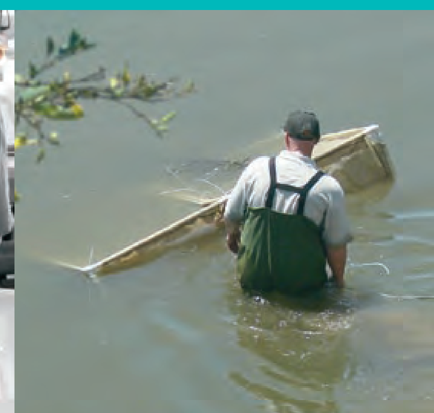
SAN JOAQUIN RIVER AGREEMENT

VERNALIS ADAPTIVE MANAGEMENT PLAN

ANNUAL TECHNICAL REPORT



2008

SAN JOAQUIN RIVER GROUP AUTHORITY

Figure 1-1

Figure 2-1

2008 ANNUAL TECHNICAL REPORT

On implementation and Monitoring of the San Joaquin River Agreement and the Vernalis Adaptive Management Plan

Prepared by
San Joaquin River Group Authority

Prepared for the
California Water Resources Control Board
in compliance with D-1641

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EXECUTIVE SUMMARY

The San Joaquin River Agreement (SJRA) is the cornerstone of a history-making commitment to implement the State Water Resources Control Board (SWRCB) 1995 Water Quality Control Plan (WQCP) for the lower San Joaquin River and the San Francisco Bay-Delta Estuary (Bay-Delta). Vernalis Adaptive Management Plan (VAMP), officially initiated in 2000 as part of SWRCB Decision 1641, is a large-scale, long-term (12-year), experimental-management program designed to protect juvenile Chinook salmon migrating from the San Joaquin River through the Sacramento-San Joaquin Delta. The VAMP is also a scientific experiment to determine how salmon survival rates change in response to alterations in San Joaquin River flows and State Water Project (SWP)/Central Valley Project (CVP) exports with the installation of the Head of Old River Barrier (HORB).

The 2008 VAMP relied on the acoustic telemetry and tracking methodology to monitor the migration of salmon smolts through the Delta. The SJRA technical committee (SJRATC) developed an acoustic telemetry monitoring program, relying on 1,000 acoustic tagged salmon smolts. The VAMP test period was conducted over the period of April 22-May 22 to allow the test fish to increase in size to better accommodate the acoustic tag to body weight ratio standard of less than 5 percent. The Water Year 2008 winter was dry in the San Joaquin River watershed, with seasonal precipitation in the San Joaquin Hydrologic Region (Cosumnes, Mokelumne, Stanislaus, Merced and San Joaquin Rivers) measuring only 85% of average on April 1, 2008. The forecasted April-July runoff as of April 1 in the four basins above Vernalis (Stanislaus, Tuolumne, Merced and San Joaquin) ranged from 78% to 84% of average. With the dry conditions for the current year and the very dry antecedent conditions, the forecasted mean flow without VAMP in the San Joaquin River near Vernalis for the VAMP target flow period of April 22 through May 22 was approximately 2,000 cubic feet per second (cfs), resulting in a VAMP target flow at the minimum value of 3,200 cfs. The water districts of Oakdale Irrigation District, South San Joaquin Irrigation District, Modesto Irrigation District, Turlock Irrigation District, Merced Irrigation District and San Joaquin Exchange

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Contractors Water Authority provided 78,930 acre-feet of supplement water to support the VAMP target flow.

The 2008 Annual Technical Report consolidates the annual SJRA Operations and the Vernalis Adaptive Management Plan (VAMP) Monitoring Reports. 2008 represents the ninth year of formal compliance with SWRCB Decision 1641 (D-1641). D-1641 requires the preparation of an annual report documenting the implementation and results of the SJRA program. Specifically, this 2008 report includes the following information on the implementation of the SJRA: the hydrologic chronicle; management of any additional SJRA water; the acoustic telemetry experimental design; flow monitoring in the lower San Joaquin River, Old River, and Delta; results available to date of the juvenile salmon acoustic tag study; discussion of complementary investigations; and conclusions and recommendations.

Technical problems with the electronic transmitters substantially increased the data processing time and likely will bias estimates of survival and travel times. Results on the survival, distribution and behavior of acoustic tagged fish will be made available in a future stand-alone report.

The VAMP is intended to employ an adaptive management strategy using current knowledge to protect Chinook salmon as they migrate through the Delta, while gathering information to allow more efficient protection in the future. 2008 represented the second year of a monitoring program relying fully on the use of acoustic telemetry technology. With the assistance of the United States Geological Survey (USGS) the key monitoring stations at Jersey Point and Chipps Island were deployed in 2008. Resources from the USGS Columbia River Research Laboratory (CRRL) provided tagging training and helped with refinement to the experimental design. In addition, the technical committee adopted a water quality monitoring study to address questions of potential fish mortality near the Stockton Waste Water Treatment Plant. With concerns for the protection of endangered delta smelt the Head of Old River Barrier was not installed in 2008. Specific experimental objectives of VAMP 2008 included:

- Quantification of Chinook salmon smolt survival along individual river segments between Durham Ferry, Stockton Waste Water Treatment Plant (WWTP), Jersey Point and Chipps Island by detection of acoustic signals from transmitters implanted in the test fish.
- Evaluation of migration path selection at the San Joaquin River – Old River flow split at the Head of Old River and at the San Joaquin River – Turner Cut split under the 2008 flow conditions.
- Monitoring predator behavior in the Delta (near the CVP export facility.
- Evaluation of fish mortality across Clifton Court Forebay between the Clifton Court Forebay inlet structure and the Skinner Fish Facility.
- Study water quality conditions near the Stockton Waste Water Treatment Plant Chinook
- Establish a new release site on the San Joaquin River near Stockton.
- Evaluation of acoustic tag reliability and tag battery life.
- Health and physiological testing of VAMP fish at the Merced River Hatchery (MRH) to evaluate the incidence of disease.


Total # buckets to be loaded:
Actual # buckets loaded:
Bucket ID
Expected # of fish in bucket


2

Condition and short term mortality of "dummy tagged" salmon held for 48 hours in net pens at Durham Ferry and Stockton.

The VAMP design provides for a 31-day pulse flow (target flow) in the San Joaquin River at the Vernalis gage along with a corresponding reduction in SWP/CVP exports. The magnitude of the pulse flow is based on an estimated flow (existing flow) that would occur during the pulse period absent the VAMP. As part of the implementation planning, the VAMP hydrology and biology groups meet regularly throughout the year to review current and projected information on hydrologic conditions occurring within the San Joaquin River watershed. This facilitates communication and coordination for both the VAMP Chinook salmon smolt survival experiments and for scheduling streamflow releases on the Tuolumne, Merced, and Stanislaus rivers to facilitate the experimental investigations and protection for juvenile salmon within the tributaries.

Hydrologic conditions in 2008 were drier then any previous VAMP years. In the March 14 operation plan the Existing Flow was forecasted to be between 2,240 and 3,220 cfs calling for a VAMP target flow of either 3,200 or 4,450cfs. As the planning proceeded in subsequent weeks the forecasted Existing Flow declined to near 2,000 cfs calling for the VAMP target flow of 3,200 cfs. A ruling by the Federal Court to protect the endangered delta smelt prohibited the installation of the spring HORB. In planning for the VAMP the SJRA Technical Committee recommended delaying the start of the VAMP pulse period from the default date of April 15th to April 22nd in an effort to provide larger sized fish for the implantation of acoustic tags. Along with evaluating survival through the Delta the study was designed to measure survival along selected segments of the San Joaquin River between Durham Ferry and Chipps Island.

With assistance of the U.S. Geological Survey the acoustic receiver stations at Jersey Point and Chipps Island were installed for the 2008 VAMP. Thus estimates of survival to Jersey Point and Chipps Island were possible.

As in prior years computerized temperature recorders were employed at the MRH, in the transport trucks, at the release sites and throughout the lower San Joaquin River and Delta for a continuous record of temperatures encountered by the migrating test fish. Overall the average temperature at all sites remained below 20° C, which is considered suitable for salmon smolts.

At the time of preparing this report the survival results from the 2008 experiment are not yet available. A separate report on the survival will be prepared for submittal to the SWRCB.

With experience in the acoustic telemetry technology and with assistance from the USGS a more defined experimental model was developed for 2008. The statistical model was based on the release-recapture models of the past with a route-specific survival component. With the use of double-detection arrays at the receiver locations an estimate of the detection probability was made at each double-array site. The detection probability allowed for estimating test fish distribution at channel junctures and separated the survival probabilities for each channel reach.

A tag life study was conducted to determine any bias in the survival estimates caused by premature failure of the acoustic tags. A random sample of 50 tags was collected for testing. These were programmed and subsequently detected continuously over time in the same standard manner as used in the field. As a result of higher then expected failure among the original batch of tags the manufacturer provided replacement tags. Of the original tags and replacement tags 21 percent and 12 percent failed within the first 11 days. All tags expired within 20 days. This higher then expected tag failure during the operational phase will bias the 2008 VAMP fish survival because tag failure cannot be separated from fish mortality.

Similar to prior VAMP experiments a small group of test fish were collected and evaluated to assess the potential mortality due to PKD. In 2008 40 test fish were randomly "dummy tagged" (non-functioning tags) and transported to the U.S. Fish and Wildlife's California/Nevada Fish Health Center. Holding tank conditions at the USFWS laboratory were matched to field conditions at the time for both water temperature and salinity levels. Cumulative mortality to Proliferative Kidney Disease (PKD) was 20 percent in 2008.

The decline in fish production at the MRH and the continued concern for the abundance of delta smelt will greatly influence future VAMP designs. A priority in designing the 2008 acoustic monitoring study was to generate similar estimates of survival so that results could be compared to those generated from the previous coded wire tag studies.

CHAPTER 1

INTRODUCTION

Actions associated with the Vernalis Adaptive Management Plan (VAMP) were implemented between April 22nd and May 22, 2008 to protect juvenile Chinook salmon and evaluate migration pathways and the survival of marked juvenile Chinook salmon migrating through the Sacramento – San Joaquin Delta. Diminished adult salmon returns and low smolt production at the Merced River Fish Hatchery did not allow for the standard VAMP coded-wire-tag (CWT) study. The 2008 VAMP utilized an alternative acoustic telemetry study technique in 2008. The VAMP start date was delayed seven days to April 22nd from the default start date of April 15th to allow for additional growth of the experimental fish. A total of 825 tagged fish were released with functioning transmitters during the experiment. An additional 77 transmitters were held for continuous monitoring in a closed system to quantify the rate of tag failure throughout the study period. Releases took place on April 29th and May 6th at Durham Ferry and on May 1st and May 8th near Stockton (at Windmill Cove, 2 miles downstream of Buckley Cove and Ladd's Marina).

The water districts coordinated their operations in order to maintain stable flow in accordance with the SJRA throughout the VAMP 31-day target flow period. State and federal export pumping was also coordinated to maintain a steady total export rate. A recent Federal Court decision prohibited the installation of the spring HORB for the 2008 VAMP period.

The acoustic telemetry method had been tested in the 2007 VAMP and appeared to work well. In 2008, the number of acoustic receivers installed was expanded to better understand the movement of salmon once they entered the Delta. With the added benefit of acoustic receivers installed at Jersey Point and Chipps Island survival estimates through the Delta were possible in 2008. The 2008 VAMP represents the ninth year of the VAMP. Results from previous VAMP experiments are available in San Joaquin River Agreement Technical Reports, for each respective year. Similar coded wire tag (CWT) experiments were conducted prior to the official implementation of VAMP with results available in South Delta Temporary Barriers Annual Reports (DWR 2001 and DWR 1998). This report describes the experimental design used in 2008, the hydrologic planning and implementation, the additional water supply arrangements and deliveries, the acoustic tag experiment and complimentary studies related to the 2008 VAMP. Conclusions and recommendations for future VAMP studies are also included.

Experimental Design Elements

The VAMP experimental design used in previous years measured salmon smolt survival through the Delta under six different combinations of flow and export rates. The experimental design includes two mark-recapture studies performed each year during the April-May juvenile salmon outmigration period that provide estimates of salmon survival under each set of conditions. During 2008, due to a combination of events, sufficient test fish were not available from the MRH to permit a CWT study. In addition concerns for delta smelt have constrained the use of traditional recovery methods. Therefore an alternative study using fewer fish from the MRH was implemented. The fish were surgically implanted with acoustic transmitters capable of emitting an electronic signal for up to 3 weeks. Stationary receivers were used to intercept the transmitted electronic signals and data were collected on salmon smolt behavior and mortality within the South Delta and through the San Joaquin River from Durham Ferry to Chipps Island. Survival was also estimated for intermediate reaches along various migration paths.

As described by the SJRA, VAMP is an experimental/management program designed to protect juvenile Chinook salmon migrating from the San Joaquin River while at the same time conducting a scientific experiment to determine how salmon survival changes in response to alterations in San Joaquin River flows, SWP/CVP export rates, and the operation of the HORB.

Due to unforeseen and excessive tag malfunction (see Chapter 5), however, it was not possible to obtain unbiased survival estimates during this study. Even though survival estimates could not be determined from the 2008 experiment, valuable information was collected on smolt behavior (smolt distribution and migration timing) and implementation of an acoustic tag experiment. This annual technical report describes the flow conditions without the HORB, the alternative experimental plan, and the findings.

The 2008 VAMP experimental design included replicate releases at Durham Ferry and Stockton, Figure 1-1 (inside front cover). During the 2008 VAMP period the Acoustic Telemetry study was conducted to evaluate movement and survival of acoustic tagged fish detected by acoustic receivers as they moved downstream. Sixteen acoustic receiver sites located along the lower San Joaquin River, Old River, in south Delta channels and at the export fish facilities were used to track smolt movement throughout the south Delta.

For the second year a cadre of biologists was trained by the CRRL in the proper surgical tagging procedures. In addition to net pen studies to assess overall condition and health of marked fish used in the acoustic tag study a sample of tags was also monitored to evaluate premature transmitter failure.

CHAPTER 2

HYDROLOGIC PLANNING AND IMPLEMENTATION

Implementation of VAMP is guided by the framework provided in the San Joaquin River Agreement (SJRA) and recognition of hydrologic conditions within the watershed. The Hydrology Group of the San Joaquin River Technical Committee (SJRTC) was established for the purpose of forecasting hydrologic conditions and for planning, coordinating, scheduling and implementing the flows required to meet the test flow target in the San Joaquin River near Vernalis. The Hydrology Group is also charged with exchanging information relevant to the forecasted flows, and coordinating with others in the SJRTC, in particular the Biology Group, responsible for planning and implementing the salmon smolt survival study.

Participation in the Hydrology Group is open to all interested parties, with the core membership consisting of the designees of the agencies responsible for the water project operations that would be contributing flow to meet the target flow. In 2008, the agencies participating in the Hydrology Group included: Merced Irrigation District (MeID), Turlock Irrigation District (TID), Modesto Irrigation District (MID), Oakdale Irrigation District (OID), South San Joaquin Irrigation District (SSJID), San Joaquin River Exchange Contractors (SJRECWA), and the U.S. Bureau of Reclamation (USBR). Though not a water provider, the California Department of Water Resources (DWR) was closely involved with the coordination of operations relating to the potential installation of the HORB and the planning of Delta exports consistent with the VAMP.

2008 VAMP Summary

The Water Year 2008[1] winter was dry in the San Joaquin River watershed, with seasonal precipitation in the San Joaquin Hydrologic Region (Cosumnes, Mokelumne, Stanislaus, Tuolumne, Merced and San Joaquin rivers) measuring only 85% of average as of April 1, 2008. The forecasted April-July runoff as of April 1st in the four basins above Vernalis (Stanislaus, Tuolumne, Merced and San Joaquin) ranged from 78% to 84% of average, resulting in a May 1st water year classification of Critical as per the San Joaquin Valley Water Year Type Index (60-20-20) defined in D-1641. The previous Water Year, 2007, was extremely dry and was classified as a Critical year as per the San Joaquin Valley Water Year Type Index (60-20-20 Index). With the very dry conditions for the current year and the antecedent conditions, the forecasted mean flow without VAMP in the San Joaquin River near Vernalis for the VAMP target flow period of April 22nd through May 22nd was approximately 2,000 cfs, resulting in a VAMP target flow at the minimum value of 3,200 cfs.

[1] *Water Year 2008 is October 2007 through September 2008.*

The planning and implementation process for the VAMP operation remained nearly unchanged from those of prior VAMP years and that outlined in the SJRA. Daily operation plans were updated on a frequent basis to keep the SJRTC informed of changed conditions. VAMP planners and reservoir operators took part in conference calls twice a week during the implementation phase of VAMP to discuss the current status of the operation and make adjustments as needed. Monitoring of real-time flow data was maintained throughout the planning and implementation phases.

VAMP Background and Description

The VAMP provides for a steady 31-day pulse flow (target flow) at the Vernalis gage on the San Joaquin River (Figure 2-1, inside front cover) during the months of April and May, along with a corresponding reduction in State Water Project (SWP) and Central Valley Project (CVP) Sacramento-San Joaquin Delta exports. The VAMP target flow and reduced Delta export are determined based on a forecast of the San Joaquin River flow that would occur during the target flow period absent the VAMP (Existing Flow) as shown in Table 2-1. The Existing Flow is defined in the SJRA as "the forecasted flows in the San Joaquin River at Vernalis during the Pulse Flow Period that would exist absent the VAMP or water acquisitions," including such flows as minimum in-stream flows, water quality or scheduled fishery releases from New Melones Reservoir, flood control releases, uncontrolled reservoir spills, and/or local runoff. Achieving the target flow requires the coordinated operation of the three major San Joaquin River tributaries upstream of Vernalis: the Merced, the Tuolumne and the Stanislaus Rivers.

As part of the development of the VAMP experimental design, the SJRTC had identified a level of variation in San Joaquin River flow and SWP/CVP export rate thought to be within an acceptable range for specific VAMP test conditions. In developing the criteria, the SJRTC examined both the ability to effectively monitor and manage flows and exports within various ranges (e.g., the ability to accurately manage and regulate export rates is substantially greater than the ability to manage San Joaquin River flows) and the flow and export differences among VAMP targets (Table 2-1). Through these discussions, the SJRTC agreed that SWP/CVP export rates would be managed to a level of plus or minus 2.5% of a given export rate target. Furthermore, the technical committees agreed that, to the extent possible, it would be desirable that exports be allocated approximately evenly between SWP and CVP diversion facilities.

Table 2-1
VAMP Vernalis Flow and Delta Export Targets

Forecasted Existing Flow (cfs)	VAMP Target Flow (cfs)	Delta Export Target Rates (cfs)
0 to 1,999	2,000	
2,000 to 3,199	3,200	1,500
3,200 to 4,449	4,450	1,500
4,450 to 5,699	5,700	2,250
5,700 to 7,000	7,000	1,500 or 3,000
Greater than 7,000	Provide stable flow to extent possible	1,500, 2,250 or 3,000*

* Suggested rates at higher flows.

The ability to manage and regulate the San Joaquin River flow near Vernalis is difficult due to uncertainty and variation in unregulated flows, inaccuracy in real-time flows due to changing channel conditions, lags and delays in transit time, and a variety of other factors. Concern was expressed that variation in San Joaquin River flow on the order of plus or minus 10% would potentially result in overlapping flow conditions between two VAMP targets. To minimize the probability of overlapping flow conditions among VAMP targets, the SJRTC explored an operational guideline of plus or minus 5% flow variation at the Vernalis gage; however, system operators expressed concern about the ability to maintain flows within this range. As a result of these discussions and analysis, the SJRTC agreed to a target range variation of plus or minus 7% of the Vernalis flow target. It was recognized by the SJRTC that these guidelines are not absolute conditions, but are to be used to evaluate the potential effect of flow and export variation on the ability to detect and assess variation in juvenile Chinook salmon survival.

Under the SJRA, the San Joaquin River Group Authority (SJRGA) member agencies MeID, OID, SSJID, SJRECWA, MID and TID have agreed to jointly provide the supplemental water needed to achieve the VAMP target flows, limited to a maximum of 110,000 acre-feet:. The MeID supplemental water would be provided on the Merced River from storage in Lake McClure and would be measured at the DWR Merced River at Cressey stream-gage. The OID and SSJID supplemental water would be provided on the Stanislaus River through diversion reductions and would be measured below Goodwin Dam. The SJRECWA supplemental water would be provided via Salt Slough, West Delta Drain, Boundary Drain and/or Orestimba Creek. The MID and TID supplemental water would be provided on the Tuolumne River from storage in Don Pedro Lake and would be measured at the Tuolumne River below LaGrange Dam stream-gage.

The target flow of 2,000 cfs shown in Table 2-1 does not represent a VAMP experiment target flow data point, but, rather, is used to define the SJRGA supplemental water obligation limit when Existing Flow is less than 2,000 cfs. In preparation of the conceptual framework for the VAMP it was recognized that in extremely dry conditions the San Joaquin River flow and associated exports would be determined in accordance with the existing biological opinions under the Endangered Species Act and the 1994 Bay-Delta Accord. In consideration of these factors, when the Existing Flow is less than 2,000 cfs, the target flow will be 2,000 cfs and the USBR, in accordance with the SJRA, shall act to purchase additional water from willing sellers to fulfill the requirements of existing biological opinions.

When the Existing Flow exceeds 7,000 cfs, the parties to the SJRA will exert their best efforts to maintain a stable flow during the VAMP target flow period to the extent reasonably permitted. Under such conditions the SJRTC shall attempt to develop a plan to carryout the studies pursuant to the SJRA.

Based upon hydrologic conditions, the target flow in a given year could either be increased to the next higher value (double-step) or the supplemental water requirement could be eliminated entirely (sequential dry year relaxation, or off-ramp). These potential adjustments to the target flow are dependent on the hydrologic year type as defined by the 60-20-20 Index, which is given a numerical indicator as shown in Table 2-2 to make this determination. A double-step flow year occurs when the sum of the numerical indicators for the previous year's year type and current year's forecasted 90 percent exceedence year type is seven (7) or greater, a general recognition of either abundant reservoir storage levels or a high probability of abundant runoff. An off-ramp year occurs when the sum of the numerical indicators for the two previous years' year types and the current year's forecasted 90 percent exceedence year type is four (4) or less, an indication of extended drought conditions.

Table 2-2
San Joaquin Valley Water Year Hydrologic Year Classification Numerical Indicators Used in VAMP

Water Year Classification (60-20-20 Index)	VAMP Numerical Indicator
Wet	5
Above Normal	4
Below Normal	3
Dry	2
Critical	1

Under the SJRA, the maximum amount of supplemental water to be provided to meet VAMP target flows in any given year is 110,000 acre-feet. In a double-step year, the quantity of supplemental water required may be as high as 157,000 acre-feet. In any year in which more than 110,000 acre-feet of supplemental water is needed, the USBR will attempt to acquire the needed additional water on a willing seller basis. In accordance with the SJRA, the SJRGA has agreed to extend a "favored purchaser" offer to the USBR through each current year's VAMP period.

Hydrologic Planning for 2008 VAMP

The SJRTC Hydrology Group held three meetings to discuss and plan the 2008 VAMP operation: February 22nd, March 14th and April 15th. At these meetings, forecasts of hydrologic and operational conditions on the San Joaquin River and its tributaries were discussed and refined.

Monthly Operation Forecast

As part of the initial planning efforts in February, a monthly operation forecast was developed by the Hydrology Group to provide an initial estimate of the Existing Flow and VAMP Target Flow. Inflows to the tributary reservoirs used in these forecasts were based on February 1st DWR Bulletin 120 runoff forecasts. The monthly operation forecasts used the 90 percent and 50 percent probability of exceedence runoff forecasts to provide a range of estimates. The initial monthly operation forecast was presented at the February 22nd SJRTC meeting. Since the previous year, Water Year 2007, was a Critical year (VAMP numerical indicator of 1) there was no chance of 2008 being a double-step year. Additionally, since Water Year 2006 was a Wet year (VAMP numerical indicator of 5) there was no chance of 2008 being an off-ramp year. Both the 90 percent and 50 percent exceedence runoff forecasts indicated an existing flow of about 2,500 cfs and, therefore, a VAMP target flow of 3,200 cfs.

Daily Operation Plan Development

Starting in mid-March, the Hydrology Group began development of a daily operation plan, updating it as hydrologic conditions and operational requirements changed. The purpose of the daily operation plan is to provide a forecast of the Existing Flow, which sets the VAMP target flow, and to coordinate the tributary operations needed to meet the target flow. It also provides a forecast of the daily flows expected during the HORB installation period. The daily operation plan calculates an estimated mean daily flow at Vernalis based on forecasts of the daily flow at the major tributary control points, estimates of ungaged flow between those control points and Vernalis, and estimates of flow in the San Joaquin River above the Merced River.

The following travel times for flows from the tributary measurement points and upper San Joaquin River to the Vernalis gage are used in the development of the daily operation plan. Whole day increments are used because the daily operation plan is developed using mean daily flows.

Flow Travel Times

a. Merced River at Cressey to Vernalis .... 3 days

b. San Joaquin River at Merced River to Vernalis .. 2 days

c. Tuolumne River below LaGrange Dam
to Vernalis .... 2 days

d. Stanislaus River below Goodwin Dam
to Vernalis .... 2 days

The forecast of the ungaged flow is the factor with the greatest uncertainty in the development of the daily operation plan. By definition, the ungaged flow at Vernalis is the unmeasured flow entering or leaving the system between the Vernalis gage and the upstream measuring points and is calculated as follows:

Table 2-3. Summary of Daily Operation Plans								
Phase	**VAMP Forecast Date**	**DWR Runoff Forecast Date**	**VAMP Target Flow Period**	**Single or Double Step**	**Assumed Ungaged Flow at Vernalis (cfs)**	**Existing Flow (cfs)**	**VAMP Target Flow (cfs)**	**SJRGA Supplemental Water Requirement (acre-feet)**
Planning	3/14/08	3/11/08	April 24 - May 24	Single	200	2,240	3,200	59,260
					600	3,220	4,450	75,490
	3/28/08	3/25/08	April 22 - May 22	Single	100	2,180	3,200	62,920
					400	2,740	3,200	28,360
	4/7/08	3/25/08	April 22 - May 22	Single	0	2,010	3,200	73,070
					200	2,210	3,200	60,770
	4/14/08	4/8/08	April 22 - May 22	Single	0	1,890	2,000	6,640
					200	2,090	3,200	68,130
	4/17/08	4/8/08	April 22 - May 22	Single	0	1,890	2,000	6,640
					200	2,090	3,200	68,330
	4/18/08	4/8/08	April 22 - May 22	Single	0	2,000	3,200	73,750
Implementation	4/28/08	—	April 22 - May 22	Single	-36	1,950	3,200	76,770
	4/30/08	—	April 22 - May 22	Single	-53	1,940	3,200	77,750
	5/15/08	—	April 22 - May 22	Single	-58	1,920	3,200	78,930

Ungaged flow at Vernalis = VNS - GDW_{lag} - LGN_{lag} - CRS_{lag} - $USJR_{lag}$

Where:

VNS = San Joaquin River near Vernalis

GDW_{lag} = Stanislaus River below Goodwin Dam lagged 2 days

LGN_{lag} = Tuolumne River below LaGrange Dam lagged 2 days

CRS_{lag} = Merced River at Cressey lagged 3 days

$USJR_{lag}$ = San Joaquin River above Merced River lagged 2 days

(USJR is not a gaged flow but is the calculated difference between the gaged flows at the San Joaquin River at Newman (NEW) and the Merced River near Stevinson (MST)).

An extensive review of historical ungaged flows has been made to determine if there are any correlations between the ungaged flow and the current hydrologic conditions that could be used to reduce the uncertainty. Unfortunately, no significant correlations were found. However, the review did indicate that the amount of ungaged flow at the beginning of the VAMP target flow period is a reasonable estimate of the average ungaged flow for target flow period. It is impossible to forecast day-to-day fluctuations of the ungaged flow, so the daily operation plan is developed assuming a constant ungaged flow throughout the target flow period essentially equal to the value entering the target flow period.

The VAMP 31-day target flow period can occur anytime between April 1st and May 31st. Factors that are considered in the determination of the timing of the VAMP target flow period include installation of HORB, and size of salmon smolts at the MRH. Until a specific start date is defined, a default target flow period of April 15th to May 15th is used for the VAMP operation planning. In its March meeting the SJRTC defined a VAMP target flow period of April 22nd to May 22nd for 2008 to allow the test fish to reach a larger size. The small delay also accommodated the complexities of implementing the acoustic monitoring program.

Table 2-4
Real-time Mean Daily Flow Data Sources

Measurement Location	Data Source
San Joaquin River near Vernalis	USGS, station 11303500 (http://waterdata.usgs.gov/ca/nwis/dv?cb_00060=on&format=html&begin_date=2008-02-01&site_no=11303500&referred_module=sw)
Stanislaus River below Goodwin Dam	USBR, Goodwin Dam Daily Operation Report (http://www.usbr.gov/mp/cvo/vungvari/gdwdop.pdf)
Tuolumne River below LaGrange Dam	USGS, station 11289650 (http://waterdata.usgs.gov/ca/nwis/dv?cb_00060=on&format=html&begin_date=2008-02-01&site_no=11289650&referred_module=sw)
Merced River at Cressey	CDEC, station CRS (http://cdec.water.ca.gov/cgi-progs/queryDgroups?s=fw2)
Merced River near Stevinson	CDEC, station MST (http://cdec.water.ca.gov/cgi-progs/queryDgroups?s=fw2)
San Joaquin River at Newman	USGS, station 11274000 (http://waterdata.usgs.gov/ca/nwis/dv?cb_00060=on&format=html&begin_date=2008-02-01&site_no=11274000&referred_module=sw)

Table 2-5
Summary of USGS Flow Measurements at the San Joaquin River near Vernalis Gage

Date	Time	Gage Height (ft)	Measured Flow (cfs)	Reported Real-time Flow (cfs)	Percent Difference	Rating Curve Shift (ft.)
3/18/08	11:40	9.97	1,850	1,910	-3.1%	+0.12
4/14/08	11:30	10.27	2,100	2,080	1.0%	+0.12
4/22/08	11:30	11.30	2,900	2,840	2.1%	+0.24
4/28/08	12:15	11.70	3,260	3,180	2.5%	+0.24
5/6/08	11:22	11.67	3,310	3,150	5.1%	+0.24
5/13/08	11:15	11.74	3,210	3,320	-3.3%	+0.24
6/2/08	11:15	9.31	1,430	1,520	-5.9%	+0.10

As part of the daily operation plan development, the determination must be made on whether the current year is likely to fall into the "off-ramp" or "double-step" category. As noted earlier, an "off-ramp" condition would occur in critically dry periods when the sum of VAMP numerical indicators for the previous two years and the current year is equal to or less than four. The 60-20-20 water year classification was "Wet" for 2006, which is a VAMP numerical indicator of five, therefore there was no possibility of 2008 being an off-ramp year since the off-ramp criterion was already exceeded without including the 2007 and 2008 numerical indicators. With 2007 being a "Critical" year with a VAMP numerical indicator of one, the maximum possible sum of indicators for 2007 and 2008 was six, thereby eliminating the option of a "double-step" condition for 2008.

The initial daily operation plan was prepared on March 14th. Modifications to the daily operation plan continued as hydrologic conditions and operational requirements changed. Table 2-3 provides a summary of the daily operation plans developed during the VAMP planning and implementation. All of the daily operation plans are provided in Appendix A-1, Tables 1 through 14.

Tributary Flow Coordination

Although the primary goal of the VAMP operation is to provide a stable target flow in the San Joaquin River near Vernalis, an important consideration in the planning and operation is that the flows that are scheduled on the Merced, Tuolumne and Stanislaus Rivers to achieve this goal are beneficial and do not conflict with studies or flow requirements on those rivers. During the development of the daily operation plan, the Hydrology Group consults with the California Department of Fish and Game (DFG) and the tributary biological teams to determine periods when pulse flows and stable flows are desirable on the tributaries, what flow rates are desired, what rates of change are acceptable, and what minimum and maximum flows are acceptable.

An example of this coordination occurred in 2008 when on April 25th, three days into the VAMP period; it was brought to the attention of the SJRTC that a team from the USBR Fisheries Applications Research Group, Denver, Colorado, was going to be on the Stanislaus River performing field work between April 28th and May 16th. There were specific periods for which they needed stable flows to do their work. The daily operation plan was modified to accommodate the planned field work.

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Implementation

Operation Conference Calls

During implementation of the VAMP pulse flow, conference calls were conducted every Tuesday and Friday at 6:30 A.M. between April 25th and May 16th to discuss the status of the pulse flow and to make operational changes if needed. These early morning calls were held so that if operational changes were called for they could be implemented on that day.

Operation Monitoring

The planning and implementation of the VAMP spring pulse flow operation was accomplished using the best available real-time data from the sources listed in Table 2-4. The real-time flow data used during the implementation of the VAMP flow have varying degrees of accuracy. The California Data Exchange Center (CDEC) real-time data has not been reviewed for accuracy or adjusted for rating shifts, whereas the USGS real-time data has had some preliminary review and adjustment. During the VAMP flow period, the real-time flows at Vernalis and in the San Joaquin River tributaries are continuously monitored. Similarly, the computed ungaged flow at Vernalis and the flow in the San Joaquin River upstream of the Merced River are continuously updated. The monitoring is done to assure that the supplemental water deliveries are adhering to the tributary allocations contained in the SJRA Division Agreement to the extent possible, as well as to determine if adjustments need to be made to the operation plan. The Division Agreement, among the SJRGA members, defines the allocation of supplemental VAMP water to be provided by each member.

Normally, the USGS makes monthly measurements of the flow at Vernalis to check the current rating curve shift for the gage. The real-time flows reported by the USGS and CDEC are dependent on the most current rating curve shift, therefore a new measurement and rating curve shift can result in a sudden and significant change in the reported real-time flow. In order to minimize the potential for these sudden and significant changes, arrangements were made with the USGS to measure the flow at Vernalis on a weekly basis between April 14th and May 13th. The results of these measurements are summarized in Table 2-5. There were no significant rating curve shifts experienced during the 2008 VAMP target flow period.

Results of Operations

The final accounting for the VAMP operation was accomplished using provisional mean daily flow data available from USGS and DWR as of July 16, 2008. Provisional data is data that has been reviewed and adjusted for rating shifts but is still considered preliminary and subject to change. Plots of the real-time and provisional flows at the primary measuring points are provided in Appendix A-2, Figures 1 through 7, to illustrate the differences between the real-time and the provisional data.

The mean daily flow in the San Joaquin River at the Vernalis gage averaged 3,160 cfs during the VAMP target flow period (April 22nd – May 22nd). Figure 2-2 shows the observed flow and the estimated existing (no VAMP) flow, along with the supplemental water contributions. A total of 75,250 acre-feet of supplemental water was provided to support the Vernalis target flow. The mean daily flow varied between a low of 2,640 cfs (May 22nd) and a high of 3,480 cfs (May 15th) during the target flow period. Over the 31-day target flow period the flow was measured to be outside the 7 % range on four occasions (April 22nd, May 12th, May 21st and May 22nd).

The sources of the flow at Vernalis are shown in Figure 2-3. Figures 2-4, 2-5 and 2-6 show the with and without VAMP flow at the tributary measurement points for the Merced, Tuolumne and Stanislaus Rivers, respectively. A tabulation of the observed mean daily flows during and around the VAMP target flow period is provided in Table 2-6.

The mean daily ungaged flow at Vernalis during the VAMP target flow period, ranged from a minimum of -338 cfs to a maximum of 196 cfs; with an average of a -56 cfs. A plot of the ungaged flow is provided in Figure 2-7.

As previously stated, the combined CVP and SWP Delta export rate target was 1,500 cfs. The observed exports, shown in Figure 2-8, averaged 1,520 cfs during the target flow period ranging from a low of 1,324 cfs (May 16th) to a high of 1,564 cfs (May 9th). Over the VAMP target flow period the export rate was measured to be outside the plus or minus 2.5 % range on five occasions (May 9th, May 16th, May 19th, May 20th and May 22th)

Hydrologic Impacts

The Merced VAMP supplemental water is provided from storage in Lake McClure on the Merced River and the MID/TID VAMP supplemental water is provided from storage in Don Pedro Lake, thereby resulting in potential impacts on reservoir storage as a result of the VAMP operation. Any storage impacts, though, would be offset by any water conservation measures that have been instituted as a result of the SJRA and that result in a reduced reliance on river diversions. The OID/SSJID VAMP supplemental water is made available from their diversion entitlements and therefore there are no storage impacts in New Melones Reservoir on the

Table 2-6
2008 Vernalis Adaptive Management Plan (VAMP)
Final Flows and Accounting of Supplemental Water Contributions
Target Flow Period: April 22 - May 22 • Target Flow: 3,200 cfs

Date	Merced R. at Cressey (3 day Travel Time to Vernalis)				Tuolumne R. blw LaGrange Dam (2 day Travel Time to Vernalis)			Stanislaus R. blw Goodwin Dam (2 day Travel Time to Vernalis)			San Joaquin R. above Merced R. Flow [2]	Ungaged Flow at Vernalis	San Joaquin River at Vernalis		
	Existing Flow [1]	Observed Flow	Merced ID Supplemental Flow	Exchange Contractors Supplemental Flow	Existing Flow [1]	Observed Flow	MID/TID Supplemental Flow	Existing Flow [1]	Observed Flow	OID/SSJID Supplemental Flow			Existing Flow [1]	Observed Flow	VAMP Supplemental Water
	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
04/01/08	250	250			176	176		1,264	1,264		487	(54)	2,380	2,380	
04/02/08	251	251			175	175		1,093	1,093		489	(64)	2,210	2,210	
04/03/08	241	241			169	169		1,007	1,007		464	(18)	2,160	2,160	
04/04/08	247	247			163	163		1,010	1,010		473	43	2,050	2,050	
04/05/08	248	248			163	163		1,008	1,008		425	129	2,020	2,020	
04/06/08	257	257			172	172		1,004	1,004		403	113	2,000	2,000	
04/07/08	260	260			176	176		1,005	1,005		416	167	2,010	2,010	
04/08/08	250	250			175	175		1,001	1,001		411	133	1,960	1,960	
04/09/08	256	256			176	176		1,004	1,004		387	26	1,880	1,880	
04/10/08	242	242			176	176		1,004	1,004		384	3	1,850	1,850	
04/11/08	245	245			182	182		1,164	1,164		361	23	1,840	1,840	
04/12/08	253	253			184	184		1,250	1,250		336	0	1,820	1,820	
04/13/08	258	258			184	184		1,250	1,250		316	11	1,960	1,960	
04/14/08	253	253			181	181		1,250	1,250		323	35	2,050	2,050	
04/15/08	244	244			170	170		1,385	1,385		343	17	2,020	2,020	
04/16/08	237	237			168	168		1,500	1,500		344	18	2,030	2,030	
04/17/08	232	232			168	168		1,520	1,520		320	29	2,180	2,180	
04/18/08	235	235			169	169		1,515	1,515		315	(16)	2,240	2,240	
04/19/08	250	219	0	0	756	756		1,519	1,519		326	(5)	2,240	2,240	
04/20/08	250	229	0	0	1,100	1,300	200	1,020	1,380	360	312	(21)	2,210	2,210	
04/21/08	250	234	0	0	1,100	1,270	170	1,020	1,353	333	296	(156)	2,680	2,680	
04/22/08	250	320	70	0	1,100	1,310	210	1,020	1,387	367	320	(291)	2,360	2,920	560
04/23/08	250	634	249	135	1,100	1,310	210	1,000	1,351	351	244	(98)	2,547	3,050	503
04/24/08	250	965	580	135	1,100	1,310	210	950	1,114	164	197	(71)	2,603	3,180	577
04/25/08	250	1,330	945	135	900	1,130	230	820	884	64	175	85	2,679	3,310	631
04/26/08	250	1,430	1,045	135	750	962	212	620	724	104	170	5	2,502	3,260	758
04/27/08	250	1,420	1,035	135	650	861	211	620	652	32	160	146	2,291	3,300	1,009
04/28/08	250	1,440	1,055	135	550	852	302	620	654	34	220	64	1,854	3,250	1,396
04/29/08	250	1,420	1,035	135	550	862	312	620	652	32	240	(3)	1,677	3,100	1,423
04/30/08	250	1,430	1,045	135	550	851	301	620	657	37	210	(46)	1,594	3,100	1,506
05/01/08	250	1,430	1,045	135	550	851	301	620	658	38	200	(104)	1,556	3,090	1,534
05/02/08	250	1,410	1,025	135	550	856	306	620	653	33	180	(8)	1,622	3,130	1,508
05/03/08	250	1,300	915	135	550	851	301	620	655	35	400	1	1,621	3,140	1,519
05/04/08	250	1,000	615	135	550	1,040	490	620	718	98	510	41	1,641	3,160	1,519
05/05/08	250	914	529	135	1,100	1,310	210	520	803	283	360	(166)	1,654	3,150	1,496
05/06/08	250	900	515	135	1,100	1,300	200	520	808	288	296	(338)	1,592	3,230	1,638
05/07/08	250	899	514	135	1,100	1,300	200	520	802	282	220	(233)	1,997	3,240	1,243
05/08/08	250	899	514	135	1,100	1,300	200	520	806	286	220	(88)	2,078	3,230	1,152
05/09/08	250	974	589	135	1,100	1,300	200	520	805	285	220	58	2,148	3,280	1,132
05/10/08	250	1,100	715	135	900	1,170	270	520	943	423	220	25	2,115	3,250	1,135
05/11/08	250	1,170	785	135	750	915	165	520	1,030	510	240	196	2,286	3,420	1,134
05/12/08	250	1,190	805	135	650	817	167	620	1,052	432	260	173	2,063	3,480	1,417
05/13/08	250	1,180	795	135	550	809	259	620	1,052	432	230	35	1,795	3,320	1,525
05/14/08	250	1,180	795	135	550	808	258	800	1,050	250	230	(59)	1,721	3,240	1,519
05/15/08	250	1,190	805	135	550	802	252	1,000	1,052	52	210	(61)	1,589	3,220	1,631
05/16/08	250	986	601	135	550	811	261	1,000	1,050	50	270	(128)	1,702	3,140	1,438
05/17/08	250	766	376	140	550	830	280	1,000	1,221	221	277	(144)	1,866	3,100	1,234
05/18/08	250	602	202	150	450	758	308	1,000	1,435	435	251	(251)	1,819	3,070	1,251
05/19/08	250	435	35	150	350	650	300	1,000	1,506	506	237	(164)	1,913	3,150	1,237
05/20/08	288	288			275	482	207	1,000	1,506	506	238	(160)	1,791	3,050	1,259
05/21/08	257	257			318	318		1,116	1,116		240	(145)	1,692	2,850	1,158
05/22/08	246	246			241	241		701	701		253	(21)	1,742	2,640	898
05/23/08	244	244			187	187		707	707		233	288	2,250	2,250	
05/24/08	233	233			178	178		703	703		274	488	1,940	1,940	
05/25/08	243	243			180	180		700	700		265	507	1,880	1,880	
05/26/08	245	245			180	180		704	704		251	501	1,900	1,900	
05/27/08	231	231			182	182		703	703		286	432	1,810	1,810	
05/28/08	232	232			184	184		707	707		291	322	1,700	1,700	
05/29/08	243	243			180	180		571	571		295	294	1,710	1,710	
05/30/08	189	189			160	160		504	504		282	247	1,660	1,660	
05/31/08	161	161			143	143		505	505		289	302	1,580	1,580	
VAMP Period															
Average (cfs):	250	987	620	119	751	999	248	745	981	236	252	(56)	1,939	3,163	1,224
Supplemental Water (ac-ft):			38,150	7,300			15,280			14,520					75,250

■ VAMP Period
[1] Existing Flow: Flow that would have occured without VAMP operation.
[2] Upper SJR = Flow in San Joaquin River above Merced River = San Joaquin River at Newman minus Merced River at Stevinson.
Observed Flow Sources:
Merced River at Cressey (CA DWR B05155): California DWR, Water Data Library, 7/16/08
Merced River near Stevinson (CA DWR B05125): California DWR, USDAY V64 Output 6/12/08
Tuolumne River below LaGrange Dam near LaGrange (USGS 11289650): USGS, provisional data as of 7/16/08
Stanislaus River below Goodwin Dam: USBR, Goodwin Reservoir Daily Operations Report - OID/SSJID/Tri-Dams, 6/25/08 (April report) and 6/2/08 (May report)
San Joaquin River near Vernalis (USGS 11303500): USGS, provisional data as of 7/16/08
San Joaquin River at Newman (USGS 11274000): USGS, provisional data as of 7/16/08

Table 2-7 Summary of VAMP Flows, 2000-2008									
Year	**60-20-20 Water Year Hydrologic Classification**	**VAMP Numerical Indicator**	**VAMP Target Flow Period**	**VAMP Target Flow (cfs)**	**Observed VAMP Flow (cfs)**	**Existing Flow (cfs)**	**VAMP Supplemental Water (acre-feet)**	**Delta Export Target (cfs)**	**Observed Delta Exports (cfs)**
2000	Above Normal	4	4/15 - 5/15	5,700	5,869	4,800	77,680	2,250	2,155
2001	Dry	2	4/20 - 5/20	4,450	4,224	2,909	78,650	1,500	1,420
2002	Dry	2	4/15 - 5/15	3,200	3,301	2,757	33,430	1,500	1,430
2003	Below Normal	3	4/15 - 5/15	3,200	3,235	2,290	58,065	1,500	1,446
2004	Dry	2	4/15 - 5/15	3,200	3,155	2,088	65,591	1,500	1,331
2005	Wet	5	5/1 - 5/31	>7,000	10,390	10,390	0	2,250	2,986 [a]
2006	Wet	5	5/1 - 5/31	>7,000	26,220/24,262 [b]	26,020	0	1,500/6,000 [b]	1,559/5,748 [b]
2007	Critical	1	4/22 - 5/22	3,200	3,263	2,721	33,330	1,500	1,486
2008	Critical	1	4/22 - 5/22	3,200	3,163	1,939	75,250	1,500	1,520

[a] May 1 through 25 average was 2,260 cfs; exports were increased starting May 26 inconjunction with increasing existing flow; May 26 through 31 average was 6,012 cfs.
[b] “First fish release-recapture period”/”Second fish release-recapture period”

Stanislaus River due to the SJRA. Due to the extended nature of the VAMP, a 12-year plan, the storage impacts can potentially carry over from year to year. Reservoir storage impacts are reduced or eliminated when the reservoirs make flood control releases.

If it is assumed that Merced ID diversions from the Merced River are the same as they would have been without the SJRA, then the storage impact on Lake McClure following the 2008 VAMP operation and Fall SJRA transfer would be -92,110 acre-feet, as shown in Figure 2-9. However, as a result of the SJRA, Merced ID has undertaken a number of conservation measures that have resulted in a reduced reliance on Merced River diversions. Any reductions in Merced River diversions would offset the storage deficit shown in Figure 2-8. The impact of the Merced ID SJRA related conservation measures on Merced River diversions have not yet been quantified. It should be noted that even under the assumption that the storage deficit is equal to the supplemental water contribution, the SJRA has resulted in no reductions in Merced River flow during the nine years of VAMP operation as shown in Appendix B-1, Figure 3.

The cumulative storage impact to Don Pedro Reservoir as a result of the 2008 VAMP operation is -19,650 acre-feet, as shown in Figure 2-10.

Summary of Historical VAMP Operations

2008 marks the ninth year of VAMP operation in compliance with D-1641. Annual VAMP technical reports for the previous years are available at the SJRGA website, www.sjrg.org. A summary of the VAMP target flows for these first nine years is provided in Table 2-7. A summary of the SJRGA supplemental water contributions is provided in Table 2-8. The SJRTC Hydrology Group monitors the cumulative impact of the SJRA on reservoir storage and stream flows. Plots of storage and flow impacts throughout the nine years of VAMP operation are provided in Appendix B-1, Figures 1 through 4.

Over the first nine years of the program considerable variation has occurred in both the flow entering the system upstream of the Merced River and the ungaged flow within the system. With each update of the daily operation plan throughout the planning and implementation phases the upstream and ungaged flows would vary causing the SJRGA to reduce or increase the contribution of supplemental water in order to support the VAMP target flow. Analysis of the variability in the ungaged flow at Vernalis and the San Joaquin River above Merced River flow and how these affect the forecasting of the existing and supplemental flows is ongoing.

Figure 2-2
2008 VAMP - San Joaquin River near Vernalis with and without VAMP

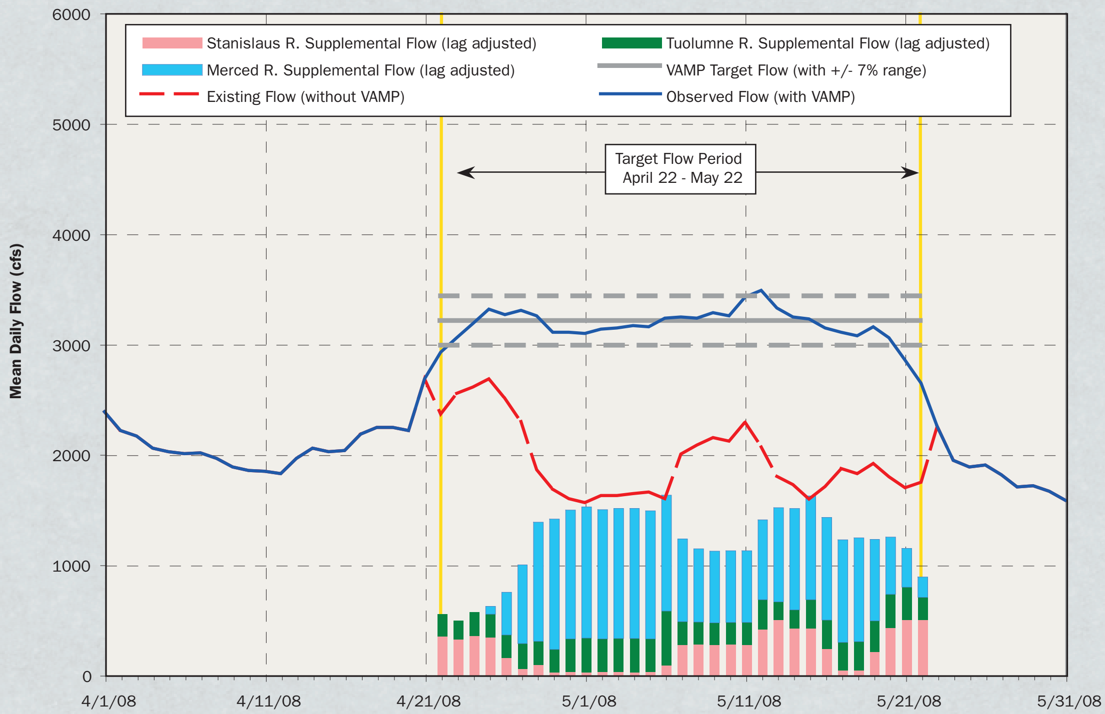


Figure 2-3
2008 VAMP: San Joaquin River Near Vernalis with Lagged Contributions from Primary Sources

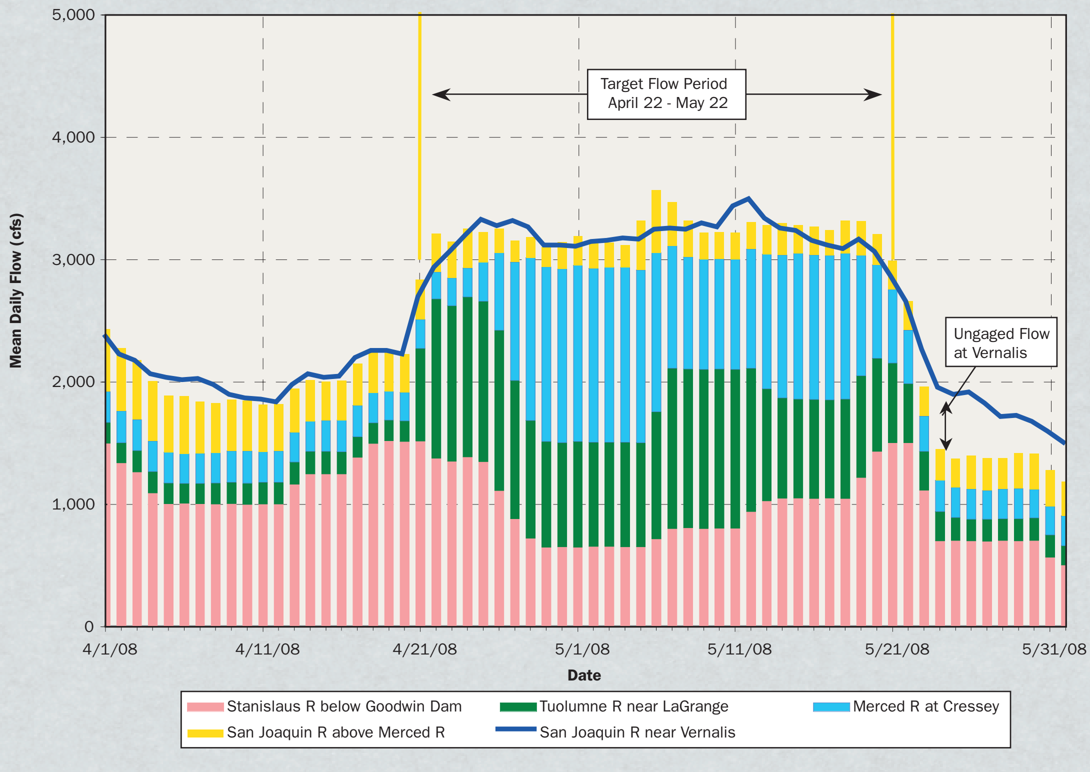


Figure 2-4
2008 VAMP - Merced River at Cressey with and without VAMP

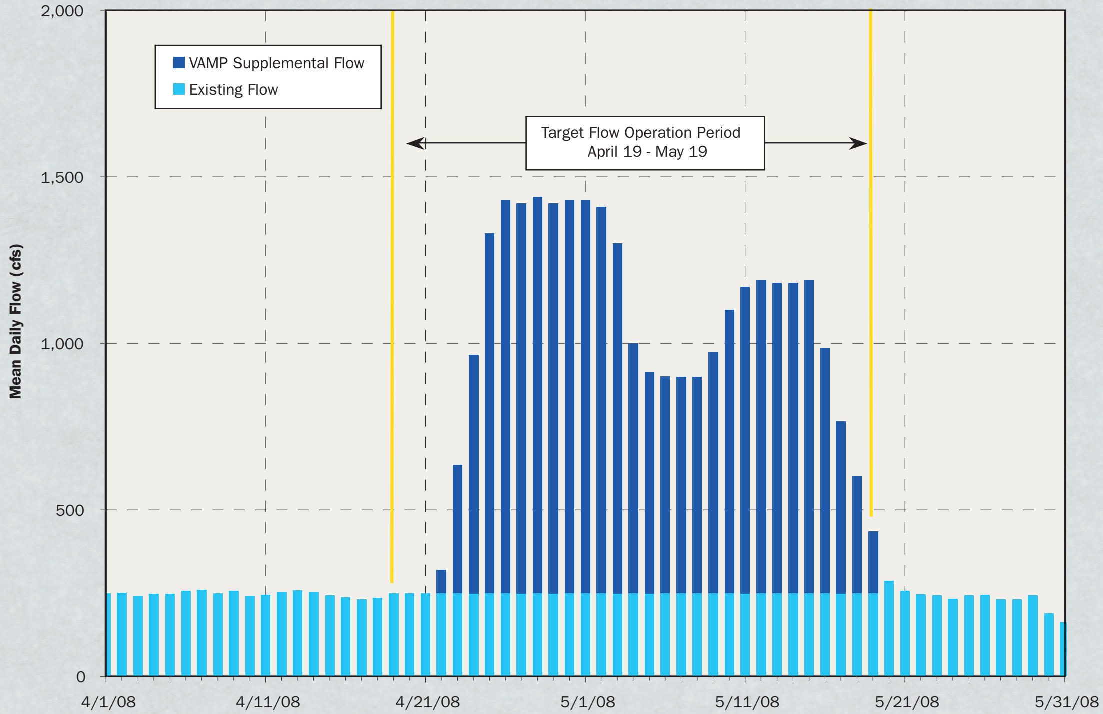


Figure 2-5
2008 VAMP - Tuolumne River below LaGrange Dam with and without VAMP

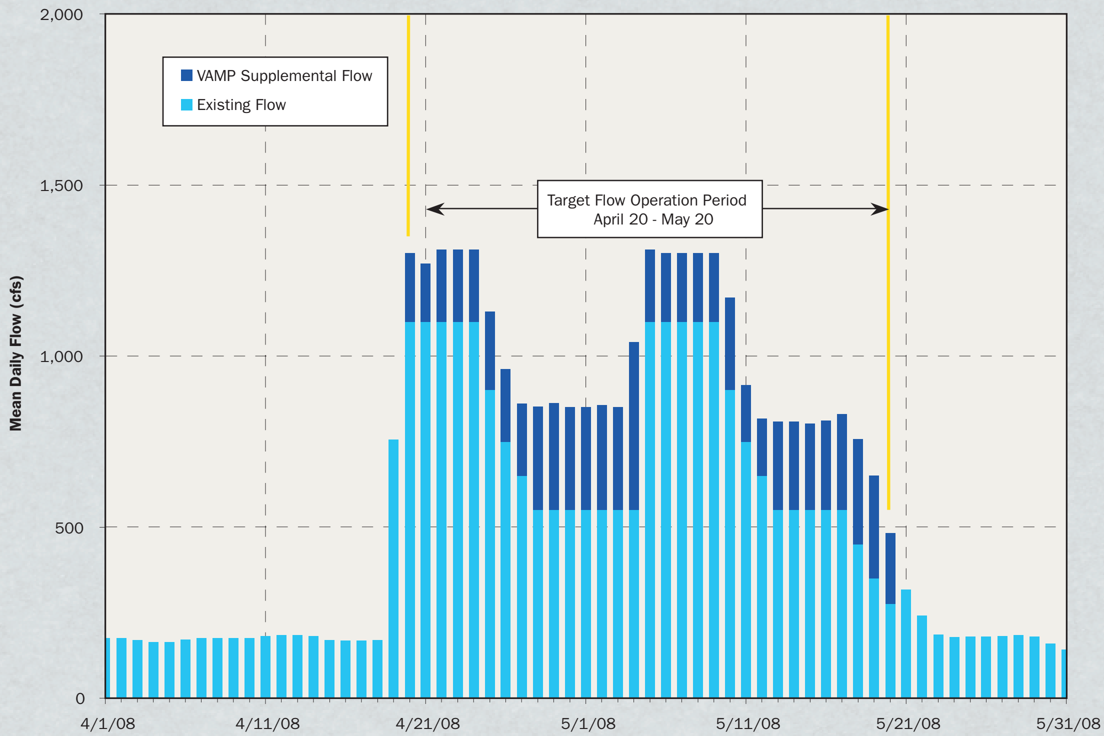


Figure 2-6
2008 VAMP - Stanislaus River below Goodwin Dam with and without VAMP

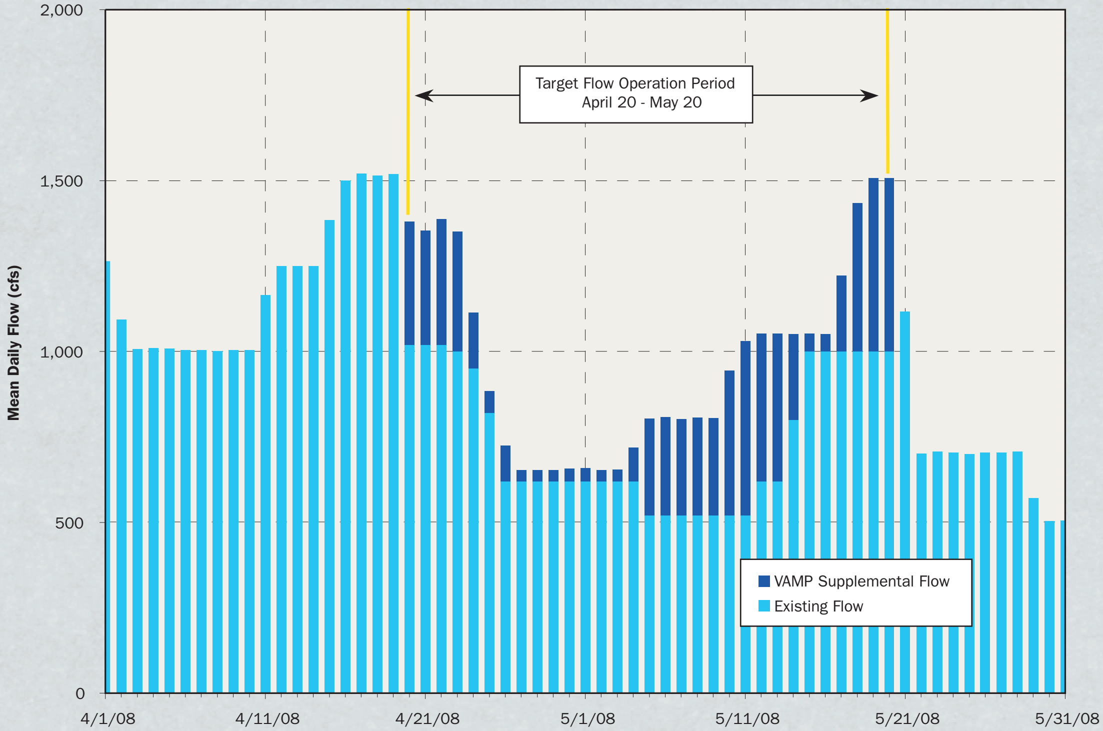


Figure 2-7
2008 VAMP - Ungaged Flow in San Joaquin River at Vernalis

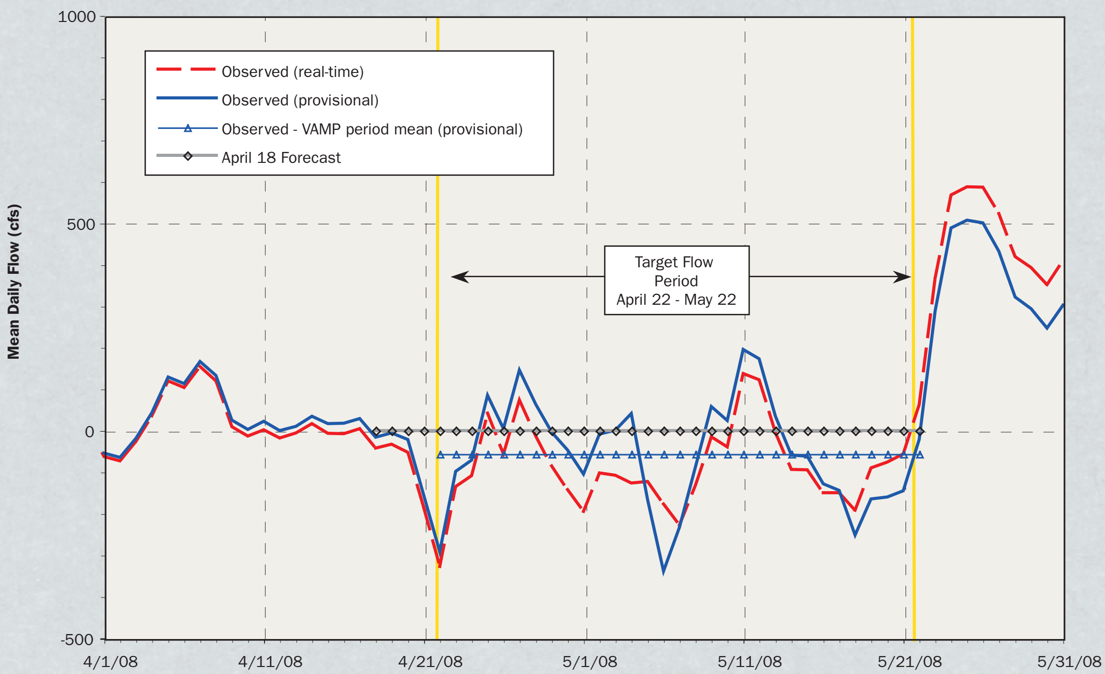


Figure 2-8
2008 VAMP - Federal and State Delta Exports

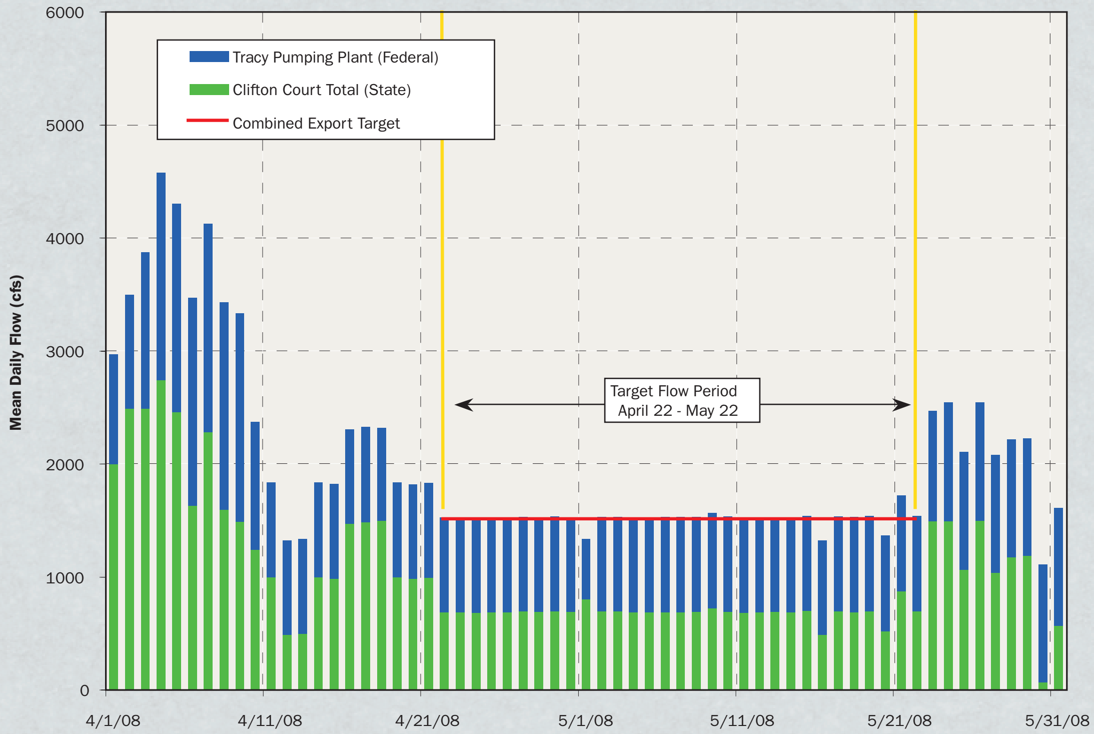
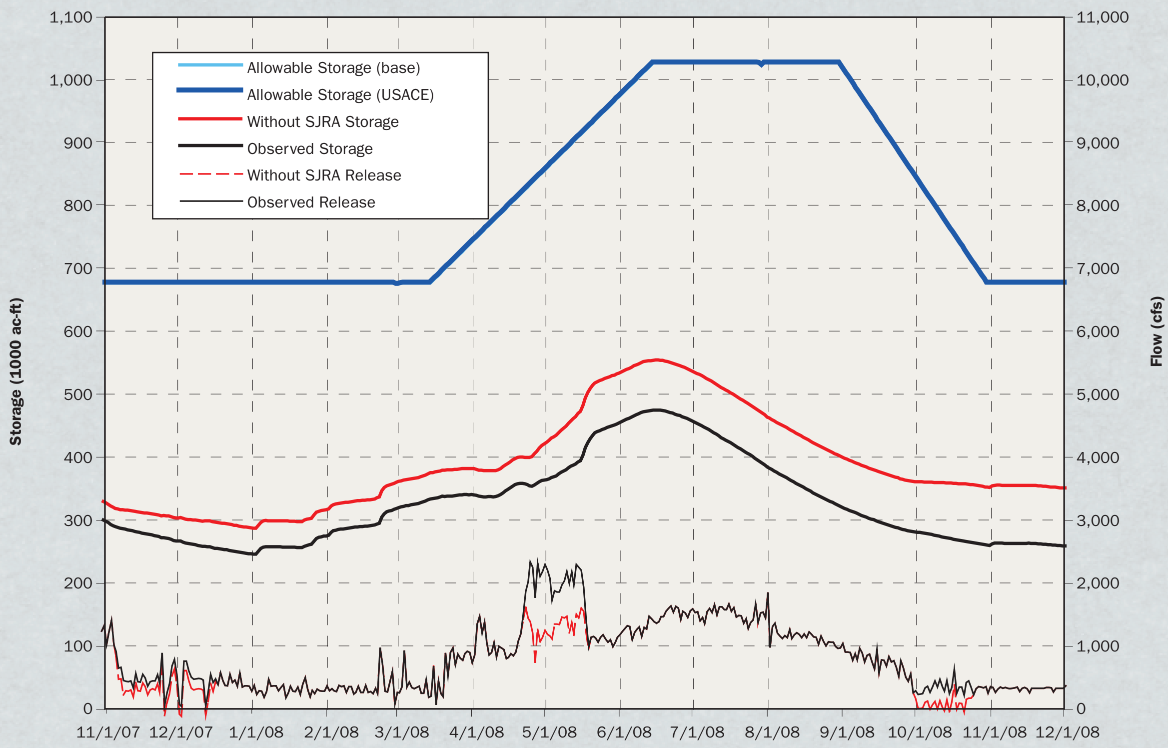


Figure 2-9
San Joaquin River Agreement Storage and Flow Impacts
Merced River - Lake McClure Storage and Release - 2008



CHAPTER 2

Figure 2-10
San Joaquin River Agreement Storage and Flow Impacts Tuolumne River
- New Don Pedro Reservoir Storage and Release - 2008

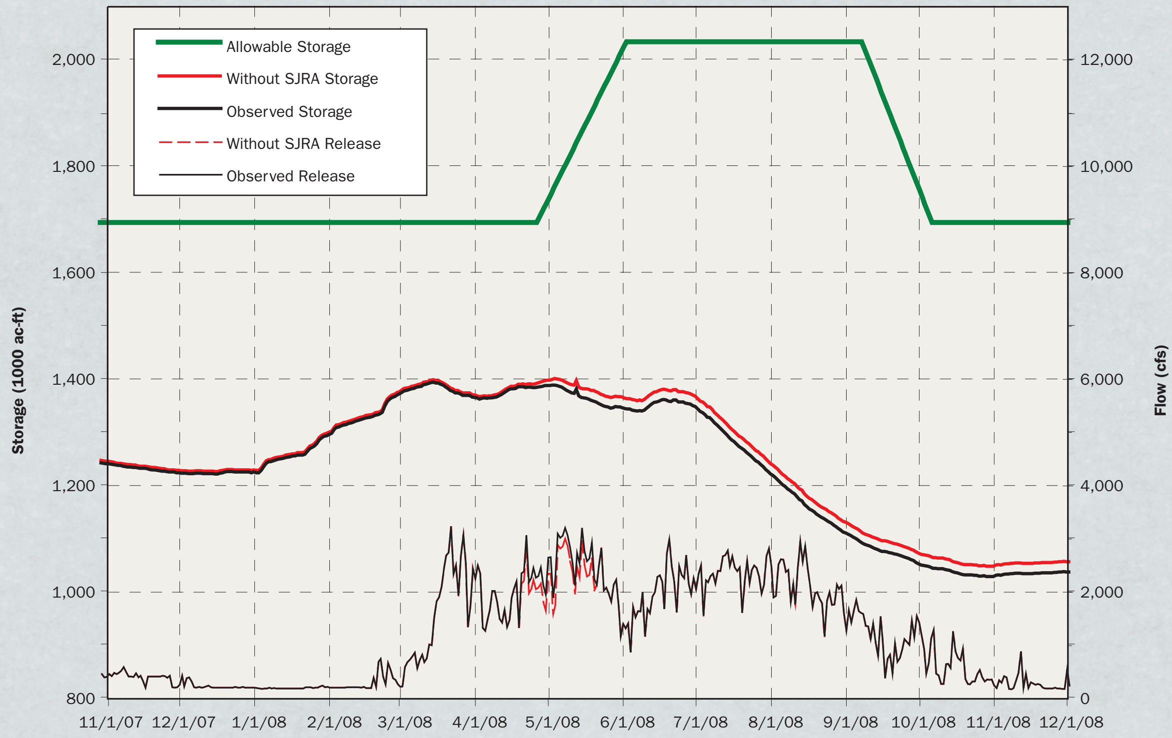


Table 2-8
Summary of VAMP Supplemental Water Contributions, 2000-2008

Year	VAMP Supplemental Water (acre-feet)		Supplemental Water (acre-feet)					
			Merced ID	Oakdale ID	South San Joaquin ID	SJRECWA	Modesto ID	Turlock ID
2000	77,680	Observed:	42,770	7,300 [a]	7,300 [b]	8,280	5,580	6,450
		Division Agreement:	41,180	7,300	7,300	7,300	7,300	7,300
		Deviation:	+ 1590			+ 980	- 1,720	- 850
2001	78,650	Observed:	42,120	7,365	7,365	7,740	7,030	7,030
		Division Agreement:	42,150	7,300	7,300	7,300	7,300	7,300
		Deviation:	- 30	+ 65	+ 65	+ 440	- 270	- 270
2002	33,430	Observed:	25,840	3,795	3,795	0	0	0
		Division Agreement:	25,000	4,215	4,215	0	0	0
		Deviation:	+ 840	- 420	- 420	0	0	0
2003	58,065	Observed:	33,257	5,039	5,039	5,000 [c]	4,865	4,865
		Division Agreement:	33,065	5,000	5,000	5,000	5,000	5,000
		Deviation:	+ 192	+ 39	+ 39		- 135	- 135
2004	65,591	Observed:	37,680	5,880	5,880	5,000 [c]	5,576	5,576
		Division Agreement:	36,500	7,045.5	7,045.5	5,000	5,000	5,000
		Deviation:	+ 1,180	- 1165.5	- 1165.5		+ 576	+ 576
2005	0	Observed:	0	0	0	0	0	0
		Division Agreement:	0	0	0	0	0	0
		Deviation:	0	0	0	0	0	0
2006	0	Observed:	0	0	0	0	0	0
		Division Agreement:	0	0	0	0	0	0
		Deviation:	0	0	0	0	0	0
2007	33,330	Observed:	28,960	2,185 [d]	2,185 [d]	0	0	0
		Division Agreement:	25,000	4,165	4,165	0	0	0
		Deviation:	+ 3,960	- 1,980	- 1,980	0	0	0
2008	75,250	Observed:	38,150	7,260	7,260	7300 [c]	7,640	7,640
		Division Agreement:	38,750	7,300	7,300	7,300	7,300	7,300
		Deviation:	- 600	- 40	- 40	0	+ 340	+ 340

[a] Provided by Modesto ID
[b] Provided by Merced ID (54.55%), Oakdale ID (15.91%), Modesto ID (15.91%) and Turlock ID (13.64%)
[c] Provided by Merced ID
[d] Provided by Modesto ID/Turlock ID on the Tuolumne River due to flow constraints on the Stanislaus River

CHAPTER 3

ADDITIONAL WATER SUPPLY ATTANGEMENTS AND DELIVERIES

Paragraph 8.4 of the SJRA states that "Merced Irrigation District (MeID) shall provide, and the USBR shall purchase 12,500 acre-feet of water…during October of all years." The SJRA also states in Paragraph 8.4.4 that "Water purchased pursuant to Paragraph 8.4 may be scheduled for months other than October provided Merced, DFG and USFWS all agree." Paragraph 8.5 of the SJRA states that "Oakdale Irrigation District (OID) shall sell 15,000 acre-feet of water to the USBR in every year of this Agreement." Paragraph 8.5 also states, "In addition to the 15,000 acre-feet, Oakdale will sell the difference between the water made available to VAMP under the SJRGA division agreement and 11,000 acre-feet," which is referred to as the Difference Water. The purpose of additional water supply deliveries in the fall months is to provide instream flows to attract and assist adult salmon during spawning.

Merced Irrigation District

The Paragraph 8.4 water is referred to as the Fall SJRA Transfer Water. The daily schedule for the Fall SJRA Transfer Water is developed by the California Department of Fish and Game (DFG), United States Fish and Wildlife Services (USFWS) and MeID.

The schedule for the Fall SJRA Water Transfer was finalized on September 25, 2008, with the transfer commencing on October 1. A daily summary of the Fall SJRA Water Transfer is provided in Table 3-1 and Figure 3-1.

Oakdale Irrigation District

The combined Paragraph 8.5 water is referred to as the OID Additional Water.

OID provided 7,260 acre-feet of supplemental water for the 2008 VAMP operation, resulting in 3,740 acre-feet of Difference Water. The total additional water purchased by the USBR from OID was 18,740 acre-feet (15,000 acre-feet plus 3,740 acre-feet of Difference Water). The OID additional water is made available in New Melones reservoir for use by the USBR for any authorized purpose of the New Melones project.

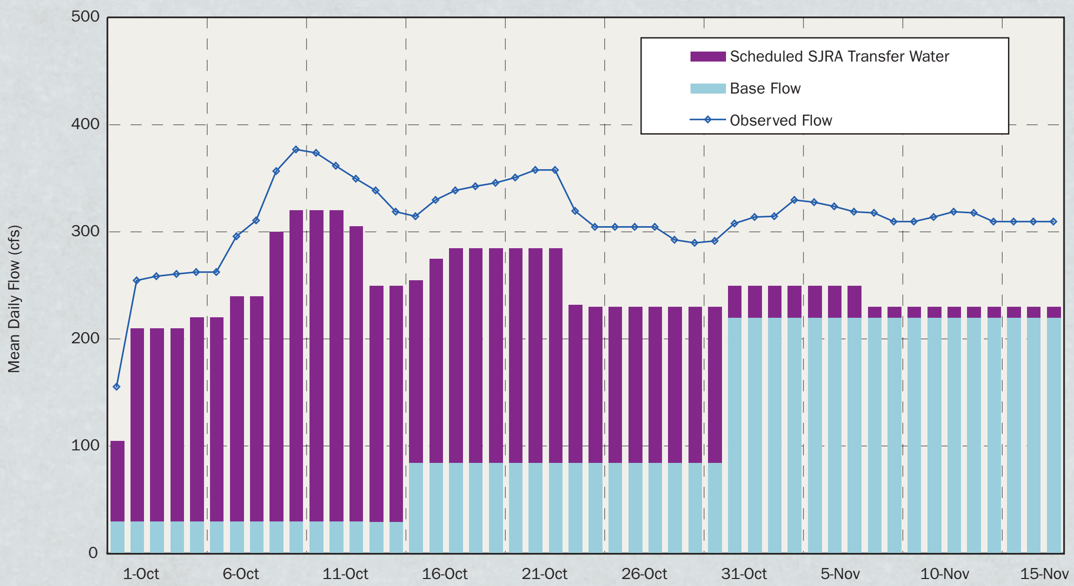
The 18,740 ac-ft of OID Additional Water was released from May 13 through September 30 to provide supplemental flow to the Stanislaus River for fishery purposes.

Table 3-1
2008 Merced Irrigation District SJRA Fall Water Transfer Daily Summary

		SCHEDULED			OBSERVED		
		SJRA Transfer Water				SJRA Transfer Water	
Date	Base Flow at Shaffer Br/Cressey (cfs)	SJRA Transfer Water Flow (cfs)	Cumulative SJRA Transfer Water Volume (acre-ft)	Target Flow at Shaffer Br/Cressey (cfs)	Shaffer Br/ Cressey Flow (cfs)	SJRA Transfer Water Flow (cfs)	Cumulative SJRA Transfer Water Volume (acre-ft)
1-Oct	30	75	149	105	155	125	248
2-Oct	30	180	506	210	254	224	692
3-Oct	30	180	863	210	258	228	1,144
4-Oct	30	180	1,220	210	260	230	1,601
5-Oct	30	190	1,597	220	262	232	2,061
6-Oct	30	190	1,974	220	262	232	2,521
7-Oct	30	210	2,390	240	295	265	3,047
8-Oct	30	210	2,807	240	310	280	3,602
9-Oct	30	270	3,342	300	356	326	4,249
10-Oct	30	290	3,917	320	376	346	4,935
11-Oct	30	290	4,493	320	373	343	5,615
12-Oct	30	290	5,068	320	361	331	6,272
13-Oct	30	275	5,613	305	349	319	6,904
14-Oct	30	220	6,050	250	338	308	7,515
15-Oct	30	220	6,486	250	318	288	8,087
16-Oct	85	170	6,823	255	314	229	8,541
17-Oct	85	190	7,200	275	329	244	9,025
18-Oct	85	200	7,597	285	338	253	9,527
19-Oct	85	200	7,993	285	342	257	10,036
20-Oct	85	200	8,390	285	345	260	10,552
21-Oct	85	200	8,787	285	350	265	11,078
22-Oct	85	200	9,183	285	357	272	11,617
23-Oct	85	200	9,580	285	357	272	12,157
24-Oct	85	147	9,872	232	319	173	12,500
25-Oct	85	145	10,159	230	304		
26-Oct	85	145	10,447	230	304		
27-Oct	85	145	10,735	230	304		
28-Oct	85	145	11,022	230	304		
29-Oct	85	145	11,310	230	292		
30-Oct	85	145	11,597	230	289		
31-Oct	85	145	11,885	230	291		
1-Nov	220	30	11,944	250	307		
2-Nov	220	30	12,004	250	313		
3-Nov	220	30	12,063	250	314		
4-Nov	220	30	12,123	250	329		
5-Nov	220	30	12,182	250	327		
6-Nov	220	30	12,242	250	323		
7-Nov	220	30	12,301	250	318		
8-Nov	220	10	12,321	230	317		
9-Nov	220	10	12,341	230	309		
10-Nov	220	10	12,361	230	309		
11-Nov	220	10	12,381	230	313		
12-Nov	220	10	12,401	230	318		
13-Nov	220	10	12,420	230	317		
14-Nov	220	10	12,440	230	309		
15-Nov	220	10	12,460	230	309		
16-Nov	220	10	12,480	230	309		
17-Nov	220	10	12,500	230	309		

Figure 3-1

Merced I.D. Fall 2008 Water Transfer Merced River Flow at Shaffer Bridge/Cressey

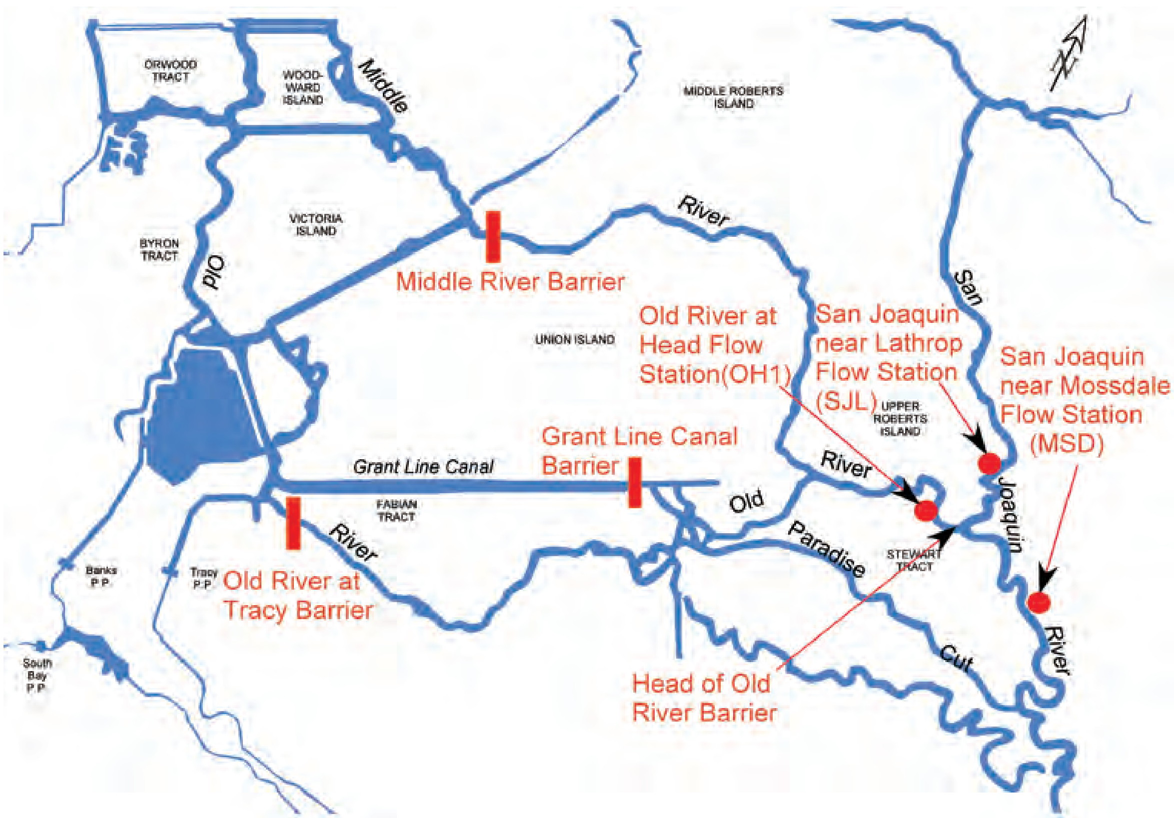


CHAPTER 4

HEAD OF OLD RIVER BARRIER INSTALLATION AND FLOWS

Installation of the 2008 temporary spring Head of Old River Barrier (HORB) was prohibited in a Federal Court decision by United States District Court Judge Wanger for increased protection for delta smelt.

Figure 4-1
Location Map - South Delta Barriers Program



Flow Measurements at and Around the Head of Old River

The Department of Water Resources (DWR) operates three Acoustic Doppler Current Meters (ADCM) in the vicinity of Head of Old River as shown in Figure 4-1. One in the San Joaquin River 1,500 feet downstream of Old River (San Joaquin River below Old River near Lathrop, SJL) and another located in Old River 840 feet downstream of the Head of Old River (Old River at Head, OH1). The third acoustical Doppler was installed in 2006 at the abutment of the railroad bridge near Mossdale (San Joaquin River at Mossdale Bridge, about 10,000 feet upstream from the Head of Old River.

The ADCMs record velocity measurements at a 15-minute interval from which flow values can be determined. Table 4-1 lists the daily minimum, maximum and mean daily flows for the April 1, 2008 through June 30, 2008 period for the three ADCMs. These values are depicted graphically in Figures 4-2, 4-3, and 4-4.

Figure 4-5 presents in graphical format a comparison of the mean daily flow for the San Joaquin River gage at Mossdale and the San Joaquin River near Vernalis gage for the period April 1, 2008 through June 30, 2008.

Table 4-1
Measured Flows in San Joaquin River at Mossdale, Old River at Head and San Joaquin River below Old River.

	Old River at Head (OH1)			San Joaquin River below Old River (SJL)			San Joaquin River at Mossdale (MSD)			Flow Split (% of Total Flow)	
Date	Minimum Flow (cfs)	Maximum Flow (cfs)	Mean Daily Flow (cfs)	Minimum Flow (cfs)	Maximum Flow (cfs)	Mean Daily Flow (cfs)	Minimum Flow (cfs)	Maximum Flow (cfs)	Mean Daily Flow (cfs)	OH1	SJL
4/1/2008	882	2530	1704	-753	1995	931	1913	3077	2534	64.7%	35.3%
4/2/2008	829	2649	1724	-944	1862	774	1810	2858	2394	69.0%	31.0%
4/3/2008				-866	1804	711	1583	2851	2293		
4/4/2008				-990	1828	610	1438	2729	2173		
4/5/2008				-1048	1811	580	1236	2804	2156		
4/6/2008				-1309	1818	535	1167	2831	2157		
4/7/2008				-1326	1785	594	1022	2836	2205		
4/8/2008				-1372	1759	480	784	2769	2047		
4/9/2008	286	2749	1545	-1518	1826	498	558	2874	1956	75.6%	24.4%
4/10/2008	140	2429	1514	-1528	1940	587	519	2723	1917	72.1%	27.9%
4/11/2008	206	2515	1331	-1284	1872	659	627	2718	1876	66.9%	33.1%
4/12/2008	318	2123	1325	-1127	1869	630	679	2555	1759	67.8%	32.2%
4/13/2008	517	2322	1366	-979	1868	653	695	2648	1821	67.6%	32.4%
4/14/2008	512	2096	1359	-1076	1808	588	915	2749	1879	69.8%	30.2%
4/15/2008	572	2314	1417	-1024	1730	651	929	2710	1836	68.5%	31.5%
4/16/2008	655	2319	1479	-882	1667	608	1112	2625	1961	70.9%	29.1%
4/17/2008	695	2342	1540	-830	1703	640	1104	2584	1995	70.6%	29.4%
4/18/2008	671	2347	1543	-965	1754	600	1022	2684	2009	72.0%	28.0%
4/19/2008	510	2280	1453	-1256	1789	513	1019	2761	1981	73.9%	26.1%
4/20/2008	402	2324	1501	-1213	1846	648	992	2855	2047	69.8%	30.2%
4/21/2008	564	2431	1646	-1138	1876	769	1108	3169	2391	68.2%	31.8%
4/22/2008	1056	2640	1836	-828	2050	1045	1789	3579	2863	63.7%	36.3%
4/23/2008	1026	2774	1918	-879	2188	1098	1803	3708	2977	63.6%	36.4%
4/24/2008	1150	2763	1984	-699	2337	1322	2260	4006	3262	60.0%	40.0%
4/25/2008	1277	2554	2021	-282	2394	1459	2555	3955	3359	58.1%	41.9%
4/26/2008	1244	2498	1994	-197	2349	1484	2505	4024	3388	57.3%	42.7%
4/27/2008	1322	2512	2005	199	2342	1552	2831	4042	3422	56.4%	43.6%
4/28/2008	1302	2362	1970	278	2228	1506	2767	3964	3359	56.7%	43.3%
4/29/2008	1181	2538	1910	-603	2199	1254	2506	3700	3141	60.4%	39.6%
4/30/2008	1257	2506	1937	-495	2191	1346	2302	3646	3183	59.0%	41.0%
5/1/2008	1340	2454	1930	-201	2167	1347	2417	3544	3151	58.9%	41.1%
5/2/2008	1324	2512	1981	-462	2187	1218	2340	3658	3129	61.9%	38.1%
5/3/2008	1264	2632	2010	-707	2271	1189	2258	3803	3201	62.8%	37.2%
5/4/2008	1163	2697	2009	-1006	2289	1084	2037	3904	3195	65.0%	35.0%
5/5/2008	1092	2846	2083	-1343	2452	1045	2028	4202	3261	66.6%	33.4%
5/6/2008	1012	2809	2054	-1533	2511	1121	1828	4285	3353	64.7%	35.3%
5/7/2008	1055	2741	2048	-1571	2483	1098	1798	4400	3423	65.1%	34.9%
5/8/2008	1095	2814	2095	-1362	2492	1136	2023	4322	3439	64.8%	35.2%
5/9/2008	1079	2740	2062	-1275	2405	1165	2163	4472	3529	63.9%	36.1%
5/10/2008	1133	2689	2038	-893	2357	1264	2256	4293	3465	61.7%	38.3%
5/11/2008	1213	2623	2005	-789	2330	1317	2672	4365	3622	60.4%	39.6%
5/12/2008	1415	2694	2113	-634	2316	1443	2969	4490	3788	59.4%	40.6%
5/13/2008	1416	2552	2027	-49	2236	1440	2999	4181	3627	58.5%	41.5%
5/14/2008	1291	2525	1970	-438	2213	1302	2582	3953	3381	60.2%	39.8%
5/15/2008	1361	2525	1982	-678	2173	1225	2379	3949	3314	61.8%	38.2%
5/16/2008	1142	2615	1958	-939	2227	1042	2113	3878	3197	65.3%	34.7%
5/17/2008	1079	2747	1943	-1054	2219	984	2004	3904	3141	66.4%	33.6%
5/18/2008	1039	2652	1919	-1187	2195	925	1764	3948	3093	67.5%	32.5%
5/19/2008	987	2702	1961	-1305	2230	936	1788	4160	3193	67.7%	32.3%
5/20/2008	951	2554	1880	-1443	2222	810	1656	4111	3073	69.9%	30.1%
5/21/2008	769	2362	1750	-1424	2123	863	1581	3992	2983	67.0%	33.0%
5/22/2008	249	2372	1635	-1678	2178	844	1134	4051	2835	65.9%	34.1%
5/23/2008	628	2350	1626	-1356	1926	521	1152	3502	2438	75.8%	24.2%
5/24/2008	372	2177	1437	-1529	1776	471	546	3091	2011	75.3%	24.7%
5/25/2008	628	1989	1337	-1121	1651	481	757	2861	1902	73.6%	26.4%
5/26/2008	500	1869	1318	-952	1641	478	901	2782	1917	73.4%	26.6%
5/27/2008	540	1796	1273	-957	1482	527	894	2532	1855	70.7%	29.3%
5/28/2008	374	1931	1202	-980	1406	454	654	2293	1651	72.6%	27.4%
5/29/2008	287	1836	1186	-1082	1468	423	387	2284	1608	73.7%	26.3%
5/30/2008	235	1909	1193	-1207	1547	403	384	2469	1568	74.7%	25.3%
5/31/2008	149	1952	1135	-1476	1617	359	60	2474	1478	76.0%	24.0%
6/1/2008	-36	1799	1037	-1625	1735	335	-88	2452	1373	75.6%	24.4%
6/2/2008	-248	1856	1058	-1749	1858	301	-158	2556	1366	77.9%	22.1%
6/3/2008	-360	1751	1020	-1953	1877	160	-326	2493	1223	86.4%	13.6%
6/4/2008	-645	1755	970	-2371	1998	130	-729	2518	1203	88.2%	11.8%
6/5/2008	-370	1553	940	-2046	1886	168	-502	2419	1171	84.9%	15.1%
6/6/2008	-308	1561	867	-1975	1905	161	-602	2391	1091	84.3%	15.7%
6/7/2008	-194	1478	785	-1655	1807	243	-402	2057	1032	76.3%	23.7%
6/8/2008	119	1349	787	-1458	1583	293	-287	1999	1064	72.9%	27.1%
6/9/2008	99	1275	814	-1100	1418	308	-23	1835	1078	72.6%	27.4%
6/10/2008	-7	1312	730	-1169	1315	289	-119	1823	1009	71.6%	28.4%
6/11/2008	-16	1323	704	-1175	1292	326	-148	1674	982	68.4%	31.6%
6/12/2008	-199	1166	649	-1269	1411	260	-289	1729	876	71.4%	28.6%
6/13/2008	-425	1222	588	-1344	1477	155	-456	1776	782	79.1%	20.9%
6/14/2008	-632	1437	608	-1676	1620	128	-626	2012	821	82.6%	17.4%
6/15/2008	-680	1457	641	-1807	1684	161	-663	2205	884	79.9%	20.1%
6/16/2008	-629	1468	678	-1738	1829	148	-582	2187	895	82.1%	17.9%
6/17/2008	-649	1470	646	-1747	1874	130	-620	2067	831	83.2%	16.8%
6/18/2008	-699	1340	615	-1618	1743	96	-585	2024	769	86.5%	13.5%
6/19/2008	-611	1344	563	-1650	1672	93	-656	2201	793	85.8%	14.2%
6/20/2008	-584	1196	556	-1603	1556	73	-668	2090	760	88.4%	11.6%
6/21/2008	-634	1360	577	-1529	1689	42	-633	2030	711	93.2%	6.8%
6/22/2008	-400	1301	615	-1485	1589	45	-551	2083	775	93.1%	6.9%
6/23/2008	-61	1419	622	-1440	1472	90	-417	1954	822	87.4%	12.6%
6/24/2008	37	1478	634	-1329	1356	146	-237	1655	803	81.3%	18.7%
6/25/2008	70	1243	628	-1378	1263	197	-164	1387	764	76.1%	23.9%
6/26/2008	15	1462	642	-1414	1190	218	-215	1408	777	74.7%	25.3%
6/27/2008	-123	1613	661	-1809	1442	128	-170	1359	703	83.8%	16.2%
6/28/2008	-133	1551	634	-2041	1705	115	-440	1535	701	84.6%	15.4%
6/29/2008	-366	1601	583	-2179	1809	161	-525	1767	750	78.3%	21.7%
6/30/2008	-474	1541	622	-2360	1961	188	-499	1879	835	76.8%	23.2%

No Data

Figure 4-2
Daily Flow Range - Old River at Head

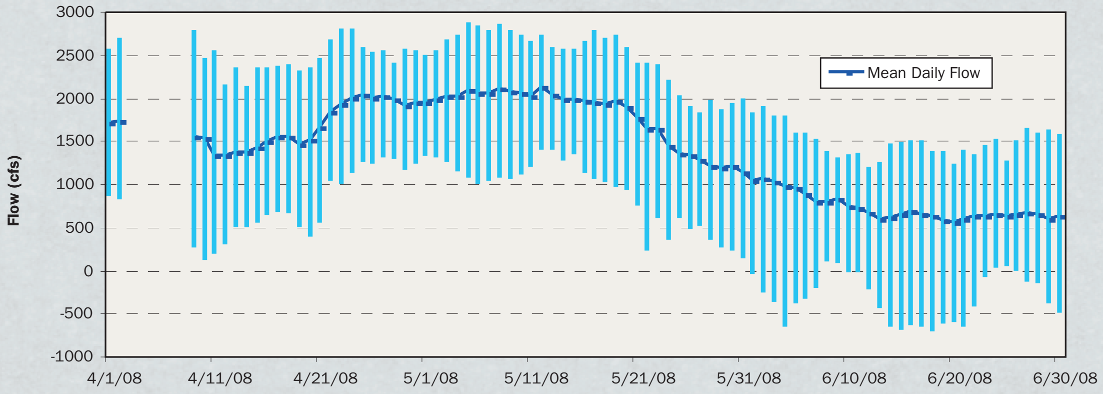
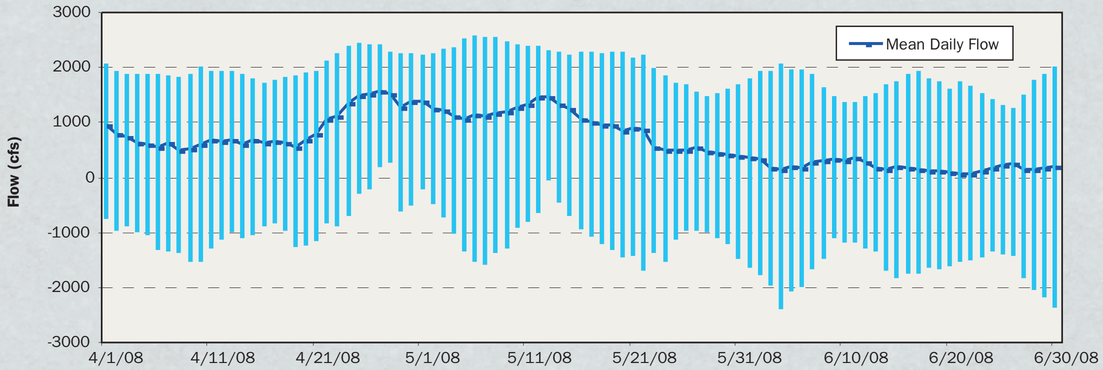


Figure 4-3
Daily Flow Range - San Joaquin River below Old River Gage



CHAPTER 4

Figure 4-4
Daily Flow Range - San Joaquin River at Mossdale

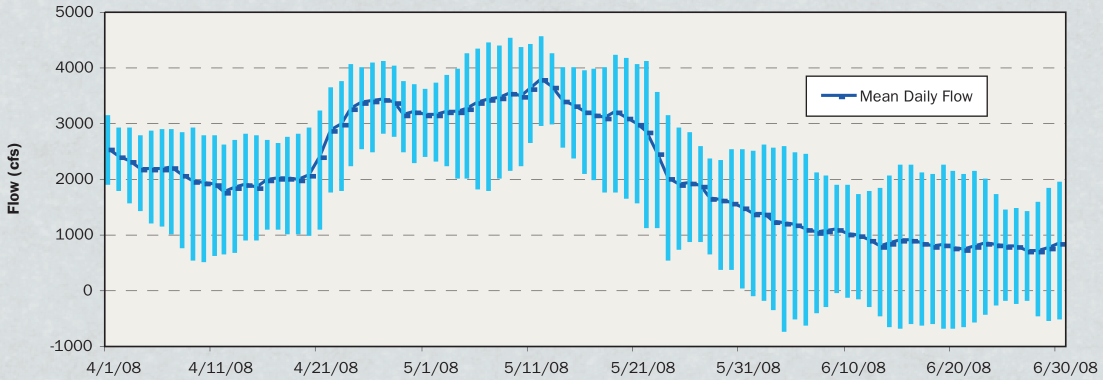
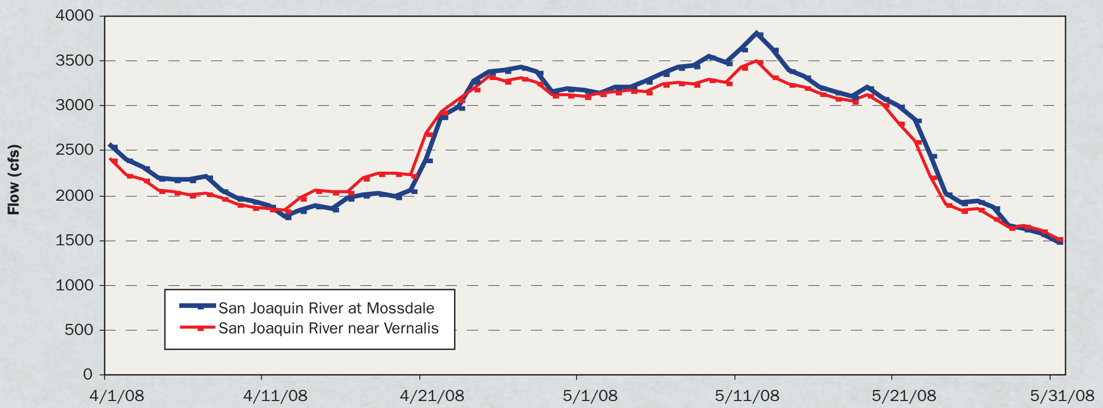


Figure 4-5
San Joaquin River Flow near Varnalis and at Mossdale



CHAPTER 5

SALMON SMOLT SURVIVAL INVESTIGATIONS

The biological investigations associated with the 2008 VAMP study have transitioned away from use of coded wire tagged (CWT) salmon and toward acoustic telemetry methodologies. The lack of study fish from the Merced River Fish Hatchery (MRH), starting in 2007, has prompted this transition. The trawling associated with the recapture of the CWT outmigrants at Chipps Island has been reduced to decrease catches of delta smelt. This reduction in sampling would have resulted in fewer recoveries of the CWT fish even if study fish had been available. Compared to traditional mark-recapture techniques, acoustic telemetry provides greater temporal and spatial coverage of the outmigration process. Further, continuous, simultaneous monitoring at several locations allows estimation of distribution probabilities at junctions and reach-specific survival throughout the study region. Moreover, acoustic telemetry data are amenable to a suite of robust and well developed statistical approaches that allow us to quantify the uncertainty associated with estimates of survival, detection, and distribution probabilities.

Introduction

During the 2008 study, Chinook salmon smolts were acoustically tagged with Hydroacoustic Technology Incorporated (HTI) tags and released at two locations (Durham Ferry and Stockton) in the San Joaquin River. Releases were made on April 29th (Durham Ferry), May 1st (Stockton), May 6th (Durham Ferry) and May 8th (Stockton). Each release was divided in half with half released during the day and the other half released at night. Releases at Stockton occurred during the day and at night on the slack tide following the flood or ebb tides. This design facilitated easier transportation and was intended to obtain an "average" survival rate for juvenile salmon migrating through the Delta. If there is a difference in survival for groups released during the day versus at night, the study needed to get an estimate of survival that incorporated both conditions. At Stockton where the tide is variable, releases were made on the slack tides during the day and at night to obtain estimates of survival that incorporated the varying tidal cycles as well as the diurnal differences.

Each tagged fish was detected and uniquely identified as it passed acoustic receivers placed at various locations throughout the Delta. Detection data from monitoring sites will be analyzed within a release-recapture model to simultaneously estimate survival, route distribution, and detection probabilities throughout the Delta.

Unfortunately, the transmitters used in this study were fundamentally flawed. Transmitters exhibited inaccurate coding and premature failure. The former substantially increased data processing time, while the latter has likely biased estimates of survival and travel times (see Appendix C3) by violating the most basic assumption of mark-recapture models: marks (i.e., transmitters) function properly throughout the duration of the study. For these reasons, results on the survival, distribution and behavior of acoustic tagged fish released as part of VAMP in 2008 are not yet available. The results will be available in the future as a stand-alone report or if available, will be attached to this report at the time of its submittal to the State Water Resources Control Board. In lieu of the results we will present the survival model and its capabilities and limitations based on the conceptual model shown in Figure 5-8, which forms the basis of survival and distribution probabilities for juvenile Chinook salmon outmigrants during the VAMP studies.

Transmitter Implantation and Fish Holding

Tagging operations occurred at the MRH during the weeks of April 28 and May 5, 2008. Study fish were withheld food for 24-36 hours (h) prior to transmitter implantation. During each week of tagging fish were surgically implanted with HTI acoustic transmitters following procedures defined by Adams et al. 1998 and Martinelli et al. 1998. The HTI Model 795 S micro acoustic tag used for this study weighed 0.65 g in air, was 16.4 mm long, with a diameter of 6.7 mm. We used a minimum fish size of 12 g, which translated into a 5.4% transmitter to body weight ratio.

On the first day of each tagging week fish were implanted with tags to be released at Durham Ferry. On the third day of each tagging week fish were implanted with tags to be released at Stockton. Fish were transported to release sites on the second and forth days of each tagging week. For each release site and release date, there were two separate release times, and therefore two separate transportation efforts (Table 5-1). Tagging efforts and fish holding were organized to maintain clear separation of these subgroups.

In order to evaluate the effects of tagging, transportation and release, several groups of fish were implanted with inactive, or dummy, transmitters. For each release effort (day and night) at each release site, 10 fish implanted with dummy transmitters were included (Table 5-1) in the tagging process. To monitor for potential disease progression in study fish, an additional 40 fish were tagged and transferred to the U.S. Fish and Wildlife Service's California/Nevada Fish Health Center at Coleman National Fish Hatchery (CNFHC). Fish in all dummy-tagged groups were subjected to identical tagging procedures as the study fish, and they were interspersed randomly into the tagging order for each release group.

Tagging procedures were based on a standard operating procedure (SOP) developed by the CRRL. The SOP directed all aspects of the tagging operation, and several quality assurance checks were made during each tagging session to ensure compliance with the SOP guidance. Prior to transmitter implantation, fish were anesthetized in 70 mg/L tricane methanesulfonate buffered with an equal concentration of sodium bicarbonate until they lost equilibrium. Fish were removed from anesthesia, and were measured (Fork Length (FL) to nearest mm) and weighed

Table 5-1
Tag and Release Dates by Groups

		Tag Date	Rel Date	Rel Time	Number					
					Tagged	Trans-ported	Mortalities	Released [2]	Non-Function Tags	Eff. Release [3]
Week 1										
	Experimental Groups									
	DF1A	4/28/08	4/29/08	17:20 (Day)	144	144	0	144	16	128
	DF1B	4/28/08	4/29/08	22:25 (Night)	141	139	1	138	20	118
	ST1A	4/30/08	5/1/08	14:55 (Day)	95	93	0	93	4 [1]	89
	ST1B	4/30/08	5/1/08	22:12 (Night)	95	95	1	94	17	77
	Week 1 Experimental Total				475	471	2	469	57	412
	Dummy-Tagged Groups									
	DF1A-Dummy	4/28/08	N/A	N/A	10	10	N/A	N/A	N/A	N/A
	DF1B-Dummy	4/28/08	N/A	N/A	10	10	N/A	N/A	N/A	N/A
	ST1A-Dummy	4/30/08	N/A	N/A	10	10	N/A	N/A	N/A	N/A
	ST1B-Dummy	4/30/08	N/A	N/A	10	10	N/A	N/A	N/A	N/A
	Coleman-Dummy	4/30/08	N/A	N/A	40	N/A	N/A	N/A	N/A	N/A
	Week 1 Dummy Total				80					
Week 2										
	Experimental Groups									
	DF2A	5/5/08	5/6/08	16:35 (Day)	140	140	1	139	7	132
	DF2B	5/5/08	5/6/08	22:00 (Night)	144	144	0	144	10	134
	ST2A	5/7/08	5/8/08	16:57 (Day)	85	85	0	85	13	72
	ST2B	5/7/08	5/8/08	22:17 (Night)	78	78	0	78	3	75
	Week 2 Experimental Total				447	447	1	446	33	413
	Dummy-Tagged Groups									
	DF2A-Dummy	5/5/08	5/6/08	N/A	10	10	N/A	N/A	N/A	N/A
	DF2B-Dummy	5/5/08	5/6/08	N/A	10	10	N/A	N/A	N/A	N/A
	ST2A-Dummy	5/7/08	5/8/08	N/A	10	10	N/A	N/A	N/A	N/A
	ST2B-Dummy	5/7/08	5/8/08	N/A	10	10	N/A	N/A	N/A	N/A
	Week 2 Dummy Total				40					

[1] Two non-functional tags from ST1A were held at hatchery and not transported or released. These are not included in the non-function column.
[2] Non-function tags represent tags that were not heard during the 24 h holding period after tagging .
[3] The number released with functioning transmitters may differ from the number released due to a number of defective tags (Appendix C-3).

(to nearest 0.1 g). Following implantation procedures outlined in Adams et al. 1998 and Martinelli et al. 1998, fish were surgically implanted with acoustic transmitters. Typical surgery times were less than 3 minutes. Fish were then placed into perforated 19 liter (L) holding containers with high dissolved oxygen concentrations (110 – 130%) to recover from anesthesia effects. Holding containers were perforated, starting 15 cm from the bottom, to allow water exchange. The non-perforated section of the container held 7 L of water to allow transfer without complete dewatering. Each holding container was stocked with three tagged fish, and was covered with a snap-on lid. Holding containers were held in shaded, labeled tanks with flowing water for approximately 24 h after tagging. Water levels were adjusted in holding tanks to ensure that tagged fish had access to air to be able to adjust their buoyancy to compensate for the weight of the transmitter. All release groups were held in separate tanks.

During the 24 h recovery period tagged fish were monitored by a series of hydrophones installed in the holding tanks. This monitoring period allowed us to confirm the operational status of each transmitter prior to transportation to release sites.

Transportation to Release Sites

In order to minimize fish transfers and the associated stress to fish, specially designed transport tanks were used to move fish from MRH to the release sites. The tanks were designed to securely hold a series of 19 L perforated buckets filled with fish. Tanks had an internal frame that held 20-25 buckets in individual compartments to minimize contact between containers and to prevent tipping. Insulation was added to the exterior of the metal tanks to reduce water temperature fluctuations. Two transport tanks were positioned on a flatbed trailer equipped to deliver oxygen during transport. Salt was added to the transport tanks based on standard procedures used by the hatchery.

Immediately prior to loading, all containers were visually inspected for fish mortalities or signs of poor recovery (e.g. erratic swimming behavior). Holding containers were removed from holding tanks and loaded into the transport tanks. Thermographs positioned in each holding tank were transferred to the transport tank to record the full water temperature history for a given release group.

Water Temperature Monitoring

Water temperature at the hatchery was monitored with recording thermographs in the source tank and holding tanks. Individually numbered thermographs were initially deployed in the single source tank from which all fish were taken for tagging. When tagging was completed, the appropriate thermograph was transferred from the source tank to the holding tank that contained the corresponding batch of study fish. During this transfer the thermograph was held out of the water long enough to ensure that a temperature spike was recorded.

Fish Acclimation prior to release

After the study fish were tagged at MRH, held for approximately 24 hours and transported to the release site, they were acclimated to differences in water temperatures between the transport truck and those in the river at the release site prior to release. Introducing fish to broad changes in water temperature with no tempering period can create stress and thermal shock. To reduce the likelihood of behavioral changes or physiological shock associated with transferring study fish from the transport tanks to the river, and to document the temperature and dissolved oxygen conditions experienced by the fish from the source tank to the holding pools, during transport, and at the release sites, acclimation guidelines were developed for the releases in 2008.

Temperature and dissolved oxygen were measured and recorded at the hatchery loading site, at the hatchery entrance nearest the public road, mid-point during the transport trip, and at the release site. Thermographs were placed into transport tanks to record water temperature during transport. Water temperature in the transport tanks at MRH prior to transporting the fish to the release sites, ranged between 11 and 15 °C. Over the course of the 2 1/2 to 3 hour drive from the hatchery to the release sites the water temperatures increased in the transport tanks to between 12.8 to 17.9 °C. Water temperature in the river at the time of the releases ranged between 17.7 and 20.3°C.

Two problems occurred for the first daytime release at Durham Ferry on April 29th that were unanticipated and resulted in deviations from the guidelines developed for acclimating and releasing the fish at the release sites. These two problems were 1) the inability to obtain water from the hatchery truck at Durham Ferry due to the low pressure head between the hatchery truck and the pools and 2) the lack of the commitment from the farmer at the release site to keep his agricultural pump off for several hours after each of the releases were made.

The guidelines for acclimating the fish from the water temperature in the transport tanks to that in the river was to place the buckets containing the fish into pools containing hatchery water and increasing the water temperature by adding river water to the pools over the course of an hour. Once the water temperature had reached that in the river the fish were to be held for an additional hour prior to release.

The inability to replace the river water holding the pools rigid with cooler water from the transport truck for the first Durham Ferry release, resulted in higher water temperatures in the pools (21.2°C) than in the river (17.2°C) due to solar radiation prior to loading the buckets into the pools. Once the buckets were placed in the pools the water temperature in the pools decreased. Water temperature in the river subsequently increased to 19.1 ° C by the time the fish were released-approximately three hours later.

Water quality in the pools was maintained during the holding period through continuous exchange of water between the river and the pools using pumps.

As in past years, we had previously asked the local farmer to turn off his adjacent agricultural pump near Durham Ferry so that fish could be released without being exposed to the potential mortality associated with the agricultural pump. Once at the release site, it appeared we did not have a guarantee that the pump would be shutoff long enough for the first release or that it would be shut off for all following releases scheduled at Durham Ferry. Thus to assure the fish from our releases did not experience mortality or differential mortality associated with the operation of the agricultural pump a boat was obtained to ferry the buckets of fish downstream before releasing them. This change to the protocol increased the tempering/holding time of the first Durham Ferry group to around 3 hours and 10 minutes, with an additional 20-25 minutes to make the 3 to 5 trips downstream to release all of the fish. Immediately prior to release each bucket was checked for any dead or impaired fish. All fish were alive at the time of release at approximately 17:00 h.

For the night release at Durham Ferry on April 29th, the water temperature in the pools that had originated from the river was identical to that in the river. To make the night-time release more comparable to the day release, we did not temper the water in the pools. We held the fish in the pools for 3 hours to obtain a similar holding period to the fish released during the day. The night release was made at approximately 22:00 h using the boat ferrying method. One fish was observed dead just prior to the night release.

For both Durham Ferry releases on May 6th, 200-gallon tubs (instead of small swimming pools) were filled with river water prior to loading the buckets into the tubs. Shade structures were used to prevent the temperature of the river water from increasing once it was in the tubs. Once buckets were loaded into the tubs, the tempering was completed over 2 hours. Fish in buckets were ferried by boat on multiple trips to the release site. Releases were completed by 16:35 h and 22:00 h. No dead fish were observed in either of the Durham Ferry releases made on May 6th.

For the day and night releases at Stockton on May 1st and May 8th, the 200 gallon tubs were filled with hatchery water from the transport truck prior to putting the buckets into the tubs (Photo 5-1). Once the buckets containing the fish were placed in the tubs, river water was put into the tubs until temperature reached equilibrium, about 1 1/2 hours. Fish were held for another 30-45 minutes and then loaded into a boat and transported by boat to the release site (10 minutes). Two boat trips were made for each of the Stockton releases on each day: two for the day releases and two for the night releases.

The tagged fish were released by boat on the San Joaquin River about 300 yards downstream of Durham Ferry (river mile [RM] 69.5), and near Stockton, downstream of Buckley Cove (RM 37) at Windmill Cove in the middle of the main channel (RM35.5).

Photo 5-1
Buckets in acclimation tubs at Stockton

Dummy-tagged fish

Dummy-tagged fish were put into net pens at the release sites just after the release of the other tagged fish. A total of 80 dummy-tagged fish were held in the net pens to assess the direct effect of tagging and transport processes on the mortality of test fish. Twenty fish, implanted with dummy tags, were held at each of the release sites (Durham Ferry and Stockton) each week. Each of the day and night releases had 10 dummy-tagged fish transported with the functionally tagged groups. Dummy-tagged fish were held in net pens (volume ~ $1m^3$; mesh size ~3 mm) at each release location for 48 hours. After 48 hours, each of the dummy-tagged fish was examined for mortality and condition. Dummy tags used during the first release period were reused during the second week of tagging.

Fish were first examined for swimming vigor then euthanized for measuring and documenting general condition. Each fish was measured (fork length to nearest 1 mm) and examined qualitatively in the field for percent scale loss, body color, fin hemorrhaging, eye quality, and gill coloration. Any mortality was also documented (Table 5-2).

Table 5-2
Characteristics assessed for Chinook salmon smolt condition and short-term survival

Character	Normal	Abnormal
Percent Scale Loss	Lower relative numbers based on 0-100%	Higher relative numbers based on 0-100%
Body Color	High contrast dark dorsal surface and light sides	Low contrast dorsal surfaces and sides, coppery color
Fin Hemorrhaging	No bleeding at base of fins	Blood present at base of fins
Eyes	Normally shaped	Bulging or with hemorrhaging
Gill Color	Dark beet red to cherry red colored gill filaments	Gray to light red colored gill filaments
Vigor	Active swimming (prior to anesthesia)	Lethargic or motionless (prior to anesthesia)

Five of the seventy-nine fish (6%) with dummy tags recovered from the net pens after 48 hours were dead. One fish from the April 29th night release at Durham Ferry was not in the net pen after the 48 hour holding period (Table 5-3). Three of the five dead fish were from the Durham Ferry release on May 6th (two from the day release and one from the night release). The others were from the Stockton release made on May 8th (day release) and the Durham Ferry (night release) made on April 29th. Mean FL size ranged from 105 to 112mm for all of the groups (Table 5-3). Mean scale loss was 6% or less, all had normal body color, three had fin hemorrhaging, one had bulging eyes and five had poor gill color (Table 5-3).

Short-term survival was 94% within the net pens. Those that were found alive were swimming vigorously and were generally in good condition. These data indicate that the fish used for the VAMP in 2008 were in generally good condition; however, some mortality was observed. It interesting to note that the April 29th group released at Durham Ferry during the day did not appear to have any negative effects from being put into pools that had higher water temperatures than in the river. It is possible that the mortality of the fish in the other groups was associated with being tagged.

Release groups

The total number of fish tagged and released for the experiment was to be 950, or 475 per release period. Within each release period, approximately 285 fish (or 60%) were to be released at Durham Ferry and 190 (40%) were to be released at Stockton.The actual number released with functioning tags was less due to tag failure and some mortality during transport.

Since the proportion of fish allocated to each release site directly influences the sample size, and therefore precision of estimates lower in the system, simulated data were used to explore the relationship between

Table 5-3
Results of dummy tagged fish evaluated after being held for 48 hours at the release sites as part of VAMP 2008

Release site, Release date -day or night	Examination Date, Time	Mean (sd) ForkLength(mm)	Mortality	Mean (sd) scale loss	Normal Body Color	Fin Hemorrhaging	Normal Eye Quality	Normal Gill Color
Durham Ferry, 4/29/08- day	5/1/2008, 17:15	111 (6)	0/10	4(2)	10/10	10/10	10/10	10/10
Durham Ferry, 4/29/08 -night	5/1/2008, 22:00	112 (4)	1/9	3(1)	8/8	8/8	7/8	8/8
Stockton, 5/1/08-day	5/3/2008, 15:00	107 (2)	0/10	6(3)	10/10	8/10	10/10	10/10
Stockton, 5/1/08 -night	5/3/2008, 22:00	112 (8)	0/10	3(1)	10/10	10/10	10/10	10/10
Durham Ferry, 5/6/08 – day	5/8/2008, 16:13	105 (2)	2/10	6(4)	8/8	8/8	8/8	4/8
Durham Ferry, 5/6/08 - night	5/8/2008, 20:40	109 (2)	1/10	3(1)	9/9	9/9	9/9	9/9
Stockton, 5/8/08 – day	5/10/2008, 17:00	110 (4)	1/10	4(2)	9/9	9/9	9/9	9/9
Stockton, 5/8/08 – night	5/10/2008, 22:15	110 (5)	0/10	3(2)	10/10	9/10	10/10	9/10

the proportion of tags allocated to each site and the precision of parameter estimates. These data were used to select the optimal allocation to each site. Given two release periods (separated by one week) at each site, both full and reduced models were used with a "predicted" data set to estimate the precision about each parameter with a range of tag allocations. As expected with a fixed number of tags available for each release period (n = 475), allocating more tags to a given release site under the full model increased the precision of estimates based solely on fish released at that site, but decreased precision of estimates based on fish released at the other site (Figure 5-1). The intersection of the two lines represents the allocation that provides highest precision for both release groups *given the specific input parameters* in the model (in this case, the "predicted" scenario). However, the relationship between allocation (i.e., sample size) and precision is non-linear; "flatter" segments of the curve may be considered more stable. Thus, the optimal tag allocation, based on both intersection (to maximize precision for both releases) and stability (to minimize risk) was selected. Visual assessment of "precision versus allocation" curves for all parameters under the "predicted" scenario suggested that the optimal tag allocation would be 60 % (n = 285) to Durham Ferry and 40 % (n = 190) to Stockton, respectively.

Another simulation was conducted to investigate how using 50 fish (15 to each Durham Ferry release; 10 to each Stockton release) in the experiment instead of in a tag life study would increase the precision of parameter estimates. We ran the full and reduced models under the "predicted" scenario, where 300 and 200 tagged smolts (versus 285 and 190) are released at Durham Ferry and Stockton, respectively. Incorporating these extra tags caused the standard error for each parameter to increase by no more than 0.004 and 0.002 under the full and reduced models, respectively. Given the value of tag life data and the minimal increase in precision associated with allocating an additional 50 fish to the experimental releases, it was concluded that these tags were most valuable when allocated to a tag life study.

Fish Monitoring

Receiver locations

The hydrophone receiver network shown in Figure 5-2 was developed as part of a series of collaborative and collegial VAMP biology group meetings involving SJRA partners along with agency (NOAA, EPA, USGS, etc.) and stakeholder input. Throughout these discussions a hierarchy of study objectives were discussed in relation to the tradeoffs associated with a variety of different hydrophone placement scenarios. Principal objectives of the proposed hydrophone layout are to: 1) estimate overall survival to Chipps Island and 2) to compare overall survival in the main stem San Joaquin River to survival in the central delta, which is potentially a function of San Joaquin River flows and export rates.

Receivers at Chipps Island and Jersey Point were difficult to deploy due to the large channel width at those locations. Multi-port (4) hydrophones were placed across the channel to assure detection of the acoustically tagged fish as they passed these locations. At Chipps Island, Jersey Point and Three-Mile Slough, independent dual arrays were deployed so that survival to those locations could be estimated.

In addition, acoustic receivers were located upstream (STP (n)) and downstream (STP(s)) of the Stockton Waste Water Treatment Plant (WWTP) to estimate mortality that occurred between the two receivers. During the 2007 experiment, 116 of 800 tags released were found "not moving" near the Stockton WWTP.

Receiver Monitoring

Personnel from the DFG, USFWS Stockton Office, DWR and the USBR maintained a total of 20 receivers. The receivers were monitored once per week from April 28th through May 28th. At each site, the receiver strongbox was opened and the battery was removed, replacing it with a fully-charged battery. The Universal Serial Bus (USB) flash drives with the acoustic monitoring data on it were replaced with empty flash drives each week. Used batteries were recharged for use the following week. USGS maintained the multi-port receivers at Jersey Point and Chipps Island (MAL).

Eleven sites required use of a boat operator and crew to change out the batteries and retrieve the data. Sites that were maintained using a boat were Three Mile Slough (TMS, north and south), False River (FAL), North Old River (OSJ), Stockton Waste Water Treatment Facility (STP north (n) and south (s)), channel marker 16 and 18 (SJT), Middle River (MR) and Turner Cut (TRN, north and south) (Figure 5-2 and Photo 5-2).

Temperature Monitoring

Water temperature was monitored during the VAMP 2008 study using individual computerized temperature recorders (e.g., HOBO U22 Water Temp Pro v2 manufactured by Onset Computer Corporation). Water temperatures were measured at locations along the longitudinal gradient of the San Joaquin River and interior Delta channels between Durham Ferry and Chipps Island – locations along the migratory pathway for the juvenile Chinook salmon released as part of these tests (Appendix C-1). As part of the 2008 VAMP monitoring program, additional temperature recorders

Figure 5-1
Relation between tag allocation (proportion of total, n = 500, tags allocated to Durham Ferry) and predicted precision (standard error), for S6 under the full model; "predicted" scenario. The solid line represents estimates based solely on fish released at Durham Ferry; the dashed line represents estimates based solely on fish released at Stockton.

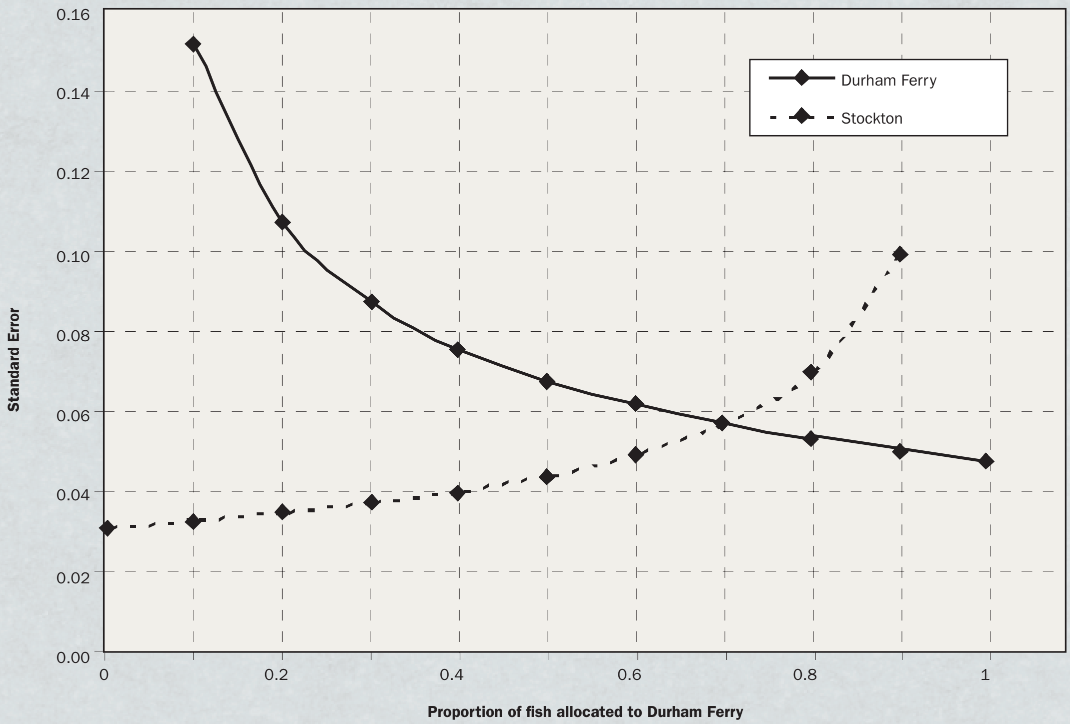


Figure 5-2
Map of primary (red) and secondary (yellow) priority acoustic monitoring sites, with number of independent arrays in parentheses.

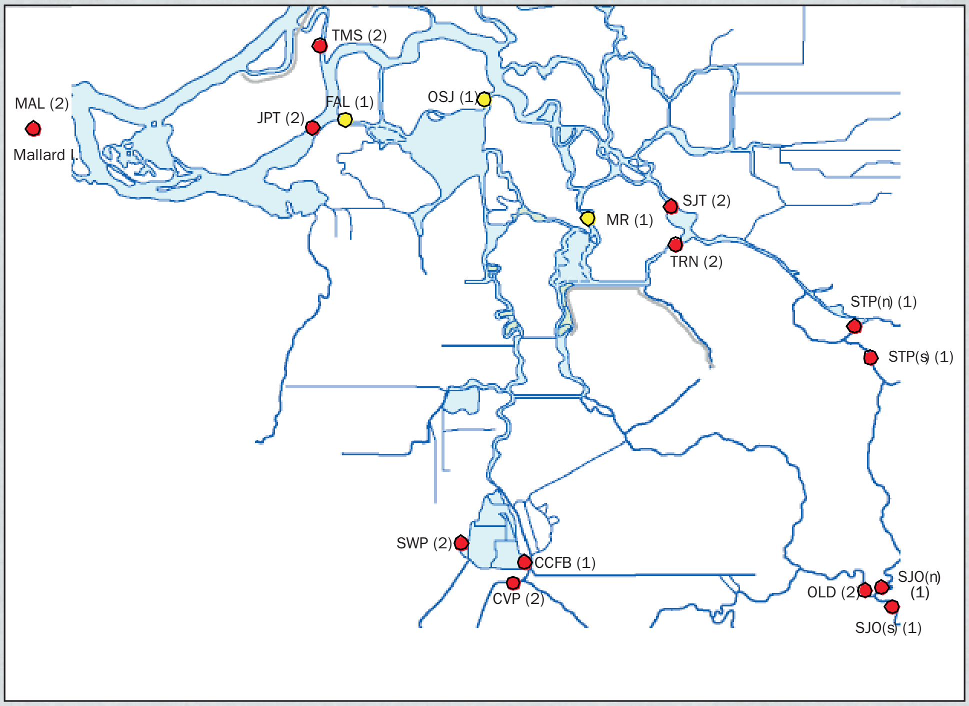


Photo 5-2
Battery maintenance being performed at San Joaquin River, Channel Marker 16

were deployed in the south and central Delta (Appendix C-1) to provide geographic coverage for characterizing water temperature conditions while juvenile salmon emigrated from the lower San Joaquin River through the Delta. Water temperature was recorded at 24-minute intervals throughout the period of the VAMP 2008 investigations. Water temperatures were also recorded within the hatchery raceways at the MRH coincident with the period when juvenile Chinook salmon were being tagged and held.

Results of water temperature monitoring within the MRH showed that juvenile Chinook salmon were reared in, and acclimated to, water temperatures of approximately 11°- 17° C (52° - 63° F) prior to release into the lower San Joaquin River (Appendix C-2). Results of water temperature monitoring at Durham Ferry, Stockton (confluence), and Chipps Island during the April-May fall-run Chinook salmon smolt emigration from the San Joaquin River through the Delta are shown in Figures 5-3, 5-4, and 5-5. Water temperature monitoring showed that water temperatures throughout the lower San Joaquin River and Delta (Appendix C-2) were higher than those at the hatchery during the spring months, which is consistent with results of temperature monitoring in all previous years of the VAMP tests. Water temperatures measured within the lower San Joaquin River and Delta (Figures 5-3 , 5-4 , and 5-5 ; Appendix C-2) were within a range considered to be suitable (typically < 20 C; 68 F) during April and the majority of May in the mainstem San Joaquin River (e.g., Durham Ferry, Stockton, and Chipps Island, and at other monitoring locations (Appendix C-2) but exceeded 20 C (68 F) in the lower San Joaquin River in late May; Appendix C-2). Water temperatures within the lower San Joaquin River showed a typical seasonal pattern of increasing temperature during the spring months. Results of the 2008 water temperature monitoring, in contrast to results from previous years, showed that water temperatures in the lower river were similar to water temperatures observed further downstream during April and were lower at Chipps Island in late May (Figure 5-5) when compared to temperatures further upstream (Figures 5-3 and 5-4). Water temperatures measured in the river during April-May would not be expected to result in adverse effects or reduced survival of emigrating juvenile Chinook salmon released as part of the VAMP 2008 investigations. Water temperatures measured downstream within the Delta during April and early May were within the general range considered to be suitable for juvenile fall-run Chinook salmon migration.

Evaluation for delayed mortality and saltwater survival – Effects of Proliferative Kidney Disease.

Introduction:

Proliferative Kidney Disease has been diagnosed in MRH juvenile Chinook salmon for several decades (Hedrick et al 1986). This trout and salmon disease is caused by the myxosporean parasite of freshwater bryozoans, *Tetracapsuloides bryosalmonae* (Canning et al. 2002). The progressive kidney inflammation and associated hypoplastic anemia is likely to reduce the fitness and performance of affected fish (Clifton-Hadley et al. 1987). Nichols and Foott (2002) report *T. bryosalmonae* infections in natural juvenile Chinook salmon collected in the Merced and Tuolumne Rivers. The bryozoan *Fredericella* is reported as a host for *T. bryosalmonae* and was observed at the water intakes of MRH (Okamura and Wood 2002). Okamura and Wood speculate that salmonids may be an accidental host for this bryozoan parasite given the strong inflammatory response characterized by PKD and the observation that infections can occur from water supplies without fish. The incidence of *T. bryosalmonae* infection in MRH salmon inspected prior to and shortly after release has ranged from 4 – 100% (Harmon et al. 2004). The vast majority of these infections have been deemed early and the fish were asymptomatic. In 2005, the performance of MRH Chinook was tracked in swim and saltwater challenges through mid-June (Foott et al. 2007).

The objective of the study in 2008 was to follow the health status and saltwater adaptation performance of *T. byrosalmonae* infected MRH juvenile Chinook salmon used for the Vernalis Adaptive Management Plan (VAMP) out-migrant salmon study. These fish were reared at temperatures similar to the San Joaquin River at the CNFHC wet laboratory for a period of time that encompassed the out-migration of the VAMP study population.

Figure 5-3
Water temperatures at Durham Ferry during April-May, 2008

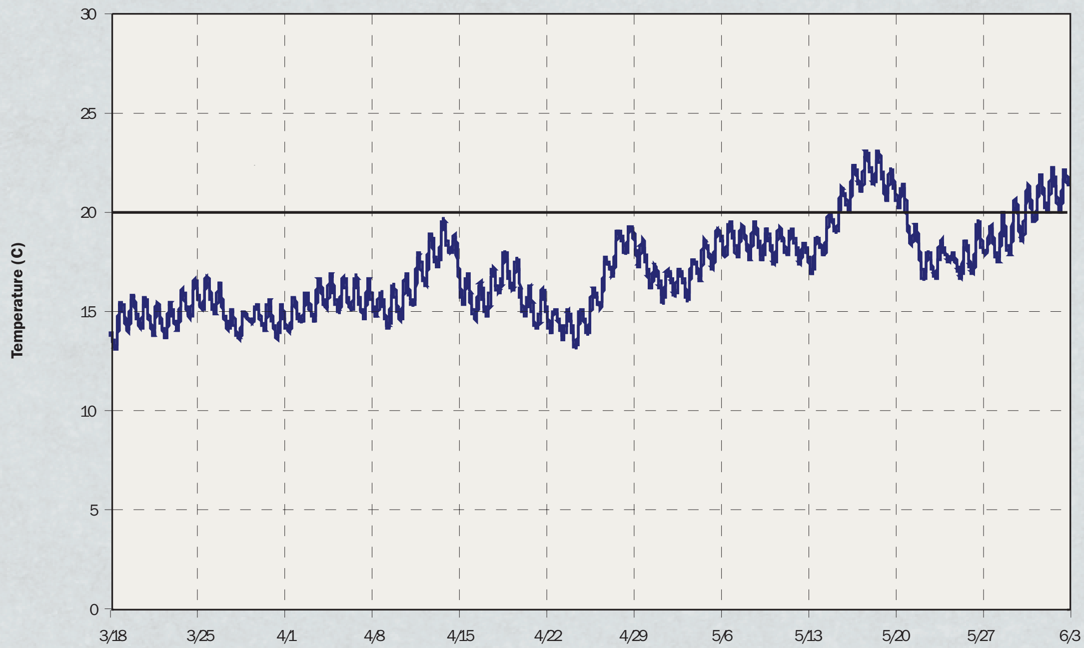


Figure 5-4
Water temperatures at the Confluence (top) during April - May, 2008.

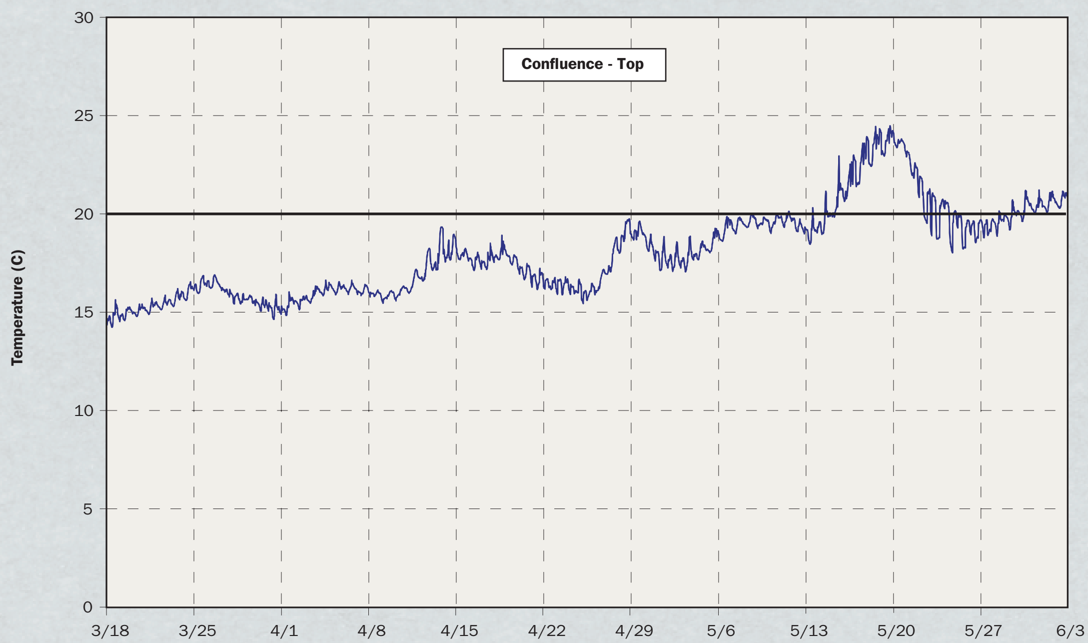


Figure 5-5
Water temperatures at Chipps Island during April - May, 2008

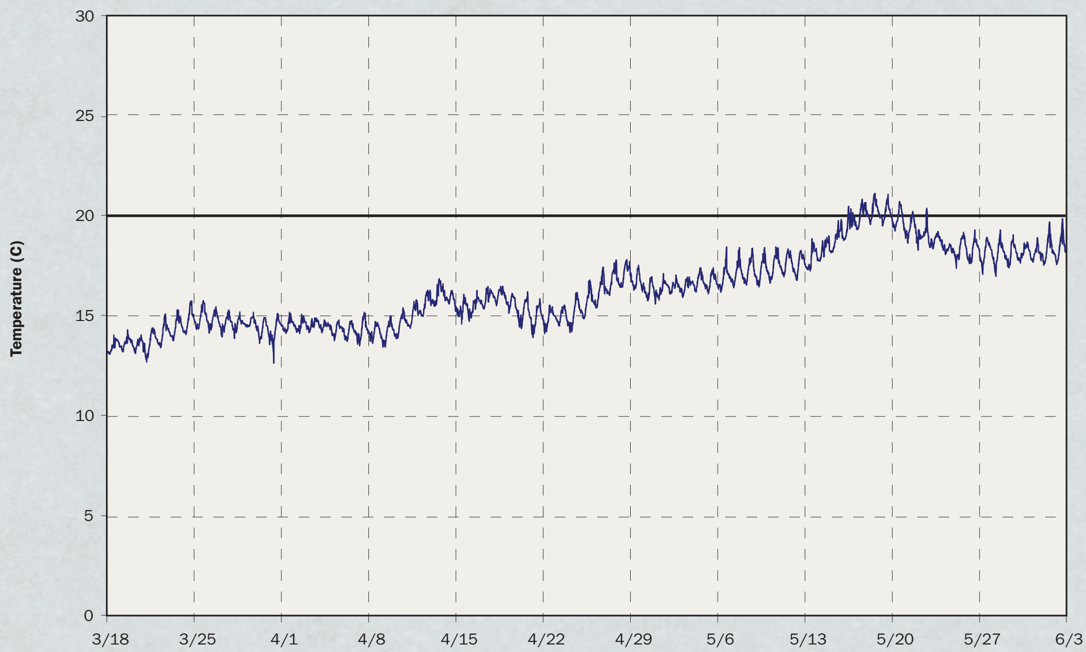
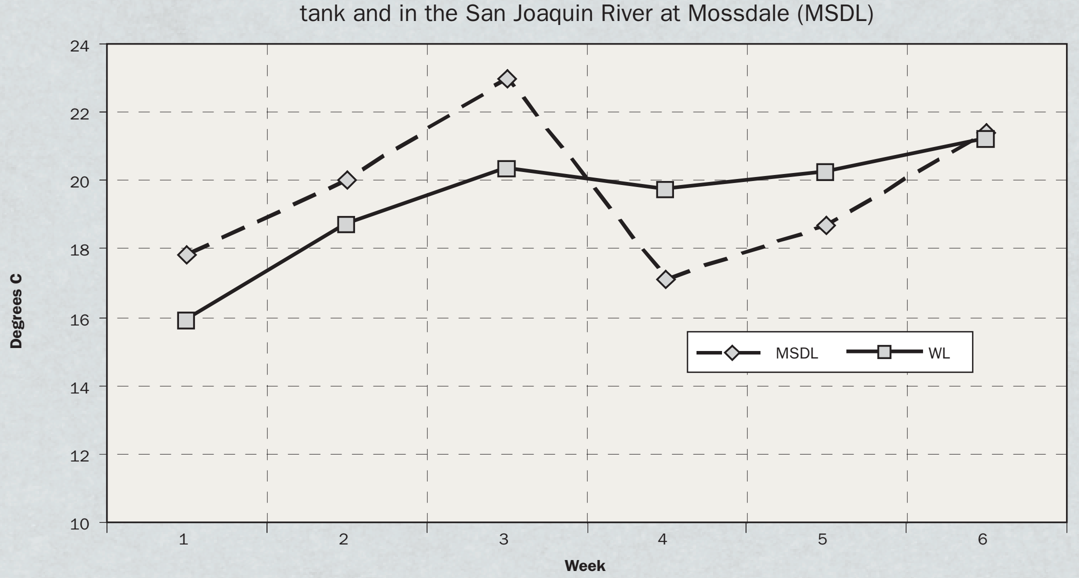


Figure 5-6
Mean weekly water temperature in wetlab (WL)
tank and in the San Joaquin River at Mossdale (MSDL)



Methods

On May 2, 2008, forty "dummy-tagged" (implanted with non-functioning sonic tags) Chinook juveniles were transported from the MRH to the CNFHC wet lab. The fish had been tagged in 2 separate lots and were held in separate sections of a 750 L rectangular tank supplied with 19 L min^{-1} of single-pass, ozone- treated water at temperatures similar to the San Joaquin River (Photo 5-3).

Water temperature was monitored hourly with an Onset‰ Stowaway temperature logger. Daily mean water temperatures at Mossdale (http://cdec.water.ca.gov) were examined to approximate the San Joaquin River temperatures experienced by the MRH released salmon. A commercial salmon diet (Silvercup Salmon #2) was fed at 1.2% body weight per day. Kidney tissue was collected from mortalities for imprints, histology, and bacterial culture.

Photo 5-3
Fish holding tanks used for health studies of tagged fish.

Saltwater (SW) challenge – Four to seven salmon were held in a 0.03 m^3 cage within a 628 L tank supplied with 10 – 27 mg /L saltwater (Instant Ocean aquarium salt mix). The water was re-circulated through a chiller (12- 13°C) and aerated. The salinity was raised from 10 to 20 mg / L at 32h and from 20 to 27 mg /L at 64 h of the challenge. At 96 h, all fish were rapidly netted and euthanized with an overdose of MS222 in saltwater, gently dried, weighed to the nearest 0.1 g and the fork length measured (mm), bled into a heparinized microhematocrit tube from the severed caudal peducle, and gill lamellae placed into SEI buffer and frozen at -70°C. An imprint was made with kidney tissue for *Renibacterium salmoninarum* direct fluorescent antibody testing and the remaining kidney was fixed in Davidson's fixative for 24h, transferred to 50% ethanol, and later processed for 6µm paraffin sections stained with hematoxylin and eosin. After centrifugation, hematocrit was recorded for each blood sample. Plasma was frozen for later sodium (flame photometer) as well as magnesium and total protein measurements (colorimetric assays). Gill Sodium-Potassium - Adenosine Triphosphatase activity (ATPase = µmoles ADP / mg protein / hr) was assayed by the method of McCormick and Bern (1989). Condition factor was calculated as: KFL = (Wt / FL^3) * 10,000). . Plasma chemistry data was analyzed by ANOVA (1-way on means or Kruskal-Wallis on ranks).

PKD score – Each kidney section was scored 0, 1, 2, or 3 for *T. bryosalmonae* (Tb) location in the kidney and occurrence of kidney inflammation. These scores were multiplied by 3 to obtain weight factors.

0 = no Tb observed, no inflammation
0x3 = 0 Tb score

1 = Tb only observed in blood sinuses with no inflammation {early stage infection}
1x3 = 3 Tb score

2 = Tb observed in the kidney interstitium with minor to moderate level of inflammation
2x3 = 6 Tb score

3 = similar to #2 but severe inflammation and /or granulomas observed (disease state).
3x3 = 9 Tb score

A fish was considered anemic if its hematocrit was $\leq$ 25% and it was given an anemia score of 6. The PKD score was a summation of the Tb (0, 3, 6 and 9) and anemia (0, 6) score. PKD scores ranged from 0 (normal) to 15 (clinical disease).

Results and Discussion

Mean weekly water temperature was increased from 16° to 21°C over the 6 week study and was relatively similar to the temperature profile at Mossdale (Figure 5-6). The salmon showed a poor feed response throughout the study. Eight mortalities (8 / 40 = 20%) occurred to salmon held in freshwater between May 14th (9 days post-transferred {dpt}) and June 12th (40 dpt).

All exhibited clinical signs of Proliferative Kidney Disease such as pale gills (anemic) as well as swollen spleen and kidney. Aeromonid bacteria (motile gram-negative, cytochrome oxidase positive) were isolated from 2 of 3 mortalities assayed. It is assumed that these opportunistic bacteria were not the primary cause of death but were secondary infections. Histological examination of mortalities did not demonstrate significantly different kidney pathology than live cohorts sampled at similar times. There was no difference in mortality between the 2 tag lots and the population was combined on May 23rd (21 dpt). One mortality had shed its tag and another showed hemorrhage associated with the tag suture. One to three cells resembling *Renibacterium salmoninarum* were observed in 2 of 39 kidney DFAT imprints. This low-level infection has been seen in previous MRH release groups and does not appear to be a health threat for the smolts (Nichols and Foott 2002). It appears that Proliferative Kidney Disease was the predominate cause of death.

Histological results - It appears that the population was experiencing clinical PKD at the time of the first saltwater challenge on May 23rd (21 dpt). Parasites were observed in the kidney interstitium and were often associated with varying degrees of inflammation (Figure 5-7). There was a 62% incidence of clinical PKD (score > 9) observed in all 39 salmon sampled for kidney histology. The prevalence of clinical PKD ranged from 50% in the May 23rd sample to 69% in the June 6th sample. It can be argued that the 6June challenge population was affected by PKD to the greatest degree as 6 of the 13 fish in this SW challenge were judged to be anemic. This data is reflective in the higher mean PKD score (Table 5-4).

Figure 5-7
High magnification micrograph (600x) of kidney showing Tetracapsuloides byrosalmonae.

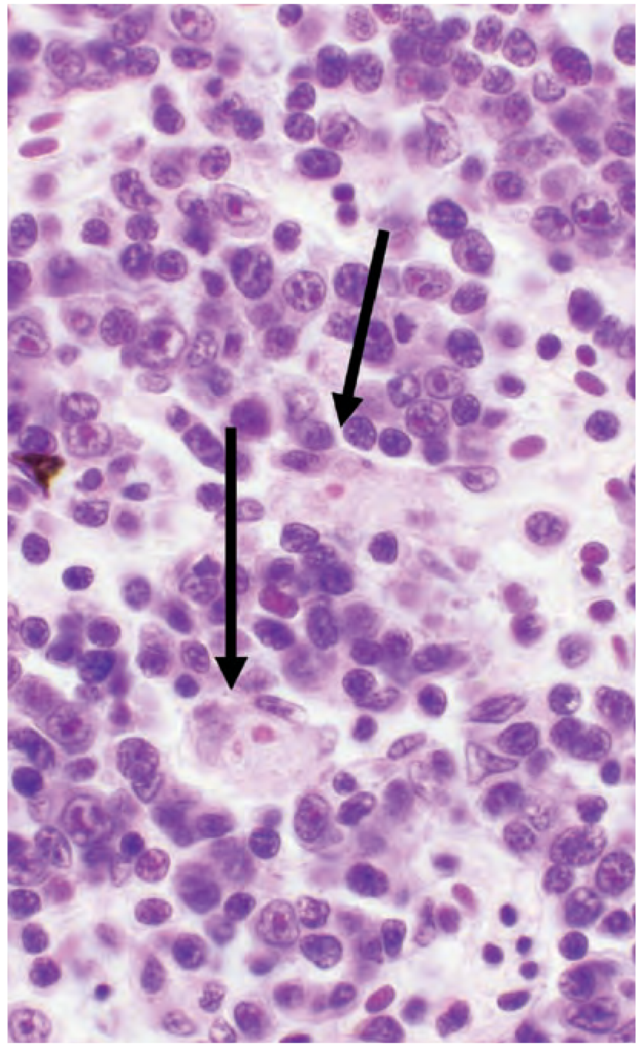


Table 5-4
Saltwater challenge data for MRH Chinook groups. Mean (std) for weight (g), fork length (mm), condition factor (KFL), plasma sodium (mmol/L), plasma protein and magnesium (g/dL), gill ATPase activity (mmol ADP/ mg protein/ h), and mean PKD score. Plasma data from one fish in the June 6th challenge was excluded due to extreme values indicating probable contamination. Subscripts (a, ab, b) indicate statistically significant relationships among groups (P< 0.05, ANOVA).

DATE	May 23rd	June 6th	June 15th
Weight (g)	16.68 (2.8)	18.88 (3.8)	17.34 (4.1)
Forklength (mm)	115 (6)	118 (6)	118 (7)
Condition Factor (KFL)	1.10 (0.11)	1.14 (0.12)	1.03 (0.10)
PLASMA			
Number sampled	12	12	7
Sodium (mmol/L)	147.5 (4.7) a	151.6 (std = 8.7) ab	162 (std = 11.9) b
Protein (g/dL)	1.54 (0.35)	1.70 (std = 0.19)	1.68 (std = 0.21)
Magnesium (g/dL)	2.35 (0.56)	2.25 (std = 0.05)	3.06 (std = 1.29)
Hematocrit	32% (1)	27% (6)	27% (8)
ATPase** (mmolADP	3.79 (1.12) a	2.27 (0.78) b	3.02 (1.04) ab
PKD score	8	10	9

Saltwater challenge- MRH salmon had high survival and maintained normal plasma constituent levels after 96 h of increasing salinity. Hedrick and Aronstien (1987) reported similar findings with *T. byrosalmonae* – infected juvenile Chinook held in saltwater. The only mortality occurred in the June 13th challenge. No statistically significant difference ($P<0.05$) was observed in condition factor (KFL), plasma protein or plasma magnesium values (Table 5-4). The June 13th (42 dpt) challenge group had significantly higher plasma sodium levels than the May 23rd (21 dpt) group however all sampled fish had concentrations below 170 mmol / L. Blackburn and Clarke (1987) report that 170 mmol / L is a threshold value for successful ion regulation in juvenile Chinook in 24 h SW challenges.

While not statistically significant, fish in the June 13th challenge had 4 indicators (reduced KFL, elevated magnesium and sodium, lower gill ATPase activity) of osmoregulatory impairment. It is unclear how PKD is related to these changes as the kidney histopathology was not judged to be different from the June 6th sample group. It is possible that chronic stress due to disease and high water temperature rearing were affecting osmoregulation. Reduced condition factor can occur when the fish is dehydrated and altered divalent ion ($Mg2+$) regulation would indicate kidney dysfunction (Clarke and Hirano 1995).

Sodium regulation occurs primarily in the gill and should not be directly affected by kidney inflammation. A freezer failure resulted in the movement of gill ATPase samples from -80°C to -20°C for several days. The effect on activity is unknown but could have caused a general reduction in the entire sample set. The range of ATPase activity values (1 to 6 mmol ADP/ mg protein/ h) were much lower than gill samples from previous VAMP studies (Table 5-4). The 2008 data is viewed as comparative between challenge groups but is suspect for accurate activity levels. The May 23rd group had significantly higher activities than the June 6th group ($F= 7.217$, $P= 0.003$).

Significance to VAMP study – It is unlikely that PKD affected the short-term performance of the two VAMP release groups (April 29th – May 1st, May 6th– May 8th) as the first SW challenge occurred 2 weeks after the first tagged cohort had been released into San Joaquin river. The May 23rd group appeared to be just entering a clinical phase of disease (44% with a moderate PKD-6 score and only 17% anemic). Only one freshwater mortality occurred prior to May 26th.

The 2008 MRH salmon responded in a similar manner as in 2005 (Foott et al 2007). Anorexia and anemia were prevalent in the PKD affected salmon. Cumulative mortality due to PKD was 27% in 2005 compared to 20% in 2008. Survival in seawater was high in both years. It is unclear how to separate the effects of PKD from extended rearing in high water temperatures on salt water adaptation. As in 2005, histopathology rating of the kidney (PKD score) was not informative for predicting salt water adaptation. In order to examine the effect of PKD on early estuary and ocean survival, it is advisable to employ longer term salt water rearing (example Bodega Marine Laboratory).

The Survival Model

The statistical model is based on the classic release-recapture models of Cormack (1964), Jolly (1965), and Seber (1965) and the route-specific survival model of Skalski et al (2002). A key feature of the hydrophone network is the inclusion of independent double-detection arrays at several sites. The model utilizes these double-detection arrays to estimate a detection probability at each double-array site; thereby allowing estimation of distribution at junctions and the separation of detection and survival probabilities for the last reach (i.e., JPT/TMS to MAL). When the assumptions of the survival model are met, this approach provides robust estimates of survival and route distribution probabilities (Table 5-5) that have not been attainable in prior studies. Specifically, we anticipated robust estimates of survival through the system for: 1) migrants that enter the central delta through Old River (SCDA), 2) migrants that enter the Central Delta through Turner Cut (SCDB), and 3) migrants that remain in the main stem of the San Joaquin River until passing Turner Cut (S_3, S_4, S_5, S_6). Additionally, the model will provide estimates of distribution probabilities at the junctions of Old River and Turner Cut (A and B, respectively). By comparing these survival probabilities and relating them to route distribution probabilities, we can elucidate the effects of migration pathway (i.e., entering the central delta though either of these pathways) on overall survival through the delta.

Estimating overall survival and other derived parameters

In addition to the reach- and route-specific parameters we have identified (Table 5-5); any number of parameters may be derived as a function of these individual parameters. For example, we may wish to estimate “overall” survival ($S_{overall}$; probability of survival from release at Durham Ferry to Mallard Island for all tagged fish) for comparison to previous and/or future studies. From the full model, the point estimate can simply be calculated as the weighted product of all reach- and route-specific survival probabilities:

Table 5-5: Definitions of survival and route entrainment parameters	
Parameter	**Definition**
S_1	Survival from Durham Ferry to SJO(s)
S_2	Survival from SJO(s) to SJO(n)/OLD
S_3	Survival from SJO(n) to STP(s); or survival from release to STP(s) for fish rel. at Stockton
S_4	Survival from STP(s) to STP(n)
S_5	Survival from STP(n) to SJT/TRN
S_6	Survival from SJT to TMS/JPT/SWP/CVP (including fish that enter the Central Delta through MR, OSJ, and FAL)
S_7	Survival from TMS/JPT/SWP/CVP to MAL
S_{CDA}	Survival from OLD to TMS/JPT/SWP/CVP for fish that enter the central delta through OLD
S_{CDB}	Survival from TRN to TMS/JPT/SWP/CVP for fish that enter the central delta through TRN
A	Proportion of fish that enter the central delta through Old River, of those that survive to OLD/SJO(s)
B	Proportion of fish that enter the central delta through Turner Cut, of those that survive to TRN/SJT
S_{36}	Survival from SJO(n) to TMS/JPT/SWP/CVP for fish that remain in the main stem through this reach (this parameter is derived for direct comparison to SCDA)
$S_{overall}$	Survival from Durham Ferry to MAL; or from Stockton to MAL for fish rel. at Stockton
S_{CC}	Survival from CCFB to SWP

$$S_{overall} = \underline{S_1*S_2*S_3*(1\text{-}A)*S_4*S5*S6*(1\text{-}B)*S_7} + \underline{S_1*S_2*S_{CDA}*A*S_7} + \underline{S_1*S_2*S_3*(1\text{-}A)*S_4*S_5*S_{CDB}*B*S_7}$$

= (Overall survival for fish that **remain in the main stem**) + (Overall survival for fish that **enter Central Delta through OLD**) + (Overall survival for fish that **enter Central Delta through TRN**)

Further, we can estimate the precision (i.e., standard error) about Soverall using the "Delta" method (Seber 1982). Alternatively, we can estimate overall survival directly in a simplified model, where *N* fish are released at Durham Ferry, and *n* fish are detected at Mallard Island with a detection probability of *p*. Both methods should result in the same parameter estimates and associated estimates of precision; however, the latter requires constructing a new model and input data set. Thus, the method of deriving parameters from individual parameter estimates in a single model is often preferred. Another key derived parameter is S_{36}: the probability of surviving from SJO (n) to TMS/JPT for fish that remain in the main stem through this reach. We will compare S_{36} to S_{CDA} to determine if survival to JPT/MAL is lower for fish that enter the central delta through Old River than for those that remain in the main stem.

Model selection: pooling data between the two release sites

A large proportion of tagged fish released at Durham Ferry are expected to enter the central delta though Old River, effectively reducing sample sizes in the lower main stem San Joaquin River. For this reason, releases at Stockton are intended to supplement sample sizes in the lower main stem San Joaquin River. Under the full model (Figure 5-8), all parameters are estimated separately for each release site. Ideally, however, survival and entrainment probabilities could be pooled among the two releases to effectively increase the sample size and provide increased precision about each parameter estimate. A set of candidate models will be developed to represent pooling various combinations of parameters, where no parameters are pooled in the full model (i.e., least reduced) and all possible parameters are pooled in the most reduced model. We will use model selection (Burnham and Anderson 1998) to select the most parsimonious model (i.e., determine which parameters may be pooled). Thus, pooled estimates will only be reported when supported by model selection.

Predator Studies

If acoustic-tagged salmon were consumed by an untagged predatory fish and the predator swims past a fixed-station acoustic receiver prior to tag defecation, data collected by the receivers would likely be misinterpreted as live salmon passing fixed stations. This circumstance would bias the juvenile salmon survival estimates high. Thus, data were needed on predator movements to assist in interpretation of study results. Thirty striped bass were tagged with acoustic transmitters (tags; model 795-G, HTI) to monitor fish movements and behavior during the VAMP study. The 3.1-gram tags measuring 11 x 25 mm were surgically implanted in striped bass caught in the vicinity of the Tracy Fish Facilities. Tagged bass were released immediately upstream of the trashracks at the facilities. The acoustic transmitters (model 795-G) were similar, but larger, than the 0.7-gram transmitters (model 795-S) implanted in salmon smolts. The transmitter batteries

Figure 5-8
Schematic of proposed survival model for 2008 VAMP study
for smolts released at a) Durham Ferry and b) Stockton.

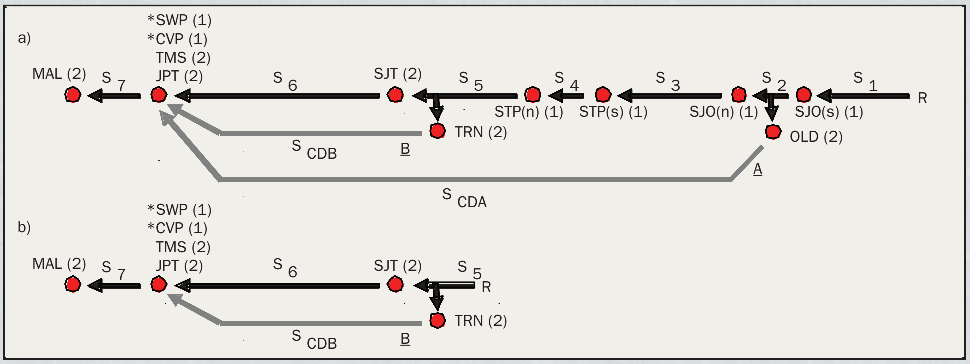


Figure 5-9
Comparison of Antioch and Chipps Island survival estimates and differential or combined differential recovery rates compared to differential ocean recovery rates for 1996-2005 CWT releases

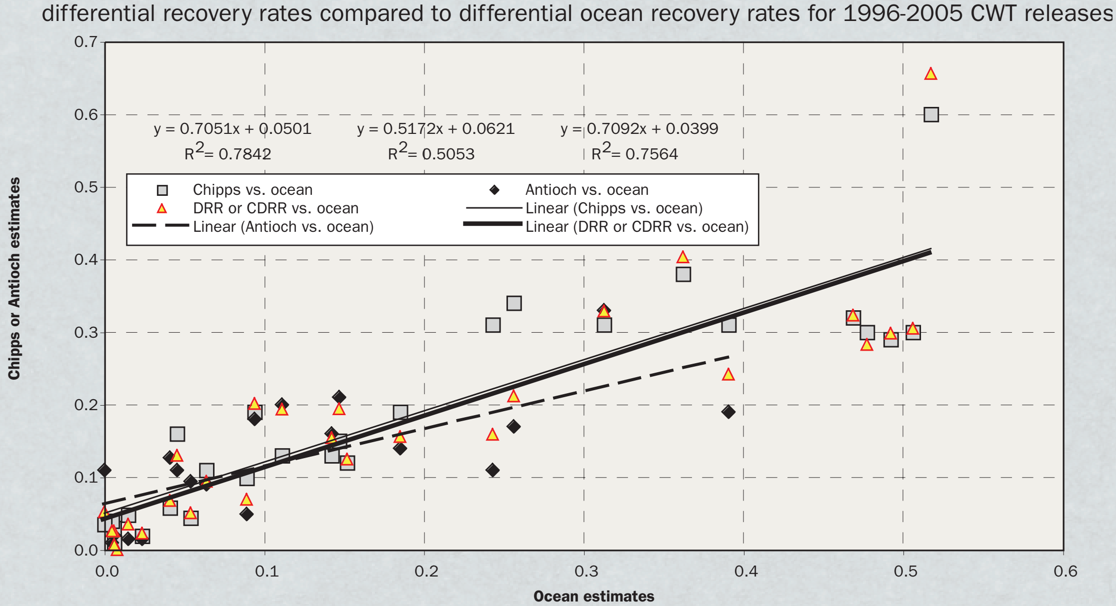


Table 5-6
Absolute survival estimates and differential recovery rates based on Chipps Island, Antioch, or ocean recoveries of Merced River Hatchery salmon released as part of South Delta studies betweeen 1996 and 2006.

Release Year	San Joaquin River (Merced River Origin) Tag Number	Release Number	Release Site	Release Date	Chipps Island Recovs.	Antioch Recovs.	Expanded Adult Ocean Recoveries (Age 1+ to 4+)	Chipps Island	Antioch	DRR or CDRR	Ocean DRR
		CWT Smolt Releases						Absolute Survival Estimates		Differential Recovery Rates	
1996	061110412	22,198	Dos Reis	1-May-96	2		3				
	061110413	25,414	Dos Reis	1-May-96	2		37				
	061110414	16,050	Dos Reis	1-May-96	1		8				
	061110415	31,208	Dos Reis	1-May-96	5		10				
	061110501	46,190	Jersey Point	3-May-96	39		186				
	Effective Release	94,870	Dos Reis		10		58	0.120		0.125	0.152
	Effective Release	46,190	Jersey Point		39		186				
1997	062545	48,973	Dos Reis	29-Apr-97	9		180				
	062546	53,483	Dos Reis	29-Apr-97	7		168				
	062547	51,576	Jersey Point	2-May-97	27		356				
	Effective Release	102,456	Dos Reis		16		348	0.290		0.298	0.492
	Effective Release	51,576	Jersey Point		27		356				
	062548	46,674	Dos Reis	8-May-97	5		90	0.300		0.283	0.477
	062549	47,534	Jersey Point	12-May-97	18		192				
1998	61110809	26,465	Mossdale	16-Apr-98	25		60				
	61110810	25,264	Mossdale	16-Apr-98	31		39				
	61110811	25,926	Mossdale	16-Apr-98	32		58				
	61110806	26,215	Dos Reis	17-Apr-98	34		48				
	61110807	26,366	Dos Reis	17-Apr-98	25		35				
	61110808	24,792	Dos Reis	17-Apr-98	34		62				
	61110812	24,598	Jersey Point	20-Apr-98	87		110				
	61110813	25,673	Jersey Point	20-Apr-98	100		91				
	Effective Release	77,655	Mossdale		88		157	0.300		0.305	0.506
	Effective Release	77,373	Dos Reis		93		145	0.320		0.323	0.469
	Effective Release	50,271	Jersey Point		187		201				
1999	062642	24,765	Mossdale	19-Apr-99	8		128				
	062643	24,773	Mossdale	19-Apr-99	15		135				
	062644	25,279	Mossdale	19-Apr-99	13		132				
	062645	25,014	Dos Reis	19-Apr-99	20		151				
	062646	24,841	Dos Reis	19-Apr-99	19		225				
	0601110815	25,101	Jersey Point	21-Apr-99	34		334				
	062647	24,359	Jersey Point	21-Apr-99	25		387				
	Effective Release	74,817	Mossdale		36		395	0.380		0.403	0.362
	Effective Release	49,855	Dos Reis		39		376	0.600		0.656	0.517
	Effective Release	49,460	Jersey Point		59		721				
2000	06-45-63	24,457	Durham Ferry	17-Apr-00	11	11	296				
	06-04-01	23,529	Durham Ferry	17-Apr-00	7	6	215				
	06-04-02	24,177	Durham Ferry	17-Apr-00	10	10	232				
	06-44-01	23,465	Mossdale	18-Apr-00	9	14	207				
	06-44-02	22,784	Mossdale	18-Apr-00	9	16	174				
	06-44-03	25,527	Jersey Point	20-Apr-00	24	50	649				
	06-44-04	25,824	Jersey Point	20-Apr-00	41	47	704				
	Effective Release	72,163	Durham Ferry		28	27	743	0.310	0.190	0.242	0.391
	Effective Release	46,249	Mossdale		18	30	381	0.310	0.330	0.329	0.313
	Effective Release	51,351	Jersey Point		65	97	1353				
	601060914	23,698	Durham Ferry	28-Apr-00	7	8	46				
	601060915	26,805	Durham Ferry	28-Apr-00	5	15	45				
	0601110814	23,889	Durham Ferry	28-Apr-00	10	8	70				
	0601061001	25,572	Durham Ferry	1-May-00	48	76	358				
	0601061002	24,661	Jersey Point	1-May-00	30	76	230				
	Effective Release	74,392	Durham Ferry		22	31	161	0.190	0.140	0.156	0.185
	Effective Release	50,233	Jersey Point		78	152	588				
2001	06-44-29	23,351	Durham Ferry	30-Apr-01	14	28	95				
	06-44-30	22,720	Durham Ferry	30-Apr-01	22	30	158				
	06-44-31	22,376	Durham Ferry	30-Apr-01	17	18	111				
	06-44-32	23,022	Mossdale	1-May-01	17	18	122				
	06-44-33	22,191	Mossdale	1-May-01	14	15	106				
	06-44-34	24,444	Jersey Point	4-May-01	50	156	470				
	06-44-35	24,993	Jersey Point	4-May-01	61	173	556				
	Effective Release	68,447	Durham Ferry		53	76	364	0.340	0.170	0.212	0.256
	Effective Release	45,213	Mossdale		31	33	228	0.310	0.110	0.159	0.243
	Effective Release	49,437	Jersey Point		111	329	1026				
	06-44-36	24,029	Durham Ferry	7-May-01	2	8	17				
	06-44-37	23,907	Durham Ferry	7-May-01	5	11	45				
	06-44-38	24,054	Durham Ferry	7-May-01	2	10	28				
	06-44-39	23,882	Mossdale	8-May-01	4	8	25				
	06-44-40	25,310	Mossdale	8-May-01	4	11	27				
	06-44-41	25,910	Jersey Point	11-May-01	17	43	243				
	06-44-42	25,466	Jersey Point	11-May-01	27	53	335				
	Effective Release	71,990	Durham Ferry		9	29	90	0.130	0.200	0.194	0.111
	Effective Release	49,192	Mossdale		8	19	52	0.190	0.180	0.201	0.094
	Effective Release	51,376	Jersey Point		44	96	578				
2002	06-44-71	23,920	Durham Ferry	18-Apr-02	4	11	33				
	06-44-72	25,176	Durham Ferry	18-Apr-02	9	20	96				
	06-44-73	23,872	Durham Ferry	18-Apr-02	4	12	74				
	06-44-74	24,747	Durham Ferry	18-Apr-02	4	20	67				
	06-44-57	25,515	Mossdale	19-Apr-02	6	13	76				
	06-44-58	25,272	Mossdale	19-Apr-02	7	29	69				
	06-44-59	24,802	Jersey Point	22-Apr-02	46	101	494				

Table 5-6
Absolute survival estimates and differential recovery rates based on Chipps Island, Antioch, or ocean recoveries of Merced River Hatchery salmon released as part of South Delta studies betweeen 1996 and 2006.

Release Year	San Joaquin River (Merced River Origin) Tag Number	Release Number	Release Site	Release Date	Chipps Island Recovs.	Antioch Recovs.	Expanded Adult Ocean Recoveries (Age 1+ to 4+)	Chipps Island	Antioch	DRR or CDRR	Ocean DRR
		CWT Smolt Releases						Absolute Survival Estimates		Differential Recovery Rates	
2002	Effective Release	50,787	Mossdale		13	42	145	0.150	0.210	0.194	0.147
	Effective Release	48,930	Jersey Point		83	190	950				
	06-44-70	24,680	Durham Ferry	25-Apr-02	3	6	23				
	06-44-75	24,659	Durham Ferry	25-Apr-02	5	2	21				
	06-44-76	24,783	Durham Ferry	25-Apr-02	3	4	7				
	06-44-77	24,381	Durham Ferry	25-Apr-02	4	6	6				
	06-44-78	24,519	Mossdale	26-Apr-02	2	3	26				
	06-44-79	24,820	Mossdale	26-Apr-02	3	4	14				
	06-44-80	24,032	Jersey Point	30-Apr-02	18	43	307				
	06-44-81	22,880	Jersey Point	30-Apr-02	28	32	290				
	Effective Release	98,503	Durham Ferry		15	18	57	0.160	0.110	0.130	0.045
	Effective Release	49,339	Mossdale		5	7	40	0.110	0.090	0.094	0.064
	Effective Release	46,912	Jersey Point		46	75	597				
2003	06-02-82	24,453	Durham Ferry	21-Apr-03	0	1	9				
	06-02-83	25,927	Durham Ferry	21-Apr-03	2	4	0				
	06-27-42	24,069	Durham Ferry	21-Apr-03	1	1	10				
	06-27-48	24,471	Mossdale	22-Apr-03	2	2	3				
	06-27-43	25,212	Mossdale	22-Apr-03	3	2	5				
	06-27-44	24,414	Jersey Point	25-Apr-03	57	71	265				
	Effective Release	74,449	Durham Ferry		3	6	19	0.019	0.015	0.023	0.024
	Effective Release	49,683	Mossdale		5	4	8	0.048	0.015	0.035	0.015
	Effective Release	24,414	Jersey Point		57	71	265				
	06-27-45	24,685	Durham Ferry	28-Apr-03	0	0	6				
	06-27-46	25,189	Durham Ferry	28-Apr-03	0	0	0				
	06-27-47	24,628	Durham Ferry	28-Apr-03	0	0	4				
	06-27-49	24,180	Mossdale	29-Apr-03	0	0	5				
	06-27-50	24,346	Mossdale	29-Apr-03	1	0	0				
	06-27-51	25,692	Jersey Point	2-May-03	39	35	426				
	Effective Release	74,502	Durham Ferry		0	0	10			0.000	0.008
	Effective Release	48,526	Mossdale		1	0	5	0.010		0.007	0.006
	Effective Release	25,692	Jersey Point		39	35	426				
2004	06-27-52	23,440	Durham Ferry	22-Apr-04	0	1	3				
	06-27-53	21,714	Durham Ferry	22-Apr-04	1	1	0				
	06-27-54	23,328	Durham Ferry	22-Apr-04	1	0	0				
	06-27-55	23,783	Durham Ferry	22-Apr-04	1	0	0				
	06-46-70	25,319	Mossdale	23-Apr-04	0	1	0				
	06-45-82	23,586	Mossdale	23-Apr-04	1	0	0				
	06-45-83	24,803	Mossdale	23-Apr-04	2	0	2				
	06-45-80	22,911	Jersey Point	26-Apr-04	25	22	129				
	Effective Release	92,265	Durham Ferry		3	2	3	0.030	0.020	0.026	0.006
	Effective Release	73,708	Mossdale		3	1	2	0.040	0.010	0.026	0.005
	Effective Release	22,911	Jersey Point		25	22	129				
2005	06-46-72	23,414	Durham Ferry	2-May-05	5	0	5				
	06-46-73	23,193	Durham Ferry	2-May-05	2	2	3				
	06-46-74	23,660	Durham Ferry	2-May-05	4	3	3				
	06-46-75	23,567	Durham Ferry	2-May-05	1	1	0				
	06-46-97	22,302	Dos Reis	3-May-05	1	1	0				
	06-46-98	24,149	Dos Reis	3-May-05	1	3	0				
	06-45-91	22,675	Dos Reis	3-May-05	1	3	0				
	06-45-88	22,767	Jersey Point	6-May-05	32	31	30				
	Effective Release	93,834	Durham Ferry		12	6	11	0.099	0.049	0.069	0.089
	Effective Release	69,126	Dos Reis		3	7	0	0.035	0.110	0.052	0.000
	Effective Release	22,767	Jersey Point		32	31	30				
	06-45-84	22,777	Durham Ferry	9-May-05	2	1	5				
	06-45-85	22,968	Durham Ferry	9-May-05	1	1	0				
	06-45-86	23,012	Durham Ferry	9-May-05	3	3	2				
	06-45-87	22,806	Durham Ferry	9-May-05	0	2	0				
	06-45-89	21,443	Dos Reis	10-May-05	3	5	4				
	06-45-90	23,755	Dos Reis	10-May-05	2	2	0				
	06-46-99	23,448	Dos Reis	10-May-05	1	0	0				
	06-47-00	23,231	Jersey Point	13-May-05	38	27	33				
	Effective Release	91,563	Durham Ferry		6	7	7	0.044	0.094	0.051	0.054
	Effective Release	68,646	Dos Reis		6	7	4	0.058	0.127	0.068	0.041
	Effective Release	23,231	Jersey Point		38	27	33				
2006	06-47-13	24,703	Mossdale	4-May-06	7	5	0				
	06-47-14	24,315	Mossdale	4-May-06	2	4	0				
	06-47-16	25,602	Dos Reis	5-May-06	7	3	0				
	06-47-15	26,192	Jersey Point	8-May-06	58	26	0				
	Effective Release	49,018	Mossdale		9	9	0	0.080	0.180	0.115	
	Effective Release	25,602	Dos Reis		7	3	0	0.120	0.110	0.122	
	Effective Release	26,192	Jersey Point		58	26	0				
	06-47-21	25,105	Mossdale	19-May-06	2	0	0				
	06-47-22	24,008	Mossdale	19-May-06	0	0	0				
	06-47-24	23,980	Jersey Point	22-May-06	44	14	0				
	Effective Release	49,113	Mossdale		2	0	0	0.030	0.000	0.017	
	Effective Release	23,980	Jersey Point		44	14	0				

were expected to last for the duration of the one-month study. Each transmitter was individually identifiable and did not overlap with smolt transmitters. Movements of tagged bass were monitored with the fixed-station acoustic receiver (data logger) network deployed to monitor smolts during the VAMP study (Figure 5-2). Each fixed-station receiver recorded the unique tag code and date/time of passing acoustic-tagged bass. These data were anticipated to provide information on striped bass movements within the study area and possible affinity to specific locales during spring 2008.

Survival Through the Delta in Past Years

Ocean Recovery Information

Ocean recovery data of CWT salmon groups can provide an additional source of recoveries for estimating survival through the Delta. The ocean harvest data may be more reliable due to the greater number of CWT recoveries and the extended recovery period.

Adult ocean recovery data are gathered from commercial and sport ocean harvest checked at various ports by DFG. The Pacific States Marine Fisheries Commission database of ocean harvest CWT data was the source of recoveries through 2007. The ocean CWT recovery data accumulate over a one to four year period after the year a study release is made as nearly all of a given year-class of salmon have been either harvested or spawned by age five. Consequently, these data are essentially complete for releases made through 2003 and partially available for CWT releases made from 2004 to 2006 (no releases were made in 2007 and 2008). Differential recovery rates (DRR) based on Chipps Island or ocean recoveries and combined differential recovery rates (CDRR) based on both Antioch and Chipps Island recoveries for salmon produced at the MRH are shown in Table 5-6. Absolute survival estimates based on Chipps Island and Antioch survival indices are also included. The earlier releases were made as part of south Delta survival evaluations (1996-1999) with the later releases associated with VAMP (2000-2006). Releases have been made at several locations: Dos Reis, Mossdale, Durham Ferry, and Jersey Point. The Chipps Island and Antioch survival estimates and combined differential (Antioch and Chipps Island recoveries summed) or differential recovery rates (Chipps Island recoveries only) are graphed in relation to the differential recovery rate using the ocean recovery information in Figure 5-9.

Results of this comparative analysis of survival estimates and differential recovery rates for Chinook salmon produced in the MRH show: (1) there is general agreement between survival estimates and differential recovery rates based on juvenile CWT salmon recoveries at Chipps Island and adult recoveries from the ocean fishery (r2=0.78), (2) there is less agreement with Antioch trawling which has fewer years of data, and (3) additional comparisons need to be made, as more data becomes available from recoveries of VAMP study fish in the ocean fishery.

San Joaquin River Salmon Protection

One of the VAMP objectives is to provide improved conditions to increase the survival of juvenile Chinook salmon smolts produced in the San Joaquin River tributaries during their downstream migration through the lower river and Delta. It is hypothesized that these actions to improve conditions for the juveniles will translate into greater adult abundance and escapement in future years than would otherwise occur without the actions.

To determine if VAMP has been successful in targeting the migration period of naturally produced juvenile salmon, catches of unmarked salmon in the Kodiak trawl at Mossdale and in salvage at the CVP and SWP facilities were compared prior to and during the VAMP period.

Unmarked and Marked Salmon Captured at Mossdale

The default time period of VAMP (April 15th to May 15th) was chosen based on historical data that indicated a high percentage of the salmon smolts emigrating from the San Joaquin tributaries passed into the Delta at Mossdale during that time. In 2008, the start of the VAMP period was shifted by one week, to April 22nd, to allow additional time for test fish to grow for use in the acoustic telemetry study. Densities (catch per 10,000 cubic meters) of unmarked juvenile salmon captured at Mossdale during January through June are shown in Figure 5-10. Unmarked salmon do not have an adipose clip or any other external mark (i.e., Panjet or Bismark brown) and can be juveniles from natural spawning or unmarked hatchery fish from the MRH. On May 27th a total of 7,460 unmarked smolts were released at MRH, the only release of unmarked hatchery smolts from MRH during 2008. As in prior years, there is no way to determine how many unmarked hatchery smolts were captured in the trawl. No adipose fin clipped salmon were released from MRH during 2008.

A peak density of unmarked juvenile salmon at Mossdale occurred on May 16th and 19th (May 17th-18th were not sampled), near the end of the VAMP period and immediately followed an initial decrease in flows in the Tuolumne and Merced rivers (Figure 5-10). An earlier peak also occurred on April 28th (April 26th-27th were not sampled) a few days after Vernalis flow exceeded 3,000 cfs. Densities may have been as high or higher on


4-22-08
2 of 4


MS-222
2mL/
10L

days when no sampling was conducted (i.e., sampling was only conducted 5 days/week). The size of the juvenile salmon captured in the Mossdale trawl during January through June is shown in Figure 5-11. Some salmon in the 50-69 mm range (parr) were in the catch from mid-April through May.

Salmon Salvage and Losses at Delta Export Pumps

Fish salvage operations at the CVP and SWP export facilities capture juvenile salmon and transport them by tanker truck to release sites in the western Sacramento-San Joaquin Delta. The untagged salmon are potentially from any source in the Central Valley. It is not certain which unmarked salmon recovered are of San Joaquin basin origin; although the timing of salvage and fish size can be compared with Mossdale trawl data and recovery data for tagged MRH smolts at the salvage facilities to provide some general indications as to the origin of the unmarked fish. It was estimated by DWR that the proportion of the water in the Clifton Court Forebay (CCF) of the SWP from the San Joaquin River (SJR) increased from approximately 10% during early January to approximately 20% from late January through mid-March (based on Real Time Data and Forecasting Project Water Quality Weekly Reports from DWR Office of Water Quality). The proportion gradually increased after mid-March reaching a high of approximately 65% in late May. The proportion gradually decreased during June to approximately 35%. It may be assumed that the proportion of the CVP water source from the SJR was similar in 2008.

The estimated salmon losses at the CVP and SWP are based on expanded salvage and an estimate of screen efficiency and survival through the facility and salvage process. The CVP pumps divert directly from the Old River channel and direct losses are estimated to range from about 50 to 80% of the number salvaged. Four to five salmon are estimated to be lost per salvaged salmon at the SWP because of high predation rates in CCF. The SWP losses are therefore about six to eight times higher, per salvaged salmon, than for the CVP. The loss estimates do not include any indirect mortality in the Delta due to water export operations or additional mortality associated with post-release predation.

Density of salmon encountering both of the export and fish salvage facilities off Old River is represented by the combined salvage and loss estimated per acre-foot of water pumped. The DFG and DWR maintain a database of daily, weekly, and monthly salvage data. The number and density of juvenile salmon that migrated through the system, the placement of the HORB, and the amount of water pumped by each facility are some of the factors that influence the number of juvenile salmon salvaged and lost. Density is an indicator of when concentrations of juvenile salmon may be more susceptible to the export facilities and salvage system. Additionally, salvage efficiency is lower for smaller-sized salmon (fry and parr), so their salvage numbers and estimated losses are underrepresented.

The size distribution of unmarked salmon in the Mossdale trawl (Figure 5-10) during January through June generally overlaps with the size distribution of those salvaged at the fish facilities (Figure 5-16, Source S. Greene, DWR). Based on comparisons with Mossdale data, it appears that some salmon salvaged before, during, and after the VAMP period could have been from the San Joaquin basin (Figure 5-11).

The weekly data covering the period of April 23rd to May 20th approximated the 2008 VAMP period. A review of weekly data for January through June indicates that CVP and SWP salvage and losses started to increase in early April, peaked during late April through mid-May coincident to the VAMP period, and remained elevated through late May (Figure 5-12 and Figure 5-13). Salmon densities based on combined salvage and loss estimates were also highest during much of the VAMP period at the CVP and SWP (Figure 5-14); the peak at both facilities occurred during early May. As in other years, relatively large seasonal numbers and densities were observed before and after VAMP when exports approximated or exceeded flows at Vernalis (Figure 5-15).

Results of these analyses show that the 2008 VAMP test period coincided with the mid-portion of the San Joaquin River salmon smolt emigration period when migration densities were highest. Unfortunately, sampling at Mossdale was only conducted 5 days/week during the VAMP period rather than daily as in most recent years. Production estimates at Mossdale could be improved by ensuring that sampling is conducted daily when most salmon smolts are emigrating.

SEE USEFUL WEB PAGES

Figure 5-10
Mossdale Kodiak trawl individual daily forklengths of juvenile Chinook salmon, January through June 2008

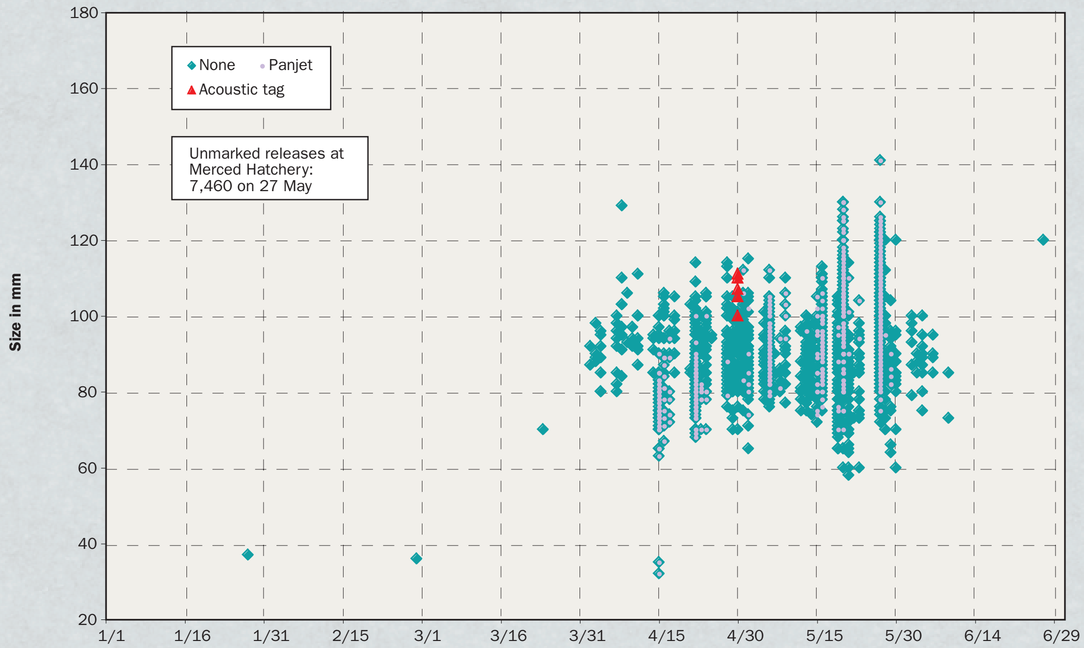


Figure 5-11
Average daily densities of unmarked salmon caught in the Mossdale Kodiak trawl

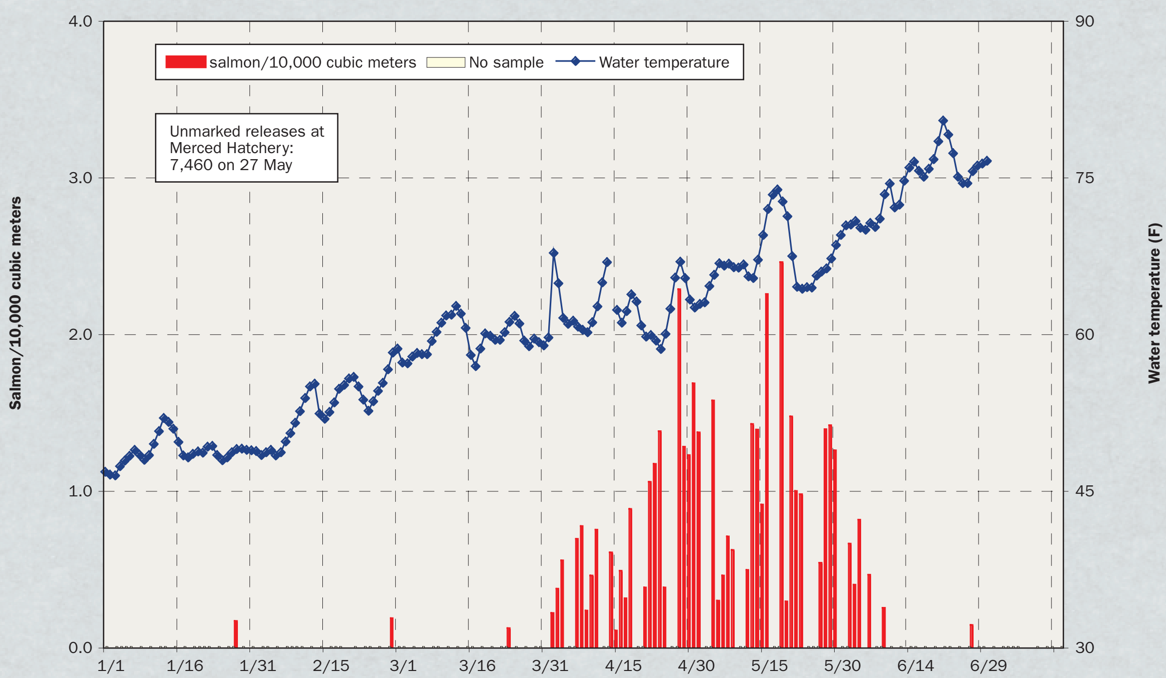


Figure 5-12
2008 CVP estimated salmon salvage and loss

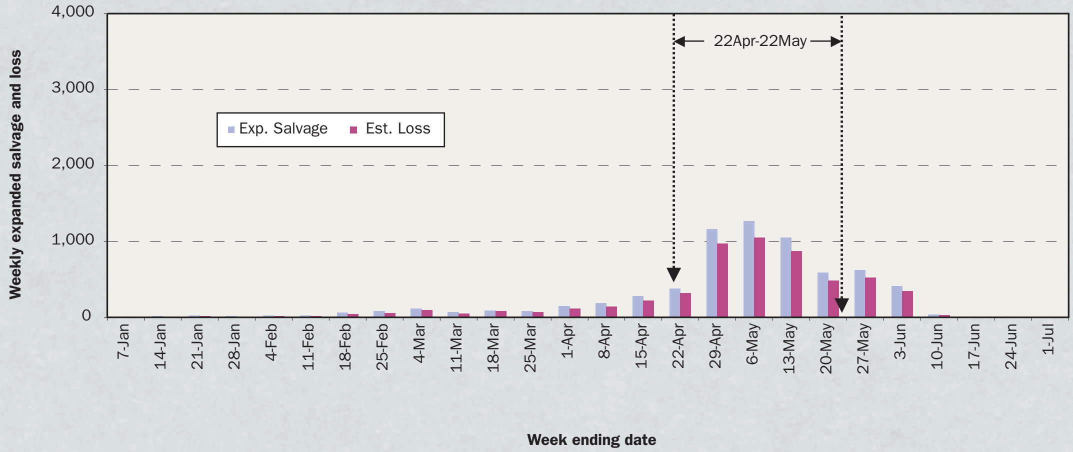


Figure 5-13
2008 SWP estimated salmon salvage and loss

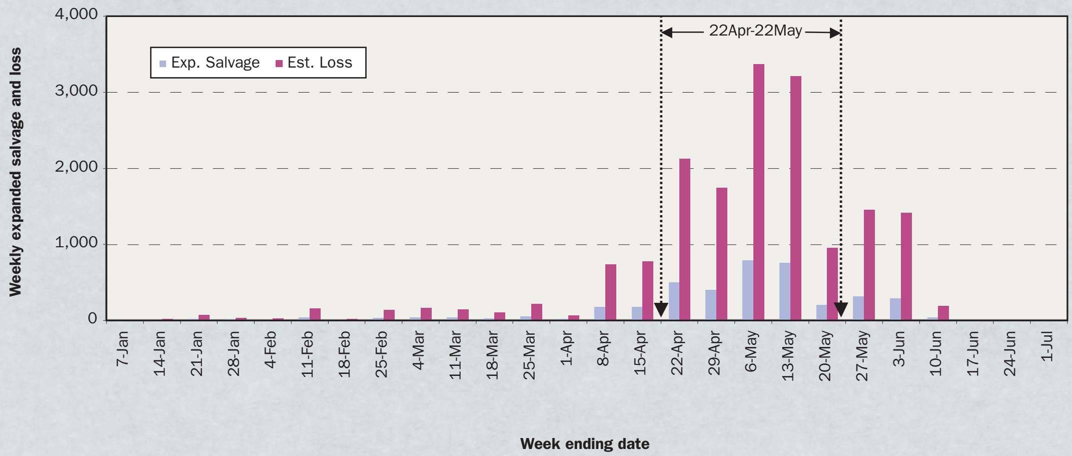


Figure 5-14
2008 SWP & CVP Combined salvage and loss density

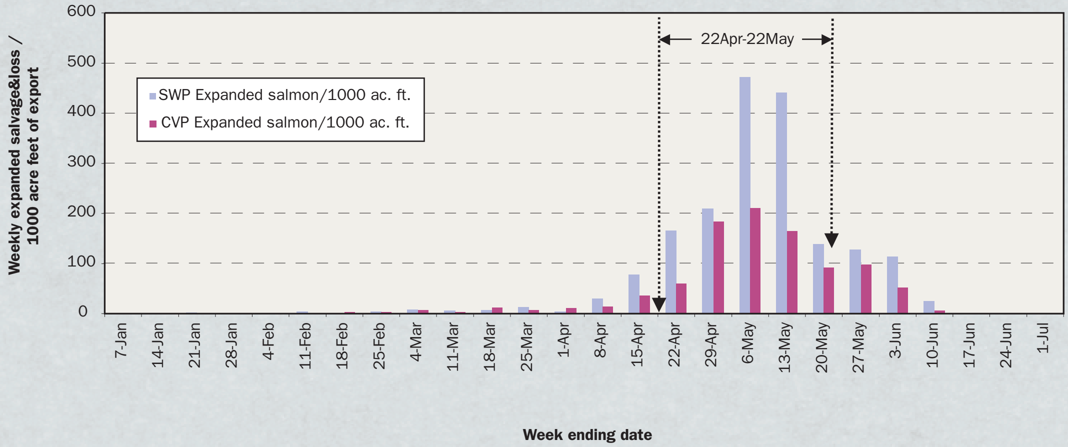


Figure 5-15
2008 weekly export rates and Vernalis flow

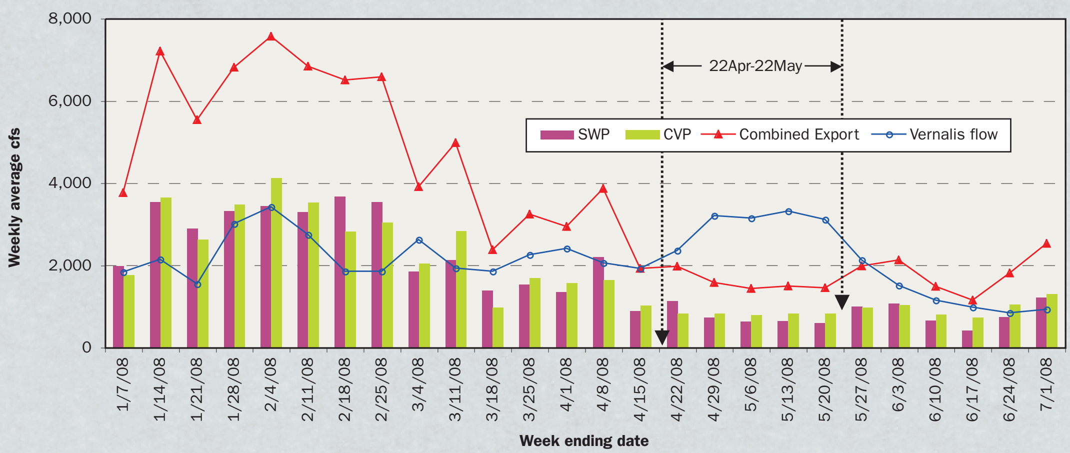
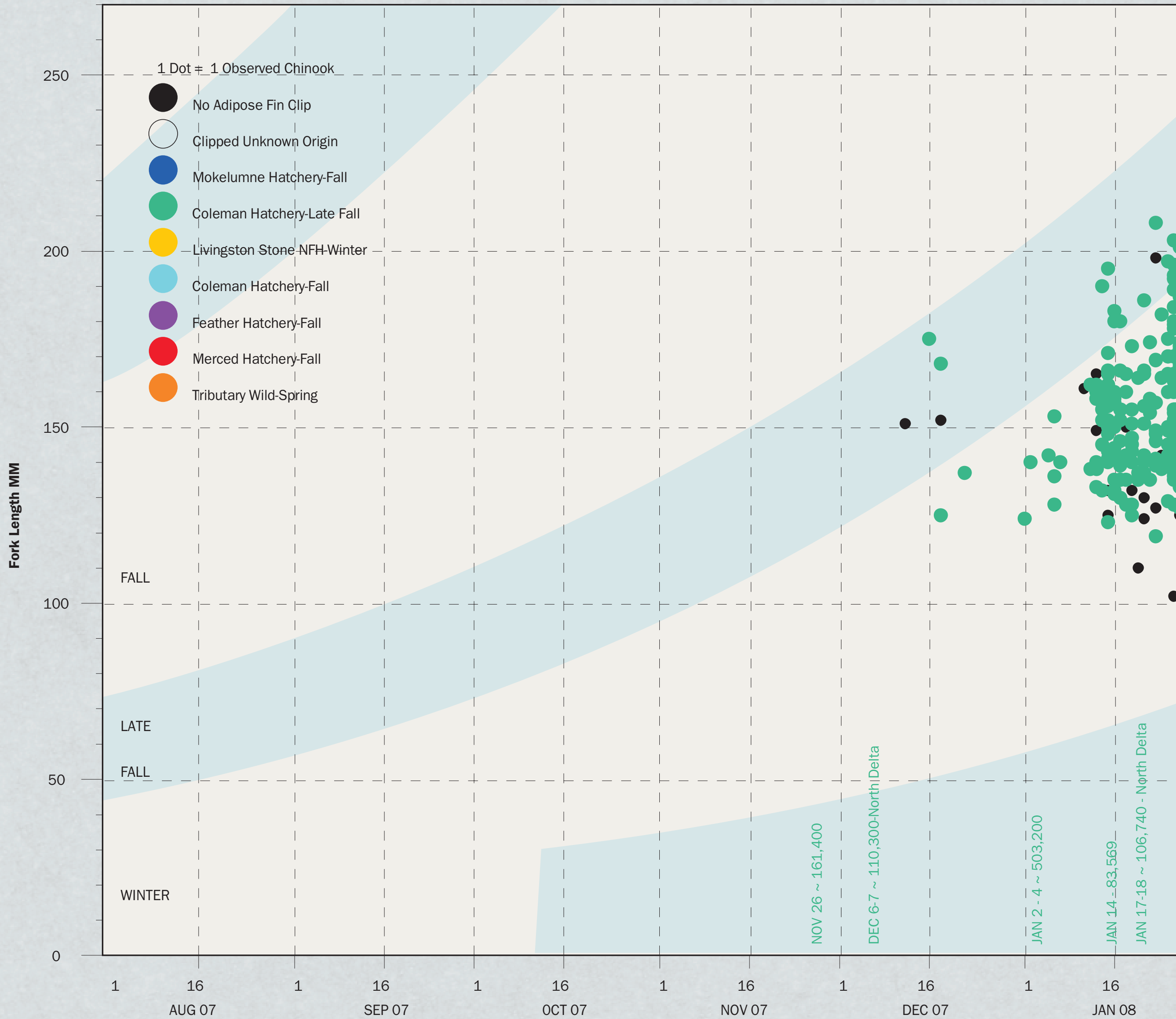
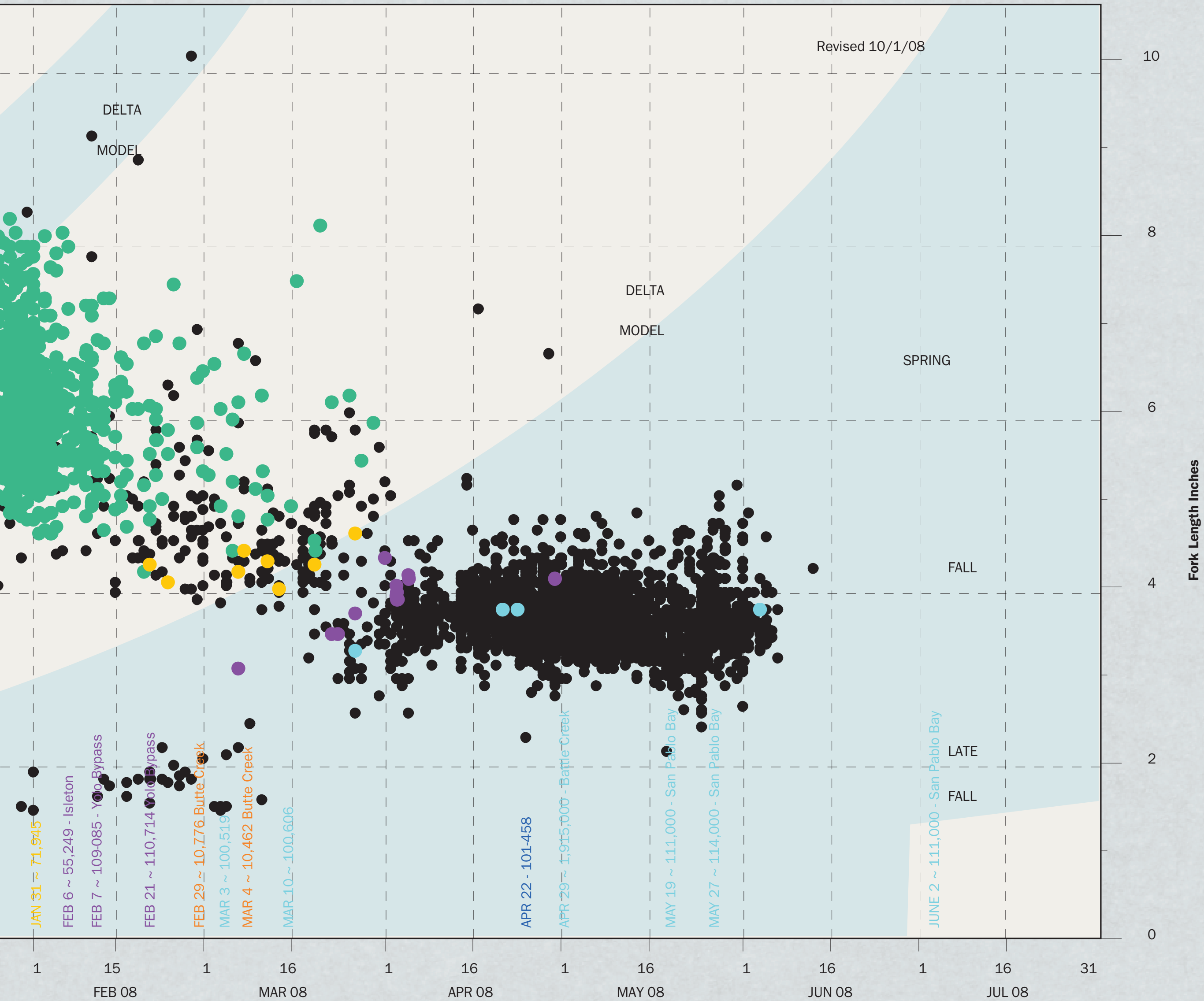


Figure 5-16
Observed Chinook Salvage at the SWP & CVP Delta Fish Facilities 8/1/07 Through 7/31/08




Revised 10/1/08
DELTA
MODEL
DELTA
MODEL
SPRING
FALL
LATE
FALL
Fork Length Inches
10
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JAN 31 ~ 71,545
FEB 6 ~ 55,249 - Isleton
FEB 7 ~ 109-085 - Yolo Bypass
FEB 21 ~ 110,714 Yolo Bypass
FEB 29 ~ 10,776 Butte Creek
MAR 3 ~ 100,519
MAR 4 ~ 10,462 Butte Creek
MAR 10 ~ 100,606
APR 22 - 101-458
APR 29 ~ 1,915,000 - Battle Creek
MAY 19 ~ 111,000 - San Pablo Bay
MAY 27 ~ 114,000 - San Pablo Bay
JUNE 2 ~ 111,000 - San Pablo Bay
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MAY 08
JUN 08
JUL 08

CHAPTER 6

COMPLEMENTARY STUDIES RELATED TO THE VAMP

Throughout 2008 several fishery studies were conducted to advance the understanding of juvenile salmon abundance and survival in the San Joaquin River basin. Following are summary reports of the information developed in each study.

Review of Juvenile Salmon Data from the San Joaquin River Tributaries to the South Delta during January through June, 2008

Contributed by Tim Ford, Turlock and Modesto Irrigation Districts, and Chrissy Sonke, FISHBIO Environmental

The VAMP includes protective measures for San Joaquin River (SJR) smolts during a 31-day period in April and May, and evaluations are conducted annually to determine how these measures (i.e., river flow and exports) relate to delta survival. However, juvenile salmon from the spawning areas of the Stanislaus, Tuolumne, and Merced Rivers (referred to here as tributaries) can migrate to the SJR and delta over a longer season that may range from January to June. Their migration and rearing patterns vary among tributaries and among years in response to flow releases, runoff events, turbidity, and other factors.

During 2008, rotary screw trapping was conducted near the confluences of the Stanislaus, Tuolumne, and Merced Rivers with the SJR. Seining was also conducted in the SJR from below the head of Old River (HOR) to upstream of the Tuolumne River confluence. This review presents data from those rotary screw traps (RST) and seining to identify the presence and movement of juvenile salmon from the tributaries into the mainstem San Joaquin River relative to observations at the Mossdale Trawl and in CVP and SWP salvage facilities. Salmon were assigned to lifestage category based on a forklength scale, where <50 mm= fry, 50-69 mm= parr, and ≥ 70 mm= smolt.

Stanislaus River RST monitoring was conducted at River Mile (RM) 9 (Caswell site) between January 21st and June 26th; Tuolumne River RST monitoring was conducted at RM 5 (Grayson site) between January 29th and June 4th; and Merced River RST monitoring was conducted at RM 2 (Hatfield site) between March 3rd and June 5th. Weekly seining during Jan-Jun was done at up to 8 sites from River Mile 51 (Dos Reis) to River Mile 83 (North of Tuolumne River) and two other sites were seined every two weeks from mid-January to late May at River Mile 78 and 90. Trawling was conducted in the San Joaquin River at Mossdale near RM 54 (downstream of the tributaries, and just upstream of the HOR) with a schedule of three days/week, January 2nd through March 30th; five days per week, March 31st through June 6th; and three to five days per week during the remainder of June. Although salvage data of unmarked salmon does not distinguish which salmon originate from the San Joaquin tributaries, they can be compared to timing, abundance, and size of salmon collected in the San Joaquin basin monitoring. Flow and rainfall patterns in the basin are shown in Figure 6-1.

Overall, Chinook outmigrant abundance in 2008 was extremely low in the San Joaquin Basin (i.e., 483 juvenile Chinook captured in the three tributaries), consistent with the low 2007 adult returns (i.e., total basin estimated escapement was about 1,195). Estimated escapement to the San Joaquin Basin during fall 2007 was only 21% of the previous year, and was the lowest observed since the 1987-1992 drought.

At the Stanislaus River RST, there were no obvious peaks in fry movement (Figure 6-2) and fry catch never exceeded eight fish per day. RST sampling was not conducted during the fry outmigration period on the Merced River (Figure 6-3). A seasonal peak catch of fry (n=69) at the Tuolumne River RST (Figure 6-4) occurred on February 29th following increasing runoff from rain

Figure 6-1
San Joaquin Basin Flows and Rainfall, 2008

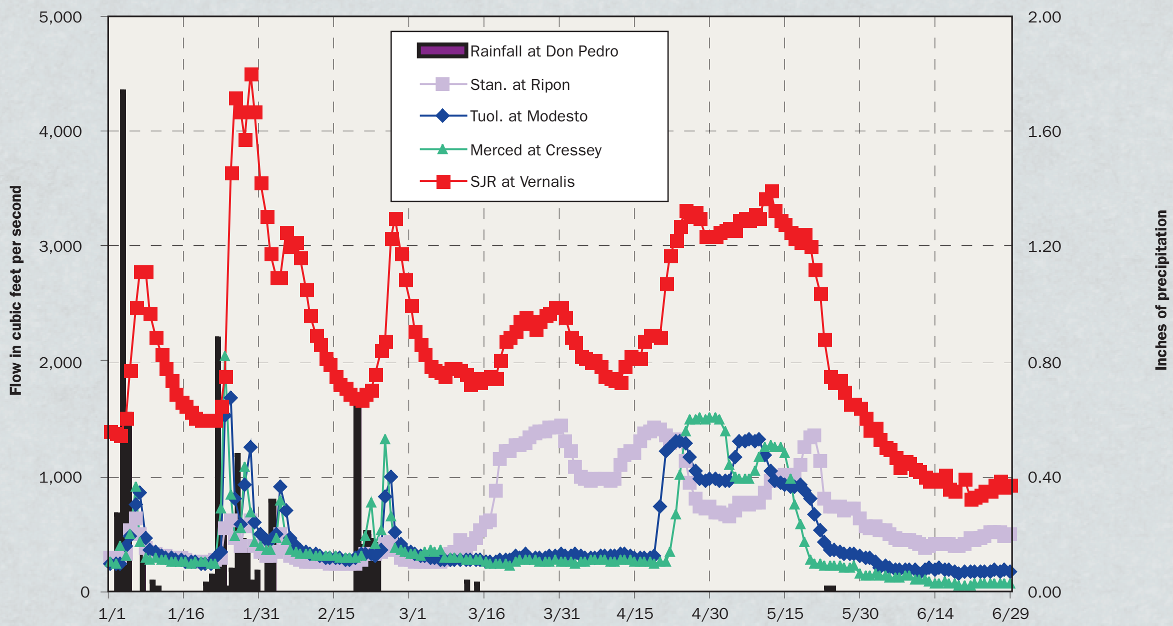
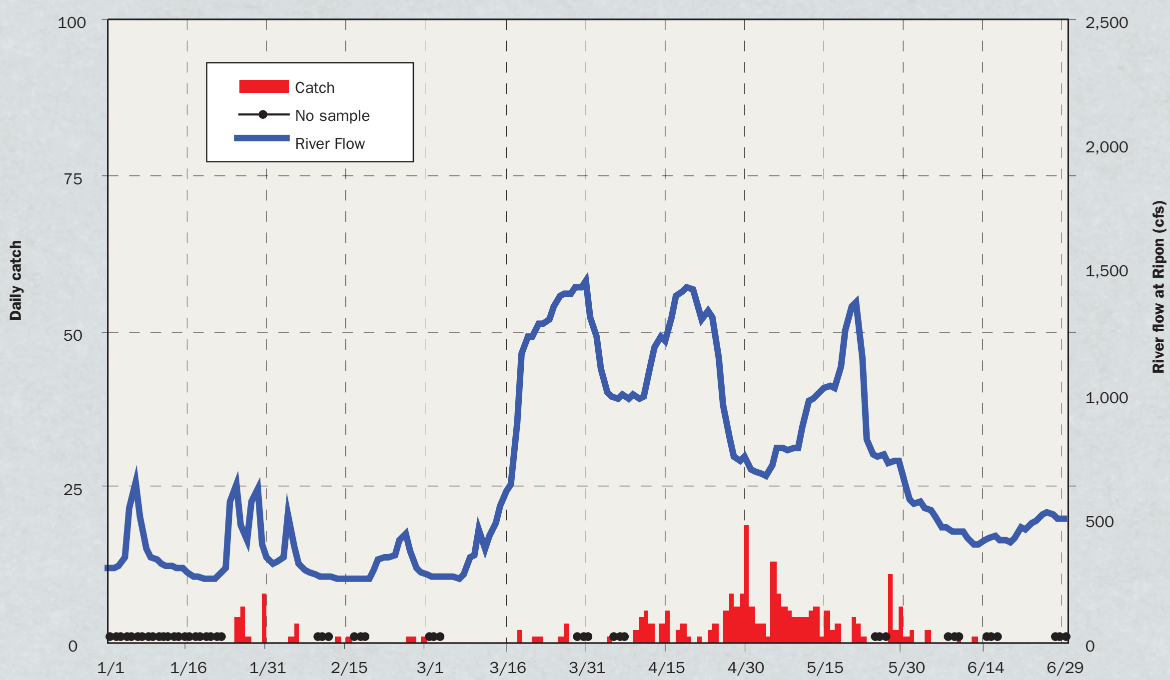


Figure 6-2
Stanislaus screw trap catch of unmarked juvenile Chinook salmon



CHAPTER 6

Figure 6-3
Merced screw trap catch of unmarked juvenile Chinook salmon

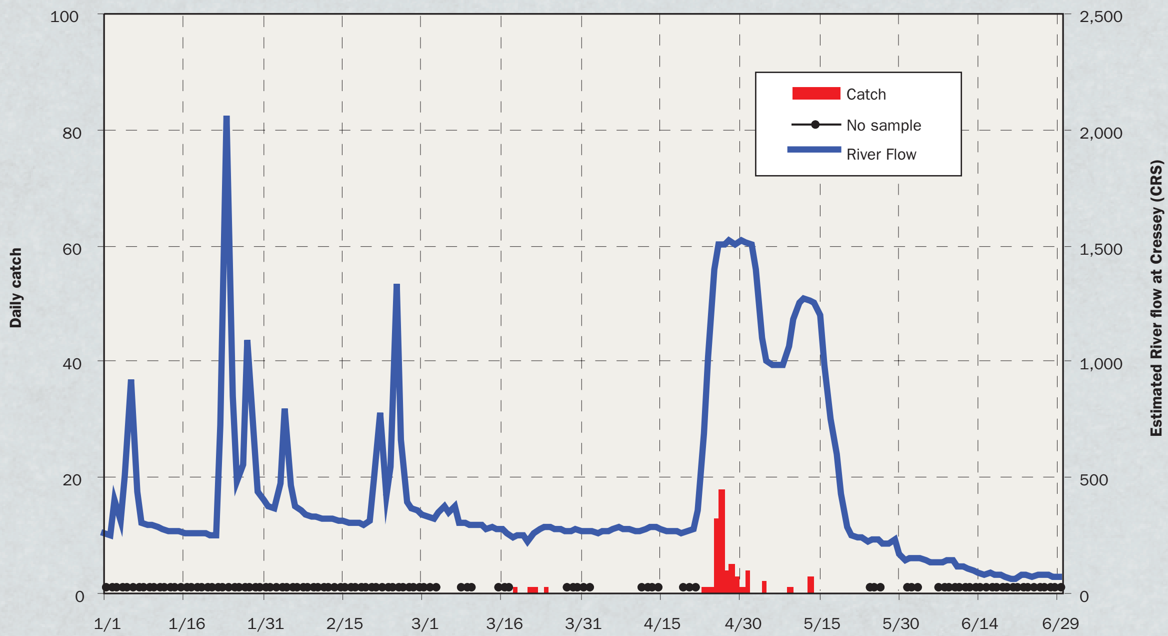


Figure 6-4
Tuolumne screw trap catch of unmarked juvenile Chinook salmon

events during February 20th - 24th; this peak represents 54% of all fry and 36% of all juveniles captured in the three tributary RSTs combined. A smaller elevated catch was observed under similar conditions on the Tuolumne River in early February. Only two salmon fry were captured in the Mossdale trawl (Figure 6-5) and numbers salvaged at the CVP and SWP facilities (Figures 5-12 and 5-13) were also low which is consistent with the low numbers of fry migrating out of the Stanislaus and Tuolumne Rivers.

Small, seasonal peak catches during the parr/smolt outmigration period were observed on the Merced River on April 26th (Figure 6-3) and 30 Apr on the Stanislaus River (Figure 6-2), and were subsequently detected at Mossdale during April 28th through May 2nd. At the Tuolumne River RST there were no obvious peaks in parr/smolt catch. Seasonal peak parr/smolt catch occurred at Mossdale on May 16th (Figure 6-5), coincident with peak recovery of marked salmon from several releases in the lower Merced River at Hatfield Park. This "Pied Piper effect", where natural migrants are stimulated to migrate with released hatchery salmon, is a trend commonly observed in the RSTs. Seining in the SJR captured only three salmon: one (82 mm) at Route 132 (RM 77) on January 10th; one (74 mm) at Dos Reis (RM 51) on April 18th; and one (84 mm) at Mossdale (RM 56) on April 22nd. Very low catches of juvenile salmon were observed by mid-May in the Tuolumne and Merced Rivers, and by the end of May in the Stanislaus River and the San Joaquin River at Mossdale.

Average size in RST and trawl catches (Figure 6-6) shows that most fish observed prior to mid-March averaged <50 mm fork length (FL). In contrast, average size in the salvage prior to late March shows that most fish were substantially larger than those emigrating from the San Joaquin Basin. Although salvage operations are relatively less effective at capture of fry, the absence of fry in the salvage combined with low abundance of fry observed at upstream monitoring locations suggests that few fry of San Joaquin Basin origin were entrained by the pumps during 2008. Instead it appears that salvage during January through March was dominated by larger fish of other runs from the Sacramento Basin (Figure 5-16). Average size at all locations typically increased by early April to >80 mm FL (Figure 6-6).

To obtain more useful information on salmon movement into the Delta, daily monitoring at the lower end of each of the three San Joaquin tributaries and at Mossdale for the entire season (roughly January through June) is a high priority. Further evaluation of the trawl and salvage efficiency on smaller juvenile salmon is necessary. These data would help to refine existing protective measures for fry to smolts, if warranted, and to identify alternative strategies that may protect a larger proportion of the juvenile salmon population migrating from the San Joaquin tributaries.

2008 Mossdale Trawl Summary

Contributed by H. Steve Tsao
California Department of Fish and Game

Introduction

Since 1988 DFG has conducted monitoring of the fall-run Chinook salmon smolt out-migrant population in the San Joaquin River from the HOR to about two miles downstream of Mossdale Landing County Park (RM 56) (Figure 6-7). This essential measurement of timing and production for out-migrating fall-run Chinook salmon smolts has been performed at this location to:

1) Determine annual salmon smolt production in the San Joaquin Basin,

2) Develop smolt production trend information,

3) Determine timing and magnitude of smolt out-migration into the Delta from the San Joaquin tributaries.

4) Document the occurrences of other species including listed species such as steelhead and delta smelt.

Methods

Sampling is performed with a 6 x 25 foot (1.87m x 7.6m) Kodiak trawl net. The Kodiak trawl uses two boats to pull a net equipped with spreader bars, wings, and a "belly" in the throat of the net (to improve capture vulnerability). The cod end of the trawl net is secured using a rope. The sampling intensity was 5 days a week from April 1st to June 6th, and 3 days a week from June 9th to June 30th. The entire sampling period was from April 1st to June 30th, 2008 with a total of 58 sample days out of the study period of 91 days. All trawling occurred during daylight hours, starting between 0700 to 0800 hours. A sampling day usually consisted of 10 tows at 20 minutes per tow. A sampling day may have been extended if a trawl efficiency test was conducted. Sampling was also conducted 3 days per week from July to March by the USFWS Stockton Office.

All fish were identified to species and enumerated. The first 30 per tow of all species, except Chinook salmon, were also measured. Chinook salmon were checked for dye mark. All non-marked Chinook salmon were considered "natural" for the purpose of this study. All Chinook salmon were measured (fork length, mm).

Water temperature, turbidity, weather, and beginning tow time were recorded for each tow. Velocity was

Figure 6-5
Mossdale kodiak trawl catch of unmarked juvenile Chinook salmon

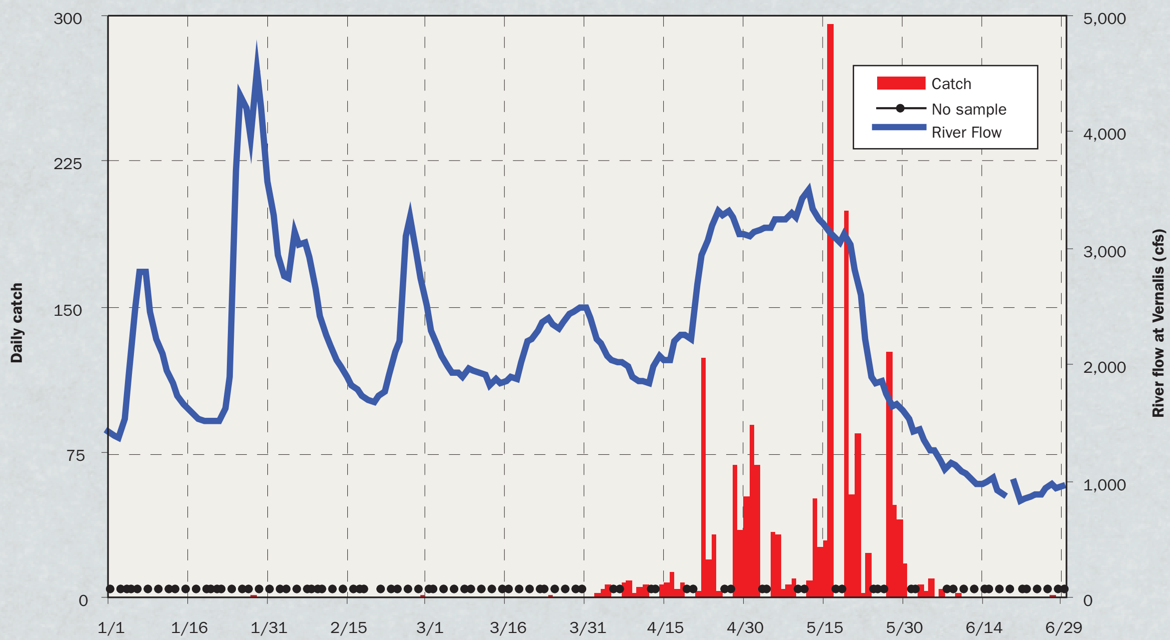
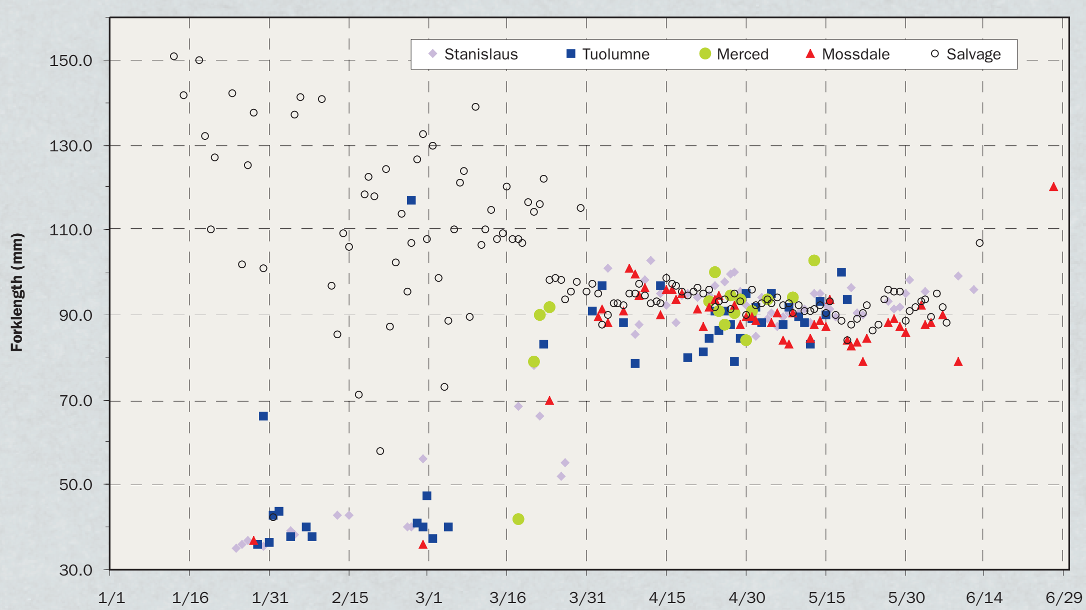


Figure 6-6
Daily average forklength of unmarked juvenile Chinook salmon



recorded by using a General Oceanics Inc model 2030R digital flow meter. A Garmin GPS Map 172c was used to map the location of all sampling tows. This mapping was done to evaluate differences in catch rate verses tidal influence throughout the sampling area (Figure 6-8). The tidal information at Grant Line Canal was provided by NOAA. The mean daily river flow data that is used in this report were taken from the U.S. Geological Survey mean daily stream flow gauge at Vernalis.

Analysis

Smolt Production Index Calculation (Smolt/ac-ft Method)

The 2008 natural smolt production from the San Joaquin River drainage was estimated by two different methods. The first method, smolt production index calculation (smolt/ac-ft method) involves taking the actual number of non-marked Chinook salmon and dividing by the actual volume sampled to get Chinook/ac-ft. This number is then expanded by the daily mean flow recorded at Vernalis for a 5-hour index and expanded again for a 24-hour daily estimate. These daily average smolt densities are then expanded by multiplying by the daily mean flow recorded at Vernalis. Production for days not sampled within the study period was estimated by averaging smolt/ac-ft for the two days before and two days after the non-sampled period.

The natural smolt index estimates (E_I) are calculated as follow:

$$E_I = \sum_{i=1}^{n=91} \left[\left(\frac{C_i}{V_{Ti}} \right) \left(V_{Pi} \right) \left(\frac{24}{5} \right) \right]$$

Where:
EI = Smolt Production Index Estimation
n = days in the index period
C = daily non-marked Chinook catch
VT = daily volume of trawl sampled
VP = daily 5-hour volume of water passing Mossdale
i = ith Day

The 95% confidence interval around this index was calculated as +1.96 x the Standard Deviation of the mean smolt density (smolt/ac-ft) in the trawl catch over the 91 days.

Vulnerability Expansion Estimation (Single Year Population Ratio Method)

The second method, vulnerability expansion calculation (single year population ratio method), which DFG believes to be a more accurate estimate due to the uneven distribution of smolts in the channel, is determined based on the recapture rates of dye marked vulnerability release groups. There were 5 vulnerability test groups in 2008 (Table 6-1). A population ratio was calculated based on these 5 test groups. The population ratio was used to calculate a 5-hour index, and extrapolated to a 24-hour seasonal estimate (Figure 6-9). Production for days not sampled within the study period were estimated by averaging smolt catch and minutes towed for the two days before and two days after the non-sampled period.

The population ratio (r) was calculated as follow:

$$r = \frac{\sum_{i=1}^{n} y}{\sum_{i=1}^{n} x} = \frac{\overline{y}}{\overline{x}}$$

Where:
r = population ratio
n = number of vulnerability test groups
y = number of marked fish captured
x = number of marked fish released (effective release)
i = ith day

$$E_V = \sum_{i=1}^{N=91} \left\{ \left[\frac{(C_i/r)}{(T_i/300)} \right] \left(\frac{24}{5} \right) \right\}$$

Where:
EV = Vulnerability Expansion Estimation
r = population ratio
C = daily non-marked Chinook catch
T = tow duration
i = ith day
N = number of days sampled

For the purpose of the analysis, vulnerability to the trawl was assumed to be from the beginning of the first tow that fish were detected to the end of the last tow the fish were detected on the day of release. Detection of the test group of fish subsequent to the day of release was not used in the analysis (this was less than 5 fish total for all releases). Travel time from release point to the trawl, time vulnerable to the trawl, and the percent vulnerability as related to flow were determined for each test group (Table 6-1).

Results

Between April 1 and June 30, 2008, 1,696 non-marked Chinook salmon smolts were captured in the Mossdale trawl. Daily capture of non-marked salmon ranged from 0 to 296 individuals with an average of 35. Figure 6-9 shows the expanded daily catch of non-marked Chinook. Average forklength of non-marked Chinook was 88.3 mm and ranged from 58 - 129 mm.

The smolt production estimate for the San Joaquin basin was 188,652 using the smolt production index

Figure 6-7
Location Map of Mossdale Trawl Area in Lower San Joaquin River, 2008

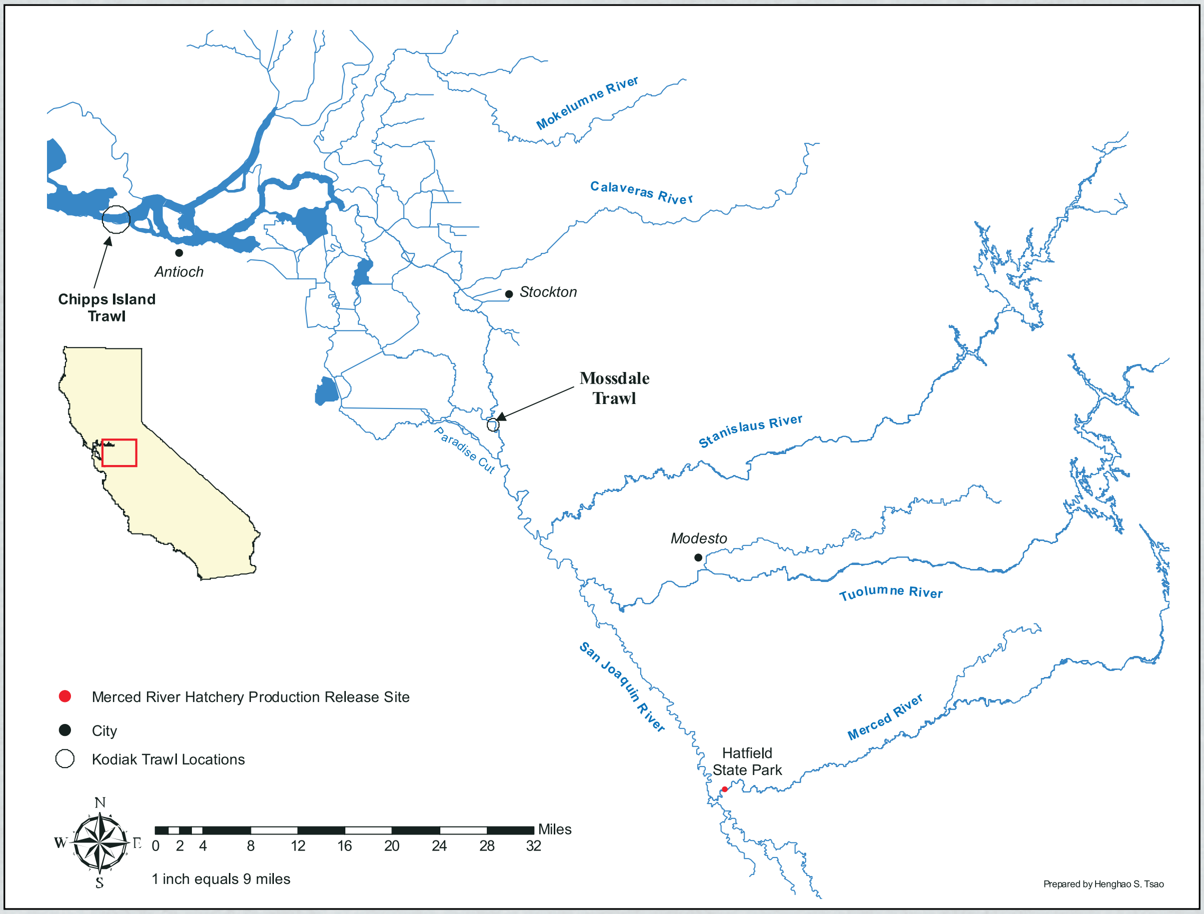
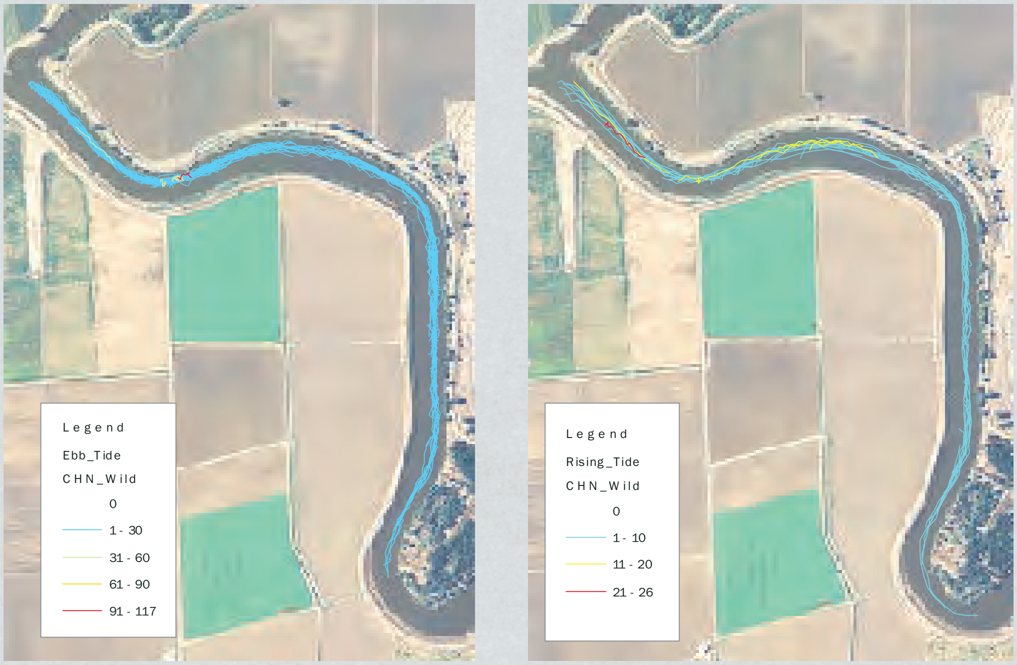


Figure 6-8
GPS Trace of Sampling Tows During Mossdale Trawl, 2008



Type of Tide	Number of CHN caught	Number of tow	Average CHN per tow
Ebb	1399	438	3.19
Rising	297	162	1.83
Total	1696	600	2.83

0.4 0.2 0 0.4 Miles
1:11,925

Table 6-1
Dye marked smolt release from Merced River Hatchery for vulnerability studies in the San Joaquin River at Mossdale Landing, April through May, 2008

Release Date /Time	Water Temp. (°C) Truck/River	Effective # Released	Number Recovered	Streamflow (cfs) at Vernalis	Beginning and Ending Recovery Time
15-Apr-08 9:00	10/16	2009	80	2010	10:54 14:35
22-Apr-08 8:22	9.5/13	5017	149	2822	10:14 15:21
6-May-08 7:01	11/17	2830	110	3126	9:24 14:28
20-May-08 7:45	13/20	4992	371	3046	9:11 14:15
27-May-08 7:00	12.5/16.5	2999	324	1805	8:48 14:59

estimation, and 285,887 using the vulnerability expansion estimation (Table 6-2). The vulnerability expansion estimation is thought to be more accurate than the smolt/ac-ft index method because it should account for an uneven distribution of migrating smolts in the river channel.

Four steelhead/ rainbow trout (RBT) were captured during the 2008 sampling period. All RBTs were measured and returned to the river. Forklength ranged from 214- 251 mm (240 mm average), and all samples were in the stage of smolting.

2008 Water Quality Survey in Support of the Vernalis Adaptive Management Plan (VAMP)

Contributed by Sharon Borglin, Jeremy Hanlon, Justin Graham, Chelsea Spier, Kennedy Nyugen, Remie Burks and William Stringfellow

Ecological Engineering Research Program, University of the Pacific

Introduction

During the 2008 Vernalis Adaptive Management Plan (VAMP) fish release the Ecological Engineering Research Program (EERP) at the University of the Pacific (UOP) conducted a water quality sampling program (WQ) to determine ambient conditions in the San Joaquin River (SJR) near the City of Stockton Waste Water Treatment Plant (WWTP). This study was commissioned following detection of numerous immobile fish tags in the SJR near the WWTP during the 2007 VAMP fish release. In 2007 during mobile monitoring in the SJR from Mossdale to the Stockton Deep Water Ship Channel, a high number of acoustic transmitters were detected at a very small, localized site adjacent to the Stockton WWTP outfall (SJRGA, 2007; Vogel, 2007). The area of concern was 0.75 miles downstream of the Highway 4 Bridge, 1.7 miles upstream of the Stockton Deep Water Ship Channel, and adjacent to a railroad bridge and the Stockton WWTP outfall. A total of 116 tags were found at this site which included some fish from all of the upstream releases made on the SJR during the proceeding two weeks. This may be a minimum number lost at that location as the mobile monitoring was done on May 17 and 18, 2007 after the battery life of some of the tags from the first week fish release may have ended. These tags were motionless, indicating the tags were either in dead fish or had been defecated by a predator. An investigation by the Regional Water Quality Control Board and an independent investigation commissioned by the City of Stockton (RBI Inc, 2007) found that the WWTP was in compliance with discharge permit requirements during the 2007 VAMP period. The cause of the high fish mortality observed in this area in 2007 could not be determined, but the local concentration of immobile tags strongly suggests that this area was a hostile environment for juvenile salmon in May 2007.

To determine if water quality could have been a factor in the mortality observed, EERP conducted a monitoring program in the SJR to determine physical and chemical water quality in the area of high fish mortality seen in 2007. This study was conducted to establish a more complete picture of water quality conditions during the period of the 2008 VAMP fish releases from May 1st to May 15th, 2008. In this report we present flow and water quality data collected in a six-mile reach of the San Joaquin River between Brandt Bridge (River Mile 46.7) and Burns Cutoff near Channel Point (River mile 40.5) (Figure 6-10).

Figure 6-9
Expanded daily catch of non-marked Chinook based on vulnerability estimates and flow at Vernalis, 2008

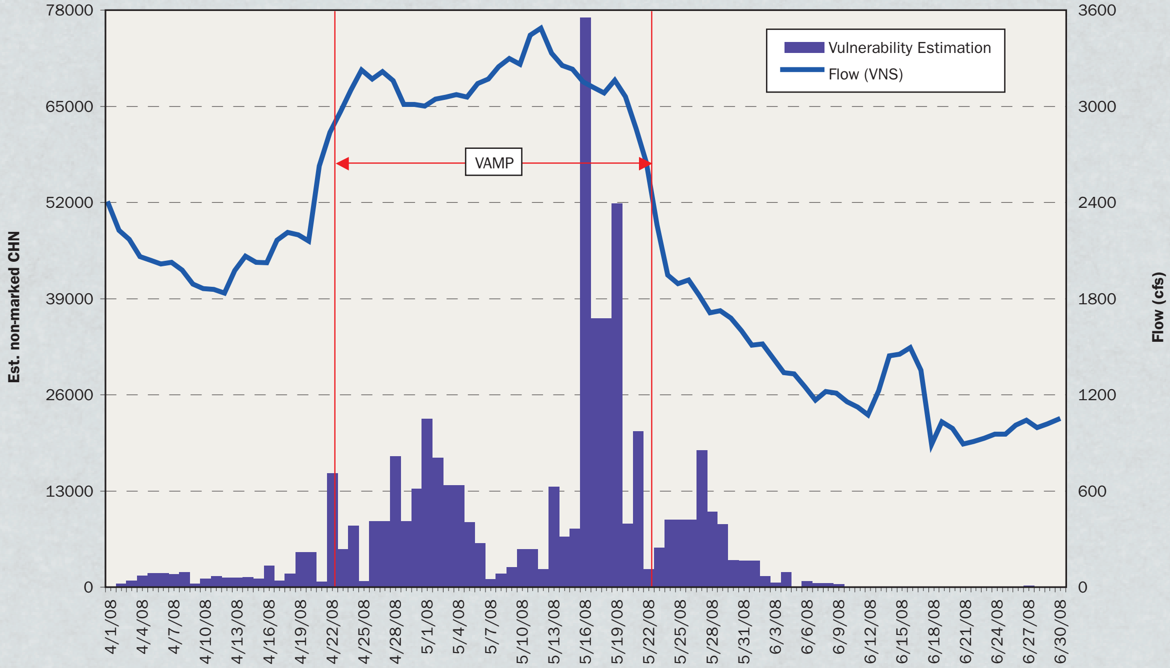


Figure 6-10
Map of study area showing sampling sites

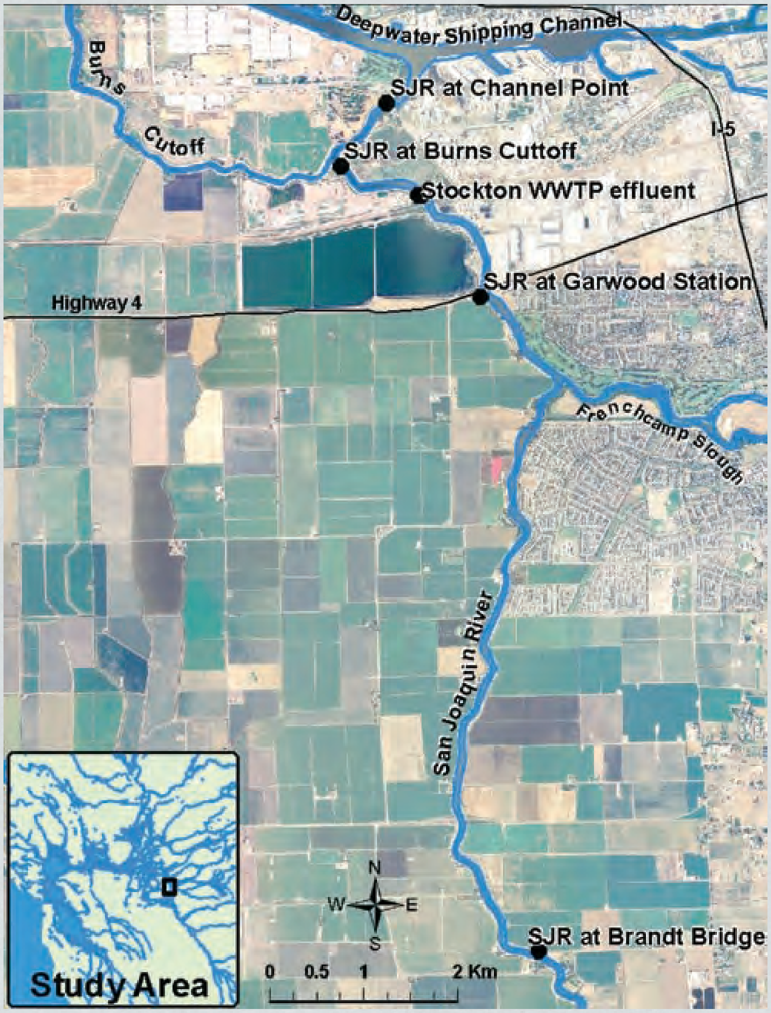


Table 6-2 Smolt Production seasonal estimates and sampling period for the duration of the study.				
Year	Sampling Period (Days)	Percentage of Day Sampled (%)	Smolt/ac-ft Estimate	"Vulnerability Smolt Production Annually Population Ratio Method (95% confidence range)"
2008	91	63.7	188,652 + 8,010	285,886 : (29,043 - 67,432)
2007	75	76	273,798 + 7,490	920,006***
2006	75	85.3	848,394 + 12,888	1,808,143 : (1,749,531- 1,866,755)
2005	89	80.9	363,800 + 14,700	621,403 : (388,884- 1,119,550)
2004	61	88.5	92,500 + 66,500	297,348 : (191,222- 665,160)
2003	88	80.7	107,500 + 60,300	368,424 : (277,626- 545,121)
2002	74	87.8	229,100 + 557,100	2,254,647 : (1,455,066- 5,179,591)
2001	103	78.6	279,800 + 286,000	928,996 : (586,790- 2,228,789)
2000	88	81.8	211,100 + 181,900	484,703**
1999	119	71.4	146,900 + 63,500	438,979**
1998	99	67.7	1,075,000 + 562,800	2,844,637**
1997	92	69.6	168,600 + 89,400	635,517**
1996	89	85.4	381,900 + 626,900	1,155,319**
1995	60	78.3	1,108,900 + 2,640,000	3,361,384**
1994	63	73	67,500 + 62,200	453,245**
1993	83	61.4	54,200 + 21,800	269,035**
1992	72	44.4	23,600 + 6,300	280,395**
1991	59	66.1	*	538,005**
1990	82	69.5	*	263,932**
1989	54	100	*	4,241,862**

* Data is currently being reevaluated.
** 1989-2000 estimates based on the natural log of all vulnerability tests (1989-2005).
*** 2007 estimates based on the natural log of all vulnerability tests (1989-2006)

CHAPTER 6

Materials and Methods

To document ambient river conditions during the 2008 VAMP fish releases, water quality grab samples were collected daily from May 1st through 15th, 2008 on the outgoing tide at four sites along the SJR; one upstream background site (Brandt Bridge), a site directly above the WWTP (Garwood), a site located at the WWTP outfall (Outfall), and a site downstream of the WWTP (Burns Cutoff). Samples of the WWTP effluent were also collected (Figure 6-10).

In conjunction with the grab sample data, continuous water quality sondes were deployed at four SJR sites; DO-01 Channel Point (for DO-194 Burns Cutoff), DO-84 SJR at Garwood Bridge, DO-127 SJR at Brandt Bridge, and DO-195 SJR at Stockton WWTP Outfall (Figure 6-10). All sampling was coordinated with fish-cage and fish tagging studies conducted as part of the 2008 VAMP research program. Fish cages were located at Brandt Bridge, Stockton WWTP outfall, and Burns Cutoff (Nichols and Foott, 2008).

River and effluent flows

River flow data was collected at two continuous water quality sampling locations, DO-84 SJR at Garwood Station and DO-127 SJR at Brandt Bridge. The flow measurement station SJR at Brandt Bridge (station ID: BDT) is operated by the Department of Water Resources (DWR). The flow measurement station SJR at Garwood Bridge (station ID: SJG) is operated by USGS. Data from both sites was taken directly from the CDEC website. Flow data was measured and recorded by DWR or USGS every fifteen minutes at the two stations. Effluent flow data for the WWTP was recorded from the flow meter at the water quality sampling site DO-193 WWTP during grab sampling events.

Daily Water Quality Monitoring

Samples were collected in bottles attached to a pole and were depth integrated by moving the bottle between the top and bottom of the water column during filling. All grab samples were collected by boat on an outgoing tide. Samples of WWTP discharge were collected at the same time as the other grab samples.

In addition to the grab samples, water quality field data was collected at each location using an YSI 6600 multi-parameter sonde connected to an YSI 650 MDS handset (YSI Inc., Yellow Springs, CO). While the sonde logged water quality data, water samples were collected according to established protocols (Graham and Hanlon, 2008; Puckett, 2002). A description and photo documentation of sampling activities were also made.

Samples were returned to the EERP laboratory and analyzed for the constituents listed in Table 6-3. All data in the project was collected in accordance with rigorous, Surface Water Ambient Monitoring Program (SWAMP) compatible, QA/QC procedures (Puckett, 2002; Stringfellow, 2005; Borglin et al., 2006; California Department of Fish and Game, 2007). Briefly, samples were received by the laboratory the same day they were sampled, logged in and inspected for damage, and stored at 4°C until filtering and analysis. All filtration and preservation of samples were completed within 24 hours. Samples were collected, preserved, stored, and analyzed by methods outlined in Standard Methods for the Analysis of Water and Wastewater (Clesceri et al., 1998; Clesceri et al., 2005).

Continuous Water Quality Monitoring

Daily WQ grab sampling was supplemented with deployment of continuous monitoring devices (YSI 6600 sondes) monitoring chlorophyll a, pH, dissolved oxygen, and other key WQ parameters at 15-minute intervals (Table 6-3, field measurements). The sonde depth averaged around 3 ft but varied with the tidal cycle (Graham and Hanlon, 2008). Sondes were not deployed in the Stockton WWTP effluent or at the confluence of the SJR and Burns Cutoff. Continuous data for the Burns Cutoff location was collected at Channel Point, approximately 0.5 miles downstream. Data for pH was obtained from permanently installed monitors at the WWTP site and recorded at the time of field sampling.

Quality Assurance Summary

Quality assurance samples were run in parallel with all the sample analysis. Quality assurance samples included some or all of the following: a lab duplicate, field duplicate, matrix spike, matrix spike duplicate, calibration check standards, laboratory control standard, trip and lab blanks. From May 1st through May 15th, 2008, 98.9% of all laboratory quality assurance and 100% of all field quality assurance checks were within passing range. Proficiency check samples, standards with unknown concentration to the laboratory analyst, were run before the start and at the end of the project. All results were within established acceptable ranges.

Table 6-3
List of field and laboratory measurements made as part of the Water Quality Survey in Support of the Vernalis Adaptive Management Plan (VAMP) May 2008.

Field	Laboratory
Spec Cond mS/cm	Chlorophyll-a (Chl-a), ug/L
TDS mg/L	Pheophytin-a ug/L
DO mg/L	Alkalinity, mg CaCO3/L
pH	Total Organic Carbon (TOC), mg/L
ORP mV	Dissolved Organic Carbon (DOC), mg/L
Turbidity	Total Suspended Solids (TSS), mg/L
Sonde Chl-a ug/L	Volatile Suspended Solids (VSS), mg/L
	Total Nitrogen (TN) mg/L
	Total Ammonia Nitrogen (TAN), mg/L
	Nitrate Nitrogen (NO3-N), mg/L
	Nitrate Nitrogen (NO2-N), mg/L
	Total Phosphate (TP) mg/L
	Soluble Reactive Phosphate (PO4-P) mg/L

Findings: Water Quality

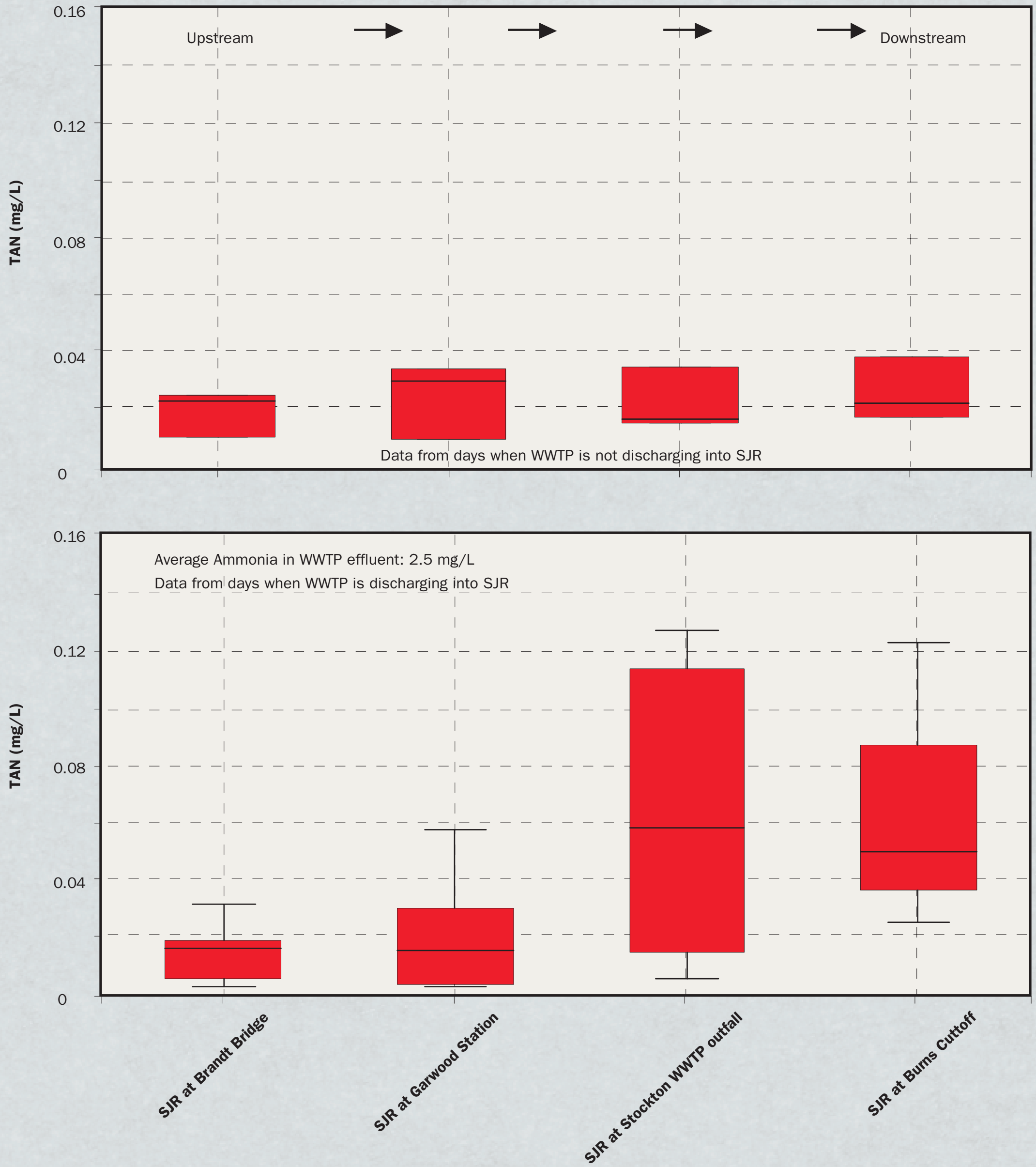
Field and laboratory results collected during the daily, grab sampling events are displayed in Tables 1 and 2 in Appendix D. All data was collected successfully with the exception of the loss of a set of chlorophyll samples on May 6th due to a refrigeration problem. Chlorophyll was quantified on this date by in-field sonde measurements at the time of sampling and continuous deployment sonde measurements, so no information was lost.

Concentrations of Total Ammonia Nitrogen (TAN) are shown in Figure 6-11. Concentrations of nitrite (NO_2-N) and nitrate (NO_3-N) over time showed similar trends. In the box and whisker plot in Figure 6-11, the central horizontal line in the box represents the data median, the box represents the upper and lower quartiles (representing ± 25% of the data) and the whiskers are the data maximum and minimum. The plots are aligned with the sites from upstream to downstream on the x-axis and include only the river sites. The top plot is the data from days when the WWTP was not discharging into the SJR, and the bottom plot is from days where there was WWTP discharge. The average WWTP value is reported above the lower plot.

Figures 6-12 and 6-13 show a time integrated 3-D plot of the TAN and NO3-N data, respectively. In the foreground, the x-axis represents the 15 days of sampling time increasing from left to right. The z-axis

Figure 6-11

Total Ammonia Nitrogen (TAN) concentration in the SJR upstream and downstream of the Stockton WWTP measured by the EERP laboratory in support of the 2008 VAMP project



CHAPTER 6

Figure 6-12
3-D plot of the Total Ammonia Nitrogen (TAN) concentration in the SJR upstream and downstream of the Stockton WWTP measured by the EERP laboratory in support of the 2008 VAMP project. The yellow ribbon represents treatment plant effluent concentration.

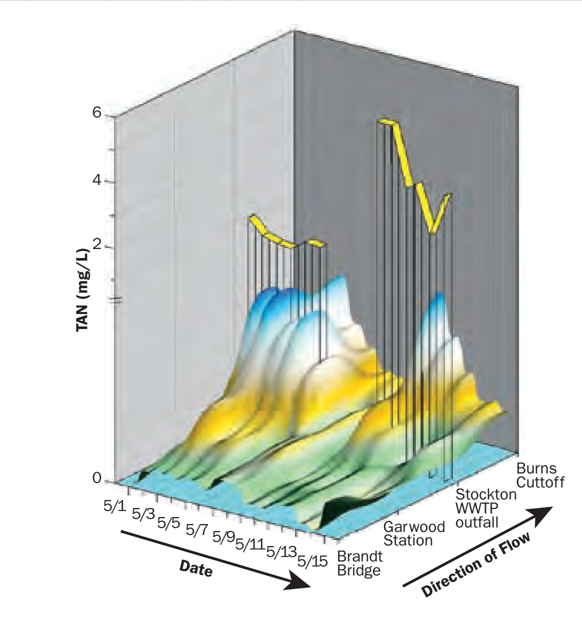


Figure 6-13
3-D plots of Nitrate-N concentration in the SJR upstream and downstream of the Stockton WWTP measured by the EERP laboratory in support of the 2008 VAMP project. The yellow ribbon represents the treatment plant effluent concentration.

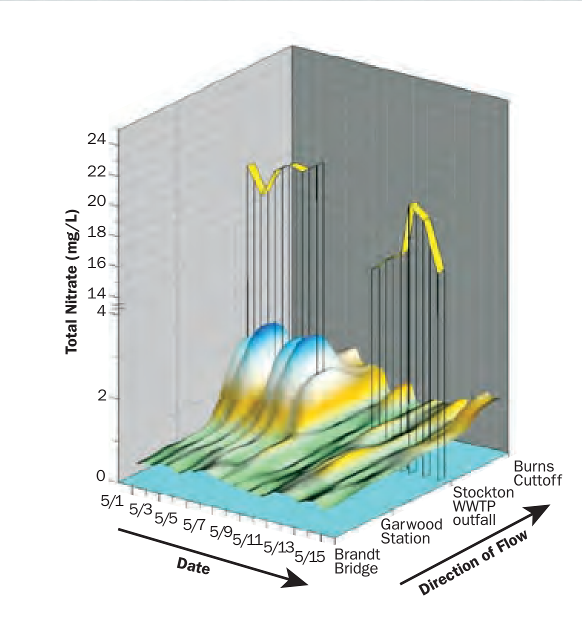


Table 6-4
Observed ammonia concentrations (TAN and un-ionized NH^3) and chronic criteria concentration (CCC) in the SJR during VAMP (May 1 May 15, 2008)

Sample Site	Average TAN (mg N/L)	Maximum TAN (mg N/L)	Average NH^3 (mg N/L)	Maximum NH3 (mg N/L)	Average CCC (mg TAN/L)	Minimum CCC (mg TAN/L)
Brandt Bridge (DO-127)	0.0159	0.0312	0.0005	0.001	2.949	1.847
Garwood (DO-84)	0.0202	0.0575	0.0007	0.002	2.634	1.496
SJR @ Stockton WWTP effluent (DO-195)	0.055	0.126	0.0011	0.002	3.105	1.734
Burns Cut (DO-194)	0.0541	0.1216	0.0014	0.005	3.088	1.67
Stockton WWTP effluent (DO-193)	2.5052	5.3232	0.0055	0.014	6.367	4.892

represents the relative position of each sample point in the river from upstream in the foreground towards downstream in the background. The y-axis represents the measured value of the indicated parameter. It can be seen from this data that after the discharge from the WWTP shut down both the TAN and NO3-N values diminished at the outfall river site DO-195. It was observed during field sampling that when the WWTP resumed discharging that the plume had a different character, with less aeration and it is possible that there was less mixing at the sample location, so the sample collected was not as influenced by the WWTP effluent. The Burn's cut site, DO-194, shows similar patterns before and after the WWTP shutoff.

Figures 6-12 and 6-13 indicate that concentrations of N compounds in the SJR are higher downstream during periods of the Stockton WWTP discharge. A two-tailed statistical t-test with unequal variance was performed to compare water quality at the upstream reference station (DO-127 Brant Bridge) and the downstream station (DO-194 SJR at Burns Cutoff) to see if differences in water quality upstream and downstream of the WWTP were significant. The t-test shows that all measured nitrogen compounds (TAN, nitrate, and nitrite) show a significant increase in concentration downstream of the WWTP discharges into the SJR.

Statistical comparisons were made between the upstream and downstream stations separately for the period of time when the WWTP was discharging and when it was not discharging. The results indicate that for many water quality variables, concentrations at upstream and downstream locations were statistically different only when the WWTP was discharging. These variables included specific conductance, alkalinity, total and dissolved organic carbon, ammonia-N, nitrate-N, nitrite-N, and total-N. This result further supports the conclusion that WWTP discharge can influence ambient water quality conditions in the SJR.

Other parameters with significant increases after the WWTP began discharging (95% confidence interval) include volatile suspended solids, phosphate-P and turbidity. Those parameters with no significant change include total suspended solids, mineral solids, chlorophyll, total P, dissolved oxygen, alkalinity, chlorine, and pH.

Findings: Ammonia and Fish Toxicity

The regulatory criteria for ammonia in water were established by USEPA (1999) and consist not of a single value but an equation that is dependent on several factors: (1) the presence of salmonids (2) presence of early life stages (3) pH and (4) temperature. The complex nature of ammonia toxicity is due to the fact that the ammonium ion (NH_4+), which is predominant at low pH, is much less toxic than ammonia (NH3) which is predominant at higher pH. The chronic criteria concentration (CCC) was calculated for all the sites during the VAMP period assuming early life stages and salmonids present using the following equation given by USEPA (1999):

$$CCC = 0.854 \cdot \left(\frac{0.0676}{1 + 10^{7.688\text{-}pH}} + \frac{2.912}{1 + 10^{pH\text{-}7.688}} \right) \cdot MIN\ (2.85,\ 1.45 \cdot 10^{0.028 \cdot (25\text{-}T)})$$

Where T = temperature. For example, on May 3rd site DO-195, the SJR at the WWTP outfall, had a pH of 7.58 and temperature of 17.04°C, resulting in a CCC for this site of 4.05 mg/L TAN. The measured value of TAN on this date was 0.126 mg/L. The overall average CCC value for the river was found to be 2.9 +/- 0.8 mg TAN/L. The observed concentrations of TAN, NH_3-N, and the CCC for each location are given in Table 6-4. As can be seen from this table, TAN levels were well below the CCC during the VAMP period. Also note that the CCC is higher in the WWTP effluent samples due to the lower pH in those samples. The acute criteria are calculated in a similar manner and are generally one order of magnitude larger than the CCC.

The 1999 USEPA guidelines for CCC use fish death as a measurable endpoint after 30 days of exposure in a controlled system. However, it has been shown that values of ammonia below the CCC can cause changes in fish behavior that can influence fish survivability in real systems. Several studies have found that levels of TAN from 0.001 – 0.25 mg/L are detrimental to the swimming speed of salmonids, therefore reducing survivability (Buhl, 2002; Randall and Tsui, 2002; McKenzie et al., 2003; Passell et al., 2007). In addition, some studies have shown that when fish are swimming, feeding, or stressed by additional contaminants such as Cu, salt, chlorine or other environmental conditions they will have increased sensitivity to ammonia (Randall and Tsui, 2002; Passell et al., 2007). Cu at levels as low as 0.08 µM (5 ¨µg/L) has been shown to increase the level of ammonia in blood because it interferes with the ion regulatory systems and impairs ammonia excretion and increases internal ammonia production from food digestion (McKenzie et al., 2003). While Cu was not measured in this study, historical data shows an average value of 1.7 ¨µg/L Cu in the SJR, with measured values ranging from 1 to 70 µg/L (DWR, 2004; Buck et al., 2007).

Conclusions

Water quality monitoring was performed in the SJR adjacent to the Stockton WWTP during the 2008 VAMP fish release. Results demonstrate that the WWTP discharge has an effect on water quality especially in respect to N compounds, including TAN. However, concentrations of ammonia are below the CCC established by the USEPA for protection of fish health. Further study is need to determine if a combination of water quality constituents, including salts, Cu, and chlorine, could combine to create conditions that would reduce the survivability of salmonids in the SJR.

Survival and Physiological Evaluation of Chinook Salmon held in the San Joaquin River near the Stockton Wastewater Treatment Plant, May 2008.

Contributed by Ken Nichols and J. Scott Foott, USFWS, CA-NV Fish Health Center

Introduction

As a component of the 2008 Vernalis Adaptive Management Plan (VAMP) study on reach-specific survival and distribution of migrating Chinook salmon in the San Joaquin River and delta, the CA-NV FHC conducted a bioassay to assess acute water quality effects on salmon. In 2007, acoustic tags from juvenile Chinook salmon were detected "not moving" near the Stockton Waste Water Treatment Plant (WWTP). Due to the mortality observed in 2007, aquatic bioassays were conducted in the critical reach near the WWTP during the initial 24 hours of the 2008 VAMP study releases.

Methods

Fish

Juvenile Chinook salmon used in this study were reared at the California Department of Fish and Game Merced River Hatchery (MRH) and were cohorts of the acoustic tagged Chinook used in the VAMP survival and distribution studies. Exposures began on the same days as the acoustic tagged fish were released at Durham Ferry. The first exposure began on May 1st and the second exposure on May 8th. Prior to transport, weight and fork length were measured from 20 fish of the tank population used for the study. This data was not collected at the exposure sites to speed necropsy. Another 60 salmon were transported in an aerated 80 gal tank to the bioassay sites in 6 live cages (10 fish / cage). Total transport time averaged 2 hours.

Sites

The three exposure sites were at the Stockton WWTP outfall (WWTP), Burn's Cut about 0.5 miles downstream of the water treatment plant (Downstream), and a control site at Bryant Bridge approximately 8 miles upstream of the WWTP (Control). Two live cages were placed at each site. Temperature and dissolved oxygen were measured at each site using a Hach HQ10 portable LDO meter at the end of each exposure.

Figure 6-14
Photomicrograph of Microvesecular hepatocyte vacuoles in the liver of juvenile fall Chinook salmon. H&E stain.

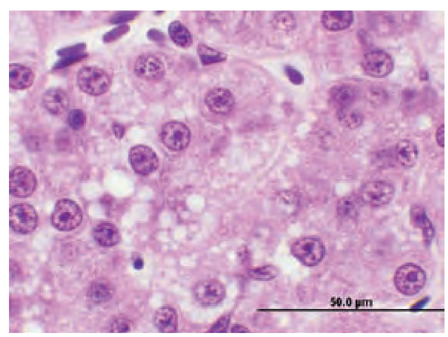


Figure 6-15
Photomicrograph of epithelial edema in the gill of juvenile fall Chinook salmon. H&E stain.

Table 6-5
Histological evaluation of gill, liver, and kidney from MRH salmon used as sentinels for VAMP release 1 (April 29th - May 1st). Data recorded as number of fish showing abnormality over total fish sampled at 4 or 24h at the control, WWTP outfall, or downstream of outfall. Also listed is the incidence of *T. bryosalmonae* (Tb) infection and number of infected fish showing severe interstitial hyperplasia (inflammation).

	Control		WWTP		Downstream	
	4h	24h	4h	24h	4h	24h
Epithelial edema in >10% of gill	3/10	1/10	1/10	1/9	0/5	1/5
Vacuolated hepatocytes	3/9	3/8	2/9	2/9	2/4	1/5
Incidence of Tb infection	80%	100%	50%	66%	80%	80%
Interstitial inflammation	1/8	3/10	0/10	0/9	0/5	0/5

Table 6-6
Histological evaluation of gill, liver, and kidney from MRH salmon used as sentinels for VAMP release 2 (May 6 th- May 8 th). Data recorded as number of fish showing abnormality over total fish sampled at 4 or 24h at the control, WWTP outfall, or downstream of outfall. Also listed is the incidence of *T. bryosalmonae* (Tb) infection and number of infected fish showing severe interstitial hyperplasia (inflammation).

	Control		WWTP		Downstream	
	4 hr	24 hr	4 hr	24 hr	4 hr	24 hr
Epithelial edema in >10% of gill	0/10	0/10	1/10	0/10	2/10	0/10
Vacuolated hepatocytes	1/10	1/10	3/10	0/10	5/10	3/10
Incidence of Tb infection	80%	90%	60%	90%	70%	100%
Interstitial inflammation	1/10	0/10	0/10	0/10	0/10	2/10

Table 6-7
Blood chemistry data for 2008 VAMP fish used in live cage bioassays at the Stockton Waste Water Treatment Plant outfall (WWTP) 0.5 miles downstream of the WWTP (Downstream) and 8 miles upstream of the WWTP (Control). Exposures corresponded with the 2008 VAMP release groups on May 1st and May 8 and fish were held in live cages at the sites for 4 and 24 hours before sampling. Data presented as mean ± SE (n).

Exposure	Time	Site	HCT (%)	TP (mg/dl)	Cl- (mEq/l)
May 1st	4 hrs	Control	39.0±1.9 (10)	29.3±2.1 (10)	124±3 (10)
		WWTP	40.5±1.3 (10)	37.2±3.4 (10)	134±6 (10)
		Downstream	45.6±4.5 (5)	29.1±1.7 (5)	138±10 (5)
	24 hrs	Control	33.5±1.5 (10)	29.0±2.1 (9)	148±11 (9)
		WWTP	36.1±1.9 (10)	25.6±1.1 (10)	128±3 (10)
		Downstream	35.8±0.5 (4)	26.5±1.2 (4)	117±1 (5)
May 8th	4 hrs	Control	42.0±0.9 (10)	32.5±1.1 (10)	120±7 (10)
		WWTP	42.9±1.7 (9)	35.6±1.2 (10)	117±5 (10)
		Downstream	40.3±1.2 (10)	33.6±1.1 (10)	117±6 (10)
	24 hrs	Control	38.3±1.4 (9)	25.0±0.8 (9)	119±1 (9)
		WWTP	42.0±0.8 (10)	28.4±1.6 (10)	110±6 (10)
		Downstream	34.3±1.2 (10)	31.0±4.0 (10)	123±3 (10)

Sampling

One live cage at each of the 3 sites was sampled after 4 and the other at 24 hours post exposure. Fish were euthanized in an overdose of MS222 and immediately bled into heparinized microhematocrit tubes from the severed caudal peduncle. Blood was used to prepare a blood smear, assay for methemoglobin, centrifuged to obtain the hematocrit value and collect plasma. Plasma was held on dry ice for frozen transportation back to -80ºC storage. Tissues were collected for histology, and samples of gill, liver and kidney collected and frozen in liquid nitrogen for further analysis, if needed, by Dr. Inge Warner (UC Davis).

Assays

Histopathology – The gills, viscera (intestinal tract, pyloric caeca, heart, liver and spleen) and posterior kidney were rapidly removed from the fish and immediately fixed in Davidson's fixative, processed for 5 mm paraffin sections and stained with hematoxylin and eosin (Humason 1979). All tissues for a given fish were placed on one slide and identified by a unique code number. Each slide was examined at low (40X) and high magnification (400X).

Methemoglobin (metHb) Assay – Elevated nitrite levels can induce methemoglobinema in fish (Wedemeyer 1996). A blood sample was tested for percent methemoglobin using a method modified from Fairbanks and Klee (1994). In short, 20 ml of blood was diluted in 1980 ml phosphate buffer (0.067M, pH 6.7). The samples was mixed and split into 2 cuvets (A and B). A solution of 20% $K_3Fe(CN)_6$ was added to cuvet B and allowed to react for 2 min. The absorbance (630 nm) of both cuvets was then read in a spectrophotometer (A_1 and B_1) using 50% phosphate buffer in water as a blank. A drop of neutralized cyanide (6% acetic acid and 5% sodium cyanide in water) was added to all cuvets. The sample was mixed and absorbance read again (A_2 and B_2). The percent metHb was then calculated as $100*(A_1-A_2)/(B_1-B_2)$.

White blood cell count – Blood smears were stained with a Diff-Quick stain kit (Dade-Behring, Newark DE) and read at 1000X magnification. A total of 100 white blood cells were counted and identified to lymphocyte, thrombocyte, neutrophil, or monocyte. The ratio of leukocytes to granulocytes (neutrophil) was calculated.

Plasma total protein and chloride – Plasma was stored at -80ºC until analyzed. Total protein was measured using colorimetric analysis reagents from Point Scientific (Canton, Michigan, kit T7528) and bovine serum albumin as a standard. Plasma chloride was measured using colorimetric analysis reagents from Point Scientific (kit C7501).

Results

Fish

Average (SE) fork length and weight was 96.8mm (0.3mm) and 9.8g (0.1g) for the May 1st exposure, and 106.0mm (0.6mm) and 12.3g (0.2g) for the May 8th exposure. All fish survived the exposures. Due to a failure of the anchor system, one of the two live cages was lost at the Burn's Cut site in the May 1st exposure. The 10 fish from the remaining live cage were split for the 4 and 24 hr samples.

Sites

The Stockton Waste Water Treatment Plant was discharging effluent during the May 1st (first) exposure period, but the plant was not discharging during the May 8th (second) exposure. The plant was down for maintenance and did not discharge for the entire 24 hour exposure period. Dissolved oxygen measurements at the exposure sites ranged from 7.8-9.8 mg/L. Water temperature measurements ranged from 17.1 to 19.6ºC on the May 1 exposure and 19.4 to 21.5ºC on the May 8th exposure.

Assays

Histopathology

Most of the fish in the experiment were infected with *Tetracapsuloides bryosalmonae* (Tb) with associated kidney inflammation apparent in only a few samples (Tables 6-5 and 6-6). There was no difference in *Tb* infection between exposure groups or sites. The incidence of microvesicular hepatocyte vacuoles (Fig. 6-14) in the liver was higher in fish exposed May 1st compared to fish exposed on May 8th. Similarly, edema of the gill epithelial layer (Figure 6-15) was noted in a few fish from all groups. These changes were observed in fish from all exposure sites with no evidence of a difference between sites.

MetHb assay

This assay failed to perform under field conditions. Results were highly variable ranging from negative values to well over 100% MetHb.

Hematocrit

Values were all within normal range (25-55 %, Table 6-7). The only significant difference detected was between the May 8th Downstream and WWTP 24 hour exposure groups (P<0.001, ANOVA). None of the fish had HCT values suggesting anemia.

White blood cell count

No obvious differences between groups were observed in the WBC counts, but a high number of lysed cells made counts difficult and possibly biased. This assay was not used in any analysis.

Plasma total protein

No differences were detected between fish at any of the sites in the May 1st exposure groups or May 8th exposure groups (P>0.05, ANOVA) (Table 1). A potential hyperproteinemia ($\geq$40 mg/dl) was observed in several (7 of 107) fish. These fish were noted at all sites and no pattern in exposure time or location was evident (data not shown)

Plasma chloride

A difference was observed in the May 1st (24 h) exposure groups between the WWTP and the control site (P=0.028, ANOVA). No differences were detected in any of the other exposure groups. Three of the 10 fish in the May 1st WWTP 24 h exposure group were hyperchloremic (>140 mEq /L) which caused this group to stand out. In total, 7 of 108 fish were potentially hyperchloremic and were detected in samples from all 3 sites. One fish from the May 8th Downstream 24 h exposure group appeared hypochloremic.

Discussion

The purpose of this VAMP study component was to determine if there was localized acute mortality or morbidity associated the WWTP effluent as hypothesized in 2007. None of the fish in this study died and no significant site specific sub-lethal effects were identified. In past monitoring of VAMP study fish, the most significant health finding for study fish was infection with *T. bryosalmonae* (Foott et al. 2007). While the incidence of *T. bryosalmonae* (causative agent of Proliferative Kidney Disease or PKD) was high in the all the exposure groups, it appeared that the infections were in early stages and would not influence the fish's performance. The MRH Fall Chinook become infected with *T. bryosalmonae* at the hatchery, and mortality due to PKD does not occur until June after the VAMP studies are completed (Foott et al. 2007). Elevated plasma protein and chloride values (hyperproteinemia and hyperchloremia) were observed in fish from all sites and both exposure periods. These elevated plasma chemistry values were likely not a result of the exposure site, but rather changes due to our handling of the fish or samples. Possible explanations of these elevated plasma chemistry values include: plasma reduction due to shock, contamination of the plasma in the field, or desiccation of the plasma.

A difference in HCT values was detected between the WWTP and downstream sites during the May 8th exposure, but the difference was not large enough to have any biological significance as none of the fish were anemic. Elevated HCT can result from the stress response of splenic contraction and erythrocyte swelling (Wells and Weber 1991). The histopathological changes observed in the gills did not appear to be related to exposure site, and were more likely artifacts of delayed fixation. Hepatocyte vacuoles appeared to be a mix of fat and glycogen. This condition is not atypical for hatchery salmon fed high energy diets.

Two of the assays attempted in this study did not perform well enough to be included in the analysis. The metHb assay relied on the ability to quickly and consistently process the blood sample in the field. Several factors which may have interfered with the metHb assay including: multiple fish were processed at a time delaying some steps; warm weather likely caused blood to clot and reagents react and degrade faster than expected; bright sunlight and dust may have interfered with the spectrophotometer. This assay may perform much better in the lab where a single fish could be processed at a time and environmental conditions could be better controlled. The white blood cell count assay was impaired by high numbers of smudge and ghost cells which may have been affected by field conditions including temperature and delayed processing.

CHAPTER 7

CONCLUSIONS AND RECOMMENDATIONS

Start of the VAMP pulse flow period was again delayed from the default period to April 22 to May 22 to allow the test fish to increase in size. 2008 was the second consecutive year with a Critical year classification. Even though the projected Existing Flow was estimated to be slightly less than 2,000 cfs the SJRGA committed to providing the supplemental water necessary to support a VAMP target flow of 3,200 cfs. The final average Vernalis pulse flow over the 31-day period was 3,163 cfs, varying between 2,640 cfs and 3,480 cfs. Combined exports averaged 1,520 cfs. Flow monitoring was conducted by DWR using Acoustic Doppler Current Meters in the San Joaquin River upstream and downstream of the Old River and downstream of the HOR and in the Old River. The results for survival component and predator monitoring of the VAMP study in 2008 have been delayed as the USGS continues to analyze the data that was collected. Unfortunately the 2008 results will be hampered by a lower than acceptable acoustic tag reliability caused by premature battery failure.

Planning for the 2008 study was initiated by the SJRA Technical Committee in August of 2007. The acoustic telemetry study implemented in 2008 involved the efforts of the USFWS, USGS, DFG and SJRGA consultants. Studies complimentary to VAMP were conducted by various consultants and agencies. In particular, the studies by the University of the Pacific and Natural Resource Scientists, Inc. evaluated water quality conditions and predation, respectively.

Conclusions and recommendations have been developed, and summarized in Table 7-1. The conclusions and recommendations include both technical and policy/ management issues that will affect the implementation of future VAMP operations and investigations.

Table 7-1
Summary of VAMP 2008 conclusions and recommendations

CONCLUSIONS	RECOMMENDATIONS FOR 2009
The flow data collected in 2008 at the San Joaquin River near Lathrop, Old River at Head and San Joaquin River near Mossdale Bridge ADCMs provided useful information on the flow split at the Head of Old River	The 2005 through 2008 flow data should be compared against DWR-DSM2 modeling results. Continue to measure the stage and flow monitoring at these locations.
Premature failure (battery failure) of the acoustic tags negated the ability to accurately predict smolt survival.	Increase manufacturer quality control and provide additional field verification of tag reliability. Continue tag life study in 2009.
Access to the fish release sites at Durham Ferry was limited and difficult, requiring added fish handling	Relocate the Durham Ferry release site to provide improved access.
There were difficulties in tempering the fish at Durham Ferry.	Improve processes for transporting, tempering and releasing test fish.
Short-term survival (48-hours post-transport) was high (94%) indicating that handling, transport, and release likely had minimal effect on short-term smolt survival.	Continue net pen studies and fish health inspections.
The timing of VAMP has been designed to adaptively change within a few weeks.	Continue to identify opportunities when it would be beneficial to delay the VAMP period to stabilize VAMP test conditions and to increase protection for juvenile Chinook salmon outmigrating from the San Joaquin basin.
Further evaluation of survival rate versus export rate is needed. The VAMP is limited by data at the target conditions of 7000 cfs flow with a HORB with exports at 1500 or 3000 cfs.	Evaluate the possibility of amending the San Joaquin River Agreement to achieve needed test conditions of 7000 cfs flow with a HORB at exports of 1500 or 3000 cfs. Prescribing target conditions will allow the most critical data to be obtained quickly so that the role of exports can be identified in the most efficient manner.
The Acoustic Telemetry study conducted in 2008 was challenging and had less than satisfactory tag reliability.	Continue to coordinate among agencies and plan early. Repeat tag life study in 2009.

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Signatories to The San Joaquin River Agreement

U.S. BUREAU OF RECLAMATION

U.S. FISH AND WILDLIFE SERVICE

CALIFORNIA DEPARTMENT OF WATER RESOURCES

CALIFORNIA DEPARTMENT OF FISH AND GAME

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SOUTH SAN JOAQUIN IRRIGATION DISTRICT*

MODESTO IRRIGATION DISTRICT*

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MERCED IRRIGATION DISTRICT*

SAN JOAQUIN RIVER EXCHANGE

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CANAL WATER AUTHORITY

SAN JOAQUIN RIVER GROUP AUTHORITY

*San Joaquin River Group Authority Members

2008 Useful Web Pages

Page 4 San Joaquin River Agreement
www.sjrg.org/agreement.htm

Page 4 SWRCB Decision 1641
www.waterrights.ca.gov/hearings/Decisions.htm

Page 9 VAMP Annual Technical Reports
www.sjrg.org

Page 9 VAMP Experimental Design
www.sjrg.org/agreement.htm

Page 14 CDEC Daily
http://cdec.water.ca.gov/cgi-progs/queryDgroups?s=fw2

Page 14 Vernalis, USGS Daily(USGS, station 11303500)
http://waterdata.usgs.gov/ca/nwis/dv?cb_00060=on&format=html&begin_date=2008-02-01&site_no=11303500&referred_module=sw

Page 14 Newman, USGS Daily(USGS, station 11274000)
http://waterdata.usgs.gov/ca/nwis/dv?cb_00060=on&format=html&begin_date=2008-02-01&site_no=11274000&referred_module=sw

Page 14 LaGrange, USGS Daily
(USGS, station 11289650)
(http://waterdata.usgs.gov/ca/nwis/dv?cb_00060=on&format=html&begin_date 2008-02-01&site_no=11289650&referred_module=sw

Page 14 Goodwin, USBR Daily
(USBR, Goodwin Dam Daily Operation Report)
http://www.usbr.gov/mp/cvo/vungvari/gdwdop.pdf

Page 14 Cressey, CDEC Daily(CDEC, station CRS)
http://cdec.water.ca.gov/cgi-progs/queryDgroups?s=fw2

Page 14 Stevinson, CDEC Daily(CDEC, station MST)
http://cdec.water.ca.gov/cgi-progs/queryDgroups?s=fw2

Page 50 CVP and SWP Salvage Data
www.iep.ca.gov

Page 50 USFWS Stockton
www.delta.dfg.ca.gov/data/salvage

Page 48 Pacific States Marine Fisheries Commission
Regional Mark Information System
www.psmfc.org/Regional_Mark_Processing_Center_RMPC

Common Acronyms and Abbreviations

ADCP	Acoustic Doppler Current Profiler
Bay-Delta	Sacramento and San Joaquin Rivers San Francisco Bay Delta
CCF	Clifton Court Forebay
CDEC	California Data Exchange Center
CDRR	Combined Differential Recovery Rate
CFS	Cubic Feet Per Second
CNFHC	California/Nevada Fish Health Center
CPUE	Catch Per Unit Effort
CRR	Combined Recovery Rate
CRRL	Columbia River Research Laboratory
CVP	Central Valley Project
CWT	Coded-Wire Tagged
D-1641 SWRCB	Water Rights Decision 1641 of the
DFG Game	California Department of Fish and
DWR	California Department of Water Resources
GLC	Grant Line Canal
HTI	Hydroacoustic Technology Incorporated
HOR	Head of Old River
HORB	Head of Old River Barrier
Merced	Merced Irrigation District
MID	Modesto Irrigation District
MR	Middle River
MRH	Merced River Hatchery
MSL	Mean Sea Level
NOAA	National Oceanic and Atmospheric Administration Fisheries
OID	Oakdale Irrigation District
ORT	Old River at Tracy
PKD	Proliferative Kidney Disease
RM	River Mile
RST	Rotary Screw Trap
SDWA	South Delta Water Agency
SJRA	San Joaquin River Agreement
SJRECWA	San Joaquin River Exchange Contractors Water Authority
SJRGA	San Joaquin River Group Authority
SJRTC	San Joaquin River Technical Committee
SSJID	South San Joaquin Irrigation District
SWP	State Water Project
SWRCB	State Water Resources Control Board
TAN	Total Ammonia Nitrogen
TBP	Temporary Barriers Project
TID	Turlock Irrigation District
USB	Universal Serial Bus
USBR	United States Bureau of Reclamation
USFWS	United States Fish and Wildlife Service
USGS	United States Geologic Survey
VAMP	Vernalis Adaptive Management Plan
WQCP	Water Quality Control Plan for the Bay-Delta Estuary
WWTP	Waste Water Treatment Plant

APPENDIX

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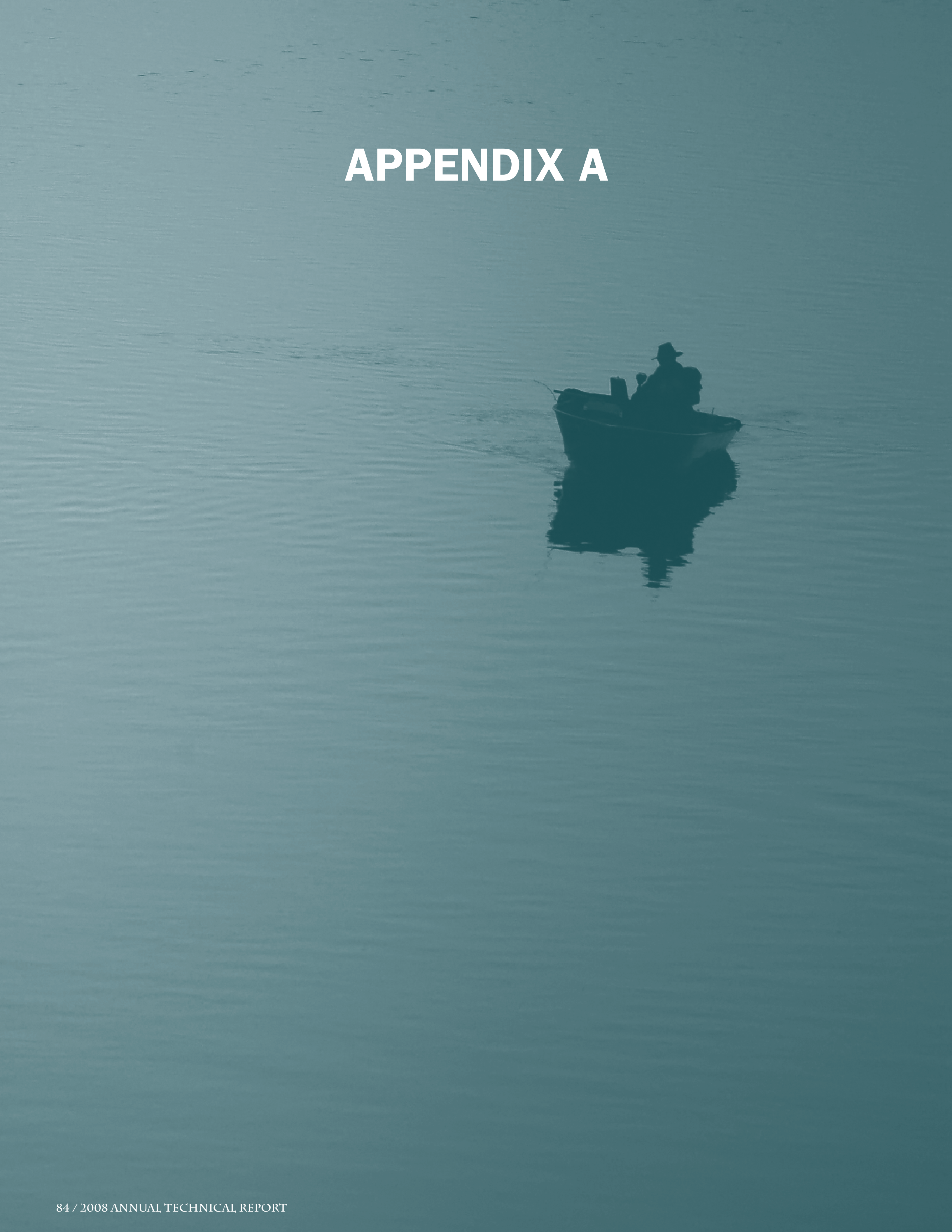
APPENDIX A



Appendix A-1, Table 1

2008 VAMP DAILY OPERATION PLAN — MARCH 14, 2008
(A1) LOW UNGAGED FLOW
Target Flow Period: April 24 - May 24 • Flow Target: 3,200 cfs
Bold Numbers: observed real-time mean daily flows

	San Joaquin River near Vernalis						Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus R blw Goodwin					
Date	Existing Flow	VAMP Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced River 2 day lag)	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. Flow	Exch Contr VAMP Suppl. Flow	VAMP Flow (3 day lag)	Existing Flow - base FERC Volume	Existing Flow - Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2 day lag)	Existing Flow - Base	Existing Flow- reshaped	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol. S=Stan.
	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		(cfs)	(cfs)	(cfs)	
3/15/08																				
3/16/08																				
3/17/08																				
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3/25/08																				
3/26/08																				
3/27/08																				
3/28/08																				
3/29/08							250			250										
3/30/08					492		250			250	170	170		170	746	746			746	
3/31/08					488		250			250	170	170		170	746	746			746	
4/1/08	1,858			1,858	484	200	250			250	170	170		170	746	746			746	
4/2/08	1,854			1,854	480	200	250			250	170	170		170	746	746			746	
4/3/08	1,850			1,850	476	200	250			250	170	170		170	746	746			746	
4/4/08	1,846			1,846	472	200	250			250	170	170		170	746	746			746	
4/5/08	1,842			1,842	468	200	250			250	170	170		170	746	746			746	
4/6/08	1,838			1,838	464	200	250			250	170	170		170	746	746			746	
4/7/08	1,834			1,834	460	200	250			250	170	170		170	746	746			746	
4/8/08	1,830			1,830	456	200	250			250	170	170		170	746	746			746	
4/9/08	1,826			1,826	452	200	250			250	170	170		170	746	746			746	
4/10/08	1,822			1,822	448	200	250			250	170	170		170	746	746			746	
4/11/08	1,818			1,818	444	200	250			250	170	170		170	746	746			746	
4/12/08	1,814			1,814	440	200	250			250	170	170		170	746	746			746	
4/13/08	1,810			1,810	436	200	250			250	170	170		170	746	746			746	
4/14/08	1,806			1,806	432	200	250			250	170	170		170	746	746			746	
4/15/08	1,802			1,802	428	200	250			250	250	250		250	746	746			746	
4/16/08	1,798			1,798	424	200	250			250	250	250		250	746	746			746	
4/17/08	1,874			1,874	420	200	250			250	250	250		250	746	746			746	
4/18/08	1,870			1,870	416	200	250			250	250	250		250	746	746			746	
4/19/08	1,866			1,866	412	200	250			250	250	250		250	746	746			746	
4/20/08	1,862			1,862	408	200	250			250	250	250		250	746	746			746	
4/21/08	1,858			1,858	404	200	250	557	81	888	250	250		250	746	746			746	
4/22/08	1,854			1,854	400	200	250	557	81	888	732	732	163	895	746	746	135	0	881	
4/23/08	1,850			1,850	396	200	250	557	81	888	732	732	163	895	746	746	135	0	881	
4/24/08	2,328	936	1.86	3,264	392	200	250	557	81	888	732	732	163	895	746	746	135	0	881	
4/25/08	2,324	936	3.71	3,260	388	200	250	557	81	888	732	732	163	895	746	746	135	0	881	
4/26/08	2,320	936	5.57	3,256	384	200	250	557	81	888	732	732	163	895	746	746	135	0	881	
4/27/08	2,316	936	7.43	3,252	380	200	250	557	81	888	732	732	163	895	746	746	135	0	881	
4/28/08	2,312	936	9.28	3,248	376	200	250	557	81	888	732	732	163	895	746	746	135	0	881	
4/29/08	2,308	936	11.14	3,244	372	200	250	557	81	888	732	732	163	895	746	746	135	0	881	
4/30/08	2,304	936	13.00	3,240	368	200	250	557	81	888	732	732	163	895	746	746	135	0	881	
5/1/08	2,300	936	14.85	3,236	364	200	250	557	81	888	732	732	163	895	707	707	174	0	881	
5/2/08	2,296	936	16.71	3,232	360	200	250	557	81	888	732	732	163	895	707	707	174	0	881	
5/3/08	2,253	975	18.64	3,228	356	200	250	557	81	888	732	732	163	895	707	707	174	0	881	
5/4/08	2,249	975	20.58	3,224	352	200	250	557	81	888	732	732	163	895	707	707	174	0	881	
5/5/08	2,245	975	22.51	3,220	348	200	250	557	81	888	732	732	163	895	707	707	174	0	881	
5/6/08	2,241	975	24.44	3,216	344	200	250	557	81	888	732	732	163	895	707	707	174	0	881	
5/7/08	2,237	975	26.38	3,212	340	200	250	557	81	888	732	732	163	895	707	707	174	0	881	
5/8/08	2,233	975	28.31	3,208	336	200	250	557	81	888	732	732	163	895	707	707	174	0	881	
5/9/08	2,229	975	30.25	3,204	332	200	250	557	81	888	732	732	163	895	707	707	174	0	881	
5/10/08	2,225	975	32.18	3,200	328	200	250	557	81	888	732	732	163	895	707	707	174	0	881	
5/11/08	2,221	975	34.11	3,196	324	200	250	557	81	888	732	732	163	895	707	707	174	0	881	
5/12/08	2,217	975	36.05	3,192	320	200	250	557	81	888	732	732	163	895	707	707	174	0	881	
5/13/08	2,213	975	37.98	3,188	316	200	250	557	81	888	732	732	163	895	707	707	174	0	881	
5/14/08	2,209	975	39.92	3,184	312	200	250	557	81	888	732	732	163	895	707	707	174	0	881	
5/15/08	2,205	975	41.85	3,180	308	200	250	557	81	888	732	732	163	895	707	707	174	0	881	
5/16/08	2,201	975	43.78	3,176	304	200	250	557	81	888	732	732	163	895	707	707	174	0	881	
5/17/08	2,197	975	45.72	3,172	300	200	250	557	81	888	732	732	163	895	707	707	174	0	881	
5/18/08	2,193	975	47.65	3,168	296	200	250	557	81	888	732	732	163	895	707	707	174	0	881	
5/19/08	2,189	975	49.58	3,164	292	200	250	557	81	888	732	732	163	895	707	707	174	0	881	
5/20/08	2,185	975	51.52	3,160	288	200	250	557	81	888	732	732	163	895	707	707	174	0	881	
5/21/08	2,181	975	53.45	3,156	284	200	250	557	81	888	732	732	163	895	707	707	174	0	881	
5/22/08	2,177	975	55.39	3,152	280	200	250			250	617	617	163	780	707	707	174	0	881	
5/23/08	2,173	975	57.32	3,148	276	200	250			250	563	563		563	707	707			707	
5/24/08	2,054	975	59.25	3,029	272	200	250			250	510	510		510	707	707			707	
5/25/08	1,996	0		1,996	268	200	250			250	456	456		456	707	707			707	
5/26/08	1,939	0		1,939	264	200	250			250	402	402		402	707	707			707	
5/27/08	1,881	0		1,881	260	200	250			250	349	349		349	707	707			707	
5/28/08	1,823	0		1,823	256	200	250			250	295	295		295	707	707			707	
5/29/08	1,766	0		1,766	252	200	250			250	241	241		241	707	707			707	
5/30/08	1,708	0		1,708	248	200	250			250	188	188		188	707	707			707	
5/31/08	1,650	0		1,650	244	200	250			250	161	161		161	707	707			707	
VAMP Period																				
Avg. (cfs):	2,236	964		3,200	340	200	250	557	81	888	728	728	163	891	718	718	163	0	881	
Supplemental Water (TAF):		59.25						34.25	4.98				10.02				10.00			

VAMP flow operation period

APPENDIX A

Appendix A-1, Table 2

2008 VAMP DAILY OPERATION PLAN — MARCH 14, 2008
(A2) HIGH UNGAGED FLOW
Target Flow Period: April 24 - May 24 • Flow Target: 4,450 cfs
Bold Numbers: observed real-time mean daily flows

	San Joaquin River near Vernalis						Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus R blw Goodwin					
Date	Existing Flow	VAMP Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced River 2 day lag)	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. Flow	Exch Contr VAMP Suppl. Flow	VAMP Flow (3 day lag)	Existing Flow - base FERC Volume	Existing Flow - Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2 day lag)	Existing Flow - Base	Existing Flow-reshaped	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol. S=Stan.
	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		(cfs)	(cfs)	(cfs)	
3/15/08																				
3/16/08																				
3/17/08																				
3/18/08																				
3/19/08																				
3/20/08																				
3/21/08																				
3/22/08																				
3/23/08																				
3/24/08																				
3/25/08																				
3/26/08																				
3/27/08																				
3/28/08																				
3/29/08							250			250										
3/30/08					492		250			250	170	170		170	391	391			391	
3/31/08					488		250			250	170	170		170	391	391			391	
4/1/08	1,903			1,903	484	600	250			250	170	170		170	391	391			391	
4/2/08	1,899			1,899	480	600	250			250	170	170		170	391	391			391	
4/3/08	1,895			1,895	476	600	250			250	170	170		170	391	391			391	
4/4/08	1,891			1,891	472	600	250			250	170	170		170	391	391			391	
4/5/08	1,887			1,887	468	600	250			250	170	170		170	391	391			391	
4/6/08	1,883			1,883	464	600	250			250	170	170		170	391	391			391	
4/7/08	1,879			1,879	460	600	250			250	170	170		170	391	391			391	
4/8/08	1,875			1,875	456	600	250			250	170	170		170	391	391			391	
4/9/08	1,871			1,871	452	600	250			250	170	170		170	391	391			391	
4/10/08	1,867			1,867	448	600	250			250	170	170		170	391	391			391	
4/11/08	1,863			1,863	444	600	250			250	170	170		170	391	391			391	
4/12/08	1,859			1,859	440	600	250			250	170	170		170	391	391			391	
4/13/08	1,855			1,855	436	600	250			250	170	170		170	391	391			391	
4/14/08	1,851			1,851	432	600	250			250	170	170		170	391	391			391	
4/15/08	1,847			1,847	428	600	250			250	250	250		250	391	391			391	
4/16/08	1,843			1,843	424	600	250			250	250	250		250	391	391			391	
4/17/08	1,919			1,919	420	600	250			250	250	250		250	391	391			391	
4/18/08	1,915			1,915	416	600	250			250	250	250		250	391	391			391	
4/19/08	1,911			1,911	412	600	250			250	250	250		250	391	391			391	
4/20/08	1,907			1,907	408	600	250			250	250	250		250	391	391			391	
4/21/08	1,903			1,903	404	600	250	634	119	1,003	250	250		250	391	391			391	
4/22/08	1,899			1,899	400	600	250	634	119	1,003	1,060	1,060	237	1,297	977	977	237	0	1,214	
4/23/08	1,895			1,895	396	600	250	634	119	1,003	1,060	1,060	237	1,297	977	977	237	0	1,214	
4/24/08	3,287	1,227	2.43	4,514	392	600	250	634	119	1,003	1,060	1,060	237	1,297	977	977	237	0	1,214	
4/25/08	3,283	1,227	4.87	4,510	388	600	250	634	119	1,003	1,060	1,060	237	1,297	977	977	237	0	1,214	
4/26/08	3,279	1,227	7.30	4,506	384	600	250	634	119	1,003	1,060	1,060	237	1,297	977	977	237	0	1,214	
4/27/08	3,275	1,227	9.73	4,502	380	600	250	634	119	1,003	1,060	1,060	237	1,297	977	977	237	0	1,214	
4/28/08	3,271	1,227	12.17	4,498	376	600	250	634	119	1,003	1,060	1,060	237	1,297	977	977	237	0	1,214	
4/29/08	3,267	1,227	14.60	4,494	372	600	250	634	119	1,003	1,060	1,060	237	1,297	977	977	237	0	1,214	
4/30/08	3,263	1,227	17.04	4,490	368	600	250	634	119	1,003	1,060	1,060	237	1,297	977	977	237	0	1,214	
5/1/08	3,259	1,227	19.47	4,486	364	600	250	634	119	1,003	1,060	1,060	237	1,297	977	977	237	0	1,214	
5/2/08	3,255	1,227	21.90	4,482	360	600	250	634	119	1,003	1,060	1,060	237	1,297	977	977	237	0	1,214	
5/3/08	3,251	1,227	24.34	4,478	356	600	250	634	119	1,003	1,060	1,060	237	1,297	977	977	237	0	1,214	
5/4/08	3,247	1,227	26.77	4,474	352	600	250	634	119	1,003	1,060	1,060	237	1,297	977	977	237	0	1,214	
5/5/08	3,243	1,227	29.20	4,470	348	600	250	634	119	1,003	1,060	1,060	237	1,297	977	977	237	0	1,214	
5/6/08	3,239	1,227	31.64	4,466	344	600	250	634	119	1,003	1,060	1,060	237	1,297	977	977	237	0	1,214	
5/7/08	3,235	1,227	34.07	4,462	340	600	250	634	119	1,003	1,060	1,060	237	1,297	977	977	237	0	1,214	
5/8/08	3,231	1,227	36.51	4,458	336	600	250	634	119	1,003	1,060	1,060	237	1,297	977	977	237	0	1,214	
5/9/08	3,227	1,227	38.94	4,454	332	600	250	634	119	1,003	1,060	1,060	237	1,297	977	977	237	0	1,214	
5/10/08	3,223	1,227	41.37	4,450	328	600	250	634	119	1,003	1,060	1,060	237	1,297	977	977	237	0	1,214	
5/11/08	3,219	1,227	43.81	4,446	324	600	250	634	119	1,003	1,060	1,060	237	1,297	977	977	237	0	1,214	
5/12/08	3,215	1,227	46.24	4,442	320	600	250	634	119	1,003	1,060	1,060	237	1,297	977	977	237	0	1,214	
5/13/08	3,211	1,227	48.67	4,438	316	600	250	634	119	1,003	1,060	1,060	237	1,297	977	977	237	0	1,214	
5/14/08	3,207	1,227	51.11	4,434	312	600	250	634	119	1,003	1,060	1,060	237	1,297	977	977	237	0	1,214	
5/15/08	3,203	1,227	53.54	4,430	308	600	250	634	119	1,003	1,060	1,060	237	1,297	977	977	237	0	1,214	
5/16/08	3,199	1,227	55.98	4,426	304	600	250	634	119	1,003	1,060	1,060	237	1,297	977	977	237	0	1,214	
5/17/08	3,195	1,227	58.41	4,422	300	600	250	634	119	1,003	1,060	1,060	237	1,297	977	977	237	0	1,214	
5/18/08	3,191	1,227	60.84	4,418	296	600	250	634	119	1,003	1,060	1,060	237	1,297	977	977	237	0	1,214	
5/19/08	3,187	1,227	63.28	4,414	292	600	250	634	119	1,003	1,060	1,060	237	1,297	977	977	237	0	1,214	
5/20/08	3,183	1,227	65.71	4,410	288	600	250	634	119	1,003	1,060	1,060	237	1,297	977	977	237	0	1,214	
5/21/08	3,179	1,227	68.14	4,406	284	600	250	634	119	1,003	1,060	1,060	237	1,297	977	977	237	0	1,214	
5/22/08	3,175	1,227	70.58	4,402	280	600	250			250	925	925	237	1,162	977	977	237	0	1,214	
5/23/08	3,171	1,227	73.01	4,398	276	600	250			250	825	825		825	740	740			740	
5/24/08	3,032	1,227	75.45	4,259	272	600	250			250	725	725		725	740	740			740	
5/25/08	2,691	0		2,691	268	600	250			250	625	625		625	740	740			740	
5/26/08	2,587	0		2,587	264	600	250			250	525	525		525	740	740			740	
5/27/08	2,483	0		2,483	260	600	250			250	425	425		425	740	740			740	
5/28/08	2,379	0		2,379	256	600	250			250	325	325		325	740	740			740	
5/29/08	2,275	0		2,275	252	600	250			250	225	225		225	740	740			740	
5/30/08	2,171	0		2,171	248	600	250			250	175	175		175	740	740			740	
5/31/08	2,067	0		2,067	244	600	250			250	175	175		175	740	740			740	
VAMP Period																				
Avg. (cfs):	3,222	1,227		4,449	340	600	250	634	119	1,003	1,055	1,055	237	1,292	977	977	237	0	1,214	
Supplemental Water (TAF):		75.45						38.98	7.32				14.57				14.57			

VAMP flow operation period

Appendix A-1, Table 3

2008 VAMP DAILY OPERATION PLAN — MARCH 28, 2008

(B1) LOW UNGAGED FLOW

Target Flow Period: April 22 - May 22 • Flow Target: 3,200 cfs

Bold Numbers: observed real-time mean daily flows

	San Joaquin River near Vernalis						Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus R blw Goodwin					
Date	Existing Flow	VAMP Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced River 2 day lag	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. Flow	Exch Contr VAMP Suppl. Flow	VAMP Flow (3 day lag)	Existing Flow - base FERC Volume	Existing Flow - Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2 day lag)	Existing Flow - Base	Existing Flow- reshaped	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol. S=Stan.
	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		(cfs)	(cfs)	(cfs)	
3/15/08	**1,870**			**1,870**	**781**	**-14**	**268**			**268**	**163**	**163**		**163**	**803**	**803**			**803**	
3/16/08	**1,900**			**1,900**	**785**	**-77**	**265**			**265**	**162**	**162**		**162**	**806**	**806**			**806**	
3/17/08	**1,940**			**1,940**	**763**	**-81**	**247**			**247**	**162**	**162**		**162**	**1,199**	**1,199**			**1,199**	
3/18/08	**1,910**			**1,910**	**762**	**-111**	**232**			**232**	**168**	**168**		**168**	**1,500**	**1,500**			**1,500**	
3/19/08	**2,080**			**2,080**	**757**	**-309**	**239**			**239**	**175**	**175**		**175**	**1,503**	**1,503**			**1,503**	
3/20/08	**2,240**			**2,240**	**755**	**-437**	**239**			**239**	**173**	**173**		**173**	**1,519**	**1,519**			**1,519**	
3/21/08	**2,270**			**2,270**	**783**	**-397**	**217**			**217**	**164**	**164**		**164**	**1,510**	**1,510**			**1,510**	
3/22/08	**2,320**			**2,320**	**777**	**-366**	**250**			**250**	**159**	**159**		**159**	**1,512**	**1,512**			**1,512**	
3/23/08	**2,390**			**2,390**	**757**	**-306**	**273**			**273**	**162**	**162**		**162**	**1,515**	**1,515**			**1,515**	
3/24/08	**2,420**			**2,420**	**738**	**-245**	**281**			**281**	**160**	**160**		**160**	**1,505**	**1,505**			**1,505**	
3/25/08	**2,370**			**2,370**	**733**	**-314**	**277**			**277**	**159**	**159**		**159**	**1,510**	**1,510**			**1,510**	
3/26/08	**2,340**			**2,340**	**681**	**-336**	**268**			**268**	**159**	**159**		**159**	**1,510**	**1,510**			**1,510**	
3/27/08	**2,380**			**2,380**	**671**	**-303**	**265**			**265**	**159**	**159**		**159**	**1,509**	**1,509**			**1,509**	
3/28/08																				
3/29/08							250			250										
3/30/08					534		250			250	150	150		150	746	746			746	
3/31/08					530		250			250	150	150		150	746	746			746	
4/1/08	1,780			1,780	526	100	250			250	150	150		150	746	746			746	
4/2/08	1,776			1,776	522	100	250			250	150	150		150	746	746			746	
4/3/08	1,772			1,772	518	100	250			250	150	150		150	746	746			746	
4/4/08	1,768			1,768	514	100	250			250	150	150		150	746	746			746	
4/5/08	1,764			1,764	510	100	250			250	150	150		150	746	746			746	
4/6/08	1,760			1,760	506	100	250			250	150	150		150	746	746			746	
4/7/08	1,756			1,756	502	100	250			250	150	150		150	746	746			746	
4/8/08	1,752			1,752	498	100	250			250	150	150		150	746	746			746	
4/9/08	1,748			1,748	494	100	250			250	150	150		150	746	746			746	
4/10/08	1,744			1,744	490	100	250			250	150	150		150	746	746			746	
4/11/08	1,740			1,740	486	100	250			250	150	150		150	746	746			746	
4/12/08	1,736			1,736	482	100	250			250	150	150		150	746	746			746	
4/13/08	1,732			1,732	478	100	250			250	150	150		150	746	746			746	
4/14/08	1,728			1,728	474	100	250			250	150	150		150	746	746			746	
4/15/08	1,724			1,724	470	100	250			250	250	250		250	746	746			746	
4/16/08	1,720			1,720	466	100	250			250	250	250		250	746	746			746	
4/17/08	1,816			1,816	462	100	250			250	250	250		250	746	746			746	
4/18/08	1,812			1,812	457	100	250			250	250	250		250	746	746			746	
4/19/08	1,808			1,808	453	100	250	519	81	850	250	250		250	746	746			746	
4/20/08	1,803			1,803	449	100	250	519	81	850	705	1,000	200	1,200	746	600	0	0	600	
4/21/08	1,799			1,799	445	100	250	519	81	850	705	1,000	200	1,200	746	600	0	0	600	
4/22/08	2,399	800	1.59	3,199	440	100	250	519	81	850	705	1,000	200	1,200	746	600	0	0	600	
4/23/08	2,395	800	3.17	3,195	436	100	250	519	81	850	705	1,000	200	1,200	746	600	0	0	600	
4/24/08	2,391	800	4.76	3,191	432	100	250	519	81	850	705	1,000	200	1,200	746	600	0	0	600	
4/25/08	2,386	800	6.35	3,186	428	100	250	869	81	1,200	705	925	175	1,100	746	600	0	0	600	
4/26/08	2,382	800	7.93	3,182	423	100	250	869	81	1,200	705	850	150	1,000	746	600	0	0	600	
4/27/08	2,303	775	9.47	3,078	419	100	250	869	81	1,200	705	775	125	900	746	600	0	0	600	
4/28/08	2,224	1,100	11.65	3,324	415	100	250	869	81	1,200	705	700	0	700	746	600	0	0	600	
4/29/08	2,144	1,075	13.79	3,219	411	100	250	534	81	865	705	625	0	625	746	1,000	0	0	1,000	
4/30/08	2,065	950	15.67	3,015	407	100	250	269	81	600	705	550	50	600	746	1,000	400	0	1,400	
5/1/08	2,386	950	17.55	3,336	402	100	250	269	81	600	705	500	100	600	707	1,000	500	0	1,500	
5/2/08	2,307	1,065	19.67	3,372	398	100	250	269	81	600	705	500	100	600	707	1,000	500	0	1,500	
5/3/08	2,252	950	21.55	3,202	394	100	250	619	81	950	705	500	100	600	707	1,000	500	0	1,500	
5/4/08	2,248	950	23.43	3,198	390	100	250	619	81	950	705	500	100	600	707	1,000	100	0	1,100	
5/5/08	2,244	950	25.32	3,194	385	100	250	619	81	950	705	1,000	200	1,200	707	500	100	0	600	
5/6/08	2,240	900	27.10	3,140	381	100	250	619	81	950	705	1,000	200	1,200	707	500	100	0	600	
5/7/08	2,235	1,000	29.09	3,235	377	100	250	619	81	950	705	1,000	200	1,200	707	500	100	0	600	
5/8/08	2,231	1,000	31.07	3,231	373	100	250	619	81	950	705	1,000	200	1,200	707	500	100	0	600	
5/9/08	2,227	1,000	33.05	3,227	368	100	250	869	81	1,200	705	1,000	200	1,200	707	500	100	0	600	
5/10/08	2,223	1,000	35.04	3,223	364	100	250	869	81	1,200	705	900	200	1,100	707	500	100	0	600	
5/11/08	2,219	1,000	37.02	3,219	360	100	250	869	81	1,200	705	800	200	1,000	707	500	100	0	600	
5/12/08	2,114	1,250	39.50	3,364	356	100	250	869	81	1,200	705	700	200	900	707	500	100	0	600	
5/13/08	2,010	1,250	41.98	3,260	351	100	250	869	81	1,200	705	600	200	800	707	500	100	0	600	
5/14/08	1,906	1,250	44.46	3,156	347	100	250	569	81	900	705	500	140	640	707	500	300	0	800	
5/15/08	1,802	1,250	46.94	3,052	343	100	250	369	81	700	705	400	200	600	707	1,000	400	0	1,400	
5/16/08	1,697	1,390	49.70	3,087	339	100	250	369	81	700	705	400	200	600	707	1,000	500	0	1,500	
5/17/08	2,093	1,250	52.18	3,343	335	100	250	369	81	700	705	400	200	600	707	1,000	500	0	1,500	
5/18/08	2,089	1,150	54.46	3,239	331	100	250	369	81	700	705	400	200	600	707	1,000	500	0	1,500	
5/19/08	2,085	1,150	56.74	3,235	327	100	250	369	81	700	705	400	200	600	707	1,000	500	0	1,500	
5/20/08	2,081	1,150	59.02	3,231	323	100	250			250	705	400	200	600	707	950	160	0	1,110	
5/21/08	2,077	1,150	61.30	3,227	319	100	250			250	575	375		375	707	707			707	
5/22/08	2,023	810	62.91	2,833	315	100	250			250	450	275		275	707	707			707	
5/23/08	1,751	0		1,751	311	100	250			250	325	230		230	707	707			707	
5/24/08	1,647	0		1,647	307	100	250			250	225	225		225	707	707			707	
5/25/08	1,598	0		1,598	303	100	250			250	150	150		150	707	707			707	
5/26/08	1,589	0		1,589	299	100	250			250	150	150		150	707	707			707	
5/27/08	1,510	0		1,510	295	100	250			250	150	150		150	707	707			707	
5/28/08	1,506	0		1,506	291	100	250			250	150	150		150	707	707			707	
5/29/08	1,502	0		1,502	287	100	250			250	150	150		150	707	707			707	
5/30/08	1,498	0		1,498	283	100	250			250	150	150		150	707	707			707	
5/31/08	1,494	0		1,494	279	100	250			250	150	125		125	707	707			707	
VAMP Period																				
Avg. (cfs):	2,177	1,023		3,200	385	100	250	594	81	925	705	720	163	883	721	721	186	0	907	
Supplemental Water (TAF):		62.91						36.50	4.98				10.00				11.42			

VAMP flow operation period

APPENDIX A

Appendix A-1, Table 4

2008 VAMP DAILY OPERATION PLAN — MARCH 28, 2008
(B2) HIGH UNGAGED FLOW
Target Flow Period: April 22 - May 22 • Flow Target: 3,200 cfs
Bold Numbers: observed real-time mean daily flows

Date	San Joaquin River near Vernalis: Existing Flow	San Joaquin River near Vernalis: VAMP Suppl. Flow	San Joaquin River near Vernalis: Cum. VAMP Suppl. Flow	San Joaquin River near Vernalis: VAMP Flow	SJR above Merced River 2 day lag)	Ungaged Flow above Vernalis	Merced River at Cressey: Existing Flow	Merced River at Cressey: MeID VAMP Suppl. Flow	Merced River at Cressey: Exch Contr VAMP Suppl. Flow	Merced River at Cressey: VAMP Flow (3 day lag)	Tuolumne River at LaGrange: Existing Flow - base FERC Volume	Tuolumne River at LaGrange: Existing Flow - Adjusted FERC Pulse	Tuolumne River at LaGrange: VAMP Suppl. Flow	Tuolumne River at LaGrange: VAMP Flow (2 day lag)	Stanislaus R blw Goodwin: Existing Flow - Base	Stanislaus R blw Goodwin: Existing Flow-reshaped	Stanislaus R blw Goodwin: VAMP Suppl. Flow	Stanislaus R blw Goodwin: Other Suppl. Flow	Stanislaus R blw Goodwin: VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol. S=Stan.
	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		(cfs)	(cfs)	(cfs)	
3/15/08	**1,870**			**1,870**	**781**	**-14**	**268**			**268**	**163**	**163**		**163**	**803**	**803**			**803**	
3/16/08	**1,900**			**1,900**	**785**	**-77**	**265**			**265**	**162**	**162**		**162**	**806**	**806**			**806**	
3/17/08	**1,940**			**1,940**	**763**	**-81**	**247**			**247**	**162**	**162**		**162**	**1,199**	**1,199**			**1,199**	
3/18/08	**1,910**			**1,910**	**762**	**-111**	**232**			**232**	**168**	**168**		**168**	**1,500**	**1,500**			**1,500**	
3/19/08	**2,080**			**2,080**	**757**	**-309**	**239**			**239**	**175**	**175**		**175**	**1,503**	**1,503**			**1,503**	
3/20/08	**2,240**			**2,240**	**755**	**-437**	**239**			**239**	**173**	**173**		**173**	**1,519**	**1,519**			**1,519**	
3/21/08	**2,270**			**2,270**	**783**	**-397**	**217**			**217**	**164**	**164**		**164**	**1,510**	**1,510**			**1,510**	
3/22/08	**2,320**			**2,320**	**777**	**-366**	**250**			**250**	**159**	**159**		**159**	**1,512**	**1,512**			**1,512**	
3/23/08	**2,390**			**2,390**	**757**	**-306**	**273**			**273**	**162**	**162**		**162**	**1,515**	**1,515**			**1,515**	
3/24/08	**2,420**			**2,420**	**738**	**-245**	**281**			**281**	**160**	**160**		**160**	**1,505**	**1,505**			**1,505**	
3/25/08	**2,370**			**2,370**	**733**	**-314**	**277**			**277**	**159**	**159**		**159**	**1,510**	**1,510**			**1,510**	
3/26/08	**2,340**			**2,340**	**681**	**-336**	**268**			**268**	**159**	**159**		**159**	**1,510**	**1,510**			**1,510**	
3/27/08	**2,380**			**2,380**	**671**	**-303**	**265**			**265**	**159**	**159**		**159**	**1,509**	**1,509**			**1,509**	
3/28/08																				
3/29/08							250			250										
3/30/08					534		250			250	180	180		180	391	391			391	
3/31/08					530		250			250	180	180		180	391	391			391	
4/1/08	1,755			1,755	526	400	250			250	180	180		180	391	391			391	
4/2/08	1,751			1,751	522	400	250			250	180	180		180	391	391			391	
4/3/08	1,747			1,747	518	400	250			250	180	180		180	391	391			391	
4/4/08	1,743			1,743	514	400	250			250	180	180		180	391	391			391	
4/5/08	1,739			1,739	510	400	250			250	180	180		180	391	391			391	
4/6/08	1,735			1,735	506	400	250			250	180	180		180	391	391			391	
4/7/08	1,731			1,731	502	400	250			250	180	180		180	391	391			391	
4/8/08	1,727			1,727	498	400	250			250	180	180		180	391	391			391	
4/9/08	1,723			1,723	494	400	250			250	180	180		180	391	391			391	
4/10/08	1,719			1,719	490	400	250			250	180	180		180	391	391			391	
4/11/08	1,715			1,715	486	400	250			250	180	180		180	391	391			391	
4/12/08	1,711			1,711	482	400	250			250	180	180		180	391	391			391	
4/13/08	1,707			1,707	478	400	250			250	180	180		180	391	391			391	
4/14/08	1,703			1,703	474	400	250			250	180	180		180	391	391			391	
4/15/08	1,699			1,699	470	400	250			250	250	250		250	391	391			391	
4/16/08	1,695			1,695	466	400	250			250	250	250		250	391	391			391	
4/17/08	1,761			1,761	462	400	250			250	250	250		250	391	391			391	
4/18/08	1,757			1,757	457	400	250			250	250	250		250	391	391			391	
4/19/08	1,753			1,753	453	400	250	400	0	650	250	250		250	391	391			391	
4/20/08	1,748			1,748	449	400	250	400	0	650	722	1,000	0	1,000	977	700	0	0	700	
4/21/08	1,744			1,744	445	400	250	400	0	650	722	1,000	0	1,000	977	700	0	0	700	
4/22/08	2,799	400	0.79	3,199	440	400	250	400	0	650	722	1,000	0	1,000	977	700	0	0	700	
4/23/08	2,795	400	1.59	3,195	436	400	250	400	0	650	722	1,000	0	1,000	977	700	0	0	700	
4/24/08	2,790	400	2.38	3,190	432	400	250	400	0	650	722	1,000	0	1,000	977	700	0	0	700	
4/25/08	2,786	400	3.17	3,186	428	400	250	750	0	1,000	722	900	0	900	977	700	0	0	700	
4/26/08	2,782	400	3.97	3,182	423	400	250	750	0	1,000	722	800	0	800	977	700	0	0	700	
4/27/08	2,678	400	4.76	3,078	419	400	250	750	0	1,000	722	700	0	700	977	700	0	0	700	
4/28/08	2,574	750	6.25	3,324	415	400	250	500	0	750	722	600	0	600	977	700	45	0	745	
4/29/08	2,469	750	7.74	3,219	411	400	250	250	0	500	722	500	0	500	977	1,100	0	0	1,100	
4/30/08	2,365	795	9.31	3,160	407	400	250	150	0	400	722	500	0	500	977	1,500	0	0	1,500	
5/1/08	2,661	500	10.30	3,161	402	400	250	150	0	400	722	500	0	500	977	1,500	0	0	1,500	
5/2/08	3,057	250	10.80	3,307	398	400	250	150	0	400	722	500	0	500	977	1,500	0	0	1,500	
5/3/08	3,052	150	11.10	3,202	394	400	250	150	0	400	722	500	0	500	977	1,500	0	0	1,500	
5/4/08	3,048	150	11.40	3,198	390	400	250	200	0	450	722	1,000	0	1,000	977	1,000	200	0	1,200	
5/5/08	3,044	150	11.69	3,194	385	400	250	400	0	650	722	1,000	0	1,000	977	600	400	0	1,000	
5/6/08	3,040	350	12.39	3,390	381	400	250	500	0	750	722	1,000	0	1,000	977	600	150	0	750	
5/7/08	2,635	600	13.58	3,235	377	400	250	500	0	750	722	1,000	0	1,000	977	600	150	0	750	
5/8/08	2,631	550	14.67	3,181	373	400	250	500	0	750	722	1,000	0	1,000	977	600	150	0	750	
5/9/08	2,627	650	15.96	3,277	368	400	250	750	0	1,000	722	900	0	900	977	600	150	0	750	
5/10/08	2,623	650	17.25	3,273	364	400	250	750	0	1,000	722	800	0	800	977	600	150	0	750	
5/11/08	2,518	650	18.54	3,168	360	400	250	750	0	1,000	722	700	0	700	977	600	150	0	750	
5/12/08	2,414	900	20.32	3,314	356	400	250	500	0	750	722	600	0	600	977	600	150	0	750	
5/13/08	2,310	900	22.11	3,210	351	400	250	250	0	500	722	500	0	500	977	1,100	0	0	1,100	
5/14/08	2,206	900	23.89	3,106	347	400	250	250	0	500	722	500	0	500	977	1,500	0	0	1,500	
5/15/08	2,602	500	24.88	3,102	343	400	250	250	0	500	722	500	0	500	977	1,500	0	0	1,500	
5/16/08	2,997	250	25.38	3,247	339	400	250	250	0	500	722	500	0	500	977	1,500	0	0	1,500	
5/17/08	2,993	250	25.87	3,243	335	400	250	250	0	500	722	500	0	500	977	1,500	0	0	1,500	
5/18/08	2,989	250	26.37	3,239	331	400	250	250	0	500	722	500	0	500	977	1,500	0	0	1,500	
5/19/08	2,985	250	26.87	3,235	327	400	250	250	0	500	722	500	0	500	977	1,500	0	0	1,500	
5/20/08	2,981	250	27.36	3,231	323	400	250			250	722	500	0	500	977	1,000	0	0	1,000	
5/21/08	2,977	250	27.86	3,227	319	400	250			250	600	482		482	740	740			740	
5/22/08	2,473	250	28.35	2,723	315	400	250			250	475	475		475	740	740			740	
5/23/08	2,191	0		2,191	311	400	250			250	350	350		350	740	740			740	
5/24/08	2,180	0		2,180	307	400	250			250	250	250		250	740	740			740	
5/25/08	2,051	0		2,051	303	400	250			250	180	180		180	740	740			740	
5/26/08	1,947	0		1,947	299	400	250			250	180	180		180	740	740			740	
5/27/08	1,873	0		1,873	295	400	250			250	180	180		180	740	740			740	
5/28/08	1,869	0		1,869	291	400	250			250	180	180		180	740	740			740	
5/29/08	1,865	0		1,865	287	400	250			250	180	180		180	740	740			740	
5/30/08	1,861	0		1,861	283	400	250			250	180	180		180	740	740			740	
5/31/08	1,857	0		1,857	279	400	250			250	180	130		130	740	740			740	
VAMP Period																				
Avg. (cfs):	2,739	461		3,200	385	400	250	406	0	656	722	726	0	726	977	977	55	0	1,032	
Supplemental Water (TAF):		28.35						24.99	0.00				0.00				3.36			

VAMP flow operation period (shaded)

Appendix A-1, Table 5

2008 VAMP DAILY OPERATION PLAN — APRIL 7, 2008

(C1) LOW UNGAGED FLOW

Target Flow Period: April 22 - May 22 • Flow Target: 3,200 cfs

Bold Numbers: observed real-time mean daily flows

Date	San Joaquin River near Vernalis: Existing Flow	VAMP Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced River 2 day lag	Ungaged Flow above Vernalis	Merced River at Cressey: Existing Flow	MeID VAMP Suppl. Flow	Exch Contr VAMP Suppl. Flow	VAMP Flow (3 day lag)	Tuolumne River at LaGrange: Existing Flow - base FERC Volume	Existing Flow - Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2 day lag)	Stanislaus R blw Goodwin: Existing Flow - Base	Existing Flow- reshaped	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol. S=Stan.
	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		(cfs)	(cfs)	(cfs)	
3/15/08	**1,820**			**1,820**	**781**	**-64**	**268**			**268**	**163**	**163**		**163**	**803**	**803**			**803**	
3/16/08	**1,850**			**1,850**	**785**	**-127**	**265**			**265**	**162**	**162**		**162**	**806**	**806**			**806**	
3/17/08	**1,880**			**1,880**	**763**	**-141**	**247**			**247**	**162**	**162**		**162**	**1,199**	**1,199**			**1,199**	
3/18/08	**1,860**			**1,860**	**762**	**-161**	**232**			**232**	**168**	**168**		**168**	**1,500**	**1,500**			**1,500**	
3/19/08	**2,010**			**2,010**	**757**	**-379**	**239**			**239**	**175**	**175**		**175**	**1,503**	**1,503**			**1,503**	
3/20/08	**2,180**			**2,180**	**755**	**-497**	**239**			**239**	**173**	**173**		**173**	**1,519**	**1,519**			**1,519**	
3/21/08	**2,210**			**2,210**	**783**	**-457**	**217**			**217**	**164**	**164**		**164**	**1,510**	**1,510**			**1,510**	
3/22/08	**2,270**			**2,270**	**777**	**-416**	**250**			**250**	**159**	**159**		**159**	**1,512**	**1,512**			**1,512**	
3/23/08	**2,350**			**2,350**	**757**	**-346**	**273**			**273**	**162**	**162**		**162**	**1,515**	**1,515**			**1,515**	
3/24/08	**2,390**			**2,390**	**738**	**-275**	**281**			**281**	**160**	**160**		**160**	**1,505**	**1,505**			**1,505**	
3/25/08	**2,330**			**2,330**	**733**	**-354**	**277**			**277**	**159**	**159**		**159**	**1,510**	**1,510**			**1,510**	
3/26/08	**2,290**			**2,290**	**681**	**-386**	**268**			**268**	**159**	**159**		**159**	**1,510**	**1,510**			**1,510**	
3/27/08	**2,350**			**2,350**	**671**	**-333**	**265**			**265**	**159**	**159**		**159**	**1,509**	**1,509**			**1,509**	
3/28/08	**2,410**			**2,410**	**597**	**-217**	**260**			**260**	**166**	**166**		**166**	**1,500**	**1,500**			**1,500**	
3/29/08	**2,430**			**2,430**	**598**	**-177**	**260**			**260**	**160**	**160**		**160**	**1,503**	**1,503**			**1,503**	
3/30/08	**2,480**			**2,480**	**583**	**-48**	**268**			**268**	**160**	**160**		**160**	**1,503**	**1,503**			**1,503**	
3/31/08	**2,480**			**2,480**	**583**	**-41**	**257**			**257**	**159**	**159**		**159**	**1,339**	**1,339**			**1,339**	
4/1/08	**2,380**			**2,380**	**563**	**-126**	**256**			**256**	**170**	**170**		**170**	**1,264**	**1,264**			**1,264**	
4/2/08	**2,210**			**2,210**	**566**	**-139**	**259**			**259**	**169**	**169**		**169**	**1,093**	**1,093**			**1,093**	
4/3/08	**2,160**			**2,160**	**542**	**-94**	**249**			**249**	**163**	**163**		**163**	**1,007**	**1,007**			**1,007**	
4/4/08	**2,050**			**2,050**	**550**	**-34**	**258**			**258**	**158**	**158**		**158**	**1,010**	**1,010**			**1,010**	
4/5/08	**2,020**			**2,020**	**499**	**49**	**260**			**260**	**161**	**161**		**161**	**1,008**	**1,008**			**1,008**	
4/6/08	**2,000**			**2,000**	**476**	**33**	**272**			**272**	**169**	**169**		**169**	**1,004**	**1,004**			**1,004**	
4/7/08	1,926			1,926	432	0	250			250	180	180		180	391	391			391	
4/8/08	1,909			1,909	428	0	250			250	180	180		180	391	391			391	
4/9/08	1,275			1,275	424	0	250			250	180	180		180	391	391			391	
4/10/08	1,249			1,249	420	0	250			250	180	180		180	391	391			391	
4/11/08	1,245			1,245	416	0	250			250	180	180		180	391	391			391	
4/12/08	1,241			1,241	412	0	250			250	180	180		180	391	391			391	
4/13/08	1,237			1,237	408	0	250			250	180	180		180	391	391			391	
4/14/08	1,233			1,233	404	0	250			250	180	180		180	391	391			391	
4/15/08	1,229			1,229	400	0	250			250	250	250		250	391	391			391	
4/16/08	1,225			1,225	396	0	250			250	250	250		250	391	391			391	
4/17/08	1,291			1,291	392	0	250			250	250	250		250	391	391			391	
4/18/08	1,287			1,287	388	0	250			250	250	250		250	391	391			391	
4/19/08	1,283			1,283	384	0	250	471	119	840	250	250		250	391	391			391	
4/20/08	1,279			1,279	380	0	250	471	119	840	720	1,050	250	1,300	746	600	100	0	700	
4/21/08	1,275			1,275	376	0	250	471	119	840	720	1,050	250	1,300	746	600	100	0	700	
4/22/08	2,280	940	1.86	3,220	372	0	250	471	119	840	720	1,050	250	1,300	746	600	100	0	700	
4/23/08	2,276	940	3.73	3,216	369	0	250	511	119	880	720	1,050	250	1,300	746	600	100	0	700	
4/24/08	2,272	940	5.59	3,212	365	0	250	531	119	900	720	950	350	1,300	746	600	100	0	700	
4/25/08	2,269	940	7.46	3,209	361	0	250	531	119	900	720	850	400	1,250	746	600	100	0	700	
4/26/08	2,165	1,080	9.60	3,245	357	0	250	531	119	900	720	750	300	1,050	746	600	350	0	950	
4/27/08	2,061	1,150	11.88	3,211	353	0	250	531	119	900	720	650	250	900	746	600	500	0	1,100	
4/28/08	1,957	1,300	14.46	3,257	349	0	250	531	119	900	720	550	200	750	746	700	500	0	1,200	
4/29/08	1,853	1,400	17.24	3,253	345	0	250	581	119	950	720	500	250	750	746	1,000	200	0	1,200	
4/30/08	1,849	1,350	19.91	3,199	341	0	250	681	119	1,050	720	500	250	750	746	1,000	200	0	1,200	
5/1/08	2,095	1,100	22.10	3,195	337	0	250	831	119	1,200	720	500	250	750	707	1,000	110	0	1,110	
5/2/08	2,091	1,150	24.38	3,241	333	0	250	831	119	1,200	720	500	250	750	707	900	0	0	900	
5/3/08	2,087	1,160	26.68	3,247	329	0	250	831	119	1,200	720	500	250	750	707	900	0	0	900	
5/4/08	1,983	1,200	29.06	3,183	325	0	250	631	119	950	720	500	410	910	707	800	0	0	800	
5/5/08	1,979	1,200	31.44	3,179	321	0	250	531	119	900	720	1,000	300	1,300	707	500	200	0	700	
5/6/08	1,875	1,360	34.14	3,235	317	0	250	531	119	900	720	1,000	300	1,300	707	500	200	0	700	
5/7/08	2,071	1,250	36.61	3,271	313	0	250	531	119	900	720	1,000	300	1,300	707	500	200	0	700	
5/8/08	2,067	1,150	38.90	3,217	310	0	250	531	119	900	720	1,000	300	1,300	707	500	200	0	700	
5/9/08	2,063	1,150	41.18	3,213	306	0	250	531	119	900	720	1,000	300	1,300	707	500	250	0	750	
5/10/08	2,060	1,150	43.46	3,210	302	0	250	531	119	900	720	900	250	1,150	707	500	400	0	900	
5/11/08	2,056	1,200	45.84	3,256	298	0	250	531	119	900	720	800	200	1,000	707	500	550	0	1,050	
5/12/08	1,952	1,300	48.42	3,252	294	0	250	531	119	900	720	700	250	950	707	600	550	0	1,150	
5/13/08	1,848	1,400	51.19	3,248	290	0	250	781	119	1,150	720	600	300	900	707	600	550	0	1,150	
5/14/08	1,844	1,450	54.07	3,294	286	0	250	781	119	1,150	720	600	100	700	707	600	550	0	1,150	
5/15/08	1,740	1,500	57.04	3,240	282	0	250	781	119	1,150	720	550	100	650	707	1,000	200	0	1,200	
5/16/08	1,736	1,550	60.12	3,286	278	0	250	781	119	1,150	720	500	100	600	707	1,000	200	0	1,200	
5/17/08	2,082	1,200	62.50	3,282	274	0	250	781	119	1,150	720	450	100	550	707	1,000	200	0	1,200	
5/18/08	2,028	1,200	64.88	3,228	270	0	250	576	119	945	720	450	100	550	707	1,000	200	0	1,200	
5/19/08	1,974	1,200	67.26	3,174	266	0	250	271	119	640	720	400	100	500	707	1,000	200	0	1,200	
5/20/08	1,970	1,200	69.64	3,170	262	0	250			250	720	400	100	500	707	950	250	0	1,200	
5/21/08	1,916	995	71.61	2,911	258	0	250			250	350	350		350	707	707			707	
5/22/08	1,862	740	73.08	2,602	254	0	250			250	300	300		300	707	707			707	
5/23/08	1,565	0		1,565	250	0	250			250	250	250		250	707	707			707	
5/24/08	1,511	0		1,511	246	0	250			250	200	200		200	707	707			707	
5/25/08	1,457	0		1,457	242	0	250			250	150	150		150	707	707			707	
5/26/08	1,403	0		1,403	238	0	250			250	150	150		150	707	707			707	
5/27/08	1,349	0		1,349	234	0	250			250	150	150		150	740	740			740	
5/28/08	1,345	0		1,345	230	0	250			250	150	150		150	740	740			740	
5/29/08	1,374	0		1,374	226	0	250			250	150	150		150	740	740			740	
5/30/08	1,370	0		1,370	222	0	250			250	150	150		150	740	740			740	
5/31/08	1,366	0		1,366	218	0	250			250	150	130		130	740	740			740	
VAMP Period																				
Avg. (cfs):	2,012	1,189		3,199	321	0	250	595	119	962	720	719	237	957	721	721	237	0	958	
Supplemental Water (TAF):		73.08						36.57	7.32				14.60				14.60			

VAMP flow operation period

APPENDIX A

Appendix A-1, Table 6

2008 VAMP DAILY OPERATION PLAN — APRIL 7, 2008
(C2) HIGH UNGAGED FLOW
Target Flow Period: April 22 - May 22 • Flow Target: 3,200 cfs
Bold Numbers: observed real-time mean daily flows

	San Joaquin River near Vernalis						Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus R blw Goodwin					
Date	Existing Flow	VAMP Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced River 2 day lag)	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. Flow	Exch Contr VAMP Suppl. Flow	VAMP Flow (3 day lag)	Existing Flow - base FERC Volume	Existing Flow - Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2 day lag)	Existing Flow - Base	Existing Flow- reshaped	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol. S=Stan.
	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		(cfs)	(cfs)	(cfs)	
3/15/08	**1,820**			**1,820**	**781**	**-64**	**268**			**268**	**163**	**163**		**163**	**803**	**803**			**803**	
3/16/08	**1,850**			**1,850**	**785**	**-127**	**265**			**265**	**162**	**162**		**162**	**806**	**806**			**806**	
3/17/08	**1,880**			**1,880**	**763**	**-141**	**247**			**247**	**162**	**162**		**162**	**1,199**	**1,199**			**1,199**	
3/18/08	**1,860**			**1,860**	**762**	**-161**	**232**			**232**	**168**	**168**		**168**	**1,500**	**1,500**			**1,500**	
3/19/08	**2,010**			**2,010**	**757**	**-379**	**239**			**239**	**175**	**175**		**175**	**1,503**	**1,503**			**1,503**	
3/20/08	**2,180**			**2,180**	**755**	**-497**	**239**			**239**	**173**	**173**		**173**	**1,519**	**1,519**			**1,519**	
3/21/08	**2,210**			**2,210**	**783**	**-457**	**217**			**217**	**164**	**164**		**164**	**1,510**	**1,510**			**1,510**	
3/22/08	**2,270**			**2,270**	**777**	**-416**	**250**			**250**	**159**	**159**		**159**	**1,512**	**1,512**			**1,512**	
3/23/08	**2,350**			**2,350**	**757**	**-346**	**273**			**273**	**162**	**162**		**162**	**1,515**	**1,515**			**1,515**	
3/24/08	**2,390**			**2,390**	**738**	**-275**	**281**			**281**	**160**	**160**		**160**	**1,505**	**1,505**			**1,505**	
3/25/08	**2,330**			**2,330**	**733**	**-354**	**277**			**277**	**159**	**159**		**159**	**1,510**	**1,510**			**1,510**	
3/26/08	**2,290**			**2,290**	**681**	**-386**	**268**			**268**	**159**	**159**		**159**	**1,510**	**1,510**			**1,510**	
3/27/08	**2,350**			**2,350**	**671**	**-333**	**265**			**265**	**159**	**159**		**159**	**1,509**	**1,509**			**1,509**	
3/28/08	**2,410**			**2,410**	**597**	**-217**	**260**			**260**	**166**	**166**		**166**	**1,500**	**1,500**			**1,500**	
3/29/08	**2,430**			**2,430**	**598**	**-177**	**260**			**260**	**160**	**160**		**160**	**1,503**	**1,503**			**1,503**	
3/30/08	**2,480**			**2,480**	**583**	**-48**	**268**			**268**	**160**	**160**		**160**	**1,503**	**1,503**			**1,503**	
3/31/08	**2,480**			**2,480**	**583**	**-41**	**257**			**257**	**159**	**159**		**159**	**1,339**	**1,339**			**1,339**	
4/1/08	**2,380**			**2,380**	**563**	**-126**	**256**			**256**	**170**	**170**		**170**	**1,264**	**1,264**			**1,264**	
4/2/08	**2,210**			**2,210**	**566**	**-139**	**259**			**259**	**169**	**169**		**169**	**1,093**	**1,093**			**1,093**	
4/3/08	**2,160**			**2,160**	**542**	**-94**	**249**			**249**	**163**	**163**		**163**	**1,007**	**1,007**			**1,007**	
4/4/08	**2,050**			**2,050**	**550**	**-34**	**258**			**258**	**158**	**158**		**158**	**1,010**	**1,010**			**1,010**	
4/5/08	**2,020**			**2,020**	**499**	**49**	**260**			**260**	**161**	**161**		**161**	**1,008**	**1,008**			**1,008**	
4/6/08	**2,000**			**2,000**	**476**	**33**	**272**			**272**	**169**	**169**		**169**	**1,004**	**1,004**			**1,004**	
4/7/08	2,006			2,006	432	80	250			250	180	180		180	391	391			391	
4/8/08	2,009			2,009	428	100	250			250	180	180		180	391	391			391	
4/9/08	1,425			1,425	424	150	250			250	180	180		180	391	391			391	
4/10/08	1,449			1,449	420	200	250			250	180	180		180	391	391			391	
4/11/08	1,445			1,445	416	200	250			250	180	180		180	391	391			391	
4/12/08	1,441			1,441	412	200	250			250	180	180		180	391	391			391	
4/13/08	1,437			1,437	408	200	250			250	180	180		180	391	391			391	
4/14/08	1,433			1,433	404	200	250			250	180	180		180	391	391			391	
4/15/08	1,429			1,429	400	200	250			250	250	250		250	391	391			391	
4/16/08	1,425			1,425	396	200	250			250	250	250		250	391	391			391	
4/17/08	1,491			1,491	392	200	250			250	250	250		250	391	391			391	
4/18/08	1,487			1,487	388	200	250			250	250	250		250	391	391			391	
4/19/08	1,483			1,483	384	200	250	319	81	650	250	250		250	391	391			391	
4/20/08	1,479			1,479	380	200	250	319	81	650	720	1,050	250	1,300	746	600	100	0	700	
4/21/08	1,475			1,475	376	200	250	319	81	650	720	1,050	250	1,300	746	600	100	0	700	
4/22/08	2,480	750	1.49	3,230	372	200	250	319	81	650	720	1,050	250	1,300	746	600	100	0	700	
4/23/08	2,476	750	2.98	3,226	369	200	250	469	81	800	720	1,050	250	1,300	746	600	100	0	700	
4/24/08	2,472	750	4.46	3,222	365	200	250	569	81	900	720	950	250	1,200	746	600	100	0	700	
4/25/08	2,469	750	5.95	3,219	361	200	250	619	81	950	720	850	175	1,025	746	600	100	0	700	
4/26/08	2,365	900	7.74	3,265	357	200	250	619	81	950	720	750	100	850	746	600	200	0	800	
4/27/08	2,261	925	9.57	3,186	353	200	250	669	81	1,000	720	650	100	750	746	600	400	0	1,000	
4/28/08	2,157	1,000	11.55	3,157	349	200	250	669	81	1,000	720	550	100	650	746	700	300	0	1,000	
4/29/08	2,053	1,200	13.93	3,253	345	200	250	669	81	1,000	720	500	150	650	746	1,000	0	0	1,000	
4/30/08	2,049	1,150	16.21	3,199	341	200	250	719	81	1,050	720	500	150	650	746	1,000	0	0	1,000	
5/1/08	2,295	900	18.00	3,195	337	200	250	869	81	1,200	720	500	150	650	707	1,000	0	0	1,000	
5/2/08	2,291	900	19.79	3,191	333	200	250	869	81	1,200	720	500	150	650	707	900	0	0	900	
5/3/08	2,287	950	21.67	3,237	329	200	250	869	81	1,200	720	500	150	650	707	900	0	0	900	
5/4/08	2,183	1,100	23.85	3,283	325	200	250	619	81	950	720	500	150	650	707	800	0	0	800	
5/5/08	2,179	1,100	26.03	3,279	321	200	250	569	81	900	720	1,000	300	1,300	707	500	0	0	500	
5/6/08	2,075	1,100	28.21	3,175	317	200	250	569	81	900	720	1,000	300	1,300	707	500	0	0	500	
5/7/08	2,271	1,000	30.20	3,271	313	200	250	519	81	850	720	1,000	300	1,300	707	500	0	0	500	
5/8/08	2,267	950	32.08	3,217	310	200	250	369	81	700	720	1,000	300	1,300	707	500	50	0	550	
5/9/08	2,263	950	33.97	3,213	306	200	250	319	81	650	720	1,000	300	1,300	707	500	240	0	740	
5/10/08	2,260	950	35.85	3,210	302	200	250	319	81	650	720	900	100	1,000	707	500	600	0	1,100	
5/11/08	2,256	990	37.81	3,246	298	200	250	369	81	700	720	800	100	900	707	500	700	0	1,200	
5/12/08	2,152	1,100	40.00	3,252	294	200	250	419	81	750	720	700	100	800	707	600	600	0	1,200	
5/13/08	2,048	1,200	42.38	3,248	290	200	250	769	81	1,100	720	600	100	700	707	600	600	0	1,200	
5/14/08	2,044	1,150	44.66	3,194	286	200	250	869	81	1,200	720	600	50	650	707	600	400	0	1,000	
5/15/08	1,940	1,200	47.04	3,140	282	200	250	869	81	1,200	720	550	50	600	707	1,000	0	0	1,000	
5/16/08	1,936	1,300	49.62	3,236	278	200	250	869	81	1,200	720	500	75	575	707	1,000	0	0	1,000	
5/17/08	2,282	1,000	51.60	3,282	274	200	250	869	81	1,200	720	450	100	550	707	1,000	0	0	1,000	
5/18/08	2,228	1,025	53.63	3,253	270	200	250	569	81	900	720	450	75	525	707	1,000	100	0	1,100	
5/19/08	2,174	1,050	55.72	3,224	266	200	250	269	81	600	720	400	100	500	707	1,000	100	0	1,100	
5/20/08	2,170	1,125	57.95	3,295	262	200	250			250	720	400	65	465	707	950	150	0	1,100	
5/21/08	2,116	850	59.63	2,966	258	200	250			250	350	350		350	707	707			707	
5/22/08	2,062	565	60.75	2,627	254	200	250			250	300	300		300	707	707			707	
5/23/08	1,765	0		1,765	250	200	250			250	250	250		250	707	707			707	
5/24/08	1,711	0		1,711	246	200	250			250	200	200		200	707	707			707	
5/25/08	1,657	0		1,657	242	200	250			250	150	150		150	707	707			707	
5/26/08	1,603	0		1,603	238	200	250			250	150	150		150	707	707			707	
5/27/08	1,549	0		1,549	234	200	250			250	150	150		150	740	740			740	
5/28/08	1,545	0		1,545	230	200	250			250	150	150		150	740	740			740	
5/29/08	1,574	0		1,574	226	200	250			250	150	150		150	740	740			740	
5/30/08	1,570	0		1,570	222	200	250			250	150	150		150	740	740			740	
5/31/08	1,566	0		1,566	218	200	250			250	150	130		130	740	740			740	
VAMP Period																				
Avg. (cfs):	2,212	988		3,200	321	200	250	582	81	913	720	719	163	882	721	721	163	0	884	
Supplemental Water (TAF):		60.75						35.78	4.98				10.00				10.00			

VAMP flow operation period

Appendix A-1, Table 7

2008 VAMP DAILY OPERATION PLAN – APRIL 14, 2008
(D1) LOW UNGAGED FLOW
Target Flow Period: April 22 - May 22 • Flow Target: 3,200 cfs
Bold Numbers: observed real-time mean daily flows

	San Joaquin River near Vernalis						Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus R blw Goodwin					
Date	Existing Flow	VAMP Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced River 2 day lag)	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. Flow	Exch Contr VAMP Suppl. Flow	VAMP Flow (3 day lag)	Existing Flow - base FERC Volume	Existing Flow - Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2 day lag)	Existing Flow - Base	Existing Flow-reshaped	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol. S=Stan.
	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		(cfs)	(cfs)	(cfs)	
3/15/08	**1,820**			**1,820**	**735**	**-24**	**268**			**268**	**163**	**163**		**163**	**803**	**803**			**803**	
3/16/08	**1,850**			**1,850**	**735**	**-87**	**265**			**265**	**162**	**162**		**162**	**806**	**806**			**806**	
3/17/08	**1,880**			**1,880**	**716**	**-95**	**247**			**247**	**162**	**162**		**162**	**1,199**	**1,199**			**1,199**	
3/18/08	**1,860**			**1,860**	**713**	**-111**	**232**			**232**	**168**	**168**		**168**	**1,500**	**1,500**			**1,500**	
3/19/08	**2,010**			**2,010**	**706**	**-332**	**239**			**239**	**175**	**175**		**175**	**1,503**	**1,503**			**1,503**	
3/20/08	**2,180**			**2,180**	**703**	**-448**	**239**			**239**	**173**	**173**		**173**	**1,519**	**1,519**			**1,519**	
3/21/08	**2,210**			**2,210**	**727**	**-406**	**217**			**217**	**164**	**164**		**164**	**1,510**	**1,510**			**1,510**	
3/22/08	**2,270**			**2,270**	**719**	**-364**	**250**			**250**	**159**	**159**		**159**	**1,512**	**1,512**			**1,512**	
3/23/08	**2,350**			**2,350**	**697**	**-290**	**273**			**273**	**162**	**162**		**162**	**1,515**	**1,515**			**1,515**	
3/24/08	**2,390**			**2,390**	**674**	**-217**	**281**			**281**	**160**	**160**		**160**	**1,505**	**1,505**			**1,505**	
3/25/08	**2,330**			**2,330**	**668**	**-294**	**277**			**277**	**159**	**159**		**159**	**1,510**	**1,510**			**1,510**	
3/26/08	**2,290**			**2,290**	**615**	**-323**	**268**			**268**	**159**	**159**		**159**	**1,510**	**1,510**			**1,510**	
3/27/08	**2,350**			**2,350**	**605**	**-268**	**265**			**265**	**159**	**159**		**159**	**1,509**	**1,509**			**1,509**	
3/28/08	**2,410**			**2,410**	**530**	**-151**	**260**			**260**	**166**	**166**		**166**	**1,500**	**1,500**			**1,500**	
3/29/08	**2,430**			**2,430**	**531**	**-111**	**260**			**260**	**160**	**160**		**160**	**1,503**	**1,503**			**1,503**	
3/30/08	**2,480**			**2,480**	**513**	**19**	**268**			**268**	**160**	**160**		**160**	**1,503**	**1,503**			**1,503**	
3/31/08	**2,480**			**2,480**	**511**	**26**	**257**			**257**	**159**	**159**		**159**	**1,339**	**1,339**			**1,339**	
4/1/08	**2,380**			**2,380**	**489**	**-56**	**256**			**256**	**170**	**170**		**170**	**1,264**	**1,264**			**1,264**	
4/2/08	**2,210**			**2,210**	**491**	**-67**	**259**			**259**	**169**	**169**		**169**	**1,093**	**1,093**			**1,093**	
4/3/08	**2,160**			**2,160**	**465**	**-20**	**249**			**249**	**163**	**163**		**163**	**1,007**	**1,007**			**1,007**	
4/4/08	**2,050**			**2,050**	**474**	**41**	**258**			**258**	**158**	**158**		**158**	**1,010**	**1,010**			**1,010**	
4/5/08	**2,020**			**2,020**	**426**	**126**	**260**			**260**	**161**	**161**		**161**	**1,008**	**1,008**			**1,008**	
4/6/08	**2,000**			**2,000**	**404**	**109**	**272**			**272**	**169**	**169**		**169**	**1,004**	**1,004**			**1,004**	
4/7/08	**2,010**			**2,010**	**417**	**157**	**275**			**275**	**172**	**172**		**172**	**1,005**	**1,005**			**1,005**	
4/8/08	**1,960**			**1,960**	**412**	**123**	**268**			**268**	**171**	**171**		**171**	**1,001**	**1,001**			**1,001**	
4/9/08	**1,880**			**1,880**	**390**	**14**	**271**			**271**	**172**	**172**		**172**	**1,004**	**1,004**			**1,004**	
4/10/08	**1,850**			**1,850**	**386**	**-9**	**256**			**256**	**172**	**172**		**172**	**1,004**	**1,004**			**1,004**	
4/11/08	**1,840**			**1,840**	**363**	**6**	**260**			**260**	**178**	**178**		**178**	**1,164**	**1,164**			**1,164**	
4/12/08	**1,820**			**1,820**	**339**	**-13**	**271**			**271**	**180**	**180**		**180**	**1,250**	**1,250**			**1,250**	
4/13/08	**1,960**			**1,960**	**321**	**-1**	**278**			**278**	**180**	**180**		**180**	**1,250**	**1,250**			**1,250**	
4/14/08	**2,050**			**2,050**	**328**	**21**	**274**			**274**	**177**	**177**		**177**	**1,250**	**1,250**			**1,250**	
4/15/08	**2,010**			**2,010**	**346**	**-12**	**266**			**266**	**165**	**165**		**165**	**1,385**	**1,385**			**1,385**	
4/16/08	**2,010**			**2,010**	**348**	**-23**	**259**			**259**	**163**	**163**		**163**	**1,500**	**1,500**			**1,500**	
4/17/08	2,170			2,170	312	0	250			250	250	250		250	1,500	1,500			1,500	
4/18/08	2,277			2,277	308	0	250			250	250	250		250	1,500	1,500			1,500	
4/19/08	2,321			2,321	304	0	250	0	0	250	250	250		250	1,500	1,500			1,500	
4/20/08	2,308			2,308	300	0	250	0	0	250	650	850	0	850	745	620	0	0	620	
4/21/08	2,304			2,304	297	0	250	0	0	250	650	850	0	850	745	620	0	0	620	
4/22/08	2,020	0	0.00	2,020	293	0	250	0	0	250	650	850	0	850	745	620	0	0	620	
4/23/08	2,017	0	0.00	2,017	290	0	250	0	0	250	650	850	0	850	745	620	0	0	620	
4/24/08	2,013	0	0.00	2,013	286	0	250	150	0	400	650	850	0	850	745	620	0	0	620	
4/25/08	2,010	0	0.00	2,010	283	0	250	200	0	450	650	700	0	700	745	620	0	0	620	
4/26/08	2,006	0	0.00	2,006	279	0	250	250	0	500	650	625	0	625	745	620	0	0	620	
4/27/08	1,853	150	0.30	2,003	276	0	250	200	0	450	650	525	0	525	745	620	0	0	620	
4/28/08	1,774	200	0.69	1,974	272	0	250	50	0	300	650	500	0	500	745	720	0	0	720	
4/29/08	1,671	250	1.19	1,921	269	0	250	0	0	250	650	500	0	500	745	1,020	0	0	1,020	
4/30/08	1,742	200	1.59	1,942	265	0	250	0	0	250	650	500	0	500	745	1,020	0	0	1,020	
5/1/08	2,039	50	1.69	2,089	262	0	250	0	0	250	650	500	0	500	745	1,020	0	0	1,020	
5/2/08	2,035	0	1.69	2,035	258	0	250	0	0	250	650	500	0	500	745	1,000	0	0	1,000	
5/3/08	2,032	0	1.69	2,032	255	0	250	50	0	300	650	500	0	500	745	950	0	0	950	
5/4/08	2,008	0	1.69	2,008	251	0	250	100	0	350	650	600	0	600	745	820	0	0	820	
5/5/08	1,955	0	1.69	1,955	248	0	250	100	0	350	650	900	0	900	745	520	0	0	520	
5/6/08	1,921	50	1.79	1,971	244	0	250	100	0	350	650	900	0	900	745	520	0	0	520	
5/7/08	1,918	100	1.98	2,018	241	0	250	100	0	350	650	900	0	900	745	520	0	0	520	
5/8/08	1,914	100	2.18	2,014	237	0	250	100	0	350	650	900	0	900	745	520	0	0	520	
5/9/08	1,911	100	2.38	2,011	234	0	250	100	0	350	650	900	0	900	745	520	0	0	520	
5/10/08	1,907	100	2.58	2,007	230	0	250	200	0	450	650	900	0	900	745	520	0	0	520	
5/11/08	1,904	100	2.78	2,004	227	0	250	250	0	500	650	800	0	800	745	520	0	0	520	
5/12/08	1,900	100	2.98	2,000	223	0	250	300	0	550	650	700	0	700	745	620	0	0	620	
5/13/08	1,797	200	3.37	1,997	220	0	250	300	0	550	650	600	0	600	745	620	0	0	620	
5/14/08	1,793	250	3.87	2,043	216	0	250	150	0	400	650	500	0	500	745	620	0	0	620	
5/15/08	1,690	300	4.46	1,990	213	0	250	150	0	400	650	450	0	450	745	1,020	0	0	1,020	
5/16/08	1,586	300	5.06	1,886	209	0	250	150	0	400	650	400	0	400	745	1,020	0	0	1,020	
5/17/08	1,933	150	5.36	2,083	206	0	250	150	0	400	650	400	0	400	745	1,020	0	0	1,020	
5/18/08	1,879	150	5.65	2,029	202	0	250	100	0	350	650	400	0	400	745	1,020	0	0	1,020	
5/19/08	1,876	150	5.95	2,026	199	0	250	100	0	350	650	400	0	400	745	1,020	0	0	1,020	
5/20/08	1,872	150	6.25	2,022	195	0	250			250	650	400	0	400	745	970	0	0	970	
5/21/08	1,869	100	6.45	1,969	191	0	250			250	350	350		350	737	737			737	
5/22/08	1,815	100	6.64	1,915	187	0	250			250	300	300		300	737	737			737	
5/23/08	1,528	0		1,528	183	0	250			250	250	250		250	737	737			737	
5/24/08	1,474	0		1,474	179	0	250			250	200	200		200	737	737			737	
5/25/08	1,420	0		1,420	175	0	250			250	150	150		150	737	737			737	
5/26/08	1,366	0		1,366	171	0	250			250	150	150		150	737	737			737	
5/27/08	1,312	0		1,312	167	0	250			250	150	150		150	737	737			737	
5/28/08	1,308	0		1,308	163	0	250			250	150	150		150	737	737			737	
5/29/08	1,304	0		1,304	159	0	250			250	150	150		150	737	737			737	
5/30/08	1,300	0		1,300	155	0	250			250	150	150		150	737	737			737	
5/31/08	1,296	0		1,296	151	0	250			250	130	130		130	737	737			737	
VAMP Period																				
Avg. (cfs):	1,892	108		2,000	248	0	250	108	0	358	650	650	0	650	745	745	0	0	745	
Supplemental Water (TAF):		6.64						6.64	0.00				0.00				0.00			

VAMP flow operation period

APPENDIX A

Appendix A-1, Table 8

2008 VAMP DAILY OPERATION PLAN — APRIL 14, 2008
(D2) HIGH UNGAGED FLOW
Target Flow Period: April 22 - May 22 • Flow Target: 3,200 cfs
Bold Numbers: observed real-time mean daily flows

	San Joaquin River near Vernalis						Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus R blw Goodwin					
Date	Existing Flow	VAMP Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced River 2 day lag	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. Flow	Exch Contr VAMP Suppl. Flow	VAMP Flow (3 day lag)	Existing Flow - base FERC Volume	Existing Flow - Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2 day lag)	Existing Flow - Base	Existing Flow- reshaped	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol. S=Stan.
	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		(cfs)	(cfs)	(cfs)	
3/15/08	1,820			1,820	781	-64	268			268	163	163		163	803	803			803	
3/16/08	1,850			1,850	785	-127	265			265	162	162		162	806	806			806	
3/17/08	1,880			1,880	763	-141	247			247	162	162		162	1,199	1,199			1,199	
3/18/08	1,860			1,860	762	-161	232			232	168	168		168	1,500	1,500			1,500	
3/19/08	2,010			2,010	757	-379	239			239	175	175		175	1,503	1,503			1,503	
3/20/08	2,180			2,180	755	-497	239			239	173	173		173	1,519	1,519			1,519	
3/21/08	2,210			2,210	783	-457	217			217	164	164		164	1,510	1,510			1,510	
3/22/08	2,270			2,270	777	-416	250			250	159	159		159	1,512	1,512			1,512	
3/23/08	2,350			2,350	757	-346	273			273	162	162		162	1,515	1,515			1,515	
3/24/08	2,390			2,390	738	-275	281			281	160	160		160	1,505	1,505			1,505	
3/25/08	2,330			2,330	733	-354	277			277	159	159		159	1,510	1,510			1,510	
3/26/08	2,290			2,290	681	-386	268			268	159	159		159	1,510	1,510			1,510	
3/27/08	2,350			2,350	671	-333	265			265	159	159		159	1,509	1,509			1,509	
3/28/08	2,410			2,410	597	-217	260			260	166	166		166	1,500	1,500			1,500	
3/29/08	2,430			2,430	598	-177	260			260	160	160		160	1,503	1,503			1,503	
3/30/08	2,480			2,480	583	-48	268			268	160	160		160	1,503	1,503			1,503	
3/31/08	2,480			2,480	583	-41	257			257	159	159		159	1,339	1,339			1,339	
4/1/08	2,380			2,380	563	-126	256			256	170	170		170	1,264	1,264			1,264	
4/2/08	2,210			2,210	566	-139	259			259	169	169		169	1,093	1,093			1,093	
4/3/08	2,160			2,160	542	-94	249			249	163	163		163	1,007	1,007			1,007	
4/4/08	2,050			2,050	550	-34	258			258	158	158		158	1,010	1,010			1,010	
4/5/08	2,020			2,020	499	49	260			260	161	161		161	1,008	1,008			1,008	
4/6/08	2,000			2,000	476	33	272			272	169	169		169	1,004	1,004			1,004	
4/7/08	2,010			2,083	417	157	275			275	172	172		172	1,005	1,005			1,005	
4/8/08	1,960			2,032	412	123	268			268	171	171		171	1,001	1,001			1,001	
4/9/08	1,880			1,880	390	14	271			271	172	172		172	1,004	1,004			1,004	
4/10/08	1,850			1,850	386	-9	256			256	172	172		172	1,004	1,004			1,004	
4/11/08	1,840			1,840	363	6	260			260	178	178		178	1,164	1,164			1,164	
4/12/08	1,820			1,820	339	-13	271			271	180	180		180	1,250	1,250			1,250	
4/13/08	1,960			1,960	321	-1	278			278	180	180		180	1,250	1,250			1,250	
4/14/08	2,050			2,050	328	21	274			274	177	177		177	1,250	1,250			1,250	
4/15/08	2,010			2,010	346	-12	266			266	165	165		165	1,385	1,385			1,385	
4/16/08	2,010			2,010	348	-23	259			259	163	163		163	1,500	1,500			1,500	
4/17/08	2,320			2,320	312	150	250			250	250	250		250	1,500	1,500			1,500	
4/18/08	2,477			2,477	308	200	250			250	250	250		250	1,500	1,500			1,500	
4/19/08	2,521			2,521	304	200	250	0	0	250	250	250		250	1,500	1,500			1,500	
4/20/08	2,508			2,508	300	200	250	0	0	250	650	950	250	1,200	745	1,020	280	0	1,300	
4/21/08	2,504			2,504	297	200	250	0	0	250	650	950	250	1,200	745	1,020	280	0	1,300	
4/22/08	2,720	530	1.05	3,250	293	200	250	50	0	300	650	950	250	1,200	745	1,020	280	0	1,300	
4/23/08	2,717	530	2.10	3,247	290	200	250	265	135	650	650	950	250	1,200	745	1,000	250	0	1,250	
4/24/08	2,713	530	3.15	3,243	286	200	250	565	135	950	650	850	250	1,100	745	950	0	0	950	
4/25/08	2,690	550	4.24	3,240	283	200	250	915	135	1,300	650	750	175	925	745	820	30	0	850	
4/26/08	2,536	650	5.53	3,186	279	200	250	1,015	135	1,400	650	650	100	750	745	620	80	0	700	
4/27/08	2,303	905	7.33	3,208	276	200	250	1,015	135	1,400	650	550	100	650	745	620	80	0	700	
4/28/08	1,999	1,230	9.77	3,229	272	200	250	1,015	135	1,400	650	500	150	650	745	620	80	0	700	
4/29/08	1,896	1,330	12.41	3,226	269	200	250	1,015	135	1,400	650	500	150	650	745	620	80	0	700	
4/30/08	1,842	1,380	15.14	3,222	265	200	250	1,015	135	1,400	650	500	150	650	745	620	80	0	700	
5/1/08	1,839	1,380	17.88	3,219	262	200	250	1,015	135	1,400	650	500	150	650	745	620	80	0	700	
5/2/08	1,835	1,380	20.62	3,215	258	200	250	1,015	135	1,400	650	500	150	650	745	620	80	0	700	
5/3/08	1,832	1,380	23.36	3,212	255	200	250	915	135	1,300	650	500	150	650	745	620	80	0	700	
5/4/08	1,828	1,380	26.09	3,208	251	200	250	615	135	1,000	650	500	150	650	745	620	80	0	700	
5/5/08	1,825	1,380	28.83	3,205	248	200	250	515	135	900	650	900	300	1,200	745	520	180	0	700	
5/6/08	1,821	1,280	31.37	3,101	244	200	250	465	135	850	650	900	300	1,200	745	520	180	0	700	
5/7/08	2,118	1,230	33.81	3,348	241	200	250	365	135	750	650	900	300	1,200	745	520	180	0	700	
5/8/08	2,114	1,130	36.05	3,244	237	200	250	365	135	750	650	900	300	1,200	745	520	280	0	800	
5/9/08	2,111	1,080	38.19	3,191	234	200	250	365	135	750	650	900	300	1,200	745	520	470	0	990	
5/10/08	2,107	1,080	40.33	3,187	230	200	250	415	135	800	650	800	100	900	745	520	680	0	1,200	
5/11/08	2,104	1,270	42.85	3,374	227	200	250	515	135	900	650	700	100	800	745	520	680	0	1,200	
5/12/08	2,000	1,280	45.39	3,280	223	200	250	565	135	950	650	600	100	700	745	620	580	0	1,200	
5/13/08	1,897	1,330	48.03	3,227	220	200	250	715	135	1,100	650	500	100	600	745	620	580	0	1,200	
5/14/08	1,893	1,330	50.67	3,223	216	200	250	715	135	1,100	650	500	50	550	745	620	580	0	1,200	
5/15/08	1,790	1,380	53.40	3,170	213	200	250	715	135	1,100	650	450	50	500	745	1,020	180	0	1,200	
5/16/08	1,786	1,480	56.34	3,266	209	200	250	715	135	1,100	650	400	75	475	745	1,020	180	0	1,200	
5/17/08	2,133	1,080	58.48	3,213	206	200	250	715	135	1,100	650	400	75	475	745	1,020	180	0	1,200	
5/18/08	2,079	1,105	60.67	3,184	202	200	250	565	135	950	650	400	75	475	745	1,020	180	0	1,200	
5/19/08	2,076	1,105	62.87	3,181	199	200	250	260	135	645	650	400	75	475	745	1,020	180	0	1,200	
5/20/08	2,072	1,105	65.06	3,177	195	200	250			250	650	400	65	465	745	970	230	0	1,200	
5/21/08	2,069	955	66.95	3,024	191	200	250			250	350	350		350	737	737			737	
5/22/08	2,015	690	68.32	2,705	187	200	250			250	300	300		300	737	737			737	
5/23/08	1,728	0		1,728	183	200	250			250	250	250		250	737	737			737	
5/24/08	1,674	0		1,674	179	200	250			250	200	200		200	737	737			737	
5/25/08	1,620	0		1,620	175	200	250			250	150	150		150	737	737			737	
5/26/08	1,566	0		1,566	171	200	250			250	150	150		150	737	737			737	
5/27/08	1,512	0		1,512	167	200	250			250	150	150		150	737	737			737	
5/28/08	1,508	0		1,508	163	200	250			250	150	150		150	737	737			737	
5/29/08	1,504	0		1,504	159	200	250			250	150	150		150	737	737			737	
5/30/08	1,500	0		1,500	155	200	250			250	150	150		150	737	737			737	
5/31/08	1,496	0		1,496	151	200	250			250	130	130		130	737	737			737	
VAMP Period																				
Avg. (cfs):	2,089	1,111		3,200	248	200	250	594	118	961	650	650	163	813	745	741	237	0	979	
Supplemental Water (TAF):		68.32						36.50	7.23				10.00				14.60			

VAMP flow operation period

Appendix A-1, Table 9

2008 VAMP DAILY OPERATION PLAN — APRIL 14, 2008
(E1) LOW UNGAGED FLOW
Target Flow Period: April 22 - May 22 • Flow Target: 3,200 cfs
Bold Numbers: observed real-time mean daily flows

	San Joaquin River near Vernalis						Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus R blw Goodwin					
Date	Existing Flow	VAMP Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced River 2 day lag	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. Flow	Exch Contr VAMP Suppl. Flow	VAMP Flow (3 day lag)	Existing Flow - base FERC Volume	Existing Flow - Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2 day lag)	Existing Flow - Base	Existing Flow- reshaped	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol. S=Stan.
	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		(cfs)	(cfs)	(cfs)	
3/15/08	**1,820**			**1,820**	**735**	**-24**	**268**			**268**	**163**	**163**		**163**	**803**	**803**			**803**	
3/16/08	**1,850**			**1,850**	**735**	**-87**	**265**			**265**	**162**	**162**		**162**	**806**	**806**			**806**	
3/17/08	**1,880**			**1,880**	**716**	**-95**	**247**			**247**	**162**	**162**		**162**	**1,199**	**1,199**			**1,199**	
3/18/08	**1,860**			**1,860**	**713**	**-111**	**232**			**232**	**168**	**168**		**168**	**1,500**	**1,500**			**1,500**	
3/19/08	**2,010**			**2,010**	**706**	**-332**	**239**			**239**	**175**	**175**		**175**	**1,503**	**1,503**			**1,503**	
3/20/08	**2,180**			**2,180**	**703**	**-448**	**239**			**239**	**173**	**173**		**173**	**1,519**	**1,519**			**1,519**	
3/21/08	**2,210**			**2,210**	**727**	**-406**	**217**			**217**	**164**	**164**		**164**	**1,510**	**1,510**			**1,510**	
3/22/08	**2,270**			**2,270**	**719**	**-364**	**250**			**250**	**159**	**159**		**159**	**1,512**	**1,512**			**1,512**	
3/23/08	**2,350**			**2,350**	**697**	**-290**	**273**			**273**	**162**	**162**		**162**	**1,515**	**1,515**			**1,515**	
3/24/08	**2,390**			**2,390**	**674**	**-217**	**281**			**281**	**160**	**160**		**160**	**1,505**	**1,505**			**1,505**	
3/25/08	**2,330**			**2,330**	**668**	**-294**	**277**			**277**	**159**	**159**		**159**	**1,510**	**1,510**			**1,510**	
3/26/08	**2,290**			**2,290**	**615**	**-323**	**268**			**268**	**159**	**159**		**159**	**1,510**	**1,510**			**1,510**	
3/27/08	**2,350**			**2,350**	**605**	**-268**	**265**			**265**	**159**	**159**		**159**	**1,509**	**1,509**			**1,509**	
3/28/08	**2,410**			**2,410**	**530**	**-151**	**260**			**260**	**166**	**166**		**166**	**1,500**	**1,500**			**1,500**	
3/29/08	**2,430**			**2,430**	**531**	**-111**	**260**			**260**	**160**	**160**		**160**	**1,503**	**1,503**			**1,503**	
3/30/08	**2,480**			**2,480**	**513**	**19**	**268**			**268**	**160**	**160**		**160**	**1,503**	**1,503**			**1,503**	
3/31/08	**2,480**			**2,480**	**511**	**26**	**257**			**257**	**159**	**159**		**159**	**1,339**	**1,339**			**1,339**	
4/1/08	**2,380**			**2,380**	**489**	**-56**	**256**			**256**	**170**	**170**		**170**	**1,264**	**1,264**			**1,264**	
4/2/08	**2,210**			**2,210**	**491**	**-67**	**259**			**259**	**169**	**169**		**169**	**1,093**	**1,093**			**1,093**	
4/3/08	**2,160**			**2,160**	**465**	**-20**	**249**			**249**	**163**	**163**		**163**	**1,007**	**1,007**			**1,007**	
4/4/08	**2,050**			**2,050**	**474**	**41**	**258**			**258**	**158**	**158**		**158**	**1,010**	**1,010**			**1,010**	
4/5/08	**2,020**			**2,020**	**426**	**126**	**260**			**260**	**161**	**161**		**161**	**1,008**	**1,008**			**1,008**	
4/6/08	**2,000**			**2,000**	**404**	**109**	**272**			**272**	**169**	**169**		**169**	**1,004**	**1,004**			**1,004**	
4/7/08	**2,010**			**2,010**	**417**	**157**	**275**			**275**	**172**	**172**		**172**	**1,005**	**1,005**			**1,005**	
4/8/08	**1,960**			**1,960**	**412**	**123**	**268**			**268**	**171**	**171**		**171**	**1,001**	**1,001**			**1,001**	
4/9/08	**1,880**			**1,880**	**390**	**14**	**271**			**271**	**172**	**172**		**172**	**1,004**	**1,004**			**1,004**	
4/10/08	**1,850**			**1,850**	**386**	**-9**	**256**			**256**	**172**	**172**		**172**	**1,004**	**1,004**			**1,004**	
4/11/08	**1,840**			**1,840**	**363**	**6**	**260**			**260**	**178**	**178**		**178**	**1,164**	**1,164**			**1,164**	
4/12/08	**1,820**			**1,820**	**339**	**-13**	**271**			**271**	**180**	**180**		**180**	**1,250**	**1,250**			**1,250**	
4/13/08	**1,960**			**1,960**	**321**	**-1**	**278**			**278**	**180**	**180**		**180**	**1,250**	**1,250**			**1,250**	
4/14/08	**2,050**			**2,050**	**328**	**21**	**274**			**274**	**177**	**177**		**177**	**1,250**	**1,250**			**1,250**	
4/15/08	**2,010**			**2,010**	**346**	**-12**	**266**			**266**	**165**	**165**		**165**	**1,385**	**1,385**			**1,385**	
4/16/08	**2,010**			**2,010**	**348**	**-23**	**259**			**259**	**163**	**163**		**163**	**1,500**	**1,500**			**1,500**	
4/17/08	2,170			2,170	312	0	250			250	250	250		250	1,500	1,500			1,500	
4/18/08	2,277			2,277	308	0	250			250	250	250		250	1,500	1,500			1,500	
4/19/08	2,321			2,321	304	0	250	0	0	250	250	250		250	1,500	1,500			1,500	
4/20/08	2,308			2,308	300	0	250	0	0	250	650	850	0	850	745	620	0	0	620	
4/21/08	2,304			2,304	297	0	250	0	0	250	650	850	0	850	745	620	0	0	620	
4/22/08	2,020	0	0.00	2,020	293	0	250	0	0	250	650	850	0	850	745	620	0	0	620	
4/23/08	2,017	0	0.00	2,017	290	0	250	0	0	250	650	850	0	850	745	620	0	0	620	
4/24/08	2,013	0	0.00	2,013	286	0	250	150	0	400	650	850	0	850	745	620	0	0	620	
4/25/08	2,010	0	0.00	2,010	283	0	250	200	0	450	650	700	0	700	745	620	0	0	620	
4/26/08	2,006	0	0.00	2,006	279	0	250	250	0	500	650	625	0	625	745	620	0	0	620	
4/27/08	1,853	150	0.30	2,003	276	0	250	200	0	450	650	525	0	525	745	620	0	0	620	
4/28/08	1,774	200	0.69	1,974	272	0	250	50	0	300	650	500	0	500	745	720	0	0	720	
4/29/08	1,671	250	1.19	1,921	269	0	250	0	0	250	650	500	0	500	745	1,020	0	0	1,020	
4/30/08	1,742	200	1.59	1,942	265	0	250	0	0	250	650	500	0	500	745	1,020	0	0	1,020	
5/1/08	2,039	50	1.69	2,089	262	0	250	0	0	250	650	500	0	500	745	1,020	0	0	1,020	
5/2/08	2,035	0	1.69	2,035	258	0	250	0	0	250	650	500	0	500	745	1,000	0	0	1,000	
5/3/08	2,032	0	1.69	2,032	255	0	250	50	0	300	650	500	0	500	745	950	0	0	950	
5/4/08	2,008	0	1.69	2,008	251	0	250	100	0	350	650	600	0	600	745	820	0	0	820	
5/5/08	1,955	0	1.69	1,955	248	0	250	100	0	350	650	900	0	900	745	520	0	0	520	
5/6/08	1,921	50	1.79	1,971	244	0	250	100	0	350	650	900	0	900	745	520	0	0	520	
5/7/08	1,918	100	1.98	2,018	241	0	250	100	0	350	650	900	0	900	745	520	0	0	520	
5/8/08	1,914	100	2.18	2,014	237	0	250	100	0	350	650	900	0	900	745	520	0	0	520	
5/9/08	1,911	100	2.38	2,011	234	0	250	100	0	350	650	900	0	900	745	520	0	0	520	
5/10/08	1,907	100	2.58	2,007	230	0	250	200	0	450	650	900	0	900	745	520	0	0	520	
5/11/08	1,904	100	2.78	2,004	227	0	250	250	0	500	650	800	0	800	745	520	0	0	520	
5/12/08	1,900	100	2.98	2,000	223	0	250	300	0	550	650	700	0	700	745	620	0	0	620	
5/13/08	1,797	200	3.37	1,997	220	0	250	300	0	550	650	600	0	600	745	620	0	0	620	
5/14/08	1,793	250	3.87	2,043	216	0	250	150	0	400	650	500	0	500	745	620	0	0	620	
5/15/08	1,690	300	4.46	1,990	213	0	250	150	0	400	650	450	0	450	745	1,020	0	0	1,020	
5/16/08	1,586	300	5.06	1,886	209	0	250	150	0	400	650	400	0	400	745	1,020	0	0	1,020	
5/17/08	1,933	150	5.36	2,083	206	0	250	150	0	400	650	400	0	400	745	1,020	0	0	1,020	
5/18/08	1,879	150	5.65	2,029	202	0	250	100	0	350	650	400	0	400	745	1,020	0	0	1,020	
5/19/08	1,876	150	5.95	2,026	199	0	250	100	0	350	650	400	0	400	745	1,020	0	0	1,020	
5/20/08	1,872	150	6.25	2,022	195	0	250			250	650	400	0	400	745	970	0	0	970	
5/21/08	1,869	100	6.45	1,969	191	0	250			250	350	350		350	737	737			737	
5/22/08	1,815	100	6.64	1,915	187	0	250			250	300	300		300	737	737			737	
5/23/08	1,528	0		1,528	183	0	250			250	250	250		250	737	737			737	
5/24/08	1,474	0		1,474	179	0	250			250	200	200		200	737	737			737	
5/25/08	1,420	0		1,420	175	0	250			250	150	150		150	737	737			737	
5/26/08	1,366	0		1,366	171	0	250			250	150	150		150	737	737			737	
5/27/08	1,312	0		1,312	167	0	250			250	150	150		150	737	737			737	
5/28/08	1,308	0		1,308	163	0	250			250	150	150		150	737	737			737	
5/29/08	1,304	0		1,304	159	0	250			250	150	150		150	737	737			737	
5/30/08	1,300	0		1,300	155	0	250			250	150	150		150	737	737			737	
5/31/08	1,296	0		1,296	151	0	250			250	130	130		130	737	737			737	
VAMP Period																				
Avg. (cfs):	1,892	108		2,000	248	0	250	108	0	358	650	650	0	650	745	745	0	0	745	
Supplemental Water (TAF):		6.64						6.64	0.00				0.00				0.00			

VAMP flow operation period

APPENDIX A

Appendix A-1, Table 10

2008 VAMP DAILY OPERATION PLAN — APRIL 14, 2008
(E2) HIGH UNGAGED FLOW
Target Flow Period: April 22 - May 22 • Flow Target: 3,200 cfs
Bold Numbers: observed real-time mean daily flows

	San Joaquin River near Vernalis						Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus R blw Goodwin					
Date	Existing Flow	VAMP Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced River 2 day lag)	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. Flow	Exch Contr VAMP Suppl. Flow	VAMP Flow (3 day lag)	Existing Flow - base FERC Volume	Existing Flow - Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2 day lag)	Existing Flow - Base	Existing Flow- reshaped	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol. S=Stan.
	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		(cfs)	(cfs)	(cfs)	
3/15/08	1,820			1,820	781	-64	268			268	163	163		163	803	803			803	
3/16/08	1,850			1,850	785	-127	265			265	162	162		162	806	806			806	
3/17/08	1,880			1,880	763	-141	247			247	162	162		162	1,199	1,199			1,199	
3/18/08	1,860			1,860	762	-161	232			232	168	168		168	1,500	1,500			1,500	
3/19/08	2,010			2,010	757	-379	239			239	175	175		175	1,503	1,503			1,503	
3/20/08	2,180			2,180	755	-497	239			239	173	173		173	1,519	1,519			1,519	
3/21/08	2,210			2,210	783	-457	217			217	164	164		164	1,510	1,510			1,510	
3/22/08	2,270			2,270	777	-416	250			250	159	159		159	1,512	1,512			1,512	
3/23/08	2,350			2,350	757	-346	273			273	162	162		162	1,515	1,515			1,515	
3/24/08	2,390			2,390	738	-275	281			281	160	160		160	1,505	1,505			1,505	
3/25/08	2,330			2,330	733	-354	277			277	159	159		159	1,510	1,510			1,510	
3/26/08	2,290			2,290	681	-386	268			268	159	159		159	1,510	1,510			1,510	
3/27/08	2,350			2,350	671	-333	265			265	159	159		159	1,509	1,509			1,509	
3/28/08	2,410			2,410	597	-217	260			260	166	166		166	1,500	1,500			1,500	
3/29/08	2,430			2,430	598	-177	260			260	160	160		160	1,503	1,503			1,503	
3/30/08	2,480			2,480	583	-48	268			268	160	160		160	1,503	1,503			1,503	
3/31/08	2,480			2,480	583	-41	257			257	159	159		159	1,339	1,339			1,339	
4/1/08	2,380			2,380	563	-126	256			256	170	170		170	1,264	1,264			1,264	
4/2/08	2,210			2,210	566	-139	259			259	169	169		169	1,093	1,093			1,093	
4/3/08	2,160			2,160	542	-94	249			249	163	163		163	1,007	1,007			1,007	
4/4/08	2,050			2,050	550	-34	258			258	158	158		158	1,010	1,010			1,010	
4/5/08	2,020			2,020	499	49	260			260	161	161		161	1,008	1,008			1,008	
4/6/08	2,000			2,000	476	33	272			272	169	169		169	1,004	1,004			1,004	
4/7/08	2,010			2,083	417	157	275			275	172	172		172	1,005	1,005			1,005	
4/8/08	1,960			2,032	412	123	268			268	171	171		171	1,001	1,001			1,001	
4/9/08	1,880			1,880	390	14	271			271	172	172		172	1,004	1,004			1,004	
4/10/08	1,850			1,850	386	-9	256			256	172	172		172	1,004	1,004			1,004	
4/11/08	1,840			1,840	363	6	260			260	178	178		178	1,164	1,164			1,164	
4/12/08	1,820			1,820	339	-13	271			271	180	180		180	1,250	1,250			1,250	
4/13/08	1,960			1,960	321	-1	278			278	180	180		180	1,250	1,250			1,250	
4/14/08	2,050			2,050	328	21	274			274	177	177		177	1,250	1,250			1,250	
4/15/08	2,010			2,010	346	-12	266			266	165	165		165	1,385	1,385			1,385	
4/16/08	2,010			2,010	348	-23	259			259	163	163		163	1,500	1,500			1,500	
4/17/08	2,320			2,320	312	150	250			250	250	250		250	1,500	1,500			1,500	
4/18/08	2,477			2,477	308	200	250			250	250	250		250	1,500	1,500			1,500	
4/19/08	2,521			2,521	304	200	250	0	0	250	250	250		250	1,500	1,500			1,500	
4/20/08	2,508			2,508	300	200	250	0	0	250	650	950	250	1,200	745	1,020	280	0	1,300	
4/21/08	2,504			2,504	297	200	250	0	0	250	650	950	250	1,200	745	1,020	280	0	1,300	
4/22/08	2,720	530	1.05	3,250	293	200	250	50	0	300	650	950	250	1,200	745	1,020	280	0	1,300	
4/23/08	2,717	530	2.10	3,247	290	200	250	265	135	650	650	950	250	1,200	745	1,000	250	0	1,250	
4/24/08	2,713	530	3.15	3,243	286	200	250	565	135	950	650	850	250	1,100	745	950	0	0	950	
4/25/08	2,690	550	4.24	3,240	283	200	250	915	135	1,300	650	750	175	925	745	820	30	0	850	
4/26/08	2,536	650	5.53	3,186	279	200	250	1,015	135	1,400	650	650	100	750	745	620	80	0	700	
4/27/08	2,303	905	7.33	3,208	276	200	250	1,015	135	1,400	650	550	100	650	745	620	80	0	700	
4/28/08	1,999	1,230	9.77	3,229	272	200	250	1,015	135	1,400	650	500	150	650	745	620	80	0	700	
4/29/08	1,896	1,330	12.41	3,226	269	200	250	1,015	135	1,400	650	500	150	650	745	620	80	0	700	
4/30/08	1,842	1,380	15.14	3,222	265	200	250	1,015	135	1,400	650	500	150	650	745	620	80	0	700	
5/1/08	1,839	1,380	17.88	3,219	262	200	250	1,015	135	1,400	650	500	150	650	745	620	80	0	700	
5/2/08	1,835	1,380	20.62	3,215	258	200	250	1,015	135	1,400	650	500	150	650	745	620	80	0	700	
5/3/08	1,832	1,380	23.36	3,212	255	200	250	915	135	1,300	650	500	150	650	745	620	80	0	700	
5/4/08	1,828	1,380	26.09	3,208	251	200	250	615	135	1,000	650	500	150	650	745	620	80	0	700	
5/5/08	1,825	1,380	28.83	3,205	248	200	250	515	135	900	650	900	300	1,200	745	520	180	0	700	
5/6/08	1,821	1,280	31.37	3,101	244	200	250	465	135	850	650	900	300	1,200	745	520	180	0	700	
5/7/08	2,118	1,230	33.81	3,348	241	200	250	365	135	750	650	900	300	1,200	745	520	180	0	700	
5/8/08	2,114	1,130	36.05	3,244	237	200	250	365	135	750	650	900	300	1,200	745	520	280	0	800	
5/9/08	2,111	1,080	38.19	3,191	234	200	250	365	135	750	650	900	300	1,200	745	520	470	0	990	
5/10/08	2,107	1,080	40.33	3,187	230	200	250	415	135	800	650	800	100	900	745	520	680	0	1,200	
5/11/08	2,104	1,270	42.85	3,374	227	200	250	515	135	900	650	700	100	800	745	520	680	0	1,200	
5/12/08	2,000	1,280	45.39	3,280	223	200	250	565	135	950	650	600	100	700	745	620	580	0	1,200	
5/13/08	1,897	1,330	48.03	3,227	220	200	250	715	135	1,100	650	500	100	600	745	620	580	0	1,200	
5/14/08	1,893	1,330	50.67	3,223	216	200	250	715	135	1,100	650	500	50	550	745	620	580	0	1,200	
5/15/08	1,790	1,380	53.40	3,170	213	200	250	715	135	1,100	650	450	50	500	745	1,020	180	0	1,200	
5/16/08	1,786	1,480	56.34	3,266	209	200	250	715	135	1,100	650	400	75	475	745	1,020	180	0	1,200	
5/17/08	2,133	1,080	58.48	3,213	206	200	250	715	135	1,100	650	400	75	475	745	1,020	180	0	1,200	
5/18/08	2,079	1,105	60.67	3,184	202	200	250	565	135	950	650	400	75	475	745	1,020	180	0	1,200	
5/19/08	2,076	1,105	62.87	3,181	199	200	250	260	135	645	650	400	75	475	745	1,020	180	0	1,200	
5/20/08	2,072	1,105	65.06	3,177	195	200	250			250	650	400	65	465	745	970	230	0	1,200	
5/21/08	2,069	955	66.95	3,024	191	200	250			250	350	350		350	737	737			737	
5/22/08	2,015	690	68.32	2,705	187	200	250			250	300	300		300	737	737			737	
5/23/08	1,728	0		1,728	183	200	250			250	250	250		250	737	737			737	
5/24/08	1,674	0		1,674	179	200	250			250	200	200		200	737	737			737	
5/25/08	1,620	0		1,620	175	200	250			250	150	150		150	737	737			737	
5/26/08	1,566	0		1,566	171	200	250			250	150	150		150	737	737			737	
5/27/08	1,512	0		1,512	167	200	250			250	150	150		150	737	737			737	
5/28/08	1,508	0		1,508	163	200	250			250	150	150		150	737	737			737	
5/29/08	1,504	0		1,504	159	200	250			250	150	150		150	737	737			737	
5/30/08	1,500	0		1,500	155	200	250			250	150	150		150	737	737			737	
5/31/08	1,496	0		1,496	151	200	250			250	130	130		130	737	737			737	
VAMP Period																				
Avg. (cfs):	2,089	1,111		3,200	248	200	250	594	118	961	650	650	163	813	745	741	237	0	979	
Supplemental Water (TAF):		68.32						36.50	7.23				10.00				14.60			

VAMP flow operation period

Appendix A-1, Table 11

2008 VAMP DAILY OPERATION PLAN — APRIL 18, 2008

Target Flow Period: April 22 - May 22 • Flow Target: 3,200 cfs

Bold Numbers: observed real-time mean daily flows

	San Joaquin River near Vernalis						Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus R blw Goodwin					
Date	Existing Flow	VAMP Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced River 2 day lag	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. Flow	Exch Contr VAMP Suppl. Flow	VAMP Flow (3 day lag)	Existing Flow - base FERC Volume	Existing Flow - Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2 day lag)	Existing Flow - Base	Existing Flow-reshaped	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol. S=Stan.
	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		(cfs)	(cfs)	(cfs)	
3/15/08	1,820			1,820	781	-64	268			268	163	163		163	803	803			803	
3/16/08	1,850			1,850	785	-127	265			265	162	162		162	806	806			806	
3/17/08	1,880			1,880	763	-141	247			247	162	162		162	1,199	1,199			1,199	
3/18/08	1,860			1,860	762	-161	232			232	168	168		168	1,500	1,500			1,500	
3/19/08	2,010			2,010	757	-379	239			239	175	175		175	1,503	1,503			1,503	
3/20/08	2,180			2,180	755	-497	239			239	173	173		173	1,519	1,519			1,519	
3/21/08	2,210			2,210	783	-457	217			217	164	164		164	1,510	1,510			1,510	
3/22/08	2,270			2,270	777	-416	250			250	159	159		159	1,512	1,512			1,512	
3/23/08	2,350			2,350	757	-346	273			273	162	162		162	1,515	1,515			1,515	
3/24/08	2,390			2,390	738	-275	281			281	160	160		160	1,505	1,505			1,505	
3/25/08	2,330			2,330	733	-354	277			277	159	159		159	1,510	1,510			1,510	
3/26/08	2,290			2,290	681	-386	268			268	159	159		159	1,510	1,510			1,510	
3/27/08	2,350			2,350	671	-333	265			265	159	159		159	1,509	1,509			1,509	
3/28/08	2,410			2,410	597	-217	260			260	166	166		166	1,500	1,500			1,500	
3/29/08	2,430			2,430	598	-177	260			260	160	160		160	1,503	1,503			1,503	
3/30/08	2,480			2,480	583	-48	268			268	160	160		160	1,503	1,503			1,503	
3/31/08	2,480			2,480	583	-41	257			257	159	159		159	1,339	1,339			1,339	
4/1/08	2,380			2,380	563	-126	256			256	170	170		170	1,264	1,264			1,264	
4/2/08	2,210			2,210	566	-139	259			259	169	169		169	1,093	1,093			1,093	
4/3/08	2,160			2,160	542	-94	249			249	163	163		163	1,007	1,007			1,007	
4/4/08	2,050			2,050	550	-34	258			258	158	158		158	1,010	1,010			1,010	
4/5/08	2,020			2,020	499	49	260			260	161	161		161	1,008	1,008			1,008	
4/6/08	2,000			2,000	476	33	272			272	169	169		169	1,004	1,004			1,004	
4/7/08	2,010			2,083	417	157	275			275	172	172		172	1,005	1,005			1,005	
4/8/08	1,960			2,032	412	123	268			268	171	171		171	1,001	1,001			1,001	
4/9/08	1,880			1,880	390	14	271			271	172	172		172	1,004	1,004			1,004	
4/10/08	1,850			1,850	386	-9	256			256	172	172		172	1,004	1,004			1,004	
4/11/08	1,840			1,840	363	6	260			260	178	178		178	1,164	1,164			1,164	
4/12/08	1,820			1,820	339	-13	271			271	180	180		180	1,250	1,250			1,250	
4/13/08	1,960			1,960	321	-1	278			278	180	180		180	1,250	1,250			1,250	
4/14/08	2,050			2,050	328	21	274			274	177	177		177	1,250	1,250			1,250	
4/15/08	2,010			2,010	346	-12	266			266	165	165		165	1,385	1,385			1,385	
4/16/08	2,010			2,010	348	-23	259			259	163	163		163	1,500	1,500			1,500	
4/17/08	2,150			2,150	325	-20	257			257	164	164		164	1,520	1,520			1,520	
4/18/08	2,277			2,277	320	0	250			250	150	150		150	1,500	1,500			1,500	
4/19/08	2,268			2,268	316	0	250	0	0	250	150	150		150	1,500	1,500			1,500	
4/20/08	2,227			2,227	312	0	250	0	0	250	751	1,100	200	1,300	745	1,020	330	0	1,350	
4/21/08	2,216			2,216	308	0	250	0	0	250	751	1,100	200	1,300	745	1,020	330	0	1,350	
4/22/08	2,682	530	1.05	3,212	305	0	250	50	0	300	751	1,100	200	1,300	745	1,020	330	0	1,350	
4/23/08	2,678	530	2.10	3,208	301	0	250	265	135	650	751	1,100	200	1,300	745	1,000	350	0	1,350	
4/24/08	2,675	530	3.15	3,205	298	0	250	565	135	950	751	1,100	200	1,300	745	950	0	0	950	
4/25/08	2,651	600	4.34	3,251	294	0	250	915	135	1,300	751	900	200	1,100	745	820	30	0	850	
4/26/08	2,598	600	5.53	3,198	291	0	250	1,065	135	1,450	751	750	200	950	745	620	30	0	650	
4/27/08	2,264	930	7.38	3,194	287	0	250	1,065	135	1,450	751	650	200	850	745	620	30	0	650	
4/28/08	1,911	1,280	9.92	3,191	283	0	250	1,065	135	1,450	751	550	300	850	745	620	30	0	650	
4/29/08	1,807	1,430	12.75	3,237	280	0	250	1,065	135	1,450	751	550	300	850	745	620	30	0	650	
4/30/08	1,703	1,530	15.79	3,233	276	0	250	1,065	135	1,450	751	550	300	850	745	620	30	0	650	
5/1/08	1,700	1,530	18.82	3,230	273	0	250	1,065	135	1,450	751	550	300	850	745	620	30	0	650	
5/2/08	1,696	1,530	21.86	3,226	269	0	250	1,065	135	1,450	751	550	300	850	745	620	30	0	650	
5/3/08	1,693	1,530	24.89	3,223	266	0	250	965	135	1,350	751	550	300	850	745	620	30	0	650	
5/4/08	1,689	1,530	27.93	3,219	262	0	250	725	135	1,110	751	550	435	985	745	620	30	0	650	
5/5/08	1,686	1,530	30.96	3,216	259	0	250	615	135	1,000	751	1,100	200	1,300	745	520	130	0	650	
5/6/08	1,682	1,565	34.07	3,247	255	0	250	515	135	900	751	1,100	200	1,300	745	520	130	0	650	
5/7/08	2,129	1,190	36.43	3,319	251	0	250	415	135	800	751	1,100	200	1,300	745	520	230	0	750	
5/8/08	2,125	1,080	38.57	3,205	248	0	250	365	135	750	751	1,100	200	1,300	745	520	330	0	850	
5/9/08	2,121	1,080	40.71	3,201	244	0	250	365	135	750	751	1,100	200	1,300	745	520	395	0	915	
5/10/08	2,118	1,080	42.85	3,198	241	0	250	465	135	850	751	900	100	1,000	745	520	705	0	1,225	
5/11/08	2,114	1,095	45.02	3,209	237	0	250	565	135	950	751	750	150	900	745	520	705	0	1,225	
5/12/08	1,911	1,305	47.61	3,216	234	0	250	565	135	950	751	650	150	800	745	620	605	0	1,225	
5/13/08	1,757	1,455	50.50	3,212	230	0	250	615	135	1,000	751	550	250	800	745	620	605	0	1,225	
5/14/08	1,754	1,455	53.39	3,209	226	0	250	615	135	1,000	751	550	250	800	745	620	605	0	1,225	
5/15/08	1,650	1,555	56.47	3,205	223	0	250	615	135	1,000	751	550	250	800	745	1,020	205	0	1,225	
5/16/08	1,646	1,605	59.65	3,251	219	0	250	615	135	1,000	751	550	250	800	745	1,020	205	0	1,225	
5/17/08	2,043	1,205	62.04	3,248	216	0	250	615	135	1,000	751	550	250	800	745	1,020	205	0	1,225	
5/18/08	2,039	1,205	64.43	3,244	212	0	250	615	135	1,000	751	450	275	725	745	1,020	205	0	1,225	
5/19/08	2,036	1,205	66.82	3,241	209	0	250	280	170	700	751	350	300	650	745	1,020	205	0	1,225	
5/20/08	1,932	1,230	69.26	3,162	205	0	250			250	751	275	300	575	745	970	255	0	1,225	
5/21/08	1,829	1,255	71.75	3,084	201	0	250			250	210	210		210	737	737			737	
5/22/08	1,700	1,005	73.75	2,705	197	0	250			250	150	150		150	737	737			737	
5/23/08	1,398	0		1,398	193	0	250			250	150	150		150	737	737			737	
5/24/08	1,334	0		1,334	189	0	250			250	150	150		150	737	737			737	
5/25/08	1,330	0		1,330	185	0	250			250	150	150		150	737	737			737	
5/26/08	1,326	0		1,326	181	0	250			250	150	150		150	737	737			737	
5/27/08	1,322	0		1,322	177	0	250			250	150	150		150	737	737			737	
5/28/08	1,318	0		1,318	173	0	250			250	150	150		150	737	737			737	
5/29/08	1,314	0		1,314	169	0	250			250	150	150		150	737	737			737	
5/30/08	1,310	0		1,310	165	0	250			250	150	150		150	737	737			737	
5/31/08	1,306	0		1,306	161	0	250			250	150	150		150	737	737			737	
VAMP Period																				
Avg. (cfs):	2,001	1,199		3,200	259	0	250	606	119	975	751	751	237	988	745	741	237	0	979	
Supplemental Water (TAF):		73.75						37.25	7.30				14.60				14.60			

VAMP flow operation period

APPENDIX A

Appendix A-1, Table 12

2008 VAMP DAILY OPERATION PLAN — APRIL 28, 2008

Target Flow Period: April 22 - May 22 • Flow Target: 3,200 cfs

Bold Numbers: observed real-time mean daily flows

Date	San Joaquin River near Vernalis						Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus R blw Goodwin					
	Existing Flow	VAMP Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced River 2 day lag	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. Flow	Exch Contr VAMP Suppl. Flow	VAMP Flow (3 day lag)	Existing Flow - base FERC Volume	Existing Flow - Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2 day lag)	Existing Flow - Base	Existing Flow-reshaped	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol. S=Stan.
	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		(cfs)	(cfs)	(cfs)	
3/15/08	1,820			1,820	781	-28	268			268	163	163		163	803	803			803	
3/16/08	1,850			1,850	785	-91	265			265	162	162		162	806	806			806	
3/17/08	1,880			1,880	763	-99	247			247	162	162		162	1,199	1,199			1,199	
3/18/08	1,860			1,906	762	-115	232			232	168	168		168	1,500	1,500			1,500	
3/19/08	2,010			2,053	757	-336	239			239	175	175		175	1,503	1,503			1,503	
3/20/08	2,180			2,225	755	-452	239			239	173	173		173	1,519	1,519			1,519	
3/21/08	2,210			2,258	783	-409	217			217	164	164		164	1,510	1,510			1,510	
3/22/08	2,270			2,318	777	-368	250			250	159	159		159	1,512	1,512			1,512	
3/23/08	2,350			2,400	757	-296	273			273	162	162		162	1,515	1,515			1,515	
3/24/08	2,390			2,441	738	-224	281			281	160	160		160	1,505	1,505			1,505	
3/25/08	2,330			2,383	733	-301	277			277	159	159		159	1,510	1,510			1,510	
3/26/08	2,290			2,348	681	-328	268			268	159	159		159	1,510	1,510			1,510	
3/27/08	2,350			2,409	671	-274	265			265	159	159		159	1,509	1,509			1,509	
3/28/08	2,410			2,472	597	-155	260			260	166	166		166	1,500	1,500			1,500	
3/29/08	2,430			2,492	598	-115	260			260	160	160		160	1,503	1,503			1,503	
3/30/08	2,480			2,542	583	14	268			268	160	160		160	1,503	1,503			1,503	
3/31/08	2,480			2,542	583	21	257			257	159	159		159	1,339	1,339			1,339	
4/1/08	2,380			2,444	563	-62	256			256	170	170		170	1,264	1,264			1,264	
4/2/08	2,210			2,276	566	-73	259			259	169	169		169	1,093	1,093			1,093	
4/3/08	2,160			2,228	542	-26	249			249	163	163		163	1,007	1,007			1,007	
4/4/08	2,050			2,120	550	36	258			258	158	158		158	1,010	1,010			1,010	
4/5/08	2,020			2,090	499	119	260			260	161	161		161	1,008	1,008			1,008	
4/6/08	2,000			2,071	476	104	272			272	169	169		169	1,004	1,004			1,004	
4/7/08	2,010			2,081	417	155	275			275	172	172		172	1,005	1,005			1,005	
4/8/08	1,960			2,029	412	120	268			268	171	171		171	1,001	1,001			1,001	
4/9/08	1,880			1,876	390	10	271			271	172	172		172	1,004	1,004			1,004	
4/10/08	1,850			1,846	386	-13	256			256	172	172		172	1,004	1,004			1,004	
4/11/08	1,840			1,836	363	2	260			260	178	178		178	1,164	1,164			1,164	
4/12/08	1,820			1,816	339	-17	271			271	180	180		180	1,250	1,250			1,250	
4/13/08	1,960			1,956	321	-5	278			278	180	180		180	1,250	1,250			1,250	
4/14/08	2,050			2,046	328	17	274			274	177	177		177	1,250	1,250			1,250	
4/15/08	2,010			2,006	346	-16	266			266	165	165		165	1,385	1,385			1,385	
4/16/08	2,010			2,006	348	-27	259			259	163	163		163	1,500	1,500			1,500	
4/17/08	2,145			2,145	325	-25	257			257	164	164		164	1,520	1,520			1,520	
4/18/08	2,195			2,195	321	-82	260			260	165	165		165	1,515	1,515			1,515	
4/19/08	2,176			2,176	331	-92	250	0	0	249	755	755		755	1,519	1,519			1,519	
4/20/08	2,136			2,136	318	-122	250	8	0	258	751	1,100	200	1,300	745	1,020	360	0	1,380	
4/21/08	2,599			2,599	303	-266	250	15	0	265	751	1,100	170	1,270	745	1,020	333	0	1,353	
4/22/08	2,261	560	1.11	2,820	326	-427	250	101	0	351	751	1,100	210	1,310	745	1,020	367	0	1,387	
4/23/08	2,439	511	2.12	2,950	255	-234	250	292	135	677	751	1,100	210	1,310	745	1,000	351	0	1,351	
4/24/08	2,488	592	3.30	3,080	213	-208	250	627	135	1,012	751	1,100	210	1,310	745	950	164	0	1,114	
4/25/08	2,548	662	4.61	3,210	200	-57	250	1,008	135	1,393	751	900	230	1,130	745	820	64	0	884	
4/26/08	2,359	801	6.20	3,160	184	-154	250	1,108	135	1,493	751	750	212	962	745	620	104	0	724	
4/27/08	2,144	1,056	8.29	3,200	179	-26	250	1,110	135	1,495	751	650	211	861	745	620	32	0	652	
4/28/08	1,804	1,459	11.19	3,263	283	0	250	1,065	135	1,450	751	550	300	850	745	620	30	0	650	S
4/29/08	1,699	1,486	14.14	3,185	280	0	250	1,065	135	1,450	751	550	300	850	745	620	30	0	650	S
4/30/08	1,703	1,575	17.26	3,278	276	0	250	1,065	135	1,450	751	550	300	850	745	620	30	0	650	S
5/1/08	1,700	1,530	20.29	3,230	273	0	250	1,065	135	1,450	751	550	300	850	745	620	30	0	650	S
5/2/08	1,696	1,530	23.33	3,226	269	0	250	1,065	135	1,450	751	550	300	850	745	620	30	0	650	S
5/3/08	1,693	1,530	26.36	3,223	266	0	250	915	135	1,300	751	550	300	850	745	620	30	0	650	
5/4/08	1,689	1,530	29.40	3,219	262	0	250	615	135	1,000	751	550	435	985	745	620	30	0	650	
5/5/08	1,686	1,530	32.43	3,216	259	0	250	565	135	950	751	1,100	200	1,300	745	520	280	0	800	S
5/6/08	1,682	1,515	35.44	3,197	255	0	250	565	135	950	751	1,100	200	1,300	745	520	280	0	800	S
5/7/08	2,129	1,230	37.88	3,359	251	0	250	565	135	950	751	1,100	200	1,300	745	520	280	0	800	S
5/8/08	2,125	1,180	40.22	3,305	248	0	250	565	135	950	751	1,100	200	1,300	745	520	280	0	800	S
5/9/08	2,121	1,180	42.56	3,301	244	0	250	615	135	1,000	751	1,100	200	1,300	745	520	280	0	800	S
5/10/08	2,118	1,180	44.90	3,298	241	0	250	615	135	1,000	751	900	100	1,000	745	520	480	0	1,000	
5/11/08	2,114	1,180	47.24	3,294	237	0	250	665	135	1,050	751	750	150	900	745	520	680	0	1,200	
5/12/08	1,911	1,330	49.88	3,241	234	0	250	665	135	1,050	751	650	150	800	745	620	580	0	1,200	S
5/13/08	1,757	1,580	53.01	3,337	230	0	250	665	135	1,050	751	550	250	800	745	620	580	0	1,200	S
5/14/08	1,754	1,530	56.05	3,284	226	0	250	665	135	1,050	751	550	250	800	745	620	580	0	1,200	S
5/15/08	1,650	1,630	59.28	3,280	223	0	250	665	135	1,050	751	550	250	800	745	1,020	180	0	1,200	S
5/16/08	1,646	1,630	62.51	3,276	219	0	250	665	135	1,050	751	550	250	800	745	1,020	180	0	1,200	S
5/17/08	2,043	1,230	64.95	3,273	216	0	250	665	135	1,050	751	550	250	800	745	1,020	180	0	1,200	
5/18/08	2,039	1,230	67.39	3,269	212	0	250	665	135	1,050	751	450	275	725	745	1,020	180	0	1,200	
5/19/08	2,036	1,230	69.83	3,266	209	0	250	280	170	700	751	350	300	650	745	1,020	180	0	1,200	
5/20/08	1,932	1,255	72.32	3,187	205	0	250			250	751	275	300	575	745	970	230	0	1,200	
5/21/08	1,829	1,280	74.86	3,109	201	0	250			250	210	210		210	737	737			737	
5/22/08	1,700	980	76.80	2,680	197	0	250			250	150	150		150	737	737			737	
5/23/08	1,398	0		1,398	193	0	250			250	150	150		150	737	737			737	
5/24/08	1,334	0		1,334	189	0	250			250	150	150		150	737	737			737	
5/25/08	1,330	0		1,330	185	0	250			250	150	150		150	737	737			737	
5/26/08	1,326	0		1,326	181	0	250			250	150	150		150	737	737			737	
5/27/08	1,322	0		1,322	177	0	250			250	150	150		150	737	737			737	
5/28/08	1,318	0		1,318	173	0	250			250	150	150		150	737	737			737	
5/29/08	1,314	0		1,314	169	0	250			250	150	150		150	737	737			737	
5/30/08	1,310	0		1,310	165	0	250			250	150	150		150	737	737			737	
5/31/08	1,306	0		1,306	161	0	250			250	150	150		150	737	737			737	
VAMP Period																				
Avg. (cfs):	1,951	1,249		3,200	245	-36	250	652	119	1,021	751	751	239	990	745	741	239	0	980	
Supplemental Water (TAF):		76.80						40.09	7.30				14.70				14.71			

VAMP flow operation period

Appendix A-1, Table 13

2008 VAMP DAILY OPERATION PLAN — APRIL 30, 2008

Target Flow Period: April 22 - May 22 • Flow Target: 3,200 cfs

Bold Numbers: observed real-time mean daily flows

	San Joaquin River near Vernalis						Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus R blw Goodwin					
Date	Existing Flow	VAMP Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced River 2 day lag	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. Flow	Exch Contr VAMP Suppl. Flow	VAMP Flow (3 day lag)	Existing Flow - base FERC Volume	Existing Flow - Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2 day lag)	Existing Flow - Base	Existing Flow-reshaped	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol. S=Stan.
	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		(cfs)	(cfs)	(cfs)	
3/15/08	**1,820**			**1,820**	**735**	**-28**	**268**			**268**	**167**	**167**		**167**	**803**	**803**			**803**	
3/16/08	**1,850**			**1,850**	**735**	**-91**	**265**			**265**	**166**	**166**		**166**	**806**	**806**			**806**	
3/17/08	**1,880**			**1,880**	**716**	**-99**	**247**			**247**	**166**	**166**		**166**	**1,199**	**1,199**			**1,199**	
3/18/08	**1,860**			**1,860**	**713**	**-115**	**232**			**232**	**172**	**172**		**172**	**1,500**	**1,500**			**1,500**	
3/19/08	**2,010**			**2,010**	**705**	**-336**	**239**			**239**	**179**	**179**		**179**	**1,503**	**1,503**			**1,503**	
3/20/08	**2,180**			**2,180**	**703**	**-452**	**239**			**239**	**177**	**177**		**177**	**1,519**	**1,519**			**1,519**	
3/21/08	**2,210**			**2,210**	**727**	**-409**	**217**			**217**	**170**	**170**		**170**	**1,510**	**1,510**			**1,510**	
3/22/08	**2,270**			**2,270**	**720**	**-368**	**250**			**250**	**165**	**165**		**165**	**1,512**	**1,512**			**1,512**	
3/23/08	**2,350**			**2,350**	**698**	**-296**	**273**			**273**	**168**	**168**		**168**	**1,515**	**1,515**			**1,515**	
3/24/08	**2,390**			**2,390**	**674**	**-224**	**281**			**281**	**166**	**166**		**166**	**1,505**	**1,505**			**1,505**	
3/25/08	**2,330**			**2,330**	**668**	**-301**	**277**			**277**	**165**	**165**		**165**	**1,510**	**1,510**			**1,510**	
3/26/08	**2,290**			**2,290**	**613**	**-328**	**268**			**268**	**165**	**165**		**165**	**1,510**	**1,510**			**1,510**	
3/27/08	**2,350**			**2,350**	**604**	**-274**	**265**			**265**	**164**	**164**		**164**	**1,509**	**1,509**			**1,509**	
3/28/08	**2,410**			**2,410**	**529**	**-155**	**260**			**260**	**172**	**172**		**172**	**1,500**	**1,500**			**1,500**	
3/29/08	**2,430**			**2,430**	**530**	**-115**	**260**			**260**	**166**	**166**		**166**	**1,503**	**1,503**			**1,503**	
3/30/08	**2,480**			**2,480**	**513**	**14**	**268**			**268**	**166**	**166**		**166**	**1,503**	**1,503**			**1,503**	
3/31/08	**2,480**			**2,480**	**511**	**21**	**257**			**257**	**165**	**165**		**165**	**1,339**	**1,339**			**1,339**	
4/1/08	**2,380**			**2,380**	**489**	**-62**	**256**			**256**	**176**	**176**		**176**	**1,264**	**1,264**			**1,264**	
4/2/08	**2,210**			**2,210**	**490**	**-73**	**259**			**259**	**175**	**175**		**175**	**1,093**	**1,093**			**1,093**	
4/3/08	**2,160**			**2,160**	**466**	**-26**	**249**			**249**	**169**	**169**		**169**	**1,007**	**1,007**			**1,007**	
4/4/08	**2,050**			**2,050**	**474**	**36**	**258**			**258**	**163**	**163**		**163**	**1,010**	**1,010**			**1,010**	
4/5/08	**2,020**			**2,020**	**426**	**119**	**260**			**260**	**163**	**163**		**163**	**1,008**	**1,008**			**1,008**	
4/6/08	**2,000**			**2,000**	**404**	**104**	**272**			**272**	**172**	**172**		**172**	**1,004**	**1,004**			**1,004**	
4/7/08	**2,010**			**2,010**	**417**	**155**	**275**			**275**	**176**	**176**		**176**	**1,005**	**1,005**			**1,005**	
4/8/08	**1,960**			**1,960**	**412**	**120**	**268**			**268**	**175**	**175**		**175**	**1,001**	**1,001**			**1,001**	
4/9/08	**1,880**			**1,880**	**390**	**10**	**271**			**271**	**176**	**176**		**176**	**1,004**	**1,004**			**1,004**	
4/10/08	**1,850**			**1,850**	**386**	**-13**	**256**			**256**	**176**	**176**		**176**	**1,004**	**1,004**			**1,004**	
4/11/08	**1,840**			**1,840**	**363**	**2**	**260**			**260**	**182**	**182**		**182**	**1,164**	**1,164**			**1,164**	
4/12/08	**1,820**			**1,820**	**339**	**-17**	**271**			**271**	**184**	**184**		**184**	**1,250**	**1,250**			**1,250**	
4/13/08	**1,960**			**1,960**	**321**	**-5**	**278**			**278**	**184**	**184**		**184**	**1,250**	**1,250**			**1,250**	
4/14/08	**2,050**			**2,050**	**328**	**17**	**274**			**274**	**181**	**181**		**181**	**1,250**	**1,250**			**1,250**	
4/15/08	**2,010**			**2,010**	**346**	**-16**	**266**			**266**	**170**	**170**		**170**	**1,385**	**1,385**			**1,385**	
4/16/08	**2,010**			**2,010**	**348**	**-27**	**259**			**259**	**168**	**168**		**168**	**1,500**	**1,500**			**1,500**	
4/17/08	**2,150**			**2,150**	**325**	**-25**	**257**			**257**	**168**	**168**		**168**	**1,520**	**1,520**			**1,520**	
4/18/08	**2,200**			**2,200**	**321**	**-82**	**260**			**260**	**169**	**169**		**169**	**1,515**	**1,515**			**1,515**	
4/19/08	**2,180**			**2,180**	**331**	**-92**	**250**	**0**	**0**	**249**	**756**	**756**		**756**	**1,519**	**1,519**			**1,519**	
4/20/08	**2,140**			**2,140**	**318**	**-122**	**250**	**8**	**0**	**258**	**751**	**1,100**	**200**	**1,300**	**745**	**1,020**	**360**	**0**	**1,380**	
4/21/08	**2,600**			**2,600**	**303**	**-266**	**250**	**15**	**0**	**265**	**751**	**1,100**	**170**	**1,270**	**745**	**1,020**	**333**	**0**	**1,353**	
4/22/08	**2,261**	**560**	**1.11**	**2,820**	**326**	**-427**	**250**	**101**	**0**	**351**	**751**	**1,100**	**210**	**1,310**	**745**	**1,020**	**367**	**0**	**1,387**	
4/23/08	**2,439**	**511**	**2.12**	**2,950**	**255**	**-234**	**250**	**292**	**135**	**677**	**751**	**1,100**	**210**	**1,310**	**745**	**1,000**	**351**	**0**	**1,351**	
4/24/08	**2,488**	**592**	**3.30**	**3,080**	**213**	**-208**	**250**	**627**	**135**	**1,012**	**751**	**1,100**	**210**	**1,310**	**745**	**950**	**164**	**0**	**1,114**	
4/25/08	**2,548**	**662**	**4.61**	**3,210**	**200**	**-57**	**250**	**1,008**	**135**	**1,393**	**751**	**900**	**230**	**1,130**	**745**	**820**	**64**	**0**	**884**	
4/26/08	**2,359**	**801**	**6.20**	**3,160**	**184**	**-154**	**250**	**1,108**	**135**	**1,493**	**751**	**750**	**212**	**962**	**745**	**620**	**104**	**0**	**724**	
4/27/08	**2,144**	**1,056**	**8.29**	**3,200**	**179**	**-26**	**250**	**1,110**	**135**	**1,495**	**751**	**650**	**211**	**861**	**745**	**620**	**32**	**0**	**652**	
4/28/08	**1,691**	**1,459**	**11.19**	**3,150**	**241**	**-113**	**250**	**1,129**	**135**	**1,514**	**751**	**550**	**302**	**852**	**745**	**620**	**34**	**0**	**654**	S
4/29/08	**1,514**	**1,486**	**14.14**	**3,000**	**256**	**-185**	**250**	**1,113**	**135**	**1,498**	**751**	**550**	**312**	**862**	**745**	**620**	**32**	**0**	**652**	S
4/30/08	1,421	1,581	17.27	3,002	276	-240	250	1,065	135	1,450	751	550	300	850	745	620	30	0	650	S
5/1/08	1,676	1,608	20.46	3,284	273	0	250	1,065	135	1,450	751	550	300	850	745	620	30	0	650	S
5/2/08	1,696	1,578	23.59	3,274	269	0	250	1,065	135	1,450	751	550	300	850	745	620	30	0	650	S
5/3/08	1,693	1,530	26.63	3,223	266	0	250	915	135	1,300	751	550	300	850	745	620	30	0	650	
5/4/08	1,689	1,530	29.66	3,219	262	0	250	615	135	1,000	751	550	435	985	745	620	30	0	650	
5/5/08	1,686	1,530	32.70	3,216	259	0	250	515	135	900	751	1,100	200	1,300	745	520	280	0	800	S
5/6/08	1,682	1,515	35.70	3,197	255	0	250	515	135	900	751	1,100	200	1,300	745	520	280	0	800	S
5/7/08	2,129	1,230	38.14	3,359	251	0	250	515	135	900	751	1,100	200	1,300	745	520	280	0	800	S
5/8/08	2,125	1,130	40.38	3,255	248	0	250	515	135	900	751	1,100	200	1,300	745	520	280	0	800	S
5/9/08	2,121	1,130	42.62	3,251	244	0	250	615	135	1,000	751	1,100	200	1,300	745	520	280	0	800	S
5/10/08	2,118	1,130	44.86	3,248	241	0	250	715	135	1,100	751	900	100	1,000	745	520	480	0	1,000	
5/11/08	2,114	1,130	47.11	3,244	237	0	250	815	135	1,200	751	750	150	900	745	520	480	0	1,000	
5/12/08	1,911	1,330	49.74	3,241	234	0	250	815	135	1,200	751	650	150	800	745	620	430	0	1,050	S
5/13/08	1,757	1,480	52.68	3,237	230	0	250	815	135	1,200	751	550	250	800	745	620	430	0	1,050	S
5/14/08	1,754	1,530	55.71	3,284	226	0	250	815	135	1,200	751	550	250	800	745	800	250	0	1,050	S
5/15/08	1,650	1,630	58.95	3,280	223	0	250	815	135	1,200	751	550	250	800	745	1,000	50	0	1,050	S
5/16/08	1,826	1,450	61.82	3,276	219	0	250	615	135	1,000	751	550	250	800	745	1,000	50	0	1,050	S
5/17/08	2,023	1,250	64.30	3,273	216	0	250	460	140	850	751	550	250	800	745	1,000	300	0	1,300	
5/18/08	2,019	1,250	66.78	3,269	212	0	250	250	150	650	751	450	350	800	745	1,000	500	0	1,500	
5/19/08	2,016	1,300	69.36	3,316	209	0	250	50	150	450	751	350	300	650	745	1,000	500	0	1,500	
5/20/08	1,912	1,450	72.24	3,362	205	0	250			250	751	275	150	425	745	1,000	500	0	1,500	
5/21/08	1,809	1,200	74.62	3,009	201	0	250			250	210	210		210	737	737			737	
5/22/08	1,730	850	76.30	2,580	197	0	250			250	150	150		150	737	737			737	
5/23/08	1,398	0		1,398	193	0	250			250	150	150		150	737	737			737	
5/24/08	1,334	0		1,334	189	0	250			250	150	150		150	737	737			737	
5/25/08	1,330	0		1,330	185	0	250			250	150	150		150	737	737			737	
5/26/08	1,326	0		1,326	181	0	250			250	150	150		150	737	737			737	
5/27/08	1,322	0		1,322	177	0	250			250	150	150		150	737	737			737	
5/28/08	1,318	0		1,318	173	0	250			250	150	150		150	737	737			737	
5/29/08	1,314	0		1,314	169	0	250			250	150	150		150	737	737			737	
5/30/08	1,310	0		1,310	165	0	250			250	150	150		150	737	737			737	
5/31/08	1,306	0		1,306	161	0	250			250	150	150		150	737	737			737	
VAMP Period																				
Avg. (cfs):	1,935	1,241		3,176	243	-53	250	648	119	1,016	751	751	237	988	745	745	237	0	982	
Supplemental Water (TAF):		76.30						39.82	7.30				14.58				14.60			

VAMP flow operation period

APPENDIX A

Appendix A-1, Table 14

2008 VAMP DAILY OPERATION PLAN — MAY 15, 2008

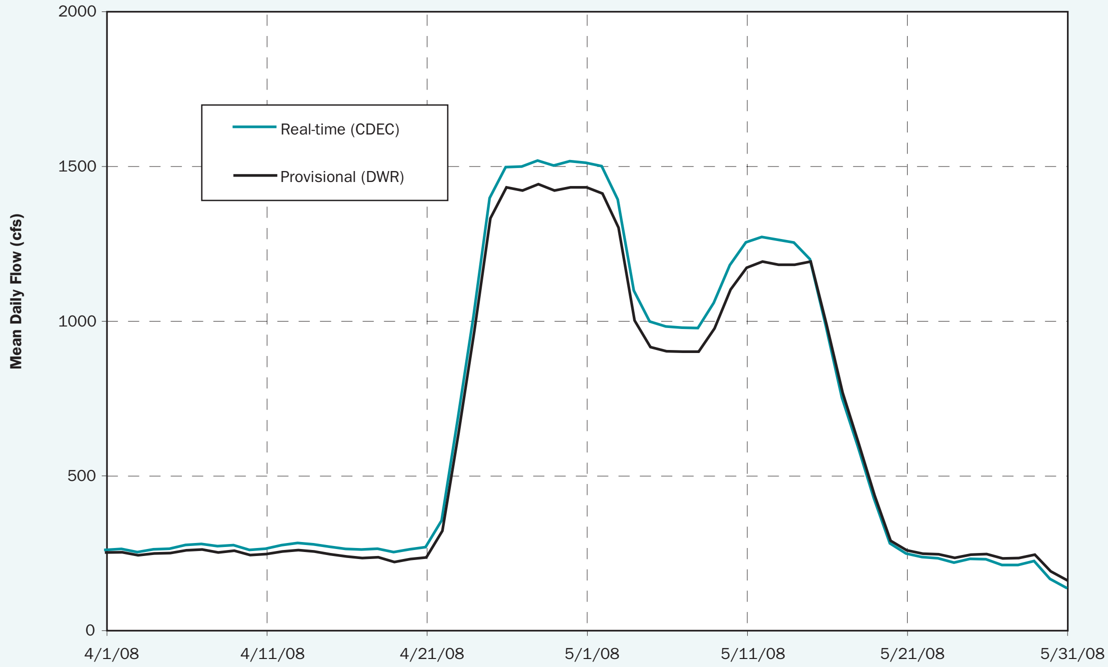
Target Flow Period: April 22 - May 22 • Flow Target: 3,200 cfs

Bold Numbers: observed real-time mean daily flows

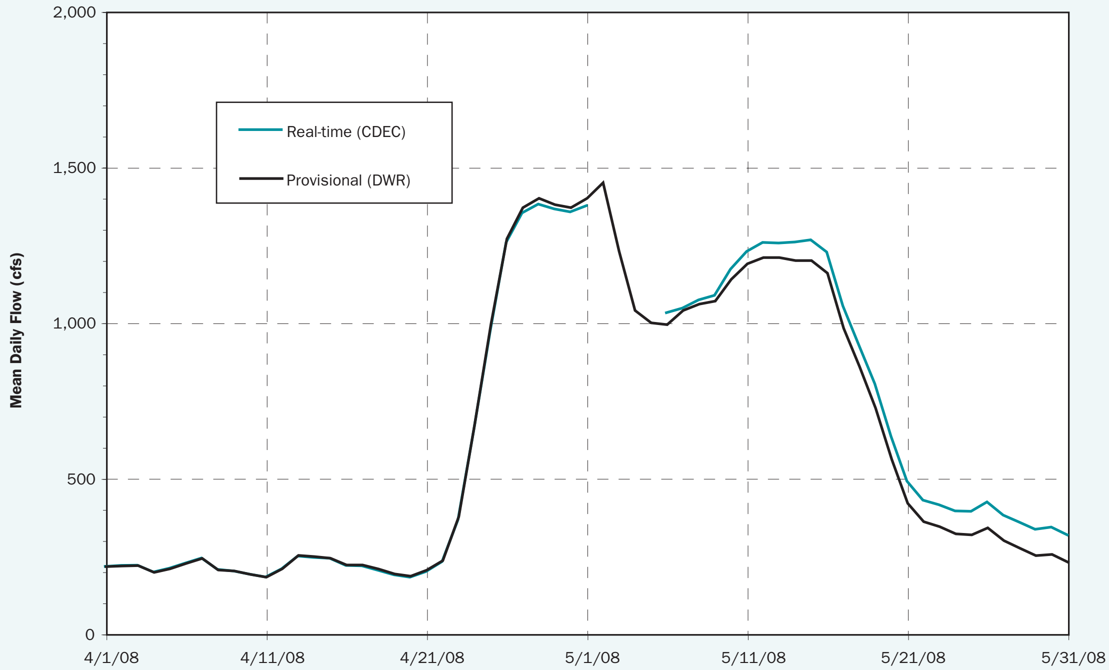
	San Joaquin River near Vernalis						Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus R blw Goodwin					
Date	Existing Flow	VAMP Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced River 2 day lag	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. Flow	Exch Contr VAMP Suppl. Flow	VAMP Flow (3 day lag)	Existing Flow - base FERC Volume	Existing Flow - Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2 day lag)	Existing Flow - Base	Existing Flow-reshaped	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol. S=Stan.
	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		(cfs)	(cfs)	(cfs)	
3/15/08	**1,820**			**1,820**	**735**	**-28**	**268**			**268**	**167**	**167**		**167**	**803**	**803**			**803**	
3/16/08	**1,850**			**1,850**	**735**	**-91**	**265**			**265**	**166**	**166**		**166**	**806**	**806**			**806**	
3/17/08	**1,880**			**1,880**	**716**	**-99**	**247**			**247**	**166**	**166**		**166**	**1,199**	**1,199**			**1,199**	
3/18/08	**1,860**			**1,860**	**713**	**-115**	**232**			**232**	**172**	**172**		**172**	**1,500**	**1,500**			**1,500**	
3/19/08	**2,010**			**2,010**	**705**	**-336**	**239**			**239**	**179**	**179**		**179**	**1,503**	**1,503**			**1,503**	
3/20/08	**2,180**			**2,180**	**703**	**-452**	**239**			**239**	**177**	**177**		**177**	**1,519**	**1,519**			**1,519**	
3/21/08	**2,210**			**2,210**	**727**	**-409**	**217**			**217**	**170**	**170**		**170**	**1,510**	**1,510**			**1,510**	
3/22/08	**2,270**			**2,270**	**720**	**-368**	**250**			**250**	**165**	**165**		**165**	**1,512**	**1,512**			**1,512**	
3/23/08	**2,350**			**2,350**	**698**	**-296**	**273**			**273**	**168**	**168**		**168**	**1,515**	**1,515**			**1,515**	
3/24/08	**2,390**			**2,390**	**674**	**-224**	**281**			**281**	**166**	**166**		**166**	**1,505**	**1,505**			**1,505**	
3/25/08	**2,330**			**2,330**	**668**	**-301**	**277**			**277**	**165**	**165**		**165**	**1,510**	**1,510**			**1,510**	
3/26/08	**2,290**			**2,290**	**613**	**-328**	**268**			**268**	**165**	**165**		**165**	**1,510**	**1,510**			**1,510**	
3/27/08	**2,350**			**2,350**	**604**	**-274**	**265**			**265**	**164**	**164**		**164**	**1,509**	**1,509**			**1,509**	
3/28/08	**2,410**			**2,410**	**529**	**-155**	**260**			**260**	**172**	**172**		**172**	**1,500**	**1,500**			**1,500**	
3/29/08	**2,430**			**2,430**	**530**	**-115**	**260**			**260**	**166**	**166**		**166**	**1,503**	**1,503**			**1,503**	
3/30/08	**2,480**			**2,480**	**513**	**14**	**268**			**268**	**166**	**166**		**166**	**1,503**	**1,503**			**1,503**	
3/31/08	**2,480**			**2,480**	**511**	**21**	**257**			**257**	**165**	**165**		**165**	**1,339**	**1,339**			**1,339**	
4/1/08	**2,380**			**2,380**	**489**	**-62**	**256**			**256**	**176**	**176**		**176**	**1,264**	**1,264**			**1,264**	
4/2/08	**2,210**			**2,210**	**490**	**-73**	**259**			**259**	**175**	**175**		**175**	**1,093**	**1,093**			**1,093**	
4/3/08	**2,160**			**2,160**	**466**	**-26**	**249**			**249**	**169**	**169**		**169**	**1,007**	**1,007**			**1,007**	
4/4/08	**2,050**			**2,050**	**474**	**36**	**258**			**258**	**163**	**163**		**163**	**1,010**	**1,010**			**1,010**	
4/5/08	**2,020**			**2,020**	**426**	**119**	**260**			**260**	**163**	**163**		**163**	**1,008**	**1,008**			**1,008**	
4/6/08	**2,000**			**2,000**	**404**	**104**	**272**			**272**	**172**	**172**		**172**	**1,004**	**1,004**			**1,004**	
4/7/08	**2,010**			**2,010**	**417**	**155**	**275**			**275**	**176**	**176**		**176**	**1,005**	**1,005**			**1,005**	
4/8/08	**1,960**			**1,960**	**412**	**120**	**268**			**268**	**175**	**175**		**175**	**1,001**	**1,001**			**1,001**	
4/9/08	**1,880**			**1,880**	**390**	**10**	**271**			**271**	**176**	**176**		**176**	**1,004**	**1,004**			**1,004**	
4/10/08	**1,850**			**1,850**	**386**	**-13**	**256**			**256**	**176**	**176**		**176**	**1,004**	**1,004**			**1,004**	
4/11/08	**1,840**			**1,840**	**363**	**2**	**260**			**260**	**182**	**182**		**182**	**1,164**	**1,164**			**1,164**	
4/12/08	**1,820**			**1,820**	**339**	**-17**	**271**			**271**	**184**	**184**		**184**	**1,250**	**1,250**			**1,250**	
4/13/08	**1,960**			**1,960**	**321**	**-5**	**278**			**278**	**184**	**184**		**184**	**1,250**	**1,250**			**1,250**	
4/14/08	**2,050**			**2,050**	**328**	**17**	**274**			**274**	**181**	**181**		**181**	**1,250**	**1,250**			**1,250**	
4/15/08	**2,010**			**2,020**	**346**	**-6**	**266**			**266**	**170**	**170**		**170**	**1,385**	**1,385**			**1,385**	
4/16/08	**2,010**			**2,030**	**348**	**-7**	**259**			**259**	**168**	**168**		**168**	**1,500**	**1,500**			**1,500**	
4/17/08	**2,180**			**2,180**	**325**	**5**	**257**			**257**	**168**	**168**		**168**	**1,520**	**1,520**			**1,520**	
4/18/08	**2,240**			**2,240**	**321**	**-42**	**260**			**260**	**169**	**169**		**169**	**1,515**	**1,515**			**1,515**	
4/19/08	**2,240**			**2,240**	**331**	**-32**	**250**	**0**	**0**	**249**	**756**	**756**		**756**	**1,519**	**1,519**			**1,519**	
4/20/08	**2,210**			**2,210**	**318**	**-52**	**250**	**8**	**0**	**258**	**751**	**1,100**	**200**	**1,300**	**745**	**1,020**	**360**	**0**	**1,380**	
4/21/08	**2,680**			**2,680**	**303**	**-186**	**250**	**15**	**0**	**265**	**751**	**1,100**	**170**	**1,270**	**745**	**1,020**	**333**	**0**	**1,353**	
4/22/08	**2,361**	**560**	**1.11**	**2,920**	**326**	**-327**	**250**	**101**	**0**	**351**	**751**	**1,100**	**210**	**1,310**	**745**	**1,020**	**367**	**0**	**1,387**	
4/23/08	**2,539**	**511**	**2.12**	**3,050**	**255**	**-134**	**250**	**292**	**135**	**677**	**751**	**1,100**	**210**	**1,310**	**745**	**1,000**	**351**	**0**	**1,351**	
4/24/08	**2,588**	**592**	**3.30**	**3,180**	**213**	**-108**	**250**	**627**	**135**	**1,012**	**751**	**1,100**	**210**	**1,310**	**745**	**950**	**164**	**0**	**1,114**	
4/25/08	**2,648**	**662**	**4.61**	**3,310**	**200**	**43**	**250**	**1,008**	**135**	**1,393**	**751**	**900**	**230**	**1,130**	**745**	**820**	**64**	**0**	**884**	
4/26/08	**2,459**	**801**	**6.20**	**3,260**	**184**	**-54**	**250**	**1,108**	**135**	**1,493**	**751**	**750**	**212**	**962**	**745**	**620**	**104**	**0**	**724**	
4/27/08	**2,244**	**1,056**	**8.29**	**3,300**	**179**	**74**	**250**	**1,110**	**135**	**1,495**	**751**	**650**	**211**	**861**	**745**	**620**	**32**	**0**	**652**	
4/28/08	**1,791**	**1,459**	**11.19**	**3,250**	**241**	**-13**	**250**	**1,129**	**135**	**1,514**	**751**	**550**	**302**	**852**	**745**	**620**	**34**	**0**	**654**	S
4/29/08	**1,614**	**1,486**	**14.14**	**3,100**	**256**	**-85**	**250**	**1,113**	**135**	**1,498**	**751**	**550**	**312**	**862**	**745**	**620**	**32**	**0**	**652**	S
4/30/08	**1,519**	**1,581**	**17.27**	**3,100**	**226**	**-142**	**250**	**1,127**	**135**	**1,512**	**751**	**550**	**301**	**851**	**745**	**620**	**37**	**0**	**657**	S
5/1/08	**1,482**	**1,608**	**20.46**	**3,090**	**226**	**-194**	**250**	**1,122**	**135**	**1,507**	**751**	**550**	**301**	**851**	**745**	**620**	**38**	**0**	**658**	S
5/2/08	**1,544**	**1,586**	**23.61**	**3,130**	**260**	**-102**	**250**	**1,111**	**135**	**1,496**	**751**	**550**	**306**	**856**	**745**	**620**	**33**	**0**	**653**	S
5/3/08	**1,539**	**1,601**	**26.78**	**3,140**	**270**	**-107**	**250**	**1,003**	**135**	**1,388**	**751**	**550**	**301**	**851**	**745**	**620**	**35**	**0**	**655**	
5/4/08	**1,564**	**1,596**	**29.95**	**3,160**	**260**	**-116**	**250**	**709**	**135**	**1,094**	**751**	**550**	**490**	**1,040**	**745**	**620**	**98**	**0**	**718**	
5/5/08	**1,568**	**1,582**	**33.09**	**3,150**	**260**	**-122**	**250**	**609**	**135**	**994**	**751**	**1,100**	**210**	**1,310**	**745**	**520**	**283**	**0**	**803**	S
5/6/08	**1,504**	**1,726**	**36.51**	**3,230**	**260**	**-176**	**250**	**593**	**135**	**978**	**751**	**1,100**	**200**	**1,300**	**745**	**520**	**288**	**0**	**808**	S
5/7/08	**1,903**	**1,337**	**39.16**	**3,240**	**215**	**-227**	**250**	**589**	**135**	**974**	**751**	**1,100**	**200**	**1,300**	**745**	**520**	**282**	**0**	**802**	S
5/8/08	**1,998**	**1,232**	**41.61**	**3,230**	**209**	**-132**	**250**	**588**	**135**	**973**	**751**	**1,100**	**200**	**1,300**	**745**	**520**	**286**	**0**	**806**	S
5/9/08	**2,070**	**1,210**	**44.01**	**3,280**	**204**	**-15**	**250**	**669**	**135**	**1,054**	**751**	**1,100**	**200**	**1,300**	**745**	**520**	**285**	**0**	**805**	S
5/10/08	**2,040**	**1,210**	**46.41**	**3,250**	**190**	**-39**	**250**	**791**	**135**	**1,176**	**751**	**900**	**270**	**1,170**	**745**	**520**	**423**	**0**	**943**	
5/11/08	**2,212**	**1,208**	**48.80**	**3,420**	**203**	**138**	**250**	**865**	**135**	**1,250**	**751**	**750**	**165**	**915**	**745**	**520**	**510**	**0**	**1,030**	
5/12/08	**1,983**	**1,497**	**51.77**	**3,480**	**204**	**123**	**250**	**882**	**135**	**1,267**	**751**	**650**	**167**	**817**	**745**	**620**	**432**	**0**	**1,052**	S
5/13/08	**1,719**	**1,601**	**54.95**	**3,320**	**186**	**-4**	**250**	**873**	**135**	**1,258**	**751**	**550**	**259**	**809**	**745**	**620**	**432**	**0**	**1,052**	S
5/14/08	**1,641**	**1,599**	**58.12**	**3,240**	**163**	**-83**	**250**	**864**	**135**	**1,249**	**751**	**550**	**258**	**808**	**745**	**800**	**250**	**0**	**1,050**	S
5/15/08	1,606	1,708	61.51	3,314	223	0	250	815	135	1,200	751	550	250	800	745	1,000	50	0	1,050	S
5/16/08	1,763	1,516	64.51	3,279	219	0	250	615	135	1,000	751	550	250	800	745	1,000	50	0	1,050	S
5/17/08	2,023	1,299	67.09	3,322	216	0	250	460	140	850	751	550	250	800	745	1,000	300	0	1,300	
5/18/08	2,019	1,250	69.57	3,269	212	0	250	250	150	650	751	450	250	700	745	1,000	500	0	1,500	
5/19/08	2,016	1,300	72.15	3,316	209	0	250	50	150	450	751	350	225	575	745	1,000	500	0	1,500	
5/20/08	1,912	1,350	74.82	3,262	205	0	250			250	751	275	125	400	745	1,000	500	0	1,500	
5/21/08	1,809	1,125	77.06	2,934	201	0	250			250	210	210		210	737	737			737	
5/22/08	1,730	825	78.69	2,555	197	0	250			250	150	150		150	737	737			737	
5/23/08	1,398	0		1,398	193	0	250			250	150	150		150	737	737			737	
5/24/08	1,334	0		1,334	189	0	250			250	150	150		150	737	737			737	
5/25/08	1,330	0		1,330	185	0	250			250	150	150		150	737	737			737	
5/26/08	1,326	0		1,326	181	0	250			250	150	150		150	737	737			737	
5/27/08	1,322	0		1,322	177	0	250			250	150	150		150	737	737			737	
5/28/08	1,318	0		1,318	173	0	250			250	150	150		150	737	737			737	
5/29/08	1,314	0		1,314	169	0	250			250	150	150		150	737	737			737	
5/30/08	1,310	0		1,310	165	0	250			250	150	150		150	737	737			737	
5/31/08	1,306	0		1,306	161	0	250			250	150	150		150	737	737			737	
VAMP Period																				
Avg. (cfs):	1,916	1,280		3,196	229	-58	250	681	119	1,049	751	751	240	991	745	745	240	0	985	
Supplemental Water (TAF):		78.69						41.84	7.30				14.77				14.78			

VAMP flow operation period

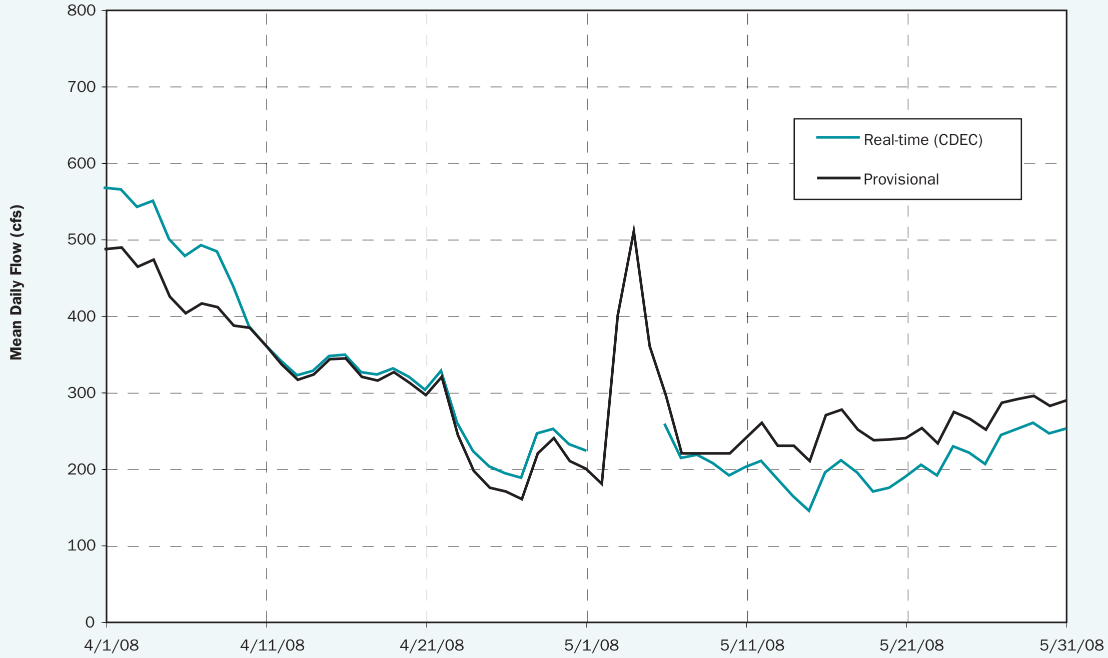
Appendix A-2, Figure 1
Merced River at Cressey



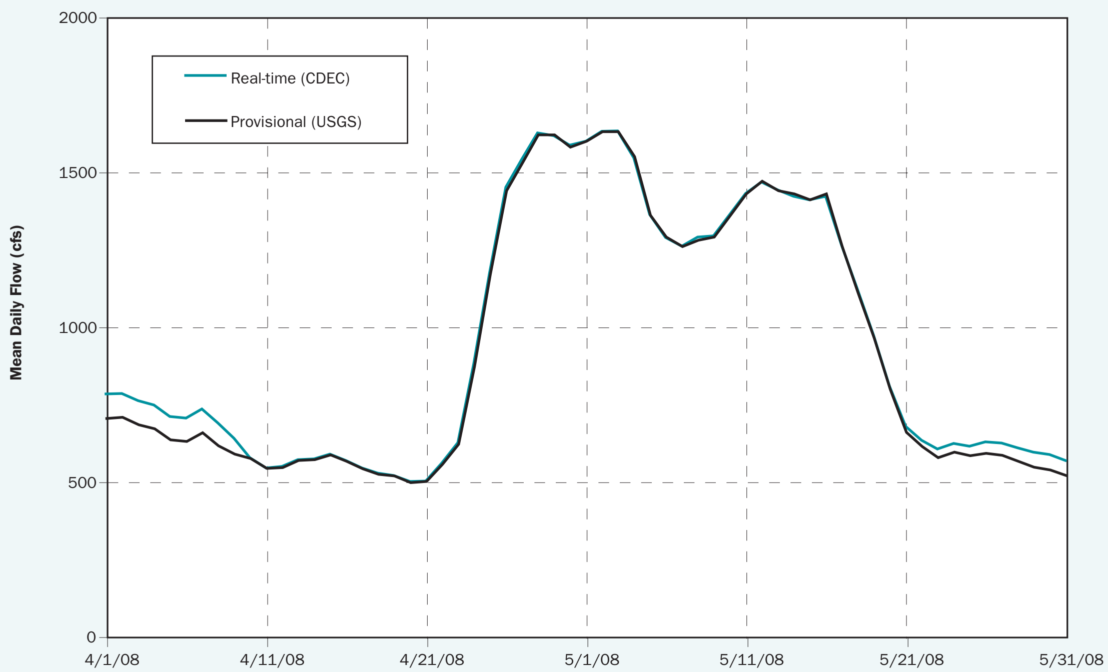
Appendix A-2, Figure 2
Merced River near Stevinson



Appendix A-2, Figure 3
San Joaquin River above Merced River

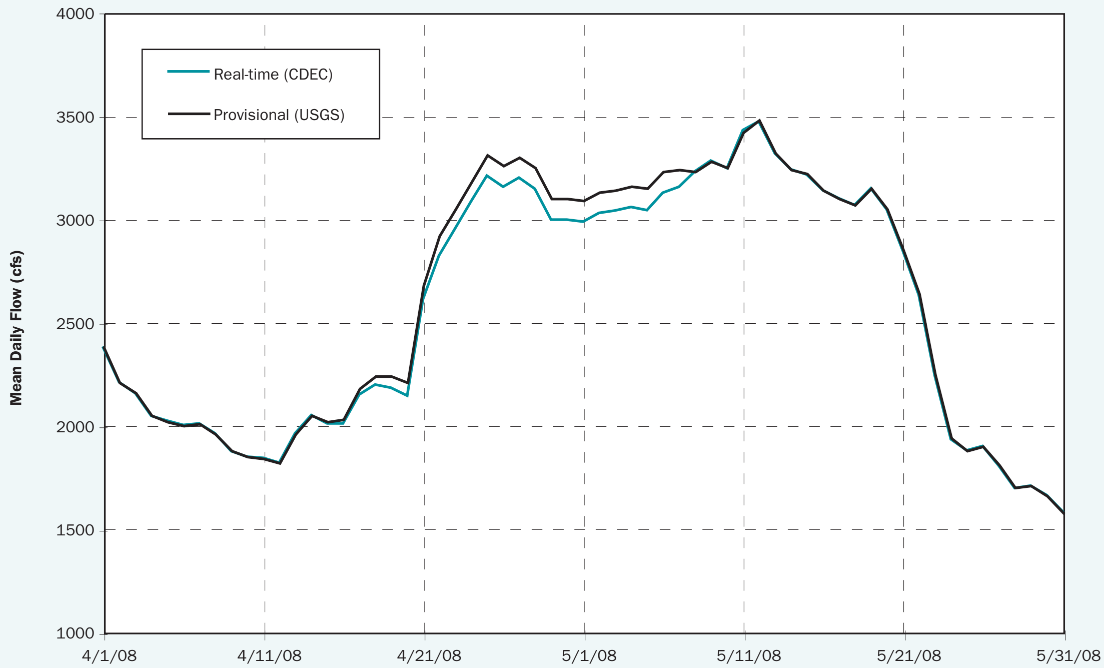


Appendix A-2, Figure 4
San Joaquin River near Newman



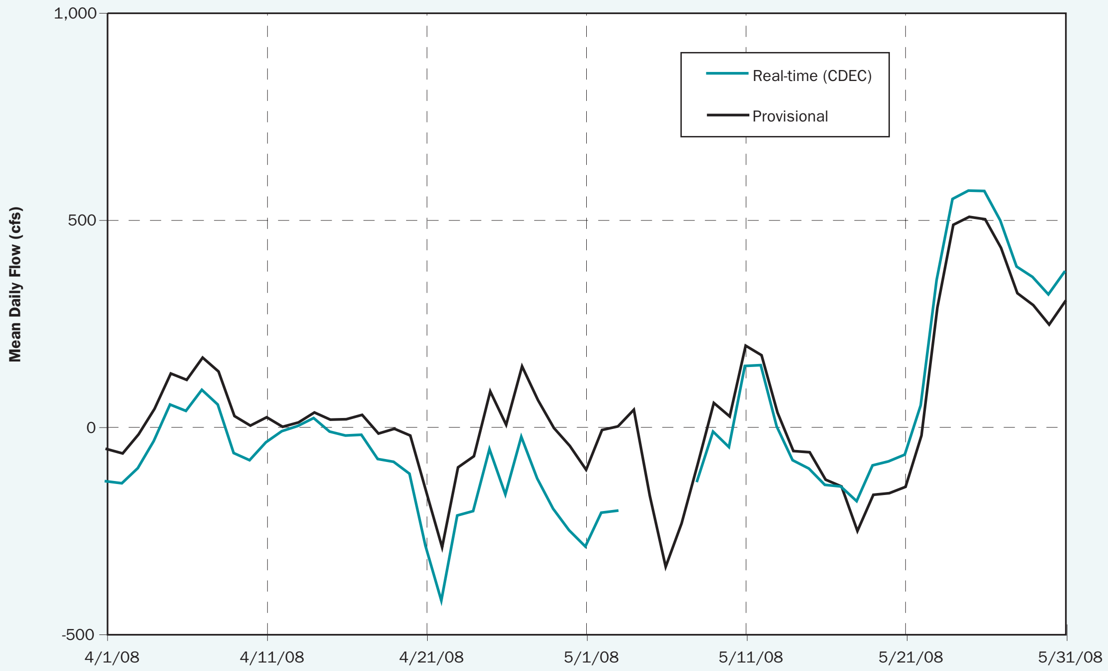
Appendix A-2, Figure 5
Tuolumne River below LaGrange Dam

Appendix A-2, Figure 6
San Joaquin River near Vernalis

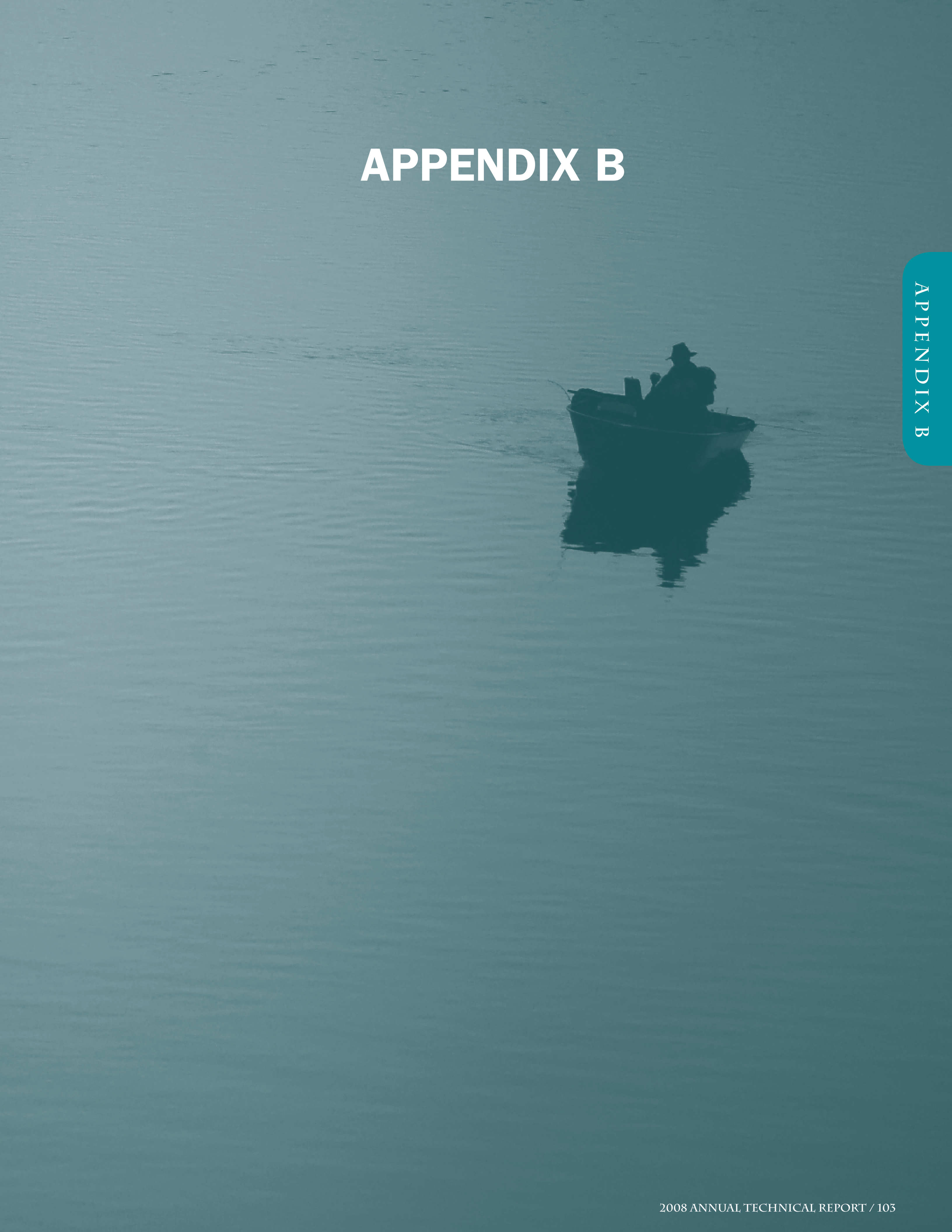


APPENDIX A

Appendix A-2, Figure 7
Ungaged Flow in San Joaquin River near Vernalis

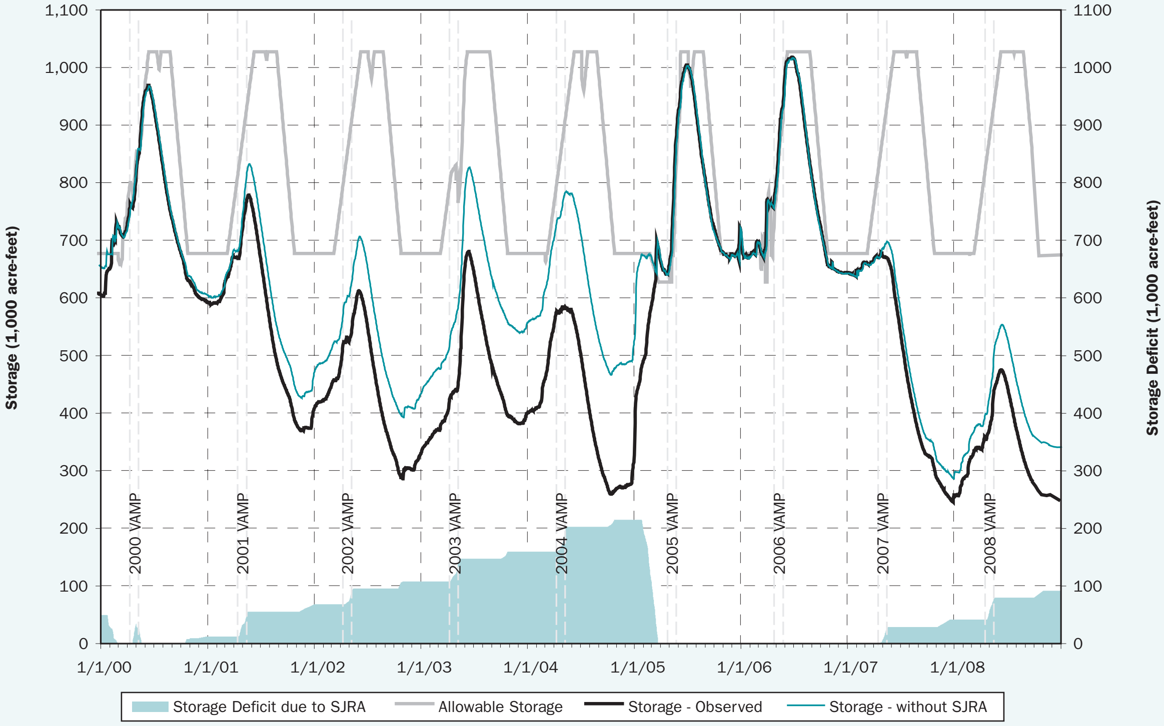


APPENDIX B

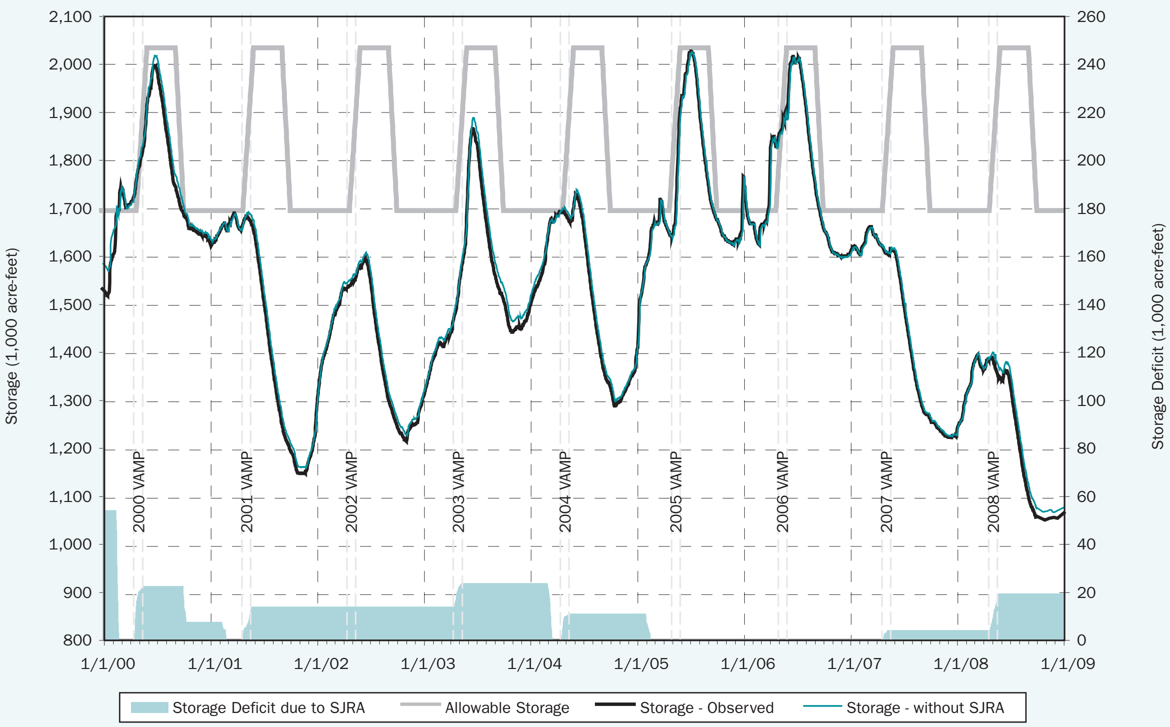


APPENDIX B

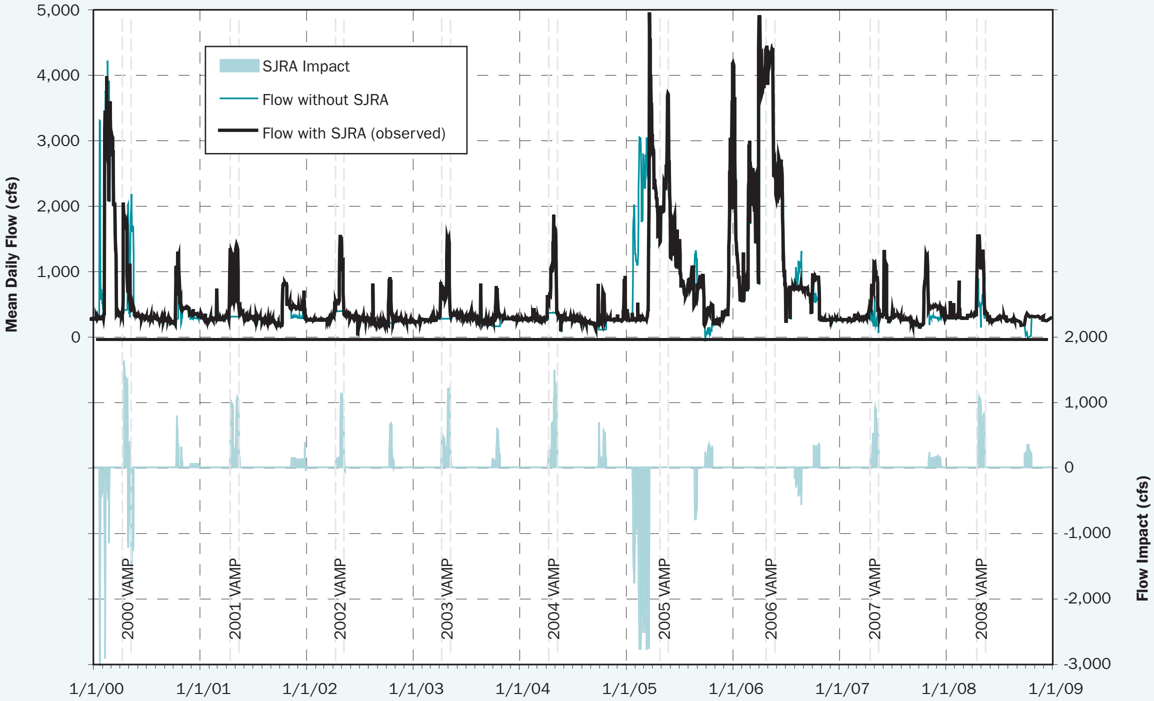
Appendix B-1, Figure 1
SJRA Storage Impacts, 2000-2008 Lake McClure (Merced River)



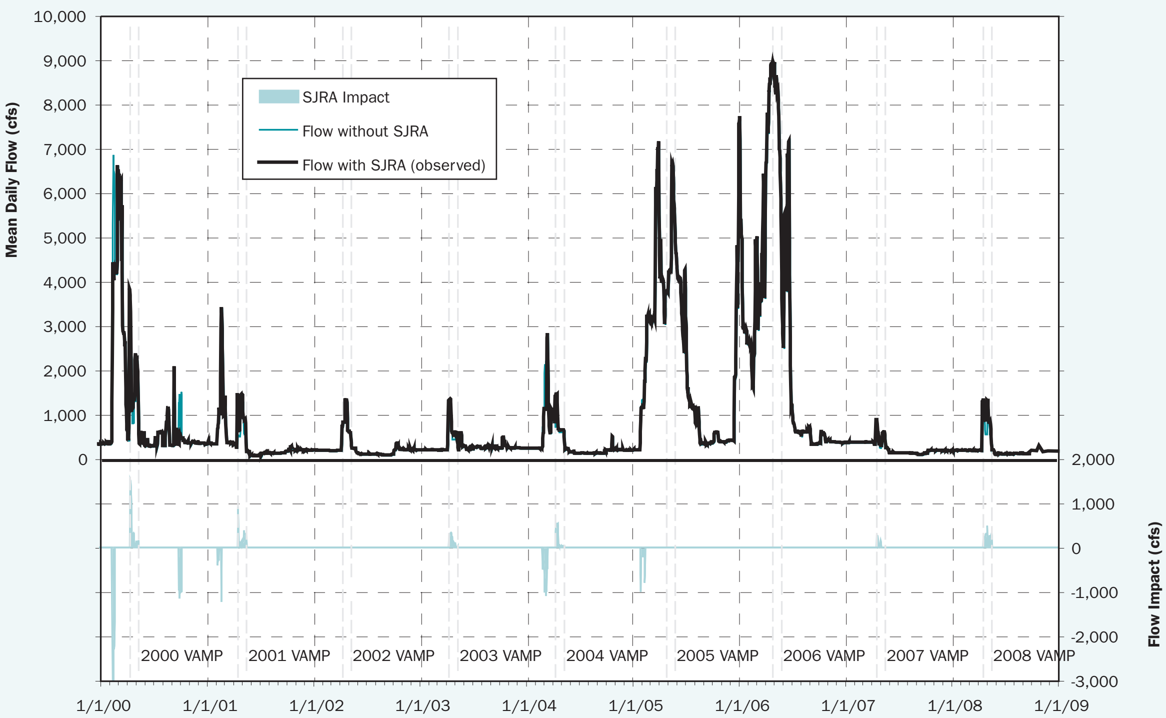
Appendix B-1, Figure 2
SJRA Storage Impacts, 2000-2008 Don Pedro Reservoir (Tuolumne River)



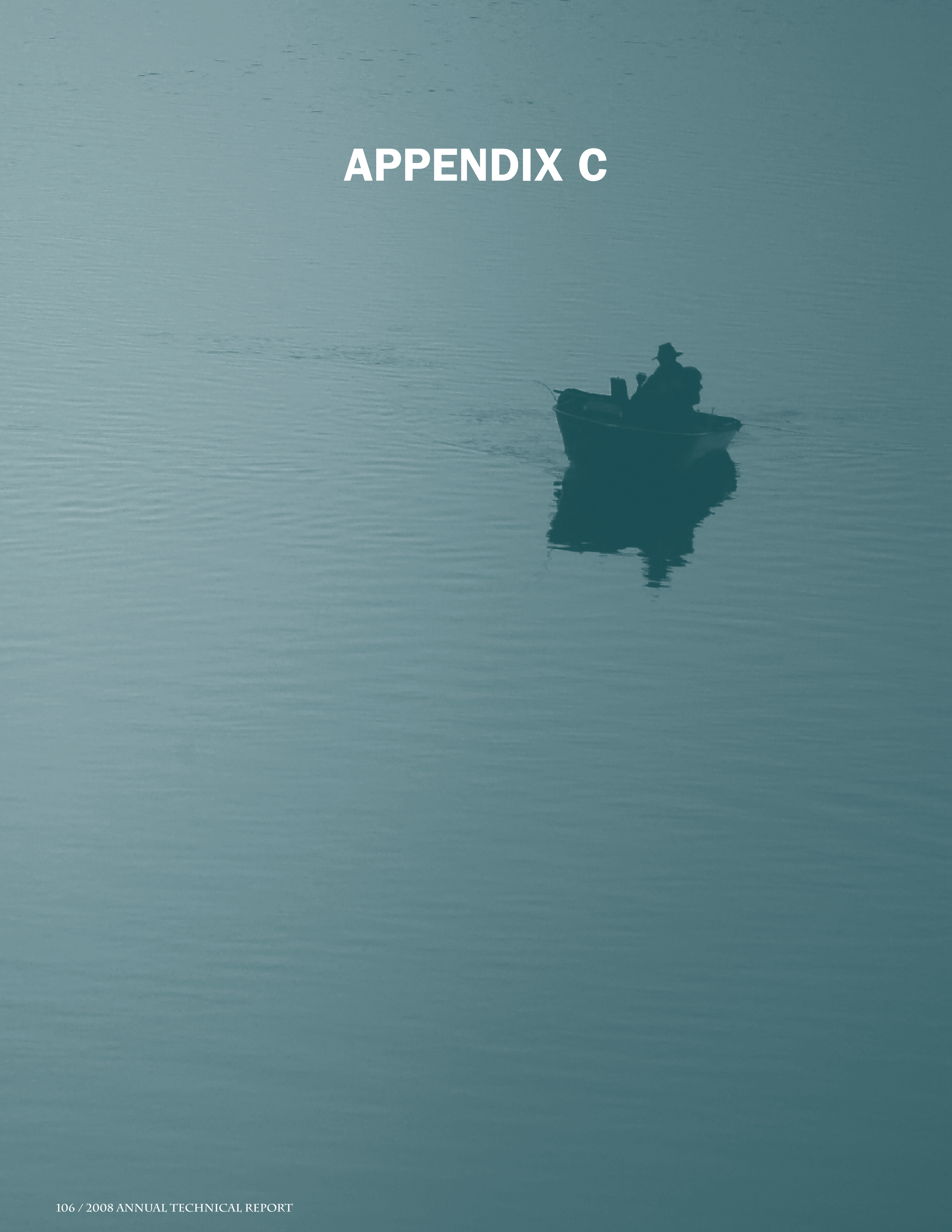
Appendix B-1, Figure 3
Merced River below Crocker-Huffman Dam 2000-2008



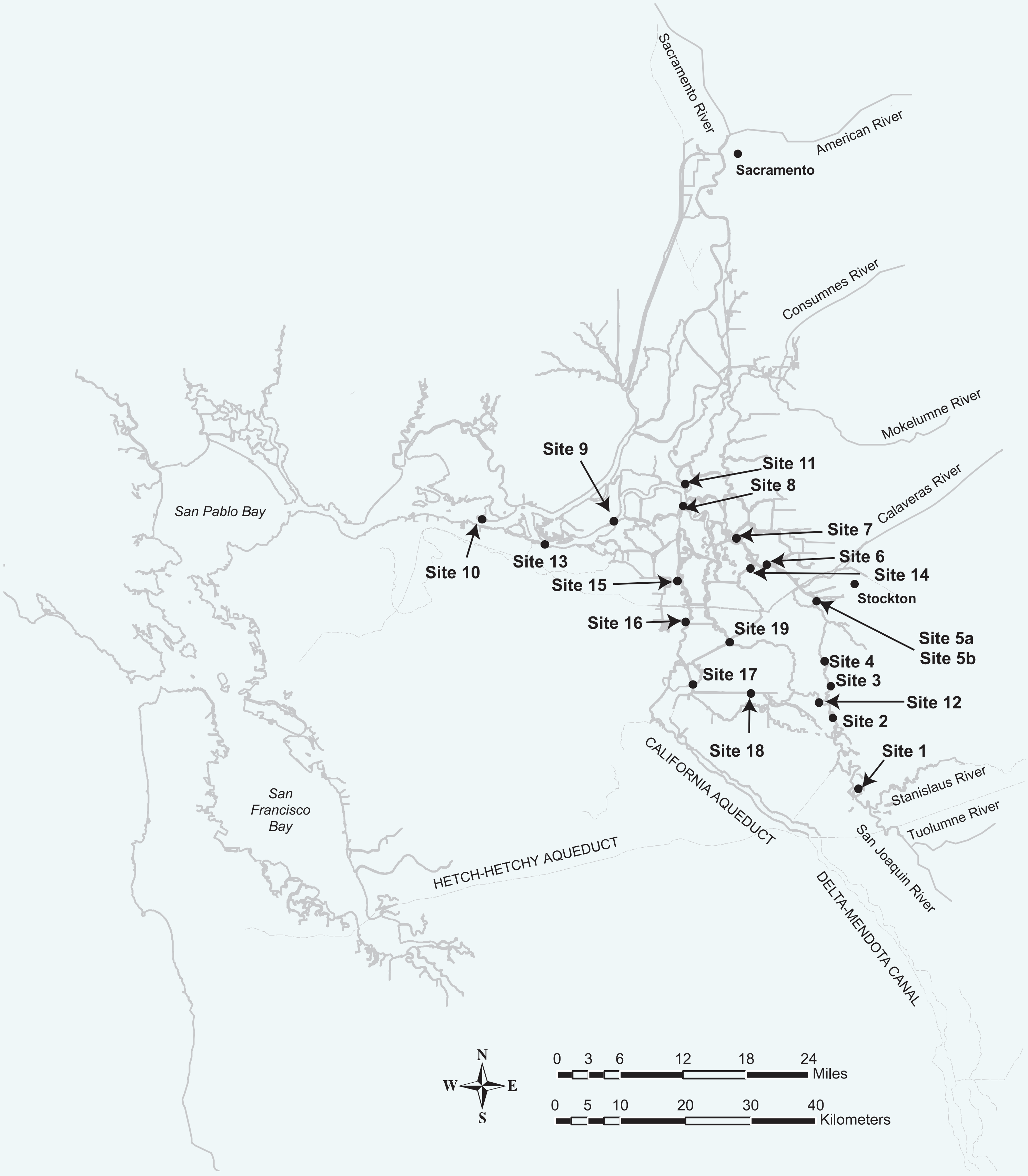
Appendix B-1, Figure 4
Tuolumne River below LaGrange Dam 2000-2008



APPENDIX C

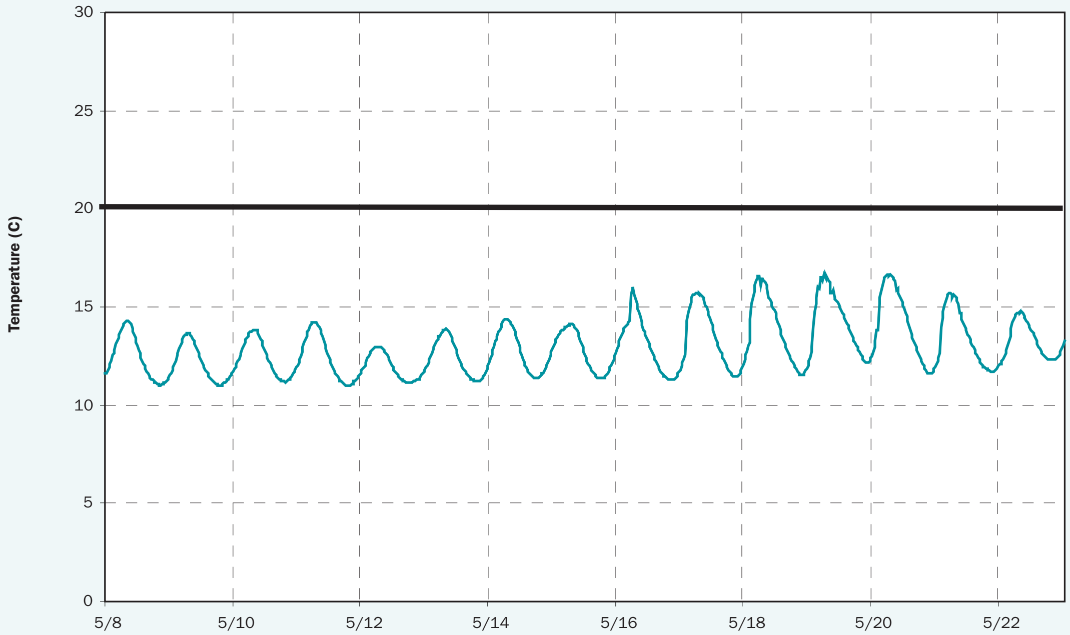


Appendix C-1
Water Temperature Monitoring Locations

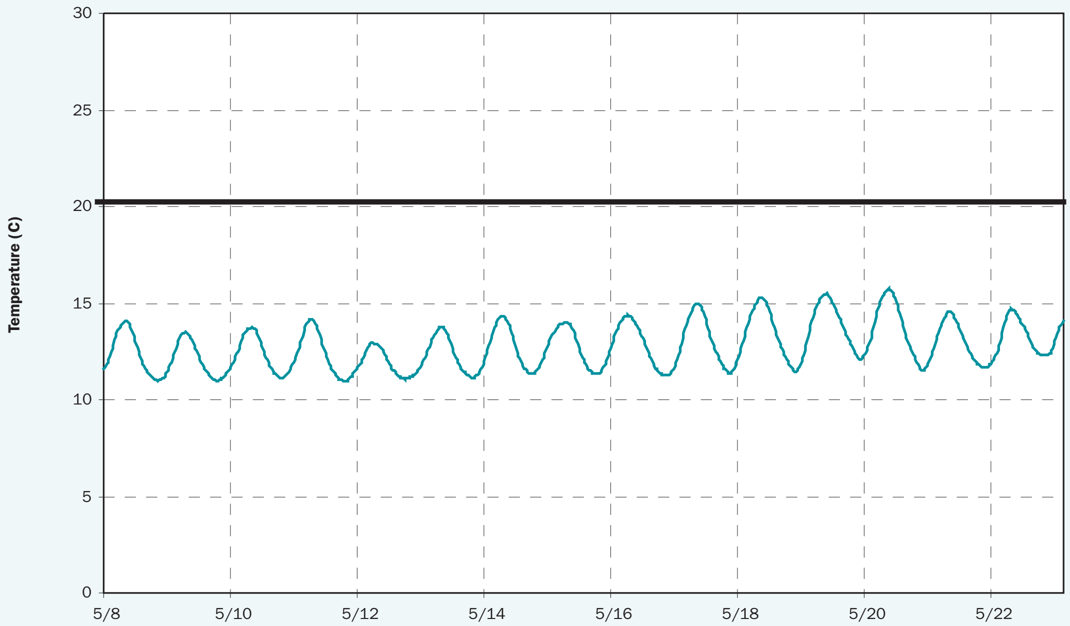


Appendix C-1, Water Temperature Monitoring Locations, 2008							
Site #	**Logger Number**	**Temperature Monitoring Location**	**Lat**	**Long**	**Distance from Durham Ferry (miles)**	**Date Deployed**	**Date Retrieved**
A	1284070	Merced River Fish Hatchery Raceway - 1	n/a	n/a	n/a	5/8/08	5/23/08
B	1284071	Merced River Fish Hatchery Raceway - 2	n/a	n/a	n/a	5/8/08	5/23/08
C	1271942	Merced River Fish Hatchery - Source Tank	n/a	n/a	n/a	4/25/08	5/8/08
1	1027492	Durham Ferry	N 37 41.260	W 121 15.604	0	3/14/08	6/7/08
2	1259805	Mossdale	N 37 47.180	W 121 18.425	11	3/14/08	6/5/08
3	1259815	Old River at HORB	N 37 48.634	W 121 19.231	14	3/14/08	6/5/08
4	1027494	Dos Reis	N 37 49.808	W 121 18.665	16	3/14/08	6/5/08
5	1259804	DWR Monitoring Station	N 37 51.877	W 121 19.386	19	3/14/08	6/5/08
6a	1259807	Confluence – Top	N 37 56.818	W 121 20.285	27	3/14/08	6/5/08
6b	1259808	Confluence-Bottom	N 37 56.818	W 121 20.285	27	3/14/08	6/5/08
7	1259798	Upstream of Channel Marker 33	N 37 59.684	W 121 24.694	33	3/15/08	6/5/08
8	1259813	Turner Cut (Channel Marker 21-22)	N 37 59.468	W121 27.267	35	3/15/08	6/5/08
9	1259806	1/2 mile upstream of Channel Marker 13 ("Q" Piling)	N 38 01.948	W 121 28.768	37	3/15/08	6/5/08
10	1259812	All Pro abandoned boat	N 38 04.520	W 121 34.422	45	3/15/08	6/6/08
11	1259796	USGS Gauging Station at Jersey Point	N 38 03.172	W121 41.637	56	3/14/08	6/6/08
12	1259810	Antioch Marina	N 38 01.369	W121 48.686	64	3/17/08	6/6/08
13	1259795	Chipps Island	N 38 03.010	W 121 55.034	72	3/17/08	6/6/08
14	1259797	Holland Riverside Marina	N 37 58.323	W 121 34.887	South Delta	3/15/08	6/6/08
15	1259811	Old River / Indian Slough Confluence	N 37 54.954	W 121 33.949	South Delta	3/15/08	6/7/08
16	1259814	CCF Radial Gates	N 37 49.773	W 121 33.096	South Delta	3/15/08	logger malfunction
17	1259803	Grant Line Canal at Tracy Blvd. Bridge	N 37 49.143	W 121 27.026	South Delta	3/15/08	6/6/08
18	1259800	Middle River at Victoria Canal Confluence	N37 53.323	W121 29.334	South Delta	3/15/08	6/6/08
19	1259801	Werner Cut (Channel above Woodward Isle)	N 37 56.319	W 121 30.584	South Delta	3/15/08	6/6/08

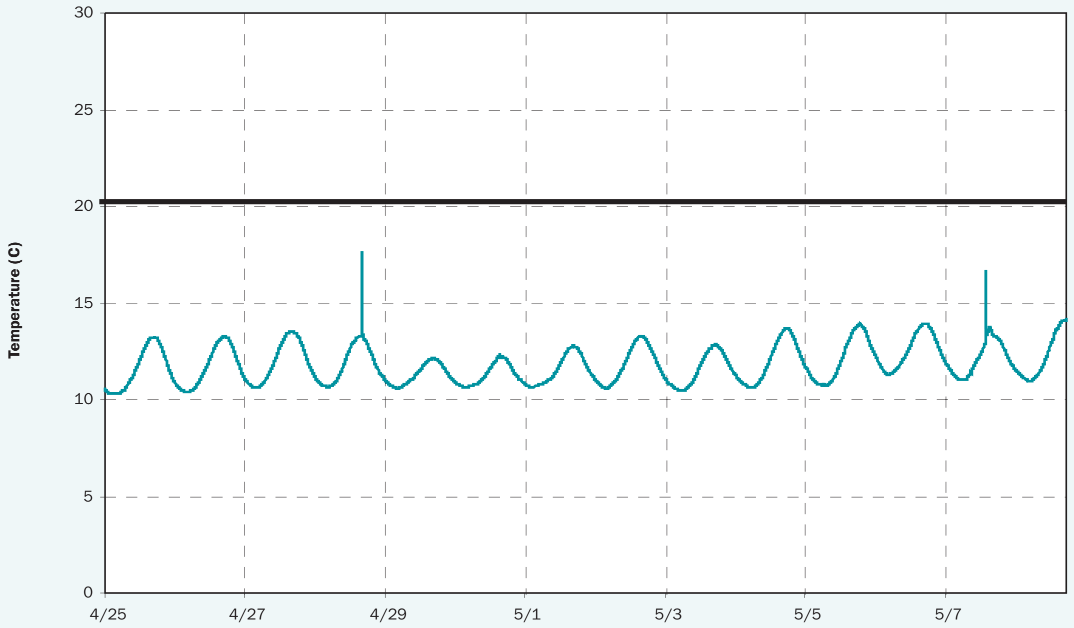
Site A
Merced River Hatchery Raceway - 1



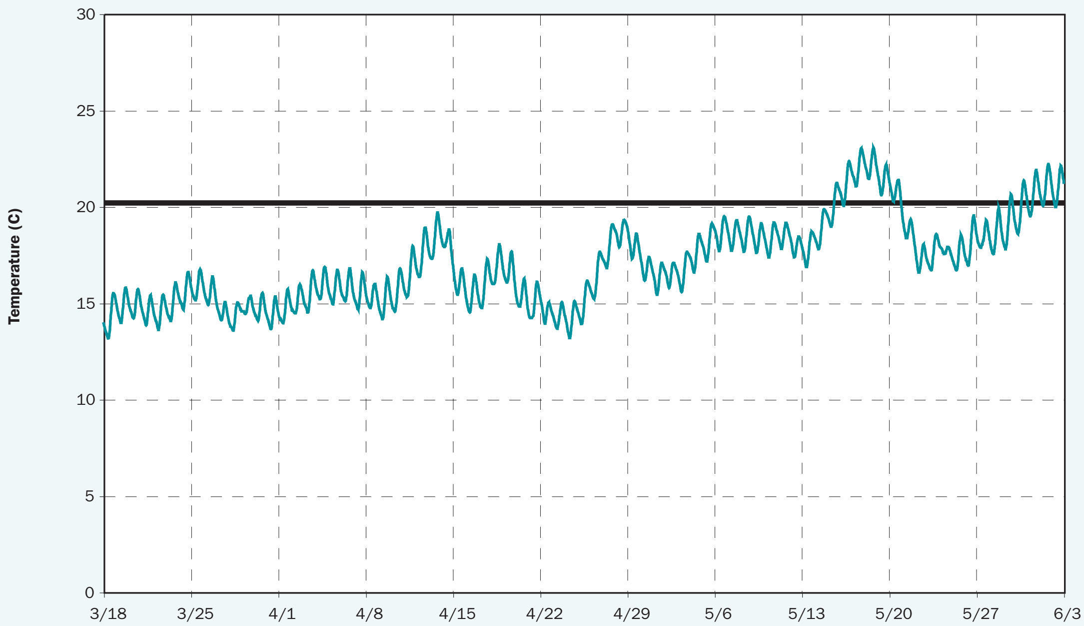
Site B
Merced River Fish Hatchery Raceway - 2

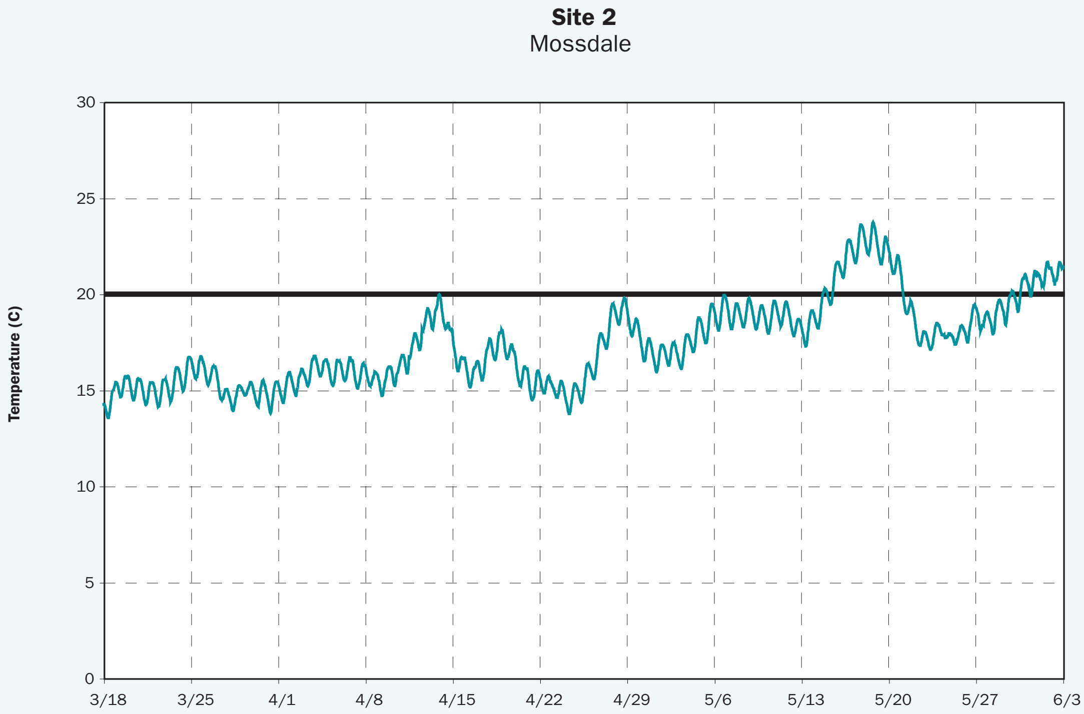


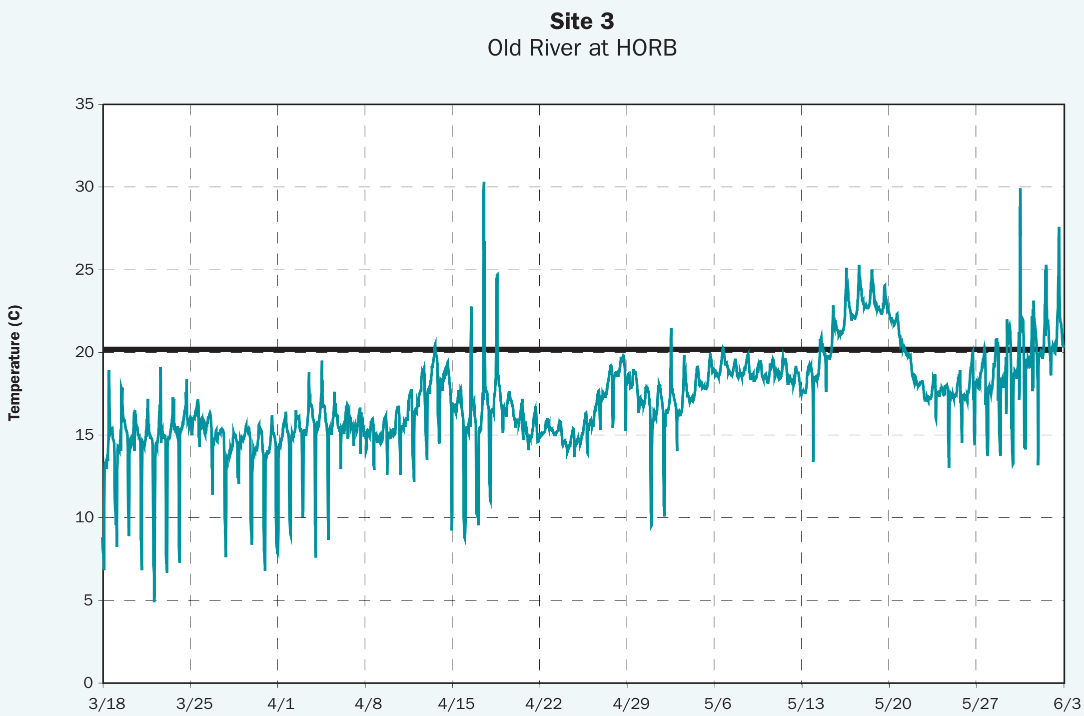
Site C
Merced River Fish Hatchery - Source Tank



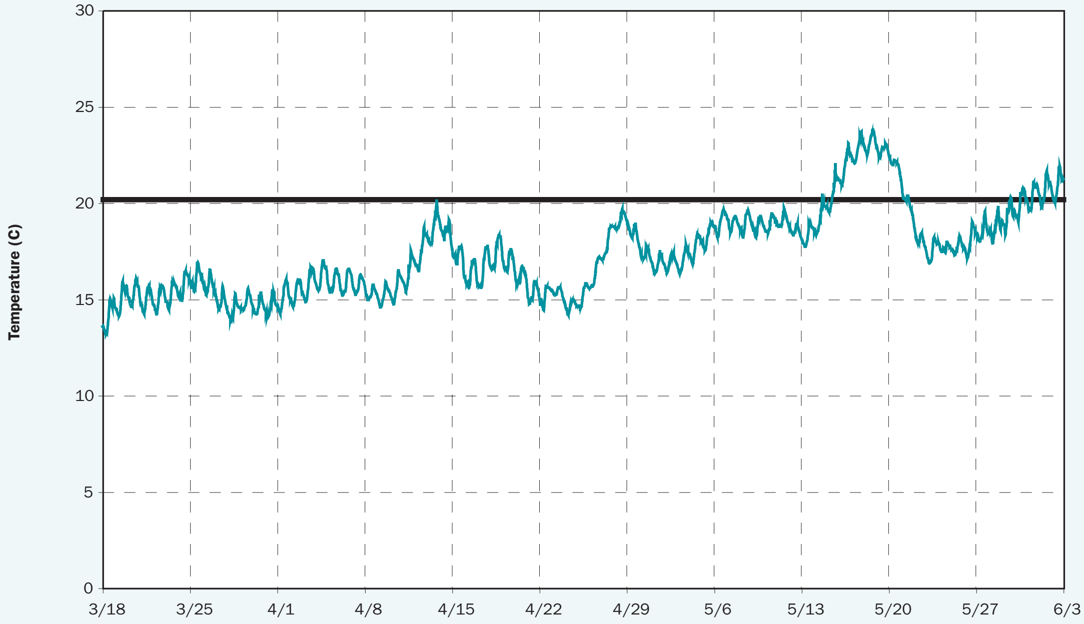
Site 1
Durham Ferry



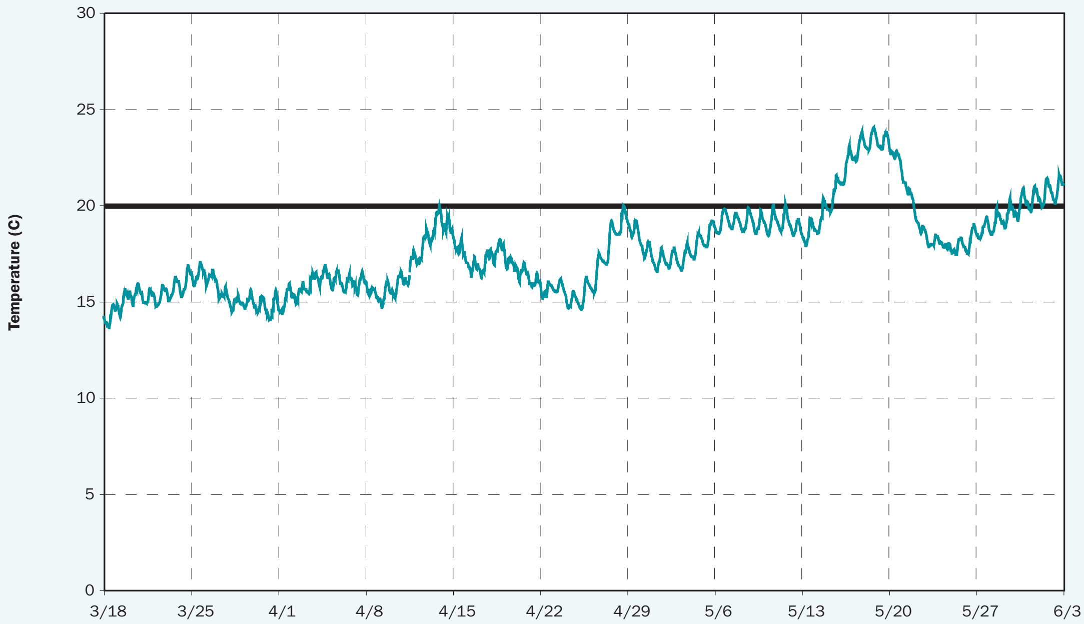

Site 2
Mossdale
Temperature (C)
30
25
20
15
10
5
0
3/18
3/25
4/1
4/8
4/15
4/22
4/29
5/6
5/13
5/20
5/27
6/3


Site 3
Old River at HORB
Temperature (C)
35
30
25
20
15
10
5
0
3/18
3/25
4/1
4/8
4/15
4/22
4/29
5/6
5/13
5/20
5/27
6/3

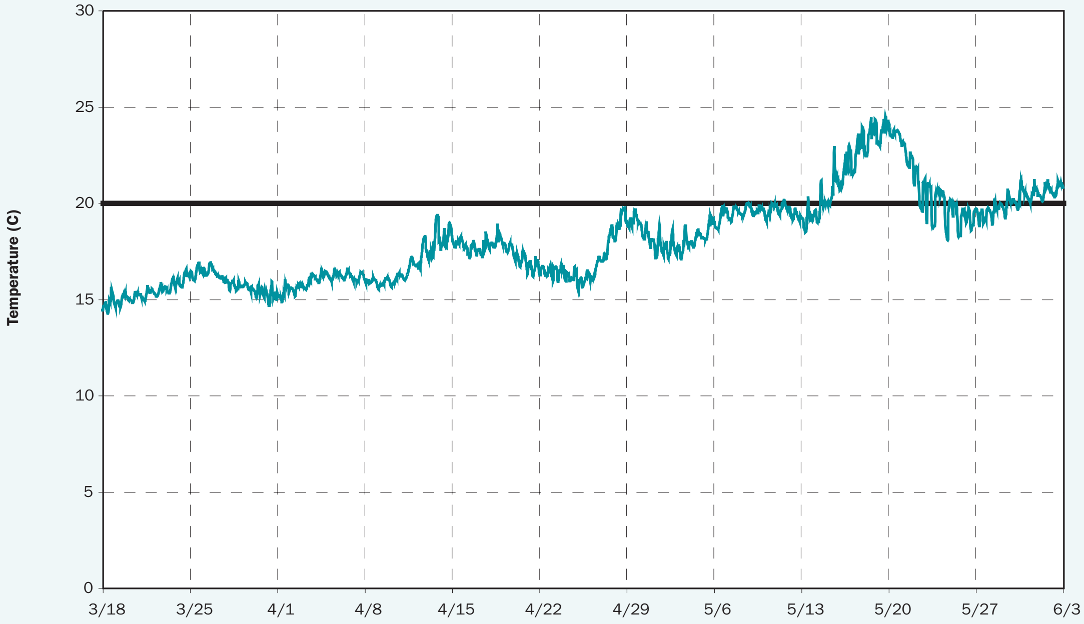
Site 4
Dos Reis



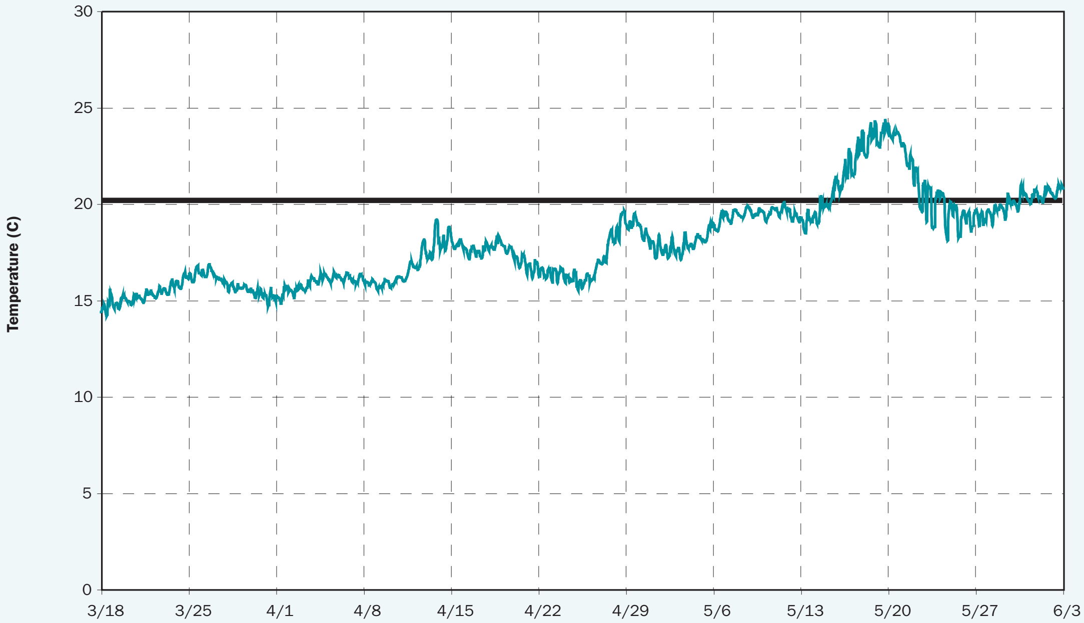
Site 5
DWR Monitoring Station



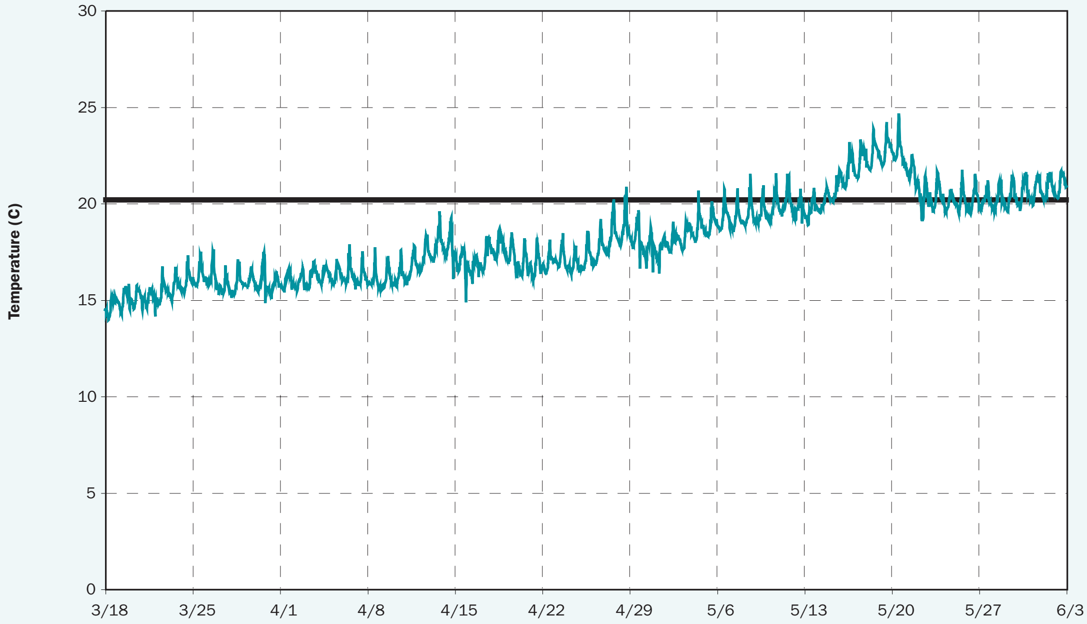
Site 6a
Confluence - Top



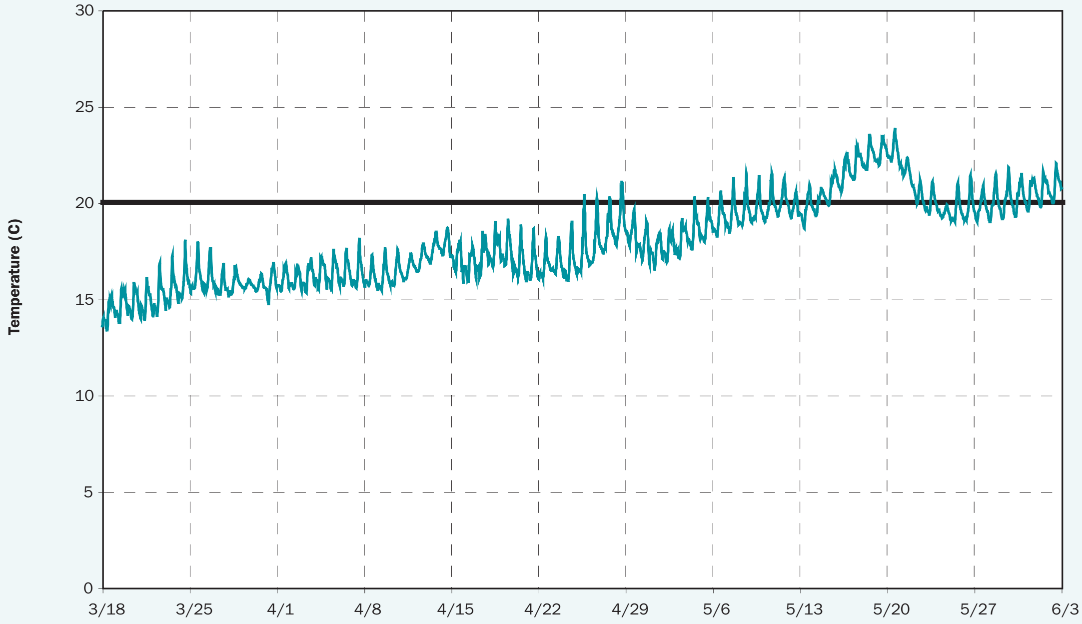
Site 6b
Confluence - Bottom



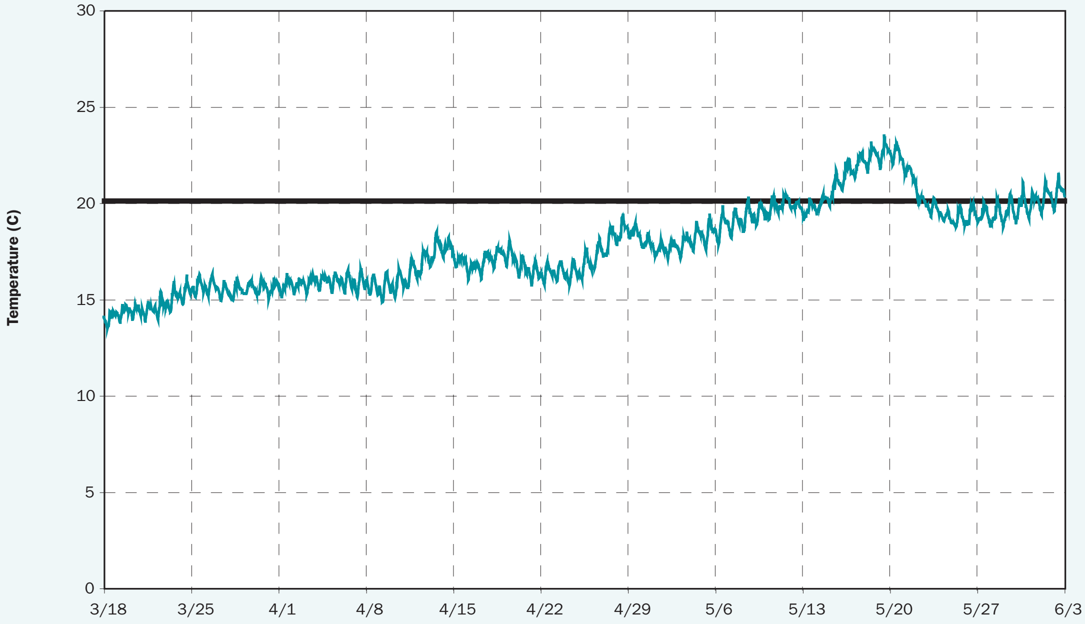
Site 7
Upstream of Channel Marker No. 33



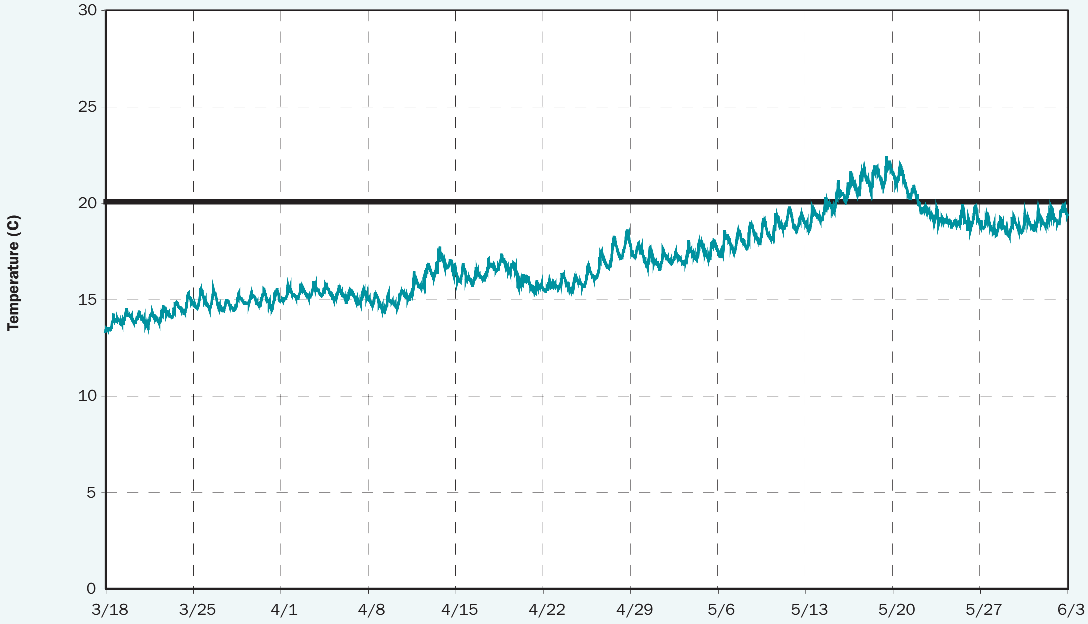
Site 8
Turner Cut



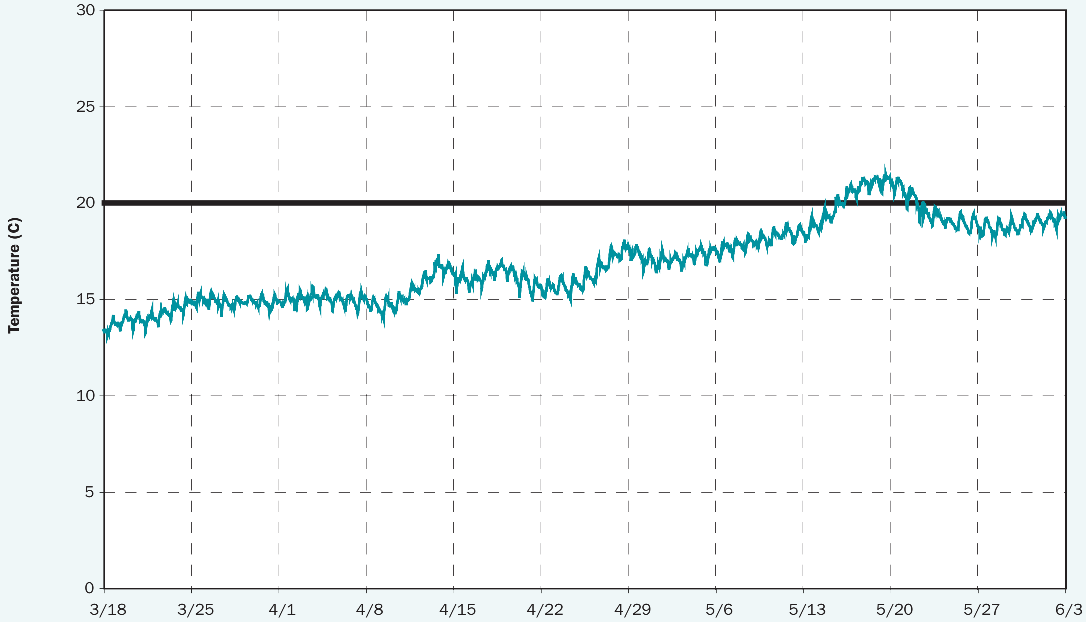
Site 9
1/2 Mile Upstream of Channel Marker 13



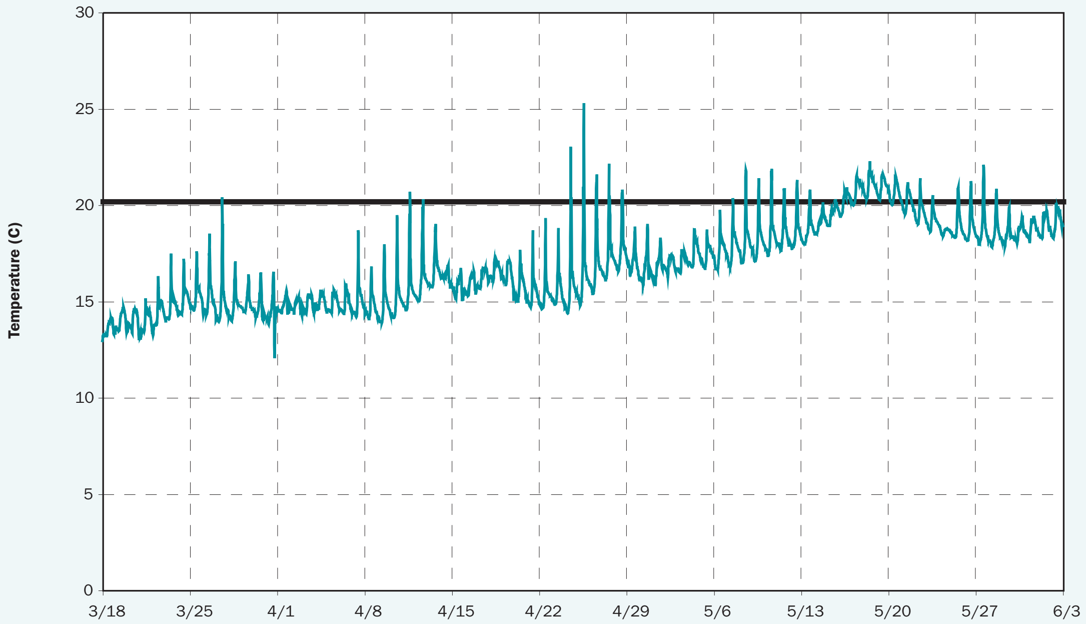
Site 10
All Pro Abandoned Boat



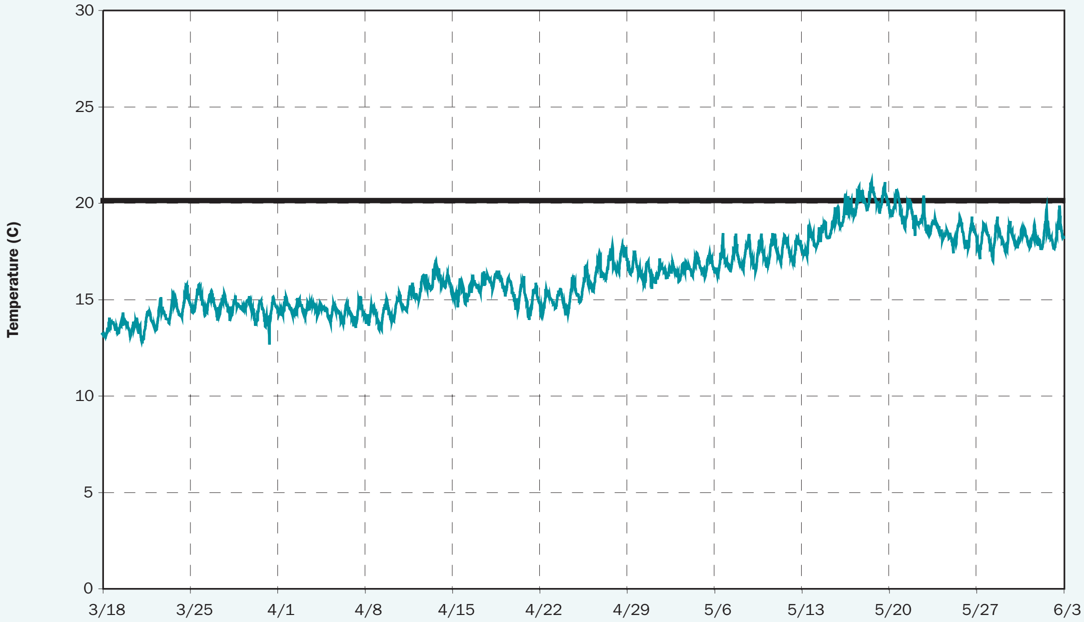
Site 11
USGS Gauging Station at Jersey Point



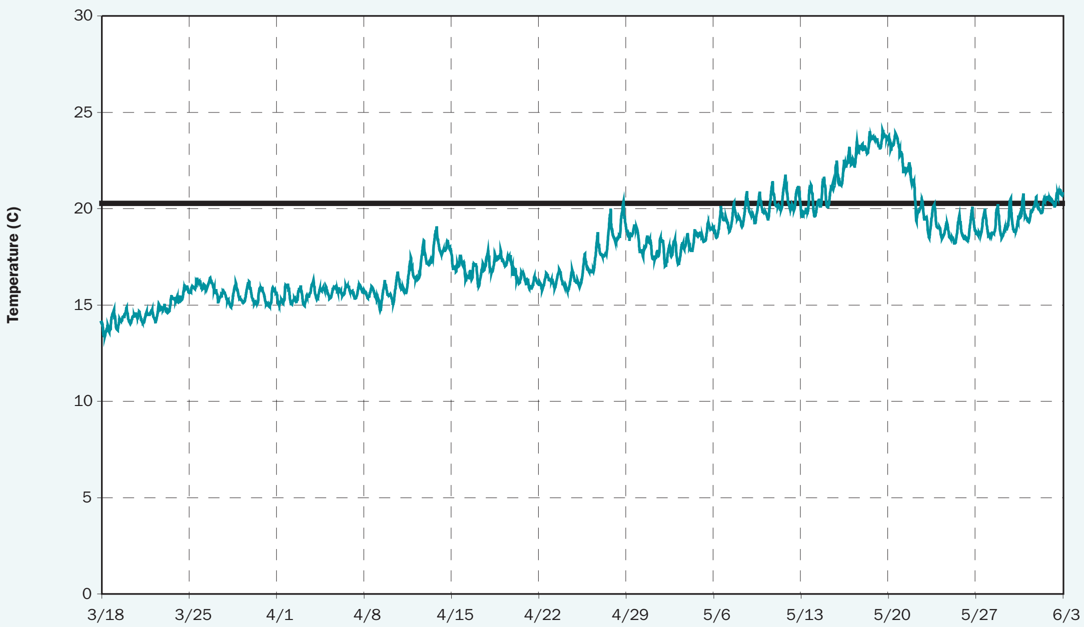
Site 12
Antioch Marina



Site 13
Chipps Island



Site 14
Holland Riverside Marina



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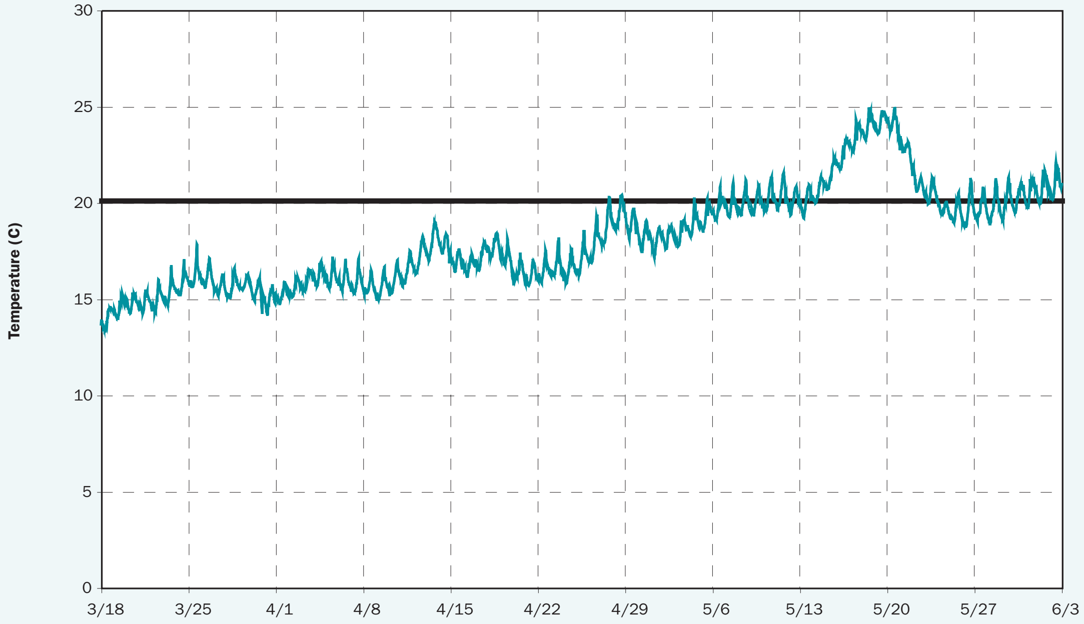
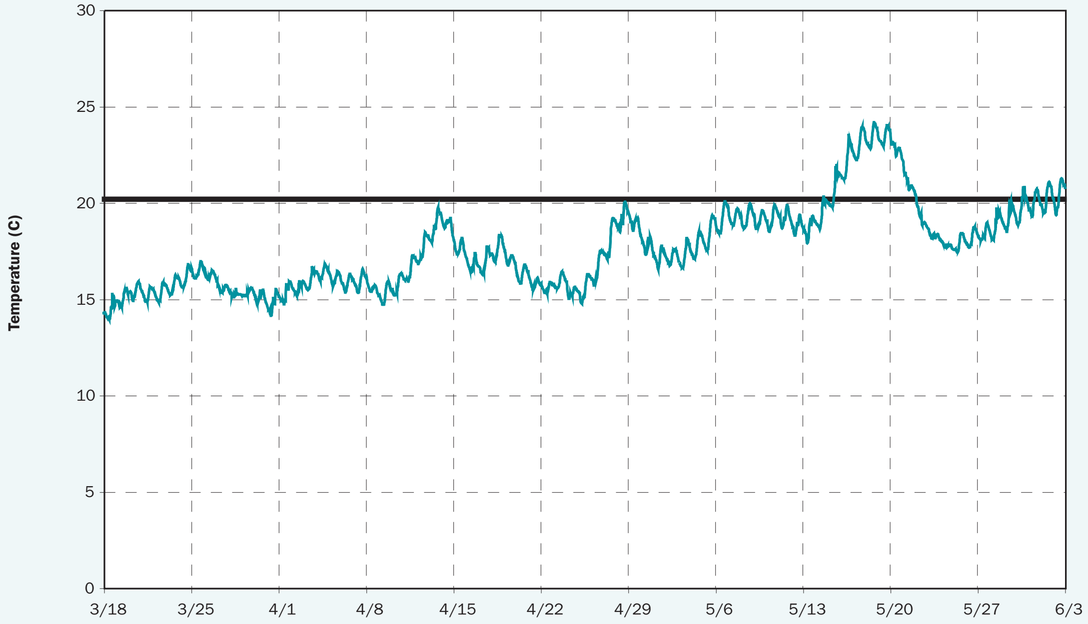
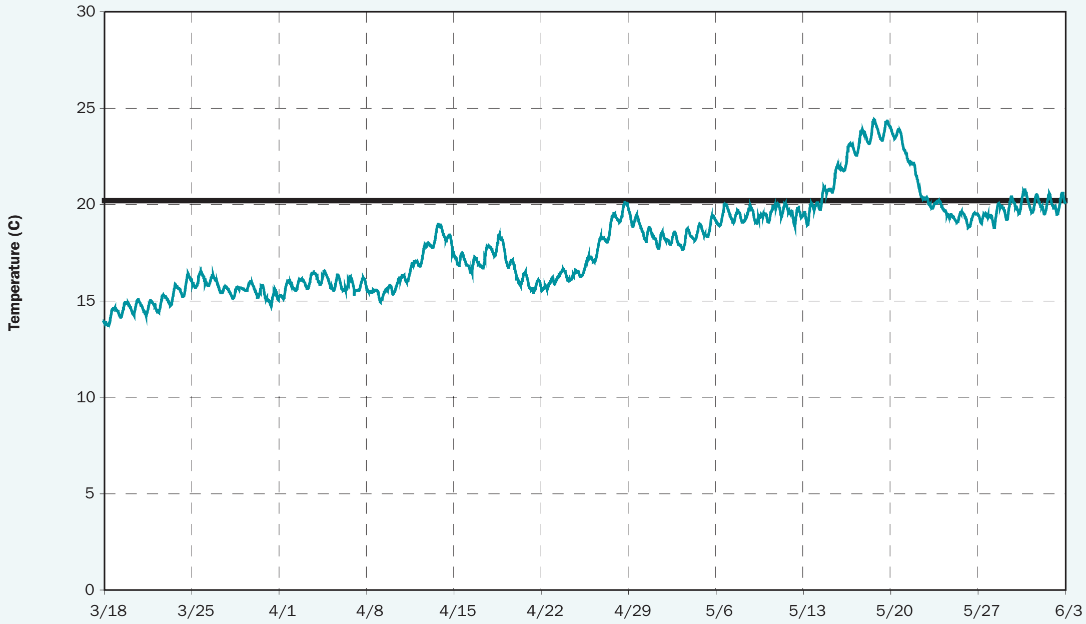
Site 15
Old River / Indian Slough Confluence



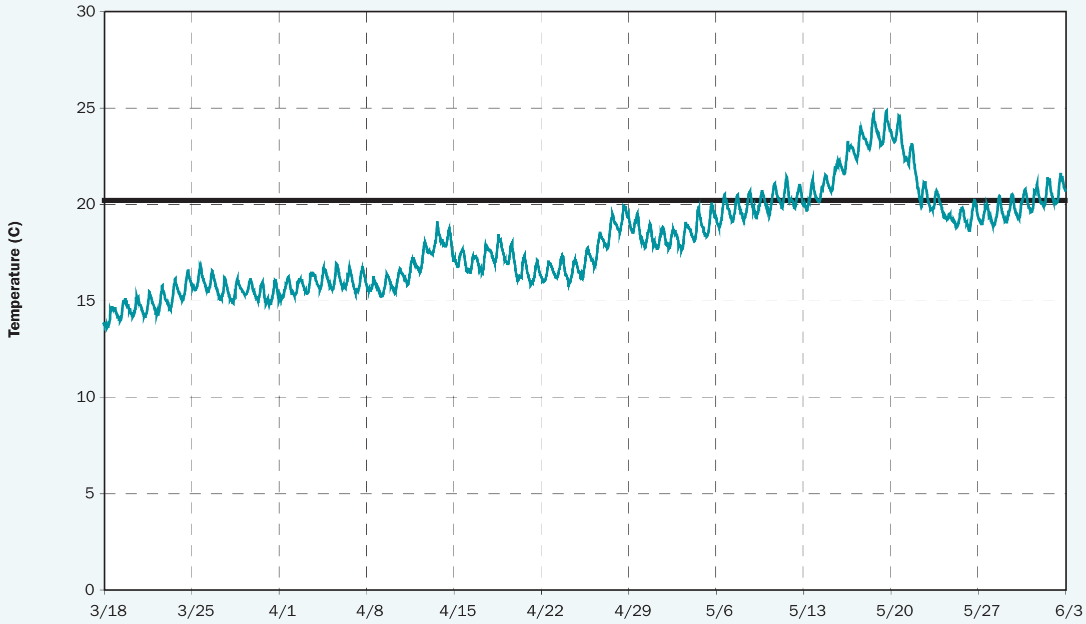
Site 17
Grant Line Canal at Tracy Blvd. Bridge



Site 18
Middle River at Victoria Canal Confluence



Site 19
Werner Cut



APPENDIX C

Appendix C-3

Preliminary summary of tag life evaluation, tag failure rates, and sample size reductions during the 2008 VAMP smolt emigration study

Provided by: United States Geological Survey, Columbia River Research Laboratory.

Background

Acoustic telemetry was used to estimate survival, distribution and travel times of migrating juvenile Chinook salmon through the lower San Joaquin River and Sacramento-San Joaquin Delta as part of the 2008 VAMP study. Because premature tag failure can result in biased survival estimates from fixed-station telemetry studies, we conducted an in-tank tag life extinction study to quantify the rate of tag extinction under the operating parameters used. HTI model 795-S acoustic transmitters (hereafter referred to simply as S tags) were selected for the 2008 VAMP studies largely due to their small size. The S tag, weighing 0.65 g in air, was recently introduced by HTI as a replacement for the 0.70 g 795-M tag. The S tag was expected to perform equally to the M tag in terms of source level (i.e., detection range) and reliability (i.e., tag life). Based on results from six separate in-tank tag extinction studies using M-tags in the Columbia River Basin between 2004 and 2007, we anticipated that minimum tag life for the S tags under our operating parameters (double-pulse encoding, 8-10 second (s) period range, 2 millisecond (ms) pulse width, CODE 2 pulse width encoding) would be no less than 11 days.

Methods

Tag life studies were conducted at the USGS Columbia River Research Laboratory, Cook, WA. A stratified random sample of 50 S tags was collected from all 1001 S tags initially allocated to the study. On May 21, 2008, we attempted to program (i.e, initialize) all 50 tags. Tag programming methodologies were consistent with those used in the field study (i.e., tags that were implanted into study fish and released into the river). Upon initial programming each tag was "sniffed" in a cup of water using an HTI sniffer and monitored through at least three transmission cycles (e.g., one cycle = "double-pulse" followed by 8-10 s delay and subsequent double-pulse). Any tag that failed to program was returned to HTI. At least five attempts were made to program each tag. Tags that operated properly were affixed to a vertical PVC stand with hook and loop closure in a fiberglass tank (1.7 m diameter) within two minutes of activation. The tank received a continuous supply of fresh water throughout the duration of the study. Inflow temperature was thermostatically controlled to match the water temperature of the San Joaquin River at Jersey Point on each day of the field study. Water temperature was also logged every 30 minutes on a temperature logger at the bottom of the tank (Onset Tidbit). An acoustic receiver (HTI model 291) with two hydrophones continuously monitored tags in the tag life tank. Detection files were processed daily to determine proper function of each tag. Tags were considered "dead" when they were not detected during any single one-hour interval. The date and time of final transmission was recorded for each tag. The active duration was calculated as the elapsed time between initial programming and final transmission.

During the field study, HTI provided an additional 94 S tags (i.e., "replacement tags") to replace tags that failed to program. To identify differences in tag life between the two batches (i.e., "original" vs. "replacement"), we conducted a second tag life study in the same tank with an additional 27 S tags. Unlike the original tags, however, the 27 replacement tags were not a subsample of the 94 used in the study, but were provided separately by HTI at a later date. Tag life study for replacement tags commenced on May 30, 2008. Programming and monitoring methodologies were consistent with those used for the original tags.

In the field study, tagged fish were released about 24 h after tag programming and implantation. During this 24 h period, all tags were held in a holding tank and monitored by an acoustic telemetry receiver. Non-active tags or tags that ceased operation were identified and removed from future analyses. Thus, any tag that failed during the first 24 h was effectively removed from the sample and sample sizes at each release were reduced accordingly. Similarly, although we documented and reported tag failure in the tag life study during the first day, these tags were not considered part of the sample that was used to infer tag life in the field.

Results/Discussion

A fundamental assumption of mark-recapture survival models is that no tags cease operation during the study period or within the study region. Premature tag failure results in biased survival estimates because such failure cannot be separated from fish mortality. The proportions

APPENDIX C

of original tags that failed to initialize or ceased operation within 24 h of initial programming were 23 and 24% for tags used in the field and tag life studies, respectively; and 14 and 4% for replacement tags (Table AC3-1). The proportions of failures were consistent between tag life and field studies for original tags, but not replacement tags. We suspect that this is because the replacement tags used in the tag life study originated from a different manufacturing lot than the replacement tags used in the field study. Additionally, replacement tags used in the tag life study may have undergone more extensive QA/QC by HTI prior to delivery.

Continuous monitoring of tag operation prior to transport and release have allowed us to document premature failure within this short interval (i.e., "infantile failure"). Effective removal of such tags from each release group (i.e., treating them as if they were never released) eliminates bias. Although such censoring of individuals reduces precision about fish survival estimates, we favor less precise, unbiased estimates over more precise, biased estimates. The reduction in sample sizes due to infantile failure ranged from 9 to 19% among release groups (Table AC3-2).

The in-tank tag life study was necessary to infer the probability of premature tag failure for fish released into the river. In the tag life study, original tags began to fail within three days of initial programming (Figure AC3-1), and tag failure exceeded 10% after 8 d for both batches. Although we expected all tags to last more than 11 d, 21 and 12% of original and replacement tags, respectively, ceased operation within 11 d of initial programming. All tags expired within 20 d.

Because the rate of tag failure during any day was conditional on the number of tags available at the start of each day, the *rate* of successes (or alternatively failures) through time is best graphically examined on a logarithmic scale. On such plots, a linear association among points indicates constant rate of loss. Logarithmic tag life curves for both original and replacement tags seem to be characterized by two distinct periods with respect to failure rates (Figure AC3-1). During the expected "operational phase," (i.e., between days 1 and 11), the average daily rate of failure was 2.3 and 1.3 % failure/day for original and replacement tags, respectively. This higher-than-expected rate of failure during the operational phase will bias estimates of fish survival from the 2008 VAMP study, because tag failure cannot be separated from fish mortality. The high rate of failure after 17 d for both batches is likely indicative of normal battery expiration. It seems that if failure was limited to this phase alone, then minimum battery life would have approached or exceeded our expectations (i.e., no less than 11 d). It will be necessary to identify causes of failure during the operational phase in order to eliminate bias in survival estimates from mark-recapture studies using these tags in future studies.

Table AC3-1: Number and proportion of HTI model 795-S tags that failed to initialize or ceased operation within 24 h of programming during the 2008 VAMP smolt emigration study (preliminary data)

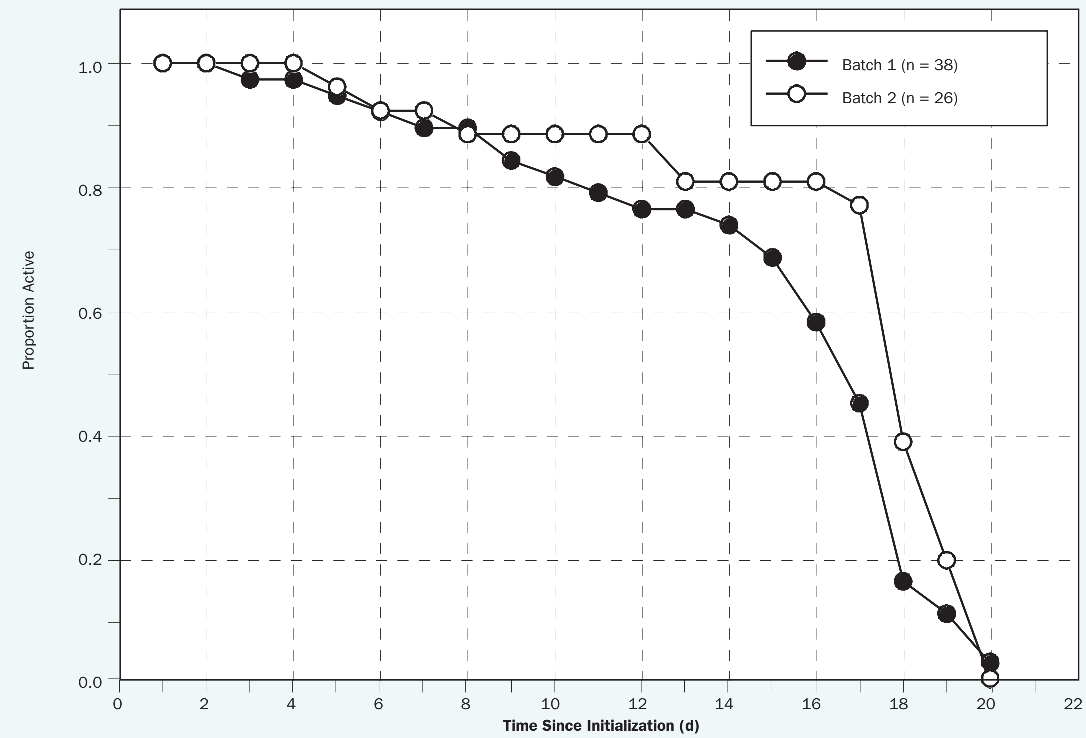
			Premature Failures ,Number (% of N)		
Batch	Usage	N	0 ≤ 2 h	2 < 24 h	Total
Original	Field study	951	194	24	218
			(0.20)	(0.03)	(0.23)
	Tag life	50	11	1	12
			(0.22)	(0.02)	(0.24)
Replacement	Field Study	94	13	0	13
			(0.14)	(0.00)	(0.14)
	Tag life	27	0	1	1
			(0.00)	(0.04)	(0.04)

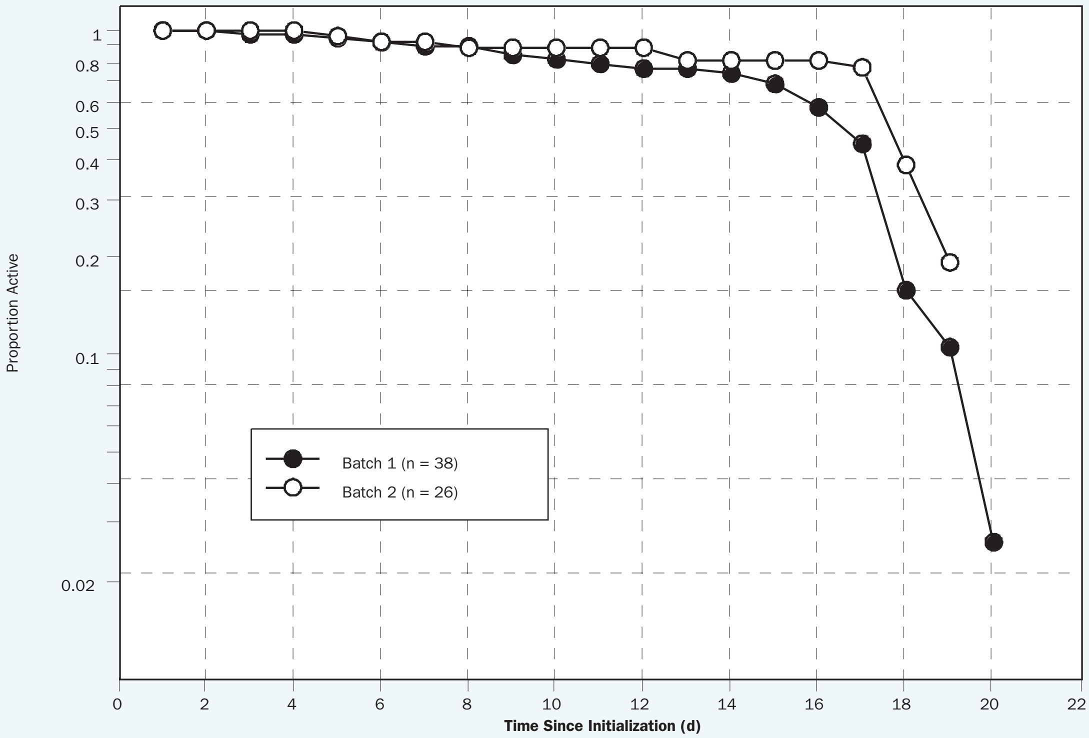
Table AC3-2: Reduction in sample sizes due to premature failure of HTI model 795-S tags during the 2008 VAMP smolt emigration study (preliminary data)

Release	Intended Sample Size	True Sample Size	%Change
DF1	285	241	-0.15
ST1	190	161	-0.15
DF2	285	258	-0.09
ST2	190	154	-0.19

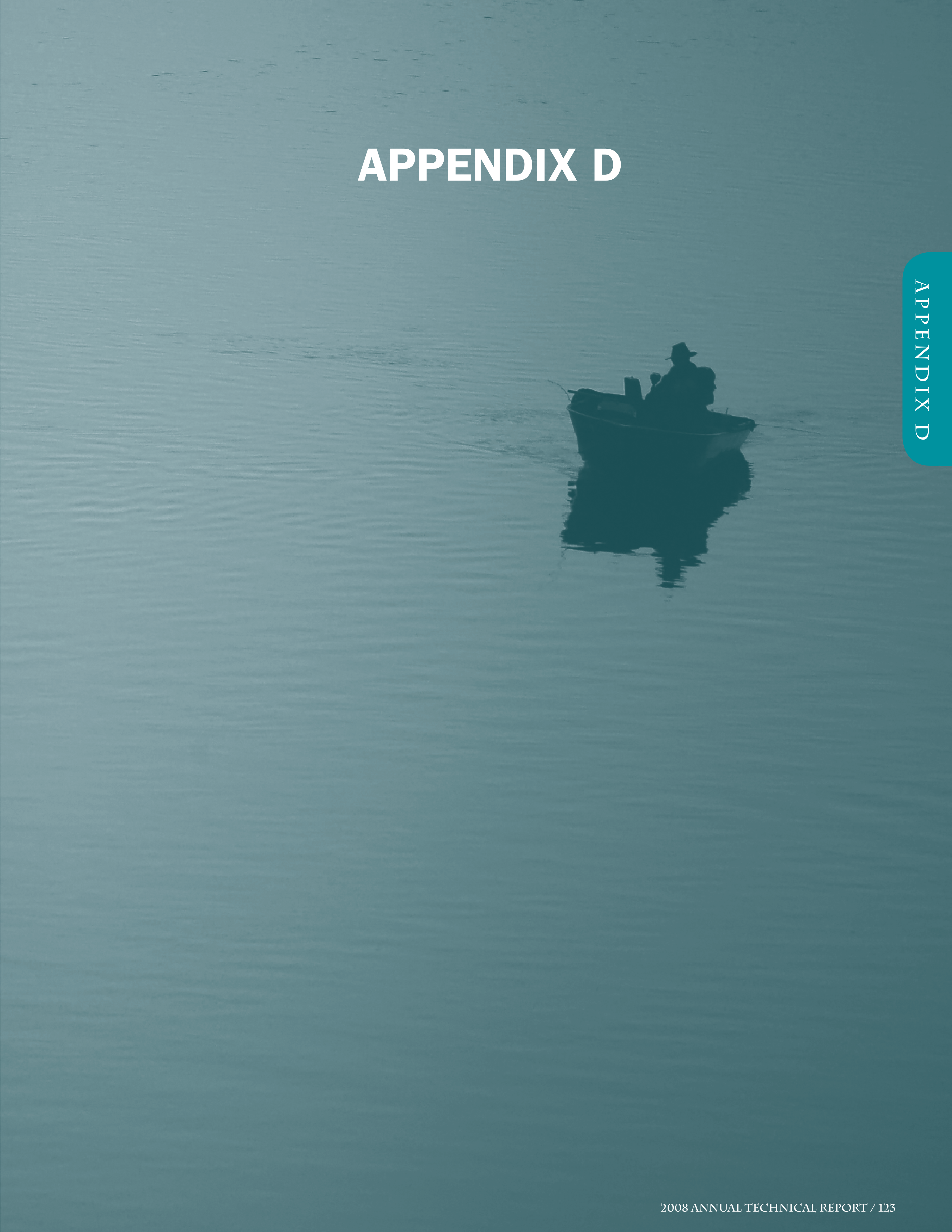
Figure AC3-1

Proportion of acoustic tags that remained active on each day of the 2008 VAMP tag life study, of those tags active one day after initialization. Presented on the (A) linear and (B) semi-log scales. Batch 1 = Original tags; Batch 2 = Replacement tags. (preliminary data)





APPENDIX D



Appendix D Table 1
Field measurements of water quality

Site number	Site name	Sample Date	Sampling Time	North (latitude)	West (longitude)	Water Temp C	Spec Cond mS/cm	TDS g/L	DO%	DO mg/L	pH	ORP mV	Turbidity
84	SJR at Garwood Station	05/01/08	7:28	37.92819	-121.32843	17.08	0.328	0.21	103.22	9.95	8.14	166.37	17.03
127	SJR at Brant Bridge	05/01/08	7:03	37.86488	-121.32267	16.49	0.329	0.21	96.15	9.39	7.82	163.42	15.80
193	Stockton WWTP effluent	05/01/08	7:50	37.93810	-121.33580	–	–	–	–	–	6.62	–	1.33
194	SJR at Burns Cuttoff	05/01/08	8:25	37.94101	-121.34505	17.05	0.340	0.22	101.79	9.82	7.90	160.60	18.29
195	SJR at Stockton WWTP outfall	05/01/08	7:46	37.93805	-121.33531	17.06	0.370	0.24	101.29	9.77	7.76	174.55	76.99
84	SJR at Garwood Station	05/02/08	8:10	37.92819	-121.32843	17.03	0.335	0.22	98.66	9.52	7.82	170.01	19.77
127	SJR at Brant Bridge	05/02/08	7:48	37.86488	-121.32267	16.52	0.334	0.22	95.20	9.28	7.62	169.75	19.10
193	Stockton WWTP effluent	05/02/08	8:35	37.93810	-121.33580	–	–	–	–	–	6.55	–	1.41
194	SJR at Burns Cuttoff	05/02/08	8:57	37.94101	-121.34505	17.13	0.355	0.23	98.38	9.47	7.66	166.88	18.16
195	SJR at Stockton WWTP outfall	05/02/08	8:26	37.93805	-121.33531	17.11	0.371	0.24	98.07	9.45	7.58	158.91	28.03
84	SJR at Garwood Station	05/03/08	9:18	37.92819	-121.32843	17.05	0.339	0.22	95.19	9.18	7.68	159.27	18.72
127	SJR at Brant Bridge	05/03/08	8:51	37.86488	-121.32267	16.49	0.333	0.22	94.83	9.25	7.63	156.71	19.28
193	Stockton WWTP effluent	05/03/08	9:35	37.93810	-121.33580	–	–	–	–	–	6.84	–	0.80
194	SJR at Burns Cuttoff	05/03/08	10:02	37.94101	-121.34505	17.08	0.348	0.23	92.62	8.93	7.60	160.92	20.14
195	SJR at Stockton WWTP outfall	05/03/08	9:32	37.93805	-121.33531	17.04	0.343	0.22	92.35	8.91	7.58	154.63	21.32
84	SJR at Garwood Station	05/04/08	9:23	37.92819	-121.32843	17.57	0.320	0.21	96.25	9.19	7.66	150.14	18.59
127	SJR at Brant Bridge	05/04/08	9:01	37.86488	-121.32267	17.09	0.337	0.22	97.53	9.40	7.65	137.82	18.65
193	Stockton WWTP effluent	05/04/08	9:45	37.93810	-121.33580	–	–	–	–	–	6.61	–	1.16
194	SJR at Burns Cuttoff	05/04/08	10:10	37.94101	-121.34505	17.64	0.349	0.23	94.92	9.05	7.54	169.18	20.58
195	SJR at Stockton WWTP outfall	05/04/08	9:37	37.93805	-121.33531	17.57	0.338	0.22	94.51	9.02	7.57	152.76	23.31
84	SJR at Garwood Station	05/05/08	9:43	37.92819	-121.32843	17.87	0.332	0.22	97.80	9.28	7.71	164.90	18.10
127	SJR at Brant Bridge	05/05/08	9:24	37.86488	-121.32267	17.73	0.342	0.22	101.28	9.63	7.78	162.58	17.94
193	Stockton WWTP effluent	05/05/08	10:10	37.93810	-121.33580	19.60	–	–	–	–	7.36	–	1.16
194	SJR at Burns Cuttoff	05/05/08	10:30	37.94101	-121.34505	18.06	0.361	0.23	95.26	9.00	7.55	156.53	19.94
195	SJR at Stockton WWTP outfall	05/05/08	10:04	37.93805	-121.33531	18.05	0.386	0.25	95.05	8.98	7.50	159.48	20.63
84	SJR at Garwood Station	05/06/08	10:41	37.92819	-121.32843	18.87	0.344	0.22	104.83	9.74	7.87	159.34	16.45
127	SJR at Brant Bridge	05/06/08	10:17	37.86488	-121.32267	18.51	0.355	0.23	108.28	10.14	8.02	142.82	15.56
193	Stockton WWTP effluent	05/06/08	11:00	37.93810	-121.33580	20.80	–	–	–	–	6.63	–	1.19
194	SJR at Burns Cuttoff	05/06/08	11:25	37.94101	-121.34505	18.94	0.362	0.24	102.21	9.49	7.71	160.80	17.84
195	SJR at Stockton WWTP outfall	05/06/08	10:56	37.93805	-121.33531	18.90	0.364	0.24	101.56	9.43	7.67	160.83	18.80
84	SJR at Garwood Station	05/07/08	11:43	37.92819	-121.32843	19.35	0.341	0.22	115.17	10.60	8.31	169.50	21.69
127	SJR at Brant Bridge	05/07/08	11:20	37.86488	-121.32267	18.82	0.343	0.22	110.99	10.33	8.16	156.87	17.95
193	Stockton WWTP effluent	05/07/08	12:05	37.93810	-121.33580	No Flow	No Flow	No Flow	No Flow	No Flow	No Flow	No Flow	No Flow
194	SJR at Burns Cuttoff	05/07/08	12:21	37.94101	-121.34505	19.32	0.345	0.22	114.20	10.52	8.24	171.40	23.38
195	SJR at Stockton WWTP outfall	05/07/08	11:57	37.93805	-121.33531	19.28	0.346	0.22	113.50	10.46	8.22	172.73	25.28
84	SJR at Garwood Station	05/08/08	11:58	37.92819	-121.32843	19.49	0.328	0.21	112.79	10.35	8.18	143.57	20.98
127	SJR at Brant Bridge	05/08/08	11:35	37.86488	-121.32267	18.76	0.331	0.22	107.01	9.97	7.95	123.68	18.10
193	Stockton WWTP effluent	05/08/08	12:15	37.93810	-121.33580	No Flow	No Flow	No Flow	No Flow	No Flow	No Flow	No Flow	No Flow
194	SJR at Burns Cuttoff	05/08/08	12:33	37.94101	-121.34505	19.51	0.331	0.21	111.38	10.22	8.12	144.87	22.07
195	SJR at Stockton WWTP outfall	05/08/08	12:11	37.93805	-121.33531	19.46	0.330	0.21	111.31	10.22	8.13	141.79	23.31

Appendix D Table 1
Field measurements of water quality

Site number	Site name	Sample Date	Sampling Time	North (latitude)	West (longitude)	Water Temp C	Spec Cond mS/cm	TDS g/L	DO%	DO mg/L	pH	ORP mV	Turbidity
84	SJR at Garwood Station	05/09/08	13:02	37.92819	-121.32843	19.53	0.329	0.21	110.89	10.17	8.02	142.56	22.97
127	SJR at Brant Bridge	05/09/08	12:34	37.86488	-121.32267	18.70	0.330	0.21	111.22	10.37	7.98	115.85	21.66
193	Stockton WWTP effluent	05/09/08	13:23	37.93810	-121.33580	No Flow	No Flow	No Flow	No Flow	No Flow	No Flow	No Flow	No Flow
194	SJR at Burns Cuttoff	05/09/08	13:48	37.94101	-121.34505	19.51	0.330	0.21	111.55	10.23	7.99	158.39	25.07
195	SJR at Stockton WWTP outfall	05/09/08	13:18	37.93805	-121.33531	19.48	0.330	0.21	111.53	10.24	8.01	144.04	24.37
84	SJR at Garwood Station	05/10/08	12:45	37.92819	-121.32843	19.46	0.335	0.22	115.91	10.64	8.19	181.57	22.75
127	SJR at Brant Bridge	05/10/08	12:25	37.86488	-121.32267	18.75	0.340	0.22	108.87	10.14	7.92	190.69	18.67
193	Stockton WWTP effluent	05/10/08	13:01	37.93810	-121.33580	21.30	–	–	–	–	6.66	–	1.42
194	SJR at Burns Cuttoff	05/10/08	13:26	37.94101	-121.34505	19.48	0.349	0.23	113.02	10.37	8.03	178.30	24.51
195	SJR at Stockton WWTP outfall	05/10/08	12:55	37.93805	-121.33531	19.40	0.349	0.23	112.64	10.36	7.96	172.34	27.47
84	SJR at Garwood Station	05/11/08	14:06	37.92819	-121.32843	19.74	0.335	0.22	114.09	10.42	7.98	138.79	22.33
127	SJR at Brant Bridge	05/11/08	13:45	37.86488	-121.32267	19.26	0.338	0.22	116.78	10.77	8.06	113.43	19.55
193	Stockton WWTP effluent	05/11/08	14:15	37.93810	-121.33580	22.20	–	–	–	–	6.75	–	1.42
194	SJR at Burns Cuttoff	05/11/08	14:38	37.94101	-121.34505	19.94	0.335	0.22	115.79	10.53	7.98	147.31	24.89
195	SJR at Stockton WWTP outfall	05/11/08	14:22	37.93805	-121.33531	19.93	0.331	0.22	114.50	10.42	7.98	142.43	28.34
84	SJR at Garwood Station	05/12/08	15:34	37.92819	-121.32843	19.07	0.330	0.21	112.25	10.39	7.98	162.39	22.87
127	SJR at Brant Bridge	05/12/08	15:14	37.86488	-121.32267	19.00	0.330	0.21	118.40	10.98	8.18	135.86	21.17
193	Stockton WWTP effluent	05/12/08	15:45	37.93810	-121.33580	20.50	–	–	–	–	6.73	–	1.10
194	SJR at Burns Cuttoff	05/12/08	16:13	37.94101	-121.34505	19.21	0.343	0.22	111.25	10.27	7.89	160.85	23.97
195	SJR at Stockton WWTP outfall	05/12/08	15:54	37.93805	-121.33531	19.22	0.333	0.22	111.57	10.30	7.95	160.94	24.91
84	SJR at Garwood Station	05/13/08	6:17	37.92819	-121.32843	18.44	0.333	0.22	102.94	9.65	8.03	141.73	24.80
127	SJR at Brant Bridge	05/13/08	5:56	37.86488	-121.32267	17.90	0.324	0.21	100.37	9.51	7.91	124.24	23.51
193	Stockton WWTP effluent	05/13/08	6:26	37.93810	-121.33580	18.80	–	–	–	–	6.62	–	0.96
194	SJR at Burns Cuttoff	05/13/08	6:51	37.94101	-121.34505	18.47	0.332	0.22	99.70	9.34	7.87	161.13	24.24
195	SJR at Stockton WWTP outfall	05/13/08	6:33	37.93805	-121.33531	18.45	0.326	0.21	100.14	9.39	7.90	155.61	25.63
84	SJR at Garwood Station	05/14/08	7:11	37.92819	-121.32843	18.78	0.334	0.22	105.82	9.85	7.91	164.90	23.21
127	SJR at Brant Bridge	05/14/08	6:47	37.86488	-121.32267	18.42	0.337	0.22	103.44	9.70	7.72	158.65	23.72
193	Stockton WWTP effluent	05/14/08	7:23	37.93810	-121.33580	20.50	–	–	–	–	6.53	–	0.65
194	SJR at Burns Cuttoff	05/14/08	7:50	37.94101	-121.34505	18.95	0.341	0.22	103.29	9.58	7.70	172.28	23.90
195	SJR at Stockton WWTP outfall	05/14/08	7:26	37.93805	-121.33531	18.91	0.327	0.21	103.35	9.60	7.79	168.91	25.20
84	SJR at Garwood Station	05/15/08	8:47	37.92819	-121.32843	19.90	0.345	0.22	108.70	9.89	7.86	168.69	22.57
127	SJR at Brant Bridge	05/15/08	8:19	37.86488	-121.32267	19.57	0.344	0.22	103.95	9.52	7.63	166.44	23.96
193	Stockton WWTP effluent	05/15/08	9:00	37.93810	-121.33580	22.40	–	–	–	–	6.62	–	0.82
194	SJR at Burns Cuttoff	05/15/08	9:22	37.94101	-121.34505	20.08	0.360	0.23	107.18	9.72	7.70	176.05	25.64
195	SJR at Stockton WWTP outfall	05/15/08	9:05	37.93805	-121.33531	20.01	0.345	0.22	107.40	9.75	7.81	172.63	28.40

Appendix D Table 2
Laboratory measurements of water quality

Site number	Site name	Sample Date	Sampling Time	Chl-a SM ug/L	Pheophyton on SM ug/L	Algal pigments ug/L	Chl-a TriChrom ug/L	4.5 Alk, mg CaCO3/L	8.3 Alk, mg CaCO3/L	Total Organic Carbon, mg/L	Dissolved Organic Carbon, mg/L	VSS, mg/L	TSS, mg/L	Mineral Solids mg/L	Total N, mg/L	NH_3-N mg/L	NO_3-N mg/L	NO_2-N, mg/L	PO_4-P, mg/L	Total P, mg/L	SUVA (L/mg-M)	Chlorine, mg/L
84	SJR at Garwood Station	05/01/08	7:28	29.4	10.1	39.5	36.8	57	0	3.1	2.3	6.030	36.047	30.016	1.17	0.02	0.59	0.00	0.07	0.21	2.924	nd
127	SJR at Brant Bridge	05/01/08	7:03	22.5	8.0	30.5	28.3	55	0	3.0	2.5	5.216	30.268	25.053	1.06	0.00	0.55	0.01	0.07	0.22	2.566	nd
193	Stockton WWTP effluent	05/01/08	7:50	4.8	5.3	10.1	8.1	83	0	11.7	11.6	2.173	2.857	0.684	24.21	1.38	19.43	0.44	0.13	0.31	1.684	nd
194	SJR at Burns Cuttoff	05/01/08	8:25	24.0	10.5	34.5	31.4	58	0	3.5	2.9	5.620	32.592	26.972	1.77	0.03	1.27	0.02	0.09	0.26	2.695	nd
195	SJR at Stockton WWTP outfall	05/01/08	7:46	25.1	9.9	35.0	32.1	60	0	3.7	3.3	3.740	27.258	23.518	2.82	0.06	2.30	0.03	0.09	0.26	2.503	nd
84	SJR at Garwood Station	05/02/08	8:10	10.7	3.1	13.8	13.1	57	0	2.5	2.4	5.292	33.282	38.574	1.00	0.02	0.65	0.01	0.08	0.24	3.026	nd
127	SJR at Brant Bridge	05/02/08	7:48	20.2	8.0	28.2	25.9	54	0	2.3	2.2	5.275	32.231	37.505	1.10	0.02	0.62	0.01	0.08	0.24	2.946	nd
193	Stockton WWTP effluent	05/02/08	8:35	4.8	5.4	10.2	8.2	79	0	11.4	10.4	3.339	1.178	4.517	23.35	0.95	17.70	0.39	0.16	0.38	1.838	nd
194	SJR at Burns Cuttoff	05/02/08	8:57	22.3	9.3	31.6	28.9	56	0	2.8	2.7	5.200	31.580	36.781	2.16	0.04	1.13	0.02	0.09	0.23	3.003	0.06
195	SJR at Stockton WWTP outfall	05/02/08	8:26	21.2	9.5	30.7	28.0	57	0	2.7	2.7	5.638	31.515	37.153	3.29	0.12	2.62	0.04	0.09	0.28	2.840	nd
84	SJR at Garwood Station	05/03/08	9:18	16.6	7.2	23.8	21.8	57	0	2.2	2.2	5.166	36.160	30.994	1.27	0.06	0.68	0.01	0.09	0.25	2.951	0.07
127	SJR at Brant Bridge	05/03/08	8:51	15.7	6.4	22.0	20.2	56	0	2.1	2.2	5.470	39.964	34.495	1.18	0.02	0.69	0.01	0.07	0.38	2.779	0.11
193	Stockton WWTP effluent	05/03/08	9:35	2.1	2.6	4.7	3.8	85	0	10.4	10.1	2.074	3.114	1.040	22.84	0.81	19.54	0.09	0.04	0.20	1.730	nd
194	SJR at Burns Cuttoff	05/03/08	10:02	15.6	9.2	24.8	21.9	57	0	2.7	2.5	5.046	39.364	34.318	2.17	0.12	1.19	0.01	0.10	0.27	2.879	nd
195	SJR at Stockton WWTP outfall	05/03/08	9:32	14.7	8.6	23.2	20.5	58	0	3.0	2.9	5.794	40.590	34.797	1.89	0.13	1.21	0.01	0.10	0.25	2.740	0.08
84	SJR at Garwood Station	05/04/08	9:23	15.0	9.3	24.3	21.3	56	0	2.2	2.4	4.887	38.086	33.199	1.20	0.03	0.65	0.01	0.11	0.20	1.391	0.02
127	SJR at Brant Bridge	05/04/08	9:01	12.3	4.9	17.2	15.8	55	0	2.2	2.2	4.740	34.588	29.848	1.22	0.02	0.57	0.01	0.10	0.25	2.182	0.11
193	Stockton WWTP effluent	05/04/08	9:45	5.2	6.8	12.0	9.5	94	0	10.9	10.8	2.924	4.177	1.253	23.87	0.77	20.14	0.09	0.16	0.35	1.162	nd
194	SJR at Burns Cuttoff	05/04/08	10:10	13.1	8.8	21.9	19.0	57	0	2.6	2.8	5.071	41.603	36.532	2.26	0.08	1.57	0.01	0.09	0.22	1.776	0.06
195	SJR at Stockton WWTP outfall	05/04/08	9:37	14.4	9.3	23.7	20.7	58	0	2.5	2.5	5.484	42.280	36.796	3.30	0.10	2.44	0.01	0.14	0.15	1.903	0.02
84	SJR at Garwood Station	05/05/08	9:43	21.3	10.6	31.9	28.7	56	0	3.4	2.4	5.54	36.350	30.809	1.12	0.03	0.74	0.01	0.10	0.23	3.087	0.03
127	SJR at Brant Bridge	05/05/08	9:24	19.6	4.7	24.3	23.5	54	0	2.8	2.2	5.35	36.929	31.581	1.19	0.02	0.70	0.01	0.07	0.21	2.946	0.08
193	Stockton WWTP effluent	05/05/08	10:10	2.7	3.8	6.5	5.1	94	0	11.1	10.0	4.67	7.140	2.471	23.38	1.09	19.93	0.16	0.15	0.38	1.856	nd
194	SJR at Burns Cuttoff	05/05/08	10:30	12.5	7.0	19.5	17.4	57	0	3.4	2.6	5.51	38.733	33.219	2.08	0.06	1.27	0.03	0.14	0.23	2.864	0.14
195	SJR at Stockton WWTP outfall	05/05/08	10:04	13.3	7.0	20.3	18.2	58	0	3.7	2.7	5.58	40.470	34.890	3.61	0.11	2.58	0.01	0.10	0.25	2.852	0.12
84	SJR at Garwood Station	05/06/08	10:41					56	0	2.9	2.4	5.404	34.494	29.090	1.18	0.00	0.31	0.01	0.07	0.19	1.891	nd
127	SJR at Brant Bridge	05/06/08	10:17					54	0	2.7	2.3	5.217	28.728	23.511	1.18	0.01	0.80	0.01	0.07	0.21	1.861	nd
193	Stockton WWTP effluent	05/06/08	11:00		samples lost			77	0	11.8	10.8	3.195	4.392	1.197	23.22	1.02	20.63	0.12	0.29	0.37	1.103	nd
194	SJR at Burns Cuttoff	05/06/08	11:25					56	0	3.4	2.6	5.229	35.870	30.641	2.13	0.04	1.25	0.01	0.09	0.22	1.859	nd
195	SJR at Stockton WWTP outfall	05/06/08	10:56					58	0	3.4	2.5	5.497	36.227	30.729	2.55	0.08	1.83	0.01	0.08	0.22	1.857	nd
84	SJR at Garwood Station	05/07/08	11:43	35.7	12.8	48.5	44.9	55	0	2.3	2.3	5.286	37.604	32.318	1.25	0.03	0.87	0.01	0.07	0.24	1.897	nd
127	SJR at Brant Bridge	05/07/08	11:20	29.5	7.2	36.7	35.0	56	0	2.2	2.2	5.006	36.151	31.145	1.14	0.03	0.69	0.01	0.05	0.21	1.833	0.04
193	Stockton WWTP effluent	05/07/08	12:05	no flow	no flow	no flow	no flow	no flow	no flow	no flow	no flow	no flow	no flow	no flow	no flow	no flow	no flow	no flow	no flow	no flow	no flow	no flow
194	SJR at Burns Cuttoff	05/07/08	12:21	23.9	8.1	32.0	29.9	56	0	2.2	2.3	5.490	40.756	35.267	1.32	0.04	0.67	0.01	0.07	0.24	1.807	0.07
195	SJR at Stockton WWTP outfall	05/07/08	11:57	30.0	14.3	44.4	40.0	56	0	2.2	2.3	5.912	44.177	38.264	1.16	0.02	0.68	0.01	0.07	0.31	1.840	nd
84	SJR at Garwood Station	05/08/08	11:58	36.3	11.9	48.2	45.1	49	0	2.8	2.2	5.265	42.352	37.087	0.77	0.04	0.45	0.01	0.05	0.27	2.686	0.08
127	SJR at Brant Bridge	05/08/08	11:35	20.1	4.3	24.3	23.5	54	0	2.7	2.1	4.783	36.824	32.040	0.96	0.02	0.62	0.01	0.05	0.23	2.585	0.08
193	Stockton WWTP effluent	05/08/08	12:15	no flow	no flow	no flow	no flow	no flow	no flow	no flow	no flow	no flow	no flow	no flow	no flow	no flow	no flow	no flow	no flow	no flow	no flow	no flow
194	SJR at Burns Cuttoff	05/08/08	12:33	25.9	8.5	34.3	32.2	55	0	3.0	2.2	5.677	43.552	37.875	0.91	0.02	1.09	0.01	0.06	0.22	2.629	0.08
195	SJR at Stockton WWTP outfall	05/08/08	12:11	21.0	7.3	28.3	26.4	56	0	2.8	2.4	5.993	48.049	42.056	0.75	0.04	0.57	0.01	0.06	0.22	2.543	0.14

Appendix D Table 2

Laboratory measurements of water quality

Site number	Site name	Sample Date	Sampling Time	Chl-a SM ug/L	Pheophyt on SM ug/L	Algal pigments ug/L	Chl-a TriChrom ug/L	4.5 Alk, mg CaCO3/L	8.3 Alk, mg CaCO3/L	Total Organic Carbon, mg/L	Dissolved Organic Carbon, mg/L	VSS, mg/L	TSS, mg/L	Mineral Solids mg/L	Total N, mg/L	NH_3-N mg/L	NO_3-N mg/L	NO_2-N, mg/L	PO_4 P, mg/L	Total P, mg/L	SUVA (L/mg-M)	Chlorine, mg/L
84	SJR at Garwood Station	05/09/08	13:02	26.34	9.59	35.93	33.33	53	0	3.130	2.217	5.219	39.187	33.967	0.74	0.01	0.50	0.01	0.06	0.20	2.652	0.13
127	SJR at Brant Bridge	05/09/08	12:34	28.58	5.64	34.22	33.23	53	0	3.339	2.178	5.396	40.948	35.552	0.85	0.01	0.58	0.01	0.06	0.22	2.686	0.05
193	Stockton WWTP effluent	05/09/08	13:23	No Flow	No Flow	No Flow	No Flow	94	0	14.154	12.345	18.473	24.541	6.068	27.24	2.93	17.61	2.78	0.94	2.89	2.180	0.05
194	SJR at Burns Cuttoff	05/09/08	13:48	23.07	8.57	31.65	29.29	52	0	2.993	2.223	5.512	43.601	38.089	0.77	0.02	0.63	0.01	0.11	0.19	2.824	0.09
195	SJR at Stockton WWTP outfall	05/09/08	13:18	18.61	6.43	25.04	23.40	54	0	2.751	2.359	5.536	42.306	36.770	0.66	0.02	0.58	0.02	0.06	0.20	2.620	0.14
84	SJR at Garwood Station	05/10/08	12:45	28.22	6.40	34.62	4.38	54	0	2.742	2.021	5.676	38.313	32.638	0.77	0.01	0.60	0.01	0.05	0.31	2.895	0.15
127	SJR at Brant Bridge	05/10/08	12:25	26.73	5.68	32.40	4.33	54	0	2.884	2.025	4.689	32.991	28.302	0.78	0.01	0.53	0.01	0.05	0.22	2.804	0.11
193	Stockton WWTP effluent	05/10/08	13:01	1.54	1.58	3.12	0.10	80	0	10.066	9.472	2.881	4.596	1.715	23.04	5.32	14.67	0.94	0.24	0.38	1.861	0.04
194	SJR at Burns Cuttoff	05/10/08	13:26	35.00	11.29	46.28	5.40	55	0	3.282	2.240	5.460	42.032	36.572	1.25	0.12	0.84	0.02	0.06	0.28	2.915	0.16
195	SJR at Stockton WWTP outfall	05/10/08	12:55	24.89	8.15	33.03	4.02	55	0	2.649	2.225	6.257	48.465	42.208	1.23	0.05	0.86	0.02	0.06	0.25	2.894	0.12
84	SJR at Garwood Station	05/11/08	14:06	24.87	4.40	29.27	28.63	54	0	2.806	1.896	5.247	36.691	31.444	0.70	0.01	0.85	0.01	0.06	0.22	3.169	0.10
127	SJR at Brant Bridge	05/11/08	13:45	33.01	5.80	38.81	37.90	54	0	2.540	1.865	5.017	35.071	30.054	0.74	0.02	0.73	0.01	0.05	0.32	3.196	0.13
193	Stockton WWTP effluent	05/11/08	14:15	7.47	2.97	10.44	9.47	101	0	10.522	10.801	2.890	4.005	1.115	21.62	5.30	15.56	0.82	0.15	0.31	1.859	1.10
194	SJR at Burns Cuttoff	05/11/08	14:38	25.55	6.56	32.11	30.63	56	0	2.766	2.013	5.391	40.278	34.887	1.18	0.09	0.84	0.01	0.06	0.25	3.363	0.16
195	SJR at Stockton WWTP outfall	05/11/08	14:22	38.20	11.64	49.84	46.93	54	0	2.791	1.941	6.529	48.884	42.355	1.23	0.03	0.69	0.01	0.06	0.23	3.395	0.18
84	SJR at Garwood Station	05/12/08	15:34	23.59	4.81	28.41	27.53	52	0	2.633	2.245	5.641	37.997	32.36	1.02	0.02	1.04	0.01	0.06	0.26	2.753	0.11
127	SJR at Brant Bridge	05/12/08	15:14	29.62	2.87	32.49	32.62	53	0	2.079	2.097	5.442	38.887	33.44	0.77	0.02	0.74	0.01	0.10	0.26	2.856	0.06
193	Stockton WWTP effluent	05/12/08	15:45	7.06	1.20	8.26	7.98	91	0	10.289	10.325	2.568	3.698	1.13	22.54	3.50	16.05	0.59	0.07	0.19	1.760	0.04
194	SJR at Burns Cuttoff	05/12/08	16:13	23.37	5.19	28.56	27.55	53	0	2.717	2.445	5.434	39.197	33.76	1.31	0.06	1.06	0.03	0.06	0.24	2.675	0.11
195	SJR at Stockton WWTP outfall	05/12/08	15:54	24.41	6.73	31.14	29.56	53	0	3.866	2.227	6.202	47.464	41.26	0.70	0.01	0.84	0.01	0.06	0.27	2.807	0.11
84	SJR at Garwood Station	05/13/08	6:17	21.26	8.04	29.30	27.08	53	0	2.815	2.112	5.649	46.825	41.177	0.79	0.00	0.67	0.01	0.06	0.25	3.172	0.13
127	SJR at Brant Bridge	05/13/08	5:56	28.89	6.88	35.77	34.29	53	0	2.574	2.097	5.563	43.930	38.368	0.84	0.01	0.63	0.01	0.05	0.22	2.961	0.10
193	Stockton WWTP effluent	05/13/08	6:26	6.19	1.04	7.23	7.04	83	0	9.669	9.867	1.844	2.508	0.664	23.70	3.68	19.53	0.41	0.07	0.16	1.792	0.04
194	SJR at Burns Cuttoff	05/13/08	6:51	17.73	8.20	25.92	23.43	54	0	2.596	2.343	5.449	39.886	34.437	1.21	0.04	0.81	0.01	0.06	0.26	3.031	0.09
195	SJR at Stockton WWTP outfall	05/13/08	6:33	17.52	7.22	24.74	22.70	53	0	2.744	2.285	5.610	46.738	41.128	1.14	0.01	0.68	0.01	0.06	0.21	3.041	0.11
84	SJR at Garwood Station	05/14/08	7:11	23.89	7.24	31.14	29.35	54	0	2.444	1.963	5.556	42.163	36.607	1.17	0.00	0.68	0.01	0.06	0.18	3.307	0.13
127	SJR at Brant Bridge	05/14/08	6:47	26.51	6.16	32.67	31.40	55	0	2.646	1.946	5.799	46.321	40.522	1.25	0.00	0.71	0.01	0.06	0.23	3.386	0.08
193	Stockton WWTP effluent	05/14/08	7:23	4.18	0.82	5.00	4.84	69	0	9.271	8.668	1.320	1.906	0.585	24.16	2.25	18.75	0.28	0.05	0.12	1.923	0.08
194	SJR at Burns Cuttoff	05/14/08	7:50	22.67	8.41	31.09	28.80	53	0	3.108	2.342	6.459	51.503	45.044	1.82	0.04	1.35	0.03	0.07	0.28	3.276	0.06
195	SJR at Stockton WWTP outfall	05/14/08	7:26	27.34	10.27	37.61	34.80	52	0	2.509	2.121	5.596	44.845	39.249	1.34	0.03	0.85	0.01	0.08	0.32	3.281	0.07
84	SJR at Garwood Station	05/15/08	8:47	27.46	6.81	34.27	32.81	55	0	2.628	1.915	5.624	40.489	34.865	1.29	0.01	0.71	0.01	0.06	0.24	3.483	0.18
127	SJR at Brant Bridge	05/15/08	8:19	30.89	7.15	38.04	36.57	57	0	2.604	1.801	5.596	46.125	40.529	1.24	0.03	0.60	0.01	0.06	0.22	3.225	0.16
193	Stockton WWTP effluent	05/15/08	9:00	4.36	1.14	5.49	5.20	70	0	9.010	9.621	1.801	2.723	0.922	24.78	3.56	15.47	0.26	0.06	0.23	1.656	0.12
194	SJR at Burns Cuttoff	05/15/08	9:22	13.23	3.53	16.76	15.95	56	0	3.304	2.299	6.135	43.090	36.955	1.90	0.03	1.27	0.01	0.08	0.25	3.119	0.12
195	SJR at Stockton WWTP outfall	05/15/08	9:05	24.03	7.11	31.14	29.42	56	0	2.779	2.022	6.672	52.878	46.206	1.50	0.01	0.79	0.01	0.08	0.25	3.357	0.17

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