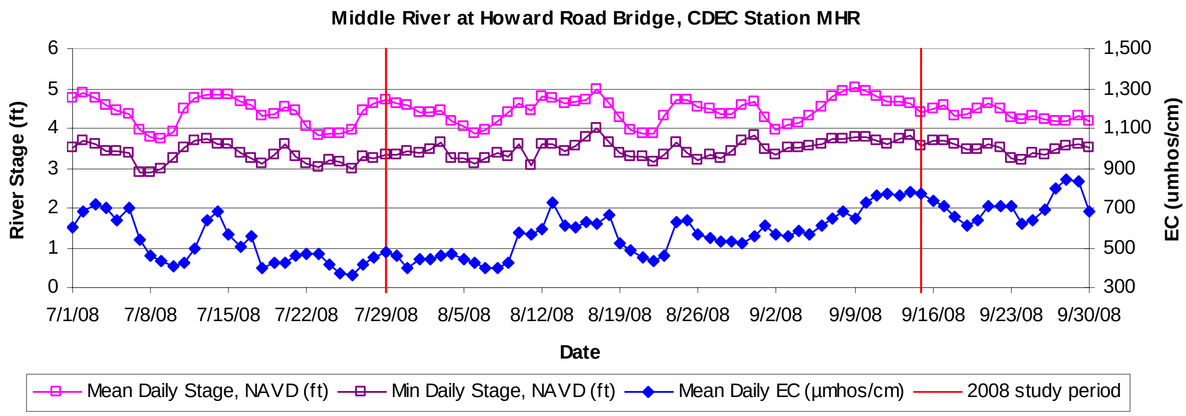


Figure 4-23. Stage and Electrical Conductivity at Middle River at Howard Road Bridge

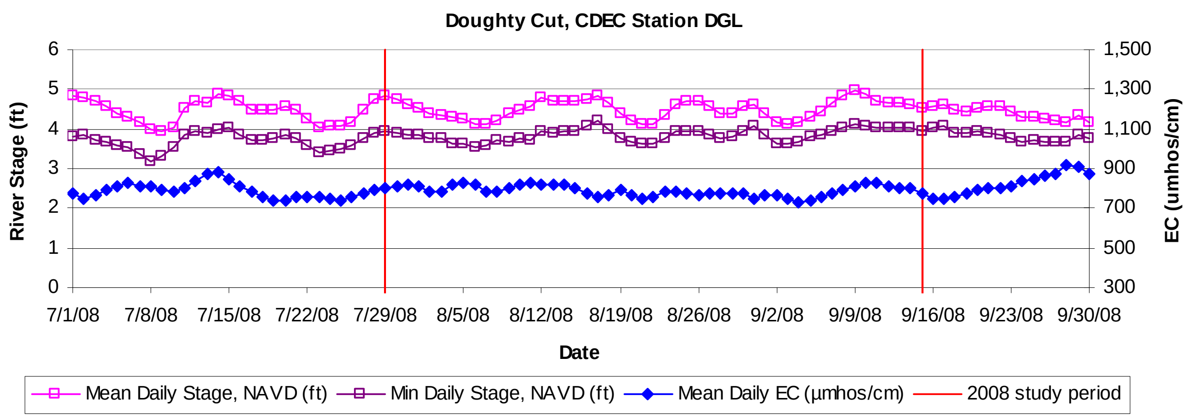


Figure 4-24. Stage and Electrical Conductivity at Old River at Doughty Cut

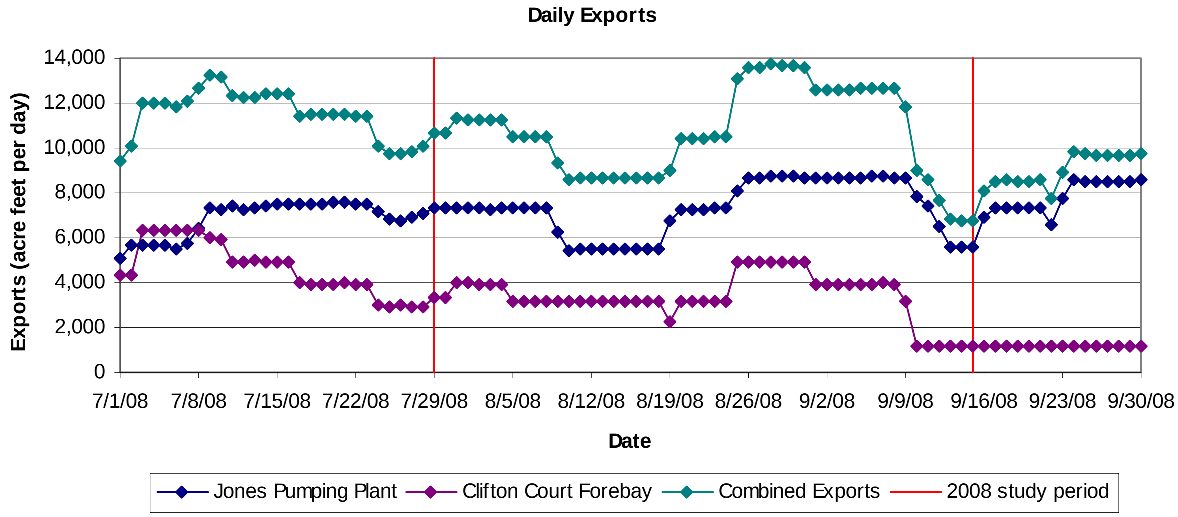


Figure 4-25. Exports at Jones Pumping Plant and Clifton Court Forebay

approximately 11,000 acre-feet during August of non-project water for other service contractors (Cross Valley Canal and Byron Bethany ID) (Reclamation 2008b).

Changes in exports at Jones Pumping Plant during the pilot study did not directly correspond with changes in recirculation (**Figures 4-24** and **4-25**). This result indicates that daily operations were influenced primarily by other factors. The potential influence of recirculation demand on export rates can be seen during the days immediately before the start of recirculation when exports at Jones Pumping Plant increased by approximately 500 acre-feet per day, and the period between August 26 and September 9, when deliveries along the upper DMC were required because of the capacity of the DMC near O'Neill Forebay.

4.2.4 Stockton Deep Water Ship Channel

The SJR regularly experiences low DO concentrations within the Stockton Deep Water Ship Channel (DWSC). This portion of the SJR has been dredged to a depth of 35 feet to allow for navigation of cargo vessels between San Francisco Bay and the Port of Stockton. The low DO has been attributed to low flow, channel geometry, upstream loading, excess phytoplankton growth, and elevated ammonia concentrations. The relationship between reduced flow through the DWSC and DO impairment is discussed in the DO TMDL Basin Plan Amendment Final Staff Report (CVRWQCB 2005).

Conditions in the DWSC between the city of Stockton and Turner Cut often violate the Basin Plan WQOs for DO. The Basin Plan WQOs require a minimum DO concentration of 5.0 mg/L at the Delta and at SJR downstream of the Merced River throughout the year and a minimum DO concentration of 6.0 mg/L at the SJR between the city of Stockton and Turner Cut from September 1 to November 30. Low DO concentrations in the DWSC occur most often from June through October. Low DO levels may pose a threat to fall-run salmon migrating upstream to spawn (DWR 2005).

Typical travel time between Vernalis and the DWSC depends on the SJR Vernalis flow rate and the tidal cycle; travel time can range from 30 hours during very high Vernalis flow to more than 75 hours when Vernalis flow is less than 500 cfs (Reclamation 2008a).

Flow and DO at Rough and Ready Island (CDEC Station RRI) for the periods before, during, and after the pilot recirculation are shown on **Figure 4-26**. Flow fluctuates with tidal cycles at this Delta site. Negative flow indicates that the flow direction is upstream rather than downstream at the time of measurement. The DO concentration at Rough and Ready Island was above 5 mg/L in July and August and generally above 6 mg/L during three weeks of September. The mean daily DO concentration ranged from 5.6 to 8.0 mg/L during the first three weeks of August.

Changes in flow at the DWSC as a result of recirculation would be influenced primarily by changes in flow at Vernalis and changes in Delta exports. Because the flow at Vernalis during the study period did not increase above pre-recirculation levels, increases in flow or DO in the DWSC did not occur.

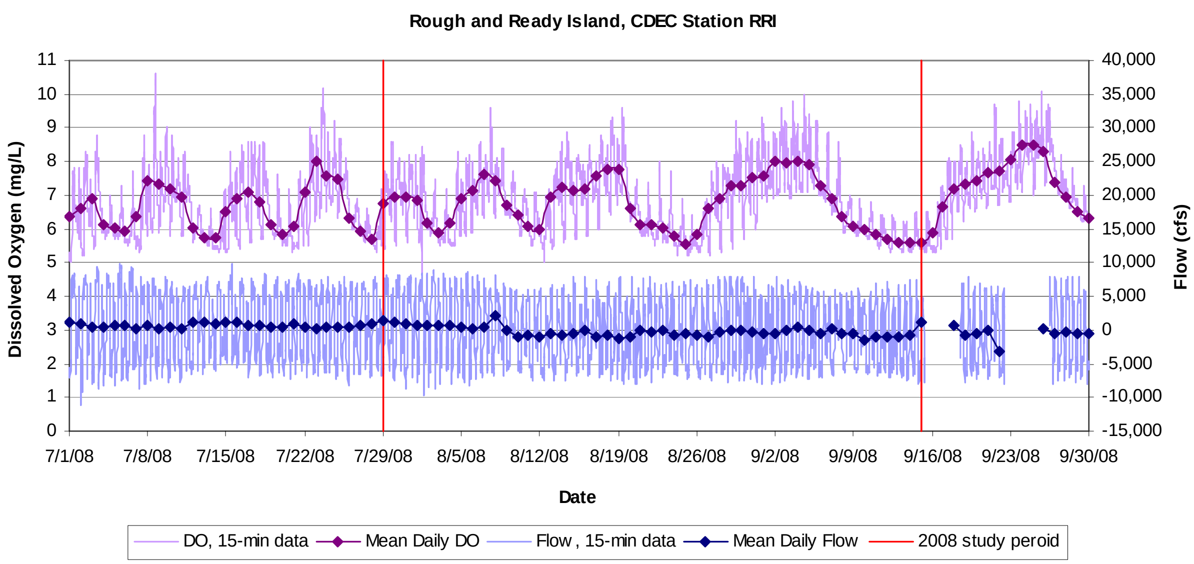


Figure 4-26. Flow and Dissolved Oxygen at Rough and Ready Island

4.3 Geological and Structural Evaluation

Reclamation conducted a geological and structural evaluation of the Wasteway before and after the pilot study (**Appendix H)**. This evaluation focused on the concrete-lined and unlined sections of the Wasteway, including drop structures, bridges, Wasteway side slopes, the Wasteway invert, vegetation, channel characteristics, and evidence of erosion or scour.

The concrete structures were found to be in excellent condition and unaffected by the pilot flows. Water plants were generally removed from the sinuous central channels. Much of the established vegetation downstream of the drop structures was flattened or removed during pilot flows. Beaver dams that were either removed or submerged by the pilot flows were rebuilt within 2 weeks of the end of the study.

Limited evidence of erosion or scour of the Wasteway invert was available. Significant deposits of erosion-resistant, vegetated fine-grain sediment were identified downstream of each drop structure. These deposits appeared to have had little or no erosion or reduction in volume as a result of the pilot recirculation. Lateral cutback erosion of the unlined portions of the Wasteway was uncommon, localized, and restricted to the bottom 2 to 4 vertical feet of the cutslope. A few inches of localized deepening of the narrow, sinuous central channel were found between MP 1.44 and MP 6.86. No widening of the channel was found. Photographs of the Wasteway taken before and after the recirculation study document these findings (**Appendix H**).

The relatively erodible, fine-grain sediment, which was filtered by vegetation and deposited under normal periods of low flow (5 to 30 cfs) downstream of drop structures and upstream of beaver dams, was flushed from the Wasteway during the pilot study. This relatively erodible sediment was the major source of turbidity during the study.

4.4 Habitat Evaluation

The changes in habitat in the Wasteway that occurred during and after the recirculation releases in the 2008 Pilot Study were assessed during three site visits. Environmental scientists from the San Joaquin District of DWR visited the Wasteway prior to the release on July 25, 2008, during the release on September 4, 2008, and after the release on September 29, 2008. A report of the site visits and photographs of the site are provided in **Appendix I**.

During the site visits, the plant and animal species present before, during, and after the releases were documented, and changes in habitat that had occurred over time were noted. The changes in species abundance and habitat based on visual observations included the following:

- Aquatic vegetation (e.g., algal mats, rush, water primrose, Johnson grass) that was present before the release in the channel immediately downstream of the headgates and at Eastin Road was absent during and following the release.
- In the unlined portion of the Wasteway, the release appeared to have resulted in scoured aquatic vegetation and exposed sediment along the banks.
- Dead and flattened aquatic vegetation was noted at several locations after the release.
- At some locations, increases in the amount of water hayacinth were noted after the release.
- An increase in the amount of exposed sediment on the right bank of the San Joaquin River downstream from the Wasteway confluence was also noted after the release.

These observations will be considered in the planning and environmental studies that will be conducted as a part of the Feasibility Study.

Chapter 5
Findings and Conclusions

During the 2008 Pilot Study, recirculation flow was observed to displace large amounts of vegetation from the Wasteway banks and build up debris throughout the Wasteway. Early flow increases resulted in accumulated soft sediments being flushed out at the NW DS site. Large mats of vegetation and increased turbidity were observed being transported into the SJR.

5.1 Water Quality Findings

The continuous monitoring indicates a baseline diurnal pattern of turbidity, temperature, pH, and DO in the SJR (**Figure 3-4, 3-5,** and **3-7** through **3-9**). The addition of DMC water to the SJR via recirculation through the Wasteway, decreased the variability of temperature, EC, pH, and DO in the SJR immediately downstream of the Wasteway confluence.

Recirculation tended to increase turbidity in the SJR from the mobilization of erodible sediments from the Wasteway. Turbidity immediately downstream of the Wasteway was elevated throughout the study, but elevated turbidity was not measured at SCL (**Figures 3-5** and **3-6**).

Similar to previous Pilot Study findings, salinity in the SJR immediately downstream of the Wasteway was reduced during recirculation, as seen by comparison of the EC at upstream and downstream locations (**Figure 3-8,** SJR US and SJR DS).

Chemical analysis revealed initial elevated concentrations of parameters measured during the "first flush" of recirculation which corresponded with increased flow at NW DS. The observed increases may have been caused by the mobilization of accumulated agricultural drainage, channel bottom sediments, and vegetation from within the Wasteway.

TSS concentrations and turbidity measurements increased substantially at NW DS and SJR DS during the first day and thereafter decreased in concentration over the following weeks of recirculation. However, TSS and turbidity remained elevated at SJR DS relative to SJR US throughout the duration of the recirculation.

Ammonia, TKN, BOD, and TOC concentrations increased at NW DS and SJR DS relative to (time zero) background concentrations within approximately

16 to 22 hours after recirculation. Shortly thereafter, concentrations were similar or reduced at SJR DS relative to SJR US for the remaining weeks of recirculation.

Dissolved arsenic, dissolved copper, dissolved mercury, total selenium, and total boron concentrations remained constant or decreased at SJR DS relative to SJR US during recirculation due to flow from the Wasteway.

Total mercury and total aluminum concentrations at SJR DS were generally elevated relative to SJR US. Increased concentrations may be due to increases in TSS concentrations.

Water and sediment toxicity testing indicated no toxicity at SJR DS and limited toxicity at NW DS. One water sample from NW DS indicated reduced growth for green algae.

Concentrations measured at SJR DS were above numeric water quality criteria for turbidity, total mercury, and total aluminum. For dissolved arsenic, concentrations measured at SJR DS were above the non-regulatory risk estimate associated with contaminated fish. For dissolved arsenic, recirculation was acting as a dilution to the SJR water. For turbidity, total mercury, and total aluminum, recirculation caused increased concentrations immediately downstream of the Wasteway, but the longitudinal extent of the concentration increments was limited, as seen by lower concentrations measured at SCL.

5.2 Downstream Response to Recirculation

Recirculation through the Wasteway was effective in increasing flow in the SJR immediately downstream of the Wasteway, but not in increasing flow at Vernalis (**Figure 5-1**). Recirculation reduced SJR salinity downstream of the Wasteway. At Crows Landing, flow in the SJR increased as EC decreased during recirculation (**Figures 5-1** and **5-2**). At Vernalis, the EC standard was met and river flow was maintained during recirculation, as Stanislaus River releases were reduced (**Figure 5-3**). Recirculation did not increase water levels in the southern Delta (**Figures 4-19** through **4-21**). Recirculation releases offset concurrent reductions in releases from the Stanislaus River. These offsets resulted in minimal to no changes in flow in the southern Delta.

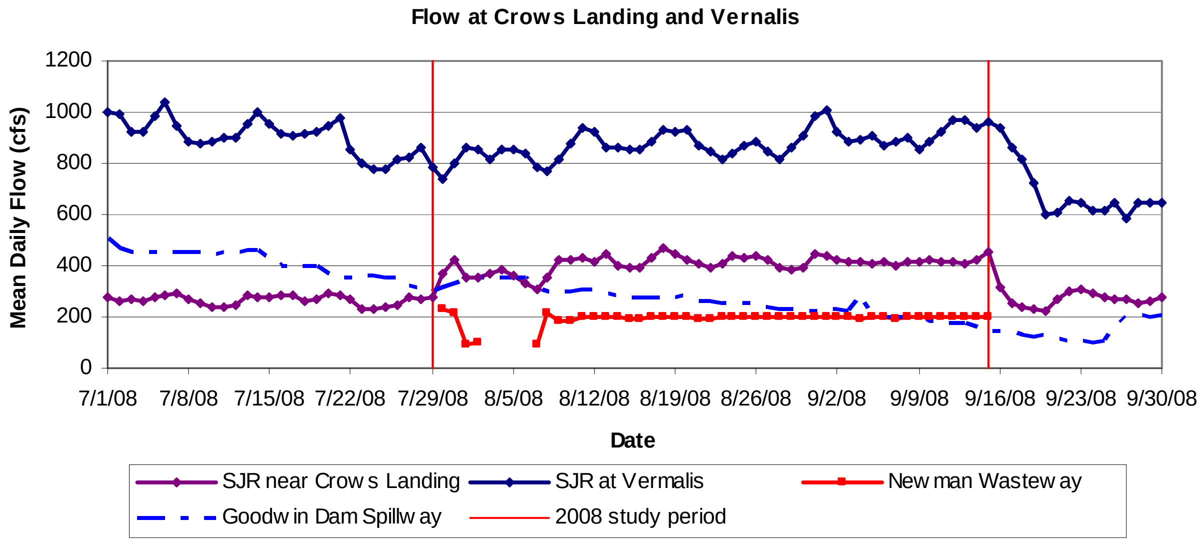


Figure 5-1. Flow at Crows Landing and Vernalis

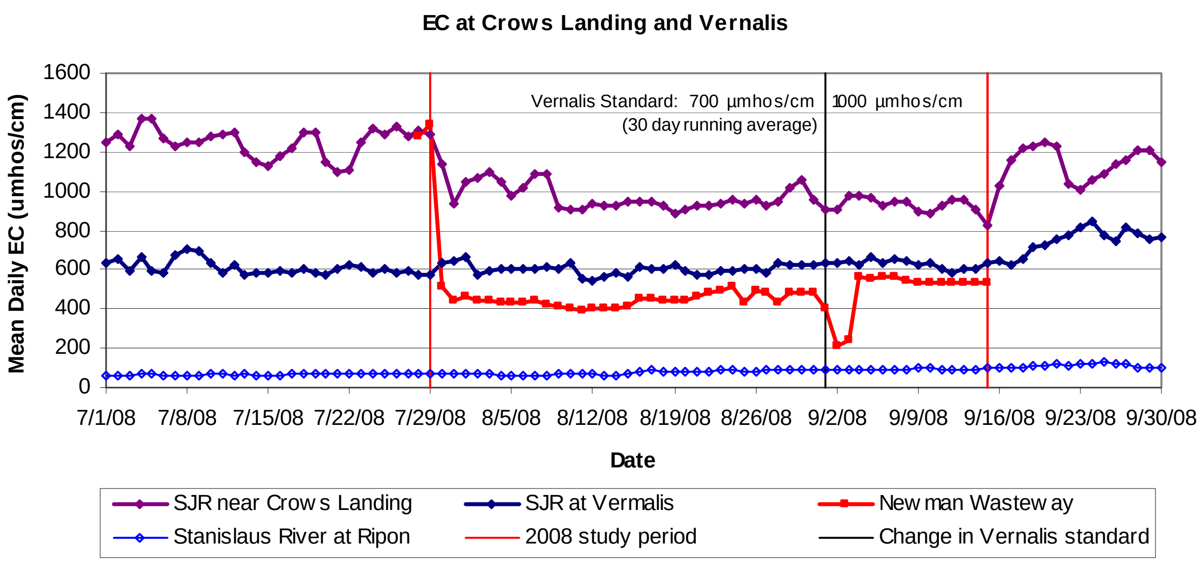


Figure 5-2. Electrical Conductivity at Crows Landing and Vernalis

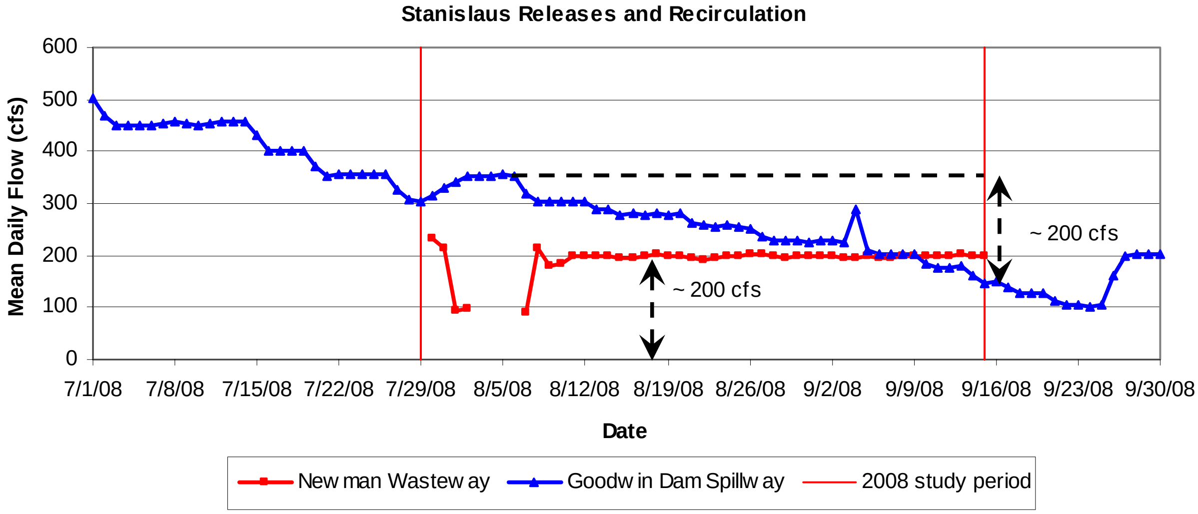


Figure 5-3. Stanislaus Releases and Recirculation

5.3 Comparison of Flow Rates and Sediment Concentration

Mobilization of sediments and other pollutants at the onset of recirculation has been a consideration during each of the Pilot Studies. Pre-wetting Wasteway sediments and utilizing a low ramping rate for recirculation has been proposed as a potential strategy to minimize sediment scour. The flow rates used during the 2007 Pilot Study were designed, in part, to test this hypothesis.

The 2004 Pilot Study report (Reclamation 2005) provides measured flow rates and TSS concentrations for the Pilot Study conducted during the period of August 19–23, 2004, with one additional sample collected on August 30. Flow in the Wasteway was increased from near zero to about 250 cfs during the first 30 hours of the study and was approximately constant from then on. Flow was measured approximately once per day, with more frequent measurements collected during the ramp-up period. TSS samples were collected approximately every 6 hours.

The 2007 Pilot Study was conducted from August 15 through September 12, 2007 (Reclamation 2008a). The flow rate varied from less than 10 to 180 cfs; however, the flow rate was maintained at about 40 cfs for much of the non-ramping periods. The flow rate was increased twice during the study. The flow was ramped up from 40 to 114 cfs and back down again from August 22 to 24 and was ramped up to 180 cfs and back down again from September 4 to 7. During these two periods, the data indicated that the flow was not held constant, but varied continuously. TSS data were collected approximately every 6 or 12 hours; however, some gaps exist in the TSS data: only one sample was collected during a 5-day gap between August 17 and 22, and no samples were collected during a 3½ day gap between August 24 and 28 and a 7-day gap between August 28 and September 4.

The flow rates during the 2004 Pilot Study were higher than the flow rates during the 2007 Pilot Study, but the TSS concentrations in 2004 were significantly lower, which is counter-intuitive, because it is expected that erosion rates would increase as flow rates increase (**Figure 5-4**).

It is possible that conditions changed between the two studies such that more erodible material was available during the 2007 Pilot Study than during the 2004 study (for example, a large storm event may have deposited a layer of erodible silt and clay in the Wasteway between pilot studies).

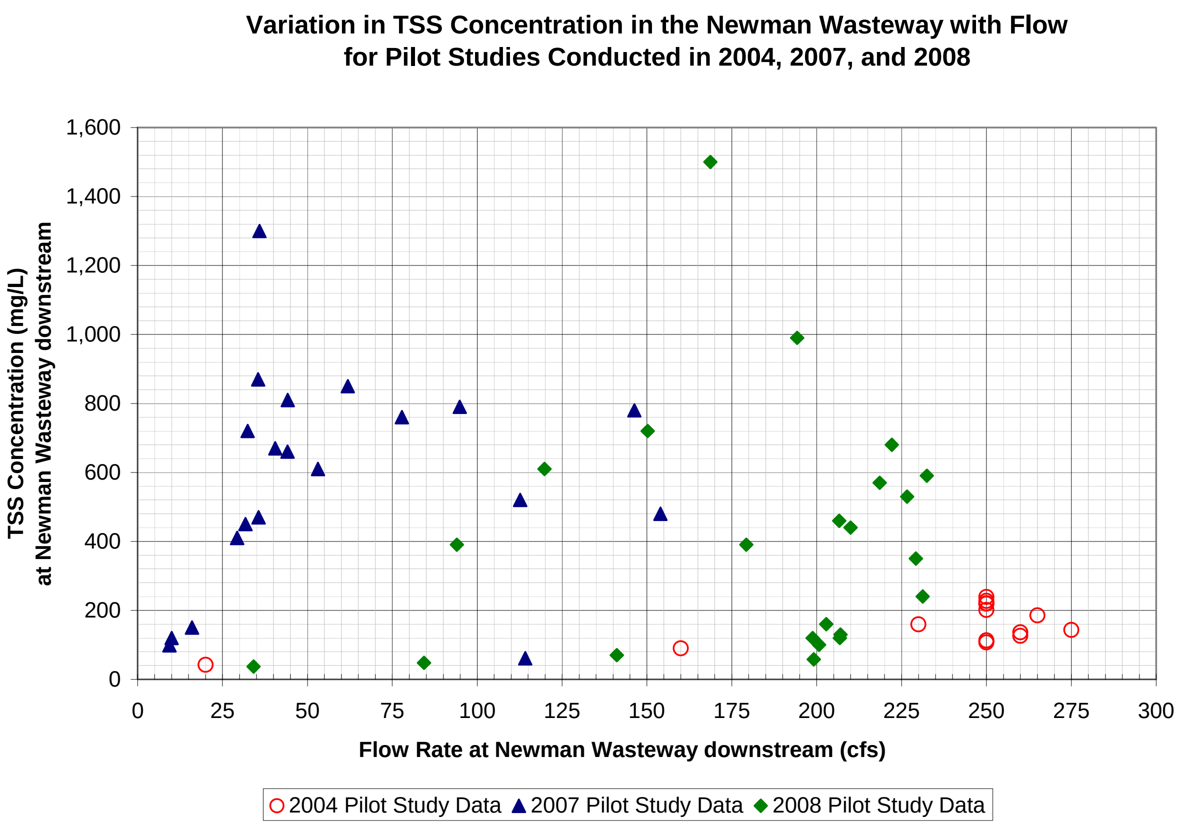


Figure 5-4. Flow Rate and TSS Concentrations in Newman Wasteway near the confluence with the San Joaquin River during the 2004, 2007, and 2008 Pilot Studies

During the 2004 pilot study, the flow rate and TSS concentration were both relatively constant except during the first 12 hours when the flows were ramped up. During the 2007 Pilot Study, the flow was more variable (though lower); only four flow rates/TSS datapoints with flows greater than 100 cfs were recorded. Over the range of flows from 30 to 180 cfs, TSS varied from about

400 to above 900 mg/L, with no relationship to flow rate, which is again counter-intuitive, because the erosion rate generally increases with flow rate.

The data from previous pilot studies and real-time data collected during recirculation indicate that ramping occurred relatively quickly during the 2008 Pilot Study, and after the first two days flow was maintained at 100 cfs for a week and 250 cfs for the duration of the study (**Figure 3-1**). The flow rates during the 2008 Pilot Study were higher than the flow rates during the 2007 Pilot Study, but the TSS concentrations were similar (**Figure 5-4**).

TSS concentrations and flow show little to no correlation during the pilot studies (**Figure 5-4**). Likewise, the correlation between turbidity and flow may be limited. For example, turbidity was variable for similar flow rates during the 2008 Pilot Study (**Figures 3-4 and 3-6**, from August 11 to September 15).

Because of the lack of correlation between flow and TSS concentrations during the pilot recirculation, flow ramping may not be effective at reducing sediment mobilization.

5.4 Lessons Learned

The lessons learned during the 2008 Pilot Study include the following:

- **Ramping Rates**. Flow ramping may not be effective at reducing sediment mobilization. Because data indicate little correlation between flow rate and TSS concentrations, it may be more desirable to increase flow rates relatively quickly due to practical considerations.
- **Continuous Flow Meters**. Continuous flow monitoring could be used to further characterize the flow in the Wasteway. Potential improvements for future efforts include instrumentation selection,[6] an improved mounting system for the pressure sensor, and dedicated staff to maintain the flow meters.
- **Continuous YSI Logging Meters**. The YSI meters provided insight to the diurnal fluctuations and/or weekly trends associated with pH, DO, temperature, turbidity, and EC. Future studies can use the 2008 Pilot Study data as a basis for comparison.
- **Sampling Frequency**. During the 2008 Pilot Study, grab sampling was frequent enough to characterize the first flush from the Wasteway. Although the YSI meters may provide data more frequently than needed

[6] A 15 psig in-situ Aqua Troll pressure sensor was found to be more effective than the more sensitive 5 psig Aqua Troll in the supercritical flow environment of the upper portion of the Wasteway. The 15 psig Aqua Troll is also more effective than a Marsh McBirney FloDar in the wind affected region of the lower Wasteway. Furthermore, the Aqua Troll is less susceptible to vandalism because it is underwater.

for some parameters, if the sampling frequency specified in the 2007 Pilot Study is required (every 30 minutes for the first 12 hours for selected parameters), then YSI meters may provide a more practical solution than measurements from grab samples.

- **Parameters**. Water quality parameters that were either not detected or detected significantly below the water quality standards may not need to be included in future studies. Parameters that caused decreases in SJR concentrations include arsenic, selenium, and boron. The results of the BOD and toxicity tests were generally below the detection limits.
- **Effects of Recirculation**. The effects from irrigation diversions would have been difficult to quantify without previous arrangements to collect data from the diverters. Coordination of future recirculation experiments with efforts to acquire irrigation diversion data should be considered.

This page intentionally left blank

Chapter 6
References

Ayers, R. S. and D. W. Westcot. 1985. *Water Quality for Agriculture*. Irrigation and Drainage Paper No. 29, Rev. 1. Rome. Available at http://www.fao.org/DOCREP/003/T0234E/T0234E00.htm.

CDEC (California Data Exchange Center). 2009. Historical Data. Available at http://cdec.water.ca.gov/selectQuery.html. Accessed on January 26 and January 29, 2009.

CVRWQCB (California Regional Water Quality Control Board. 2002. *Amendment to the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins for Bacteria*. Staff Report for Resolution No. R5-2002-0150. September. Available at http://www.waterboards.ca.gov/centralvalley/water_issues/basin_plans/bacteria.shtml.

———. 2004. *Amendments to the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins for the Control of Salt and Boron Discharges into the Lower San Joaquin River*. Draft Final Staff Report. Appendix 1: Technical TMDL Report. July. Available at http://www.waterboards.ca.gov/centralvalley/programs/tmdl/vernalis-salt-boron/appendix1.pdf.

———. 2005. *Amendments to the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins for the Control Program for Factors Contributing to the Dissolved Oxygen Impairment in the Stockton Deep Water Ship Channel*, Final Staff Report. Sacramento, CA. February 28.

———. 2007a. *Water Quality Control Plan (Basin Plan) for the Sacramento River and San Joaquin River Basins,* 4th Edition. Revised October 2007 (with Approved Amendments). Sacramento, California.

———. 2007b. *San Joaquin Watershed Surface Water Ambient Monitoring Program.* Available at http://www.swrcb.ca.gov/centralvalley/water_issues/water_quality_studies/surface_water_ambient_monitoring/eastsideinfo.shtml.

DWR (California Department of Water Resources). 2005. *California Water Plan*. Volume 3.

———. n.d. Temporary Barriers Project Information. Available at http://baydeltaoffice.water.ca.gov/sdb/tbp/index_tbp.cfm. Accessed on January 6, 2009.

ENTRIX, Inc. 2008. Delta-Mendota Canal Recirculation Feasibility Study, Fisheries and Aquatic Ecosystems Technical Memorandum, Existing Conditions and Analytical Approach. January 4.

EPA. (U.S. Environmental Protection Agency). 1986. *Quality Criteria for Water (Gold Book)*. EPA.440/5-86-001. Office of Water, Regulations, and Standards. Available at http://www.epa.gov/waterscience/ criteria/library/goldbook.pdf.

———. 1999. 1999 *Update of Ambient Water Quality Criteria for Ammonia*. EPA 822-R-99-014. Office of Water. December. Access online at http://www.epa.gov/waterscience/criteria/ammonia/99update.pdf.

———. 2006. *Reregistration Eligibility Decision for Coppers*. EPA 738-R-06-020. Office of Prevention, Pesticides, and Toxic Substances, Washington, DC. July.

———. 2008a. Arsenic in Drinking Water. Accessed in May 2008. http://www.epa.gov/safewater/arsenic/index.html.

———. 2008b. Ecological Toxicity Information. Region 5. Access online at http://www.epa.gov/region5superfund/ecology/html/toxprofiles.htm. Last updated on May 19, 2008.

———. 2008c. Current National Recommended Ambient Water Quality Criteria. Available at http://www.epa.gov/waterscience/criteria/wqctable/ index.html. Website updated on November 4, 2008.

Marshack, J. 2008. *Compilation of Water Quality Goals*. Program Support Unit for the California Regional Water Quality Control Board, Central Valley Region.

Reclamation (Bureau of Reclamation). 2005. *San Joaquin River Recirculation Pilot Study Final Report*. Sacramento, CA.

———. 2007. *Delta-Mendota Canal Recirculation Feasibility Study: Initial Alternatives Information Report*. Sacramento, CA.

———. 2008a. *San Joaquin River Recirculation Pilot Study Draft Report*. Sacramento, CA.

———. 2008b. Water Accounting Reports, Delta Operations. Mid-Pacific Region, Central Valley Operations. Available at http://www.usbr.gov/mp/cvo/pmdoc.html. Accessed on January 6, 2009.

———. 2009. *Engineering Geologic Evaluation of the Newman Wasteway and Structures*. Delta Mendota Canal Recirculation Feasibility Study. Mid Pacific Region Geology Branch. Sacramento, CA. January.

———. In press. *Delta-Mendota Canal Recirculation Draft Plan Formulation Report*. Sacramento, CA.

This page intentionally left blank