San Joaquin River Group Authority

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Home

SJRG Agreement

Executive Summary
Background
Annual Report
Final EIS-EIR
Supplemental EIS/EIR

Operations and Technical Data

Fish Program
Head of Old River
Run-off Forecast

Administration

Notices
Events
Calendar
VAMP Newsletter

Annual Technical Reports

Adobe Acrobat Reader™ is required. Download it free.

2007 Annual Technical Report

- Cover
- Title Page
- Table of Contents
- Executive Summary
- Chapter 1 - Introduction
- Chapter 2 - VAMP HydrologicPlanning and Implementation
- Chapter 3 - Additional Water SupplyArrangements and Deliveries
- Chapter 4 - Head of Old River Barrier
- Chapter 5 - Salmon Smolt Survival Investigations
- Chapter 6 - Complimentary Studies Related to the VAMP
- Chapter 7 - Conclusions and Recommendations
- References Cited and Contributing Authors
- Appendix - Table of Contents
- Appendix A - Hydrology and Operation Plans
- Appendix B - Historical Data
- Appendix C - Chinook Salmon Survival Investigations
- Appendix D - Field Standard Operating Procedure

2006 Annual Technical Report

- Cover
- Title Page
- Table of Contents
- Executive Summary
- Chapter 1 - Introduction
- Chapter 2 - VAMP HydrologicPlanning and Implementation

- Chapter 3 - Additional Water SupplyArrangements and Deliveries
- Chapter 4 - Head of Old River Barrier
- Chapter 5 - Salmon Smolt Survival Investigations
- Chapter 6 - Complimentary Studies Related to the VAMP
- Chapter 7 - Conclusions and Recommendations
- References Cited and Contributing Authors
- Appendix - TOC
- Appendix A - Hydrology and Operation Plans
- Appendix B - Historical Data
- Appendix C - Chinook Salmon Survival Investigations
- Appendix D - Errata for the Year 2005 Annual Technical Report

2005 Annual Technical Report

- Cover
- Executive Summary
- Chapter 1 (Introduction)
  Chapter 2 (VAMP Hydrologic Planning and Implementation)
- Chapter 3 (Additional Water Supply Arrangements & Deliveries)
- Chapter 4 (Head of Old River Barrier)
- Chapter 5 (Salmon Smolt Survival Investigations)
- Chapter 6 (Complimentary Studies Related to the VAMP)
- Chapter 7 (Conclusions and Recommendations)
- References Cited and Contributing Authors
- **Technical Appendices**
- Appendices (TOC)
- Appendix A (Hydrology & Operation Plans)
- Appendix B (Historic Data)
- Appendix C (Chinook Salmon Survival Investigations)
- Appendix D (Errata)
- Back Cover (Contact Info)

2004 Annual Technical Report

- Executive Summary
- Chapter 1 (Introduction)
- Chapter 2 (Vamp Hydrologic Planning and Implementation)
- Chapter 3 (Additional Water Supply Arrangements and Deliveries)

- Chapter 4 (Head Of Old River Barrier)
- Chapter 5 (Salmon Smolt Survival Investigations)
- Chapter 6 (Complimentary Studies Related To The Vamp)
- Chapter 7 (Conclusions and Recommendations)
- References Cited
- **Technical Appendices**
- Appendix A (Hydrology and Operation Plans)
- Appendix B (Head Of Old River Barrier Operation)
- Appendix C (Chinook Salmon Survival Investigation)
- Appendix D (Historic Data)
- Appendix E (Errata)

2003 Annual Technical Report

- Chapter 1 (Including Cover, Title Page, Table of Contents, Executive Summary, Introduction) - PDF 698 KB
- Chapter 2 (VAMP Hydrologic Planning & Implementation) - PDF 178 KB
- Chapter 3 (Additional Water Supply Arrangements & Deliveries) - PDF 122 KB
- Chapter 4 (Head of Old River Barrier) - PDF 358 KB
- Chapter 5 (Salmon Smolt Survival Investigations) - PDF 776 KB
- Chapter 6 (Complimentary Studies Related to VAMP) - PDF 1.67 MB
- Chapter 7 (Conclusions & Recommendations, Literature Cited, Contributing Authors, Signatories to the SJRA, Useful Web Pages, Common Acronyms & Abbreviations) - PDF 803 KB
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- Appendix A (Hydrology & Operation Plans) - PDF 659 KB
- Appendix B (Fall Water Transfer and Delivery Information) - PDF 672 KB
- Appendix C (Chinook Salmon Survival Investigations) - PDF 244 KB
- Appendix D (Errata for the 2002 Annual Technical Report) - PDF 664 KB

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- Chapter 5 (Salmon Smolt Survival Investigations) - PDF 776 KB
- Chapter 6 (Complimentary Studies Related to VAMP) - PDF 1.67 MB
- Chapter 7 (Conclusions & Recommendations, Literature Cited, Contributing Authors, Signatories to the SJRA, Useful Web Pages) - PDF 803 KB
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- 2001 Technical Report - PDF - 2.58 MB
- 2001 Technical Appendices - PDF - 548 KB

2000 Annual Technical Report

- 2000 Technical Report - PDF - 1.09 MB

Technical Appendices

- Appendix A (Hydrology & Operation Information) - PDF 1.51 MB
- Appendix B (Fall Water Transfer and Delivery Information) - PDF 1.44 MB
- Appendix C (Chinook Salmon Survival Investigations) - PDF 1.57 MB

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2007 Annual Technical Report

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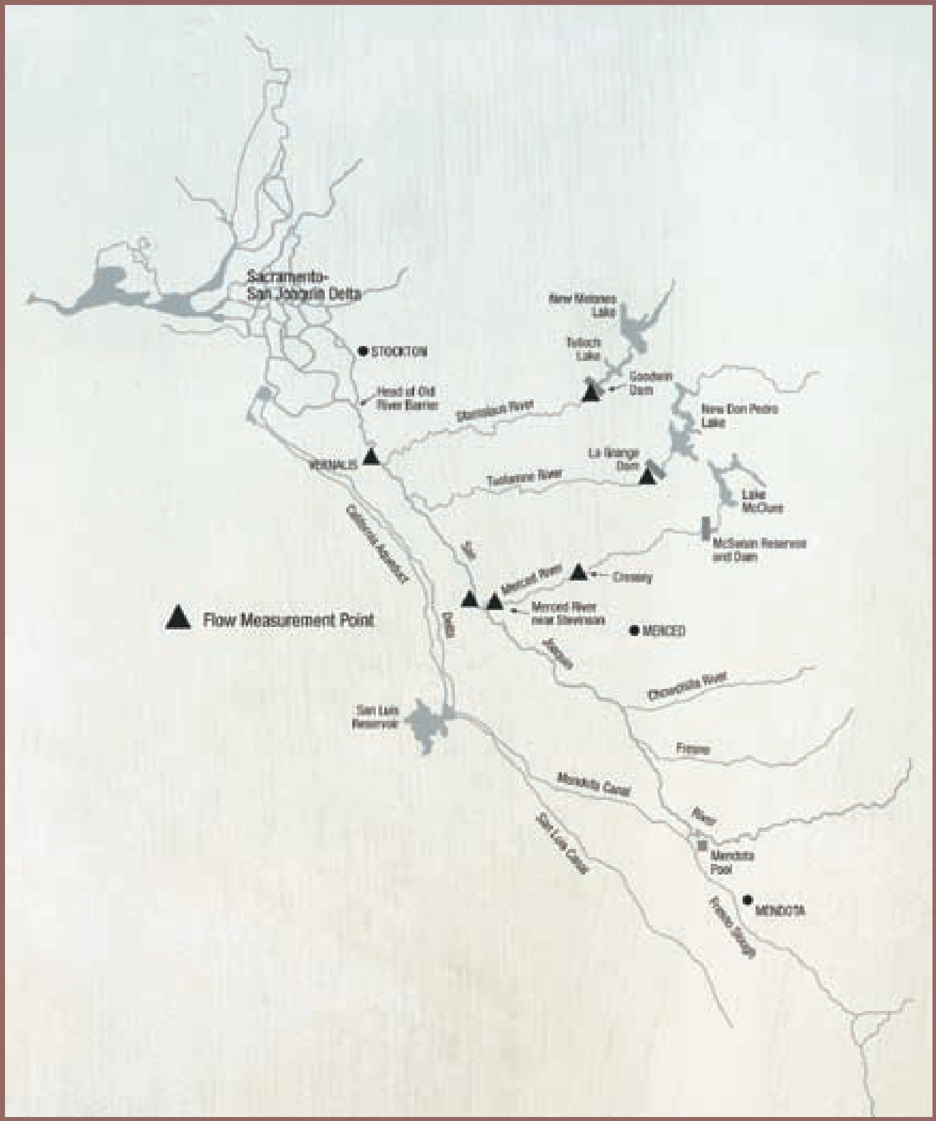
SAN JOAQUIN RIVER AGREEMENT

SAN JOAQUIN RIVER GROUP AUTHORITY

Figure 2-1
Sacramento – San Joaquin Estuary



2007 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 Resource Control Board
in compliance with D-1641

JANUARY 2008

TABLE OF CONTENTS

Executive Summary ... 3

Chapter 1
Introduction ... 8

Experimental Design Elements ... 9

Chapter 2
VAMP Hydrologoic Planning and Implementation ... 10

2007 VAMP Summary ... 10

VAMP Background and Description ... 10

Hydrologic Planning for 2007 VAMP ... 12

Implementation ... 15

Hydrologic Impacts ... 16

Summary of Historical VAMP Operations ... 16

Chapter 3
Additional Water Supply
Arrangements & Deliveries ... 24

Merced Irrigation District ... 24

Oakdale Irrigation District ... 24

Chapter 4
Head of Old River Barrier
Barrier Design, Installation and Operation ... 27

Flow Measurements at and Around
the Head of Old River ... 29

Fish Entrainment Monitoring at the
Head of Old River Barrier ... 31

Materials and Methods ... 34

Results ... 35

Chapter 5
Salmon Smolt Survival Investications
Acoustic–Tagged Smold Distribution Study ... 40

Introduction ... 40

Fish Tagging ... 40

Fish Releases ... 41

Water Temperature Monitoring ... 41

Net Pen and Health Assessments ... 43

Health and Physiological Tests ... 43

Detection of Acoustic-Tagged Fish ... 47

Fish Transit Time ... 47

Chinook Salmon Distribution and Survival ... 49

Estimates of Survival ... 49

Head of Old River Barrier Releases ... 54

Mobile Monitoring ... 55

Comparison with Past Years ... 58

San Joaquin River Salmon Protection ... 58

Chapter 6
Complimentary Studies Related to the VAMP ... 66

2007 Mossdale Trawl Summary ... 69

Survival Estimated for CWT Releases Made
in the Merced River ... 74

Comparison of Lower Merced Releases
with Sacramento River Delta Releases ... 74

Chapter 7
Conclusions and Recommendations ... 76

References Cited ... 78

Contributing Authors ... 78

Signatories to the San Joaquin River Agreement ... 79

Useful Web Pages ... 79

Acronyms and Abbreviations ... 80

Appendices ... 81

EXECUTIVE SUMMARY

The San Joaquin River Agreement (SJRA) and Vernalis Adaptive Management Plan (VAMP) 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). 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. 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 lack of returning adults to the Merced River Hatchery and subsequent low salmon smolt production resulted in the California Department of Fish and Game's (CDFG) inability to provide test fish for a coded wire tag study in 2007 VAMP. The SJRA technical committee (SJRATC) concluded that an acoustic telemetry monitoring program, relying on 1,000 acoustic tagged salmon smolts, would be conducted over the same VAMP period. The VAMP test period was delayed one week from the default period of April 15-May 15 to 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. Water Year 2007 was very dry on the San Joaquin River watershed, with the four-basin April-July forecasted runoff ranging from 41% to 52% of average. The VAMP Vernalis test flow over the April 22-May 22 period was set at 3,200 cfs based on the SJRA criteria.

The 2007 Annual Technical Report consolidates the annual SJRA Operations and the Vernalis Adaptive Management Plan (VAMP) Monitoring Reports. The VAMP 2007 program represents the eighth 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 VAMP program. Specifically, this 2007 report includes the following information on the implementation of the SJRA: the hydrologic chronicle; management of any additional SJRA water; flow and fisheries monitoring in the lower San Joaquin River, Old River, and Delta; results of the juvenile salmon acoustic tag study; discussion of complementary investigations; and conclusions and recommendations.

SEE USEFUL WEB PAGES

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. 2007 represented the first year of a monitoring program relying fully on the use of acoustic telemetry technology. Implementation of this new technology was not without some difficulties. The lack of two key monitoring stations, receiver malfunctions and the unexplained mortality near Stockton of a sizable number of test fish impacted our ability to complete a survival analysis. In addition to providing improved protection for juvenile Chinook salmon emigrating from the San Joaquin River system, specific experimental objectives of VAMP 2007 included:

- Quantification of Chinook salmon smolt survival along individual river segments between Durham Ferry, Mossdale, Head of Old River, Bowman Road (near Dos Reis), and Stockton by detection of acoustic signals from transmitters implanted in the test fish.
- Evaluation of the San Joaquin River – Old River flow split at the Head of Old River under the 2007 flow conditions with the installed HORB.
- Monitoring in Old River to evaluate the movement of salmon smolts in Old River under the 2007 flow conditions with the installed HORB.
- Evaluation of fish mortality across Clifton Court Forebay between the Clifton Court Forebay inlet structure and the Skinner Fish Facility.
- Health and physiology testing of VAMP fish was conducted at the MRH, Durham Ferry and Mossdale to evaluate the incidence of disease.

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 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 2007 were similar to those experienced in 2002. In the March 21 operation plan the existing a flow was forecasted to be between 2,182 and 2,582 cfs calling for a VAMP target flow of either 3,200 cfs or 4,450 cfs. The forecasts throughout the weeks leading up to the VAMP period indicated the HORB could safely be installed; however the uncertain condition of the Delta smelt controlled the final decision on its installation. A decision by the Delta smelt working group allowed for the barrier to be constructed and closed on April 22. The HORB culverts remained closed until May 16 when they were opened due to Delta smelt concerns. As the dry conditions continued through the spring it became evident the double step criteria would not be a factor in determining the target flow for VAMP. By April 13 forecasts of existing flow at Vernalis was projected to be about 2,770 cfs between April 22 and May 22. In planning for the VAMP the SJRA Technical Committee recommended delaying the start of the VAMP pulse period until April 22 in an effort to provide larger smolt sized fish for the implantation of acoustic tags. The study was designed to measure survival along three segments of the San Joaquin River; Durham Ferry to Mossdale, Mossdale to Bowman Road and Bowman Road to Jersey Point.

EX - 1
Proposed Fish Release and Detection Locations.

	Fish Release Locations				
	Durham Ferry to	Mossdale to	Bowman Road to	Stockton to	Downstream of HORB
Planned Detection Locations	Upstream of HORB	Upstream of HORB			Tracy Fish Facility
	Bowman Road	Bowman Road			Clifton Court Inlet
	Stockton	Stockton	Stockton		Old River at Highway 4
	Jersey Point*	Jersey Point*	Jersey Point*	Jersey Point*	
	Chipps Island*	Chipps Island*	Chipps Island*	Chipps Island*	Chipps Island*

* Jersey Point and Chipps Island receivers not installed in 2007.

In an effort to document migratory behavior of salmon entering the Old River 100 acoustically tagged fish were released in the Old River immediately downstream of the HORB.

Unfortunately due to physical and technical difficulties beyond the control of the SJRA parties the acoustic receiver stations at Jersey Point and Chipps Island could not be installed in time for the 2007 VAMP. Thus survival to Jersey Point and Chipps Island could not be estimated.

Vamp experimental test conditions that have occurred over the past eight years are summarized below:

Water temperature data were collected with a series of computerized recorders at the Merced River Fish Facility, in the transport trucks, at the release sites and throughout the lower San Joaquin River and Delta. Overall the average temperature at all sites remained below 20 C, which is considered suitable for salmon smolts.

Survival of fish between Mossdale and Stockton was relatively high, but survival estimates in some reaches were suspect due to periods of receiver malfunction. Survival between Durham Ferry and Mossdale appeared lower. As mentioned earlier without the deployment of acoustic receivers at Jersey Point and Chipps Island

EX - 2
VAMP Experimental Test Conditions.

Year	VAMP Period	Average Vernalis Flow (cfs)	Average SWP/CVP Exports (cfs)	Head of Old River Barrier
2000	April 15-May 15	5,869	2,155	Installed
2001	April 20-May 20	4,220	1,420	Installed
2002	April 15-May 15	3,300	1,430	Installed
2003	April 15-May 15	3,235	1,446	Installed
2004	April 15-May 15	3,155	1,331	Installed
2005	May 1-May 31	10,390	2,986	Not Installed
2006	May 1-May 31	26,020	1,559/5,748 (a)	Not Installed
2007	April 22 - May 22	3,263	1,486	Installed

survival through the Delta could not be estimated. Deploying receivers at these two stations are being given high priority for the 2008 study.

The health of the CWT fish in 2007 was relatively good, but all test fish examined were infected with the parasite that causes PKD. It is uncertain how such infection affects long term survival of the smolts released as part of VAMP. Dummy tags were implanted in twenty fish during tagging and held for 7 to 14 days to assess tagging and handling stress. No mortalities were observed and the condition characteristics assessed were normal.

The relationship of survival to exports is difficult to detect based on the data gathered to date. The escapement data for adult salmon indicate that the flow/export ratio explains more of the variability in adult escapement than flow alone without the HORB, but the smolt survival data is too limited to detect these effects, if they are real. These relationships could not be tested in 2007. To further refine the relationship between survival and exports with the HORB, the VAMP experiments were designed to estimate survival at a flow of 7,000 cfs at two export levels, 1,500 and 3,000 cfs. We have not yet been able to estimate survival under these experimental conditions.

In addition to recommending these conditions to test, it is noteworthy that survival from Dos Reis to Jersey Point in 2003, 2004, 2005 and the second release group in 2006, was significantly less then prior years (Figure 5-10, SJRG 2007). Flows and exports during the VAMP tests in 2003-2004 were similar to those in 2002 (Table 2), but survival was significantly less. Although, 2007 had the same VAMP targets as in 2002-2004, we were not able to estimate survival to Jersey Point. The high mortality observed near Stockton may explain some of the poor survival in past years. Future studies to estimate survival through the Delta are important in documenting these types of occurrences. Measuring survival at 3200 flow at an export rate of 1500 will help document whether survival has rebounded to pre-2003 levels.

The decline in fish production at the Merced River Hatchery and the continued concern for the abundance of Delta smelt will greatly influence future VAMP designs. A priority will be to design future acoustic monitoring studies so that results can be compared to those generated from the previous coded wire tag studies.


WARNING
JOBOX

Introduction

Actions associated with the Vernalis Adaptive Management Plan (VAMP) were implemented between April 22 and May 22, 2007 to protect juvenile Chinook salmon and evaluate 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 study. As an alternative an acoustic telemetry study was conducted in 2007. The VAMP period was postponed 7 days from previous years to allow for additional growth of the experimental fish. Fish, tagged with acoustic transmitters, were released on May 3-4 and 10-11, 2007. The water districts maintained stable flow in accordance with the SJRA throughout the April - May study period, as were the export rates. The Delta Smelt workgroup permitted installing the HORB for the 2007 VAMP period. Survival estimates through the Delta were not possible in 2007 due to the lack of acoustic receivers at Jersey Point and Chipps Island. Studies conducted in 2007, represented the eighth 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 will describe the experimental design used in 2007, the hydrologic planning and implementation, the additional water supply arrangements and deliveries, fishery monitoring within the San Joaquin River and Old River with the HORB, the acoustic tag experiment and complimentary studies related to VAMP. Conclusions and recommendations for future VAMP studies are also included.

SEE USEFUL WEB PAGES

Experimental Design Elements

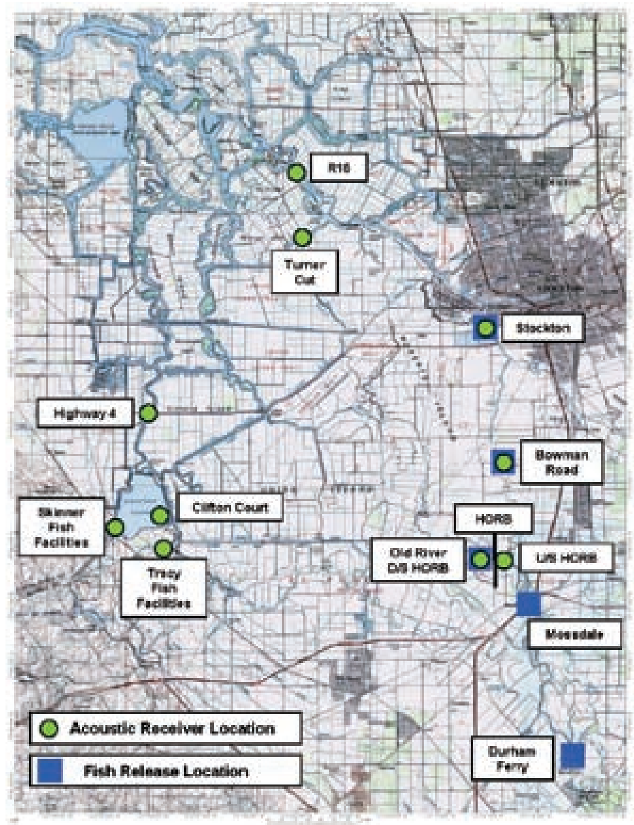
The VAMP experimental design used in previous years measured salmon smolt survival through the Delta under six different combinations of flow and export rates. The experimental design includes two mark-recapture studies performed each year during the April-May juvenile salmon outmigration period that provide estimates of salmon survival under each set of conditions. During 2007, for the first time since inception of the program, test fish were not available from the Merced River Fish Hatchery to permit a coded wire tag (CWT) study. In lieu of a CWT study an acoustic telemetry study was conducted. A total of 1,000 juvenile Chinook salmon were made available from the Merced River Hatchery (MRH) for the VAMP acoustic study. Study fish were surgically implanted with acoustic transmitters, capable of emitting an electronic signal for up to 3 weeks. It was not possible to estimate Chinook salmon survival through the entire Delta due to the lack of acoustic receivers at Jersey Point and Chipps Island. However, data was collected on salmon smolt behavior and mortality conditions within the South Delta and survival was estimated on the San Joaquin River from Durham Ferry and Mossdale to Stockton.

As described the SJRA and 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.

Even though survival estimates could not be determined from the 2007 experiment valuable information on how to implement an acoustic tag experiment was collected. This annual technical report describes the flow and HORB conditions encountered in 2007, the alternative experimental plan, and the findings.

Due to a decline of the delta smelt population in the Bay-Delta estuary the delta smelt workgroup analyzed the potential impacts of installing the HORB. Based on delta smelt monitoring and particle tracking models the workgroup permitted the HORB be installed in 2007. The 2007 VAMP experimental design included both multiple release locations (Durham Ferry, Mossdale, Old River, Bowman Road and Highway 4 at Stockton), and multiple detection locations, Figure 1-1.

Figure 1-1
Fish release locations and acoustic receiver locations during the 2007 VAMP experiments.



During the 2007 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. Fish were released at Durham Ferry, Mossdale, Old River, Bowman Road and near Stockton over 2 one week period during the VAMP. Ten acoustic receivers 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 2007 acoustic telemetry study a cadre of biologists were trained by the U.S. Geological Survey's Columbia River Research Laboratory in the proper surgical tagging procedures. The 2007 VAMP program used net pen studies to assess overall condition and health of marked fish used in the acoustic tag study. Improvements were made in 2007 relative to measuring flow in the San Joaquin River downstream of the confluence with Old River.

SEE USEFUL WEB PAGES

CHAPTER 2

VAMP HYDROLOGIC PLANNING AND IMPLEMENTATION

This section documents the planning and implementation undertaken by the Hydrology Group of the San Joaquin River Technical Committee (SJRTC) for the 2007 VAMP investigations. Implementation of VAMP is guided by the framework provided in the San Joaquin River Agreement (SJRA) and anticipated hydrologic conditions within the watershed. The Hydrology Group 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 2007, the agencies belonging to the Hydrology Group included: Merced Irrigation District (Merced), 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.

2007 VAMP Summary

The Water Year 2007[1] winter was very 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 65% of average on April 1, 2007. The forecasted April-July runoff as of April 1 in the four basins above Vernalis (Stanislaus, Tuolumne, Merced and San Joaquin) ranged from 41% to 52% of average. Water Year 2006 was classified as a Wet year as per the San Joaquin Valley Water Year Type Index (60-20-20), therefore a forecasted 90% exceedence forecast Water Year Type classification for 2007 of Dry or wetter would result in a double-step VAMP target flow for 2007. The only way for the 2007 VAMP not to be a double-step was for the 2007 Water Year Type Classification to be Critical. Due to continuing dry conditions, interrupted briefly by above average precipitation in March, the 90% exceedence forecast Water Year Type classification for 2007 as of April 1 was indeed Critical, thereby making the 2007 VAMP a single-step operation. Also, as a result of the critically dry conditions, the forecasted mean flow in the San Joaquin River near Vernalis for the VAMP test flow period of April 22 through May 22 was approximately 2,600 cfs, setting the VAMP target flow at the minimum value of 3,200 cfs.

[1]*Water Year 2007 is October 2006 through September 2007.*

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

This section provides information on the background and description of the water operations and factors to be considered when planning for the VAMP each year. 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 pulse 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 River, the Tuolumne River and the Stanislaus River.

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.

As part of the development of the VAMP experimental design, the VAMP Hydrology and Biology Groups jointly 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 VAMP Hydrology and Biology Groups 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 technical committees 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.

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 technical committees 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 Hydrology and Biology Groups agreed to a target range variation of plus or minus 7% of the Vernalis flow target. It was recognized by the Hydrology and Biology Groups that these guidelines are not absolute conditions, but are to be used by the VAMP technical committees 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 Merced, OID, SSJID, SJRECWA, MID and TID members of the San Joaquin River Group Authority (SJRGA) agencies 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 Merced supplemental water would be provided on the Merced River from storage in Lake McClure and would be measured at the Cressey gage on the Merced River. 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 gage.

The target flow of 2,000 cubic feet per second (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 2000 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 will exert their best efforts to maintain a stable flow during the VAMP pulse 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 (off-ramp). These potential adjustments to the target flow are dependent on the hydrologic year type as defined by the SWRCB San Joaquin Valley Water Year Hydrologic Classification (60-20-20 classification), 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 Classifications Used in VAMP

60-20-20 Water Year Classification	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 2007 VAMP

The SJRTC met four times between January 23 and April 16 to discuss and plan the 2007 VAMP experiment and operation. 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 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 22 SJRTC meeting. Based upon the February 14 runoff forecast the VAMP target flow would follow the single-step criteria. The 90 percent exceedence runoff forecast indicated an existing flow of about 1,800 cfs and a corresponding VAMP target flow of 2,000 cfs. The 50 percent exceedence runoff forecast indicated an existing flow of about 2,800 and a corresponding 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 that target. 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 estimates 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 major tributaries.

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

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)	Other Supplemental Water (acre-feet)	SJRGA Supplemental Water Requirement (acre-feet)
Planning	3/21/07	3/13/07	April 22 - May 22	Single	100	2,182	3,200	46,080 [1]	16,520
					500	2,582	3,200	46,080 [1]	0
			April 22 - May 22	Double	100	2,182	4,450	24,070 [1]	115,400
					500	2,582	4,450	28,060 [1]	86,800
	4/6/07	3/27/07	April 22 - May 22	Single	100	1,880	2,000	0	7,300
					300	2,080	3,200	0	68,790
					100	1,880	2,000	46,080 [1]	0
					300	2,080	3,200	46,080 [1]	22,670
	4/13/07	4/1/07	April 22 - May 22	Single	100	2,570	3,200	–	38,730
					300	2,770	3,200	–	26,430
	4/16/07	4/1/07	April 22 - May 22	Single	300	2,770	3,200	–	26,430
	4/18/07	4/1/07	April 22 - May 22	Single	300	2,700	3,200	–	30,500
Implementation	5/4/07	–	April 22 - May 22	Single	200 (5/4 - 5/22)	2,720	3,200	–	29,420

[1] Assumed b(2) water used on Stanislaus River was not part of existing flow, but offset a portion of the VAMP Supplemental Water requirement.

the system between the Vernalis gage and the upstream measuring points and is calculated as follows:

Ungaged flow at Vernalis = VNS - GDWlag - LGNlag - CRSlag - USJRlag

Where:

VNS = San Joaquin River near Vernalis

GDW = 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 pulse flow period is a reasonable estimate of the average ungaged flow for pulse 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 pulse flow period essentially equal to the value entering the pulse flow period.

The VAMP 31-day pulse flow period can occur anytime between April 1 and May 31. Factors that are considered in the determination of the timing of the VAMP pulse flow period include installation of HORB, availability of salmon smolt at the MRH, and manpower and equipment availability for salmon releases and recapture. Until a specific start date is defined, a default pulse flow period of April 15 to May 15 is used for the VAMP operation planning. In its February meeting the SJRTC defined a VAMP target flow period of April 22 to May 22 for 2007 to allow the test smolt to mature to the desirable size.

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

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?format=pre&period=31&site_no=11303500)
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?format=pre&period=31&site_no=11289650)
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?format=pre&period=31&site_no=11274000)

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 Adjustment (ft.)
2/14/07	11:18	11.34	2,760	2,670	3.4%	-0.61
3/22/07	10:32	10.66	2,180	2,110	3.3%	-0.61
4/17/07	12:13	10.18	1,840	1,780	3.4%	-0.61
4/23/07	10:52	11.95	3,800	3,210	18.4%	0
4/30/07	11:26	11.88	3,230	3,700	-12.7%	-0.56
5/7/07	11:01	11.66	3,010	3,030	-0.7%	-0.59
5/15/07	11:05	11.79	3,440	3,170	8.5%	-0.25
6/18/07	11:42	10.10	1,690	2,560	-34.0%	-0.74

and the current year is equal to or less than four. The 60-20-20 water year classification for both 2005 and 2006 was "Wet" (VAMP numerical indicator of five), therefore there was no possibility of 2007 being an off-ramp year since the off-ramp criterion was already exceeded without including the current year's numerical indicator. A "double-step" condition would occur if the sum of the VAMP numerical indicators for the previous year and current year is equal to or greater than seven, with the current year's indicator based on the 90% probability of exceedence forecast of the 60-20-20 water year classification. Since 2006 was a Wet year, a 2007 classification of Dry or wetter would result in a double-step target. The April 1 90% probability of exceedence forecast of the 60-20-20 water year classification was "Critical" making 2007 a "single-step" condition.

The initial daily operation plan was prepared on March 21. The daily operation plan was modified 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. The complete daily operation plans are provided in Appendix A-1, Tables 1 through 13.

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 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.

For the 2007 VAMP operation the Stanislaus River was expected to be at a steady flow of 1,500 cfs and therefore providing no operational flexibility. For the other tributaries the plan was for a single pulse of about 12 days on the Merced River during the middle of the VAMP period surrounded by 7 to 9 day pulses on the Tuolumne River.

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Implementation

Operation Conference Calls

During implementation of the VAMP pulse flow, conference calls were conducted every Tuesday and Thursday between April 24 and May 18 at 6:30 A.M. to discuss the status of the pulse flow and to make operational changes if needed. The calls were held at 6:30 A.M. 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 quality. The 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.

Normally, the USGS makes monthly measurements of the flow at Vernalis to check the current rating shift. The real-time flows reported by the USGS and CDEC are dependent on the most current rating shift, therefore a new measurement and 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 17 and May 15. The results of these measurements are summarized in Table 2-5.

The April 17 measurement indicated no change from the effective rating shift at that time which was -0.61 feet. However, on April 25 the USGS reported that they had measured a flow of 3,800 cfs on April 23, almost 600 cfs greater than the real-time flow of 3,210 cfs, and significantly exceeding the VAMP target flow of 3,200 cfs. This measurement resulted in a change in the rating curve shift from -0.61 feet to 0.0 feet. In response, the VAMP operation was adjusted by reducing tributary releases in an attempt to reduce the flow at Vernalis to bring it in line with the target flow. On May 1, just as the operation adjustments that had been made in response to the April 23rd measurement were being seen at Vernalis, the USGS reported that they had measured a flow of 3,280 cfs on April 30, 420 cfs less than the reported real-time flow of about 3,700 cfs. This measurement resulted in a change in the rating curve shift from 0.0 feet to -0.56 feet, almost identical to the shift in effect prior to the April 23rd measurement. Once again VAMP operations were adjusted in response, this time with increased tributary releases. The next flow measurement by the USGS was made May 7th and it agreed with the rating curve shift from the April 30th measurement. On May 16 the USGS reported that they had measured a flow of 3,440 cfs on May15, 270 cfs greater than the reported real-time flow of 3,170 cfs, changing the rating curve shift from -0.59 feet to -0.25 feet. It should be noted that the first flow measurement following the VAMP period was made on June 18th and resulted in a change in the rating curve shift from -0.25 feet to -0.74 feet. The Hydrology Group made every effort to manage the VAMP flow based on the available real-time flow data. Adjusting the 2007 operations to the changing USGS measurements resulted in a greater than desirable fluctuation in the VAMP flow. It is the author's opinion that the flow measurements made on April 23rd and May 15th are questionable for the following reasons:

• Numerous flow measurements surrounding the two questionable measurements were all in agreement with a rating curve shift of about -0.6 feet. The questionable measurements imply the repeated occurrence of significant sediment scour and deposition at the gage site, which seems unlikely considering the mean velocity at the gage site was no greater than 1.2 feet per second.

• Previous VAMP periods with similar target flows (2002, 2003 and 2004) showed little or no change in rating curve shifts during the VAMP operation.

• The variability in the mean daily flow is not reflected in the DWR Mossdale gage which is located about 12 miles downstream of the Vernalis gage and about 3 miles upstream of Old River as shown in Figure 2-2. There are no significant inflows or diversions from the San Joaquin River between the Vernalis and Mossdale gages at the subject flow rates.

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 30, 2007. 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 3,260 cfs during the VAMP target flow period (April 22 – May 22). Figure 2-3 shows the observed flow and the estimated existing (no VAMP) flow, along with the supplemental water contributions. The flow varied between 2,830 cfs and 3,790 cfs during the target flow period. The flow variability was the result of operations adjustments made in response to the reported USGS flow measurements and accompanying rating curve shifts. It is the author's opinion that the flow variability during the target flow period is likely not as large as indicated for the reasons noted previously. During the VAMP target flow period the gage height at the Vernalis gage varied from a maximum of 11.99 feet to a minimum of 11.38 feet, a difference of 0.61 feet. This gage height difference represents a flow of 510 cfs on the unadjusted rating curve, somewhat less than the 960 cfs range indicated by the gage record.

The sources of the flow at Vernalis are shown in Figure 2-4. Figures 2-5, 2-6 and 2-7 show the with and without VAMP flows at the tributary measurement points for the Merced River, Tuolumne River and Stanislaus River, 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 averaged 214 cfs during the VAMP target flow period, ranging from a minimum of -62 cfs to a maximum of 749 cfs. A plot of the ungaged flow is provided in Figure 2-8.

As previously stated, the combined CVP and SWP Delta export rate target was 1,500 cfs. The observed exports, shown in Figure 2-9, averaged 1,486 cfs during the target flow period.

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 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.

Due to the flood control operations in 2006 there were no SJRA storage impacts entering the 2007.

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 2007 VAMP operation and Fall SJRA transfer would be 41,460 acre-feet, as shown in Figure 2-10. 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 2-10. 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 eight 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 2007 VAMP operation is 4,370 acre-feet, as shown in Figure 2-11.

Summary of Historical VAMP Operations

2007 marks the eighth year of VAMP operation in compliance with D-1641. A summary of the VAMP target flows for these first eight 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 seven years of VAMP operation are provided in Appendix B-1, Figures 1 through 4.

Over the first eight 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
2007 VAMP - Flow Comparison, San Joaquin River near Vernalis and San Joaquin River at Mossdale

Figure 2-3
2007 VAMP - San Joaquin River near Vernalis with and without VAMP

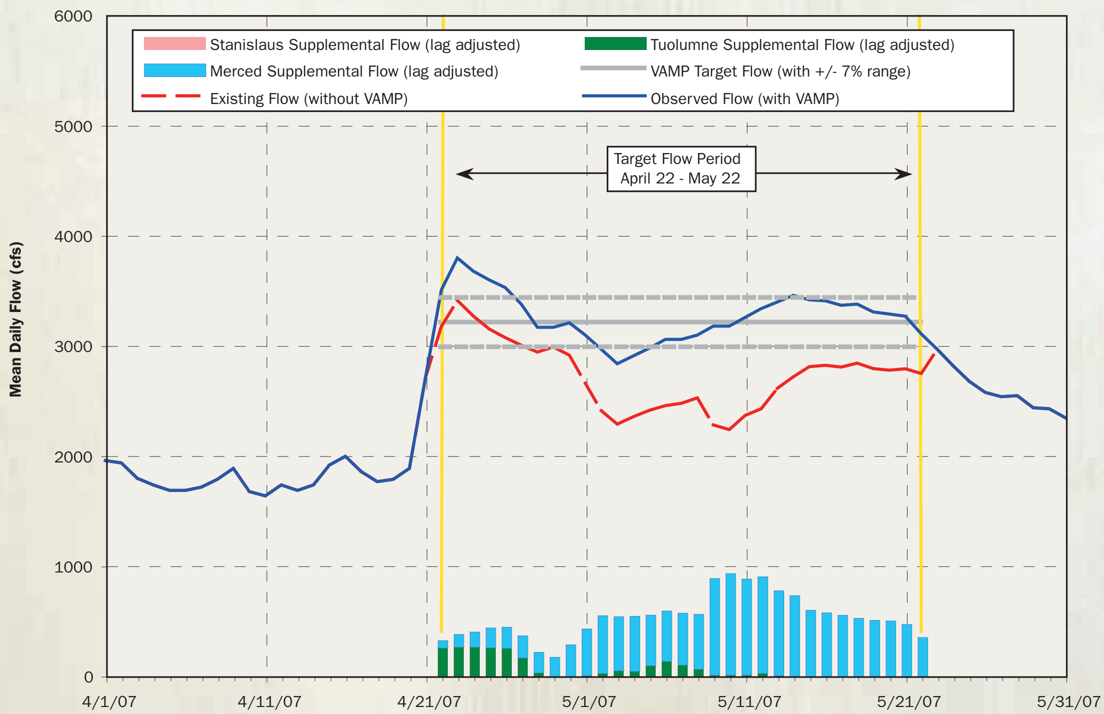


Figure 2-4
2007 VAMP: San Joaquin River near Vernalis
With Lagged Contributions from Primary Sources

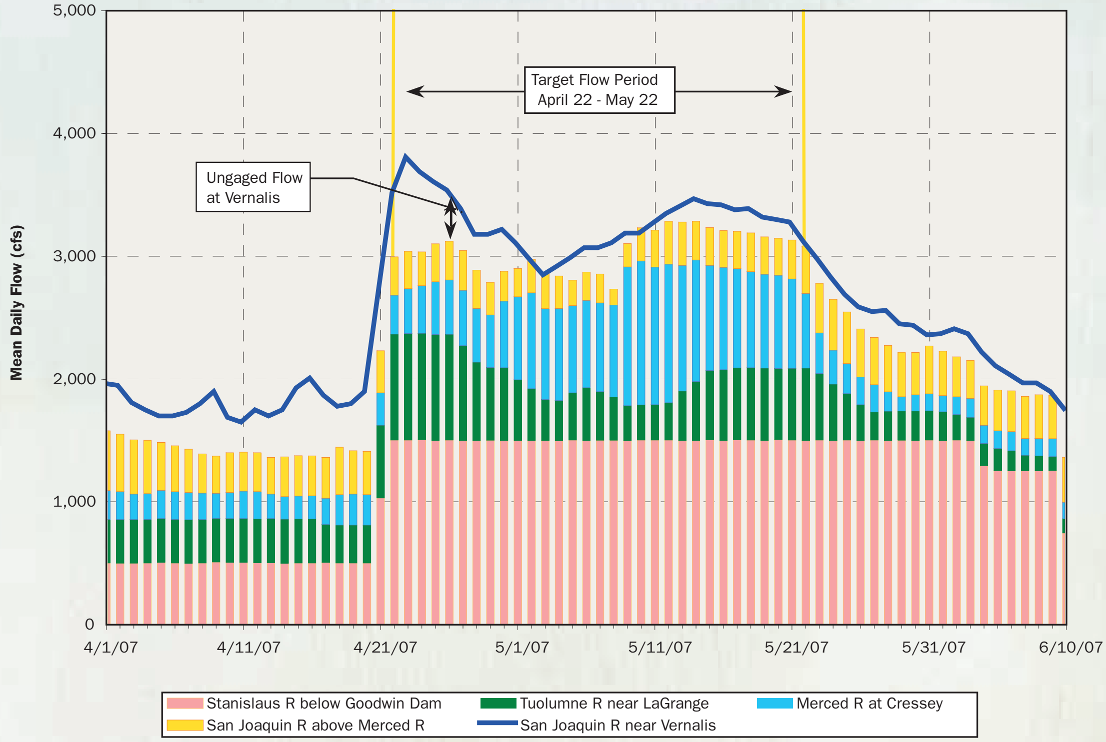


Figure 2-5
2007 VAMP - Merced River at Cressey with and without VAMP

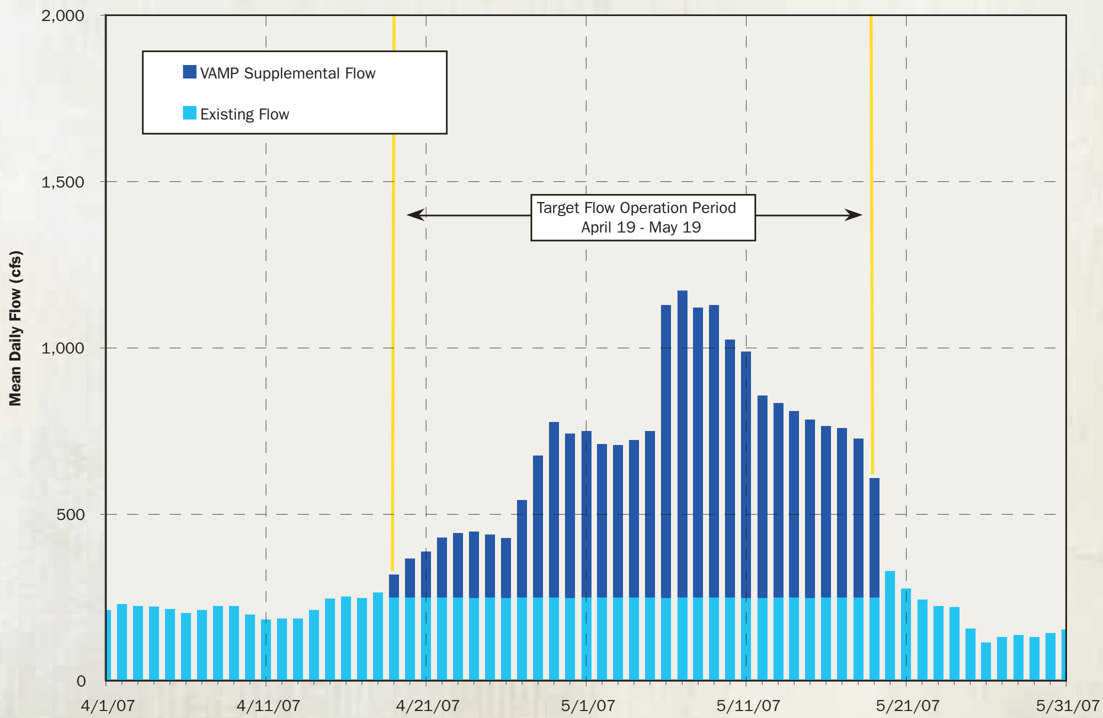


Figure 2-6
2007 VAMP - Tuolumne River below LaGrange Dam with and without VAMP

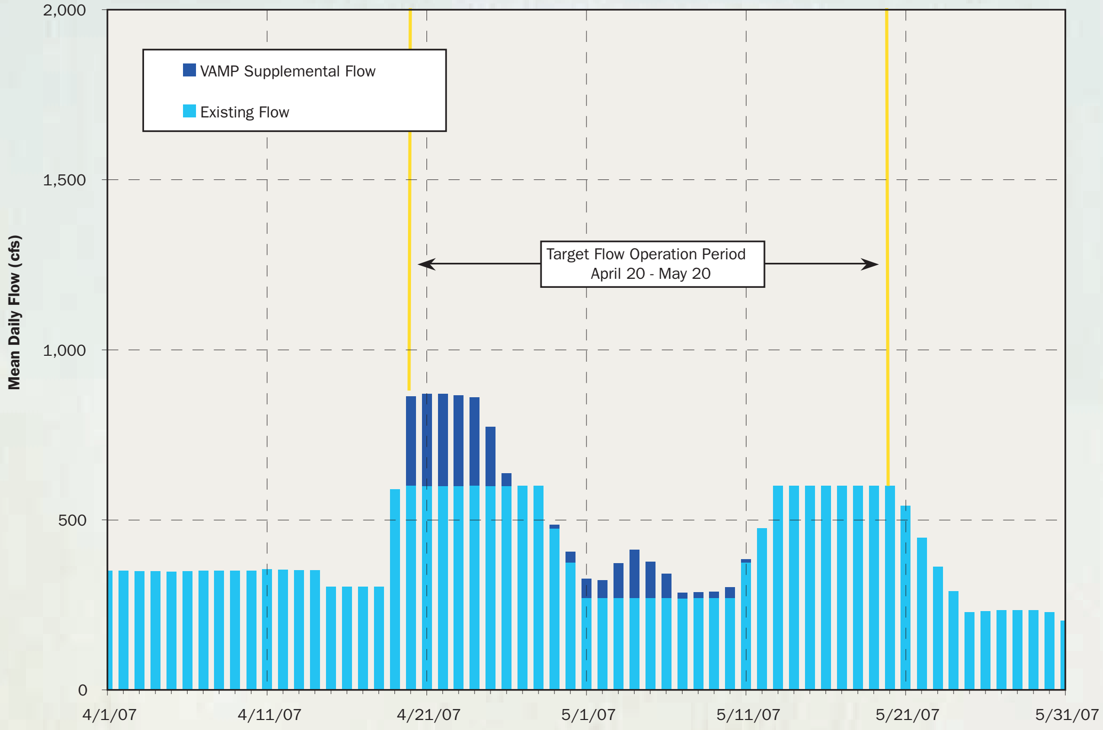


Figure 2-7
2007 VAMP - Stanislaus River below Goodwin Dam with and without VAMP

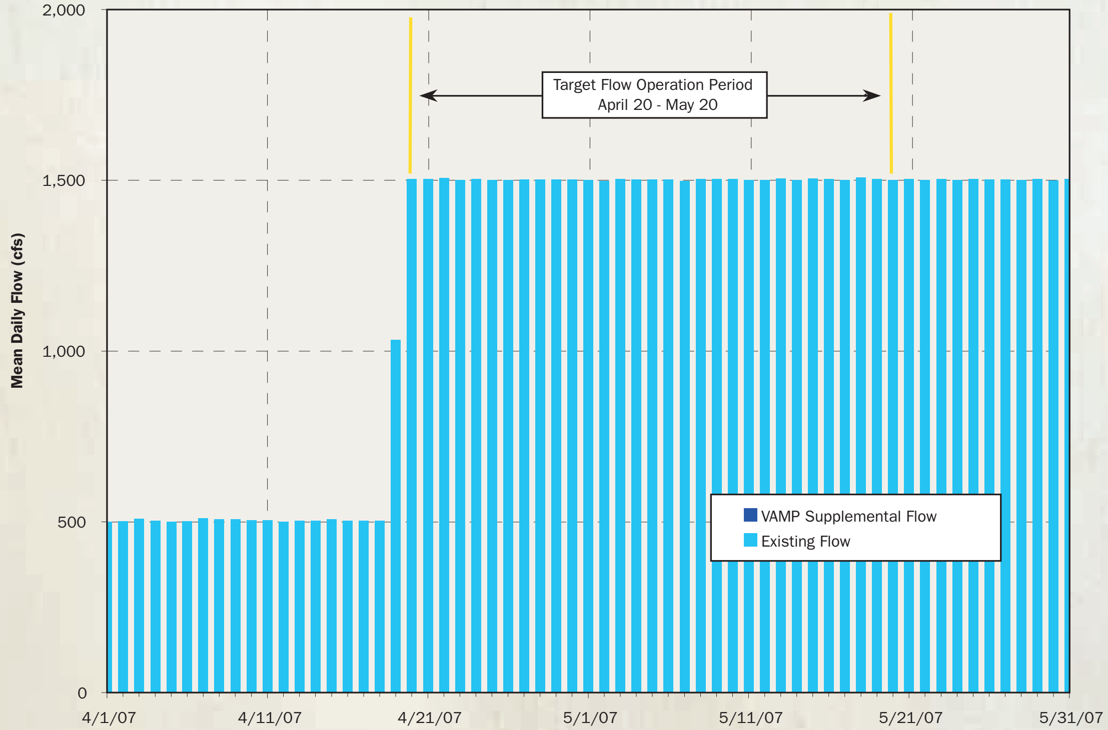


Table 2-6
2007 Vernalis Adaptive Management Plan (VAMP)
Final Flows and Accounting of Supplemental Water Contributions
Target Flow Period: April 22 - May 22 • Target Flow: greater than 3,200 cfs

	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)			Upper SJR [2]	Vernalis Ungaged	San Joaquin River at Vernalis		
Date	Existing Flow [1] (cfs)	Observed Flow (cfs)	VAMP Supple-mental Water (cfs)	Existing Flow [1] (cfs)	Observed Flow (cfs)	VAMP Supple-mental Water (cfs)	Existing Flow [1] (cfs)	Observed Flow (cfs)	VAMP Supple-mental Water (cfs)	Observed Flow (cfs)	Observed Flow (cfs)	Existing Flow [1] (cfs)	Observed Flow (cfs)	VAMP Supple-mental Water (cfs)
04/01/07	213	213		351	351		500	500		442	372	1,950	1,950	
04/02/07	231	231		350	350		502	502		431	378	1,930	1,930	
04/03/07	225	225		349	349		509	509		389	284	1,790	1,790	
04/04/07	224	224		349	349		503	503		373	228	1,730	1,730	
04/05/07	216	216		348	348		500	500		352	196	1,680	1,680	
04/06/07	204	204		349	349		502	502		318	224	1,680	1,680	
04/07/07	213	213		350	350		510	510		304	280	1,710	1,710	
04/08/07	224	224		350	350		508	508		324	389	1,780	1,780	
04/09/07	225	225		350	350		508	508		318	506	1,880	1,880	
04/10/07	199	199		351	351		504	504		314	269	1,670	1,670	
04/11/07	183	183		355	355		504	504		298	224	1,630	1,630	
04/12/07	187	187		353	353		500	500		325	330	1,730	1,730	
04/13/07	188	188		352	352		503	503		328	318	1,680	1,680	
04/14/07	213	213		352	352		503	503		326	363	1,730	1,730	
04/15/07	247	247		304	304		507	507		332	534	1,910	1,910	
04/16/07	253	253		303	303		503	503		386	615	1,990	1,990	
04/17/07	248	248		303	303		503	503		352	488	1,850	1,850	
04/18/07	265	265		303	303		503	503		352	315	1,760	1,760	
04/19/07	250	318	68	590	590		1,032	1,032		343	364	1,780	1,780	
04/20/07	250	367	117	600	863	263	1,503	1,503	0	312	469	1,880	1,880	
04/21/07	250	388	138	600	870	270	1,503	1,503	0	302	468	2,700	2,700	
04/22/07	250	430	180	600	870	270	1,507	1,507	0	275	504	3,169	3,500	331
04/23/07	250	443	193	600	866	266	1,501	1,501	0	309	749	3,403	3,790	387
04/24/07	250	448	198	600	860	260	1,504	1,504	0	316	634	3,262	3,670	408
04/25/07	250	438	188	600	774	174	1,501	1,501	0	324	488	3,144	3,590	446
04/26/07	250	429	179	600	637	37	1,500	1,500	0	312	397	3,067	3,520	453
04/27/07	250	542	292	600	592	0	1,502	1,502	0	265	323	2,998	3,370	372
04/28/07	250	676	426	600	591	0	1,502	1,502	0	243	273	2,935	3,160	225
04/29/07	250	777	527	475	486	11	1,502	1,502	0	231	372	2,981	3,160	179
04/30/07	250	743	493	375	406	31	1,502	1,502	0	273	322	2,908	3,200	292
05/01/07	250	749	499	270	326	56	1,500	1,500	0	286	189	2,653	3,090	437
05/02/07	250	711	461	270	322	52	1,497	1,497	0	264	(16)	2,402	2,960	558
05/03/07	250	708	458	270	372	102	1,504	1,504	0	207	(32)	2,281	2,830	549
05/04/07	250	723	473	270	412	142	1,502	1,502	0	230	61	2,349	2,900	551
05/05/07	250	749	499	270	377	107	1,502	1,502	0	235	163	2,407	2,970	563
05/06/07	250	1,129	879	270	341	71	1,502	1,502	0	130	178	2,450	3,050	600
05/07/07	250	1,172	922	270	286	16	1,498	1,498	0	190	194	2,470	3,050	580
05/08/07	250	1,121	871	270	287	17	1,503	1,503	0	270	357	2,520	3,090	570
05/09/07	250	1,129	879	270	288	18	1,504	1,504	0	300	67	2,275	3,170	895
05/10/07	250	1,024	774	270	301	31	1,504	1,504	0	350	(62)	2,231	3,170	939
05/11/07	250	989	739	375	385	10	1,501	1,501	0	352	37	2,361	3,250	889
05/12/07	250	857	607	475	469	0	1,500	1,500	0	316	44	2,420	3,330	910
05/13/07	250	834	584	600	565	0	1,505	1,505	0	307	111	2,606	3,390	784
05/14/07	250	810	560	600	579	0	1,501	1,501	0	299	165	2,711	3,450	739
05/15/07	250	785	535	600	590	0	1,505	1,505	0	303	176	2,803	3,410	607
05/16/07	250	764	514	600	593	0	1,503	1,503	0	314	190	2,816	3,400	584
05/17/07	250	758	508	600	593	0	1,500	1,500	0	305	156	2,800	3,360	560
05/18/07	250	727	477	600	583	0	1,508	1,508	0	301	179	2,835	3,370	535
05/19/07	250	609	359	600	589	0	1,503	1,503	0	317	142	2,786	3,300	514
05/20/07	329	329		600	591	0	1,501	1,501	0	382	134	2,772	3,280	508
05/21/07	278	278		541	541		1,504	1,504		404	128	2,783	3,260	477
05/22/07	245	245		447	447		1,500	1,500		413	20	2,741	3,100	359
05/23/07	225	225		363	363		1,504	1,504		420	181	2,960	2,960	
05/24/07	222	222		290	290		1,501	1,501		392	160	2,810	2,810	
05/25/07	157	157		229	229		1,503	1,503		385	123	2,670	2,670	
05/26/07	116	116		232	232		1,502	1,502		377	161	2,570	2,570	
05/27/07	132	132		234	234		1,502	1,502		359	191	2,530	2,530	
05/28/07	138	138		234	234		1,501	1,501		345	267	2,540	2,540	
05/29/07	132	132		234	234		1,504	1,504		390	215	2,430	2,430	
05/30/07	144	144		229	229		1,499	1,499		363	203	2,420	2,420	
05/31/07	154	154		203	203		1,504	1,504		326	70	2,340	2,340	
VAMP Period														
Average (cfs):	250	721		471	538		1,502	1,502		285	214	2,721	3,263	
Supplemental Water (ac-ft):			28,960			4,370			0					33,330

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, 7/30/07
Merced River near Stevinson (CA DWR B05125): California DWR, Water Data Library. 7/30/07
Tuolumne River below LaGrange Dam near LaGrange (USGS 11289650): USGS, provisional data as of 7/30/07
Stanislaus River below Goodwin Dam: USBR, Goodwin Reservoir Daily Operations Report - OID/SSJID/Tri-Dams, 6/18/07 (April report) and 6/26/07 (May report)
San Joaquin River near Vernalis (USGS 11303500): USGS, provisional data as of 7/30/07
San Joaquin River at Newman (USGS 11274000): USGS, provisional data as of 7/30/07

Table 2-7
Summary of VAMP Flows, 2000-2007

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

[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"

Table 2-8
Summary of VAMP Supplemental Water Contributions, 2000-2007

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:	46,750	[a]	[b]	8,280	15,200	7,450
		Division Agreement:	45,160	[a]	[b]	7,300	16,920	8,300
		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:	38,257	5,039	5,039	[c]	4,864.5	4,864.5
		Division Agreement:	38,065	5,000	5,000	[c]	5,000	5,000
		Deviation:	+ 192	+ 39	+ 39		-135.5	-135.5
2004	65,591	Observed:	42,680	5,880	5,880	[c]	5,575.5	5,575.5
		Division Agreement:	41,500	7,045.5	7,045.5	[c]	5,000	5,000
		Deviation:	+ 1,180	- 1165.5	- 1165.5		+ 575.5	+ 575.5
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

[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

Figure 2-8
2007 VAMP - Ungaged Flow in San Joaquin River at Vernalis

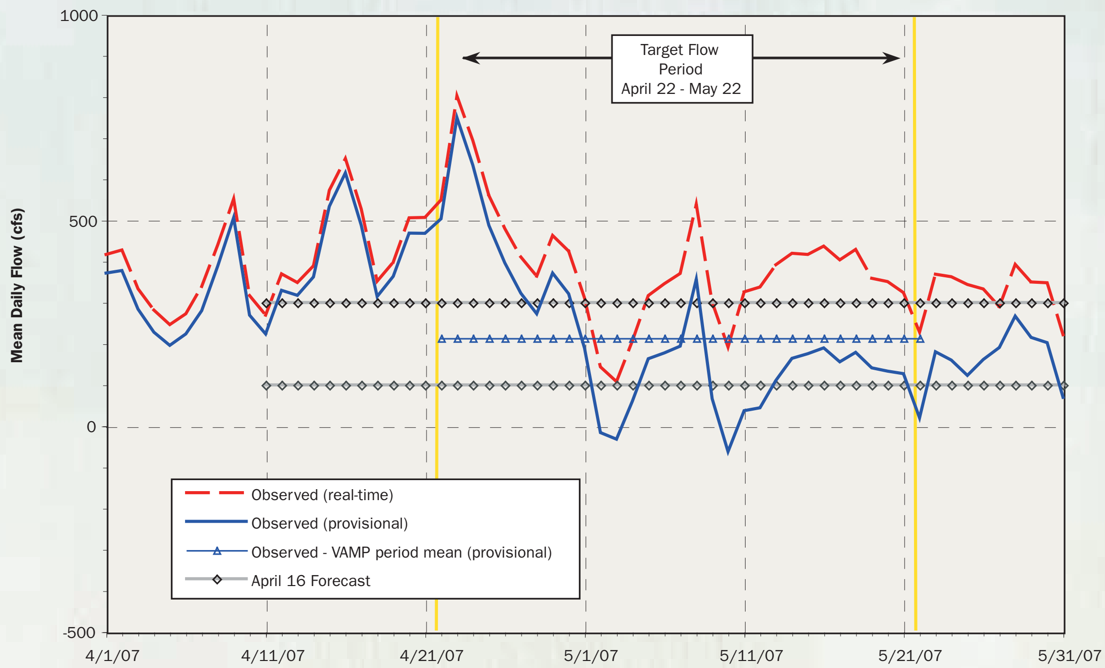


Figure 2-9
2007 VAMP - Federal and State Delta Exports

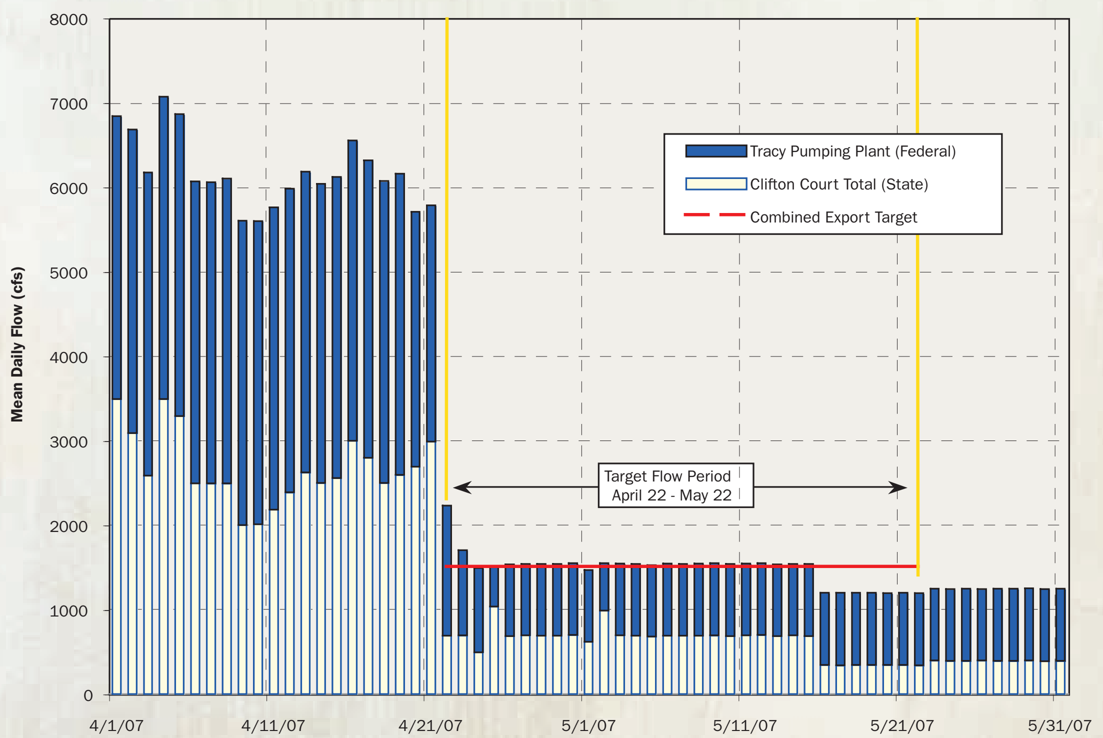


Figure 2-10
San Joaquin River Agreement Storage and Flow Impacts
Merced River - Lake McClure Storage and Release - 2007

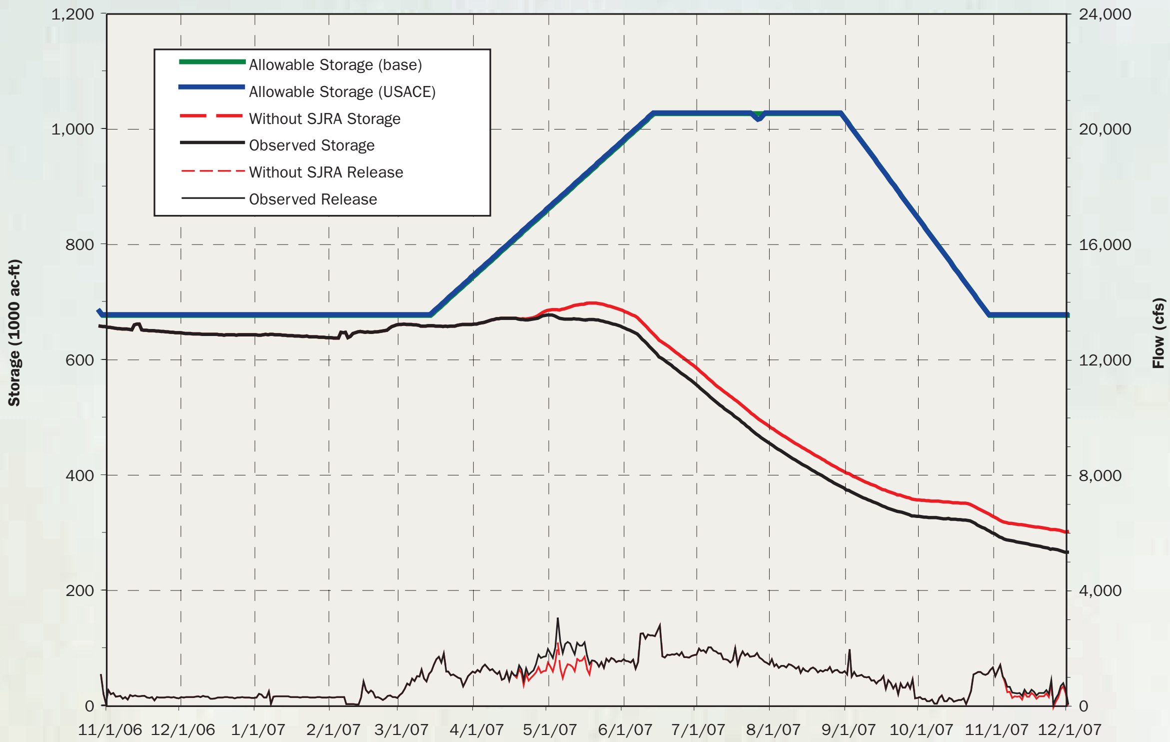
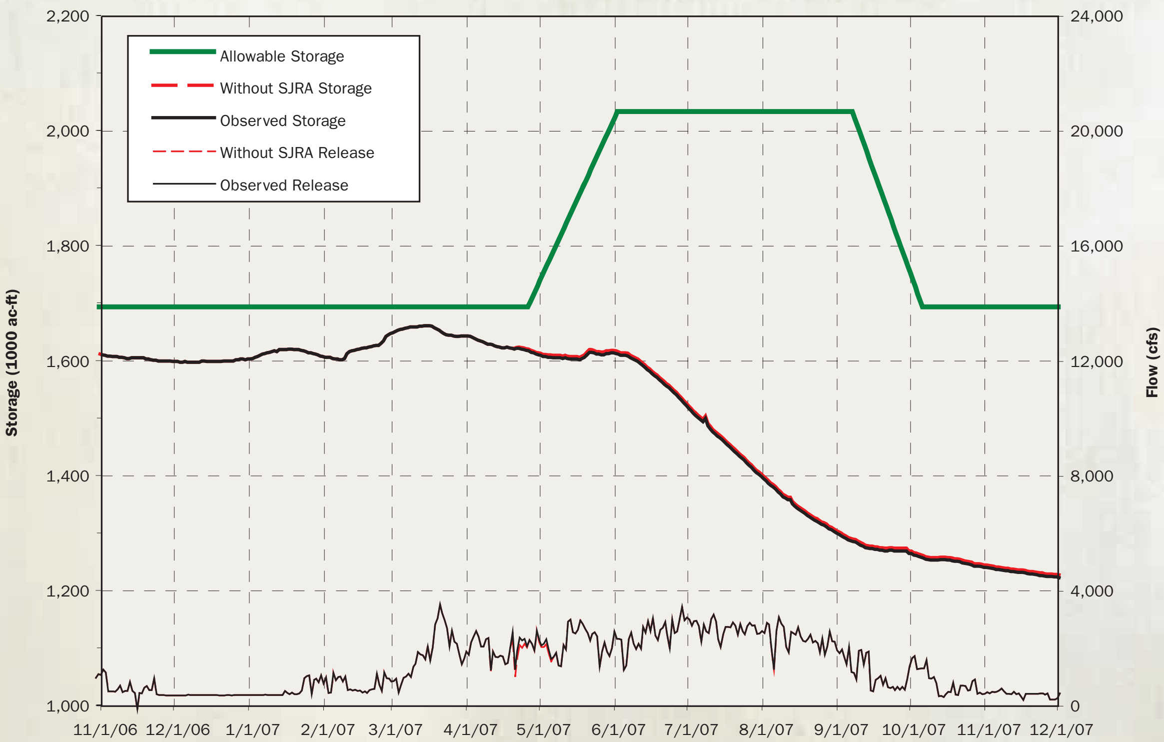


Figure 2-11
San Joaquin River Agreement Storage and Flow Impacts
Tuolumne River - New Don Pedro Reservoir Storage and Release - 2007



Additional Water Supply Arrangements & Deliveries

Paragraph 8.4 of the SJRA states that "Merced Irrigation District (Merced) 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 that "in addition to the 15,000 acre-feet, Oakdale will sell the difference between the water made available to VAMP under the SJRGA 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 Merced ID.

In addition to providing water in the fall of 2007 pursuant to the Agreement, Merced entered into a contract with USBR to transfer up to 25,000 acre-feet of water to the CALFED Environmental Water Account (EWA). This additional water transfer is referred to as the EWA Transfer Water. The EWA Transfer Water was to be delivered south of the Delta via the CVP Jones Pumping Plant and/or the SWP Banks Pumping Plant, depending on the availability of excess pumping capacity. Since the likelihood of having excess pumping capacity decreases near the end of the year, the EWA Transfer Water was scheduled to be provided first followed by the Fall SJRA Transfer Water. The schedule for the Merced 2007 fall water transfers was finalized on September 27, 2007, with the EWA Transfer Water to be provided from October 24 through November 8 and the Fall SJRA Transfer Water to be provided from November 6 through December 31, as shown in Table 3-1 and Figure 3-1. Table 3-1 also includes the final accounting for the period with provisional flow data available at the time of the writing of this report.

Oakdale Irrigation District

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

OID provided 2,185 acre-feet of supplemental water for the 2007 VAMP operation, therefore the amount of additional water purchased by the USBR from OID was 23,815 acre-feet (15,000 acre-feet plus 8,815 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.

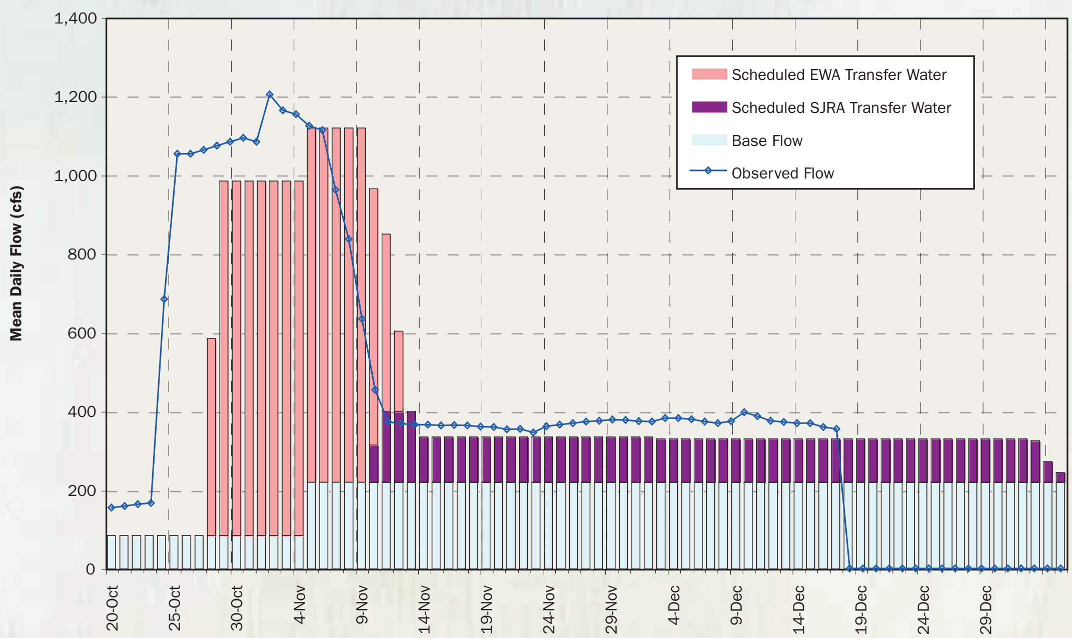
The 23,815 ac-ft of OID Additional Water was released from May 21, 2007 through June 1, 2007 to provide supplemental flow to the Stanislaus River for fishery purposes.

Table 3-1
2007 Merced Irrigation District Fall Water Transfers
Daily Summary

		SCHEDULED					OBSERVED				
		SJRA Transfer [Nov. 6 - Dec. 31]		EWA Transfer [Oct. 24 - Nov. 8]				SJRA Transfer [Nov. 6 - Dec. 31]		EWA Transfer [Oct. 24 - Nov. 8]	
Date	Base Flow at Shaffer Br/ Cressey (cfs)	SJRA Transfer Water Flow (cfs)	Cumulative SJRA Transfer Water Volume (acre-ft)	EWA Transfer Water (cfs)	EWA Transfer Balance (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)	EWA Transfer Water Flow (cfs)	Cumulative EWA Transfer Water Volume (acre-ft)
20-Oct	85	0	0	0	0	85	154				
21-Oct	85	0	0	0	0	85	158				
22-Oct	85	0	0	0	0	85	163				
23-Oct	85	0	0	0	0	85	166				
24-Oct	85	0	0	500	992	585	682			597	1,184
25-Oct	85	0	0	900	2,777	985	1,050			965	3,098
26-Oct	85	0	0	900	4,562	985	1,050			965	5,012
27-Oct	85	0	0	900	6,347	985	1,060			975	6,946
28-Oct	85	0	0	900	8,132	985	1,070			985	8,900
29-Oct	85	0	0	900	9,917	985	1,080			995	10,874
30-Oct	85	0	0	900	11,702	985	1,090			1,005	12,867
31-Oct	85	0	0	900	13,488	985	1,080			995	14,841
1-Nov	220	0	0	900	15,273	1,120	1,200			980	16,785
2-Nov	220	0	0	900	17,058	1,120	1,160			940	18,649
3-Nov	220	0	0	900	18,843	1,120	1,150			930	20,494
4-Nov	220	0	0	900	20,628	1,120	1,120			900	22,279
5-Nov	220	0	0	900	22,413	1,120	1,110			890	24,044
6-Nov	220	95	188	650	23,702	965	959	95	188	644	25,321
7-Nov	220	180	545	450	24,595	850	834	180	545	434	26,182
8-Nov	220	180	902	204	25,000	604	632	180	902	232	26,642
9-Nov	220	180	1,260	0		400	452	232	1,362		
10-Nov	220	115	1,488	0		335	371	151	1,662		
11-Nov	220	115	1,716	0		335	367	147	1,954		
12-Nov	220	115	1,944	0		335	364	144	2,240		
13-Nov	220	115	2,172	0		335	364	144	2,526		
14-Nov	220	115	2,400	0		335	362	142	2,808		
15-Nov	220	115	2,628	0		335	363	143	3,092		
16-Nov	220	115	2,856	0		335	362	142	3,374		
17-Nov	220	115	3,084	0		335	359	139	3,650		
18-Nov	220	115	3,312	0		335	358	138	3,924		
19-Nov	220	115	3,540	0		335	352	132	4,186		
20-Nov	220	115	3,769	0		335	353	133	4,450		
21-Nov	220	115	3,997	0		335	344	124	4,696		
22-Nov	220	115	4,225	0		335	360	140	4,974		
23-Nov	220	115	4,453	0		335	364	144	5,260		
24-Nov	220	115	4,681	0		335	368	148	5,554		
25-Nov	220	115	4,909	0		335	372	152	5,855		
26-Nov	220	115	5,137	0		335	374	154	6,160		
27-Nov	220	115	5,365	0		335	377	157	6,471		
28-Nov	220	115	5,593	0		335	376	156	6,780		
29-Nov	220	110	5,812	0		330	373	153	7,083		
30-Nov	220	110	6,030	0		330	372	152	7,384		
1-Dec	220	110	6,248	0		330	381	161	7,703		
2-Dec	220	110	6,466	0		330	381	161	8,022		
3-Dec	220	110	6,684	0		330	378	158	8,335		
4-Dec	220	110	6,902	0		330	372	152	8,636		
5-Dec	220	110	7,121	0		330	368	148	8,930		
6-Dec	220	110	7,339	0		330	373	153	9,233		
7-Dec	220	110	7,557	0		330	395	175	9,580		
8-Dec	220	110	7,775	0		330	386	166	9,909		
9-Dec	220	110	7,993	0		330	374	154	10,214		
10-Dec	220	110	8,212	0		330	371	151	10,514		
11-Dec	220	110	8,430	0		330	368	148	10,808		
12-Dec	220	110	8,648	0		330	368	148	11,102		
13-Dec	220	110	8,866	0		330	358	138	11,376		
14-Dec	220	110	9,084	0		330	353	133	11,640		
15-Dec	220	110	9,302	0		330	[1]				
16-Dec	220	110	9,521	0		330	[1]				
17-Dec	220	110	9,739	0		330	[1]				
18-Dec	220	110	9,957	0		330	[1]				
19-Dec	220	110	10,175	0		330	[1]				
20-Dec	220	110	10,393	0		330	[1]				
21-Dec	220	110	10,612	0		330	[1]				
22-Dec	220	110	10,830	0		330	[1]				
23-Dec	220	110	11,048	0		330	[1]				
24-Dec	220	110	11,266	0		330	[1]				
25-Dec	220	110	11,484	0		330	[1]				
26-Dec	220	110	11,702	0		330	[1]				
27-Dec	220	110	11,921	0		330	[1]				
28-Dec	220	110	12,139	0		330	[1]				
29-Dec	220	105	12,347	0		325	[1]				
30-Dec	220	52	12,450	0		272	[1]				
31-Dec	220	25	12,500	0		245	[1]				

[1] Provisional mean daily flow data not available at time of publication.

Figure 3-1
Merced I.D. Fall 2007 Water Transfers Merced River at Shaffer Bridge/Cressey



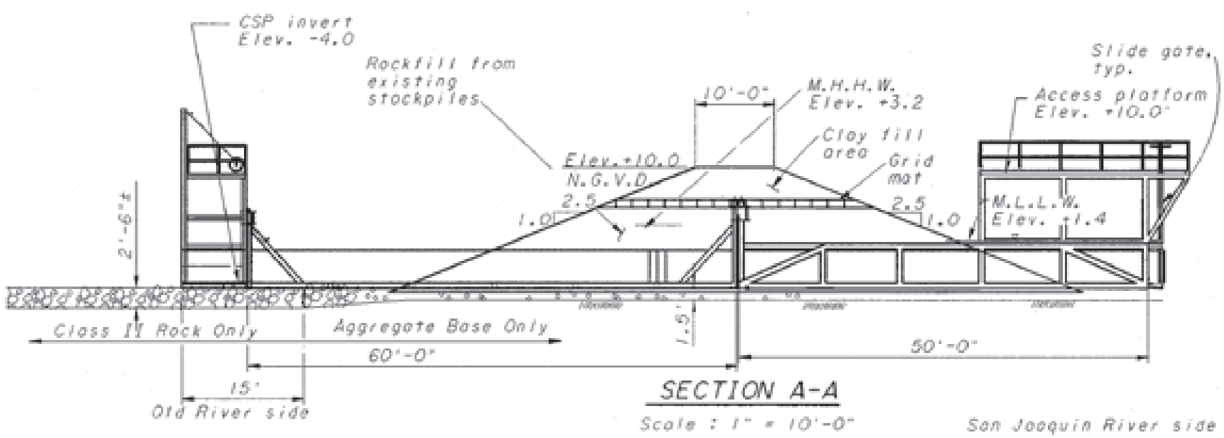
CHAPTER 4

HEAD OF OLD RIVER BARRIER

Barrier Design, Installation and Operation

Installation of the2007 temporary spring Head of Old River Barrier (HORB) was completed on April 20, two days earlier than scheduled, with the initial operation commencing on April 22. Construction clean-up continued for a short period of days following the initial operation. The spring HORB is a component of the south delta Temporary Barriers Project (TBP). The TBP mitigates for low water levels in the south delta and improves water circulation and quality for agricultural purposes

Figure 4-1
Spring Head of Old River Barrier Cross Section



The spring HORB was first constructed in 1992. Since then, the barrier has been installed in 1994, 1996, 1997, 2000, 2001, 2002, 2003, 2004 and 2007. The 1997 barrier included two open culverts, while the 2000 through 2007 barriers included six operable culverts. The HORB was not installed in 1993, 1995, 1998, 2005, and 2006 due to high San Joaquin River flows. The HORB was not installed in 1999 due to landowner access problems. The HORB, a key component of VAMP, is intended to increase San Joaquin River Chinook salmon smolt survival by preventing them from entering Old River.

Beginning in 2001, the barrier design included two versions. A "low-flow" barrier when San Joaquin River target flows are below 7,000 cfs would be built to a height of 10 feet mean sea level (MSL). A "high-flow" barrier for the target flow of 7,000 cfs would be built to a height of 11 feet MSL and additional material would be placed to raise the abutments to 13 feet MSL. Both barrier versions are equipped with six 48-inch diameter operable culverts and an overflow weir back-filled with clay. In 2007, the low-flow version was installed.

The dimensions of the 2007 HORB (Figure 4-1) were similar to the 2000, 2001, 2002, 2003, and 2004 HORB. The base width of the HORB in 2007 was 100 feet and the crest elevation was 10 feet MSL. The top of HORB was constructed with a 75-foot wide notch, protected with concrete grid mats and back-filled with clay. The HORB was designed to safely operate with flows corresponding to stages up to 8.5 feet MSL.

To help mitigate anticipated low water levels in the south delta (downstream of the HORB) caused by the operation of the HORB, two open culverts were installed in the barrier beginning in 1997, and six operable culverts were installed beginning in 2000. Operation of the culverts is controlled by slide gates located on the upstream side of HORB. DWR relied on daily modeling and field data collection to monitor water levels at three locations within the south Delta to determine when and how long to operate the culverts. Generally, the model forecasts would tend to forecast low-low water levels lower than actual levels observed in the field. Consequently, DWR takes this into consideration when making decisions regarding the culvert operations.

The downstream outlet of each culvert was designed so fyke nets could be attached to evaluate fish passage. DFG staff conducted a fishery-monitoring program as part of the 2007 HORB operations.

Permitting and Construction

The various permit conditions that are placed on the Temporary Barriers Program, by the USFWS, National Marine Fisheries Service (NMFS), and DFG, require that in-water construction activities for the Head of Old River (HOR), Middle River (MR), and Old River at Tracy (ORT) barriers can begin no earlier than April 7. In addition, construction of the northern abutment and boat ramps of the Grant Line Canal (GLC) barrier and construction of out-of-water portions of the HOR, MR, and ORT barriers may not be started any earlier than April 1. Full closure of the GLC barrier is not required but construction of the north abutment and boat ramps must be completed to the extent that full barrier closure and operation can be readily achieved in a reasonable time frame, if and when directed by DWR. The permit conditions also require that all the above work be completed by April 15th, a total of 15 working days. Following is a brief summary of the various permit conditions:

USFWS Biological Opinion
(1-1-01-F-81 dated March 30, 2001)

1) The spring HORB barrier installation may begin on April 1 but in-water work shall not occur until April 7, except for construction necessary to place the scour pad and the pad for the culverts (item No. 8, page 6);

2) DWR may begin construction of the Middle River barrier on April 1 but in-water work shall not occur until after April 7 (item No. 1, page 4);

3) DWR may begin construction of the Old River at Tracy barrier on April 1 but in-water work shall not commence before April 7 (item No. 2, page 4);

4) DWR may begin construction of the northern abutment and the boat ramp of the GLC barrier on April 1 provided that the HOR barrier is being constructed concurrently (item No. 3, page 5).

NMFS Biological Opinion
(SWR-00-SA-289: MEA on the proposed ACOE permit (200000696) filed on December 4, 2000)

1) The spring HORB installation shall begin on April 1 (item 8, page 8);

2) The MR barrier construction may begin on April 7 (item 1, page6);

3) The ORT barrier construction may begin on April 1 (item2, page 6);

4) The northern abutment and boat ramp of the GLC barrier may begin construction on April 1 provided that the HORB is being constructed concurrently (item 3, page 7).

DFG 1601 – HORB
(2081-2001-009-BD dated April 4, 2001)

HORB Spring Installation – All work in or near the stream zone will be confined to the period beginning no earlier than April 1

DFG 1601 – Agricultural Barriers

MR - All work in or near the stream zone will be confined to the period beginning no earlier than March 1

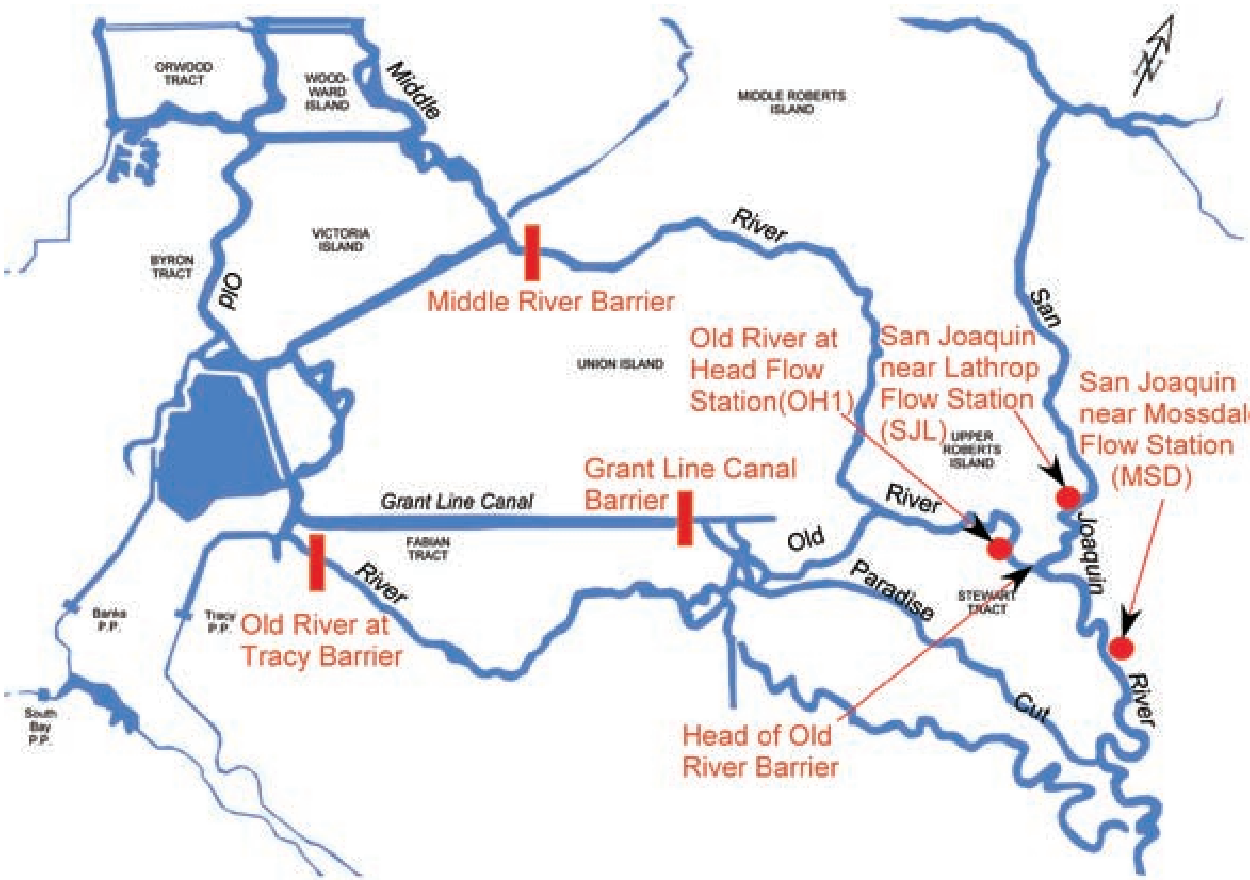
ORT – All work in or near the stream zone will be confined to the period beginning no earlier than April 1

GLC - All work in or near the stream zone will be confined to the period beginning no earlier than April 1

In addition to the above conditions, water users of the South Delta Water Agency (SDWA) and the fisheries agencies impose separate mitigation requirements on DWR for installation and operation of the HORB by itself. As a result, DWR's contractor must sequentially close and start operation of the MR and ORT barriers, and complete as much construction of north abutment and boat ramps on the GLC barrier as possible, before they can close and operate the HORB.

From the contractors point of view there are really two milestones that must be completed in sequence. First and foremost is to obtain closure and operation of the barriers in accordance with the conditions imposed by the project permits/biological opinions and mitigation requirements. The second is to satisfy DWR's contract specifications. The first milestone can be achieved within the required 15 working days but it is unlikely that the contractor can complete the entire amount of work required to satisfy DWR's contract specifications within the same time period.

Figure 4-2
South Delta Temporary Barriers



Therefore, the contractor's construction activities consist of placing enough materials to make sure they obtain closure and operation by April 15th, then following closure they continue placing barrier material above the water line until barrier construction is completed in accordance with DWR's contract specifications. The contractor then conducts site cleanup and demobilizes from the site. This is why work usually continues above water line beyond the April 15 deadline.

Barrier Operations and Monitoring Plan

A barrier operations and monitoring plan was developed based on forecasting and monitoring of tidal conditions. DWR determined the number of culverts to be opened at the HORB so that water levels at Old River near Tracy Road Bridge and Grant Line above Doughty Cut would remain above 0.0 feet MSL and Middle River near Howard Road above 0.3 feet MSL. Based on modeling results and/or field monitoring of water levels in the south delta, six culverts were open after the barrier's closure date of April 20, 2007. On April 26, 2007 three of the culverts were closed, but were reopened on May 16, 2007 because of the concern over the Delta Smelt.

Flow Measurements at and Around the Head of Old River

DWR operates two Acoustic Doppler Current Meters (ADCM) in the vicinity of head of Old River, one in the San Joaquin River 1,500 feet downstream of Old River (San Joaquin River below Old River near Lathrop, SJL) and another in Old River 840 feet downstream of the head of Old River (Old River at Head, OH1). A third acoustical Doppler was installed last year at the abutment of the railroad bridge near Mossdale (Figure 4-2). 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 flows for the March 25, 2007 through June 30, 2007 period for the three ADCMs. Figures 4-3, 4-4, and 4-5 show the daily flow range and the mean for the Old River at Head gage, the San Joaquin River below Old River gage, and the San Joaquin River at Mossdale gage respectively.

Table 4-2 shows the mean daily flow of the San Joaquin River gage at Mossdale and the San Joaquin River near Vernalis gage for the duration from April 1, 2007

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

Date	Old River at Head (OH1)			San Joaquin River below Old River (SJL)			San Joaquin River at Mossdale (MSD)			Flow Split (% of Total Flow)	
	Minimum Flow (cfs)	Maximum Flow (cfs)	Mean Flow (cfs)	Minimum Flow (cfs)	Maximum Flow (cfs)	Mean Flow (cfs)	Minimum Flow (cfs)	Maximum Flow (cfs)	Mean Flow (cfs)	OH1	SJL
3/25/2007	1,210	2,100	1,700	-1,070	1,900	638	1,110	2,900	2,190	72.7%	27.3%
3/26/2007	869	2,210	1,680	-775	1,960	682	1,340	2,920	2,190	71.1%	28.9%
3/27/2007	898	2,380	1,630	-1,090	1,920	556	1,060	2,710	2,060	74.6%	25.4%
3/28/2007	870	2,120	1,570	-899	1,880	580	1,330	2,580	2,090	73.0%	27.0%
3/29/2007	941	2,210	1,610	-915	1,660	482	1,350	2,510	2,050	76.9%	23.1%
3/30/2007	1,070	2,250	1,600	-1,130	1,560	404	1,200	2,430	1,920	79.9%	20.1%
3/31/2007	808	2,290	1,610	-1,230	1,710	333	950	2,380	1,850	82.9%	17.1%
4/1/2007	1,020	2,440	1,690	-1,300	1,720	356	1,170	2,410	1,910	82.6%	17.4%
4/2/2007	921	2,190	1,590	-1,070	1,560	417	1,120	2,550	1,950	79.2%	20.8%
4/3/2007	806	1,970	1,530	-1,060	1,560	369	969	2,400	1,810	80.6%	19.4%
4/4/2007	687	2,000	1,510	-1,210	1,630	314	822	2,410	1,760	82.8%	17.2%
4/5/2007	632	2,100	1,480	-1,230	1,470	227	597	2,330	1,630	86.7%	13.3%
4/6/2007	567	2,050	1,500	-1,290	1,730	225	301	2,340	1,600	87.0%	13.0%
4/7/2007	544	2,000	1,470	-1,350	1,910	401	365	2,410	1,650	78.6%	21.4%
4/8/2007	564	1,990	1,480	-1,210	1,860	408	688	2,500	1,740	78.4%	21.6%
4/9/2007	796	1,920	1,510	-1,100	1,910	507	839	2,580	1,870	74.9%	25.1%
4/10/2007	623	1,780	1,330	-889	1,700	476	856	2,270	1,660	73.6%	26.4%
4/11/2007	663	2,050	1,360	-1,180	1,730	309	562	2,210	1,470	81.5%	18.5%
4/12/2007	621	2,080	1,380	-1,410	1,790	322	784	2,310	1,590	81.1%	18.9%
4/13/2007	721	2,100	1,400	-1,190	1,420	259	817	2,050	1,600	84.4%	15.6%
4/14/2007	683	2,020	1,400	-1,430	1,520	197	723	2,170	1,540	87.7%	12.3%
4/15/2007	836	2,080	1,460	-1,320	1,710	297	1,070	2,390	1,710	83.1%	16.9%
4/16/2007	926	2,250	1,570	-1,110	1,670	422	1,040	2,470	1,880	78.8%	21.2%
4/17/2007	870	2,090	1,600	-1,280	1,600	269	725	2,370	1,680	85.6%	14.4%
4/18/2007	836	2,200	1,410	-1,460	1,710	349	410	2,370	1,660	80.1%	19.9%
4/19/2007	875	1,890	1,480	-1,460	1,660	368	381	2,390	1,610	80.1%	19.9%
4/20/2007	511	2,280	1,060	-1,530	2,460	1,010	-44	2,430	1,640	51.2%	48.8%
4/21/2007	464	928	665	-18	2,900	1,920	866	3,000	2,180	25.7%	74.3%
4/22/2007	389	928	668	852	3,300	2,440	1,800	3,410	2,750	21.5%	78.5%
4/23/2007	558	951	711	2,020	3,390	2,850	2,570	3,570	3,100	20.0%	80.0%
4/24/2007	559	825	673	2,200	3,280	2,830	2,730	3,440	3,080	19.2%	80.8%
4/25/2007	513	811	658	2,240	3,210	2,790	2,630	3,390	3,030	19.1%	80.9%
4/26/2007	368	703	533	2,070	3,300	2,830	2,550	3,400	3,030	15.9%	84.1%
4/27/2007	388	633	482	2,310	3,270	2,880	2,610	3,290	3,010	14.3%	85.7%
4/28/2007	351	588	445	2,040	3,130	2,720	2,390	3,270	2,910	14.1%	85.9%
4/29/2007	323	585	448	2,050	3,240	2,770	2,260	3,370	2,940	13.9%	86.1%
4/30/2007	230	657	420	2,180	3,510	2,900	2,590	3,530	3,100	12.7%	87.3%
5/1/2007	230	500	379	2,130	3,430	2,830	2,380	3,470	2,990	11.8%	88.2%
5/2/2007	256	485	381	2,000	3,310	2,710	2,210	3,280	2,880	12.3%	87.7%
5/3/2007	249	470	350	1,540	3,260	2,610	1,940	3,210	2,720	11.8%	88.2%
5/4/2007	107	488	347	1,590	3,230	2,630	2,020	3,280	2,730	11.7%	88.3%
5/5/2007	275	616	437	1,890	3,350	2,770	2,150	3,240	2,820	13.6%	86.4%
5/6/2007	277	599	416	1,990	3,360	2,830	2,230	3,420	2,930	12.8%	87.2%
5/7/2007	124	571	403	2,080	3,430	2,850	2,290	3,390	2,940	12.4%	87.6%
5/8/2007	235	513	346	2,060	3,360	2,770	2,320	3,410	2,890	11.1%	88.9%
5/9/2007	220	522	356	2,020	3,400	2,790	2,390	3,410	2,950	11.3%	88.7%
5/10/2007	223	467	358	2,250	3,310	2,800	2,580	3,330	2,970	11.3%	88.7%
5/11/2007	269	523	396	2,230	3,220	2,800	2,600	3,310	2,990	12.4%	87.6%
5/12/2007	302	564	437	2,050	3,230	2,790	2,480	3,340	2,970	13.6%	86.4%
5/13/2007	329	562	460	2,090	3,250	2,840	2,550	3,420	3,090	13.9%	86.1%
5/14/2007	339	621	466	2,010	3,430	2,870	2,530	3,550	3,160	14.0%	86.0%
5/15/2007	297	546	450	1,730	3,420	2,780	2,340	3,490	3,030	13.9%	86.1%
5/16/2007	329	777	555	1,520	3,340	2,720	2,160	3,550	3,030	17.0%	83.0%
5/17/2007	491	785	611	1,170	3,360	2,620	1,930	3,560	3,010	18.9%	81.1%
5/18/2007	408	727	583	1,080	3,400	2,640	2,120	3,670	3,050	18.1%	81.9%
5/19/2007	425	800	578	1,420	3,350	2,640	2,150	3,530	3,010	18.0%	82.0%
5/20/2007	360	711	567	1,310	3,310	2,600	2,110	3,440	2,970	17.9%	82.1%
5/21/2007	462	812	606	1,650	3,330	2,680	2,340	3,550	3,020	18.5%	81.5%
5/22/2007	411	1,910	1,210	1,170	2,840	2,320	2,630	3,490	3,000	34.3%	65.7%
5/23/2007	1,260	2,710	1,720	882	2,280	1,790	2,500	3,110	2,820	49.0%	51.0%
5/24/2007	1,020	2,500	1,530	-188	2,100	1,410	2,010	2,930	2,600	52.0%	48.0%
5/25/2007	925	2,280	1,340	-515	2,060	1,270	1,760	2,790	2,450	51.3%	48.7%
5/26/2007	827	2,310	1,230	-816	2,150	1,220	1,520	2,770	2,330	50.2%	49.8%
5/27/2007	755	2,130	1,210	-846	2,270	1,240	1,390	2,790	2,290	49.4%	50.6%
5/28/2007	790	2,280	1,290	-871	2,350	1,210	1,380	2,910	2,350	51.6%	48.4%
5/29/2007	784	2,260	1,290	-1,290	2,410	1,040	1,150	2,930	2,230	55.4%	44.6%
5/30/2007	679	2,040	1,170	-1,070	2,470	1,150	1,230	2,960	2,270	50.4%	49.6%
5/31/2007	671	2,130	1,190	-1,080	2,470	1,140	985	2,930	2,240	51.1%	48.9%
6/1/2007	759	2,120	1,220	-1,060	2,440	1,130	1,060	3,010	2,260	51.9%	48.1%
6/2/2007	742	2,180	1,240	-972	2,470	1,140	1,100	2,910	2,260	52.1%	47.9%
6/3/2007	753	2,190	1,230	-1,210	2,600	1,200	1,100	2,950	2,300	50.6%	49.4%
6/4/2007	691	2,160	1,190	-1,030	2,400	1,110	1,050	2,770	2,140	51.7%	48.3%
6/5/2007	409	2,080	1,160	-1,050	2,410	1,030	1,020	2,580	2,000	53.0%	47.0%
6/6/2007	482	1,900	1,000	-818	2,280	1,160	1,200	2,500	2,020	46.3%	53.7%
6/7/2007	504	1,880	971	-660	2,000	1,060	1,320	2,350	1,940	47.8%	52.2%
6/8/2007	513	1,900	962	-699	1,840	1,000	1,230	2,260	1,900	49.0%	51.0%
6/9/2007	528	1,930	995	-840	1,850	969	1,140	2,220	1,850	50.7%	49.3%
6/10/2007	358	1,980	932	-1,040	1,980	867	840	2,100	1,710	51.8%	48.2%
6/11/2007	434	2,030	981	-1,280	2,190	952	703	2,370	1,830	50.7%	49.3%
6/12/2007	443	2,070	1,030	-1,400	2,230	973	609	2,480	1,880	51.4%	48.6%
6/13/2007	568	2,260	1,140	-1,380	2,360	984	799	2,670	2,040	53.7%	46.3%
6/14/2007	419	2,330	1,100	-1,490	2,350	794	587	2,480	1,760	58.1%	41.9%
6/15/2007	109	2,100	944	-1,510	2,520	727	60	2,340	1,490	56.5%	43.5%
6/16/2007	96	1,840	860	-1,570	2,550	829	128	2,310	1,500	50.9%	49.1%
6/17/2007	186	2,120	891	-1,520	2,540	957	326	2,370	1,660	48.2%	51.8%
6/18/2007	205	2,160	972	-1,420	2,460	876	596	2,360	1,720	52.6%	47.4%
6/19/2007	159	2,160	994	-1,390	2,360	721	591	2,290	1,600	58.0%	42.0%
6/20/2007	6	1,880	777	-1,100	2,240	876	618	1,970	1,510	47.0%	53.0%
6/21/2007	-82	1,660	635	-1,120	1,920	813	584	1,740	1,350	43.8%	56.2%
6/22/2007	71	1,790	678	-1,240	1,720	618	383	1,550	1,170	52.3%	47.7%
6/23/2007	-10	1,740	682	-1,490	1,780	527	261	1,530	1,030	56.4%	43.6%
6/24/2007	-104	1,680	619	-1,540	1,800	516	-11	1,390	906	54.5%	45.5%
6/25/2007	-73	1,700	656	-1,510	1,880	523	-68	1,470	953	55.6%	44.4%
6/26/2007	-97	1,780	703	-1,660	1,960	378	-73	1,450	859	65.1%	34.9%
6/27/2007	-155	1,710	698	-1,660	2,130	441	-135	1,480	863	61.3%	38.7%
6/28/2007	-219	1,620	715	-1,680	2,150	467	-104	1,720	893	60.5%	39.5%
6/29/2007	-195	1,710	727	-1,750	2,200	408	-223	1,570	828	64.0%	36.0%
6/30/2007	-325	1,490	596	-1,670	2,160	430	-275	1,450	763	58.1%	41.9%

through June 30, 2007. Moreover, Figure 4-6 presents in graphical format the mean daily flow for the San Joaquin River gage at Mossdale and the San Joaquin River near Vernalis gage for the same period.

DWR at the end of each year conducts a Delta Simulation Model 2 (DSM2) modeling run to be included in the yearly published South Delta Temporary Barriers Monitoring Report. Data collected from the two ADCMs will be used to verify the flow split of the San Joaquin River and Old River at the confluence against the output generated using the model.

Seepage Monitoring

A seepage-monitoring program was initiated in April 2000, to evaluate the effects of HORB operations on seepage and groundwater on Upper Roberts Island. In 2007 no seepage was observed at any of the monitoring sites. A link to the continuous time series data in the water data library is available on the internet.

In 2007, DWR installed Doppler "Argonaut" flow measuring devices inside culverts 1, 4 and 6. Data was recorded every 15 minutes during the period when the HORB was in operation. The flow through a completely submerged culvert is primarily dependent on the water levels at the two ends of the culvert, but is also dependent on culvert inlet geometry, slope, size and roughness. If it is assumed that all of these factors are similar for all six of the culverts, then the measured flow in any of these culverts would be a reasonable estimate of the flow in each of the other culverts. Table 4-3 summarizes the measured flows in culverts 1, 4, and 6 and estimates the total mean daily flow in all six culverts.

Barrier Emergency Response Plan

In addition to the operation and monitoring plan, DWR has also prepared an "Emergency Operations Plan for the Spring HORB". The plan provided that if the daily measured or forecasted flow at Vernalis exceeded a flow that would correspond to stage at the HORB of 10.0 feet MSL, and the stage was likely to exceed 11.0 feet MSL (the height of the barrier under the "high-flow" target), the barrier would be removed. Vernalis flows and stages at the barrier were not high enough in 2007 to warrant action under the emergency operations plan.

Fish Entrainment Monitoring at the Head of Old River Barrier

All six culverts in the Head of Old River Barrier (HORB) were installed for the 2007 VAMP test period. However, only three of the six culverts were open during entrainment monitoring. The six culverts are installed to maintain water quality and water levels in the south Delta, downstream of the HORB. Since the culverts are

Table 4-2
San Joaquin River Old River Mean Daily Flows

Date	Mean Daily Flow (cfs) San Joaquin River at Mossdale [A]	Mean Daily Flow (cfs) San Joaquin River near Vernalis [B]
4/1/07	1,910	1,950
4/2/07	1,950	1,930
4/3/07	1,810	1,790
4/4/07	1,760	1,730
4/5/07	1,630	1,680
4/6/07	1,600	1,680
4/7/07	1,650	1,710
4/8/07	1,740	1,780
4/9/07	1,870	1,880
4/10/07	1,660	1,670
4/11/07	1,470	1,630
4/12/07	1,590	1,730
4/13/07	1,600	1,680
4/14/07	1,540	1,730
4/15/07	1,710	1,910
4/16/07	1,880	1,990
4/17/07	1,680	1,850
4/18/07	1,660	1,760
4/19/07	1,610	1,780
4/20/07	1,640	1,880
4/21/07	2,180	2,700
4/22/07	2,750	3,500
4/23/07	3,100	3,790
4/24/07	3,080	3,670
4/25/07	3,030	3,590
4/26/07	3,030	3,520
4/27/07	3,010	3,370
4/28/07	2,910	3,160
4/29/07	2,940	3,160
4/30/07	3,100	3,200
5/1/07	2,990	3,090
5/2/07	2,880	2,960
5/3/07	2,720	2,830
5/4/07	2,730	2,900
5/5/07	2,820	2,970
5/6/07	2,930	3,050
5/7/07	2,940	3,050
5/8/07	2,890	3,090
5/9/07	2,950	3,170
5/10/07	2,970	3,170
5/11/07	2,990	3,250
5/12/07	2,970	3,330
5/13/07	3,090	3,390
5/14/07	3,160	3,450
5/15/07	3,030	3,410
5/16/07	3,030	3,400
5/17/07	3,010	3,360
5/18/07	3,050	3,370
5/19/07	3,010	3,300
5/20/07	2,970	3,280
5/21/07	3,020	3,260
5/22/07	3,000	3,100
5/23/07	2,820	2,960
5/24/07	2,600	2,810
5/25/07	2,450	2,670
5/26/07	2,330	2,570
5/27/07	2,290	2,530
5/28/07	2,350	2,540
5/29/07	2,230	2,430
5/30/07	2,270	2,420
5/31/07	2,240	2,340
6/1/07	2,260	2,350
6/2/07	2,260	2,390
6/3/07	2,300	2,350
6/4/07	2,140	2,200
6/5/07	2,000	2,090
6/6/07	2,020	2,020
6/7/07	1,940	1,950
6/8/07	1,900	1,950
6/9/07	1,850	1,880
6/10/07	1,710	1,740
6/11/07	1,830	1,860
6/12/07	1,880	1,970
6/13/07	2,040	2,040
6/14/07	1,760	1,760
6/15/07	1,490	1,610
6/16/07	1,500	1,590
6/17/07	1,660	1,660
6/18/07	1,720	1,680
6/19/07	1,600	1,550
6/20/07	1,510	no data
6/21/07	1,350	no data
6/22/07	1,170	no data
6/23/07	1,030	1,110
6/24/07	906	1,100
6/25/07	953	1,130
6/26/07	859	1,060
6/27/07	863	1,090
6/28/07	893	1,090
6/29/07	828	1,040
6/30/07	763	1,000

Figure 4-3
Daily Flow Range - Old River at Head

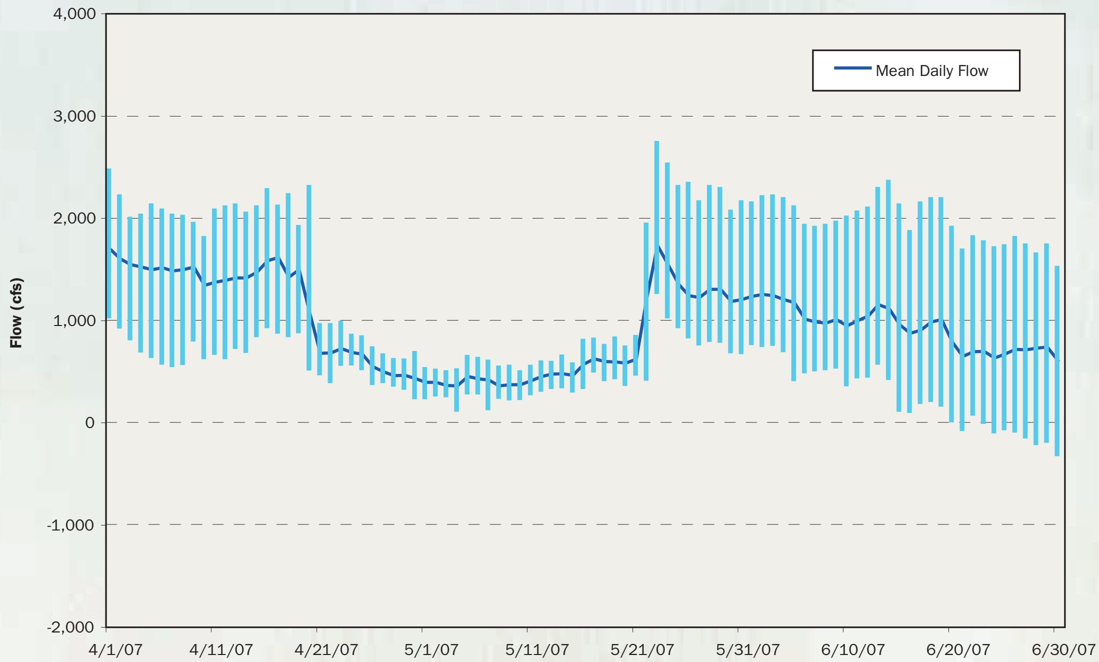


Figure 4-4
Daily Flow Range - San Joaquin River below Old River Gage

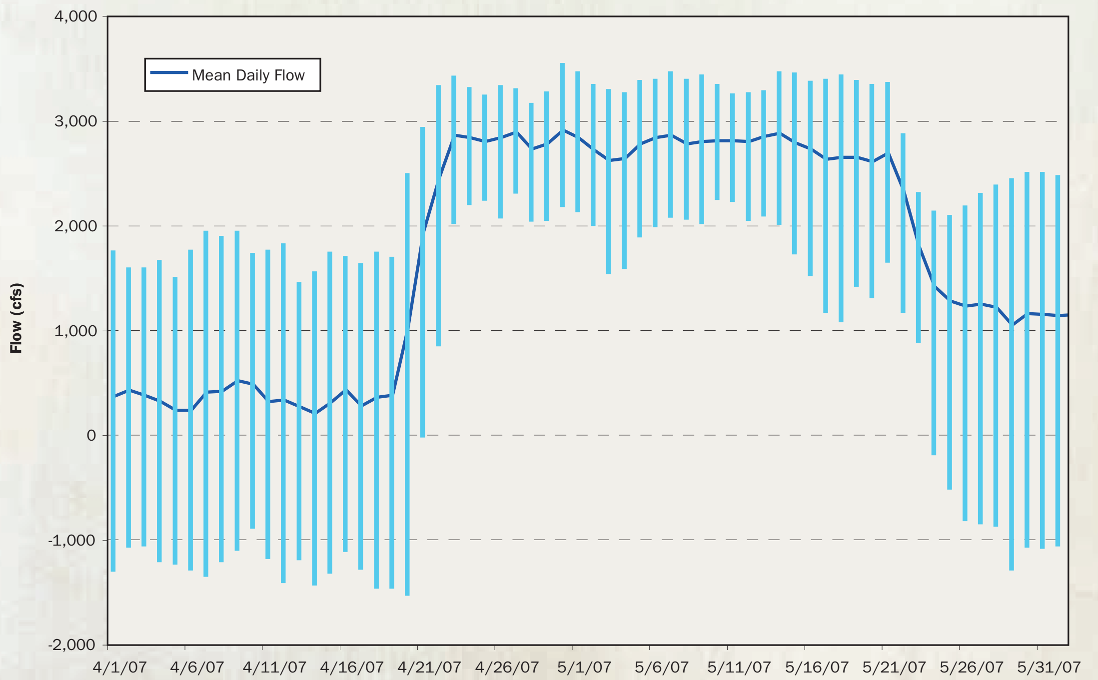


Figure 4-5
Daily Flow Range - San Joaquin River at Mossdale

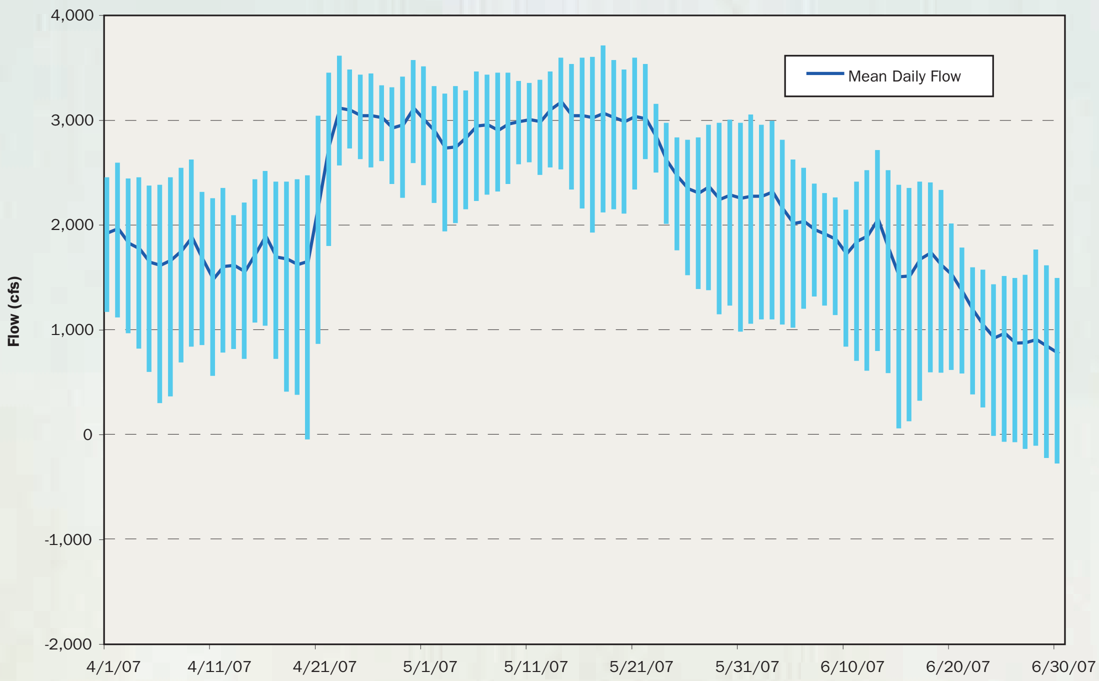


Figure 4-6
San Joaquin River Flow near Vernalis and at Mossdale

not screened, juvenile Chinook salmon and other fish species that pass near the culverts are vulnerable to entrainment. A fish monitoring program was designed and implemented by the DFG to evaluate and quantify fish entrainment at the HORB. Results from this fishery investigation are intended, in part, to provide information on the design and operation of a future permanent operable barrier at the head of Old River.

Materials and Methods

Fish entrained into the culverts were caught with fyke nets. The nets have a 48-inch cylindrical mouth tapering down to a 1-foot square cod-end, and are made of 1/2 inch braided mesh. Five of the six nets are 60 feet long and one net is 40 feet long. A live-box (15.5 x 19.5 x 36 inches), constructed of perforated aluminum sheet metal, was attached to the cod-end of each net. Each live-box has an aluminum baffle designed to reduce water velocities within the live-box and improve survival of captured fish. The culverts were numbered from 1 to 6 with number 1 located next to the shoreline (viewed from downstream) and number 6 located mid-channel (Figure 4-7). On April 27, fyke nets were attached to the downstream slide gate flanges of all six culverts. These gates were not lowered over the culverts at this time and thus, were not sampling. The slide gates on culvert numbers 1, 4 and 6, with attached nets and live boxes, were lowered over the culvert outfalls at 14:00 hours on Monday, April 29 to commence fish entrainment monitoring. Only culvert numbers 1, 4 and 6 were opened and remained opened throughout the monitoring period. On Friday, May 4, at 13:00, the nets were raised, checked, and then piled onto the frames. The nets did not fish over the weekend. The following Monday, at 13:00 hours, the nets for culvert numbers 1, 4 and 6 were lowered back into the water. All nets were removed at noon on Friday, May 11.

The fyke nets were checked at 01:00, 06:00, 13:00, and 20:00 hours Monday through Friday. The nets were checked by closing the culvert slides gate (upstream side) for about 20 minutes, enabling the live-boxes to be pulled onto a boat. Fish were removed from the live-boxes and placed into buckets. Once all the nets had been checked and reset, the collected fish were processed. All the fish were identified and counted. Salmon were checked for a clipped adipose fin and for the presence of a color-mark on the dorsal, anal, or caudal fin. Salmon that had a clipped adipose fin were saved for CWT processing. All salmon were measured (fork-lengths) to the nearest millimeter. Culvert number, date, time, water temperature, and diel-period were recorded for each net check. Except for adipose fin clipped salmon, all fish were released downstream of the HORB into Old River.

Figure 4-7
Culverts in the HORB were numbered from 1 to 6, with number 1 closest to shore. Culvert numbers 2, 3 and 5 were closed throughout the monitoring period.

Table 4-3. Flow in HORB Culverts

Date	Mean Daily Flow (cfs)				
	Measured				
	Culvert 1	Culvert 4	Culvert 6	Open Culverts	Total [1]
4/26/07 [2]	82	79	89	1,4,6	251
4/27/07	78	78	88	1,4,6	245
4/28/07	72	75	86	1,4,6	233
4/29/07	69	72	83	1,4,6	224
4/30/07	66	67	72	1,4,6	205
5/1/07	60	58	60	1,4,6	178
5/2/07	60	58	61	1,4,6	179
5/3/07	57	56	58	1,4,6	171
5/4/07	59	59	65	1,4,6	183
5/5/07	62	61	70	1,4,6	192
5/6/07	64	63	73	1,4,6	200
5/7/07	60	58	64	1,4,6	182
5/8/07	57	55	59	1,4,6	171
5/9/07	56	54	59	1,4,6	168
5/10/07	54	53	57	1,4,6	164
5/11/07	55	56	62	1,4,6	173
5/12/07	56	57	67	1,4,6	179
5/13/07	57	58	68	1,4,6	183
5/14/07	59	59	70	1,4,6	188
5/15/07	56	56	66	1,4,6	179
5/16/07 [3]	53	53	65	1,2,3,4,5,6	256
5/17/07	49	50	62	1,2,3,4,5,6	322
5/18/07	49	49	62	1,2,3,4,5,6	320
5/19/07	48	48	61	1,2,3,4,5,6	315
5/20/07	50	49	63	1,2,3,4,5,6	325
5/21/07 [4]	47	47	60	1,2,3,4,5,6	309

[1] Assumes average of measured flows for Culverts 2, 3 and 5 when open
[2] Partial day record of flow: 10:30 to 23:45
[3] Culverts 2, 3 and 5 were opened on May 16; estimate of total flow assumes these culverts were open for half of May 16.
[4] Partial day record of flow: 0:00 to 10:15

Unlike in previous years, there were no VAMP salmon releases upstream of the HORB at Mossdale or Durham Ferry. Consequently, no entrainment loss indices were calculated for 2007. Instead, an unmarked salmon average daily entrainment index (Entrainment Index) was generated from the HORB fish entrainment results to track relative changes in entrainment among years. For each year of entrainment monitoring, an Entrainment Index was calculated by dividing the total number of unmarked salmon caught by the number of days sampled. The index was not adjusted for the number of open culverts or the occasional lost entrainment samples due to gravel or debris. The Entrainment Index represents overall entrainment regardless of HORB culvert gate operation.

To track relative changes in unmarked salmon abundance just upstream of the barrier, salmon catch from the Mossdale Kodiak Trawl (MKT) was used to calculate an average 5 hour daily abundance index (Abundance Index). The Abundance Index was calculated by summing the daily catch of unmarked salmon (standardized to fifteen 20 minute tows) and dividing by the number of days sampled. The Abundance Index was calculated for the same days in which there was entrainment monitoring. Abundance and Entrainment Indices are calculated for a two to three week period during the VAMP test period. No indices were calculated for 2005 and 2006 because the HORB was not installed due to high San Joaquin River flows.

Fish catch was calculated for each culvert. Catch-Per-Unit-Effort (CPUE) for salmon comparison among years was calculated as the number of fish collected per hour per culvert. Standard deviation is used to describe the variability round the mean. DWR installed flow meters in culverts number 1, 4 and 6. Unmarked salmon entrainment density (fish/af) was calculated per culvert sampling period by dividing the catch by the amount of water that flowed through the culvert (mean flow (cfs) * sampling duration (s) * 43,560 (af/cf)).

Results

The HORB was closed on April 22; however, construction on the barrier continued for another four days. As mentioned previously, only culvert numbers 1, 4 and 6 were open during the fish monitoring period. The remaining culverts were opened May 16, after fish monitoring was completed. DFG monitored the HORB culverts over 10 days, for approximately 167 hours of sampling per culvert, and collected 95 samples. Two samples from culvert number 4 were loss due to the process of clearing the net of gravel and resetting the net at the next net check.

Table 4-4
The raw abundance and composition of fishes entrained at the HORB in 2007. Chinook salmon catch is divided into CWT salmon, unmarked salmon, color-marked salmon and radio-tagged salmon.

Species	Catch
White Catfish	185
Common Carp	85
Sacramento Sucker	81
Channel Catfish	29
Bluegill	12
Tule Perch	11
Redear Sunfish	3
Lamprey Spp.	2
Striped Bass	2
Prickly Sculpin	2
Green Sunfish	2
Golden Shiner	2
Brown Bullhead	1
Goldfish	1
Largemouth Bass	1
Threadfin Shad	1
Inland Silverside	1
Total Chinook Salmon	**51**
CWT Salmon	1
Unmarked Salmon	48
Color-Marked Salmon	0
Acoustically tagged Salmon	2
Total	**472**

Almost 500 fish were collected representing 17 species from 10 families of fish. No delta smelt (Hypomesus transpacificus), juvenile steelhead (Oncorhynchus mykiss), or splittail (Pogonichthys macrolepidotus) were collected in the fyke nets. The most abundant species was white catfish (Ictalurus catus), followed by common carp (Cyprinus carpio) (Table 4-4). Of the 51 salmon caught; 1 had a CWT; 46 were unmarked; and 2 were acoustically tagged. No color-marked salmon were caught this year. Overall, the number of salmon entrained per hour (0.1 ± 0.2) was lower than it was in previous years (0.7 in 2004, 3.4 in 2003, 2.5 in 2002, 1.4 in 2001). The mean fork length for unmarked salmon was 85 ± 7.6 mm and the one CWT salmon was 93 mm.

Unmarked salmon were caught throughout the monitoring period (Figure 4-8). The average unmarked salmon CPUE over the entire monitoring period was 0.1 ± 0.2 fish/hour/culvert. The highest unmarked salmon

Figure 4-8

The daily average number of unmarked salmon entrained per culvert hour at the HORB in 2007. The catch is separated by day and night. No sampling occurred on May 5 and 6.

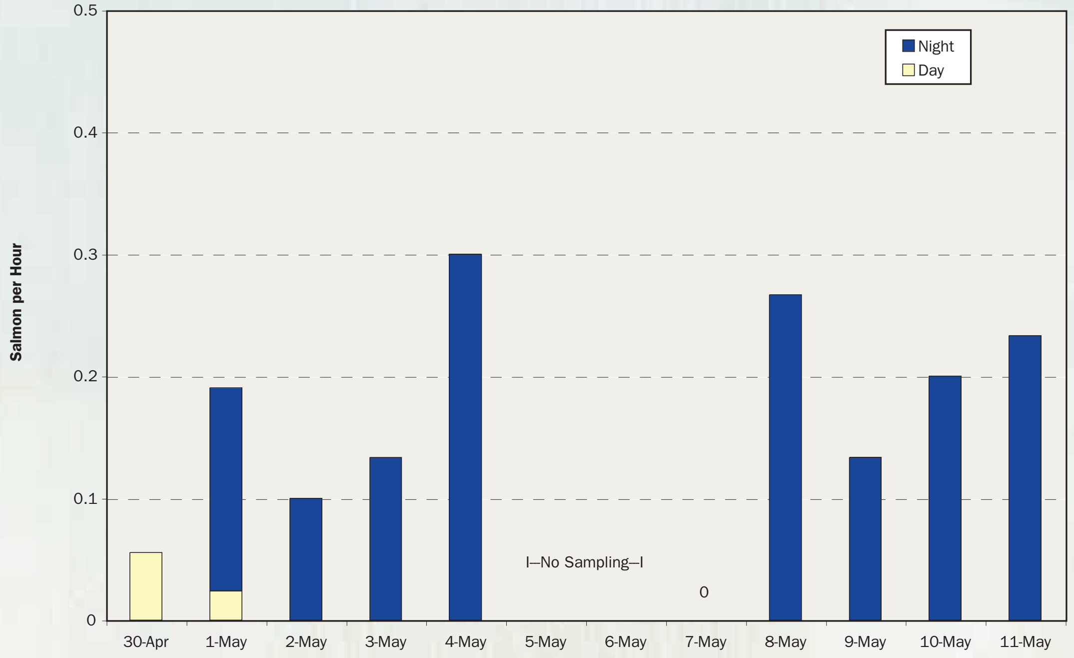


Figure 4-9

Mean unmarked salmon Abundance Index and Entrainment Index during the annual VAMP period when both Mossdale Kodiak Trawl and HORB entrainment monitoring were sampling. Indices were not calculated for 2005 and 2006 because the HORB was not installed due to high San Joaquin River flows. Mean San Joaquin River flow during VAMP was measured at Vernalis, CA.

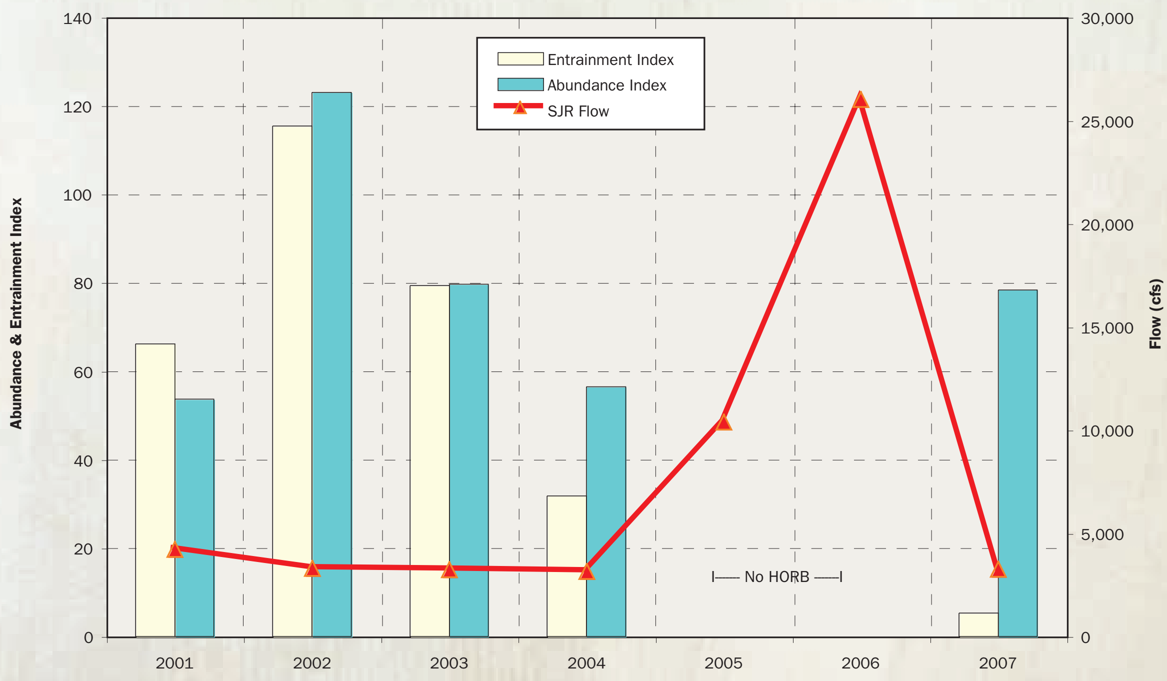


Table 4-5
The percentage of the total number of unmarked salmon caught by culvert and year, and 2007 culvert flow and entrainment fish density. Catch comparisons made only for time periods when culverts were fully operational and fyke nets were fishing. An "X" indicates the culvert was closed. Days indicate the number of days the culverts were compared in the given culvert operational status.

				Culvert Number					
	Year	Days		1	2	3	4	5	6
Catch									
	2001	6.2	Percent	3%	7%	7%	18%	20%	44%
	2002	11.0	Percent	10%	12%	16%	33%	16%	12%
	2003	19.7	Percent	X	X	X	17%	39%	45%
	2004	2.0	Percent	X	X	X	15%	39%	46%
	2004	5.9	Percent	22%	X	11%	0%	5%	62%
	2007	7.3	Percent	21%	X	X	24%	X	55%
Flow (cfs)									
	2007	7.3	Percent	33%	X	X	32%	X	34%
			Avg ± SD	59 ± 8.8	X	X	58 ± 8.5	X	61 ± 8.9
Density ((Fish/ af)*100)									
	2007	7.3	Avg ± SD	1.2 ± 3.0			1.5 ± 2.9		3.0 ± 4.1

CPUE (0.8 fish/hour/culvert) occurred on May 4 and May 8. The average CWT salmon CPUE over the entire monitoring period was 0.002 ± 0.020 fish/hour/culvert. The highest CWT salmon CPUE (0.2 fish/hour/culvert) occurred on May 10.

In order to compare relative trends in unmarked salmon entrainment, an Entrainment Index and Abundance Index was calculated for each of the previous years in which we conducted entrainment monitoring. The 2007 Abundance Index was similar to the 2001, 2003 and 2004 Abundance indices (Figure 4-9). For the most part, the Entrainment Index tracked the Abundance Index, except in 2007. Although 2003 and 2007 had nearly identical Abundance Indices, the 2007 Entrainment Index was approximately 15 times lower. Both 2003 and 2007 had 3 open culverts. Although river flow can influence emigration patterns, San Joaquin River flow was similar among study years (2001-2004 and 2007) and flow probably had a negligible affect (Figure 4-4).

Unmarked salmon entrainment was highest in culvert number 6 and lowest in culvert number 1. Approximately half of the salmon entrained in 2007 were entrained through culvert number 6, which is similar to 2003 and 2004 (Table 4-5). Although 55 % of the entrained salmon went through culvert number 6, only 34 % of the water flowed through this culvert (Table 4-5). Salmon density for fish entrained through culvert number 6 was 0.03 fish/af, twice the density of culvert numbers 1 and 4.

Salmon entrainment differed greatly between diel periods. More unmarked salmon were entrained at night (47) than during the day (2). This year's nighttime entrainment is higher than in previous years when approximately 75% of the salmon were caught at night.

Discussion

The HORB is relatively effective in keeping salmon on the San Joaquin side of the barrier. Previous studies at the HORB indicate typically less than one percent of the VAMP CWT salmon released upstream of the HORB is entrained through the HORB culverts(SJRGA, 2001, 2002, 2003, 2004). Because there was no VAMP CWT salmon releases in 2007, we were unable to estimate the percentage of salmon entrained at the HORB. As an alternative to directly estimating entrainment using CWT salmon, entrainment and abundance indices were generated for unmarked salmon to compare relative changes in entrainment among years.

Total fish entrainment at the HORB was much lower this year than in previous years. Due to a staff shortage, the fyke nets were fished over a period of 10 days. Although the number of days sampled was reduced, the proportional decrease in overall salmon entrainment was much greater than expected, even when we account for the number of operational culverts. There was an 86% decrease in CPUE compared to 2004, the previous low. A large contributing factor for the overall decline in salmon entrainment was the practically non-existent CWT salmon catch. In previous years, CWT salmon can account for more than half of all the salmon entrained.

This year's single CWT salmon catch is by far the lowest on record.

Although CWT salmon typically account for a large percentage of the overall salmon entrainment, there was also a sharp decline in unmarked salmon entrainment. This decline in entrainment might be due to a decline in the number of outmigrating juvenile salmon. However, the unmarked salmon Abundance Index during the 2007 VAMP period was similar to previous years with a barrier. While we were sampling at the HORB, it appears there was no sharp decline in the number of unmarked salmon just upstream of the barrier.

The decline in the 2007 Entrainment Index might be related to culvert gate operation. In previous years when only three culverts were opened (2003 and part of 2004), the three culverts closest to the channel were opened and the three closest to shore were closed. This year, the culvert at the end, one in the middle, and the one closest to shore were open. The zone of entrainment might be higher with three adjacent open culverts. There is probably a larger draw of water at a fixed distance from an open culvert if the adjacent culverts are also open.

Over the years, we've noticed the culvert closest to the shore (number 1) typically entrains the fewest number of salmon. It was thought that the lower entrainment might be related to lower flows in culvert number 1. Visually, it appears less water flows through culvert number 1 compared to the other culverts. Theoretically, flows should be the same in all culverts since it's the head difference between upstream and downstream water levels that is responsible for flow. In 2002, a cursory check of flows among culverts using a hand held flowmeter suggested flow through culvert number 1 was about 10 cfs lower than flow through the other five culverts (SJRGA, 2002). However, in 2007, flowmeters in culvert numbers 1, 4 and 7 indicate flow was similar among culverts.

The position of outmigrating salmon in the water column probably is the biggest factor affecting entrainment. The proximity of culvert number 1 to the shore and culvert number 6 to the center of the channel, may account for the large entrainment discrepancies between the two culverts. Salmon entrainment densities suggest salmon are more abundant in the center of the channel. Juvenile salmon may prefer to migrate down the middle of the channel rather than along the shoreline. Predation might also be higher along the shore which would reduce the number of salmon vulnerable to entrainment at culvert number 1.

The data collected over the HORB monitoring years strongly suggests salmon are more vulnerable to entrainment at night. Salmon entrainment at night was higher in 2007 than in previous years. In 2004, 80% of the unmarked salmon were entrained at night. In 2007, approximately 95 % of the entrained unmarked salmon were caught at night. Although the MKT caught between 40 and 208 unmarked salmon per day (for a total of 678) just upstream of the barrier using surface tows, the HORB entrained between 0 and 1 salmon (for a total of two) during that same daylight timeframe. This suggests salmon are more surface oriented during the day than at night. Since the culverts are placed on the bottom of the channel, salmon are less likely to be entrained if they remain near the surface.

Although overall salmon entrainment was lower this year, it appears the approximately 400 acoustically tagged salmon released upstream of the HORB were entrained at a similar rate as VAMP CWT salmon from previous studies. Acoustically tagged salmon were released at Durham Ferry and Mossdale as part of juvenile migration study in the south Delta (see Chapter 5). No acoustically tagged juvenile salmon from the first set of releases and two acoustically tagged salmon from the second set of releases were entrained at the HORB. The overall entrainment loss for acoustically tagged salmon was 0.5 % which is similar to VAMP CWT entrainment losses at the HORB from 2001-2004. It appears the modified gate operation did not benefit acoustically tagged salmon to the degree that it benefited unmarked salmon. However, the acoustically tagged salmon releases were very small compared to the relatively large VAMP CWT salmon releases of previous years. A single acoustically tagged salmon has a bigger impact on the entrainment loss calculation than a single CWT salmon has on the VAMP CWT entrainment loss calculation.

As in previous years with a barrier, a large amount of gravel was caught in the nets which resulted in three loss samples. It is recommended that VAMP delay any future CWT salmon releases by at least 5 days beyond the closure of the HORB. The delay allows for completion of the barrier and minimizes the field crew's exposure to heavy equipment operation. It also allows time for any loose material near the barrier to pass through the culverts before the nets are attached. If keeping outmigrating salmon out of Old River and in the San Joaquin River is beneficial to their survival, then it might be prudent to only open culvert numbers 1, 4 and 6 during peak salmon migration. It might be possible to further reduce salmon entrainment by opening the culverts closest to shore and only open culverts during daylight hours. A possible experiment to further test culvert gate operations on salmon entrainment is to only open culvert numbers 1, 2 and 3 for the first VAMP CWT salmon release and only open culvert numbers 4, 5 and 6 for the second VAMP release.

Salmon Smolt Survival Investigations

Acoustic–Tagged Smolt Distribution Study

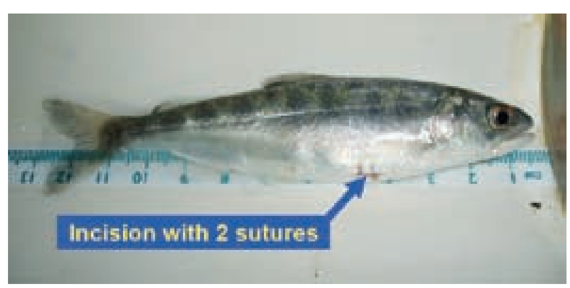
One of the primary objectives of the VAMP study, in addition to providing enhanced protection of juvenile Chinook salmon emigrating from the San Joaquin River system, is to determine the effects of San Joaquin River flows, SWP and CVP water exports, and HORB placement on survival of Chinook salmon smolts emigrating from the San Joaquin River through the Delta. Early in 2007, it was determined that Merced River Hatchery (MRH) would not meet their production needs. Thus production at the hatchery was not sufficient to provide study fish for a traditional VAMP coded-wire tag experiment. A fully supported coded-wire tag VAMP experiment would require 400,000 juvenile Chinook salmon from MRH. As an alternative, an acoustic-tag experiment using only 1,000 salmon was planned to estimate survival from Durham Ferry to Jersey Point and Chipps Island and look at mortality and distribution by reach within the San Joaquin River with the Head of Old River Barrier (HORB) in place. However, due to logistical constraints, acoustic receivers were not actually installed at Chipps Island and Jersey Point and survival was not estimated.

Introduction

A pilot acoustic-tagging salmon study was conducted in the south Delta during the spring of 2006. A summary of the results is available in the 2006 VAMP annual report (San Joaquin River Group Authority 2007). The 2006 study indicated that without the HORB in place and during high-flow conditions many (half or more) of the acoustic-tagged fish, released near Mossdale, migrated into Old River. Survival through the Delta could not be estimated in the spring of 2006 because receivers available were not effective in large channels (Chipps Island or Jersey Point). In 2007, we explored renting and deploying multi-hydrophone receivers in these large channels, however logistical problems prevented their installation in 2007.

Figure 5-1
Example acoustic transmitter, comparison to pen (Vogel 2006).

Figure 5-2
Chinook salmon smolt with implanted acoustic transmitter (Vogel 2006).



Fish Tagging

Fish used for the acoustic study were obtained from MRH. Originally, the plan was to tag and release 1,000 fish; 30 fewer fish than planned were released due to receipt of fewer tags for the experiments, tag failure, or fish mortality shortly after surgery. Ultimately, 970 juvenile Chinook salmon were surgically implanted (tagged) with Hydroacoustic Technology, Inc. (HTI) individually-identifiable acoustic transmitters (tags) and released for the experiments (Figures 1 and 2). Prior to tagging the fish at MRH, an extensive training session was conducted at Mokelumne River Fish Hatchery.

Because fish for training were unavailable at MRH, Mokelumne River Fish Hatchery provided 2,000 fish needed for training. Tagging personnel were trained by U.S. Geological Survey's Cook, Washington, Lab. Procedures for tagging followed a strict standard operating procedure (Appendix D). Tagging consisted of surgically implanting an acoustic tag in the fish's body cavity. Size and weight of fish for training were similar to those later used at MRH for the VAMP experiments. Four individuals were trained to surgical implant the tags and eight others were trained to assist and to record data. Training was conducted between April 16 and April 26.

Prior to surgical implantation, acoustic tags were weighed and programmed, and fish were weighed and measured. The duration of surgical procedure was also recorded and was usually less than 4 minutes. Tagging and support personnel began conducting actual surgical operations at MRH on April 30 and May 7. The fish were held at MRH for 48 hours prior to release. The Durham Ferry and Mossdale groups were tagged on April 30 and May 7 with the three remaining groups (upper Old River, Bowman Road, and Stockton) tagged on May 1 and May 8. Throughout the tagging process, some fish were tagged with non-operational "dummy" tags that were of a similar size and weight as the functional tags.

Fish Releases

The acoustic-tagged MRH Chinook salmon were released at four sites on the San Joaquin River and one site in Old River. The intent was to release approximately 100 fish at each location during each of two weeks of experiments. Release locations were:

- Durham Ferry
- Mossdale
- Upper Old River (downstream of the HORB)
- San Joaquin River at Bowman Road
- San Joaquin River near the Stockton Waste Water Treatment Facility (SWWTF) (Figure 3).

The fish releases were made twice over a two-week period for a total of 10 releases. The number of tagged fish released in the first week was 495. Releases were made at Durham Ferry and Mossdale on May 3 and in upper Old River, Bowman Road, and Stockton on May 4. The number of tagged fish for the second week of releases was 475. Releases were made at Durham Ferry and Mossdale on May 10 and in upper Old River, Bowman Road, and Stockton on May 11. (Table 1).

The tagged fish were acclimated for a short time prior to release. At each release location, two holding tubs, fitted with mesh covers, were filled with water from the hatchery vehicle. The groups of tagged fish were split approximately in half and transferred from the hatchery truck into the tubs. The temperature of the water from the hatchery was colder than that of the river; thus the fish were acclimated for approximately one hour prior to release. Once the fish were in the tubs and water temperatures measured, small amounts of river water were added to the tubs to slowly raise the temperature to the river temperature. Once the water temperature in the tubs was close to the river temperature (within a couple of degrees Fahrenheit), the fish were held for the balance of the hour prior to release. A GPS reading was taken at each of the five release sites.

Water Temperature Monitoring

Water temperature was monitored during the VAMP 2007 study using individual computerized temperature recorders (e.g., Onset Stowaway Temperature Monitoring/Data Loggers). 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 2007 VAMP monitoring program, additional temperature recorders were deployed in the south and central Delta (Appendix C-1) to provide geographic coverage for characterizing water temperature conditions while juvenile salmon emigrate from the lower San

Table 5-1
Release dates/times of acoustic-tagged juvenile Chinook salmon at each location during the first and second weeks of the 2007 VAMP experiments.

Release Location	First Release		Second Release	
	Date/Time	No. Fish	Date/Time	No. Fish
Durham Ferry	May 3, 2007 1130 hours	98	May 10, 2007 1140 hours	96
Mossdale	May 3, 2007 1300 hours	99	May 10, 2007 1230 hours	97
Old River (downstream of HORB)	May 4, 2007 1017 hours	99	May 11, 2007 1122 hours	95
Bowman Road	May 4, 2007 1215 hours	99	May 11, 2007 1205 hours	95
Stockton	May 4, 2007 1250-1253 hours	100	May 11, 2007 1243 hours	92

Figure 5-3
Fish release locations and acoustic receiver locations during the 2007 VAMP experiments.

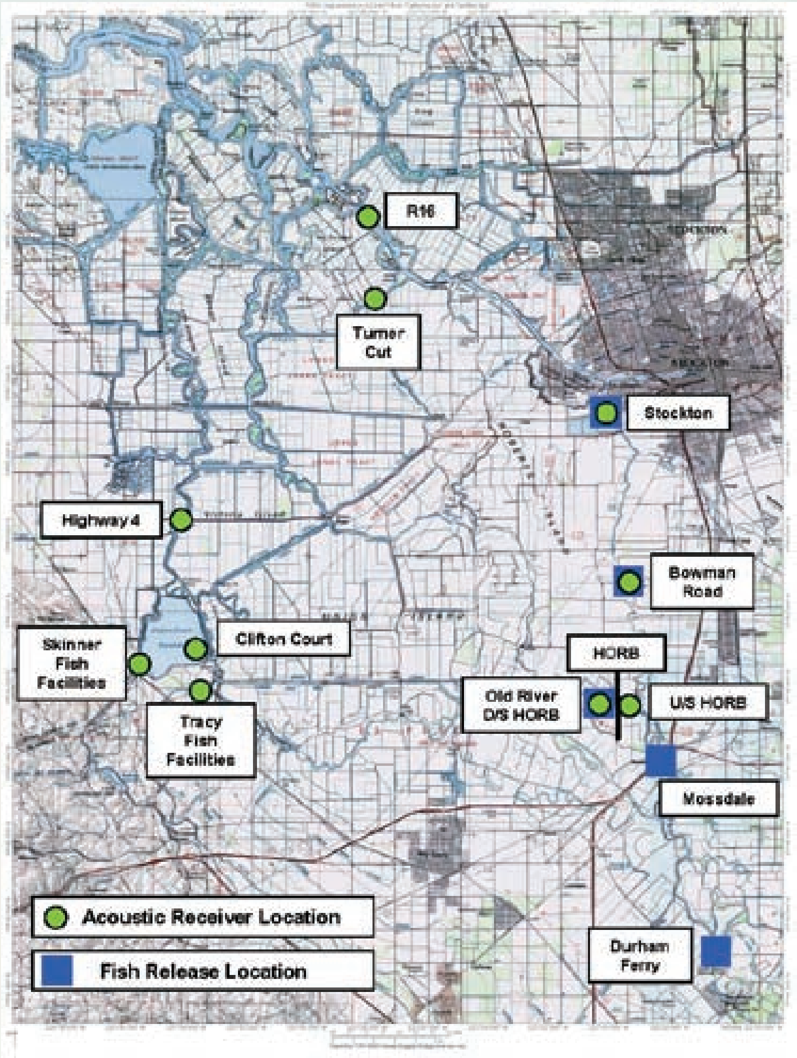
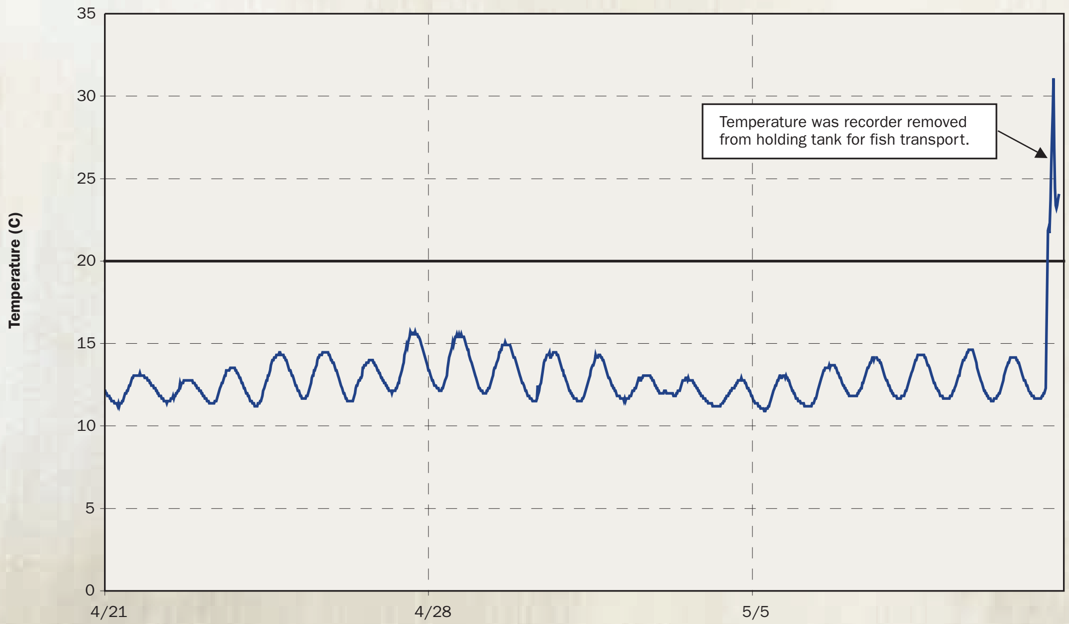


Figure 5-4
Hatchery 1, Water Temperature in Holding Tank



Joaquin River through the Delta. Water temperature was recorded at 24-minute intervals throughout the period of the VAMP 2007 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 (Appendix C-1).

A number of temperature recorders deployed as part of this year's VAMP temperature monitoring could not be relocated and were probably lost to vandalism or removed by recreational boaters.

Results of water temperature monitoring within the Merced River Hatchery showed that juvenile Chinook salmon were reared in, and acclimated to, water temperatures of approximately 11°- 16° C (52° - 61° F) prior to release into the lower San Joaquin River (Figures 5-4 and 5-5; Appendix C-2). Results of water temperature monitoring at Durham Ferry, Dos Reis, and Werner Cut, near Woodward Island, during the April-June fall-run Chinook salmon smolt emigration from the San Joaquin River through the Delta are shown in Figures 5-6, 5-7, and 5-8. 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 5-6, 5-7, and 5-8 ; Appendix C-2) were within a range considered to be suitable (typically < 20 C; 68 F) during April and May in the mainstem San Joaquin River (e.g., Durham Ferry, Old River at HORB, and Dos Reis (Appendix C-2) but exceeded 20 C (68 F) further downstream within the Delta (e.g., Old River/Indian Slough Confluence, Werner Cut – Channel above Woodward Isle; Appendix C-2). Results of the 2007 water temperature monitoring showed a longitudinal gradient of temperatures that generally increased as a function of distance downstream within the mainstem river and Delta. 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 2007 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, however temperatures during the late May and June were within the range considered to be stressful for juvenile Chinook salmon.

Net Pen and Health Assessments

A fish health assessment was conducted to determine if delayed mortality would occur in the acoustically tagged fish. For the first set of releases, 10 fish tagged with "dummy" tags were held in net pens at both Mossdale and Durham Ferry. For the second release, 20 tagged fish were held at each of the same locations. Fish were transported similarly to the other tagged fish but instead of releasing them they were placed into a net pen, held for 48 hours and then assessed for condition.. After 48 hours, fish were removed from the net pens, euthanized and examined. Each fish was measured (fork length in millimeters) and examined for scale loss, color, fin hemorrhaging, eye condition and gill color. One fish from the first Mossdale release died during the 48 hour period. One other, from the second Mossdale release had caudal fin hemorrhaging. All other characteristics examined were normal (Appendix C-3).

Dummy-tagged fish were also held at the hatchery. One set of 10 fish were tagged during the first week of tagging, on 4/30 and a second set of 10 fish were tagged during the second week of tagging on 5/7. Both sets of fish were euthanized on May 14th and examined for the same parameters as above. No mortalities were observed from either of the two groups and the condition characteristics assessed were normal.

Health and Physiological Tests

Ten fish from the first Durham Ferry and Mossdale releases (five from each location) and the twenty fish from the hatchery were used to obtain kidney samples for histological examination by the USFWS California/ Nevada Fish Health Center. Prior VAMP studies using coded wire tag fish from Merced River Hatchery has regularly found infection by the parasite (*T. bryosalmonae*) that causes Proliferative kidney disease. Findings for the samples in 2007 indicated that all 30 fish examined were infected with *T. bryosalmonae* (Table 5-2). Kidney lesions were observed in 5 of the 30 infected kidney sections. Short term survival (<2 weeks) was not likely influenced by these infections; however, Proliferative Kidney Disease is progressive and can continue after fish enter the ocean.

Table 5-2
Incidence and severity of Tetracapsuloides bryosalmonae in VAMP dummy-tagged acoustic groups released in 2007.

Group	Infected	Clinical
MRH1	10-Oct	10-Feb
MRH2	10-Oct	10-Mar
Durham Ferry	5-May	0/5
Mossdale	5-May	0/5

Figure 5-5
Hatchery 2, Water Temperature in Holding Tank

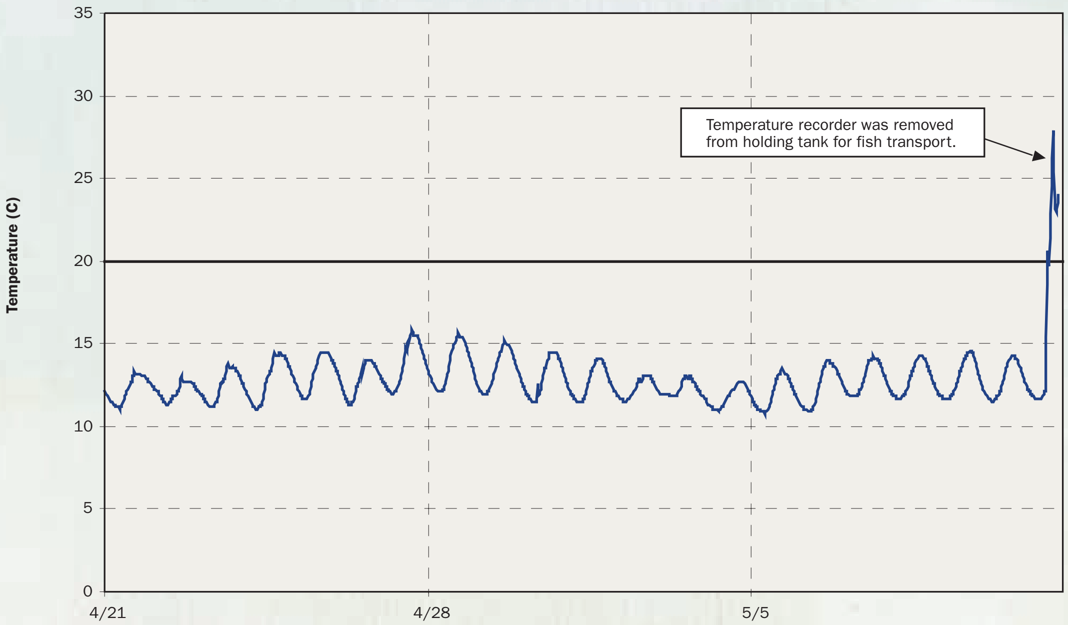


Figure 5-6
Water Temperature Monitoring at Durham Ferry

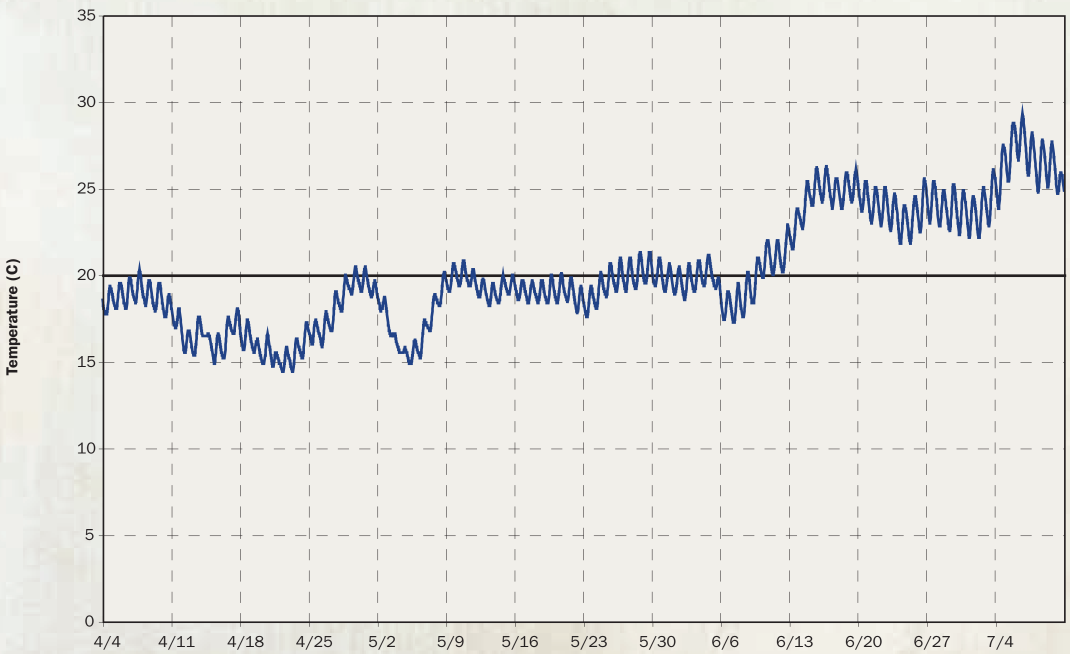


Figure 5-7
Water Temperature Monitoring at Dos Reis

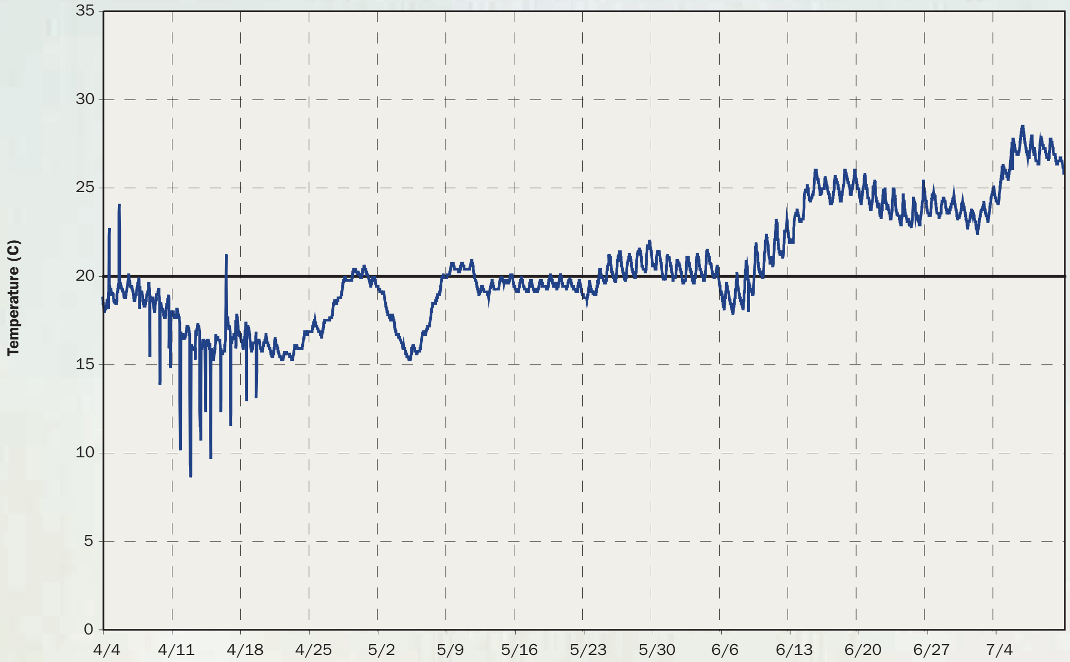


Figure 5-8
Water Temperature Monitoring at Werner Cut - Channel above Woodward Isle

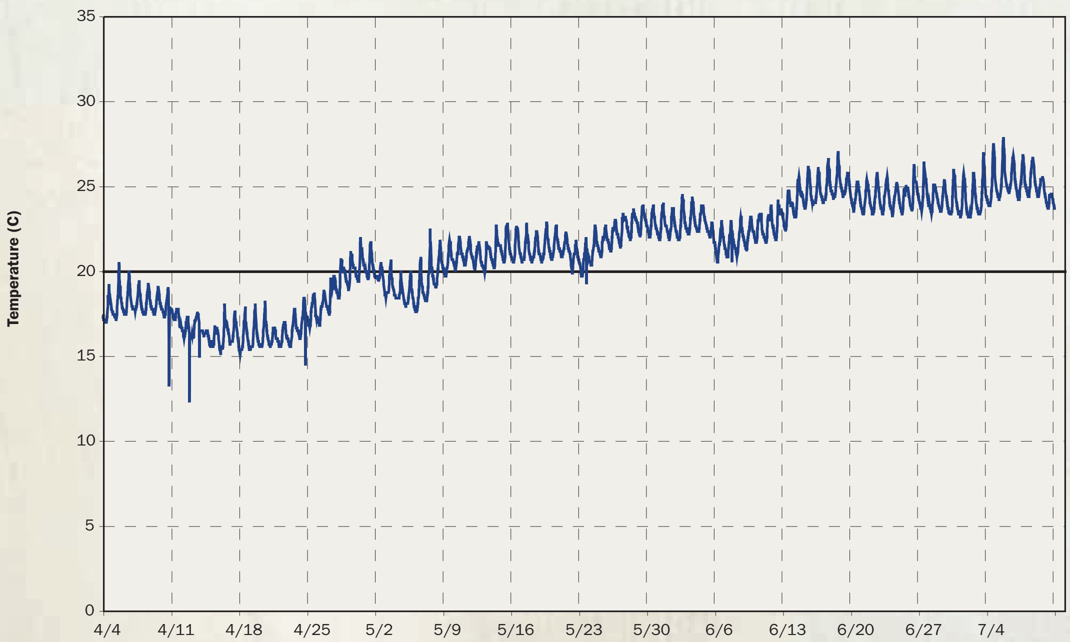


Figure 5-9
Typical deployment of acoustic receiver (Vogel 2006).

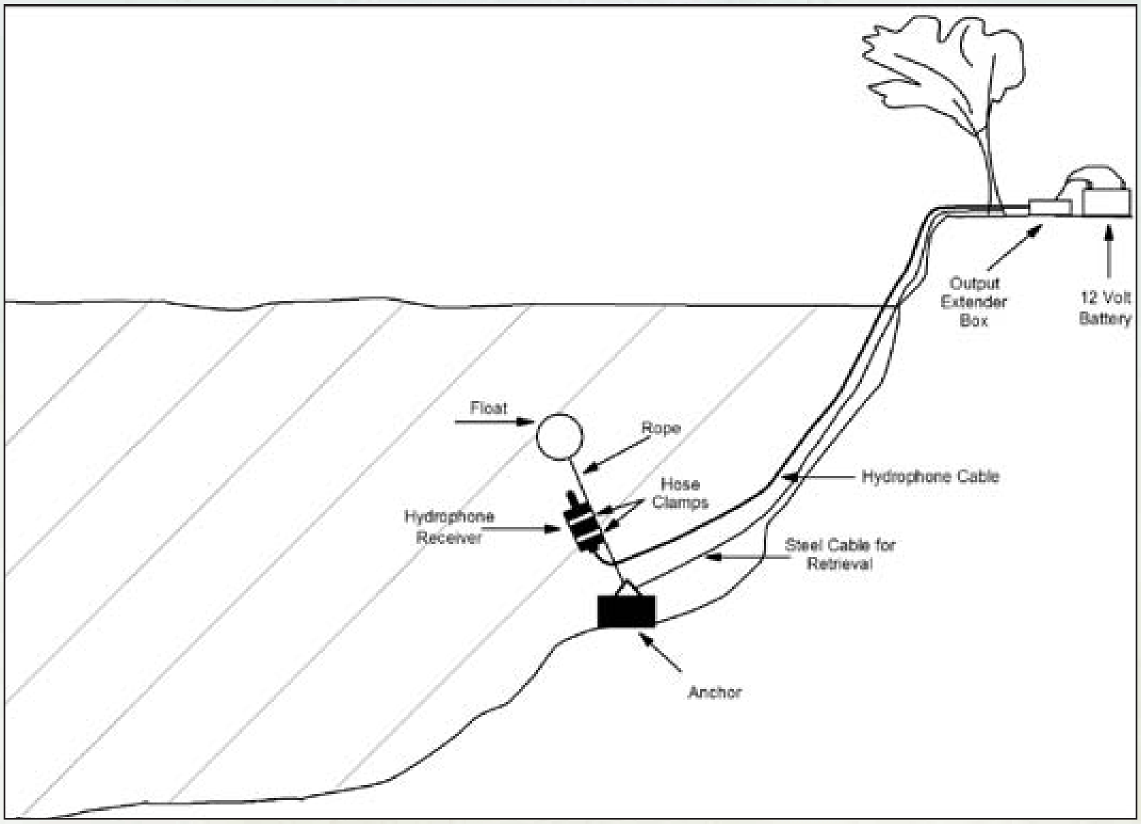
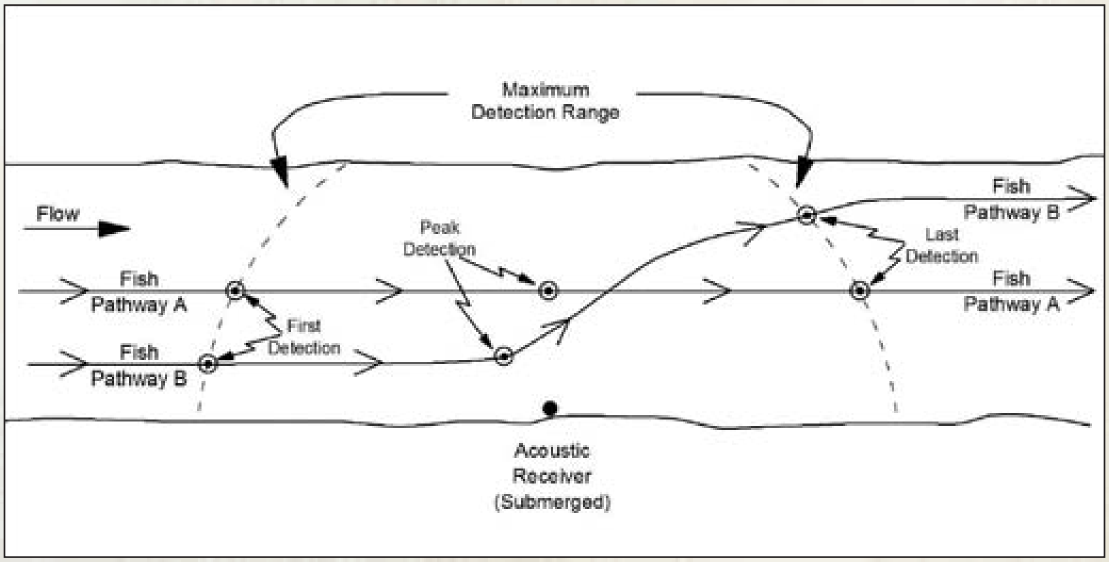


Figure 5-10
Typical acoustic receiver detection range (Vogel 2006).



CHAPTER 5

Detection of Acoustic-Tagged Fish

Ten HTI acoustic receivers were distributed at various locations in the south and central Delta to detect acoustic-tagged fish as they migrated through the Delta (Figure 5-3). The fixed-station receivers electronically logged a time stamp when each individually-identifiable tag passed the sites. Figure 5-9 shows an example deployment of a receiver in the Delta. The receivers were positioned in the channel to provide coverage across the channel to detect acoustic-tagged salmon (Figure 5-10). As previously mentioned, additional receiver sites were planned for Chipps Island and Jersey Point although logistical constraints prevented equipment being deployed. The USGS's Acoustic Doppler Current Profiler (ADCP) created frequency interference at Jersey Point and debris at the bottom of the channel at Chipps Island created logistical obstacles of laying miles of cable that could not be overcome in the timeframe available.

The ten locations where receivers were deployed in 2007 were:

1) San Joaquin River near the head of the HORB (U/S HORB),

2) Old River just downstream of the HORB (D/S HORB),

3) San Joaquin River near Bowman Road,

4) San Joaquin River near the Stockton Waste Water Treatment Plant,

5) Turner Cut,

6) San Joaquin River downstream of Turner Cut (R16),

7) Old River north of Clifton Court Forebay (Highway 4),

8) Inlet to Clifton Court Forebay (CCF),

9) Skinner Fish Facility (FF), and

10) Tracy Fish Facility (FF) (Figure 5-3).

Fish releases at Old River, Bowman Road, and Stockton were made near the acoustic receivers (Figure 3) to verify that tags were functioning at the time of release. A mobile receiver was used at the Durham Ferry and Mossdale release sites to confirm that transmitters were functioning just prior to the fish release.

Fish Transit Time

Because each acoustic receiver recorded the detection time of acoustic-tagged salmon within reception range (Figure 5-10) and each acoustic transmitter was individually identifiable, transit times and migration rates from release locations to each receiver site could be calculated. These calculations used the time of first detection by a receiver and the estimated in-channel distances between sites. Actual average speed of fish in the water would likely be faster because fish may not

take the most-direct route between locations. Net fish migration rates in the San Joaquin River were more rapid in upstream reaches as compared to downstream reaches (Tables 5-3 and 5-4), a phenomenon attributed to tidal influence further downstream. Fish released at Durham Ferry generally took about one day to reach the Old River flow split, whereas fish released at Mossdale took only about four hours. Fish released at Mossdale and Durham Ferry took about one to two days to reach Stockton, respectively. Although the sample sizes were small in the downstream-most areas, fish released at Durham Ferry and Mossdale took about three to six days to reach the San Joaquin River near R16 or Turner Cut. Fish released at Bowman Road took about a day and a half to reach Stockton. Fish released at Stockton exhibited the slowest overall net migration rates due to the large tidal seiching effects on fish migration in the lower San Joaquin River. Fish released in Old River just downstream of the HORB exhibited much slower migration rates than fish released in the San Joaquin River, undoubtedly because of the lower flows and slower water in Old River, Grant Line Canal, and Fabian

Table 5-3
Average transit time in hours (h), standard deviation (in parentheses), range in times (h), and average migration rate (mph) from fish release location to fish detection location during the first week of fish releases (May 3 – 4, 2007).

Release Site	Detection Location				
	U/S HORB	Bowman Road	Stockton	Turner Cut	R16
Durham Ferry **N = 98 fish**	N = 69 fish 29.3 h (23.1 h) 12.2 h – 162.5 h 0.50 mph	N = 66 fish 35.6 h (18.0 h) 17.8 h – 98.9 h 0.58 mph	N = 25 fish 50.9 h (23.8 h) 26.2 h – 101.9 h 0.52 mph	N = 6 fish 78.9 h (20.5 h) 64.5 h – 115.0 h 0.47 mph	N = 9 fish 161.5 h (56.1 h) 123.4 h – 302.7 h 0.23 mph
Mossdale **N = 99 fish**	N = 97 fish 3.6 h (1.8 h) 1.8 h – 10.6 h 0.78 mph	N = 83 fish 14.5 h (7.9 h) 6.7 h – 44.9 h 0.60 mph	N = 33 fish 24.6 h (8.5 h) 19.4 h – 52.6 h 0.58 mph	N = 4 fish 72.4 h (32.4 h) 42.3 h – 105.8 h 0.35 mph	N = 9 fish 154.6 h (31.6 h) 122.6 h – 212.4 h 0.17 mph
Bowman Road **N = 99 fish**			N = 31 fish 34.4 h (14.4 h) 27.3 h – 81.1 h 0.16 mph	N = 2 fish 84.0 h (23.9) 67.1 h – 100.9 h 0.20 mph	N = 4 fish 136.8 h (13.2 h) 123.4 h – 151.0 h 0.12 mph
Stockton **N = 100 fish**				N = 3 fish 50.7 h (10.3 h) 43.5 h – 62.5 h 0.21 mph	N = 9 fish 112.9 h (15.9 h) 98.7 h – 149.8 h 0.10 mph

Table 5-4
Average transit time in hours (h), standard deviation (in parentheses), range in times (h), and average migration rate (mph) from fish release location to fish detection location during the second week of fish releases (May 10 – 11, 2007).

Release Site	Detection Location				
	U/S HORB	Bowman Road	Stockton	Turner Cut	R16
Durham Ferry **N = 96 fish**	N = 56 fish[1] 17.7 h (4.5 h) 9.8 h – 27.4 h 0.83 mph	N = 36 fish 25.7 h (4.8 h) 15.4 h – 34.9 h 0.80 mph	N = 9 fish 41.2 h (10.8 h) 27.0 h – 60.4 h 0.64 mph	N = 1 fish 68.4 h (N.A.) N.A. 0.54 mph	N = 8 fish 75.3 h (11.4 h) 55.4 h – 95.4 h 0.50 mph
Mossdale **N = 97 fish**	N = 95 fish 4.0 h (1.1 h) 2.5 h – 8.1 h 0.70 mph	N = 76 fish 12.2 h (13.0 h) 6.5 h – 103.3 h 0.72 mph	N = 32 fish 22.8 h (11.7 h) 14.4 h – 60.8 h 0.63 mph	N = 7 fish 71.4 h (28.4 h) 37.2 h – 124.9 h 0.35 mph	N = 13 fish 75.6 h (26.8 h) 29.8 h – 143.3 h 0.34 mph
Bowman Road **N = 95 fish**			N = 25 fish 34.0 h (49.2 h) 3.7 h – 201.7 h 0.17 mph	N = 2 fish 63.9 h (17.0) 51.9 h – 76.0 h 0.26 mph	N = 11 fish 48.7 h (14.6 h) 29.0 h – 80.3 h 0.35 mph
Stockton **N = 92 fish**				N = 2 fish 32.1 h (13.7 h) 22.4 h – 41.7 h 0.34 mph	N = 9 fish 44.1 h (15.5 h) 19.6 h – 69.7 h 0.26 mph

[1] The acoustic receiver U/S HORB was not operational from 1800 May 11 to 1400 May 14, 2007 so some of the Durham Ferry fish likely passed the site during that period. Therefore, the data shown is probably biased toward a rapid migration rate and average travel time and migration rate would likely be slower than shown here.

Table 5-5
Average transit time in hours (h), standard deviation (in parentheses), range in times (h), and average migration rate (mph) from fish release location to fish detection location during the first week of fish releases (May 3 – 4, 2007).

Release Site	Detection Location			
	Tracy FF	Clifton Court	Skinner FF	Highway 4
Downstream HORB **N = 99 fish**	N = 22 fish 101.8 h (62.2 h) 33.7 h – 294.5 h 0.15 mph	N = 19 fish 69.0 h (25.3 h) 40.2 h – 115.6 h 0.23 mph	N = 4 fish 96.5 h (31.8 h) 68.0 h – 129.9 h 0.19 mph	N = 23 fish 85.4 h (44.0 h) 50.1 h – 242.2 h 0.24 mph

and Bell Canal. It took about three-and-a-half to four-and-a-half days for fish released in Old River to reach the Tracy FF, CCF, Skinner FF, and Highway 4 (Tables 5-5 and 5-6).

Chinook Salmon Distribution and Survival

Tables 5-7 and 5-8 provide the numbers of acoustic-tagged salmon detected at each acoustic receiver site. During the course of the study there were receivers that either did not work properly during a specific period or were not placed in the river until after some of the tagged fish may have passed by. For instance, the acoustic receiver at U/S HORB was not operational between May 11, 1800 hrs and May 14, 1400 hours. In addition, the acoustic receiver in Clifton Court Forebay did not record data from May 11, 2100 hrs to May 14, 1000 hours. The acoustic receiver placed at the Stockton site had only partial channel coverage during the study and an operational acoustic receiver was not positioned at Channel Marker R16 until May 8 at 1500 hrs due to USGS boat problems. Although the probability of detecting an individual fish does not have to be 100% to estimate survival, it is necessary to have downstream receivers to determine the detection probability for an individual receiver.

The probability of detection of each receiver for each release was estimated using the formula:

$$\hat{p}_i = \frac{r_i}{r_i + z_i} \qquad (1)$$

where i = estimated probability of detection at site i, conditional on the fish being alive at site i.

r_i = the total number of fish detected downstream of site i of those detected at site i and

z_i = the total number of fish that were not detected at site i, but were detected downstream of the site i.

Although detection probabilities were estimated to be 100% or close to 100% for the acoustic receivers positioned just upstream of the HORB and at Bowman Road (Tables 5-9 and 5-10), we know this is incorrect, based on mobile monitoring conducted near Stockton (see later section of this report and Table 5-11). During mobile monitoring near Stockton on May 17 and 18 some tags from both Durham Ferry releases were detected that hadn't been detected previously at any of the stationary monitors upstream (U/S HORB, Bowman Rd., or Stockton). But because this mobile monitoring was not conducted systematically throughout the study period, we could not use these detections to help estimate detection efficiency. We can understand how some of the Durham Ferry fish from the second release likely missed detection at the U/S HORB receiver because it was not operational for three days after release (May 11, 1800 hours to May 14, 1400 hrs.). However, it's not clear how they would have been missed at the Bowman Road receiver or why two tags from the first Durham Ferry release were also not detected at any of the stationary receivers upstream. Given the questionable issues surrounding the Durham Ferry releases, survival estimates obtained using the Durham Ferry release groups are likely more uncertain that those using the Mossdale and Bowman Road release groups to estimate survival to Stockton. Even though the Stockton receiver only had partial coverage of the channel (and low probability of detection) we have tried to account for this limitation when estimating survival

Estimates of Survival

Survival in a reach is based on the number of tags detected and the probability of detection, and is calculated as shown in the following formula:

$$S = \frac{\text{\# detected/(\# released or observed upstream).}}{\text{Detection probability}}$$

Where possible, the survival of the acoustic fish by reach was estimated. Survival by reach is estimated using the proportion detected at the receiver at the end of the reach and the probability of detection by that receiver. Standard errors can also be generated.

The longest reach where survival could be estimated was between Durham Ferry and Stockton. Reaches within this larger reach could also be estimated – Durham Ferry and Mossdale to Upstream HORB, Bowman Road and Stockton. Stockton is the end point to where survival can be estimated because the most downstream receivers were at Turner Cut and R16 and were used to estimate the probability of detection of the Stockton receiver.

Survival down the San Joaquin River for three release groups (Durham Ferry, Mossdale and Bowman Road) was estimated and shown in Figures 5-11 through 5-16. Survival estimates for all reaches between Mossdale and Stockton were relatively high. Survival seemed lower between Durham Ferry and Mossdale. A survival estimate of greater than 1.0, was estimated for the reach between Bowman Road and Stockton for the second Bowman Road release and is likely due to the combination of high survival but low detection probability calculated for the Stockton receiver. Although to confidently make assessments of differences in survival between reaches, standard errors would need to be generated to determine if significant differences exist. For our purposes it is useful to understand how survival can be generated to help plan where to place receivers in 2008 for maximum coverage and for estimating survival by reach.

Table 5-6
Average transit time in hours (h), standard deviation (in parentheses), range in times (h), and average migration rate (mph) from fish release location to fish detection location during the first week of fish releases (May 10 – 11, 2007).

Release Site	Detection Location		
	Tracy FF	Skinner FF[1]	Highway 4
Downstream HORB N = 95 fish	N = 31 fish 69.4 h (31.2 h) 31.8 h – 174.2 h 0.23 mph	N = 3 fish 96.9 h (66.0 h) 52.6 h – 172.7 h 0.19 mph	N = 10 fish 64.6 h (10.3 h) 54.2 h – 82.3 h 0.32 mph

[1] The acoustic receiver at the entrance to CCF was not operational for part of the time during the second fish release and transit times from HORB to CCF could not be determined. However, three fish were detected at Skinner FF which undoubtedly entered CCF during the down time of the CCF receiver.

Table 5-7
Numbers of acoustic-tagged salmon released at five locations on May 3 – 4, 2007 and detected passing acoustic receiver sites[1] (see Figure 3).

Release Location	Location of Acoustic Receivers									
	U/S HORB	D/S HORB	Bowman Road	Stockton[2]	Turner Cut	R16[3]	Tracy FF	Clifton Court	Skinner FF	Hwy 4
Durham Ferry N = 98 fish	69	0	66	25	6	9	0	1	0	1
Mossdale N = 99 fish	97	0	83	33	4	9	1	0	0	1
Bowman Road N = 99 fish	0	0		31	2	4	0	0	0	0
Stockton N = 100 fish	0	0	0		3	9	0	0	0	0
D/S HORB N = 99 fish	1		0	0	0	0	22	19	4	23

[1, 2] The acoustic receiver placed at the Stockton site had only partial channel coverage during the study.

[3] An operational acoustic receiver was not positioned at Channel Marker R16 until May 8 at 1500 hrs due to boat problems.

Table 5-8
Numbers of acoustic-tagged salmon released at five locations on May 10 – 11, 2007 detected at acoustic receiver sites (see Figure 3).

Release Location	Location of Acoustic Receivers									
	U/S HORB[1]	D/S HORB	Bowman Road	Stockton	Turner Cut	R16	Tracy FF	Clifton Court[2]	Skinner FF	Hwy 4
Durham Ferry N = 96 fish	56	2	36	9	1	8	1	0	0	0
Mossdale N = 97 fish	95	0	76	32	7	13	1	0	0	1
Bowman Road N = 95 fish	0	0		25	2	11	0	0	0	0
Stockton N = 92 fish	0	0	0		2	9	1	0	0	0
D/S HORB N = 95 fish	0		0	0	0	0	31	6	3	10

[1] The acoustic receiver at Old River was not operational from 1800 hrs. May 11 to 1400 hrs. May 14, 2007. Based on travel times, some of the Durham Ferry fish likely passed the site during that period whereas all fish released at Mossdale and passing the Old River flow split were assumed to have been detected.

[2] Acoustic receiver did not record data from 2100 hrs. May 11 to 1000 hrs. May 14; fish entering CCF during this period would not have been detected.

Table 5-9 Detection probability for receivers during the first week of releases, May 3-4, 2007.			
Release Locations	Receiver Locations		
	U/S HORB	Bowman Road	Stockton
Durham Ferry N = 98 fish	1	1	0.46
Mossdale N = 99 fish	1	1	0.38
Bowman Road N = 99 fish	–		0.5

Table 5-10 Detection probabilities for receivers during the second week of releases May 10-11, 2007.			
Release	Receiver Locations		
Location	U/S HORB	Bowman Road	Stockton
Durham Ferry N = 96 fish	0.947	0.875	0.125
Mossdale N = 97 fish	1	0.976	0.35
Bowman Road N = 95 fish	–		0.18

Table 5-11 Number of acoustic transmitters detected in the San Joaquin River near the railroad bridge at Stockton on May 17 and 18, 2007. The number never detected elsewhere is included in parentheses.		
Fish Release location	Release Date	Number of Acoustic Tags Detected
Durham Ferry	3-May-07	12 (2)
Mossdale	3-May-07	1 (0)
Bowman Road	4-May-07	5 (2)
Stockton	4-May-07	6 (6)
Durham Ferry	10-May-07	21 (7)
Mossdale	10-May-07	14 (0)
Bowman Road	11-May-07	26 (14)
Stockton	11-May-07	31 (31)

Most fish released at Durham Ferry and Mossdale migrated downstream via the San Joaquin River, although some were found to arrive at the Fish Facilities using multiple pathways. For instance, two individuals (3374, 3381) from the second Durham Ferry release presumably migrated into Old River through the HORB culverts, as they were detected at the receiver in Old River downstream of the HORB (Appendix C-6). One of these individuals (3374) was later detected at the Tracy Fish Facility. One additional individual from the first Durham Ferry release (3294) was detected at the U/S HORB, D/S Bowman Road and at Highway 4 receivers prior to being detected at the Clifton Court Forebay receiver, indicating that it had migrated down the San Joaquin River but turned south at one of the junctions downstream of Bowman Road. In addition, two fish released from Mossdale (3910 from the first release and 3801 from the second release) were detected at the Tracy Fish Facility, with both being detected at the receivers at U/S HORB, Bowman Road, Stockton and Turner Cut, (Appendices C-4 and C-6) One individual (3801) was observed at Hwy 4 after being observed at Tracy while another (3910) was observed at Hwy 4 prior to being detected at the Federal Fish Facility.

In at least one case, a fish released at Stockton also migrated to the Tracy Fish Facility. One individual from the second Stockton release (5978) was detected at the Tracy Fish Facility after being detected at R16 (Appendix C-6). These cases seem to show that not only do juvenile salmon migrate through the culverts of the HORB to arrive at the Fish Facilities, they also get there through Turner Cut or from other areas further downstream in the San Joaquin River.

Figure 5-11
Survival by reach for fish released at Durham Ferry during the first week of releases

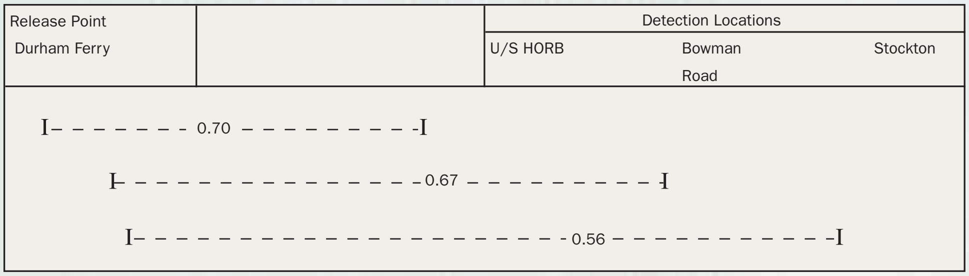


Figure 5-12
Survival by reach for fish released at Mossdale during the first week of releases

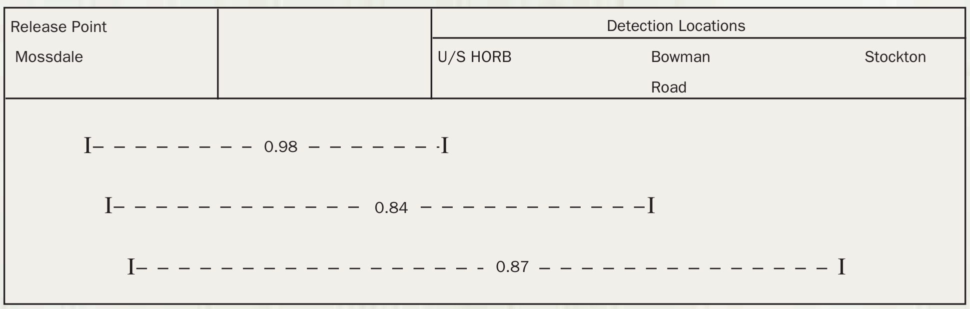


Figure 5-13
Survival by reach for fish released at Bowman Road during the first week of releases

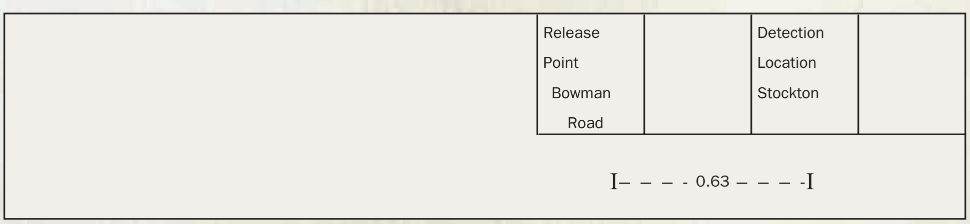


Figure 5-14

Survival by reach for fish released at Durham Ferry during the second week of releases

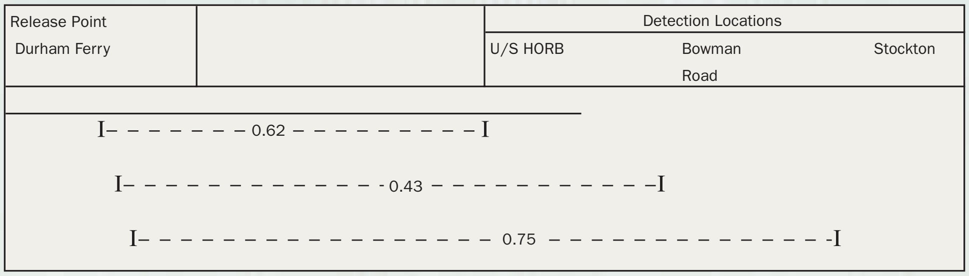


Figure 5-15

Survival by reach for fish released at Mossdale during the second week of releases

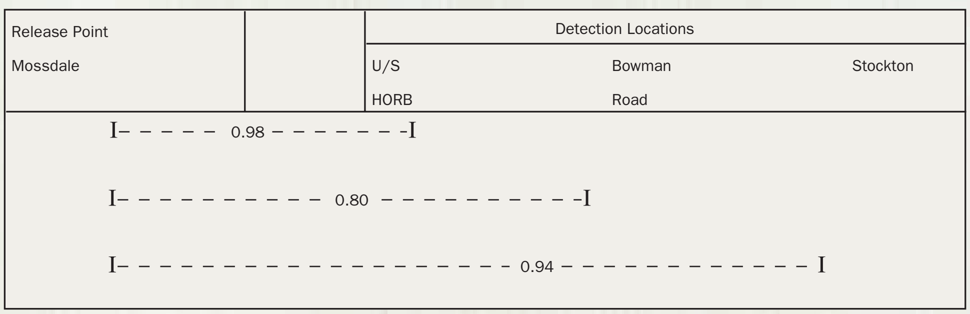


Figure 5-16

Survival by reach for fish released at Bowman Road during the second week of releases

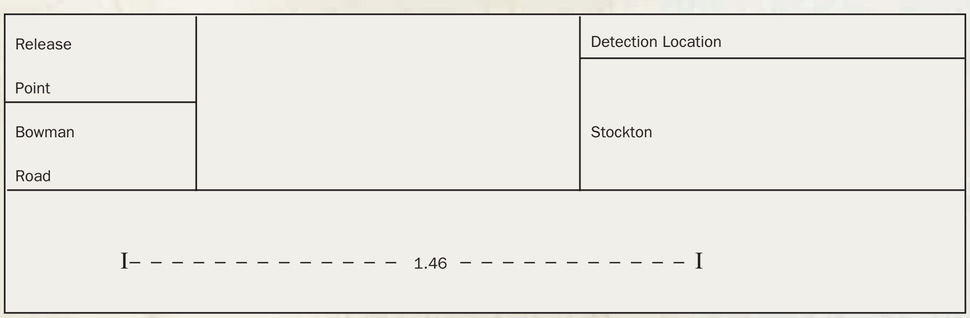


Figure 5-17
Lower San Jaoquin River near Stockton

Head Of Old River Barrier Releases

Survival was not estimated for the group of tagged fish released in Old River, downstream of HORB, because there were insufficient acoustic receivers to provide coverage in all channels where fish could subsequently migrate (e.g., Middle River, Victoria Canal). However, these fish were detected downstream at the Tracy Fish Facility near Tracy, at the entrance to Clifton Court Forebay (CCF), at the Skinner Fish Facility, and in Old River at the Highway 4 Bridge. Of the 99 fish released for the first release, 22 were detected at the Tracy FF, 19 at CCF, and 23 at Highway 4. Some of the fish were detected at more than one of the locations, with fish being detected at CCFB or Hwy 4 after being detected at Tracy or being detected at Tracy or CCFB after being detected at Hwy 4 (Appendix C-5). In one case, an individual (4673) was detected at Tracy after it had been detected in CCFB (perhaps inside a predator). If we assume the remaining 18 salmon detected in CCFB were in live salmon and stayed in CCFB, we can estimate survival through the Forebay. With four individuals detected at the Skinner FF, we estimate survival across Clifton Court Forebay to be 22% assuming 100% detection probability at both locations.

In addition, one of the individuals (4799) from the first release in Old River was detected at the U/S HORB receiver indicating that it had moved through the HORB culverts to the San Joaquin River. This tag was likely in a preditor as it would seem unusual for a salmon to move against the flow through a HORB culvert.

During the second week of fish releases in Old River, the CCF receiver did not record data a portion of the time when fish could have entered the Forebay. This was empirically documented when 3 fish detected at the Skinner FF were not detected by the CCF receiver (Appendix C-7). Of the 95 salmon released in Old River during the second week, 31 were detected at the Tracy FF and 10 at Highway 4. Again, some of these individuals were detected at more than one location (Appendix C-7). For instance, three fish detected at Tracy were also later detected at Skinner (4424) and at Hwy 4 (4515, 4760). One of these (4424) had also been detected previously at Hwy 4. One of the three fish detected in CCF (5096) had previously been detected at Tracy. For both weeks of fish releases in Old River, the numbers detected at the receivers in the south Delta were higher than we assumed; our assumption was that the numbers would have been very low because of slow water, longer exposure time to predators and unscreened diversions, and routes where fish could have migrated without detection.

Mobile Monitoring

A week after the last fish releases, a mobile acoustic receiver was used in several Delta channels in an attempt to locate non-moving transmitters. During mobile monitoring in the San Joaquin River from Mossdale to the Stockton Deep Water Ship Channel, a high number of acoustic transmitters were detected at a very small, localized site at Stockton. The area was approximately 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 waste water treatment facilities (Figure 5-17). This site was just downstream of our stationary receiver and release site near the Stockton waste water treatment facility. A total of 116 tags were found at this site which included some fish from all of the releases made on the San Joaquin River during the two weeks of releases (Table 5-11). This may be a minimum number lost at that location as the mobile monitoring was done on May 17 and 18 after the battery life of some of the tags from the first week fish releases 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 found that the waste water treatment facility was in compliance with discharge permit requirements. The cause of this high mortality remains unknown, but this area was apparently a hostile place for juvenile salmon in May.

The history of some of these individual tags was odd in that some had moved downstream past this site earlier and many of the others had never been detected upstream. For instance, three tags observed at this site from the first Durham Ferry release had been detected at R16, 9 -10 days earlier. In addition, a total of ten individuals detected in the mobile monitoring from the releases at Durham Ferry (3441, 3042, 3140, 3017, 3031, 3094, 3115, 3150, 3157, 3185), had never been detected at any of the receivers upstream (Table 5-11). Because the receiver at the HORB was not operating between May 11 and May 14, it is likely that some of the fish released on May 10 at Durham Ferry may have passed that receiver without being detected becausue it took about a day for the Durham Ferry fish to reach the HORB. However, it is unclear why they wouldn't have been detected at Bowman Road. It is also understandable that they weren't detected at receivers at Stockton, in Turner Cut and at R16 as the receivers weren't very efficient because they weren't covering the entire channel. In addition, two of the eight fish detected at R16 from the second release at Durham Ferry were also never detected upstream (Appendix C-6). It is noteworthy that these odd cases were restricted to fish released at Durham Ferry. All of the fish detected in the mobile monitoring at Stockton from the Mossdale releases had been detected at the upstream receivers (Appendices C-4 and C-6).

There were indications of piscivorous predation on some of the acoustic-tagged salmon during the study. Uncharacteristic behavior of an acoustic-tagged salmon compared to the majority of observed behavior patterns suggested some tagged fish were consumed by a predator and the transmitter inside the predator was subsequently detected passing a receiver. For example, there were instances where a transmitter was detected in a sequential downstream direction then eventually moved back upstream. Although predation could not be empirically confirmed in these cases, this behavior was considered unlikely for a salmon smolt. There were some instances where predation could be confirmed because of multiple predation events on acoustic-tagged salmon by a single predator (e.g., a predator eating two acoustic-tagged salmon). In one instance, one predator ate four acoustic-tagged salmon. This phenomenon can be observed during data processing which shows identical detailed movements of transmitters. Lastly, the acoustic receivers can determine if a transmitter remains motionless. In these latter cases, fish mortality was certain but the reason for the mortality could not be determined.

An additional site of relatively high fish mortality was located at the head of Old River flow split downstream of Mossdale. In 2006, five acoustic transmitters among 100 fish released at Mossdale were located at the same site. Based on observations of striped bass feeding activity in this area during the 2006 VAMP study, it was hypothesized that acoustic-tagged salmon were consumed by predatory fish and the transmitters were subsequently defecated and deposited on the bottom of the channel. A description of the unusual scour hole near the Old River flow split is provided in the 2006 VAMP Annual Report (SJRGA 2007). In 2007, it appeared that 19 acoustic-tagged salmon from both weeks of fish releases may have been preyed on in the same vicinity.

Numerous acoustic transmitters were also located in front of the trash racks just upstream of the Tracy FF. As with other sites where motionless transmitters were found or the transmitters exhibited unusual movements, it could not be determined where the acoustic-tagged salmon were preyed upon, only where the transmitters were found. For example, an acoustic-tagged salmon could have been eaten by a predator at another location and the predator subsequently swam to the Tracy FF trashracks where the tag was detected for long periods (anomalous behavior for a smolt at this location) or was defecated (motionless transmitter). Alternatively, the acoustic-tagged salmon may have followed the flow toward the Tracy FF but were eaten by predators residing in front of the trashracks. A total

Table 5-12
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 Recovs. (Age 1+ to 4+) Total	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 5-12
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 Recovs. (Age 1+ to 4+) Total	Chipps Island	Antioch	DRR or CDRR	Ocean DRR
		CWT Smolt Releases						Absolute Survival Estimates		Differential Recovery Rates	
	06-44-60	24,128	Jersey Point	22-Apr-02	37	89	456				
	Effective Release	97,715	Durham Ferry		21	63	270	0.130	0.160	0.154	0.142
	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				
2002	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	117				
	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	117				
2005	06-46-72	23,414	Durham Ferry	2-May-05	5	0	0				
	06-46-73	23,193	Durham Ferry	2-May-05	2	2	0				
	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	3				
	Effective Release	93,834	Durham Ferry		12	6	3	0.099	0.049	0.069	0.243
	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	3				
	06-45-84	22,777	Durham Ferry	9-May-05	2	1	0				
	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	0				
	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	0				
	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	14				
	Effective Release	91,563	Durham Ferry		6	7	0	0.044	0.094	0.051	0.000
	Effective Release	68,646	Dos Reis		6	7	0	0.058	0.127	0.068	0.000
	Effective Release	23,231	Jersey Point		38	27	14				
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				

Note: Ocean recoveries are based on data through 2006

of 57 transmitters were detected just upstream of the Tracy FF trashracks and potentially had been consumed by predators. Fifty-three acoustic tagged fish were detected at the stationary receiver at the Tracy FF from the downstream of HORB release. Four of these were later detected at other locations (Skinner, CCFB or Hwy 4). Determining which acoustic tagged fish have been eaten with certainty is problematic.

A limitation of the acoustic tag methodology is the ability to determine whether a tag is still inside a live juvenile salmon. Without this assurance it is possible that survival is biased. Although some types of behavior do indicate the tagged fish has been eaten, or that the fish has died, there are probably some cases where fish are assumed to be live and they are not. Thus it is likely survival would be over-estimated using these methods. Traditional coded-wire tag VAMP studies did not have this limitation, although they had other technical challenges.

Comparison with 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 2006. 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 2002 and partially available for CWT releases made from 2003 to 2005 - no ocean recovery data is available yet for the 2006 releases. 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 5-12. 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 5-18.

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 (r^2=0.76), (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 VAMP releases for recoveries at Antioch, Chipps Island, and 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 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 typical time period for VAMP (April 15 to May 15) was chosen based on historical data that indicated a high percentage of the juvenile salmon emigrating from the San Joaquin tributaries passed into the Delta at Mossdale during that time. The peak average catch per 10,000 cubic meters per day of unmarked juvenile salmon captured at Mossdale occurred on 23 Apr - densities may have been as high or higher on 21-22 Apr when no sampling was conducted at Mossdale and river flows were increasing. In 2007, the VAMP period was April 22 to May 22. The average daily density of unmarked juvenile salmon caught in Kodiak trawling at Mossdale during January through June is shown in Figure 5-19. Unmarked salmon do not have an adipose clip and can be juveniles from natural spawning or unmarked hatchery fish from the MRH. On May 15 a total of 35,756 unmarked smolts were released at MRH and this was the only release of unmarked hatchery smolts from MRH conducted during 2007. Peak density of unmarked juvenile salmon at Mossdale was observed on April 23 and immediately followed the leading edge of the VAMP

Figure 5-18

Comparison of Antioch and Chipps Island survival estimates and differential or combined differential recovery rates compared to differential ocean recovery rates for 1996-2006 CWT releases.

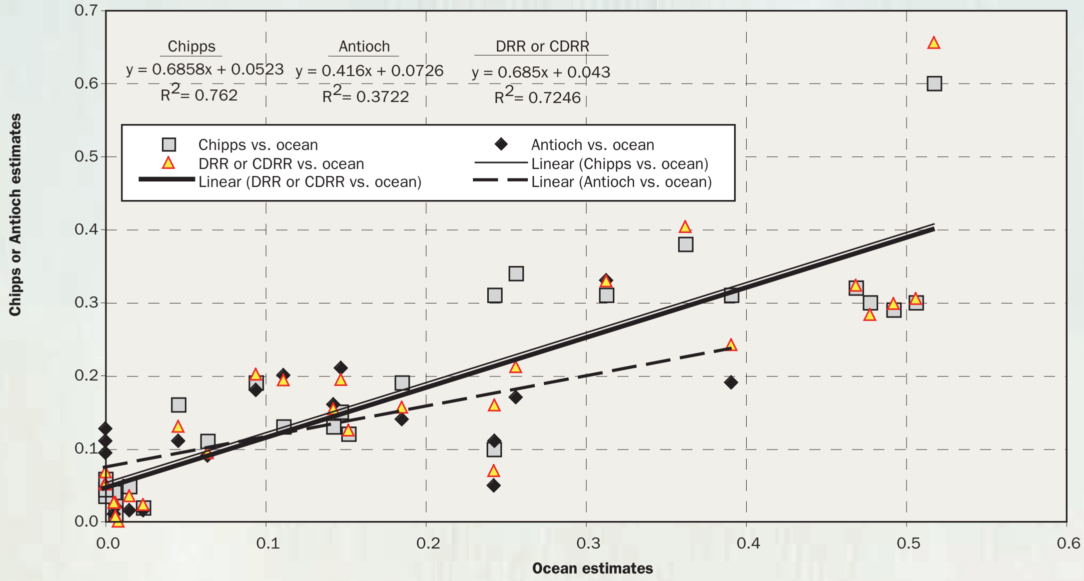
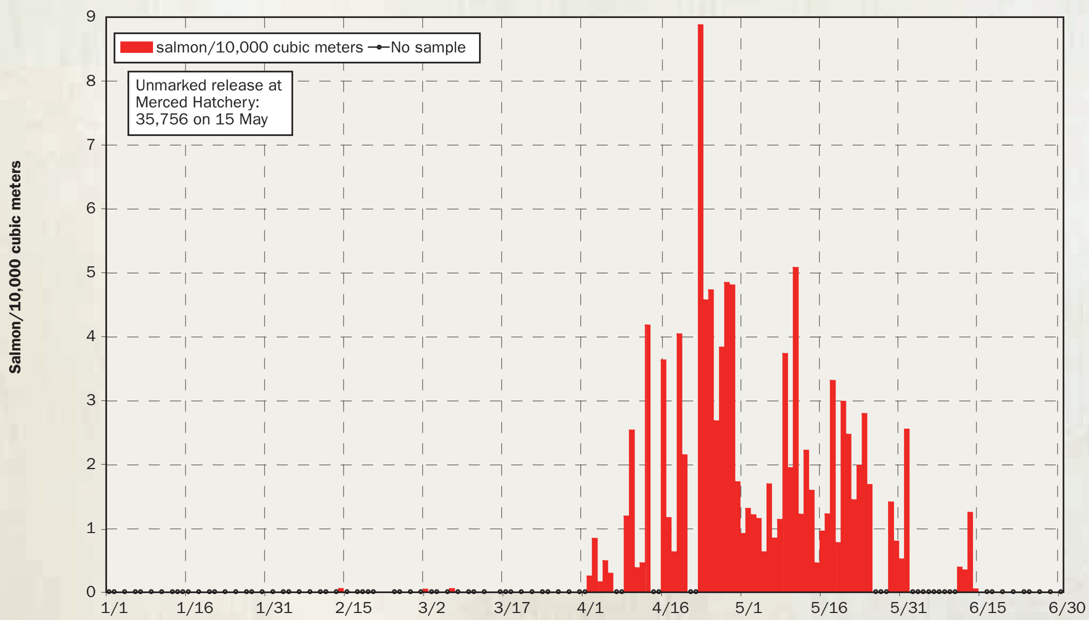


Figure 5-19

Average daily densities of unmarked salmon caught in the Mossdale Kodiak



pulse flow. (Figure 5-19). The size of the juvenile salmon captured in the Mossdale trawl during January through June is shown in Figure 5-20. Recaptures of adipose fin-clipped CWT salmon released at Merced River Hatchery on 20 Apr and 4 May and at Hatfield on 24-26 Apr and 08-09 May were prominent in the catch at Mossdale during 27-30 Apr and 9-13 May. The adipose fin clipped juvenile salmon captured at Mossdale on 04 April was a wild migrant captured and tagged on the Stanislaus River at Caswell.

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 CWT recovery data for MRH smolts at the salvage facilities to provide indications as to the origin of the unmarked fish.

The estimated salmon losses at the CVP and SWP facilities 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 Clifton Court Forebay. The SWP loss estimates 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 pre-smolts), so their salvage numbers and estimated losses are underrepresented.

The weekly data covering the period of April 23 to May 20 approximated the 2007 VAMP period. A review of weekly data for January through June indicates that the highest CVP salvage and losses occurred during the two weeks preceding the VAMP period, with lesser peaks during early March,(Figure 5-21). Highest SWP salvage and losses occurred during the week immediately preceding the VAMP period, with lesser peaks during early March and early April (Figure 5-22). Salmon densities based on combined salvage and loss estimates were highest at the CVP during the two weeks immediately preceding the VAMP period and during the three weeks immediately following the VAMP period, with a smaller peak during early March (Figure 5-23). At the SWP, salmon densities were highly variable with peak densities occurring immediately preceding the VAMP period, during the VAMP period, and late May into early June (Figure 5-23); lesser peaks were observed during early March and early April. The peak at both facilities during April preceding VAMP occurred when exports greatly exceeded Vernalis flow; the peaks observed after VAMP occurred during decreasing flow and export (Figure 5-24).

The size distribution of unmarked salmon during January through June in the Mossdale trawl (Figure 5-20) generally overlaps with the size distribution of those salvaged at the fish facilities (Figure 5-25, Source E. Chappell, DWR). Based on comparisons with Mossdale data, some salmon salvaged before, during, and after the VAMP period could have been from the San Joaquin basin (Figure 5-19).

The 2007 VAMP test period coincided with part of the peak period of San Joaquin River salmon smolt emigration. The highest daily density observed at Mossdale was on the second day of the VAMP period (April 23), and it is unfortunate that sampling was not conducted during the two days preceding the observed peak when flows were increasing. Smolt abundance and production estimates at Mossdale could be improved by ensuring that sampling is conducted daily when salmon smolts are emigrating. The most concentrated period of estimated losses in 2007 occurred in April prior to VAMP export reduction, as has been recorded in other years. Export curtailments may be more protective if based on real-time migration activity observed at Mossdale or observed salvage/density at the export facilities.

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Figure 5-20

Mossdale Kodiak trawl individual daily forklengths of juvenile Chinook salmon, January through June 2007

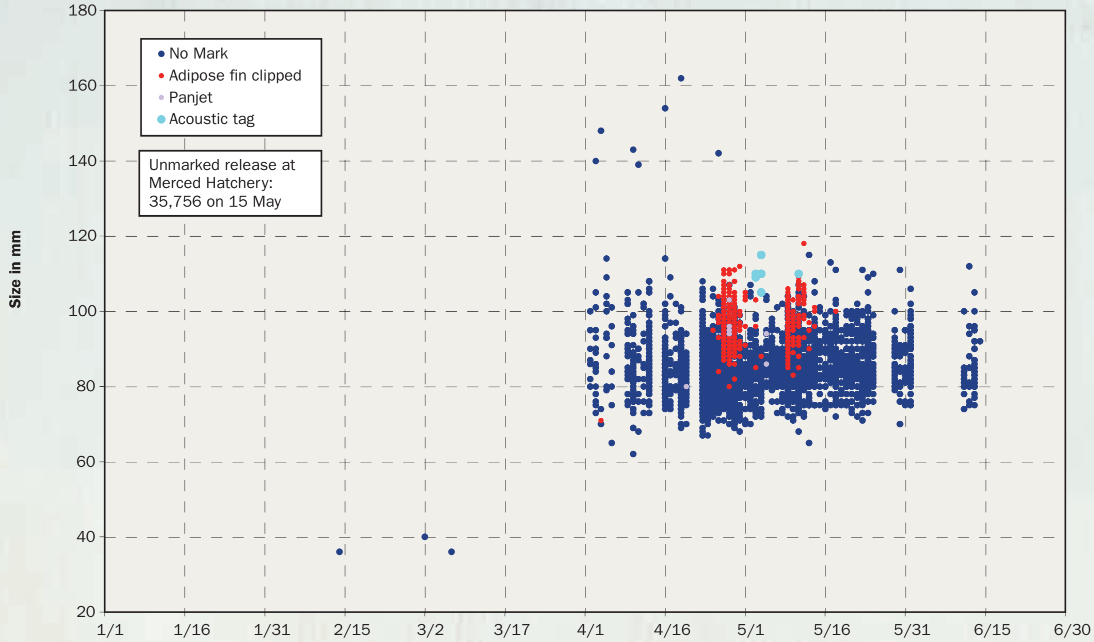


Figure 5-21

2007 CVP estimated salmon salvage and loss

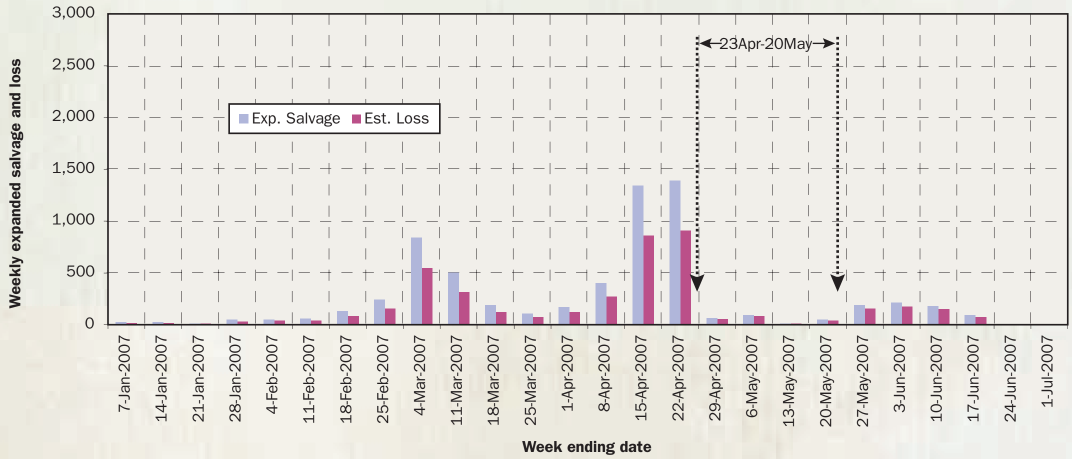


Figure 5-22

2007 SWP estimated salmon salvage and loss

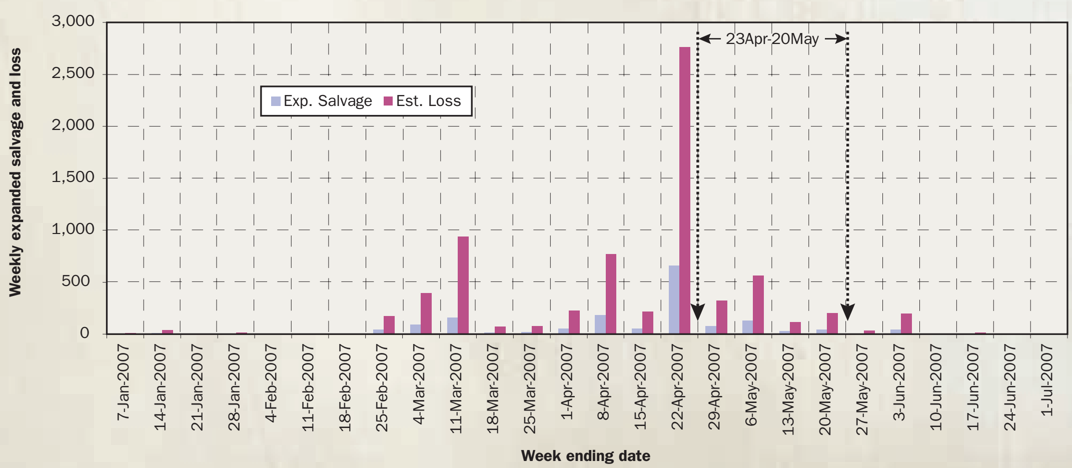


Figure 5-23
2007 SWP & CVP Combined salvage and loss density

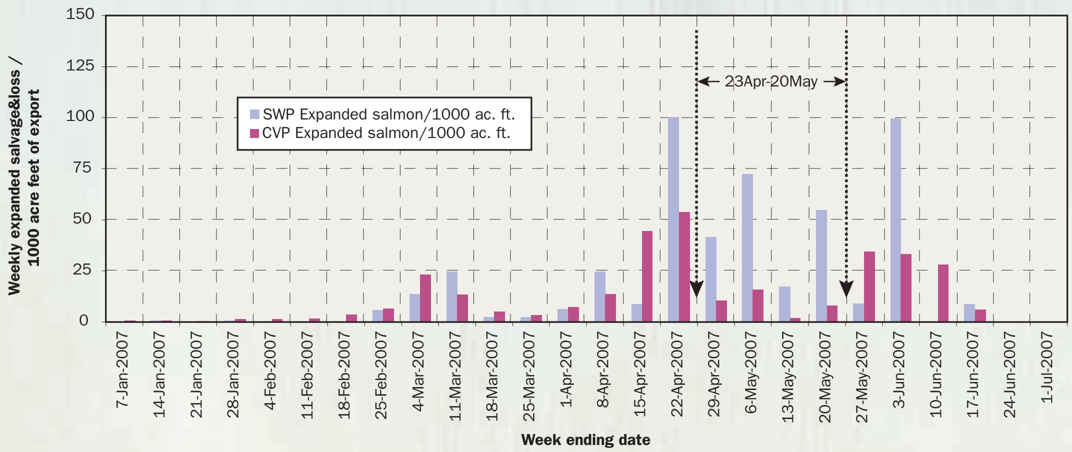


Figure 5-24
2007 weekly export rates and Vernalis flow

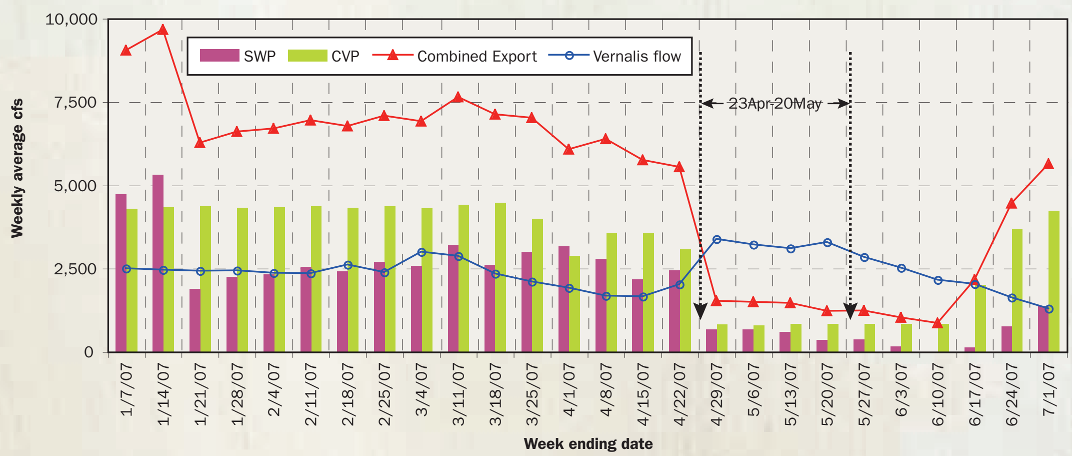
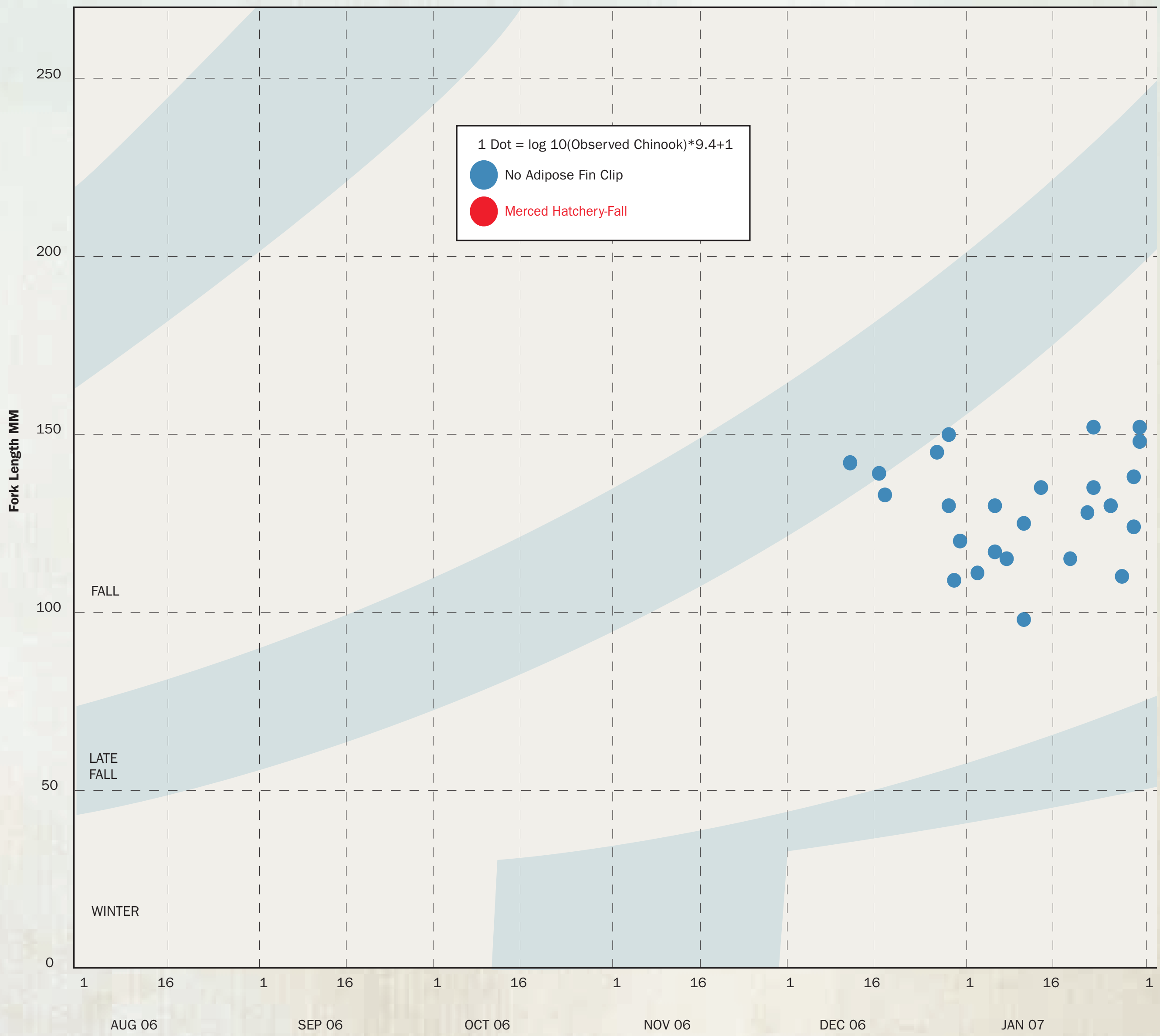
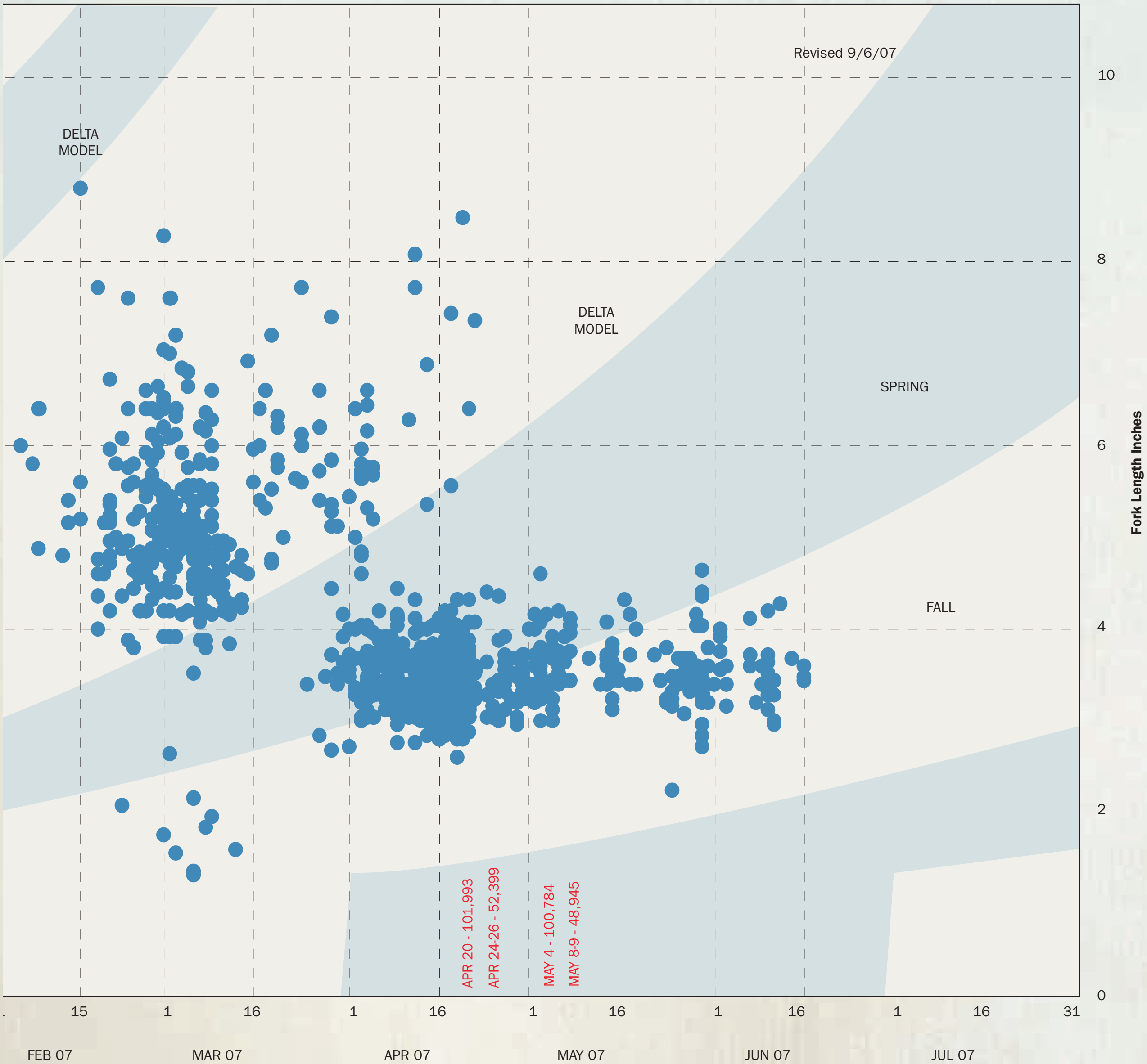


Figure 5-25
Observed Chinook Salvage at the SWP & CVP Delta Fish Facilities 8/1/06 Through 7/31/07




Revised 9/6/07
DELTA
MODEL
DELTA
MODEL
SPRING
FALL
APR 20 - 101,993
APR 24-26 - 52,399
MAY 4 - 100,784
MAY 8-9 - 48,945
10
8
6
4
2
0
Fork Length Inches
15
1
16
1
16
1
16
1
16
1
16
31
FEB 07
MAR 07
APR 07
MAY 07
JUN 07
JUL 07

CHAPTER 6

COMPLIMENTARY STUDIES RELATED TO THE VAMP

Throughout 2007 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, 2007

Contributed by Tim Ford, Turlock and Modesto Irrigation Districts, and Andrea Fuller, 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 2007, 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 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. Stanislaus River RST monitoring was conducted at River Mile (RM) 9 (Caswell site) during 11 Jan – 22 Jun; Tuolumne River RST monitoring was conducted at RM 5 (Grayson site) during 23 Mar – 29 May; and Merced River RST monitoring was conducted at RM 2 (Hatfield site) during 25 Jan - 01 Jun. 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 2 other sites were seined every 2 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 Head of Old River) with a schedule of three days/week 03 Jan – 30 Mar; five days per week 02 Apr – 20 Apr; daily during 23 Apr – 25 May; and three to five days per week during 29 May – 30 Jun. Trawling was suspended during 02 Jun – 10 Jun due to Delta smelt concerns. 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.

The seasonal peak catch of fry in the Stanislaus River RST (Figure 6-2) occurred on March 1 following increasing reservoir releases and rain events during 25 Feb – 01 Mar. The Merced River RST sampling suggests that fry did not migrate out of the Merced River during 2007 (Figure 6-3). RST sampling was not conducted during the fry outmigration season on the Tuolumne River, but Tuolumne seining recorded no salmon down to, or below, Modesto, where Dry Creek runoff enters the river, thus fry outmigration also likely did not occur in the Tuolumne River (Figure 6-4). Relatively few early fish were observed at the Mossdale trawl (Figure 6-5). It appears that peak fry migration from the Stanislaus River in 2007 was not detected at Mossdale indicating that the juveniles may have remained in the lower San Joaquin River above Mossdale and/or the relative efficiency of the trawl for fry-size salmon is less than at the rotary screw trap. However, high densities of fry at Mossdale have been detected by the Mossdale trawl in other years (SJRGA 2005). Seasonal peak catch occurred at Mossdale on 23 Apr (Figure 6-5), shortly after peak smolt catches on the Stanislaus River on 21 Apr (Figure 6-2) and coincident to the peak densities recorded at the salvage facilities (Figure 5-23). Many salmon may have also passed Mossdale undetected during 21-22 Apr as a result of no sampling effort on these days. Seasonal peak catches were observed on the Merced River on 24 Apr (Figure 6-3) and on the Tuolumne River during

Figure 6-1
San Joaquin Basin Flows and Rainfall

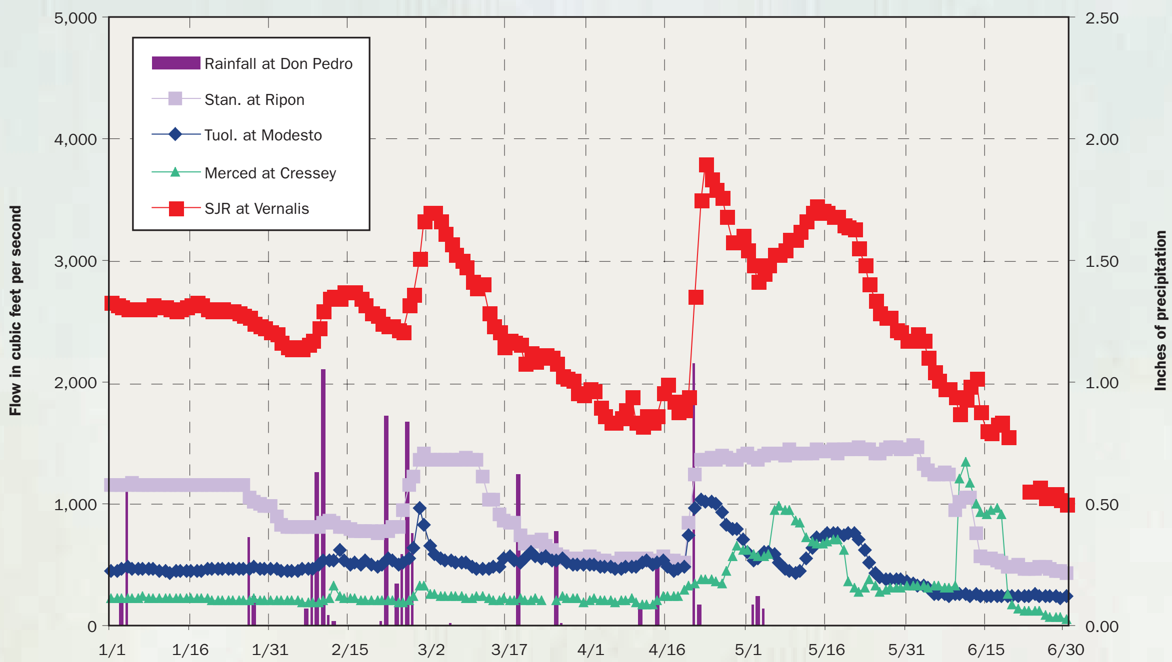


Figure 6-2
Stanislaus screw trap catch of unmarked juvenile Chinook salmon

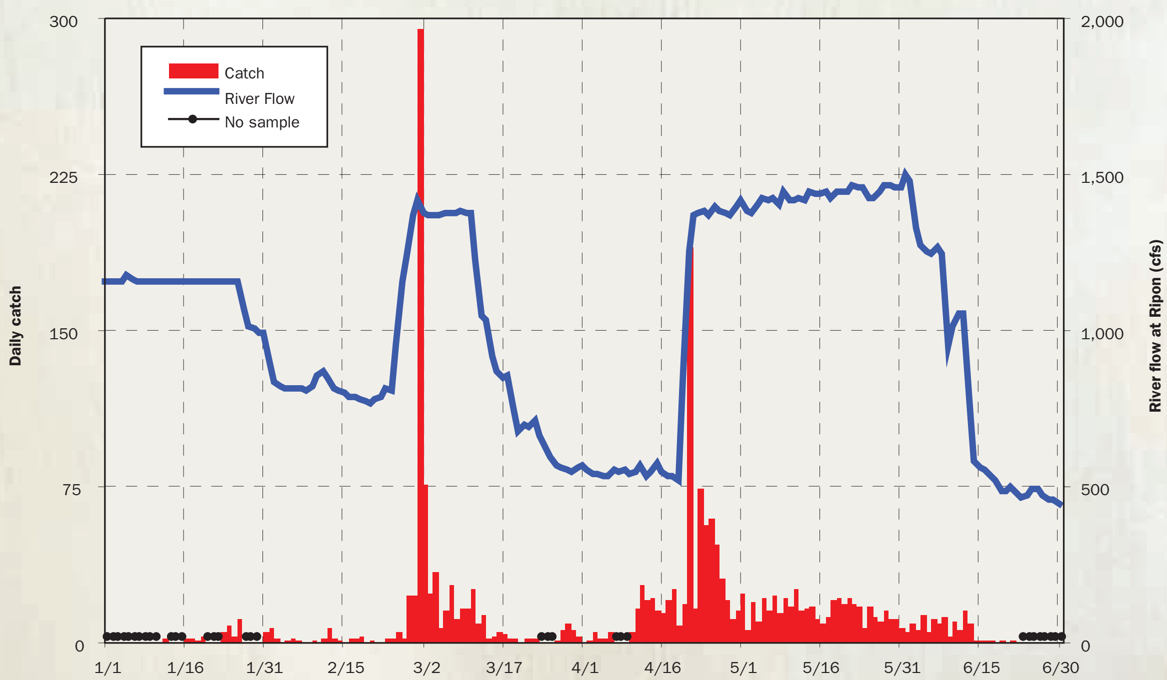
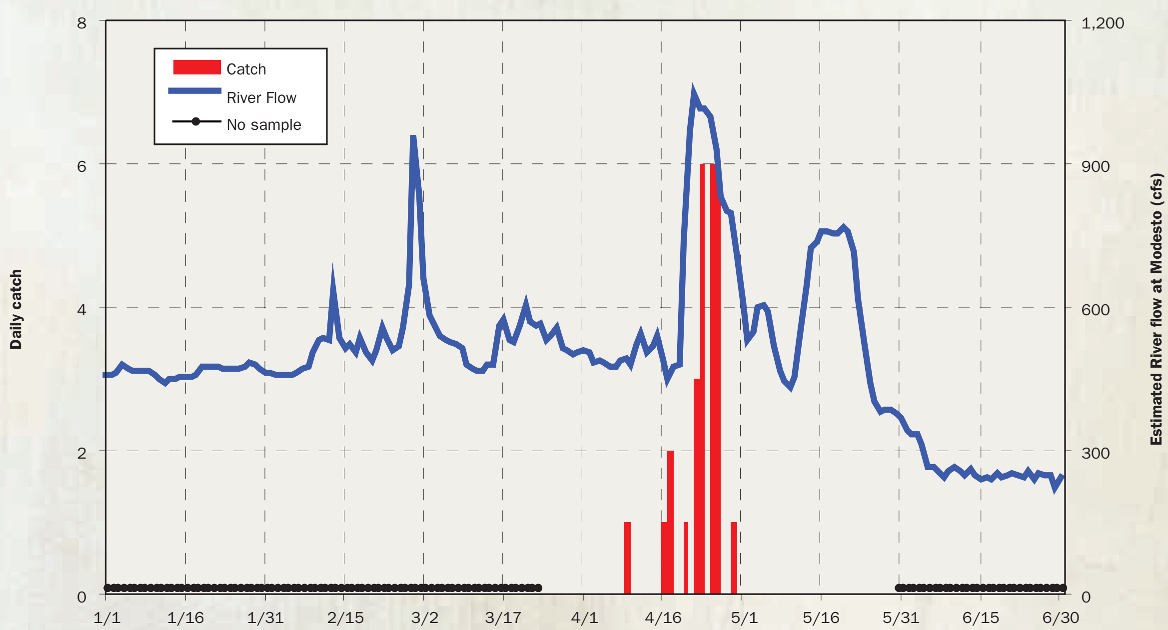


Figure 6-3
Merced screw trap catch of unmarked juvenile Chinook salmon

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



23-26 Apr (Figure 6-4), and these peaks were detected at Mossdale during 28-29 Apr. Seining in the SJR only captured two salmon prior to VAMP: one yearling salmon (155 mm) captured at Sturgeon Bend (RM 74) on 01 Mar and one young-of-year salmon (56 mm) captured at Big Beach (RM 63) on 29 Mar.

Average size in RST and trawl catch and salvage (Figure 6-6) shows that most fish observed prior to mid-March averaged <50 mm fork length (FL). Both the trawl and salvage are relatively less effective at capture of fry (salmon less than 50 mm long). Average size at all locations typically increased by early April to >70 mm FL and to >80 mm FL by early May (Figure 6-6). Low abundance of juvenile salmon was observed by 01 May in the Tuolumne River, mid-May in the Merced River, and mid June in the Stanislaus River and at Mossdale. 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 (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 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.

2007 Mossdale Trawl Summary

Contributed by Jason Guignard
California Department of Fish and Game

Introduction

Monitoring for the fall-run chinook salmon smolt out-migrant population, from the San Joaquin drainage, is conducted by CDFG two miles downstream of Mossdale Landing, County Park (river mile 56), and just upstream of the Old River confluence (Figure 6-7). This measurement of timing and production of the out-migrating fall-run Chinook salmon smolts has been performed at this location since 1988 in order 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.

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 2 to April 20, and then increased into 7 days a week from April 23 to May 25. The sampling effort was reduced back to 5 days a week during May 29 to June 15, and sampling was actually suspended briefly from June 4 to June 8 due to delta smelt concerns. The entire sampling period was from April 2 to June 15, 2007 with a total of 57 sample days out of the study period of 75 days. All trawling occurred during daylight hours, starting around 0800 hours. A sampling day usually consisted of 15 tows at 20 minutes per tow, although the first three weeks and last four weeks of sampling had 10 tows per day. Sampling is also conducted 3 days per week between mid- June and April by the USFWS in Stockton.

Water temperature, turbidity, weather, and beginning tow time were recorded for each tow. Velocity was recorded by using a digital flow meter model 2030R that is made by General Oceanics Inc. A Garmin GPSMap 172c was used to map the location of all sampling tows. This mapping is being done to evaluate differences in catch rate throughout the sampling area (Figure 6-8). 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.

All fish were identified to species and enumerated. The first 20 per tow of all species, except Chinook salmon, were also measured. Chinook salmon were checked for a clipped adipose fin and/or dye mark. All non-marked Chinook salmon were considered "natural" for the purpose of this study. All Chinook salmon were measured (fork length, mm). Chinook salmon that had a clipped adipose fin was measured, individually bagged, and labeled and saved for coded wire tag processing.

Analysis

The 2007 natural smolt production from the San Joaquin drainage was estimated by two different methods. The first method (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 (Figure 6-9). Production for days not sampled within the study period were estimated by averaging smolt/ac-ft for the 2 days before and 2 days after the non-sampled period.

The second estimate (regression vulnerability method), which we believe 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

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

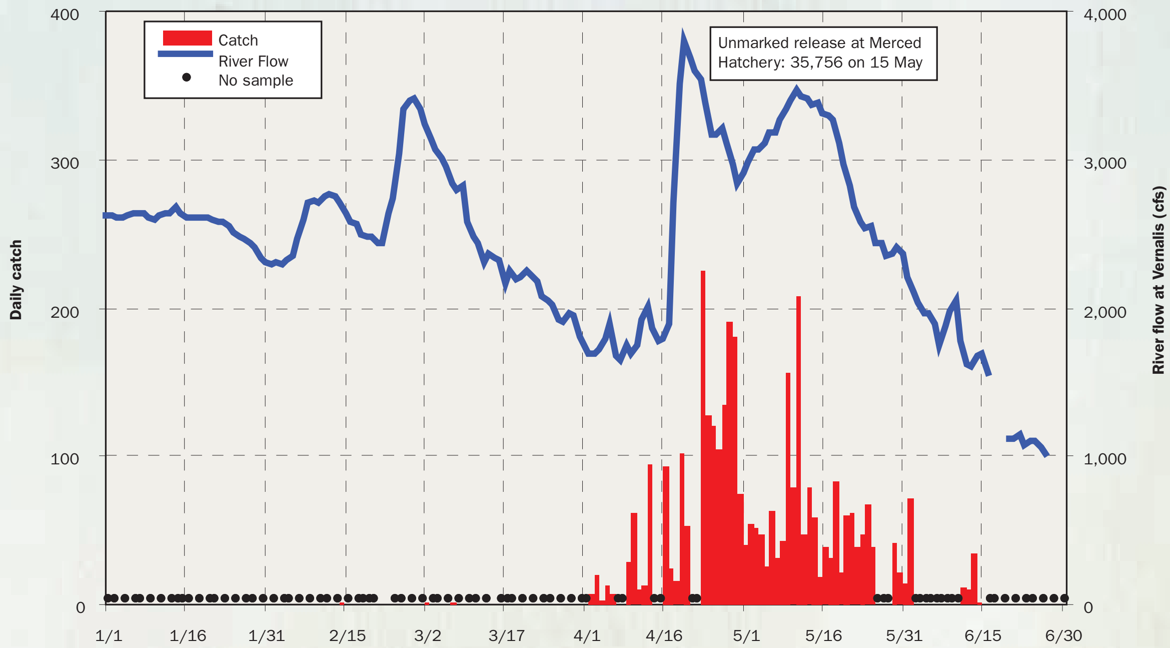


Figure 6-6
Daily average forklength of unmarked juvenile Chinook salmon

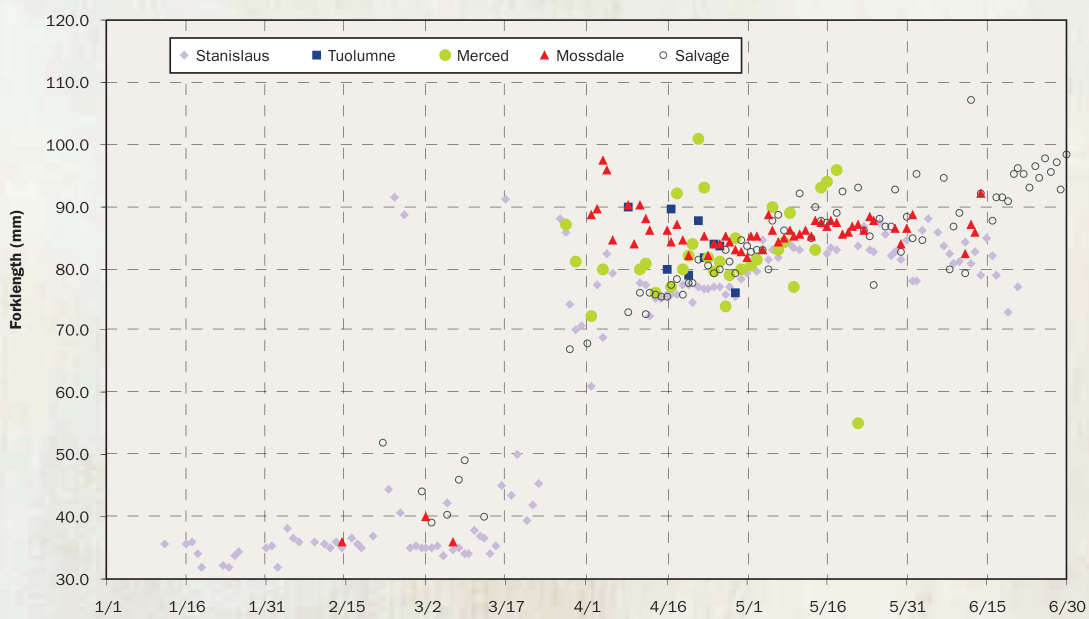


Figure 6-7
Tow Location, Mossdale to Old River

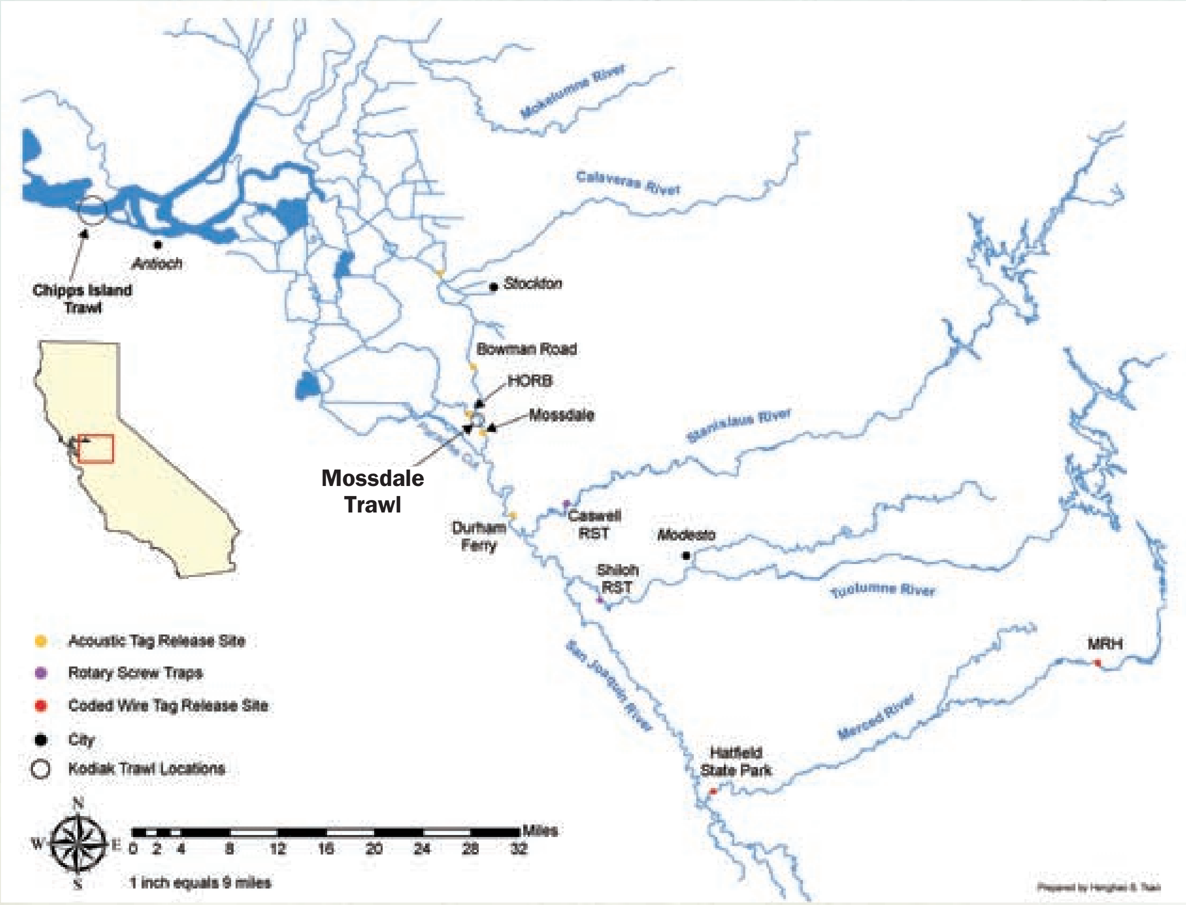


Figure 6-8
Mossdale Sampling Tows

Figure 6-9

Expanded daily catch of non-marked Chinook based on vulnerability estimates and flow at Vernalis

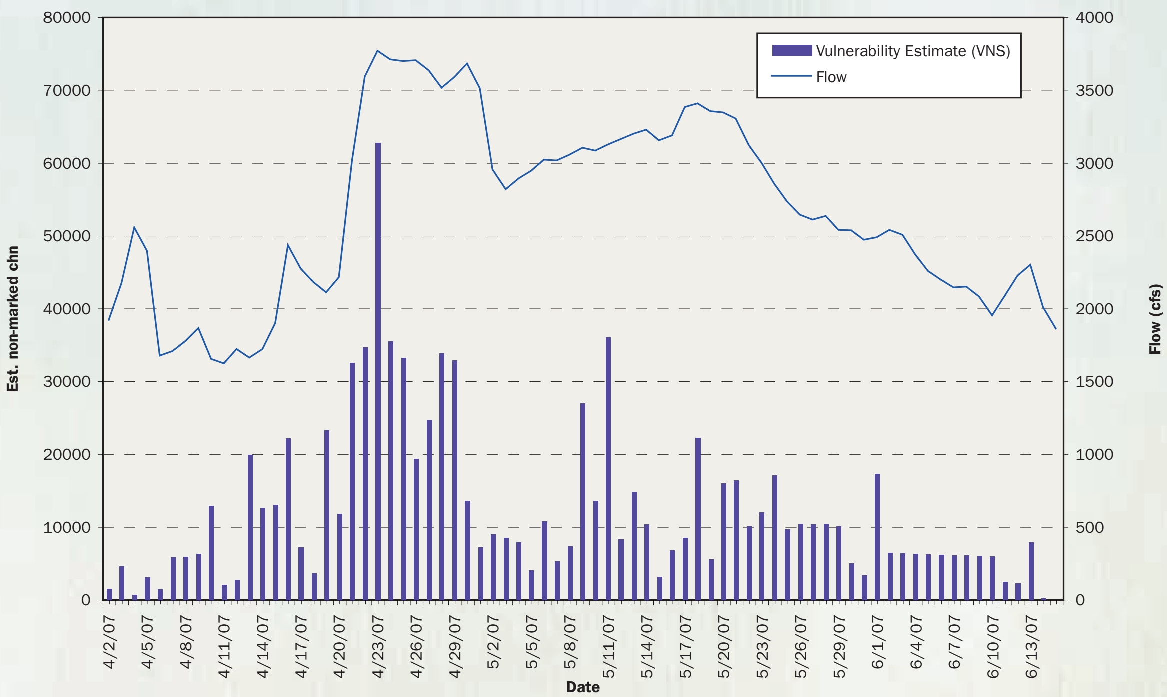
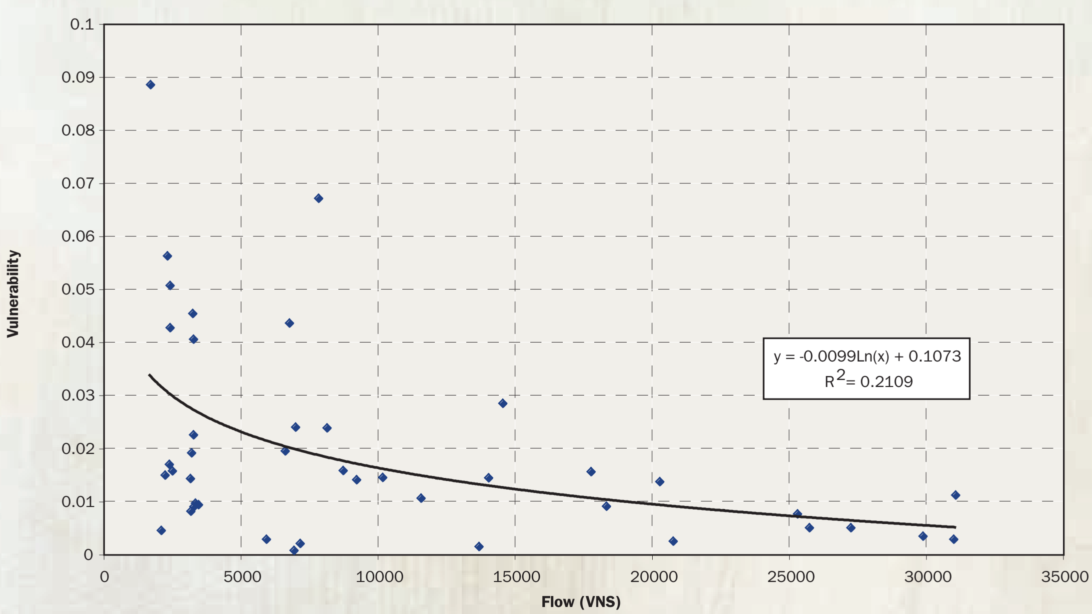


Figure 6-10

Natural log of 1989- 2006 efficiency estimates vs. flow at Vernalis.



vulnerability release groups. Due to the low number of smolts produced at Merced River Hatchery, there were no vulnerability tests performed during the 2007 sampling period. Instead, vulnerability was estimated based on the natural log of vulnerability versus flow at Vernalis from previous years tests (1989-2006) (Figure 6-10). This number is then extrapolated out to a 5-hour index and a 24-hour seasonal estimate. Production, for days not sampled within the study period was estimated based on the average smolt catch and minutes towed for the 2 days before and 2 days after the non-sampled period.

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

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

$$E_I = \sum_{i=1}^{n=75} \left[\left(\frac{C_i}{V_{Ti}} \right) \left(V_{Pi} \right) \left(\frac{24}{5} \right) \right]$$

Where:
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 75 days.

Vulnerability Expansion Calculation (Regression Vulnerability Method):

$$E_V = \sum_{i+1}^{n=75} \left[\frac{\frac{C_i}{V_i} (60 * 24)}{T_i} \right]$$

Where:
n = days in the index period
C = daily non-marked Chinook catch
V= daily vulnerability estimate
T= minutes towed
i = ith Day

For the purpose of the analysis, vulnerability to the trawl was assumed from the beginning of the first tow detected to the end of the last tow detected on the day of release where marked fish were detected. Detection of marked 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 trawl), time vulnerable to the trawl and the percent vulnerability as related to flow were determined for each test group.

Results

Between April 2 and June 15, 2007 3,392 non-marked Chinook salmon smolts were captured in the Mossdale trawl. Daily capture of non-marked salmon ranged from 0 – 225 individuals with an average of 61. Average forklength of non-marked Chinook was 85.2 millimeters (mm) and ranged from 62 - 162 mm. A total of 378 adipose fin clipped Chinook were captured between April 25 and May 18, 2007. The average forklength of marked Chinook was 96.4 mm and ranged from 80 – 118 mm.

Smolt production estimates for the San Joaquin basin ranged between 273,798 using the smolt/ac-ft estimate and 920,006 using the trawl vulnerability estimate (Table 6-1). The regression vulnerability estimate 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.

However we have assumed that the average vulnerability estimate applies to the catch in 2007. That may make the estimate of abundance using the trawl vulnerability method more uncertain than in past years where vulnerability was actually measured and applied.

Forty steelhead/ rainbow trout (RBT) were captured during the 2007 sampling period. All RBTs were measured and returned to the river. Forklength ranged from 200- 330 mm (238 mm average), and all samples exhibited advanced stages of the smoltification process. This is the highest number of steelhead captured since CDFG started sampling at Mossdale in 1988 (Figure 6-11).

Survival Estimated for CWT Releases Made in the Merced River

Contributed by Pat Brandes, U.S. Fish and Wildlife Service

Coded wire tagged salmon from the MRH were released in the Merced River between April 20 and May 8, 2007 as part of independent (complimentary to VAMP) fishery investigations. Releases were made in the upper and lower reaches of the Merced River (Merced River Hatchery and Hatfield State Park, respectively).

Survival indices to Chipps Island of lower Merced releases made at Hatfield State Park include mortality down the mainstem San Joaquin River, as well as, through the Delta (Figure 6-7). Chipps Island survival indices of the lower Merced River groups were 0.036 for the first group released on April 24. No recoveries were made at Chipps Island from the later group released on May 8th. Survival indices using Chipps Island recoveries in 2006 ranged between 0.019 – 0.106 for the groups released in the lower Merced River at Hatfield State Park. In past years survival has been similar for these groups to those released at Durham Ferry and Mossdale.

If sufficient numbers of fish are recovered in the Chipps Island trawl, survival indices can be generated for groups released on the upper Merced River (MRH). Comparison of survival indices of groups released upstream and downstream and recovered at Chipps Island provides an estimate of survival through the Merced River. This is accomplished by dividing the upstream group survival index by the downstream survival index. Unfortunately, insufficient numbers of fish were recovered from the first release group to generate survival extimates (i.e., only 1 fish from the upper Merced River and 2 fish from the lower Merced River.) No recoveries were made at Chipps Island for the second release groups from either the upper or lower Merced River release groups. Ocean recoveries will be available for these groups in future years and will provide an additional source of recoveries of which to use to estimate survival through the Merced River in 2007.

Recoveries at Chipps Island in 2007 were made prior to May 5, 2007. Sampling at Chipps Island was terminated on May 26, 2007 due to concerns related to the low population levels of delta smelt and the potential to catch some at Chipps Island.

Comparison of Lower Merced Releases with Sacramento River Delta Releases

Contributed by Pat Brandes, U.S. Fish and Wildlife Service

As in previous years, marked fish from the Feather River were released on the Sacramento River near West Sacramento in 2007. Three groups were released to index survival through the Delta for juvenile salmon originating in the Sacramento basin. Comparison of survival between the Sacramento released fish and those released in the lower Merced may provide some insight on the variation in survival between basins.

As mentioned previously, in late May of 2007, trawling at Chipps Island was suspended due to delta smelt concerns and affected the recoveries of some of the groups released at Sacramento. For instance there were no recoveries for the last group released at Sacramento on 5/14/07. The survival index for the first release on 4/16/07 at Sacramento was 0.369. This may index the true survival as it is likely most of the released fish had passed Chipps Island prior to the termination of sampling. The survival index for the second release made at Sacramento on 4/30 was 0.039. This group may have also been affected by the lack of sampling in late May. However, if we just restrict the comparison between the first Sacramento group and the first lower Merced River group, survival was much greater for the Sacramento group (0.369) than the lower Merced group (0.036).

Survival indices are typically higher for smolts migrating through the Delta from Sacramento than for smolts emigrating past Mossdale. It is unclear why this is the case although smolts entering the Delta from Mossdale are generally exposed to lower river flows than on the Sacramento River and smolts from the San Joaquin basin migrate in closer proximity to the CVP and SWP pumping plants. In 2007, samples taken from the acoustically tagged fish used in the VAMP studies had PKD as many of the VAMP fish have had in past years. All of these factors and others may result in the lower survival detected through the Delta for juvenile salmon originating from the San Joaquin basin.

Figure 6-11
Annual rainbow trout/steelhead catch and average foklength at Mossdale

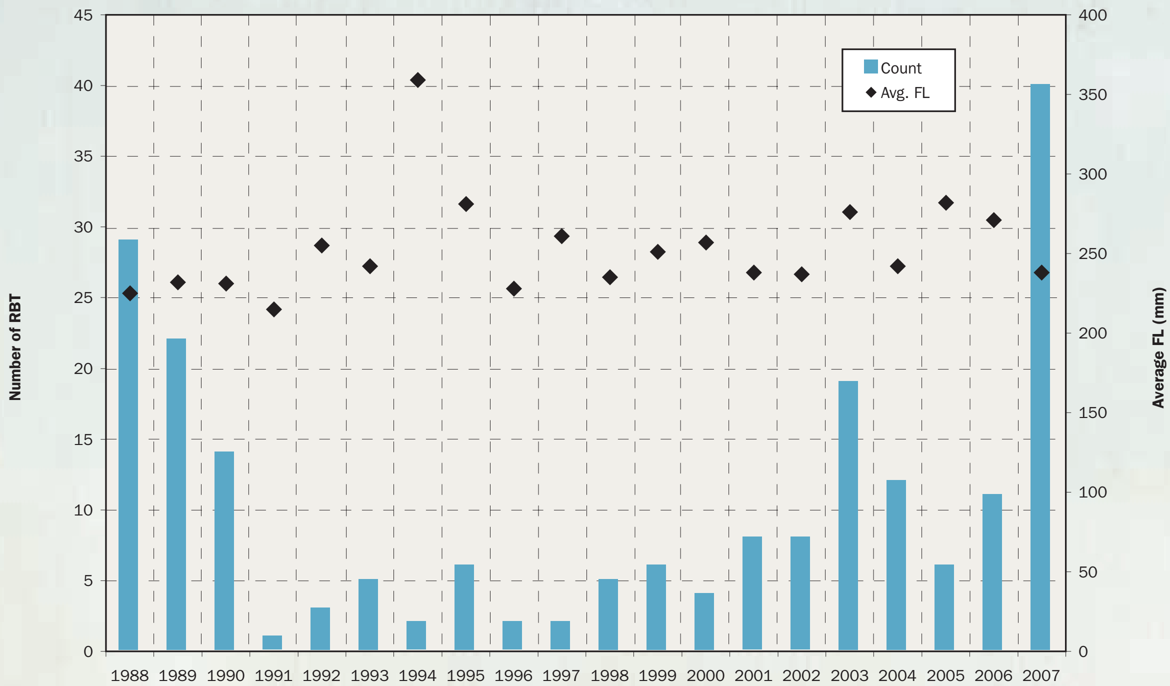


Table 6-1
Smolt production seasonal estimates and sampling period for the duration of the study.

Year	Sampling Period (Days)	Percentage of Days Sampled (%)	Smolt/ac-ft Estimate	Vulnerability Smolt Production Seasonal Estimate** (95% confidence range)
2007	75	76.0	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	73.0	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.
**2001- 2006 production estimates based on the annual vulnerability tests, 1989-2000 estimates based on the natural log of all vulnerability tests (1989-2005).

CONCLUSIONS AND RECOMMENDATIONS

After some uncertainty regarding the HORB relative to Delta smelt it was installed on April 20, two days prior to the start of the VAMP pulse flow period of April 22 to May 22. The average Vernalis pulse flow was 3,260 cfs, varying between 2,830 cfs and 3,790 cfs. Combined exports averaged 1,486 cfs. Flow monitoring was conducted in the San Joaquin River downstream of the HOR and in the Old River. Kodiak trawling was conducted in the San Joaquin River between Mossdale and the Old River. An acoustic telemetry study was implemented in 2007 to estimate movement of tagged Chinook salmon smolts. Survival estimates across the Delta were not possible in 2007, however limited survival estimates to individual receiver sites were possible. 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.

From past VAMP releases, the relationship of salmon survival to San Joaquin River flow has shown that survival increases as flows increase, with the HORB in place (SJRGA 2007). The survival to flow relationship is statistically significant when recovery from all available sources both in the trawls and ocean (Antioch, Chipps Island, and ocean fishery) are combined (SJRGA 2007). However, in 2007 survival through the Delta could not be measured due to the lack of study fish for a coded wire tag study and the inability to install receivers at Jersey Point and Chipps Island for the acoustic study. Thus the role of survival to flow with the HORB in place could not be confirmed in 2007. However, the acoustic study results appeared to indicate that predation and possibly toxicity, may contribute to the mortality of migrating salmon smolts through the Delta. These factors will require further investigation in future years.

The relationship of survival to flow without the HORB is more variable especially when including data from 2005 and 2006 (SJRG 2007). Relationships of flow to adult escapement 2 1/2 years later, indicates these relationships are likely real and that survival is improved as flows and flows relative to exports increase.

The role of exports has been difficult to identify from past VAMP CWT studies because survival with the HORB has not been estimated at VAMP targets of 7,000 cfs flow with exports at 1,500 and 3,000 cfs.

The VAMP program provides increased flows at a wide range of flows along with corresponding decreased exports and likely increases the survival of migrating salmon through the Delta.

The VAMP study was forced to change in 2007 due to the study fish limitation. Acoustic telemetry was used in 2007, but for acoustic studies to measure survival through the Delta receivers must be deployed at Jersey Point and Chipps Island. While logistically challenging, it appears it can be done given enough time and resources to overcome the challenges. Acoustic telemetry is also more expensive than the traditional CWT studies, but if the downstream receivers can be successfully installed, the acoustic telemetry study can estimate survival with greater precision in addition to providing more detailed mortality information through-out the Delta. Further effort will be spent on these deployments in 2008 for the work to be completed prior to releasing the acoustically tagged fish. Without these key detector locations, survival cannot be measured through the Delta using acoustic telemetry. CWT studies no longer appear feasible due to the continued study fish limitation. If the deployment of the downstream acoustic receivers is successful then acoustic telemetry will allow additional measurements of survival to be made at the VAMP targets to continue the assessment of the relative roles of flow and exports on survival through the Delta with and without the HORB.

One additional complication for future VAMP studies is the recent court order to prevent the installation of the HORB in 2008 for the protection of delta smelt. It is uncertain how this court order will affect the installation of the HORB for VAMP studies and the protection of juvenile Chinook salmon migrating from the San Joaquin tributaries after 2008.

Table 7-1
Summary of VAMP 2007 conclusions and recommendations

Conclusions	Recommendations for 2008
Due to unforeseen physical and technical problems acoustic receivers could not be installed at Chipps Island and Jersey Point in 2007.	Acoustic receivers at Chipps Island and Jersey Point need to be installed to allow survival estimates through the Delta to be completed.
Observed ungaged flows (accretions, depletions) between upstream measurement points and Vernalis varied significantly from those forecasted resulting in differences in forecasted and required supplemental flows.	Hydrology committee to continue refining estimates of ungaged flow and develop a management scheme to accommodate variability.
The flow data collected in 2007 at San Joaquin River near Lathrop and the Old River at Head provided useful information on the flow split at the Head of Old River	The 2005 through 2007 flow data should be compared against DWR-DSM2 modeling results. Continue to calibrate the stage and flow monitoring at the San Joaquin River near Lathrop station.
Short-term survival (48-hours post-transport) was relatively high indicating that handling, transport, and release likely had no affect on short-term smolt survival.	Continue net pen studies and fish health inspections.
Smolt abundance and production estimates could be improved by ensuring that sampling is conducted daily at Mossdale when salmon smolt are emigating.	Maintain the Mossdale Kodiak trawl at existing or higher level of effort throughout the year.
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.
Complimentary studies to evaluate mechanisms affecting survival of fish from tributaries and through the Delta were conducted.	Encourage an expansion of complementary studies to provide additional information on factors and mechanisms affecting salmon survival.

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U.S. FISH AND WILDLIFE SERVICE

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MODESTO IRRIGATION DISTRICT*

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- Columbia Canal Company
- Sal Luis Canal Company

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SAN JOAQUIN RIVER GROUP AUTHORITY

*San Joaquin River Group Authority Members

2007 Useful Web Pages

Page 3 San Joaquin River Agreement
www.sjrg.org/agreement.htm

Page 3 SWRCB Decision 1641
www.waterrights.ca.gov/hearings/Decisions.htm

Page 8 VAMP Annual Technical Reports
www.sjrg.org

Page 9 VAMP Experimental Design
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Page 14 Operation Monitoring, CDEC Daily
http://cdec.water.ca.gov/cgi-progs/
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Newman, USGS Daily
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Page 27 Temporary Barrier Program
http://sdelta.water.ca.gov/web_pg/tempmesr.html

Page 31 Reclamation District 544 Seepage Monitoring Study
http://sdelta.water.ca.gov/web_pg/tempmesr.html

Page 60 CVP and SWP Salvage Data
www.iep.ca.gov

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

Pacifica States Marine Fisheries Commission
Regional Mark Information System
www.rmis.org

Common Acronyms and Abbreviations

ADCP	Acoustic Doppler Current Profiler
Bay-Delta	Sacramento and San Joaquin Rivers San Francisco Bay Delta
CDEC	California Data Exchange Center
CDRR	Combined Differential Recovery Rate
CFS	Cubic Feet Per Second
CPUE	Catch Per Unit Effort
CRR	Combined Recovery Rate
CVP	Central Valley Project
CWT	Coded-Wire Tagged
D-1641	Water Rights Decision 1641 of the SWRCB
DFG	California Department of Fish and Game
DWR	California Department of Water Resources
GLC	Grant Line Canal
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
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
TBP	Temporary Barriers Project
TID	Turlock Irrigation District
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

TABLE OF CONTENTS

APPENDIX A
Hydrology and Operation Plans 82

A-1 Daily Operation Plan, Tables 1-13 83

A-2 Comparison of Real-time and Provisional Flows, Figures 1-7 96

APPENDIX B
Historic Data 100

B- Figure 1

Storage Impacts, 2000-2007 Lake McClure 101

B- Figure 2

Storage Impacts, 2000-2007 New Don Pedro Reservoir 101

B- Figure 3

Merced River below Crocker-Huffman Dam, 2000-2007 102

B- Figure 4

Tuolumne River below LaGrange Dam, 2000-2007 102

APPENDIX C
Chinook Salmon Survival Investigations 103

C-1 Water Temperature Monitoring Locations 104

C-2 Water Temperature Monitoring Data, Plots 1-9 106

C-3 Chinook salmon smolt conditions, 48-hours post release 111

C-4 Detections of acoustic-tagged salmon released above HORB, May 3-4 112

C-5 Detections of acoustic-tagged salmon released below HORB, May 3-4 115

C-6 Detections of acoustic-tagged salmon released above HORB, May 10-11 116

C-7 Detections of acoustic-tagged salmon released below HORB, May 10-11 119

APPENDIX D
Field Standard Operating Procedure
Surgical Tag Implementation Procedures 120

APPENDIX A

Appendix A-1, Table 1

2007 VAMP DAILY OPERATION PLAN — MARCH 21, 2007
(A1) DOUBLE-STEP; LOW UNGAGED FLOW
Target Flow Period: April 22 - May 22 • 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	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (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)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		(cfs)	(cfs)	(cfs)	
3/15/07	**2,330**				**2,330**	**782**	**4**	**215**			**215**	**349**	**349**		**349**	**804**	**804**			**804**	
3/16/07	**2,210**				**2,210**	**753**	**23**	**228**			**228**	**348**	**348**		**348**	**806**	**806**			**806**	
3/17/07	**2,260**				**2,260**	**733**	**110**	**213**			**213**	**338**	**338**		**338**	**802**	**802**			**802**	
3/18/07	**2,230**				**2,230**	**723**	**108**	**212**			**212**	**338**	**338**		**338**	**687**	**687**			**687**	
3/19/07	**2,220**				**2,220**	**701**	**119**	**216**			**216**	**337**	**337**		**337**	**603**	**603**			**603**	
3/20/07	**2,060**				**2,060**	**794**	**99**	**208**			**208**	**337**	**337**		**337**	**609**	**609**			**609**	
3/21/07																					
3/22/07																					
3/23/07																					
3/24/07																					
3/25/07																					
3/26/07																					
3/27/07																					
3/28/07																					
3/29/07						588		250													
3/30/07						584		250				300	300			768	768				
3/31/07						580		250				300	300			768	768				
4/1/07	2,002					576	100	250			250	300	300		300	768	768			768	
4/2/07	1,998					572	100	250			250	300	300		300	768	768			768	
4/3/07	1,994					568	100	250			250	300	300		300	768	768			768	
4/4/07	1,990				1,990	564	100	250			250	300	300		300	768	768			768	
4/5/07	1,986				1,986	560	100	250			250	300	300		300	768	768			768	
4/6/07	1,982				1,982	556	100	250			250	300	300		300	768	768			768	
4/7/07	1,978				1,978	552	100	250			250	300	300		300	768	768			768	
4/8/07	1,974				1,974	548	100	250			250	300	300		300	768	768			768	
4/9/07	1,970				1,970	544	100	250			250	300	300		300	768	768			768	
4/10/07	1,966				1,966	540	100	250			250	300	300		300	768	768			768	
4/11/07	1,962				1,962	536	100	250			250	300	300		300	768	768			768	
4/12/07	1,958				1,958	532	100	250			250	300	300		300	768	768			768	
4/13/07	1,954	0			1,954	528	100	250			250	300	300		300	768	768			768	
4/14/07	1,950	0			1,950	524	100	250			250	300	300		300	768	768			768	
4/15/07	1,946	0	0	0.00	1,946	520	100	250			250	250	250		250	768	768			768	
4/16/07	1,942	0	0	0.00	1,942	516	100	250			250	250	250		250	768	768			768	
4/17/07	1,888	0	0	0.00	1,888	512	100	250			250	250	250		250	768	768			768	
4/18/07	1,884	0	0	0.00	1,884	508	100	250			250	250	250		250	768	768			768	
4/19/07	1,880	0	0	0.00	1,880	504	100	250	894	179	1,323	250	250		250	768	768			768	
4/20/07	1,876	0	0	0.00	1,876	500	100	250	894	179	1,323	650	650	358	1,008	768	768	358	374	1,500	
4/21/07	1,872	0	0	0.00	1,872	496	100	250	894	179	1,323	650	650	358	1,008	768	768	358	374	1,500	
4/22/07	2,268	1,789	374	3.55	4,431	491	100	250	894	179	1,323	650	650	358	1,008	768	768	358	374	1,500	
4/23/07	2,264	1,789	374	7.10	4,427	487	100	250	894	179	1,323	650	650	358	1,008	768	768	358	374	1,500	
4/24/07	2,259	1,789	374	10.65	4,422	483	100	250	894	179	1,323	650	650	358	1,008	768	768	358	374	1,500	
4/25/07	2,255	1,789	374	14.19	4,418	478	100	250	894	179	1,323	650	650	358	1,008	768	768	358	374	1,500	
4/26/07	2,251	1,789	374	17.74	4,414	474	100	250	894	179	1,323	650	650	358	1,008	768	768	358	374	1,500	
4/27/07	2,246	1,789	374	21.29	4,409	469	100	250	894	179	1,323	650	650	358	1,008	768	768	358	374	1,500	
4/28/07	2,242	1,789	374	24.84	4,405	465	100	250	894	179	1,323	650	650	358	1,008	768	768	358	374	1,500	
4/29/07	2,237	1,789	374	28.39	4,400	461	100	250	894	179	1,323	650	650	358	1,008	768	768	358	374	1,500	
4/30/07	2,233	1,789	374	31.94	4,396	456	100	250	894	179	1,323	650	650	358	1,008	768	768	358	374	1,500	
5/1/07	2,229	1,789	374	35.48	4,392	452	100	250	894	179	1,323	650	650	358	1,008	741	741	358	401	1,500	
5/2/07	2,224	1,789	374	39.03	4,387	448	100	250	894	179	1,323	650	650	358	1,008	741	741	358	401	1,500	
5/3/07	2,193	1,789	401	42.58	4,383	443	100	250	894	179	1,323	650	650	358	1,008	741	741	358	401	1,500	
5/4/07	2,189	1,789	401	46.13	4,379	439	100	250	894	179	1,323	650	650	358	1,008	741	741	358	401	1,500	
5/5/07	2,184	1,789	401	49.68	4,374	435	100	250	894	179	1,323	650	650	358	1,008	741	741	358	401	1,500	
5/6/07	2,180	1,789	401	53.23	4,370	430	100	250	894	179	1,323	650	650	358	1,008	741	741	358	401	1,500	
5/7/07	2,176	1,789	401	56.77	4,366	426	100	250	894	179	1,323	650	650	358	1,008	741	741	358	401	1,500	
5/8/07	2,171	1,789	401	60.32	4,361	421	100	250	894	179	1,323	650	650	358	1,008	741	741	358	401	1,500	
5/9/07	2,167	1,789	401	63.87	4,357	417	100	250	894	179	1,323	650	650	358	1,008	741	741	358	401	1,500	
5/10/07	2,162	1,789	401	67.42	4,352	413	100	250	894	179	1,323	650	650	358	1,008	741	741	358	401	1,500	
5/11/07	2,158	1,789	401	70.97	4,348	408	100	250	894	179	1,323	650	650	358	1,008	741	741	358	401	1,500	
5/12/07	2,154	1,789	401	74.52	4,344	404	100	250	894	179	1,323	650	650	358	1,008	741	741	358	401	1,500	
5/13/07	2,149	1,789	401	78.07	4,339	400	100	250	894	179	1,323	650	650	358	1,008	741	741	358	401	1,500	
5/14/07	2,145	1,789	401	81.61	4,335	395	100	250	894	179	1,323	650	650	358	1,008	741	741	358	401	1,500	
5/15/07	2,141	1,789	401	85.16	4,331	391	100	250	894	179	1,323	650	650	358	1,008	741	741	358	401	1,500	
5/16/07	2,136	1,789	401	88.71	4,326	386	100	250	894	179	1,323	650	650	358	1,008	741	741	358	401	1,500	
5/17/07	2,132	1,789	401	92.26	4,322	382	100	250	894	179	1,323	650	650	358	1,008	741	741	358	401	1,500	
5/18/07	2,127	1,789	401	95.81	4,317	378	100	250	894	179	1,323	650	650	358	1,008	741	741	358	401	1,500	
5/19/07	2,123	1,789	401	99.36	4,313	373	100	250	894	179	1,323	650	650	358	1,008	741	741	358	401	1,500	
5/20/07	2,119	1,789	401	102.90	4,309	369	100	250			250	550	550	358	908	741	741	358	401	1,500	
5/21/07	2,114	1,789	401	106.45	4,304	365	100	250			250	450	450		450	741	741			741	
5/22/07	2,010	1,789	401	110.00	4,200	361	100	250			250	350	350		350	741	741			741	
5/23/07	1,906	0	0		1,906	357	100	250			250	250	250		250	741	741			741	
5/24/07	1,802	0	0		1,802	353	100	250			250	150	150		150	741	741			741	
5/25/07	1,698	0	0		1,698	349	100	250			250	150	150		150	741	741			741	
5/26/07	1,594	0	0		1,594	345	100	250			250	150	150		150	741	741			741	
5/27/07	1,590	0	0		1,590	341	100	250			250	150	150		150	741	741			741	
5/28/07	1,586	0	0		1,586	337	100	250			250	150	150		150	741	741			741	
5/29/07	1,582	0	0		1,582	333	100	250			250	150	150		150	741	741			741	
5/30/07	1,578	0	0		1,578	329	100	250			250	150	150		150	741	741			741	
5/31/07	1,574	0	0		1,574	325	100	250			250	150	150		150	741	741			741	
									VAMP Period												
Avg. (cfs):	2,182	1,789			4,362	435	100	250	894	179	1,323	647	647	358	1,005	751	751	358	391	1,500	
Supplemental Water (TAF):				110.00							54.97	11.01				22.01				22.01	

VAMP flow operation period

Appendix A-1, Table 2

2007 VAMP DAILY OPERATION PLAN — MARCH 21, 2007
(A2) SINGLE-STEP; 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	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (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)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		(cfs)	(cfs)	(cfs)	
3/15/07	**2,330**				**2,330**	**782**	**4**	**215**			**215**	**349**	**349**		**349**	**804**				**804**	
3/16/07	**2,210**				**2,210**	**753**	**23**	**228**			**228**	**348**	**348**		**348**	**806**				**806**	
3/17/07	**2,260**				**2,260**	**733**	**110**	**213**			**213**	**338**	**338**		**338**	**802**				**802**	
3/18/07	**2,230**				**2,230**	**723**	**108**	**212**			**212**	**338**	**338**		**338**	**687**				**687**	
3/19/07	**2,220**				**2,220**	**701**	**119**	**216**			**216**	**337**	**337**		**337**	**603**				**603**	
3/20/07	**2,060**				**2,060**	**794**	**99**	**208**			**208**	**337**	**337**		**337**	**609**				**609**	
3/21/07																					
3/22/07																					
3/23/07																					
3/24/07																					
3/25/07																					
3/26/07																					
3/27/07																					
3/28/07																					
3/29/07						588		250													
3/30/07						584		250				300	300			768	768				
3/31/07						580		250				300	300			768	768				
4/1/07	2,002					576	100	250			250	300	300		300	768	768			768	
4/2/07	1,998					572	100	250			250	300	300		300	768	768			768	
4/3/07	1,994					568	100	250			250	300	300		300	768	768			768	
4/4/07	1,990				1,990	564	100	250			250	300	300		300	768	768			768	
4/5/07	1,986				1,986	560	100	250			250	300	300		300	768	768			768	
4/6/07	1,982				1,982	556	100	250			250	300	300		300	768	768			768	
4/7/07	1,978				1,978	552	100	250			250	300	300		300	768	768			768	
4/8/07	1,974				1,974	548	100	250			250	300	300		300	768	768			768	
4/9/07	1,970				1,970	544	100	250			250	300	300		300	768	768			768	
4/10/07	1,966				1,966	540	100	250			250	300	300		300	768	768			768	
4/11/07	1,962				1,962	536	100	250			250	300	300		300	768	768			768	
4/12/07	1,958				1,958	532	100	250			250	300	300		300	768	768			768	
4/13/07	1,954	0			1,954	528	100	250			250	300	300		300	768	768			768	
4/14/07	1,950	0			1,950	524	100	250			250	300	300		300	768	768			768	
4/15/07	1,946	0	0	0.00	1,946	520	100	250			250	250	250		250	768	768			768	
4/16/07	1,942	0	0	0.00	1,942	516	100	250			250	250	250		250	768	768			768	
4/17/07	1,888	0	0	0.00	1,888	512	100	250			250	250	250		250	768	768			768	
4/18/07	1,884	0	0	0.00	1,884	508	100	250			250	250	250		250	768	768			768	
4/19/07	1,880	0	0	0.00	1,880	504	100	250	269	0	519	250	250		250	768	768			768	
4/20/07	1,876	0	0	0.00	1,876	500	100	250	269	0	519	650	650	0	650	768	768	0	732	1,500	
4/21/07	1,872	0	0	0.00	1,872	496	100	250	269	0	519	650	650	0	650	768	768	0	732	1,500	
4/22/07	2,268	269	732	0.53	3,269	491	100	250	269	0	519	650	650	0	650	768	768	0	732	1,500	
4/23/07	2,264	269	732	1.07	3,265	487	100	250	269	0	519	650	650	0	650	768	768	0	732	1,500	
4/24/07	2,259	269	732	1.60	3,260	483	100	250	269	0	519	650	650	0	650	768	768	0	732	1,500	
4/25/07	2,255	269	732	2.13	3,256	478	100	250	269	0	519	650	650	0	650	768	768	0	732	1,500	
4/26/07	2,251	269	732	2.67	3,252	474	100	250	269	0	519	650	650	0	650	768	768	0	732	1,500	
4/27/07	2,246	269	732	3.20	3,247	469	100	250	269	0	519	650	650	0	650	768	768	0	732	1,500	
4/28/07	2,242	269	732	3.73	3,243	465	100	250	269	0	519	650	650	0	650	768	768	0	732	1,500	
4/29/07	2,237	269	732	4.27	3,238	461	100	250	269	0	519	650	650	0	650	768	768	0	732	1,500	
4/30/07	2,233	269	732	4.80	3,234	456	100	250	269	0	519	650	650	0	650	768	768	0	732	1,500	
5/1/07	2,229	269	732	5.34	3,230	452	100	250	269	0	519	650	650	0	650	741	741	0	759	1,500	
5/2/07	2,224	269	732	5.87	3,225	448	100	250	269	0	519	650	650	0	650	741	741	0	759	1,500	
5/3/07	2,193	269	759	6.40	3,221	443	100	250	269	0	519	650	650	0	650	741	741	0	759	1,500	
5/4/07	2,189	269	759	6.94	3,217	439	100	250	269	0	519	650	650	0	650	741	741	0	759	1,500	
5/5/07	2,184	269	759	7.47	3,212	435	100	250	269	0	519	650	650	0	650	741	741	0	759	1,500	
5/6/07	2,180	269	759	8.00	3,208	430	100	250	269	0	519	650	650	0	650	741	741	0	759	1,500	
5/7/07	2,176	269	759	8.54	3,204	426	100	250	269	0	519	650	650	0	650	741	741	0	759	1,500	
5/8/07	2,171	269	759	9.07	3,199	421	100	250	269	0	519	650	650	0	650	741	741	0	759	1,500	
5/9/07	2,167	269	759	9.60	3,195	417	100	250	269	0	519	650	650	0	650	741	741	0	759	1,500	
5/10/07	2,162	269	759	10.14	3,190	413	100	250	269	0	519	650	650	0	650	741	741	0	759	1,500	
5/11/07	2,158	269	759	10.67	3,186	408	100	250	269	0	519	650	650	0	650	741	741	0	759	1,500	
5/12/07	2,154	269	759	11.20	3,182	404	100	250	269	0	519	650	650	0	650	741	741	0	759	1,500	
5/13/07	2,149	269	759	11.74	3,177	400	100	250	269	0	519	650	650	0	650	741	741	0	759	1,500	
5/14/07	2,145	269	759	12.27	3,173	395	100	250	269	0	519	650	650	0	650	741	741	0	759	1,500	
5/15/07	2,141	269	759	12.81	3,169	391	100	250	269	0	519	650	650	0	650	741	741	0	759	1,500	
5/16/07	2,136	269	759	13.34	3,164	386	100	250	269	0	519	650	650	0	650	741	741	0	759	1,500	
5/17/07	2,132	269	759	13.87	3,160	382	100	250	269	0	519	650	650	0	650	741	741	0	759	1,500	
5/18/07	2,127	269	759	14.41	3,155	378	100	250	269	0	519	650	650	0	650	741	741	0	759	1,500	
5/19/07	2,123	269	759	14.94	3,151	373	100	250	269	0	519	650	650	0	650	741	741	0	759	1,500	
5/20/07	2,119	269	759	15.47	3,147	369	100	250			250	550	550	0	550	741	741	0	759	1,500	
5/21/07	2,114	269	759	16.01	3,142	365	100	250			250	450	450		450	740	740			740	
5/22/07	2,010	269	759	16.54	3,038	361	100	250			250	350	350		350	740	740			740	
5/23/07	1,905	0	0		1,905	357	100	250			250	250	250		250	740	740			740	
5/24/07	1,801	0	0		1,801	353	100	250			250	150	150		150	740	740			740	
5/25/07	1,697	0	0		1,697	349	100	250			250	150	150		150	740	740			740	
5/26/07	1,593	0	0		1,593	345	100	250			250	150	150		150	740	740			740	
5/27/07	1,589	0	0		1,589	341	100	250			250	150	150		150	740	740			740	
5/28/07	1,585	0	0		1,585	337	100	250			250	150	150		150	740	740			740	
5/29/07	1,581	0	0		1,581	333	100	250			250	150	150		150	740	740			740	
5/30/07	1,577	0	0		1,577	329	100	250			250	150	150		150	740	740			740	
5/31/07	1,573	0	0		1,573	325	100	250			250	150	150		150	740	740			740	
										VAMP Period											
Avg. (cfs):	2,182	269			3,200	435	100	250	269	0	519	647	647	0	647	751	751	0	749	1,500	
Supplemental Water (TAF):				16.54							16.54	0.00				0.00				0.00	

VAMP flow operation period

Appendix A-1, Table 3

2007 VAMP DAILY OPERATION PLAN — MARCH 21, 2007
(B1) DOUBLE-STEP; HIGH UNGAGED FLOW
Target Flow Period: April 22 - May 22 • 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	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (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 Flow	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol. S=Stan.
	(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		(cfs)	(cfs)	(cfs)	
3/15/07	**2,330**				**2,330**	**782**	**4**	**215**			**215**	**349**	**349**		**349**	**804**				**804**	
3/16/07	**2,210**				**2,210**	**753**	**23**	**228**			**228**	**348**	**348**		**348**	**806**				**806**	
3/17/07	**2,260**				**2,260**	**733**	**110**	**213**			**213**	**338**	**338**		**338**	**802**				**802**	
3/18/07	**2,230**				**2,230**	**723**	**108**	**212**			**212**	**338**	**338**		**338**	**687**				**687**	
3/19/07	**2,220**				**2,220**	**701**	**119**	**216**			**216**	**337**	**337**		**337**	**603**				**603**	
3/20/07																					
3/21/07																					
3/22/07																					
3/23/07																					
3/24/07																					
3/25/07																					
3/26/07																					
3/27/07																					
3/28/07																					
3/29/07						588		250													
3/30/07						584		250				300	300			768	768				
3/31/07						580		250				300	300			768	768				
4/1/07	2,402					576	500	250			250	300	300		300	768	768			768	
4/2/07	2,398					572	500	250			250	300	300		300	768	768			768	
4/3/07	2,394					568	500	250			250	300	300		300	768	768			768	
4/4/07	2,390				2,390	564	500	250			250	300	300		300	768	768			768	
4/5/07	2,386				2,386	560	500	250			250	300	300		300	768	768			768	
4/6/07	2,382				2,382	556	500	250			250	300	300		300	768	768			768	
4/7/07	2,378				2,378	552	500	250			250	300	300		300	768	768			768	
4/8/07	2,374				2,374	548	500	250			250	300	300		300	768	768			768	
4/9/07	2,370				2,370	544	500	250			250	300	300		300	768	768			768	
4/10/07	2,366				2,366	540	500	250			250	300	300		300	768	768			768	
4/11/07	2,362				2,362	536	500	250			250	300	300		300	768	768			768	
4/12/07	2,358				2,358	532	500	250			250	300	300		300	768	768			768	
4/13/07	2,354	0			2,354	528	500	250			250	300	300		300	768	768			768	
4/14/07	2,350	0			2,350	524	500	250			250	300	300		300	768	768			768	
4/15/07	2,346	0	0	0.00	2,346	520	500	250			250	250	250		250	768	768			768	
4/16/07	2,342	0	0	0.00	2,342	516	500	250			250	250	250		250	768	768			768	
4/17/07	2,288	0	0	0.00	2,288	512	500	250			250	250	250		250	768	768			768	
4/18/07	2,284	0	0	0.00	2,284	508	500	250			250	250	250		250	768	768			768	
4/19/07	2,280	0	0	0.00	2,280	504	500	250	732	146	1,128	250	250		250	768	768			768	
4/20/07	2,276	0	0	0.00	2,276	500	500	250	732	146	1,128	650	650	241	891	768	768	293	439	1,500	
4/21/07	2,272	0	0	0.00	2,272	496	500	250	732	146	1,128	650	650	241	891	768	768	293	439	1,500	
4/22/07	2,668	1,412	439	2.80	4,519	491	500	250	732	146	1,128	650	650	241	891	768	768	293	439	1,500	
4/23/07	2,664	1,412	439	5.60	4,515	487	500	250	732	146	1,128	650	650	241	891	768	768	293	439	1,500	
4/24/07	2,659	1,412	439	8.40	4,510	483	500	250	732	146	1,128	650	650	241	891	768	768	293	439	1,500	
4/25/07	2,655	1,412	439	11.20	4,506	478	500	250	732	146	1,128	650	650	241	891	768	768	293	439	1,500	
4/26/07	2,651	1,412	439	14.00	4,502	474	500	250	732	146	1,128	650	650	241	891	768	768	293	439	1,500	
4/27/07	2,646	1,412	439	16.80	4,497	469	500	250	732	146	1,128	650	650	241	891	768	768	293	439	1,500	
4/28/07	2,642	1,412	439	19.60	4,493	465	500	250	732	146	1,128	650	650	241	891	768	768	293	439	1,500	
4/29/07	2,637	1,412	439	22.41	4,488	461	500	250	732	146	1,128	650	650	241	891	768	768	293	439	1,500	
4/30/07	2,633	1,412	439	25.21	4,484	456	500	250	732	146	1,128	650	650	241	891	768	768	293	439	1,500	
5/1/07	2,629	1,412	439	28.01	4,480	452	500	250	732	146	1,128	650	650	241	891	741	741	293	466	1,500	
5/2/07	2,624	1,412	439	30.81	4,475	448	500	250	732	146	1,128	650	650	241	891	741	741	293	466	1,500	
5/3/07	2,593	1,412	466	33.61	4,471	443	500	250	732	146	1,128	650	650	241	891	741	741	293	466	1,500	
5/4/07	2,589	1,412	466	36.41	4,467	439	500	250	732	146	1,128	650	650	241	891	741	741	293	466	1,500	
5/5/07	2,584	1,412	466	39.21	4,462	435	500	250	732	146	1,128	650	650	241	891	741	741	293	466	1,500	
5/6/07	2,580	1,412	466	42.01	4,458	430	500	250	732	146	1,128	650	650	241	891	741	741	293	466	1,500	
5/7/07	2,576	1,412	466	44.81	4,454	426	500	250	732	146	1,128	650	650	241	891	741	741	293	466	1,500	
5/8/07	2,571	1,412	466	47.61	4,449	421	500	250	732	146	1,128	650	650	241	891	741	741	293	466	1,500	
5/9/07	2,567	1,412	466	50.41	4,445	417	500	250	732	146	1,128	650	650	241	891	741	741	293	466	1,500	
5/10/07	2,562	1,412	466	53.21	4,440	413	500	250	732	146	1,128	650	650	241	891	741	741	293	466	1,500	
5/11/07	2,558	1,412	466	56.01	4,436	408	500	250	732	146	1,128	650	650	241	891	741	741	293	466	1,500	
5/12/07	2,554	1,412	466	58.81	4,432	404	500	250	732	146	1,128	650	650	241	891	741	741	293	466	1,500	
5/13/07	2,549	1,412	466	61.61	4,427	400	500	250	732	146	1,128	650	650	241	891	741	741	293	466	1,500	
5/14/07	2,545	1,412	466	64.42	4,423	395	500	250	732	146	1,128	650	650	241	891	741	741	293	466	1,500	
5/15/07	2,541	1,412	466	67.22	4,419	391	500	250	732	146	1,128	650	650	241	891	741	741	293	466	1,500	
5/16/07	2,536	1,412	466	70.02	4,414	386	500	250	732	146	1,128	650	650	241	891	741	741	293	466	1,500	
5/17/07	2,532	1,412	466	72.82	4,410	382	500	250	732	146	1,128	650	650	241	891	741	741	293	466	1,500	
5/18/07	2,527	1,412	466	75.62	4,405	378	500	250	732	146	1,128	650	650	241	891	741	741	293	466	1,500	
5/19/07	2,523	1,412	466	78.42	4,401	373	500	250	732	146	1,128	650	650	241	891	741	741	293	466	1,500	
5/20/07	2,519	1,412	466	81.22	4,397	369	500	250			250	550	550	241	791	741	741	293	466	1,500	
5/21/07	2,514	1,412	466	84.02	4,392	365	500	250			250	450	450		450	740	740			740	
5/22/07	2,410	1,412	466	86.82	4,288	361	500	250			250	350	350		350	740	740			740	
5/23/07	2,305	0	0		2,305	357	500	250			250	250	250		250	740	740			740	
5/24/07	2,201	0	0		2,201	353	500	250			250	150	150		150	740	740			740	
5/25/07	2,097	0	0		2,097	349	500	250			250	150	150		150	740	740			740	
5/26/07	1,993	0	0		1,993	345	500	250			250	150	150		150	740	740			740	
5/27/07	1,989	0	0		1,989	341	500	250			250	150	150		150	740	740			740	
5/28/07	1,985	0	0		1,985	337	500	250			250	150	150		150	740	740			740	
5/29/07	1,981	0	0		1,981	333	500	250			250	150	150		150	740	740			740	
5/30/07	1,977	0	0		1,977	329	500	250			250	150	150		150	740	740			740	
5/31/07	1,973	0	0		1,973	325	500	250			250	150	150		150	740	740			740	
									VAMP Period												
Avg. (cfs):	2,582	1,412			4,450	435	500	250	732	146	1,128	647	647	241	888	751	751	293	456	1,500	
Supplemental Water (TAF):				86.82							45.01	8.98				14.82				18.02	

VAMP flow operation period

Appendix A-1, Table 4

2007 VAMP DAILY OPERATION PLAN — MARCH 21, 2007
(B2) SINGLE-STEP; 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	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (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)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		(cfs)	(cfs)	(cfs)	
3/15/07	**2,330**				**2,330**	**782**	**4**	**215**			**215**	**349**	**349**		**349**	**804**				**804**	
3/16/07	**2,210**				**2,210**	**753**	**23**	**228**			**228**	**348**	**348**		**348**	**806**				**806**	
3/17/07	**2,260**				**2,260**	**733**	**110**	**213**			**213**	**338**	**338**		**338**	**802**				**802**	
3/18/07	**2,230**				**2,230**	**723**	**108**	**212**			**212**	**338**	**338**		**338**	**687**				**687**	
3/19/07	**2,220**				**2,220**	**701**	**119**	**216**			**216**	**337**	**337**		**337**	**603**				**603**	
3/20/07																					
3/21/07																					
3/22/07																					
3/23/07																					
3/24/07																					
3/25/07																					
3/26/07																					
3/27/07																					
3/28/07																					
3/29/07						588		250													
3/30/07						584		250				300	300			768	768				
3/31/07						580		250				300	300			768	768				
4/1/07	2,402					576	500	250			250	300	300		300	768	768			768	
4/2/07	2,398					572	500	250			250	300	300		300	768	768			768	
4/3/07	2,394					568	500	250			250	300	300		300	768	768			768	
4/4/07	2,390				2,390	564	500	250			250	300	300		300	768	768			768	
4/5/07	2,386				2,386	560	500	250			250	300	300		300	768	768			768	
4/6/07	2,382				2,382	556	500	250			250	300	300		300	768	768			768	
4/7/07	2,378				2,378	552	500	250			250	300	300		300	768	768			768	
4/8/07	2,374				2,374	548	500	250			250	300	300		300	768	768			768	
4/9/07	2,370				2,370	544	500	250			250	300	300		300	768	768			768	
4/10/07	2,366				2,366	540	500	250			250	300	300		300	768	768			768	
4/11/07	2,362				2,362	536	500	250			250	300	300		300	768	768			768	
4/12/07	2,358				2,358	532	500	250			250	300	300		300	768	768			768	
4/13/07	2,354	0			2,354	528	500	250			250	300	300		300	768	768			768	
4/14/07	2,350	0			2,350	524	500	250			250	300	300		300	768	768			768	
4/15/07	2,346	0	0	0.00	2,346	520	500	250			250	250	250		250	768	768			768	
4/16/07	2,342	0	0	0.00	2,342	516	500	250			250	250	250		250	768	768			768	
4/17/07	2,288	0	0	0.00	2,288	512	500	250			250	250	250		250	768	768			768	
4/18/07	2,284	0	0	0.00	2,284	508	500	250			250	250	250		250	768	768			768	
4/19/07	2,280	0	0	0.00	2,280	504	500	250	0	0	250	250	250		250	768	768			768	
4/20/07	2,276	0	0	0.00	2,276	500	500	250	0	0	250	650	650	0	650	768	768	0	732	1,500	
4/21/07	2,272	0	0	0.00	2,272	496	500	250	0	0	250	650	650	0	650	768	768	0	732	1,500	
4/22/07	2,668	0	732	0.00	3,400	491	500	250	0	0	250	650	650	0	650	768	768	0	732	1,500	
4/23/07	2,664	0	732	0.00	3,396	487	500	250	0	0	250	650	650	0	650	768	768	0	732	1,500	
4/24/07	2,659	0	732	0.00	3,391	483	500	250	0	0	250	650	650	0	650	768	768	0	732	1,500	
4/25/07	2,655	0	732	0.00	3,387	478	500	250	0	0	250	650	650	0	650	768	768	0	732	1,500	
4/26/07	2,651	0	732	0.00	3,383	474	500	250	0	0	250	650	650	0	650	768	768	0	732	1,500	
4/27/07	2,646	0	732	0.00	3,378	469	500	250	0	0	250	650	650	0	650	768	768	0	732	1,500	
4/28/07	2,642	0	732	0.00	3,374	465	500	250	0	0	250	650	650	0	650	768	768	0	732	1,500	
4/29/07	2,637	0	732	0.00	3,369	461	500	250	0	0	250	650	650	0	650	768	768	0	732	1,500	
4/30/07	2,633	0	732	0.00	3,365	456	500	250	0	0	250	650	650	0	650	768	768	0	732	1,500	
5/1/07	2,629	0	732	0.00	3,361	452	500	250	0	0	250	650	650	0	650	741	741	0	759	1,500	
5/2/07	2,624	0	732	0.00	3,356	448	500	250	0	0	250	650	650	0	650	741	741	0	759	1,500	
5/3/07	2,593	0	759	0.00	3,352	443	500	250	0	0	250	650	650	0	650	741	741	0	759	1,500	
5/4/07	2,589	0	759	0.00	3,348	439	500	250	0	0	250	650	650	0	650	741	741	0	759	1,500	
5/5/07	2,584	0	759	0.00	3,343	435	500	250	0	0	250	650	650	0	650	741	741	0	759	1,500	
5/6/07	2,580	0	759	0.00	3,339	430	500	250	0	0	250	650	650	0	650	741	741	0	759	1,500	
5/7/07	2,576	0	759	0.00	3,335	426	500	250	0	0	250	650	650	0	650	741	741	0	759	1,500	
5/8/07	2,571	0	759	0.00	3,330	421	500	250	0	0	250	650	650	0	650	741	741	0	759	1,500	
5/9/07	2,567	0	759	0.00	3,326	417	500	250	0	0	250	650	650	0	650	741	741	0	759	1,500	
5/10/07	2,562	0	759	0.00	3,321	413	500	250	0	0	250	650	650	0	650	741	741	0	759	1,500	
5/11/07	2,558	0	759	0.00	3,317	408	500	250	0	0	250	650	650	0	650	741	741	0	759	1,500	
5/12/07	2,554	0	759	0.00	3,313	404	500	250	0	0	250	650	650	0	650	741	741	0	759	1,500	
5/13/07	2,549	0	759	0.00	3,308	400	500	250	0	0	250	650	650	0	650	741	741	0	759	1,500	
5/14/07	2,545	0	759	0.00	3,304	395	500	250	0	0	250	650	650	0	650	741	741	0	759	1,500	
5/15/07	2,541	0	759	0.00	3,300	391	500	250	0	0	250	650	650	0	650	741	741	0	759	1,500	
5/16/07	2,536	0	759		3,295	386	500	250	0	0	250	650	650	0	650	741	741	0	759	1,500	
5/17/07	2,532	0	759		3,291	382	500	250	0	0	250	650	650	0	650	741	741	0	759	1,500	
5/18/07	2,527	0	759		3,286	378	500	250	0	0	250	650	650	0	650	741	741	0	759	1,500	
5/19/07	2,523	0	759		3,282	373	500	250	0	0	250	650	650	0	650	741	741	0	759	1,500	
5/20/07	2,519	0	759		3,278	369	500	250			250	550	550	0	550	741	741	0	759	1,500	
5/21/07	2,514	0	759		3,273	365	500	250			250	450	450		450	740	740			740	
5/22/07	2,410	0	759		3,169	361	500	250			250	350	350		350	740	740			740	
5/23/07	2,305	0	0		2,305	357	500	250			250	250	250		250	740	740			740	
5/24/07	2,201	0	0		2,201	353	500	250			250	150	150		150	740	740			740	
5/25/07	2,097	0	0		2,097	349	500	250			250	150	150		150	740	740			740	
5/26/07	1,993	0	0		1,993	345	500	250			250	150	150		150	740	740			740	
5/27/07	1,989	0	0		1,989	341	500	250			250	150	150		150	740	740			740	
5/28/07	1,985	0	0		1,985	337	500	250			250	150	150		150	740	740			740	
5/29/07	1,981	0	0		1,981	333	500	250			250	150	150		150	740	740			740	
5/30/07	1,977	0	0		1,977	329	500	250			250	150	150		150	740	740			740	
5/31/07	1,973	0	0		1,973	325	500	250			250	150	150		150	740	740			740	
										VAMP Period											
Avg. (cfs):	2,582	0			3,331	435	500	250	0	0	250	647	647	0	647	751	751	0	749	1,500	
Supplemental Water (TAF):				0.00							0.00	0.00				0.00				0.00	

VAMP flow operation period

Appendix A-1, Table 5

2007 VAMP DAILY OPERATION PLAN – APRIL 6, 2007
(A) SINGLE-STEP; HIGH UNGAGED FLOW; NO STANISLAUS b(2) WATER
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	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (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)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		(cfs)	(cfs)	(cfs)	
3/15/07	**2,420**				**2,420**	**870**	**10**	**215**			**215**	**349**	**349**		**349**	**804**	**804**			**804**	
3/16/07	**2,290**				**2,290**	**840**	**17**	**228**			**228**	**348**	**348**		**348**	**806**	**806**			**806**	
3/17/07	**2,350**				**2,350**	**820**	**112**	**213**			**213**	**338**	**338**		**338**	**802**	**802**			**802**	
3/18/07	**2,320**				**2,320**	**813**	**111**	**212**			**212**	**338**	**338**		**338**	**687**	**687**			**687**	
3/19/07	**2,310**				**2,310**	**791**	**122**	**216**			**216**	**337**	**337**		**337**	**603**	**603**			**603**	
3/20/07	**2,150**				**2,150**	**782**	**99**	**208**			**208**	**337**	**337**		**337**	**609**	**609**			**609**	
3/21/07	**2,240**				**2,240**	**744**	**297**	**215**			**215**	**334**	**334**		**334**	**607**	**607**			**607**	
3/22/07	**2,180**				**2,180**	**741**	**236**	**223**			**223**	**335**	**335**		**335**	**604**	**604**			**604**	
3/23/07	**2,200**				**2,200**	**703**	**307**	**212**			**212**	**334**	**334**		**334**	**547**	**547**			**547**	
3/24/07	**2,230**				**2,230**	**630**	**335**	**213**			**213**	**335**	**335**		**335**	**504**	**504**			**504**	
3/25/07	**2,210**				**2,210**	**563**	**403**	**214**			**214**	**336**	**336**		**336**	**502**	**502**			**502**	
3/26/07	**2,160**				**2,160**	**546**	**479**	**215**			**215**	**335**	**335**		**335**	**509**	**509**			**509**	
3/27/07	**2,050**				**2,050**	**545**	**436**	**234**			**234**	**335**	**335**		**335**	**503**	**503**			**503**	
3/28/07	**2,030**				**2,030**	**534**	**426**	**229**			**229**	**335**	**335**		**335**	**505**	**505**			**505**	
3/29/07	**2,000**				**2,000**	**516**	**402**	**229**			**229**	**337**	**337**		**337**	**503**	**503**			**503**	
3/30/07	**1,910**				**1,910**	**518**	**302**	**223**			**223**	**337**	**337**		**337**	**503**	**503**			**503**	
3/31/07	**1,880**				**1,880**	**494**	**295**	**198**			**198**	**338**	**338**		**338**	**501**	**501**			**501**	
4/1/07	**1,950**				**1,950**	**472**	**363**	**202**			**202**	**339**	**339**		**339**	**500**	**500**			**500**	
4/2/07	**1,920**				**1,920**	**465**	**364**	**221**			**221**	**338**	**338**		**338**	**502**	**502**			**502**	
4/3/07	**1,790**				**1,790**	**421**	**281**	**214**			**214**	**337**	**337**		**337**	**509**	**509**			**509**	
4/4/07	**1,720**				**1,720**	**414**	**213**	**213**			**213**	**337**	**337**		**337**	**503**	**503**			**503**	
4/5/07	**1,670**				**1,670**	**383**	**182**	**206**			**206**	**337**	**337**		**337**	**500**	**500**			**500**	
4/6/07	1,698				1,698	376	230	250			250	300	300		300	768	768			768	
4/7/07	1,733				1,733	369	300	250			250	300	300		300	768	768			768	
4/8/07	1,950				1,950	362	300	250			250	300	300		300	768	768			768	
4/9/07	1,987				1,987	355	300	250			250	300	300		300	768	768			768	
4/10/07	1,980				1,980	348	300	250			250	300	300		300	768	768			768	
4/11/07	1,973				1,973	341	300	250			250	300	300		300	768	768			768	
4/12/07	1,966				1,966	334	300	250			250	300	300		300	768	768			768	
4/13/07	1,959	0			1,959	327	300	250			250	300	300		300	768	768			768	
4/14/07	1,952	0			1,952	320	300	250			250	300	300		300	768	768			768	
4/15/07	1,945	0	0	0.00	1,945	313	300	250			250	250	250		250	768	768			768	
4/16/07	1,938	0	0	0.00	1,938	306	300	250			250	250	250		250	768	768			768	
4/17/07	1,881	0	0	0.00	1,881	299	300	250			250	250	250		250	768	768			768	
4/18/07	1,874	0	0	0.00	1,874	292	300	250			250	250	250		250	768	768			768	
4/19/07	1,867	0	0	0.00	1,867	307	300	250	0	0	250	250	250		250	768	768			768	
4/20/07	1,860	0	0	0.00	1,860	300	300	250	50	0	300	537	680	170	850	768	1,000	500	0	1,500	
4/21/07	1,875	0	0	0.00	1,875	296	300	250	50	0	300	537	680	170	850	768	1,000	500	0	1,500	
4/22/07	2,530	670	0	1.33	3,200	292	300	250	50	0	300	537	680	170	850	768	1,000	500	0	1,500	
4/23/07	2,526	720	0	2.76	3,246	288	300	250	50	0	300	537	680	170	850	768	1,000	500	0	1,500	
4/24/07	2,522	720	0	4.19	3,242	284	300	250	50	0	300	537	680	170	850	768	1,000	500	0	1,500	
4/25/07	2,518	720	0	5.61	3,238	280	300	250	50	0	300	537	680	170	850	768	1,000	500	0	1,500	
4/26/07	2,514	720	0	7.04	3,234	276	300	250	50	0	300	537	680	170	850	768	1,000	500	0	1,500	
4/27/07	2,510	720	0	8.47	3,230	272	300	250	50	0	300	537	680	170	850	768	1,000	500	0	1,500	
4/28/07	2,506	720	0	9.90	3,226	268	300	250	50	0	300	537	680	170	850	768	1,000	500	0	1,500	
4/29/07	2,502	720	0	11.33	3,222	264	300	250	200	0	450	537	680	170	850	768	1,000	500	0	1,500	
4/30/07	2,498	720	0	12.75	3,218	260	300	250	450	0	700	537	530	170	700	768	1,000	500	0	1,500	
5/1/07	2,494	720	0	14.18	3,214	256	300	250	880	0	1,130	537	330	170	500	741	800	700	0	1,500	
5/2/07	2,340	870	0	15.91	3,210	252	300	250	1,120	330	1,700	537	330	170	500	741	440	460	0	900	
5/3/07	1,936	1,320	0	18.53	3,256	248	300	250	1,120	330	1,700	537	320	170	490	741	500	0	0	500	
5/4/07	1,572	1,510	0	21.52	3,082	244	300	250	1,120	330	1,700	537	320	170	490	741	500	0	0	500	
5/5/07	1,618	1,620	0	24.73	3,238	240	300	250	1,110	340	1,700	537	320	170	490	741	500	0	0	500	
5/6/07	1,614	1,620	0	27.95	3,234	237	300	250	1,110	340	1,700	537	320	170	490	741	500	0	0	500	
5/7/07	1,610	1,620	0	31.16	3,230	234	300	250	1,110	340	1,700	537	320	170	490	741	500	0	0	500	
5/8/07	1,607	1,620	0	34.37	3,227	231	300	250	1,110	340	1,700	537	320	170	490	741	500	0	0	500	
5/9/07	1,604	1,620	0	37.59	3,224	228	300	250	1,110	340	1,700	537	320	170	490	741	500	0	0	500	
5/10/07	1,601	1,620	0	40.80	3,221	225	300	250	1,120	330	1,700	537	320	170	490	741	500	0	0	500	
5/11/07	1,598	1,620	0	44.01	3,218	222	300	250	1,120	330	1,700	537	320	170	490	741	500	0	0	500	
5/12/07	1,595	1,620	0	47.23	3,215	219	300	250	1,120	330	1,700	537	320	170	490	741	500	0	0	500	
5/13/07	1,592	1,620	0	50.44	3,212	216	300	250	950	0	1,200	537	320	170	490	741	500	0	0	500	
5/14/07	1,589	1,620	0	53.65	3,209	213	300	250	600	0	850	537	680	170	850	741	610	100	0	710	
5/15/07	1,586	1,620	0	56.87	3,206	210	300	250	600	0	850	537	810	170	980	741	820	100	0	920	
5/16/07	2,053	1,220	0	59.29	3,273	207	300	250	600	0	850	537	810	170	980	741	820	100	0	920	
5/17/07	2,390	870	0	61.01	3,260	204	300	250	600	0	850	537	810	170	980	741	820	100	0	920	
5/18/07	2,387	870	0	62.74	3,257	201	300	250	550	0	800	537	810	170	980	741	820	100	0	920	
5/19/07	2,384	870	0	64.46	3,254	198	300	250	250	0	500	537	810	170	980	741	820	100	0	920	
5/20/07	2,381	870	0	66.19	3,251	195	300	250			250	537	400	140	540	741	820	100	0	920	
5/21/07	2,378	820	0	67.81	3,198	192	300	250			250	250	250		250	741	741			741	
5/22/07	1,965	490	0	68.79	2,455	189	300	250			250	200	200		200	741	741			741	
5/23/07	1,733	0	0		1,733	186	300	250			250	200	200		200	741	741			741	
5/24/07	1,680	0	0		1,680	183	300	250			250	150	150		150	741	741			741	
5/25/07	1,677	0	0		1,677	180	300	250			250	150	150		150	741	741			741	
5/26/07	1,624	0	0		1,624	177	300	250			250	150	150		150	741	741			741	
5/27/07	1,621	0	0		1,621	174	300	250			250	150	150		150	741	741			741	
5/28/07	1,618	0	0		1,618	171	300	250			250	150	150		150	741	741			741	
5/29/07	1,615	0	0		1,615	168	300	250			250	150	150		150	741	741			741	
5/30/07	1,612	0	0		1,612	165	300	250			250	135	135		135	741	741			741	
5/31/07	1,609	0	0		1,609	162	300	250			250	120	120		120	741	741			741	
										VAMP Period											
Avg. (cfs):	2,081	1,119			3,200	244	300	250	594	119	962	537	537	169	706	751	751	237	0	988	
Supplemental Water (TAF):				68.79							36.50	7.30				10.39				14.60	

VAMP flow operation period

Appendix A-1, Table 6

2007 VAMP DAILY OPERATION PLAN — APRIL 6, 2007
(B) SINGLE-STEP; HIGH UNGAGED FLOW; STANISLAUS b(2) WATER
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	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (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)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		(cfs)	(cfs)	(cfs)	
3/15/07	**2,420**				**2,420**	**870**	**10**	**215**			**215**	**349**	**349**		**349**	**804**	**804**			**804**	
3/16/07	**2,290**				**2,290**	**840**	**17**	**228**			**228**	**348**	**348**		**348**	**806**	**806**			**806**	
3/17/07	**2,350**				**2,350**	**820**	**112**	**213**			**213**	**338**	**338**		**338**	**802**	**802**			**802**	
3/18/07	**2,320**				**2,320**	**813**	**111**	**212**			**212**	**338**	**338**		**338**	**687**	**687**			**687**	
3/19/07	**2,310**				**2,310**	**791**	**122**	**216**			**216**	**337**	**337**		**337**	**603**	**603**			**603**	
3/20/07	**2,150**				**2,150**	**782**	**99**	**208**			**208**	**337**	**337**		**337**	**609**	**609**			**609**	
3/21/07	**2,240**				**2,240**	**744**	**297**	**215**			**215**	**334**	**334**		**334**	**607**	**607**			**607**	
3/22/07	**2,180**				**2,180**	**741**	**236**	**223**			**223**	**335**	**335**		**335**	**604**	**604**			**604**	
3/23/07	**2,200**				**2,200**	**703**	**307**	**212**			**212**	**334**	**334**		**334**	**547**	**547**			**547**	
3/24/07	**2,230**				**2,230**	**630**	**335**	**213**			**213**	**335**	**335**		**335**	**504**	**504**			**504**	
3/25/07	**2,210**				**2,210**	**563**	**403**	**214**			**214**	**336**	**336**		**336**	**502**	**502**			**502**	
3/26/07	**2,160**				**2,160**	**546**	**479**	**215**			**215**	**335**	**335**		**335**	**509**	**509**			**509**	
3/27/07	**2,050**				**2,050**	**545**	**436**	**234**			**234**	**335**	**335**		**335**	**503**	**503**			**503**	
3/28/07	**2,030**				**2,030**	**534**	**426**	**229**			**229**	**335**	**335**		**335**	**505**	**505**			**505**	
3/29/07	**2,000**				**2,000**	**516**	**402**	**229**			**229**	**337**	**337**		**337**	**503**	**503**			**503**	
3/30/07	**1,910**				**1,910**	**518**	**302**	**223**			**223**	**337**	**337**		**337**	**503**	**503**			**503**	
3/31/07	**1,880**				**1,880**	**494**	**295**	**198**			**198**	**338**	**338**		**338**	**501**	**501**			**501**	
4/1/07	**1,950**				**1,950**	**472**	**363**	**202**			**202**	**339**	**339**		**339**	**500**	**500**			**500**	
4/2/07	**1,920**				**1,920**	**465**	**364**	**221**			**221**	**338**	**338**		**338**	**502**	**502**			**502**	
4/3/07	**1,790**				**1,790**	**421**	**281**	**214**			**214**	**337**	**337**		**337**	**509**	**509**			**509**	
4/4/07	**1,720**				**1,720**	**414**	**213**	**213**			**213**	**337**	**337**		**337**	**503**	**503**			**503**	
4/5/07	**1,670**				**1,670**	**383**	**182**	**206**			**206**	**337**	**337**		**337**	**500**	**500**			**500**	
4/6/07	1,698				1,698	376	230	250			250	300	300		300	768	768			768	
4/7/07	1,733				1,733	369	300	250			250	300	300		300	768	768			768	
4/8/07	1,950				1,950	362	300	250			250	300	300		300	768	768			768	
4/9/07	1,987				1,987	355	300	250			250	300	300		300	768	768			768	
4/10/07	1,980				1,980	348	300	250			250	300	300		300	768	768			768	
4/11/07	1,973				1,973	341	300	250			250	300	300		300	768	768			768	
4/12/07	1,966				1,966	334	300	250			250	300	300		300	768	768			768	
4/13/07	1,959	0			1,959	327	300	250			250	300	300		300	768	768			768	
4/14/07	1,952	0			1,952	320	300	250			250	300	300		300	768	768			768	
4/15/07	1,945	0	0	0.00	1,945	313	300	250			250	250	250		250	768	768			768	
4/16/07	1,938	0	0	0.00	1,938	306	300	250			250	250	250		250	768	768			768	
4/17/07	1,881	0	0	0.00	1,881	299	300	250			250	250	250		250	768	768			768	
4/18/07	1,874	0	0	0.00	1,874	292	300	250			250	250	250		250	768	768			768	
4/19/07	1,867	0	0	0.00	1,867	307	300	250	250	0	500	250	250		250	768	768			768	
4/20/07	1,860	0	0	0.00	1,860	300	300	250	250	0	500	537	600	0	600	768	768	0	732	1,500	
4/21/07	1,875	0	0	0.00	1,875	296	300	250	250	0	500	537	640	0	640	768	768	0	732	1,500	
4/22/07	2,218	250	732	0.50	3,200	292	300	250	250	0	500	537	640	0	640	768	768	0	732	1,500	
4/23/07	2,254	250	732	0.99	3,236	288	300	250	250	0	500	537	640	0	640	768	768	0	732	1,500	
4/24/07	2,250	250	732	1.49	3,232	284	300	250	250	0	500	537	640	0	640	768	768	0	732	1,500	
4/25/07	2,246	250	732	1.98	3,228	280	300	250	250	0	500	537	640	0	640	768	768	0	732	1,500	
4/26/07	2,242	250	732	2.48	3,224	276	300	250	250	0	500	537	640	0	640	768	768	0	732	1,500	
4/27/07	2,238	250	732	2.98	3,220	272	300	250	250	0	500	537	640	0	640	768	768	0	732	1,500	
4/28/07	2,234	250	732	3.47	3,216	268	300	250	250	0	500	537	640	0	640	768	768	0	732	1,500	
4/29/07	2,230	250	732	3.97	3,212	264	300	250	250	0	500	537	640	0	640	768	768	0	732	1,500	
4/30/07	2,226	250	732	4.46	3,208	260	300	250	250	0	500	537	640	0	640	768	768	0	732	1,500	
5/1/07	2,222	250	732	4.96	3,204	256	300	250	250	0	500	537	640	0	640	741	741	0	759	1,500	
5/2/07	2,218	250	732	5.45	3,200	252	300	250	500	0	750	537	640	0	640	741	741	0	759	1,500	
5/3/07	2,187	250	759	5.95	3,196	248	300	250	600	0	850	537	380	0	380	741	741	0	759	1,500	
5/4/07	2,183	250	759	6.45	3,192	244	300	250	600	0	850	537	320	0	320	741	741	0	759	1,500	
5/5/07	1,919	500	759	7.44	3,178	240	300	250	600	0	850	537	320	0	320	741	741	0	759	1,500	
5/6/07	1,855	600	759	8.63	3,214	237	300	250	600	0	850	537	320	0	320	741	741	0	759	1,500	
5/7/07	1,851	600	759	9.82	3,210	234	300	250	600	0	850	537	320	0	320	741	741	0	759	1,500	
5/8/07	1,848	600	759	11.01	3,207	231	300	250	600	0	850	537	320	0	320	741	741	0	759	1,500	
5/9/07	1,845	600	759	12.20	3,204	228	300	250	600	0	850	537	320	0	320	741	741	0	759	1,500	
5/10/07	1,842	600	759	13.39	3,201	225	300	250	600	0	850	537	320	0	320	741	741	0	759	1,500	
5/11/07	1,839	600	759	14.58	3,198	222	300	250	600	0	850	537	320	0	320	741	741	0	759	1,500	
5/12/07	1,836	600	759	15.77	3,195	219	300	250	530	0	780	537	320	0	320	741	741	0	759	1,500	
5/13/07	1,833	600	759	16.96	3,192	216	300	250	250	0	500	537	420	0	420	741	741	0	759	1,500	
5/14/07	1,830	600	759	18.15	3,189	213	300	250	250	0	500	537	700	0	700	741	741	0	759	1,500	
5/15/07	1,927	530	759	19.20	3,216	210	300	250	250	0	500	537	700	0	700	741	741	0	759	1,500	
5/16/07	2,204	250	759	19.70	3,213	207	300	250	250	0	500	537	700	0	700	741	741	0	759	1,500	
5/17/07	2,201	250	759	20.19	3,210	204	300	250	250	0	500	537	700	0	700	741	741	0	759	1,500	
5/18/07	2,198	250	759	20.69	3,207	201	300	250	250	0	500	537	700	0	700	741	741	0	759	1,500	
5/19/07	2,195	250	759	21.18	3,204	198	300	250	250	0	500	537	700	0	700	741	741	0	759	1,500	
5/20/07	2,192	250	759	21.68	3,201	195	300	250			250	537	500	0	500	741	741	0	759	1,500	
5/21/07	2,189	250	759	22.18	3,198	192	300	250			250	250	250		250	741	741			741	
5/22/07	1,986	250	759	22.67	2,995	189	300	250			250	200	200		200	741	741			741	
5/23/07	1,733	0	0		1,733	186	300	250			250	200	200		200	741	741			741	
5/24/07	1,680	0	0		1,680	183	300	250			250	150	150		150	741	741			741	
5/25/07	1,677	0	0		1,677	180	300	250			250	150	150		150	741	741			741	
5/26/07	1,624	0	0		1,624	177	300	250			250	150	150		150	741	741			741	
5/27/07	1,621	0	0		1,621	174	300	250			250	150	150		150	741	741			741	
5/28/07	1,618	0	0		1,618	171	300	250			250	150	150		150	741	741			741	
5/29/07	1,615	0	0		1,615	168	300	250			250	150	150		150	741	741			741	
5/30/07	1,612	0	0		1,612	165	300	250			250	135	135		135	741	741			741	
5/31/07	1,609	0	0		1,609	162	300	250			250	120	120		120	741	741			741	
										VAMP Period											
Avg. (cfs):	2,082	369			3,200	244	300	250	369	0	619	537	537	0	537	751	751	0	749	1,500	
Supplemental Water (TAF):				22.67							22.67	0.00				0.00				0.00	

VAMP flow operation period

Appendix A-1, Table 7

2007 VAMP DAILY OPERATION PLAN — APRIL 6, 2007
(C) SINGLE-STEP; LOW UNGAGED FLOW; NO STANISLAUS b(2) WATER
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	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (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)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		(cfs)	(cfs)	(cfs)	
3/15/07	2,420				2,420	870	10	215			215	349	349		349	804	804			804	
3/16/07	2,290				2,290	840	17	228			228	348	348		348	806	806			806	
3/17/07	2,350				2,350	820	112	213			213	338	338		338	802	802			802	
3/18/07	2,320				2,320	813	111	212			212	338	338		338	687	687			687	
3/19/07	2,310				2,310	791	122	216			216	337	337		337	603	603			603	
3/20/07	2,150				2,150	782	99	208			208	337	337		337	609	609			609	
3/21/07	2,240				2,240	744	297	215			215	334	334		334	607	607			607	
3/22/07	2,180				2,180	741	236	223			223	335	335		335	604	604			604	
3/23/07	2,200				2,200	703	307	212			212	334	334		334	547	547			547	
3/24/07	2,230				2,230	630	335	213			213	335	335		335	504	504			504	
3/25/07	2,210				2,210	563	403	214			214	336	336		336	502	502			502	
3/26/07	2,160				2,160	546	479	215			215	335	335		335	509	509			509	
3/27/07	2,050				2,050	545	436	234			234	335	335		335	503	503			503	
3/28/07	2,030				2,030	534	426	229			229	335	335		335	505	505			505	
3/29/07	2,000				2,000	516	402	229			229	337	337		337	503	503			503	
3/30/07	1,910				1,910	518	302	223			223	337	337		337	503	503			503	
3/31/07	1,880				1,880	494	295	198			198	338	338		338	501	501			501	
4/1/07	1,950				1,950	472	363	202			202	339	339		339	500	500			500	
4/2/07	1,920				1,920	465	364	221			221	338	338		338	502	502			502	
4/3/07	1,790				1,790	421	281	214			214	337	337		337	509	509			509	
4/4/07	1,720				1,720	414	213	213			213	337	337		337	503	503			503	
4/5/07	1,670				1,670	383	182	206			206	337	337		337	500	500			500	
4/6/07	1,698				1,698	376	230	250			250	300	300		300	768	768			768	
4/7/07	1,653				1,653	369	220	250			250	300	300		300	768	768			768	
4/8/07	1,860				1,860	362	210	250			250	300	300		300	768	768			768	
4/9/07	1,887				1,887	355	200	250			250	300	300		300	768	768			768	
4/10/07	1,870				1,870	348	190	250			250	300	300		300	768	768			768	
4/11/07	1,853				1,853	341	180	250			250	300	300		300	768	768			768	
4/12/07	1,836				1,836	334	170	250			250	300	300		300	768	768			768	
4/13/07	1,819	0			1,819	327	160	250			250	300	300		300	768	768			768	
4/14/07	1,752	0			1,752	320	100	250			250	300	300		300	768	768			768	
4/15/07	1,745	0	0	0.00	1,745	313	100	250			250	250	250		250	768	768			768	
4/16/07	1,738	0	0	0.00	1,738	306	100	250			250	250	250		250	768	768			768	
4/17/07	1,681	0	0	0.00	1,681	299	100	250			250	250	250		250	768	768			768	
4/18/07	1,674	0	0	0.00	1,674	292	100	250			250	250	250		250	768	768			768	
4/19/07	1,667	0	0	0.00	1,667	307	100	250	119	0	369	250	250		250	768	768			768	
4/20/07	1,660	0	0	0.00	1,660	300	100	250	119	0	369	537	703	0	703	768	768	0	0	768	
4/21/07	1,675	0	0	0.00	1,675	296	100	250	119	0	369	537	703	0	703	768	768	0	0	768	
4/22/07	2,121	119	0	0.24	2,240	292	100	250	119	0	369	537	703	0	703	768	768	0	0	768	
4/23/07	2,117	119	0	0.47	2,236	288	100	250	119	0	369	537	703	0	703	768	768	0	0	768	
4/24/07	2,113	119	0	0.71	2,232	284	100	250	119	0	369	537	703	0	703	768	768	0	0	768	
4/25/07	2,109	119	0	0.94	2,228	280	100	250	119	0	369	537	703	0	703	768	768	0	0	768	
4/26/07	2,105	119	0	1.18	2,224	276	100	250	119	0	369	537	593	0	593	768	768	0	0	768	
4/27/07	2,101	119	0	1.42	2,220	272	100	250	119	0	369	537	482	0	482	768	768	0	0	768	
4/28/07	1,987	119	0	1.65	2,106	268	100	250	119	0	369	537	390	0	390	768	768	0	0	768	
4/29/07	1,872	119	0	1.89	1,991	264	100	250	119	0	369	537	390	0	390	768	768	0	0	768	
4/30/07	1,776	119	0	2.12	1,895	260	100	250	119	0	369	537	390	0	390	768	768	0	0	768	
5/1/07	1,772	119	0	2.36	1,891	256	100	250	119	0	369	537	390	0	390	741	741	0	0	741	
5/2/07	1,768	119	0	2.60	1,887	252	100	250	119	0	369	537	390	0	390	741	741	0	0	741	
5/3/07	1,737	119	0	2.83	1,856	248	100	250	119	0	369	537	390	0	390	741	741	0	0	741	
5/4/07	1,733	119	0	3.07	1,852	244	100	250	119	0	369	537	390	0	390	741	741	0	0	741	
5/5/07	1,729	119	0	3.30	1,848	240	100	250	119	0	369	537	482	0	482	741	741	0	0	741	
5/6/07	1,725	119	0	3.54	1,844	237	100	250	119	0	369	537	593	0	593	741	741	0	0	741	
5/7/07	1,813	119	0	3.78	1,932	234	100	250	119	0	369	537	703	0	703	741	741	0	0	741	
5/8/07	1,921	119	0	4.01	2,040	231	100	250	119	0	369	537	703	0	703	741	741	0	0	741	
5/9/07	2,028	119	0	4.25	2,147	228	100	250	119	0	369	537	703	0	703	741	741	0	0	741	
5/10/07	2,025	119	0	4.48	2,144	225	100	250	119	0	369	537	703	0	703	741	741	0	0	741	
5/11/07	2,022	119	0	4.72	2,141	222	100	250	119	0	369	537	703	0	703	741	741	0	0	741	
5/12/07	2,019	119	0	4.96	2,138	219	100	250	119	0	369	537	703	0	703	741	741	0	0	741	
5/13/07	2,016	119	0	5.19	2,135	216	100	250	119	0	369	537	593	0	593	741	741	0	0	741	
5/14/07	2,013	119	0	5.43	2,132	213	100	250	119	0	369	537	482	0	482	741	741	0	0	741	
5/15/07	1,900	119	0	5.66	2,019	210	100	250	119	0	369	537	390	0	390	741	741	0	0	741	
5/16/07	1,786	119	0	5.90	1,905	207	100	250	119	0	369	537	390	0	390	741	741	0	0	741	
5/17/07	1,691	119	0	6.14	1,810	204	100	250	119	0	369	537	390	0	390	741	741	0	0	741	
5/18/07	1,688	119	0	6.37	1,807	201	100	250	119	0	369	537	390	0	390	741	741	0	0	741	
5/19/07	1,685	119	0	6.61	1,804	198	100	250	119	0	369	537	390	0	390	741	741	0	0	741	
5/20/07	1,682	119	0	6.84	1,801	195	100	250			250	537	300	0	300	741	741	0	0	741	
5/21/07	1,679	119	0	7.08	1,798	192	100	250			250	250	250		250	741	741			741	
5/22/07	1,586	119	0	7.32	1,705	189	100	250			250	200	200		200	741	741			741	
5/23/07	1,533	0	0		1,533	186	100	250			250	200	200		200	741	741			741	
5/24/07	1,480	0	0		1,480	183	100	250			250	150	150		150	741	741			741	
5/25/07	1,477	0	0		1,477	180	100	250			250	150	150		150	741	741			741	
5/26/07	1,424	0	0		1,424	177	100	250			250	150	150		150	741	741			741	
5/27/07	1,421	0	0		1,421	174	100	250			250	150	150		150	741	741			741	
5/28/07	1,418	0	0		1,418	171	100	250			250	150	150		150	741	741			741	
5/29/07	1,415	0	0		1,415	168	100	250			250	150	150		150	741	741			741	
5/30/07	1,412	0	0		1,412	165	100	250			250	135	135		135	741	741			741	
5/31/07	1,409	0	0		1,409	162	100	250			250	120	120		120	741	741			741	
										VAMP Period											
Avg. (cfs):	1,881	119			2,000	244	100	250	119	0	369	537	537	0	537	751	751	0	0	751	
Supplemental Water (TAF):				7.32							7.32	0.00				0.00				0.00	

VAMP flow operation period

Appendix A-1, Table 8

2007 VAMP DAILY OPERATION PLAN – APRIL 6, 2007
(D) SINGLE-STEP; LOW UNGAGED FLOW; STANISLAUS b(2) WATER
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	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (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)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		(cfs)	(cfs)	(cfs)	
3/15/07	**2,420**				**2,420**	**870**	**10**	**215**			**215**	**349**	**349**		**349**	**804**	**804**			**804**	
3/16/07	**2,290**				**2,290**	**840**	**17**	**228**			**228**	**348**	**348**		**348**	**806**	**806**			**806**	
3/17/07	**2,350**				**2,350**	**820**	**112**	**213**			**213**	**338**	**338**		**338**	**802**	**802**			**802**	
3/18/07	**2,320**				**2,320**	**813**	**111**	**212**			**212**	**338**	**338**		**338**	**687**	**687**			**687**	
3/19/07	**2,310**				**2,310**	**791**	**122**	**216**			**216**	**337**	**337**		**337**	**603**	**603**			**603**	
3/20/07	**2,150**				**2,150**	**782**	**99**	**208**			**208**	**337**	**337**		**337**	**609**	**609**			**609**	
3/21/07	**2,240**				**2,240**	**744**	**297**	**215**			**215**	**334**	**334**		**334**	**607**	**607**			**607**	
3/22/07	**2,180**				**2,180**	**741**	**236**	**223**			**223**	**335**	**335**		**335**	**604**	**604**			**604**	
3/23/07	**2,200**				**2,200**	**703**	**307**	**212**			**212**	**334**	**334**		**334**	**547**	**547**			**547**	
3/24/07	**2,230**				**2,230**	**630**	**335**	**213**			**213**	**335**	**335**		**335**	**504**	**504**			**504**	
3/25/07	**2,210**				**2,210**	**563**	**403**	**214**			**214**	**336**	**336**		**336**	**502**	**502**			**502**	
3/26/07	**2,160**				**2,160**	**546**	**479**	**215**			**215**	**335**	**335**		**335**	**509**	**509**			**509**	
3/27/07	**2,050**				**2,050**	**545**	**436**	**234**			**234**	**335**	**335**		**335**	**503**	**503**			**503**	
3/28/07	**2,030**				**2,030**	**534**	**426**	**229**			**229**	**335**	**335**		**335**	**505**	**505**			**505**	
3/29/07	**2,000**				**2,000**	**516**	**402**	**229**			**229**	**337**	**337**		**337**	**503**	**503**			**503**	
3/30/07	**1,910**				**1,910**	**518**	**302**	**223**			**223**	**337**	**337**		**337**	**503**	**503**			**503**	
3/31/07	**1,880**				**1,880**	**494**	**295**	**198**			**198**	**338**	**338**		**338**	**501**	**501**			**501**	
4/1/07	**1,950**				**1,950**	**472**	**363**	**202**			**202**	**339**	**339**		**339**	**500**	**500**			**500**	
4/2/07	**1,920**				**1,920**	**465**	**364**	**221**			**221**	**338**	**338**		**338**	**502**	**502**			**502**	
4/3/07	**1,790**				**1,790**	**421**	**281**	**214**			**214**	**337**	**337**		**337**	**509**	**509**			**509**	
4/4/07	**1,720**				**1,720**	**414**	**213**	**213**			**213**	**337**	**337**		**337**	**503**	**503**			**503**	
4/5/07	**1,670**				**1,670**	**383**	**182**	**206**			**206**	**337**	**337**		**337**	**500**	**500**			**500**	
4/6/07	1,698				1,698	376	230	250			250	300	300		300	768	768			768	
4/7/07	1,653				1,653	369	220	250			250	300	300		300	768	768			768	
4/8/07	1,860				1,860	362	210	250			250	300	300		300	768	768			768	
4/9/07	1,887				1,887	355	200	250			250	300	300		300	768	768			768	
4/10/07	1,870				1,870	348	190	250			250	300	300		300	768	768			768	
4/11/07	1,853				1,853	341	180	250			250	300	300		300	768	768			768	
4/12/07	1,836				1,836	334	170	250			250	300	300		300	768	768			768	
4/13/07	1,819	0			1,819	327	160	250			250	300	300		300	768	768			768	
4/14/07	1,752	0			1,752	320	100	250			250	300	300		300	768	768			768	
4/15/07	1,745	0	0	0.00	1,745	313	100	250			250	250	250		250	768	768			768	
4/16/07	1,738	0	0	0.00	1,738	306	100	250			250	250	250		250	768	768			768	
4/17/07	1,681	0	0	0.00	1,681	299	100	250			250	250	250		250	768	768			768	
4/18/07	1,674	0	0	0.00	1,674	292	100	250			250	250	250		250	768	768			768	
4/19/07	1,667	0	0	0.00	1,667	307	100	250	0	0	250	250	250		250	768	768			768	
4/20/07	1,660	0	0	0.00	1,660	300	100	250	0	0	250	537	703	0	703	768	768	0	732	1,500	
4/21/07	1,675	0	0	0.00	1,675	296	100	250	0	0	250	537	703	0	703	768	768	0	732	1,500	
4/22/07	2,121	0	732	0.00	2,853	292	100	250	0	0	250	537	703	0	703	768	768	0	732	1,500	
4/23/07	2,117	0	732	0.00	2,849	288	100	250	0	0	250	537	703	0	703	768	768	0	732	1,500	
4/24/07	2,113	0	732	0.00	2,845	284	100	250	0	0	250	537	703	0	703	768	768	0	732	1,500	
4/25/07	2,109	0	732	0.00	2,841	280	100	250	0	0	250	537	703	0	703	768	768	0	732	1,500	
4/26/07	2,105	0	732	0.00	2,837	276	100	250	0	0	250	537	593	0	593	768	768	0	732	1,500	
4/27/07	2,101	0	732	0.00	2,833	272	100	250	0	0	250	537	482	0	482	768	768	0	732	1,500	
4/28/07	1,987	0	732	0.00	2,719	268	100	250	0	0	250	537	390	0	390	768	768	0	732	1,500	
4/29/07	1,872	0	732	0.00	2,604	264	100	250	0	0	250	537	390	0	390	768	768	0	732	1,500	
4/30/07	1,776	0	732	0.00	2,508	260	100	250	0	0	250	537	390	0	390	768	768	0	732	1,500	
5/1/07	1,772	0	732	0.00	2,504	256	100	250	0	0	250	537	390	0	390	741	741	0	759	1,500	
5/2/07	1,768	0	732	0.00	2,500	252	100	250	0	0	250	537	390	0	390	741	741	0	759	1,500	
5/3/07	1,737	0	759	0.00	2,496	248	100	250	0	0	250	537	390	0	390	741	741	0	759	1,500	
5/4/07	1,733	0	759	0.00	2,492	244	100	250	0	0	250	537	390	0	390	741	741	0	759	1,500	
5/5/07	1,729	0	759	0.00	2,488	240	100	250	0	0	250	537	482	0	482	741	741	0	759	1,500	
5/6/07	1,725	0	759	0.00	2,484	237	100	250	0	0	250	537	593	0	593	741	741	0	759	1,500	
5/7/07	1,813	0	759	0.00	2,572	234	100	250	0	0	250	537	703	0	703	741	741	0	759	1,500	
5/8/07	1,921	0	759	0.00	2,680	231	100	250	0	0	250	537	703	0	703	741	741	0	759	1,500	
5/9/07	2,028	0	759	0.00	2,787	228	100	250	0	0	250	537	703	0	703	741	741	0	759	1,500	
5/10/07	2,025	0	759	0.00	2,784	225	100	250	0	0	250	537	703	0	703	741	741	0	759	1,500	
5/11/07	2,022	0	759	0.00	2,781	222	100	250	0	0	250	537	703	0	703	741	741	0	759	1,500	
5/12/07	2,019	0	759	0.00	2,778	219	100	250	0	0	250	537	703	0	703	741	741	0	759	1,500	
5/13/07	2,016	0	759	0.00	2,775	216	100	250	0	0	250	537	593	0	593	741	741	0	759	1,500	
5/14/07	2,013	0	759	0.00	2,772	213	100	250	0	0	250	537	482	0	482	741	741	0	759	1,500	
5/15/07	1,900	0	759	0.00	2,659	210	100	250	0	0	250	537	390	0	390	741	741	0	759	1,500	
5/16/07	1,786	0	759	0.00	2,545	207	100	250	0	0	250	537	390	0	390	741	741	0	759	1,500	
5/17/07	1,691	0	759	0.00	2,450	204	100	250	0	0	250	537	390	0	390	741	741	0	759	1,500	
5/18/07	1,688	0	759	0.00	2,447	201	100	250	0	0	250	537	390	0	390	741	741	0	759	1,500	
5/19/07	1,685	0	759	0.00	2,444	198	100	250	0	0	250	537	390	0	390	741	741	0	759	1,500	
5/20/07	1,682	0	759	0.00	2,441	195	100	250			250	537	300	0	300	741	741	0	759	1,500	
5/21/07	1,679	0	759	0.00	2,438	192	100	250			250	250	250		250	741	741			741	
5/22/07	1,586	0	759	0.00	2,345	189	100	250			250	200	200		200	741	741			741	
5/23/07	1,533	0	0		1,533	186	100	250			250	200	200		200	741	741			741	
5/24/07	1,480	0	0		1,480	183	100	250			250	150	150		150	741	741			741	
5/25/07	1,477	0	0		1,477	180	100	250			250	150	150		150	741	741			741	
5/26/07	1,424	0	0		1,424	177	100	250			250	150	150		150	741	741			741	
5/27/07	1,421	0	0		1,421	174	100	250			250	150	150		150	741	741			741	
5/28/07	1,418	0	0		1,418	171	100	250			250	150	150		150	741	741			741	
5/29/07	1,415	0	0		1,415	168	100	250			250	150	150		150	741	741			741	
5/30/07	1,412	0	0		1,412	165	100	250			250	135	135		135	741	741			741	
5/31/07	1,409	0	0		1,409	162	100	250			250	120	120		120	741	741			741	
									VAMP Period												
Avg. (cfs):	1,881	0			2,631	244	100	250	0	0	250	537	537	0	537	751	751	0	749	1,500	
Supplemental Water (TAF):				0.00							0.00	0.00				0.00				0.00	

VAMP flow operation period

Appendix A-1, Table 9

2007 VAMP DAILY OPERATION PLAN — APRIL 13, 2007
(A) SINGLE-STEP; 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	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (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 Flow	VAMP Suppl.	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol. S=Stan.
	(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		(cfs)	(cfs)	(cfs)	
3/15/07	2,420				2,420	788	97	215			215	349	349		349	804	804			804	
3/16/07	2,290				2,290	759	97	228			228	348	348		348	806	806			806	
3/17/07	2,350				2,350	739	194	213			213	338	338		338	802	802			802	
3/18/07	2,320				2,320	727	192	212			212	338	338		338	687	687			687	
3/19/07	2,310				2,310	710	203	216			216	337	337		337	603	603			603	
3/20/07	2,150				2,150	702	185	208			208	337	337		337	609	609			609	
3/21/07	2,240				2,240	659	378	215			215	334	334		334	607	607			607	
3/22/07	2,180				2,180	659	316	223			223	335	335		335	604	604			604	
3/23/07	2,200				2,200	609	392	212			212	334	334		334	547	547			547	
3/24/07	2,230				2,230	536	417	213			213	335	335		335	504	504			504	
3/25/07	2,210				2,210	476	497	214			214	336	336		336	502	502			502	
3/26/07	2,160				2,160	460	573	215			215	335	335		335	509	509			509	
3/27/07	2,050				2,050	461	523	234			234	335	335		335	503	503			503	
3/28/07	2,030				2,030	447	512	229			229	335	335		335	505	505			505	
3/29/07	2,000				2,000	437	486	229			229	337	337		337	503	503			503	
3/30/07	1,910				1,910	437	389	223			223	337	337		337	503	503			503	
3/31/07	1,880				1,880	414	374	198			198	338	338		338	501	501			501	
4/1/07	1,950				1,950	393	444	202			202	339	339		339	500	500			500	
4/2/07	1,920				1,920	380	444	221			221	338	338		338	502	502			502	
4/3/07	1,790				1,790	342	360	214			214	337	337		337	509	509			509	
4/4/07	1,720				1,720	328	298	213			213	337	337		337	503	503			503	
4/5/07	1,670				1,670	296	261	206			206	337	337		337	500	500			500	
4/6/07	1,670				1,670	271	288	195			195	337	337		337	502	502			502	
4/7/07	1,700				1,700	260	354	203			203	338	338		338	510	510			510	
4/8/07	1,770				1,770	279	454	215			215	338	338		338	508	508			508	
4/9/07	1,860				1,860	274	557	216			216	338	338		338	508	508			508	
4/10/07	1,650				1,650	276	322	192			192	339	339		339	504	504			504	
4/11/07	1,620				1,620	267	285	176			176	343	343		343	504	504			504	
4/12/07	1,710	0			1,710	299	375	179			179	341	341		341	800	800			800	
4/13/07	1,606	0			1,606	290	300	250			250	300	300		300	768	768			768	
4/14/07	1,916	0			1,916	281	300	250			250	300	300		300	768	768			768	
4/15/07	1,837	0	0	0.00	1,837	272	300	250			250	250	250		250	768	768			768	
4/16/07	1,899	0	0	0.00	1,899	263	300	250			250	250	250		250	768	768			768	
4/17/07	1,840	0	0	0.00	1,840	254	300	250			250	250	250		250	768	768			768	
4/18/07	1,831	0	0	0.00	1,831	245	300	250			250	250	250		250	768	768			768	
4/19/07	1,822	0	0	0.00	1,822	236	300	250	50	0	300	250	250		250	768	768			768	
4/20/07	1,813	0	0	0.00	1,813	231	300	250	100	0	350	537	800	50	850	1,500	1,500	0	0	1,500	
4/21/07	1,804	0	0	0.00	1,804	228	300	250	100	0	350	537	800	50	850	1,500	1,500	0	0	1,500	
4/22/07	3,081	100	0	0.20	3,181	225	300	250	100	0	350	537	800	50	850	1,500	1,500	0	0	1,500	
4/23/07	3,078	150	0	0.50	3,228	221	300	250	100	0	350	537	800	50	850	1,500	1,500	0	0	1,500	
4/24/07	3,075	150	0	0.79	3,225	218	300	250	100	0	350	537	800	50	850	1,500	1,500	0	0	1,500	
4/25/07	3,071	150	0	1.09	3,221	215	300	250	100	0	350	537	800	50	850	1,500	1,500	0	0	1,500	
4/26/07	3,068	150	0	1.39	3,218	212	300	250	100	0	350	537	800	50	850	1,500	1,500	0	0	1,500	
4/27/07	3,065	150	0	1.69	3,215	209	300	250	100	0	350	537	800	50	850	1,500	1,500	0	0	1,500	
4/28/07	3,062	150	0	1.98	3,212	205	300	250	450	0	700	537	800	50	850	1,500	1,500	0	0	1,500	
4/29/07	3,059	150	0	2.28	3,209	202	300	250	780	0	1,030	537	500	0	500	1,500	1,500	0	0	1,500	
4/30/07	3,055	150	0	2.58	3,205	199	300	250	780	0	1,030	537	200	0	200	1,500	1,500	0	0	1,500	
5/1/07	2,752	450	0	3.47	3,202	196	300	250	780	0	1,030	537	200	0	200	1,500	1,500	0	0	1,500	
5/2/07	2,449	780	0	5.02	3,229	193	300	250	780	0	1,030	537	200	0	200	1,500	1,500	0	0	1,500	
5/3/07	2,446	780	0	6.57	3,226	189	300	250	780	0	1,030	537	200	0	200	1,500	1,500	0	0	1,500	
5/4/07	2,443	780	0	8.11	3,223	186	300	250	780	0	1,030	537	200	0	200	1,500	1,500	0	0	1,500	
5/5/07	2,439	780	0	9.66	3,219	183	300	250	780	0	1,030	537	200	0	200	1,500	1,500	0	0	1,500	
5/6/07	2,436	780	0	11.21	3,216	180	300	250	780	0	1,030	537	200	0	200	1,500	1,500	0	0	1,500	
5/7/07	2,433	780	0	12.75	3,213	177	300	250	780	0	1,030	537	200	0	200	1,500	1,500	0	0	1,500	
5/8/07	2,430	780	0	14.30	3,210	173	300	250	780	0	1,030	537	200	0	200	1,500	1,500	0	0	1,500	
5/9/07	2,427	780	0	15.85	3,207	170	300	250	780	0	1,030	537	200	0	200	1,500	1,500	0	0	1,500	
5/10/07	2,423	780	0	17.40	3,203	167	300	250	780	0	1,030	537	200	0	200	1,500	1,500	0	0	1,500	
5/11/07	2,420	780	0	18.94	3,200	164	300	250	510	0	760	537	200	0	200	1,500	1,500	0	0	1,500	
5/12/07	2,417	780	0	20.49	3,197	161	300	250	180	0	430	537	450	30	480	1,500	1,500	0	0	1,500	
5/13/07	2,414	780	0	22.04	3,194	157	300	250	180	0	430	537	800	30	830	1,500	1,500	0	0	1,500	
5/14/07	2,661	540	0	23.11	3,201	154	300	250	180	0	430	537	800	30	830	1,500	1,500	0	0	1,500	
5/15/07	3,007	210	0	23.52	3,217	151	300	250	180	0	430	537	800	30	830	1,500	1,500	0	0	1,500	
5/16/07	3,004	210	0	23.94	3,214	148	300	250	180	0	430	537	800	30	830	1,500	1,500	0	0	1,500	
5/17/07	3,001	210	0	24.36	3,211	145	300	250	180	0	430	537	800	30	830	1,500	1,500	0	0	1,500	
5/18/07	2,998	210	0	24.77	3,208	141	300	250	180	0	430	537	800	30	830	1,500	1,500	0	0	1,500	
5/19/07	2,995	210	0	25.19	3,205	138	300	250	180	0	430	537	800	30	830	1,500	1,500	0	0	1,500	
5/20/07	2,991	210	0	25.61	3,201	135	300	250			250	537	500	30	530	1,500	1,500	0	0	1,500	
5/21/07	2,988	210	0	26.02	3,198	132	300	250			250	250	250		250	741	741			741	
5/22/07	2,685	210	0	26.44	2,895	129	300	250			250	200	200		200	741	741			741	
5/23/07	1,673	0	0		1,673	126	300	250			250	200	200		200	741	741			741	
5/24/07	1,620	0	0		1,620	123	300	250			250	150	150		150	741	741			741	
5/25/07	1,617	0	0		1,617	120	300	250			250	150	150		150	741	741			741	
5/26/07	1,564	0	0		1,564	117	300	250			250	150	150		150	741	741			741	
5/27/07	1,561	0	0		1,561	114	300	250			250	150	150		150	741	741			741	
5/28/07	1,558	0	0		1,558	111	300	250			250	150	150		150	741	741			741	
5/29/07	1,555	0	0		1,555	108	300	250			250	150	150		150	741	741			741	
5/30/07	1,552	0	0		1,552	105	300	250			250	135	135		135	741	741			741	
5/31/07	1,549	0	0		1,549	102	300	250			250	120	120		120	741	741			741	
									VAMP Period												
Avg. (cfs):	2,770	430			3,200	183	300	250	407	0	657	537	537	23	560	1,500	1,500	0	0	1,500	
Supplemental Water (TAF):				26.44							25.01	0.00				1.43				0.00	

VAMP flow operation period

Appendix A-1, Table 10

2007 VAMP DAILY OPERATION PLAN — APRIL 13, 2007
(A) SINGLE-STEP; 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	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (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)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		(cfs)	(cfs)	(cfs)	
3/15/07	**2,420**				**2,420**	**788**	**97**	**215**			**215**	**349**	**349**		**349**	**804**	**804**			**804**	
3/16/07	**2,290**				**2,290**	**759**	**97**	**228**			**228**	**348**	**348**		**348**	**806**	**806**			**806**	
3/17/07	**2,350**				**2,350**	**739**	**194**	**213**			**213**	**338**	**338**		**338**	**802**	**802**			**802**	
3/18/07	**2,320**				**2,320**	**727**	**192**	**212**			**212**	**338**	**338**		**338**	**687**	**687**			**687**	
3/19/07	**2,310**				**2,310**	**710**	**203**	**216**			**216**	**337**	**337**		**337**	**603**	**603**			**603**	
3/20/07	**2,150**				**2,150**	**702**	**185**	**208**			**208**	**337**	**337**		**337**	**609**	**609**			**609**	
3/21/07	**2,240**				**2,240**	**659**	**378**	**215**			**215**	**334**	**334**		**334**	**607**	**607**			**607**	
3/22/07	**2,180**				**2,180**	**659**	**316**	**223**			**223**	**335**	**335**		**335**	**604**	**604**			**604**	
3/23/07	**2,200**				**2,200**	**609**	**392**	**212**			**212**	**334**	**334**		**334**	**547**	**547**			**547**	
3/24/07	**2,230**				**2,230**	**536**	**417**	**213**			**213**	**335**	**335**		**335**	**504**	**504**			**504**	
3/25/07	**2,210**				**2,210**	**476**	**497**	**214**			**214**	**336**	**336**		**336**	**502**	**502**			**502**	
3/26/07	**2,160**				**2,160**	**460**	**573**	**215**			**215**	**335**	**335**		**335**	**509**	**509**			**509**	
3/27/07	**2,050**				**2,050**	**461**	**523**	**234**			**234**	**335**	**335**		**335**	**503**	**503**			**503**	
3/28/07	**2,030**				**2,030**	**447**	**512**	**229**			**229**	**335**	**335**		**335**	**505**	**505**			**505**	
3/29/07	**2,000**				**2,000**	**437**	**486**	**229**			**229**	**337**	**337**		**337**	**503**	**503**			**503**	
3/30/07	**1,910**				**1,910**	**437**	**389**	**223**			**223**	**337**	**337**		**337**	**503**	**503**			**503**	
3/31/07	**1,880**				**1,880**	**414**	**374**	**198**			**198**	**338**	**338**		**338**	**501**	**501**			**501**	
4/1/07	**1,950**				**1,950**	**393**	**444**	**202**			**202**	**339**	**339**		**339**	**500**	**500**			**500**	
4/2/07	**1,920**				**1,920**	**380**	**444**	**221**			**221**	**338**	**338**		**338**	**502**	**502**			**502**	
4/3/07	**1,790**				**1,790**	**342**	**360**	**214**			**214**	**337**	**337**		**337**	**509**	**509**			**509**	
4/4/07	**1,720**				**1,720**	**328**	**298**	**213**			**213**	**337**	**337**		**337**	**503**	**503**			**503**	
4/5/07	**1,670**				**1,670**	**296**	**261**	**206**			**206**	**337**	**337**		**337**	**500**	**500**			**500**	
4/6/07	**1,670**				**1,670**	**271**	**288**	**195**			**195**	**337**	**337**		**337**	**502**	**502**			**502**	
4/7/07	**1,700**				**1,700**	**260**	**354**	**203**			**203**	**338**	**338**		**338**	**510**	**510**			**510**	
4/8/07	**1,770**				**1,770**	**279**	**454**	**215**			**215**	**338**	**338**		**338**	**508**	**508**			**508**	
4/9/07	**1,860**				**1,860**	**274**	**557**	**216**			**216**	**338**	**338**		**338**	**508**	**508**			**508**	
4/10/07	**1,650**				**1,650**	**276**	**322**	**192**			**192**	**339**	**339**		**339**	**504**	**504**			**504**	
4/11/07	**1,620**				**1,620**	**267**	**285**	**176**			**176**	**343**	**343**		**343**	**504**	**504**			**504**	
4/12/07	**1,710**				**1,710**	**299**	**375**	**179**			**179**	**341**	**341**		**341**	**800**	**800**			**800**	
4/13/07	1,664	0			1,664	290	358	250			250	300	300		300	768	768			768	
4/14/07	1,957	0			1,957	281	341	250			250	300	300		300	768	768			768	
4/15/07	1,861	0	0	0.00	1,861	272	324	250			250	250	250		250	768	768			768	
4/16/07	1,906	0	0	0.00	1,906	263	307	250			250	250	250		250	768	768			768	
4/17/07	1,830	0	0	0.00	1,830	254	290	250			250	250	250		250	768	768			768	
4/18/07	1,804	0	0	0.00	1,804	245	273	250			250	250	250		250	768	768			768	
4/19/07	1,778	0	0	0.00	1,778	236	256	250	50	60	360	250	250		250	768	768			768	
4/20/07	1,752	0	0	0.00	1,752	231	239	250	100	60	410	537	800	150	950	1,500	1,500	0	0	1,500	
4/21/07	1,726	0	0	0.00	1,726	228	222	250	100	60	410	537	800	170	970	1,500	1,500	0	0	1,500	
4/22/07	2,881	260	0	0.52	3,141	225	100	250	100	60	410	537	800	170	970	1,500	1,500	0	0	1,500	
4/23/07	2,878	330	0	1.17	3,208	221	100	250	100	60	410	537	800	170	970	1,500	1,500	0	0	1,500	
4/24/07	2,875	330	0	1.82	3,205	218	100	250	100	60	410	537	800	170	970	1,500	1,500	0	0	1,500	
4/25/07	2,871	330	0	2.48	3,201	215	100	250	100	60	410	537	800	170	970	1,500	1,500	0	0	1,500	
4/26/07	2,868	330	0	3.13	3,198	212	100	250	100	60	410	537	800	170	970	1,500	1,500	0	0	1,500	
4/27/07	2,865	330	0	3.79	3,195	209	100	250	100	60	410	537	800	170	970	1,500	1,500	0	0	1,500	
4/28/07	2,862	330	0	4.44	3,192	205	100	250	450	70	770	537	800	170	970	1,500	1,500	0	0	1,500	
4/29/07	2,859	330	0	5.10	3,189	202	100	250	780	60	1,090	537	500	170	670	1,500	1,500	0	0	1,500	
4/30/07	2,855	330	0	5.75	3,185	199	100	250	780	60	1,090	537	200	160	360	1,500	1,500	0	0	1,500	
5/1/07	2,552	690	0	7.12	3,242	196	100	250	780	60	1,090	537	200	160	360	1,500	1,500	0	0	1,500	
5/2/07	2,249	1,000	0	9.10	3,249	193	100	250	780	60	1,090	537	200	160	360	1,500	1,500	0	0	1,500	
5/3/07	2,246	1,000	0	11.09	3,246	189	100	250	780	60	1,090	537	200	160	360	1,500	1,500	0	0	1,500	
5/4/07	2,243	1,000	0	13.07	3,243	186	100	250	780	60	1,090	537	200	160	360	1,500	1,500	0	0	1,500	
5/5/07	2,239	1,000	0	15.05	3,239	183	100	250	780	60	1,090	537	200	160	360	1,500	1,500	0	0	1,500	
5/6/07	2,236	1,000	0	17.04	3,236	180	100	250	780	60	1,090	537	200	160	360	1,500	1,500	0	0	1,500	
5/7/07	2,233	1,000	0	19.02	3,233	177	100	250	780	60	1,090	537	200	160	360	1,500	1,500	0	0	1,500	
5/8/07	2,230	1,000	0	21.00	3,230	173	100	250	780	60	1,090	537	200	160	360	1,500	1,500	0	0	1,500	
5/9/07	2,227	1,000	0	22.99	3,227	170	100	250	780	60	1,090	537	200	160	360	1,500	1,500	0	0	1,500	
5/10/07	2,223	1,000	0	24.97	3,223	167	100	250	780	60	1,090	537	200	160	360	1,500	1,500	0	0	1,500	
5/11/07	2,220	1,000	0	26.96	3,220	164	100	250	510	70	830	537	200	160	360	1,500	1,500	0	0	1,500	
5/12/07	2,217	1,000	0	28.94	3,217	161	100	250	180	60	490	537	450	160	610	1,500	1,500	0	0	1,500	
5/13/07	2,214	1,000	0	30.92	3,214	157	100	250	180	60	490	537	800	160	960	1,500	1,500	0	0	1,500	
5/14/07	2,461	740	0	32.39	3,201	154	100	250	180	60	490	537	800	160	960	1,500	1,500	0	0	1,500	
5/15/07	2,807	400	0	33.18	3,207	151	100	250	180	60	490	537	800	160	960	1,500	1,500	0	0	1,500	
5/16/07	2,804	400	0	33.98	3,204	148	100	250	180	60	490	537	800	160	960	1,500	1,500	0	0	1,500	
5/17/07	2,801	400	0	34.77	3,201	145	100	250	180	60	490	537	800	160	960	1,500	1,500	0	0	1,500	
5/18/07	2,798	400	0	35.56	3,198	141	100	250	180	60	490	537	800	160	960	1,500	1,500	0	0	1,500	
5/19/07	2,795	400	0	36.36	3,195	138	100	250	180	60	490	537	800	160	960	1,500	1,500	0	0	1,500	
5/20/07	2,791	400	0	37.15	3,191	135	100	250			250	537	500	160	660	1,500	1,500	0	0	1,500	
5/21/07	2,788	400	0	37.94	3,188	132	100	250			250	250	250		250	741	741			741	
5/22/07	2,485	400	0	38.74	2,885	129	100	250			250	200	200		200	741	741			741	
5/23/07	1,473	0	0		1,473	126	100	250			250	200	200		200	741	741			741	
5/24/07	1,420	0	0		1,420	123	100	250			250	150	150		150	741	741			741	
5/25/07	1,417	0	0		1,417	120	100	250			250	150	150		150	741	741			741	
5/26/07	1,364	0	0		1,364	117	100	250			250	150	150		150	741	741			741	
5/27/07	1,361	0	0		1,361	114	100	250			250	150	150		150	741	741			741	
5/28/07	1,358	0	0		1,358	111	100	250			250	150	150		150	741	741			741	
5/29/07	1,355	0	0		1,355	108	100	250			250	150	150		150	741	741			741	
5/30/07	1,352	0	0		1,352	105	100	250			250	135	135		135	741	741			741	
5/31/07	1,349	0	0		1,349	102	100	250			250	120	120		120	741	741			741	
										VAMP Period											
Avg. (cfs):	2,570	630			3,200	183	100	250	407	61	717	537	537	163	700	1,500	1,500	0	0	1,500	
Supplemental Water (TAF):				38.74							25.01	3.73				10.00				0.00	

VAMP flow operation period

Appendix A-1, Table 11

2007 VAMP DAILY OPERATION PLAN — APRIL 16, 2007

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	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (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)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		(cfs)	(cfs)	(cfs)	
3/15/07	**2,420**				**2,420**	**788**	**97**	**215**			**215**	**349**	**349**		**349**	**804**	**804**			**804**	
3/16/07	**2,290**				**2,290**	**759**	**97**	**228**			**228**	**348**	**348**		**348**	**806**	**806**			**806**	
3/17/07	**2,350**				**2,350**	**739**	**194**	**213**			**213**	**338**	**338**		**338**	**802**	**802**			**802**	
3/18/07	**2,320**				**2,320**	**727**	**192**	**212**			**212**	**338**	**338**		**338**	**687**	**687**			**687**	
3/19/07	**2,310**				**2,310**	**710**	**203**	**216**			**216**	**337**	**337**		**337**	**603**	**603**			**603**	
3/20/07	**2,150**				**2,150**	**702**	**185**	**208**			**208**	**337**	**337**		**337**	**609**	**609**			**609**	
3/21/07	**2,240**				**2,240**	**659**	**378**	**215**			**215**	**334**	**334**		**334**	**607**	**607**			**607**	
3/22/07	**2,180**				**2,180**	**659**	**316**	**223**			**223**	**335**	**335**		**335**	**604**	**604**			**604**	
3/23/07	**2,200**				**2,200**	**609**	**392**	**212**			**212**	**334**	**334**		**334**	**547**	**547**			**547**	
3/24/07	**2,230**				**2,230**	**536**	**417**	**213**			**213**	**335**	**335**		**335**	**504**	**504**			**504**	
3/25/07	**2,210**				**2,210**	**476**	**497**	**214**			**214**	**336**	**336**		**336**	**502**	**502**			**502**	
3/26/07	**2,160**				**2,160**	**460**	**573**	**215**			**215**	**335**	**335**		**335**	**509**	**509**			**509**	
3/27/07	**2,050**				**2,050**	**461**	**523**	**234**			**234**	**335**	**335**		**335**	**503**	**503**			**503**	
3/28/07	**2,030**				**2,030**	**447**	**512**	**229**			**229**	**335**	**335**		**335**	**505**	**505**			**505**	
3/29/07	**2,000**				**2,000**	**437**	**486**	**229**			**229**	**337**	**337**		**337**	**503**	**503**			**503**	
3/30/07	**1,910**				**1,910**	**437**	**389**	**223**			**223**	**337**	**337**		**337**	**503**	**503**			**503**	
3/31/07	**1,880**				**1,880**	**414**	**374**	**198**			**198**	**338**	**338**		**338**	**501**	**501**			**501**	
4/1/07	**1,950**				**1,950**	**393**	**444**	**202**			**202**	**339**	**339**		**339**	**500**	**500**			**500**	
4/2/07	**1,920**				**1,920**	**380**	**444**	**221**			**221**	**338**	**338**		**338**	**502**	**502**			**502**	
4/3/07	**1,790**				**1,790**	**342**	**360**	**214**			**214**	**337**	**337**		**337**	**509**	**509**			**509**	
4/4/07	**1,720**				**1,720**	**328**	**298**	**213**			**213**	**337**	**337**		**337**	**503**	**503**			**503**	
4/5/07	**1,670**				**1,670**	**296**	**261**	**206**			**206**	**337**	**337**		**337**	**500**	**500**			**500**	
4/6/07	**1,670**				**1,670**	**271**	**288**	**195**			**195**	**337**	**337**		**337**	**502**	**502**			**502**	
4/7/07	**1,700**				**1,700**	**260**	**354**	**203**			**203**	**338**	**338**		**338**	**510**	**510**			**510**	
4/8/07	**1,770**				**1,770**	**279**	**454**	**215**			**215**	**338**	**338**		**338**	**508**	**508**			**508**	
4/9/07	**1,860**				**1,860**	**274**	**557**	**216**			**216**	**338**	**338**		**338**	**508**	**508**			**508**	
4/10/07	**1,650**				**1,650**	**276**	**322**	**192**			**192**	**339**	**339**		**339**	**504**	**504**			**504**	
4/11/07	**1,620**				**1,620**	**267**	**285**	**176**			**176**	**343**	**343**		**343**	**504**	**504**			**504**	
4/12/07	**1,720**				**1,720**	**299**	**385**	**179**			**179**	**341**	**341**		**341**	**500**	**500**			**500**	
4/13/07	**1,660**				**1,660**	**290**	**354**	**181**			**181**	**340**	**340**		**340**	**503**	**503**			**503**	
4/14/07	**1,710**				**1,710**	**291**	**394**	**204**			**204**	**343**	**343**		**343**	**503**	**503**			**503**	
4/15/07	**1,890**				**1,890**	**293**	**578**	**241**			**241**	**296**	**296**		**296**	**507**	**507**			**507**	
4/16/07	1,618				1,618	284	300	250			250	250	250		250	768	768			768	
4/17/07	1,600				1,600	275	300	250			250	250	250		250	768	768			768	
4/18/07	1,843				1,843	266	300	250			250	250	250		250	768	768			768	
4/19/07	1,843				1,843	257	300	250	50	0	300	250	250		250	768	768			768	
4/20/07	1,834				1,834	231	300	250	100	0	350	537	800	50	850	1,500	1,500	0	0	1,500	
4/21/07	1,825				1,825	228	300	250	100	0	350	537	800	50	850	1,500	1,500	0	0	1,500	
4/22/07	3,081	100	0	0.20	3,181	225	300	250	100	0	350	537	800	50	850	1,500	1,500	0	0	1,500	
4/23/07	3,078	150	0	0.50	3,228	221	300	250	100	0	350	537	800	50	850	1,500	1,500	0	0	1,500	
4/24/07	3,075	150	0	0.79	3,225	218	300	250	100	0	350	537	800	50	850	1,500	1,500	0	0	1,500	
4/25/07	3,071	150	0	1.09	3,221	215	300	250	100	0	350	537	800	50	850	1,500	1,500	0	0	1,500	
4/26/07	3,068	150	0	1.39	3,218	212	300	250	100	0	350	537	800	50	850	1,500	1,500	0	0	1,500	
4/27/07	3,065	150	0	1.69	3,215	209	300	250	100	0	350	537	800	50	850	1,500	1,500	0	0	1,500	
4/28/07	3,062	150	0	1.98	3,212	205	300	250	450	0	700	537	800	50	850	1,500	1,500	0	0	1,500	
4/29/07	3,059	150	0	2.28	3,209	202	300	250	780	0	1,030	537	500	0	500	1,500	1,500	0	0	1,500	
4/30/07	3,055	150	0	2.58	3,205	199	300	250	780	0	1,030	537	200	0	200	1,500	1,500	0	0	1,500	
5/1/07	2,752	450	0	3.47	3,202	196	300	250	780	0	1,030	537	200	0	200	1,500	1,500	0	0	1,500	
5/2/07	2,449	780	0	5.02	3,229	193	300	250	780	0	1,030	537	200	0	200	1,500	1,500	0	0	1,500	
5/3/07	2,446	780	0	6.57	3,226	189	300	250	780	0	1,030	537	200	0	200	1,500	1,500	0	0	1,500	
5/4/07	2,443	780	0	8.11	3,223	186	300	250	780	0	1,030	537	200	0	200	1,500	1,500	0	0	1,500	
5/5/07	2,439	780	0	9.66	3,219	183	300	250	780	0	1,030	537	200	0	200	1,500	1,500	0	0	1,500	
5/6/07	2,436	780	0	11.21	3,216	180	300	250	780	0	1,030	537	200	0	200	1,500	1,500	0	0	1,500	
5/7/07	2,433	780	0	12.75	3,213	177	300	250	780	0	1,030	537	200	0	200	1,500	1,500	0	0	1,500	
5/8/07	2,430	780	0	14.30	3,210	173	300	250	780	0	1,030	537	200	0	200	1,500	1,500	0	0	1,500	
5/9/07	2,427	780	0	15.85	3,207	170	300	250	780	0	1,030	537	200	0	200	1,500	1,500	0	0	1,500	
5/10/07	2,423	780	0	17.40	3,203	167	300	250	780	0	1,030	537	200	0	200	1,500	1,500	0	0	1,500	
5/11/07	2,420	780	0	18.94	3,200	164	300	250	510	0	760	537	200	0	200	1,500	1,500	0	0	1,500	
5/12/07	2,417	780	0	20.49	3,197	161	300	250	180	0	430	537	450	30	480	1,500	1,500	0	0	1,500	
5/13/07	2,414	780	0	22.04	3,194	157	300	250	180	0	430	537	800	40	840	1,500	1,500	0	0	1,500	
5/14/07	2,661	540	0	23.11	3,201	154	300	250	180	0	430	537	800	40	840	1,500	1,500	0	0	1,500	
5/15/07	3,007	220	0	23.54	3,227	151	300	250	180	0	430	537	800	40	840	1,500	1,500	0	0	1,500	
5/16/07	3,004	220	0	23.98	3,224	148	300	250	180	0	430	537	800	40	840	1,500	1,500	0	0	1,500	
5/17/07	3,001	220	0	24.42	3,221	145	300	250	180	0	430	537	800	40	840	1,500	1,500	0	0	1,500	
5/18/07	2,998	220	0	24.85	3,218	141	300	250	180	0	430	537	800	40	840	1,500	1,500	0	0	1,500	
5/19/07	2,995	220	0	25.29	3,215	138	300	250	180	0	430	537	800	0	800	1,500	1,500	0	0	1,500	
5/20/07	2,991	220	0	25.73	3,211	135	300	250			250	537	500	0	500	1,500	1,500	0	0	1,500	
5/21/07	2,988	180	0	26.08	3,168	132	300	250			250	250	250		250	741	741			741	
5/22/07	2,685	180	0	26.44	2,865	129	300	250			250	200	200		200	741	741			741	
5/23/07	1,673	0	0		1,673	126	300	250			250	200	200		200	741	741			741	
5/24/07	1,620	0	0		1,620	123	300	250			250	150	150		150	741	741			741	
5/25/07	1,617	0	0		1,617	120	300	250			250	150	150		150	741	741			741	
5/26/07	1,564	0	0		1,564	117	300	250			250	150	150		150	741	741			741	
5/27/07	1,561	0	0		1,561	114	300	250			250	150	150		150	741	741			741	
5/28/07	1,558	0	0		1,558	111	300	250			250	150	150		150	741	741			741	
5/29/07	1,555	0	0		1,555	108	300	250			250	150	150		150	741	741			741	
5/30/07	1,552	0	0		1,552	105	300	250			250	135	135		135	741	741			741	
5/31/07	1,549	0	0		1,549	102	300	250			250	120	120		120	741	741			741	
										VAMP Period											
Avg. (cfs):	2,770	430			3,200	183	300	250	407	0	657	537	537	23	560	1,500	1,500	0	0	1,500	
Supplemental Water (TAF):				26.44							25.01	0.00				1.43				0.00	

VAMP flow operation period

Appendix A-1, Table 12

2007 VAMP DAILY OPERATION PLAN — APRIL 18, 2007

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	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (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)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		(cfs)	(cfs)	(cfs)	
3/15/07	**2,420**				**2,420**	**788**	**97**	**215**			**215**	**349**	**349**		**349**	**804**	**804**			**804**	
3/16/07	**2,290**				**2,290**	**759**	**97**	**228**			**228**	**348**	**348**		**348**	**806**	**806**			**806**	
3/17/07	**2,350**				**2,350**	**739**	**194**	**213**			**213**	**338**	**338**		**338**	**802**	**802**			**802**	
3/18/07	**2,320**				**2,320**	**727**	**192**	**212**			**212**	**338**	**338**		**338**	**687**	**687**			**687**	
3/19/07	**2,310**				**2,310**	**710**	**203**	**216**			**216**	**337**	**337**		**337**	**603**	**603**			**603**	
3/20/07	**2,150**				**2,150**	**702**	**185**	**208**			**208**	**337**	**337**		**337**	**609**	**609**			**609**	
3/21/07	**2,240**				**2,240**	**659**	**378**	**215**			**215**	**334**	**334**		**334**	**607**	**607**			**607**	
3/22/07	**2,180**				**2,180**	**659**	**316**	**223**			**223**	**335**	**335**		**335**	**604**	**604**			**604**	
3/23/07	**2,200**				**2,200**	**609**	**392**	**212**			**212**	**334**	**334**		**334**	**547**	**547**			**547**	
3/24/07	**2,230**				**2,230**	**536**	**417**	**213**			**213**	**335**	**335**		**335**	**504**	**504**			**504**	
3/25/07	**2,210**				**2,210**	**476**	**497**	**214**			**214**	**336**	**336**		**336**	**502**	**502**			**502**	
3/26/07	**2,160**				**2,160**	**460**	**573**	**215**			**215**	**335**	**335**		**335**	**509**	**509**			**509**	
3/27/07	**2,050**				**2,050**	**461**	**523**	**234**			**234**	**335**	**335**		**335**	**503**	**503**			**503**	
3/28/07	**2,030**				**2,030**	**447**	**512**	**229**			**229**	**335**	**335**		**335**	**505**	**505**			**505**	
3/29/07	**2,000**				**2,000**	**437**	**486**	**229**			**229**	**337**	**337**		**337**	**503**	**503**			**503**	
3/30/07	**1,910**				**1,910**	**437**	**389**	**223**			**223**	**337**	**337**		**337**	**503**	**503**			**503**	
3/31/07	**1,880**				**1,880**	**414**	**374**	**198**			**198**	**338**	**338**		**338**	**501**	**501**			**501**	
4/1/07	**1,950**				**1,950**	**393**	**444**	**202**			**202**	**339**	**339**		**339**	**500**	**500**			**500**	
4/2/07	**1,920**				**1,920**	**380**	**444**	**221**			**221**	**338**	**338**		**338**	**502**	**502**			**502**	
4/3/07	**1,790**				**1,790**	**342**	**360**	**214**			**214**	**337**	**337**		**337**	**509**	**509**			**509**	
4/4/07	**1,720**				**1,720**	**328**	**298**	**213**			**213**	**337**	**337**		**337**	**503**	**503**			**503**	
4/5/07	**1,670**				**1,670**	**296**	**261**	**206**			**206**	**337**	**337**		**337**	**500**	**500**			**500**	
4/6/07	**1,670**				**1,670**	**271**	**288**	**195**			**195**	**337**	**337**		**337**	**502**	**502**			**502**	
4/7/07	**1,700**				**1,700**	**260**	**354**	**203**			**203**	**338**	**338**		**338**	**510**	**510**			**510**	
4/8/07	**1,770**				**1,770**	**279**	**454**	**215**			**215**	**338**	**338**		**338**	**508**	**508**			**508**	
4/9/07	**1,860**				**1,860**	**274**	**557**	**216**			**216**	**338**	**338**		**338**	**508**	**508**			**508**	
4/10/07	**1,650**				**1,650**	**276**	**322**	**192**			**192**	**339**	**339**		**339**	**504**	**504**			**504**	
4/11/07	**1,620**				**1,620**	**267**	**285**	**176**			**176**	**343**	**343**		**343**	**504**	**504**			**504**	
4/12/07	**1,720**				**1,720**	**299**	**385**	**179**			**179**	**341**	**341**		**341**	**500**	**500**			**500**	
4/13/07	**1,660**				**1,660**	**290**	**354**	**181**			**181**	**340**	**340**		**340**	**503**	**503**			**503**	
4/14/07	**1,710**				**1,710**	**291**	**394**	**204**			**204**	**343**	**343**		**343**	**503**	**503**			**503**	
4/15/07	**1,890**				**1,890**	**293**	**578**	**241**			**241**	**296**	**296**		**296**	**507**	**507**			**507**	
4/16/07	**1,970**				**1,970**	**346**	**652**	**247**			**247**	**295**	**295**		**295**	**503**	**503**			**503**	
4/17/07	**1,850**				**1,850**	**314**	**550**	**237**			**237**	**295**	**295**		**295**	**503**	**503**			**503**	
4/18/07	1,685				1,685	284	300	250			250	250	250		250	768	768			768	
4/19/07	1,659				1,659	254	300	250	50	0	300	250	250		250	768	768			768	
4/20/07	1,839				1,839	231	300	250	100	0	350	599	600	250	850	1,500	1,500	0	0	1,500	
4/21/07	1,822				1,822	228	300	250	100	0	350	599	600	250	850	1,500	1,500	0	0	1,500	
4/22/07	2,881	300	0	0.60	3,181	225	300	250	100	0	350	599	600	250	850	1,500	1,500	0	0	1,500	
4/23/07	2,878	350	0	1.29	3,228	221	300	250	100	0	350	599	600	250	850	1,500	1,500	0	0	1,500	
4/24/07	2,875	350	0	1.98	3,225	218	300	250	100	0	350	599	600	250	850	1,500	1,500	0	0	1,500	
4/25/07	2,871	350	0	2.68	3,221	215	300	250	100	0	350	599	600	250	850	1,500	1,500	0	0	1,500	
4/26/07	2,868	350	0	3.37	3,218	212	300	250	100	0	350	599	600	250	850	1,500	1,500	0	0	1,500	
4/27/07	2,865	350	0	4.07	3,215	209	300	250	250	0	500	599	600	250	850	1,500	1,500	0	0	1,500	
4/28/07	2,862	350	0	4.76	3,212	205	300	250	375	0	625	599	600	100	700	1,500	1,500	0	0	1,500	
4/29/07	2,859	350	0	5.45	3,209	202	300	250	500	0	750	476	475	100	575	1,500	1,500	0	0	1,500	
4/30/07	2,855	350	0	6.15	3,205	199	300	250	650	0	900	374	375	75	450	1,500	1,500	0	0	1,500	
5/1/07	2,727	475	0	7.09	3,202	196	300	250	700	0	950	272	270	50	320	1,500	1,500	0	0	1,500	
5/2/07	2,624	575	0	8.23	3,199	193	300	250	700	0	950	272	270	0	270	1,500	1,500	0	0	1,500	
5/3/07	2,516	700	0	9.62	3,216	189	300	250	700	0	950	272	270	0	270	1,500	1,500	0	0	1,500	
5/4/07	2,513	700	0	11.01	3,213	186	300	250	700	0	950	272	270	0	270	1,500	1,500	0	0	1,500	
5/5/07	2,509	700	0	12.40	3,209	183	300	250	700	0	950	272	270	0	270	1,500	1,500	0	0	1,500	
5/6/07	2,506	700	0	13.79	3,206	180	300	250	700	0	950	272	270	0	270	1,500	1,500	0	0	1,500	
5/7/07	2,503	700	0	15.17	3,203	177	300	250	700	0	950	272	270	0	270	1,500	1,500	0	0	1,500	
5/8/07	2,500	700	0	16.56	3,200	173	300	250	700	0	950	272	270	0	270	1,500	1,500	0	0	1,500	
5/9/07	2,497	700	0	17.95	3,197	170	300	250	700	0	950	272	270	0	270	1,500	1,500	0	0	1,500	
5/10/07	2,493	700	0	19.34	3,193	167	300	250	575	0	825	272	270	0	270	1,500	1,500	0	0	1,500	
5/11/07	2,490	700	0	20.73	3,190	164	300	250	450	0	700	374	375	0	375	1,500	1,500	0	0	1,500	
5/12/07	2,487	700	0	22.12	3,187	161	300	250	350	0	600	476	475	50	525	1,500	1,500	0	0	1,500	
5/13/07	2,589	575	0	23.26	3,164	157	300	250	350	0	600	599	600	50	650	1,500	1,500	0	0	1,500	
5/14/07	2,686	500	0	24.25	3,186	154	300	250	350	0	600	599	600	50	650	1,500	1,500	0	0	1,500	
5/15/07	2,807	400	0	25.04	3,207	151	300	250	350	0	600	599	600	50	650	1,500	1,500	0	0	1,500	
5/16/07	2,804	400	0	25.83	3,204	148	300	250	350	0	600	599	600	50	650	1,500	1,500	0	0	1,500	
5/17/07	2,801	400	0	26.63	3,201	145	300	250	350	0	600	599	600	50	650	1,500	1,500	0	0	1,500	
5/18/07	2,798	400	0	27.42	3,198	141	300	250	350	0	600	599	600	50	650	1,500	1,500	0	0	1,500	
5/19/07	2,795	400	0	28.21	3,195	138	300	250	305	0	555	599	600	50	650	1,500	1,500	0	0	1,500	
5/20/07	2,791	400	0	29.01	3,191	135	300	250			250	599	600	50	650	1,500	1,500	0	0	1,500	
5/21/07	2,788	400	0	29.80	3,188	132	300	250			250	550	550		550	741	741			741	
5/22/07	2,785	355	0	30.51	3,140	129	300	250			250	425	425		425	741	741			741	
5/23/07	1,973	0	0		1,973	126	300	250			250	325	325		325	741	741			741	
5/24/07	1,845	0	0		1,845	123	300	250			250	225	225		225	741	741			741	
5/25/07	1,742	0	0		1,742	120	300	250			250	150	150		150	741	741			741	
5/26/07	1,639	0	0		1,639	117	300	250			250	150	150		150	741	741			741	
5/27/07	1,561	0	0		1,561	114	300	250			250	150	150		150	741	741			741	
5/28/07	1,558	0	0		1,558	111	300	250			250	150	150		150	741	741			741	
5/29/07	1,555	0	0		1,555	108	300	250			250	150	150		150	741	741			741	
5/30/07	1,552	0	0		1,552	105	300	250			250	135	135		135	741	741			741	
5/31/07	1,549	0	0		1,549	102	300	250			250	120	120		120	741	741			741	
										VAMP Period											
Avg. (cfs):	2,704	496			3,200	183	300	250	407	0	657	471	471	90	560	1,500	1,500	0	0	1,500	
Supplemental Water (TAF):				30.51							25.00	0.00				5.50				0.00	

VAMP flow operation period

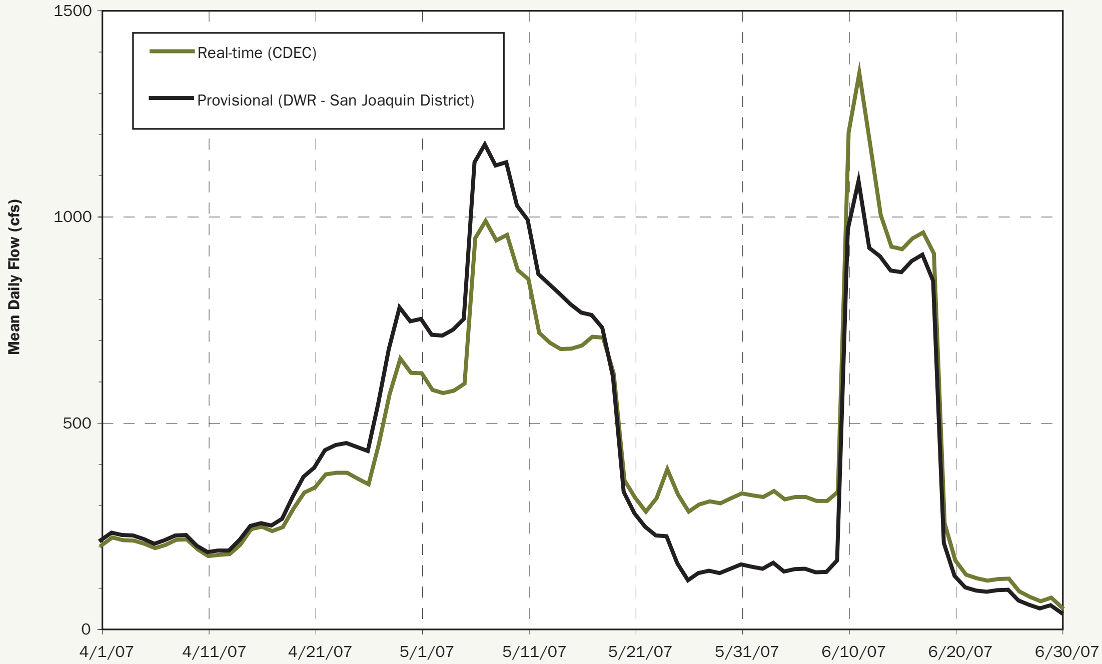
Appendix A-1, Table 13

2007 VAMP DAILY OPERATION PLAN — MAY 4, 2007
Target Flow Period: April 22 - May 22 * Flow Target: 3,200 cfs
Bold Numbers: observed real-time mean daily flows

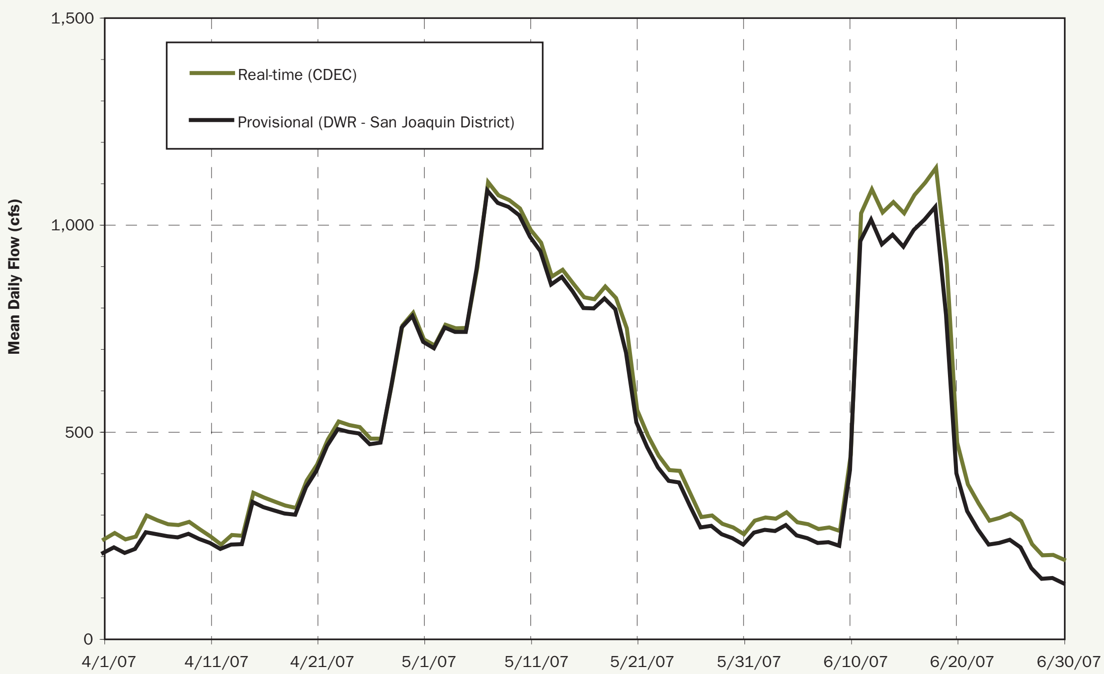
	San Joaquin River near Vernalis							Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus R blw Goodwin					
Date	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2 day lag)	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. 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)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		(cfs)	(cfs)	(cfs)	
3/15/07	2,420				2,420	788	80	215			215	349	349		349	804	804			804	
3/16/07	2,290				2,290	759	79	228			228	348	348		348	806	806			806	
3/17/07	2,350				2,350	739	176	213			213	338	338		338	802	802			802	
3/18/07	2,320				2,320	727	174	212			212	338	338		338	687	687			687	
3/19/07	2,310				2,310	710	185	216			216	337	337		337	603	603			603	
3/20/07	2,150				2,150	702	167	208			208	337	337		337	609	609			609	
3/21/07	2,240				2,240	659	360	215			215	334	334		334	607	607			607	
3/22/07	2,180				2,180	659	298	223			223	335	335		335	604	604			604	
3/23/07	2,200				2,200	609	375	212			212	334	334		334	547	547			547	
3/24/07	2,230				2,230	536	399	213			213	335	335		335	504	504			504	
3/25/07	2,210				2,210	476	479	214			214	336	336		336	502	502			502	
3/26/07	2,160				2,160	460	555	215			215	335	335		335	509	509			509	
3/27/07	2,050				2,050	461	505	234			234	335	335		335	503	503			503	
3/28/07	2,030				2,030	447	494	229			229	335	335		335	505	505			505	
3/29/07	2,000				2,000	437	469	229			229	337	337		337	503	503			503	
3/30/07	1,910				1,910	437	371	223			223	337	337		337	503	503			503	
3/31/07	1,880				1,880	414	356	198			198	338	338		338	501	501			501	
4/1/07	1,950				1,950	393	426	202			202	339	339		339	500	500			500	
4/2/07	1,920				1,920	380	436	221			221	338	338		338	502	502			502	
4/3/07	1,790				1,790	342	342	214			214	337	337		337	509	509			509	
4/4/07	1,720				1,712	328	290	213			213	337	337		337	503	503			503	
4/5/07	1,670				1,662	296	253	206			206	337	337		337	500	500			500	
4/6/07	1,670				1,662	271	280	195			195	337	337		337	502	502			502	
4/7/07	1,700				1,693	260	347	203			203	338	338		338	510	510			510	
4/8/07	1,770				1,762	279	446	215			215	338	338		338	508	508			508	
4/9/07	1,860				1,862	274	559	216			216	338	338		338	508	508			508	
4/10/07	1,650				1,652	276	324	192			192	339	339		339	504	504			504	
4/11/07	1,620				1,612	267	277	176			176	343	343		343	504	504			504	
4/12/07	1,720				1,712	299	377	179			179	341	341		341	500	500			500	
4/13/07	1,660				1,662	290	356	181			181	340	340		340	503	503			503	
4/14/07	1,710				1,712	291	396	204			204	343	343		343	503	503			503	
4/15/07	1,890				1,892	293	580	241			241	296	296		296	507	507			507	
4/16/07	1,972				1,972	346	654	247			247	295	295		295	503	503			503	
4/17/07	1,834				1,834	314	534	237			237	295	295		295	503	503			503	
4/18/07	1,744				1,744	317	359	246			246	295	295		295	503	503			503	
4/19/07	1,764				1,764	311	405	250	41	0	291	589	589		589	1,032	1,032			1,032	
4/20/07	1,874				1,874	278	522	250	80	0	330	599	600	267	867	1,503	1,503	0	0	1,503	
4/21/07	2,703				2,703	271	525	250	92	0	342	599	600	275	875	1,503	1,503	0	0	1,503	
4/22/07	3,202	308	0	0.61	3,510	242	571	250	124	0	374	599	600	275	875	1,507	1,507	0	0	1,507	
4/23/07	3,435	355	0	1.32	3,790	273	811	250	128	0	378	599	600	271	871	1,501	1,501	0	0	1,501	
4/24/07	3,313	367	0	2.04	3,680	282	714	250	128	0	378	599	600	269	869	1,504	1,504	0	0	1,504	
4/25/07	3,195	395	0	2.83	3,590	291	571	250	113	0	363	599	600	183	783	1,501	1,501	0	0	1,501	
4/26/07	3,123	397	0	3.61	3,520	281	487	250	100	0	350	599	600	45	645	1,500	1,500	0	0	1,500	
4/27/07	3,059	311	0	4.23	3,370	238	417	250	198	0	448	599	600	0	600	1,502	1,502	0	0	1,502	
4/28/07	3,012	158	0	4.54	3,170	218	381	250	318	0	568	599	600	0	599	1,502	1,502	0	0	1,502	
4/29/07	3,060	100	0	4.74	3,160	204	470	250	405	0	655	476	475	14	489	1,502	1,502	0	0	1,502	
4/30/07	3,003	198	0	5.14	3,200	243	433	250	370	0	620	374	375	32	407	1,502	1,502	0	0	1,502	
5/1/07	2,758	332	0	5.79	3,090	256	327	250	369	0	619	272	270	46	316	1,500	1,500	0	0	1,500	
5/2/07	2,523	437	0	6.66	2,960	237	153	250	329	0	579	272	270	42	312	1,497	1,497	0	0	1,497	
5/3/07	2,404	416	0	7.49	2,820	180	128	250	321	0	571	272	270	101	371	1,504	1,504	0	0	1,504	
5/4/07	2,454	411	0	8.30	2,865	186	200	250	425	0	675	272	270	150	420	1,500	1,500	0	0	1,500	
5/5/07	2,404	430	0	9.15	2,834	183	200	250	450	0	700	272	270	100	370	1,500	1,500	0	0	1,500	
5/6/07	2,406	471	0	10.09	2,877	180	200	250	700	0	950	272	270	70	340	1,500	1,500	0	0	1,500	
5/7/07	2,403	525	0	11.13	2,928	177	200	250	800	0	1,050	272	270	0	270	1,500	1,500	0	0	1,500	
5/8/07	2,400	520	0	12.16	2,920	173	200	250	800	0	1,050	272	270	0	270	1,500	1,500	0	0	1,500	
5/9/07	2,397	700	0	13.55	3,097	170	200	250	800	0	1,050	272	270	0	270	1,500	1,500	0	0	1,500	
5/10/07	2,393	800	0	15.14	3,193	167	200	250	725	0	975	272	270	0	270	1,500	1,500	0	0	1,500	
5/11/07	2,390	800	0	16.72	3,190	164	200	250	625	0	875	374	375	0	375	1,500	1,500	0	0	1,500	
5/12/07	2,387	800	0	18.31	3,187	161	200	250	500	0	750	476	475	0	475	1,500	1,500	0	0	1,500	
5/13/07	2,489	725	0	19.75	3,214	157	200	250	500	0	750	599	600	0	600	1,500	1,500	0	0	1,500	
5/14/07	2,586	625	0	20.99	3,211	154	200	250	500	0	750	599	600	0	600	1,500	1,500	0	0	1,500	
5/15/07	2,707	500	0	21.98	3,207	151	200	250	500	0	750	599	600	0	600	1,500	1,500	0	0	1,500	
5/16/07	2,704	500	0	22.97	3,204	148	200	250	500	0	750	599	600	0	600	1,500	1,500	0	0	1,500	
5/17/07	2,701	500	0	23.96	3,201	145	200	250	500	0	750	599	600	0	600	1,500	1,500	0	0	1,500	
5/18/07	2,698	500	0	24.95	3,198	141	200	250	500	0	750	599	600	0	600	1,500	1,500	0	0	1,500	
5/19/07	2,695	500	0	25.95	3,195	138	200	250	425	0	675	599	600	0	600	1,500	1,500	0	0	1,500	
5/20/07	2,691	500	0	26.94	3,191	135	200	250			250	599	600	0	600	1,500	1,500	0	0	1,500	
5/21/07	2,688	500	0	27.93	3,188	132	200	250			250	550	350		350	741	741			741	
5/22/07	2,685	425	0	28.77	3,110	129	200	250			250	425	325		325	741	741			741	
5/23/07	1,673	0	0		1,673	126	200	250			250	325	225		225	741	741			741	
5/24/07	1,645	0	0		1,645	123	200	250			250	225	150		150	741	741			741	
5/25/07	1,542	0	0		1,542	120	200	250			250	150	150		150	741	741			741	
5/26/07	1,464	0	0		1,464	117	200	250			250	150	150		150	741	741			741	
5/27/07	1,461	0	0		1,461	114	200	250			250	150	150		150	741	741			741	
5/28/07	1,458	0	0		1,458	111	200	250			250	150	150		150	741	741			741	
5/29/07	1,455	0	0		1,455	108	200	250			250	150	150		150	741	741			741	
5/30/07	1,452	0	0		1,452	105	200	250			250	135	135		135	741	741			741	
5/31/07	1,449	0	0		1,449	102	200	250			250	120	120		120	741	741			741	
										VAMP Period											
Avg. (cfs):	2,721	468			3,189	201	299	250	399	0	649	471	471	69	540	1,501	1,501	0	0	1,501	
Supplemental Water (TAF):				28.77							24.53	0.00				4.24				0.00	

VAMP flow operation period

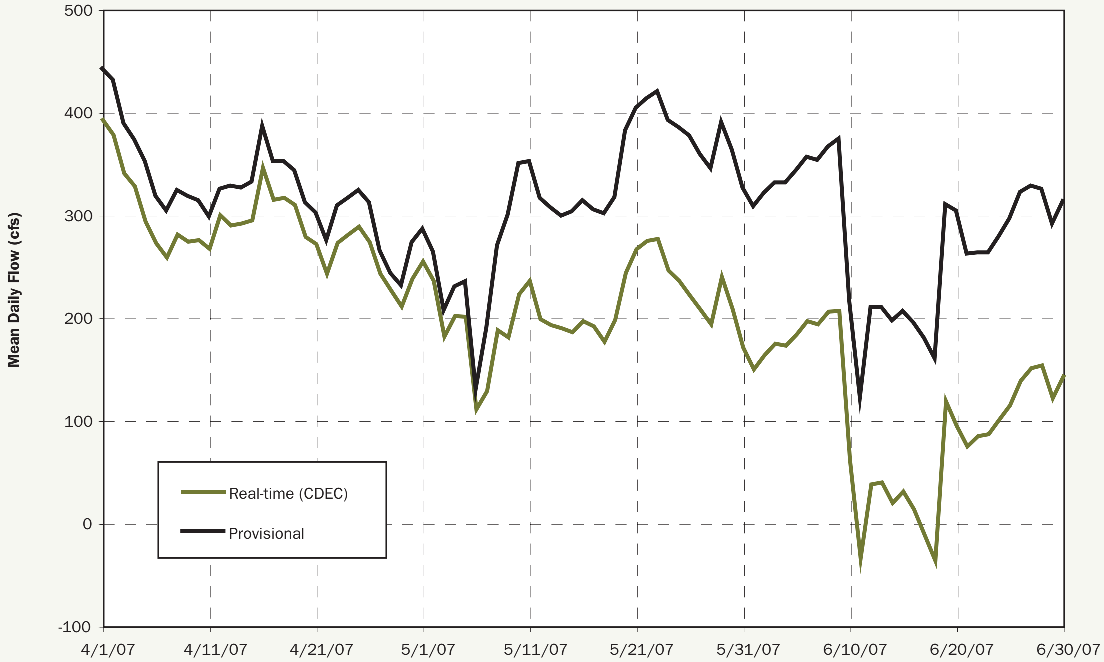
Appendix A-2, Figure 1
Merced River at Cressey



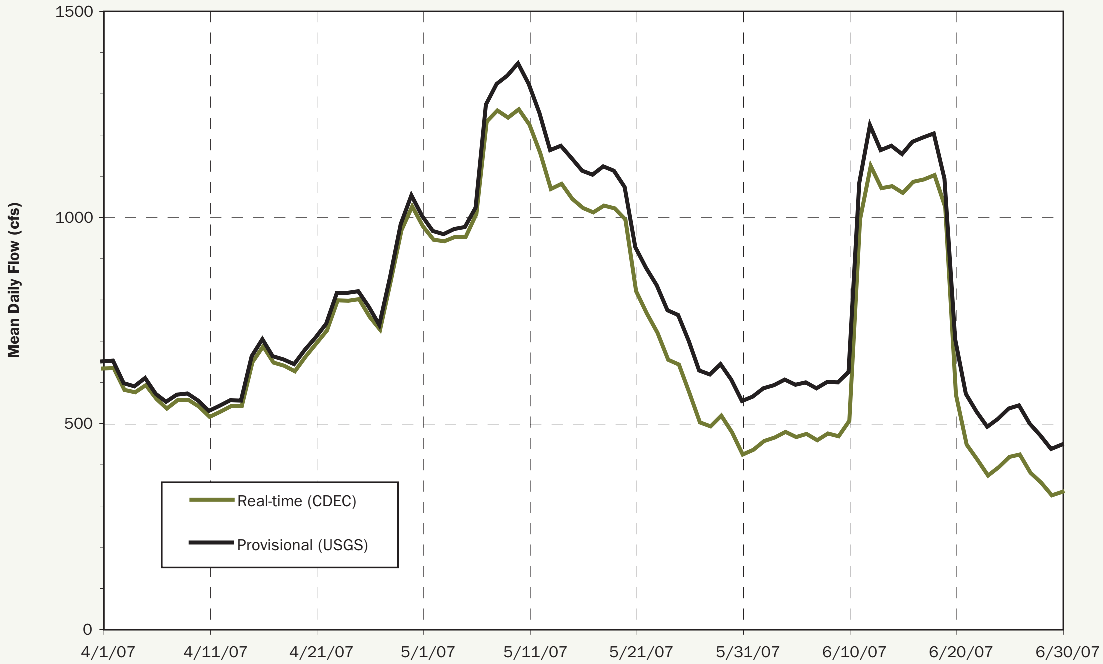
Appendix A-2, Figure 2
Merced River near Stevinson



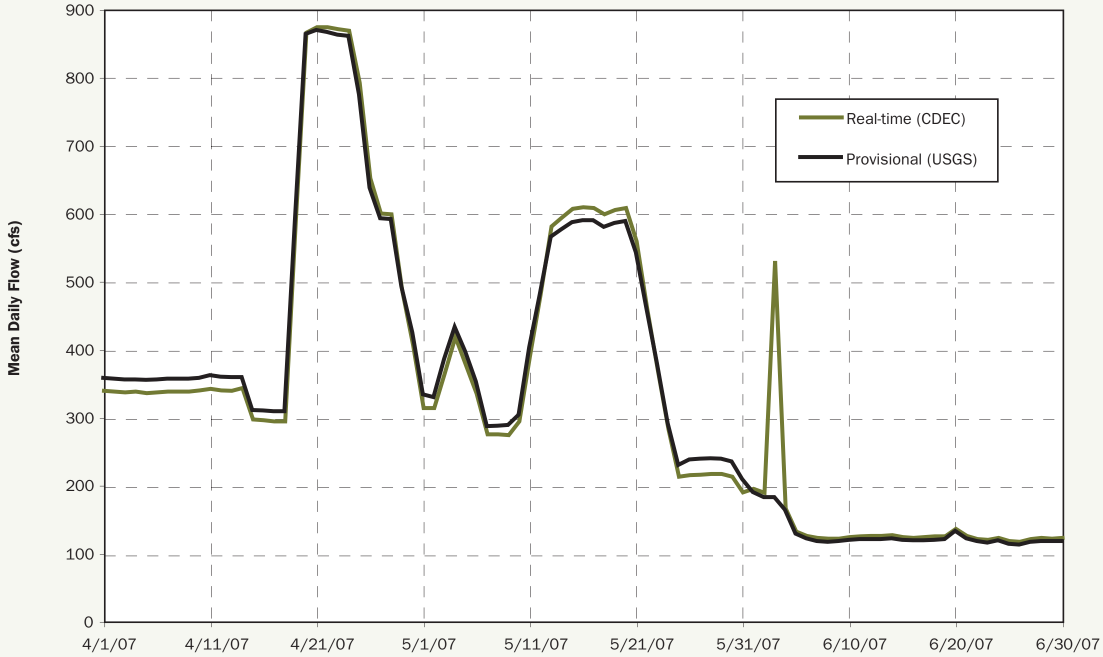
Appendix A-2, Figure 3
San Joaquin River above Merced River



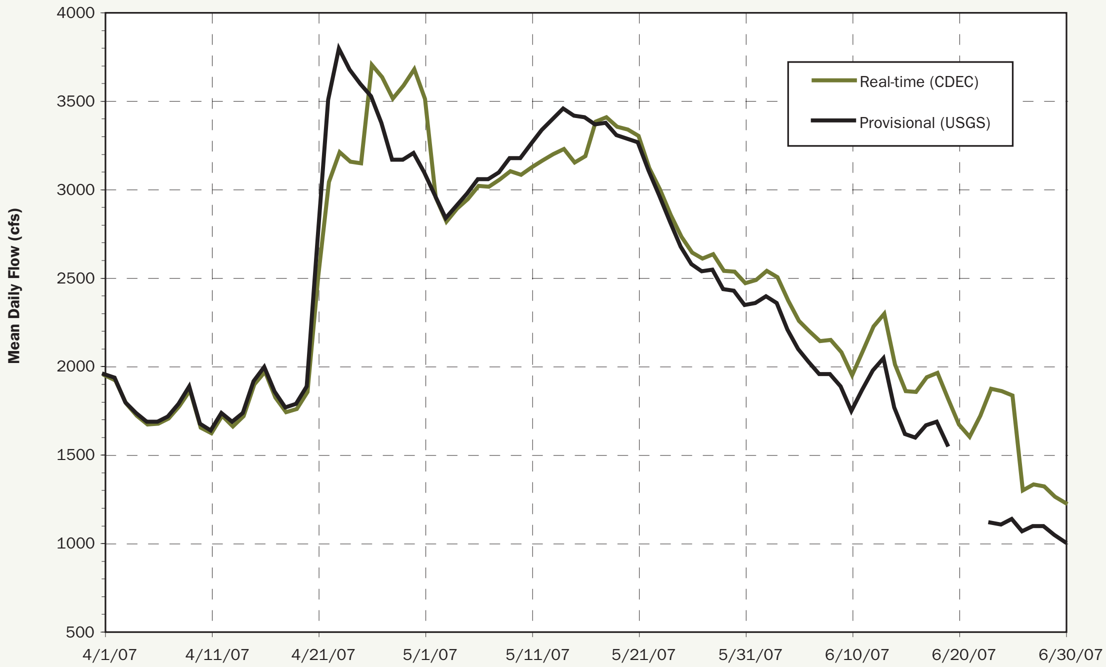
Appendix A-2, Figure 4
San Joaquin River near Newman



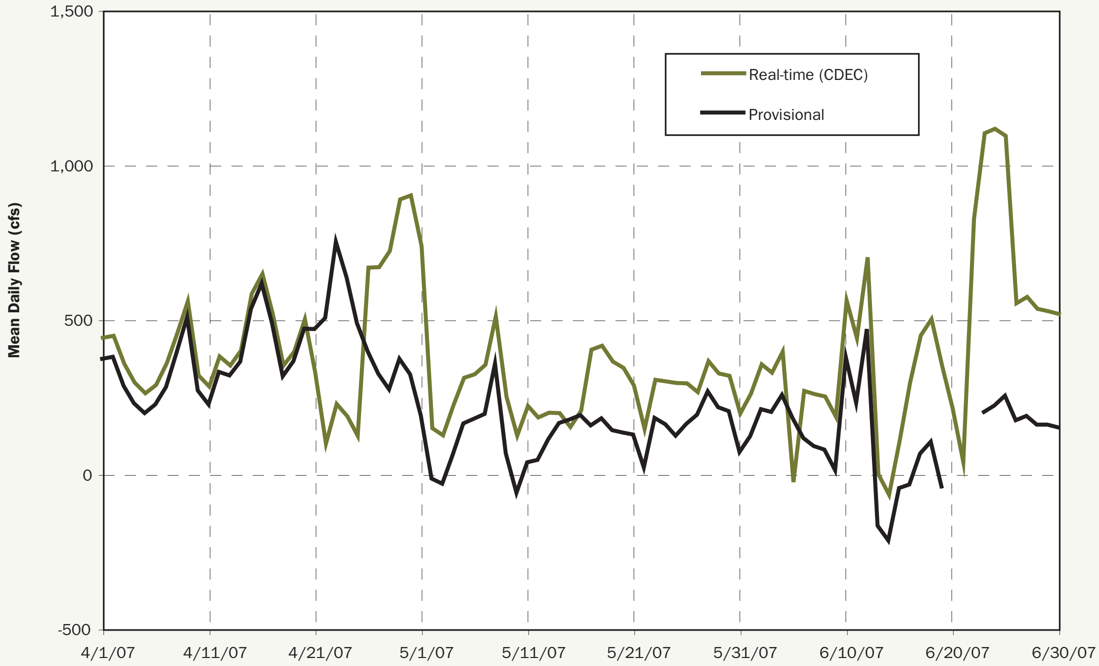
Appendix A-2, Figure 5
Tuolumne River below LaGrange Dam



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



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



San Joaquin River Group Authority

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Modesto Irrigation District

Turlock Irrigation District

Oakdale Irrigation District

Merced Irrigation District

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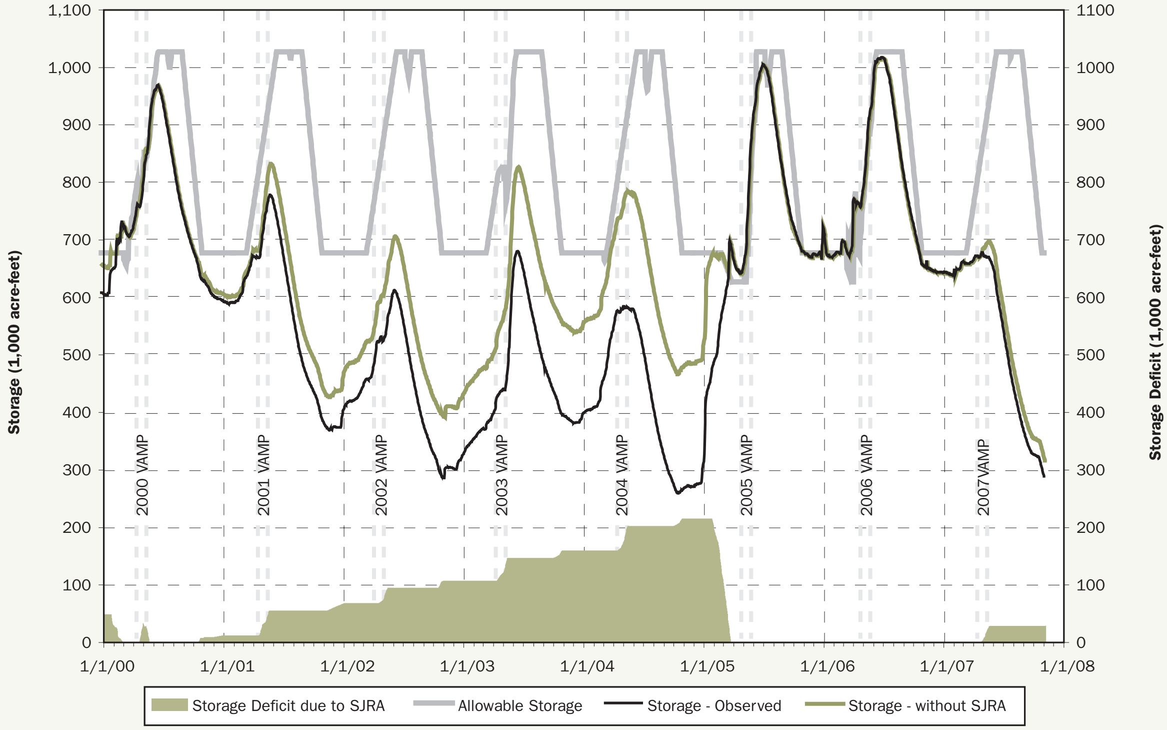
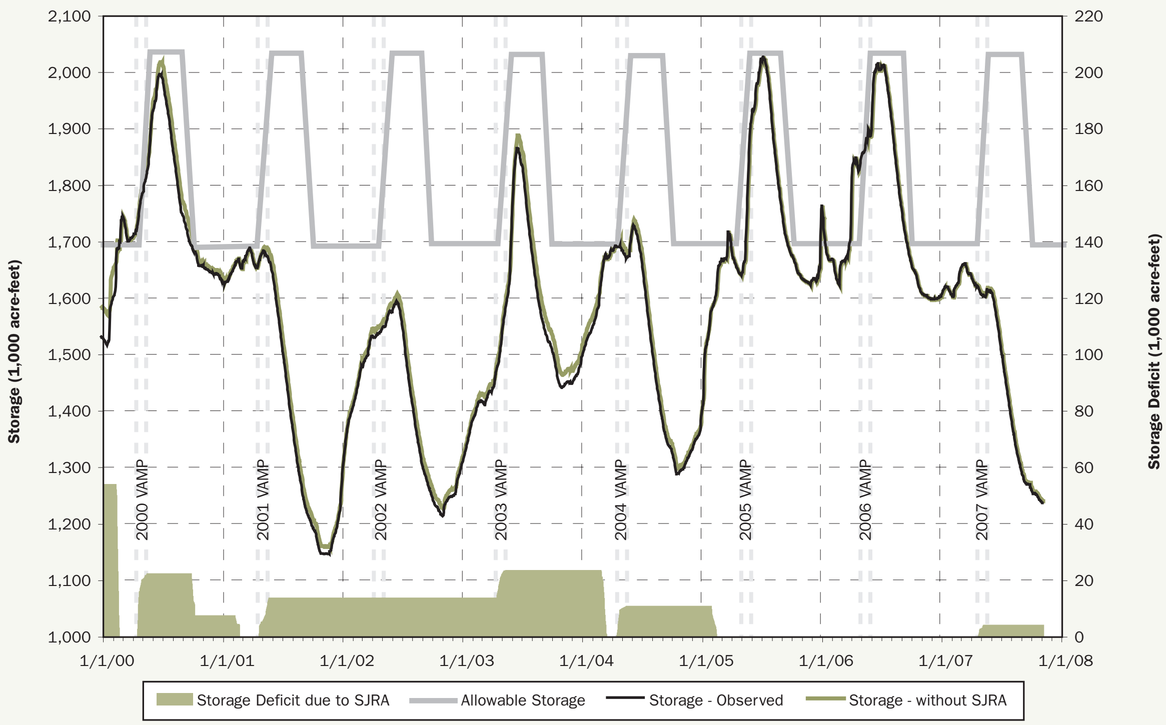
APPENDIX B

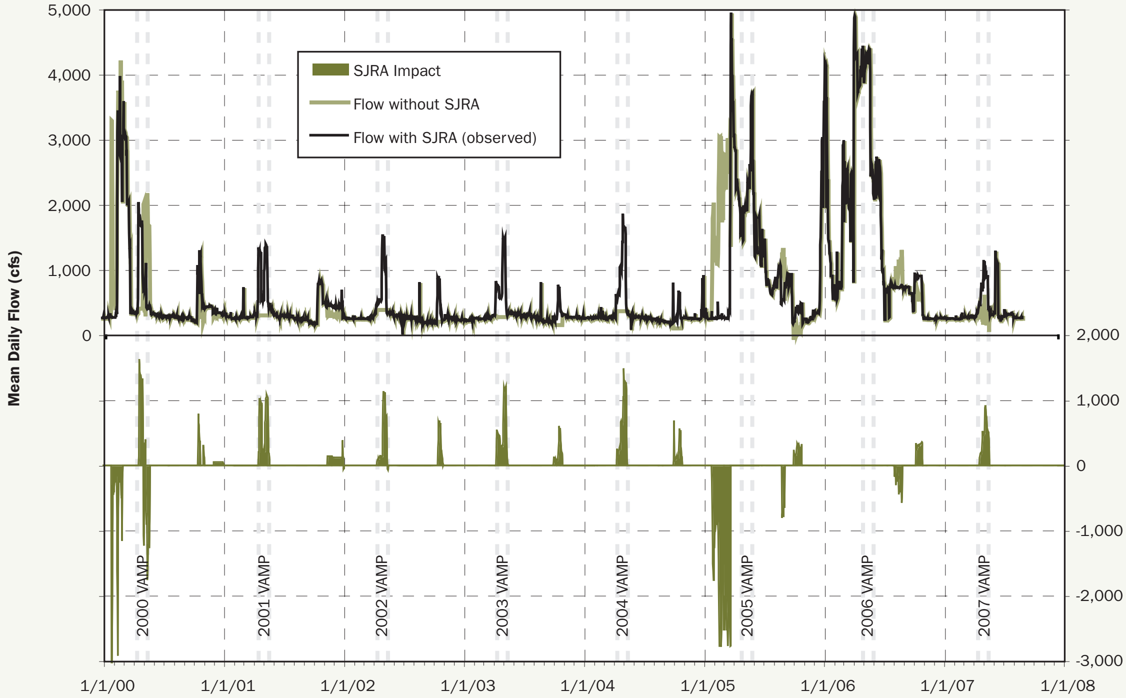
Appendix B-1, Figure 1
SJRA Storage Impacts, 2000-2007 Lake McClure (Merced River)



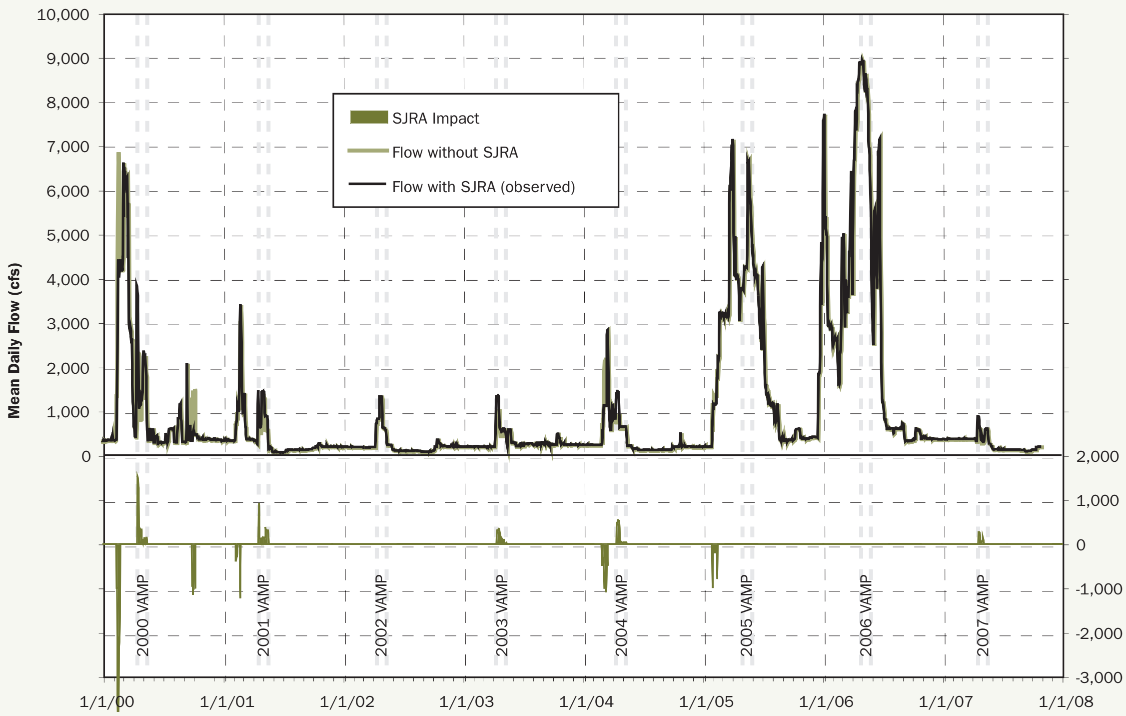
Appendix B-1, Figure 2
SJRA Storage Impacts, 2000-2007 Don Pedro Reservoir (Tuolumne River)



Appendix B-1, Figure 3
Merced River below Crocker-Huffman Dam 2000-2007



Appendix B-1, Figure 4
Tuolumne River below LaGrange Dam 2000-2007



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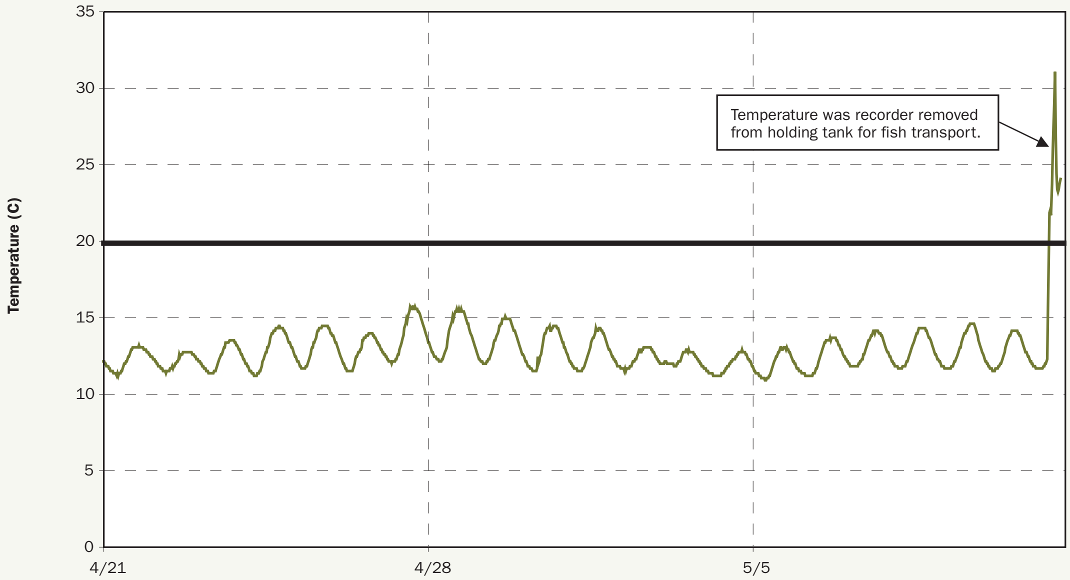
APPENDIX C

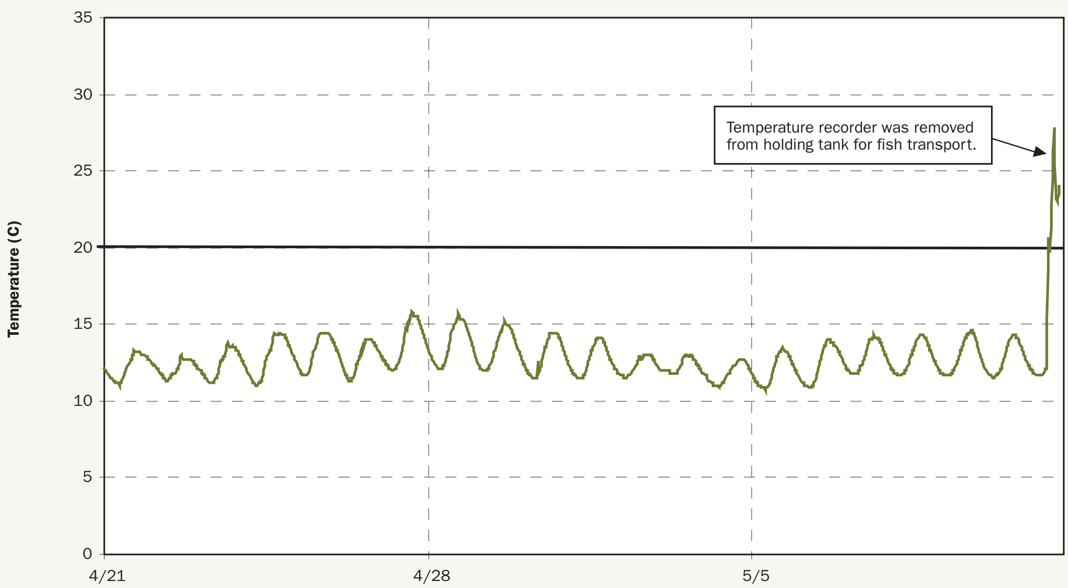
Appendix C-1
Water Temperature Monitoring Locations

Site #	Logger Number	Temperature Monitoring Location	Lat	Long	Distance from Durham Ferry	Date Deployed	Date Retrieved	Notes
Appendix C-1 VAMP 2007 Water Temperature Monitoring								
n/a	900618	Hatchery 1	n/a	n/a	n/a	4/6/07		
n/a	877664	Hatchery 2	n/a	n/a	n/a	4/6/07		
n/a	900619	Hatchery 3	n/a	n/a	n/a	4/6/07		
n/a	900620	Hatchery 4	n/a	n/a	n/a	4/6/07		
1	900616	Durham Ferry	N 37 41.381	W 121 15.657	0	4/3/07	7/19/07	Near intake pump on tree at water line
2	877665	Mossdale	N 37 47.180	W 121 18.425	11	4/3/07	Missing	Under bridge on cable
3	900625	Old River at HORB	N 37 48.457	W 121 19.872	14	4/3/07	7/19/07	On tree near flagging across from intake pump
4	900617	Dos Reis	N 37 49.808	W 121 18.665	16	4/3/07	7/19/07	On tree normally used across from launch ramp
5	877669	DWR Monitoring Station	N 37 51.869	W 121 19.376	19	4/3/07	Missing	As normal
6a	900615	Confluence – Top	N 37 56.818	W 121 20.285	27	4/3/07	Missing	As normal
6b	626431	Confluence- Bottom	N 37 56.818	W 121 20.285	27	4/3/07	Missing	As normal
7	626437	Downstream of Channel Marker 30	N 37 59.776	W 121 25.569	33	4/3/07	Missing	As normal
8	877666	Turner Cut	N 37 59.468	W121 27.267	35	4/3/07	Missing	On USGS gaging station
9	900622	"Q" Piling 1/2 mile upstream of channel marker 13	N 38 01.940	W 121 28.769	37	4/3/07	Missing	As normal
10	900624	All Pro abandoned boat	N 38 04.522	W 121 34.413	45	4/3/07	Missing	As normal
11	551654	Jersey Point USGS Gauging Station	N 38 03.172	W121 41.637	56	4/3/07	Missing	As normal
12	562570	Antioch Marina	N 38 01.147	W121 48.829	64	4/3/07	Missing	On pilings across channel from marina upstream
13	551657	Chipps Island	N 38 03.084	W 121 55.463	72	4/3/07	Missing	As normal
14	562563	Holland Riverside Marina	N 37 58.323	W 121 34.887	South Delta	4/2/07	Missing	On "No Wake" sign
15	900623	Old River / Indian Slough Confluence	N 37 54.954	W 121 33.949	South Delta	4/2/07	7/13/07	On "Indian Slough" sign
16	877663	CCF Radial Gates	N 37 49.773	W 121 33.096	South Delta	4/2/07	Missing	on DWR gaging station near intake gates
17	900626	Grant Line Canal at Travy Blvd Bridge	N 37 49.143	W 121 27.026	South Delta	4/2/07	Missing	under bridge near repairs
18	540810	Middle River at Victoria Canal Confluence	N37 53.323	W121 29.334	South Delta	4/2/07	Missing	On Staff gage
19	877668	Werner Cut: Channel above Woodward Isle	N 37 56.319	W 121 30.584	South Delta	4/2/07	7/13/07	On old pilings
Total Loggers: 24 - Set to record every 24 mins (132 days)								

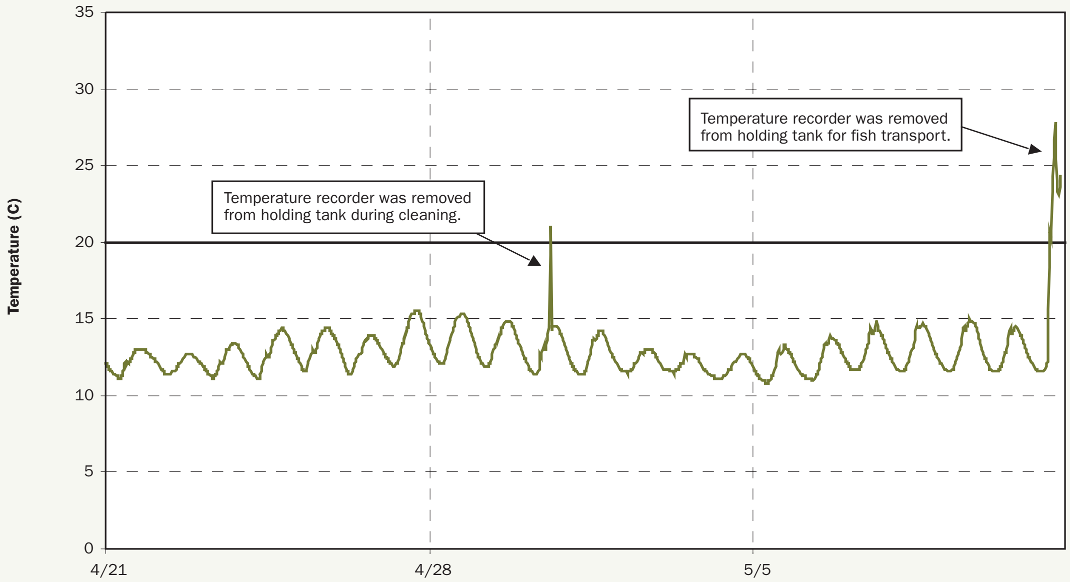
Appendix C-2
Hatchery 1
Water Temperature in Holding Tank



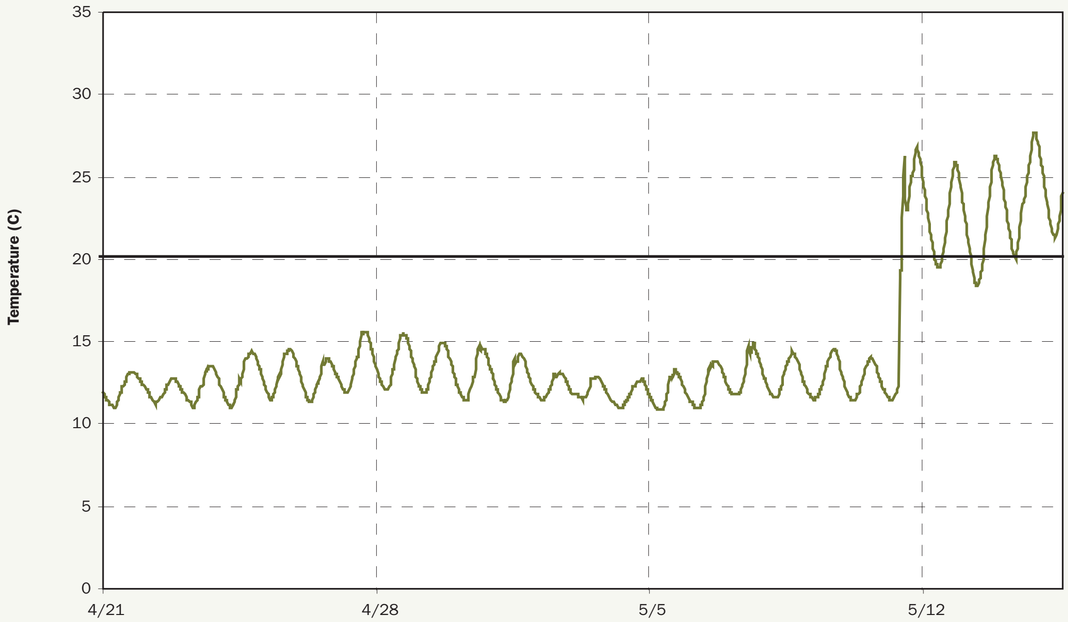
Appendix C-2
Hatchery 2
Water Temperature in Holding Tank



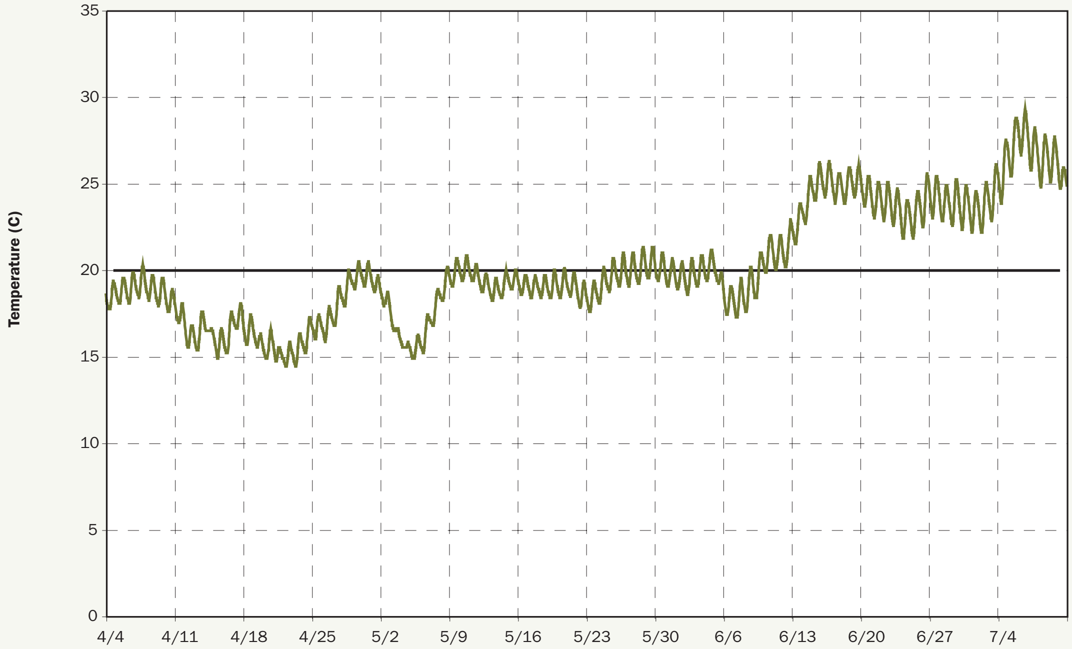
Appendix C-2
Hatchery 3
Water Temperature in Holding Tank



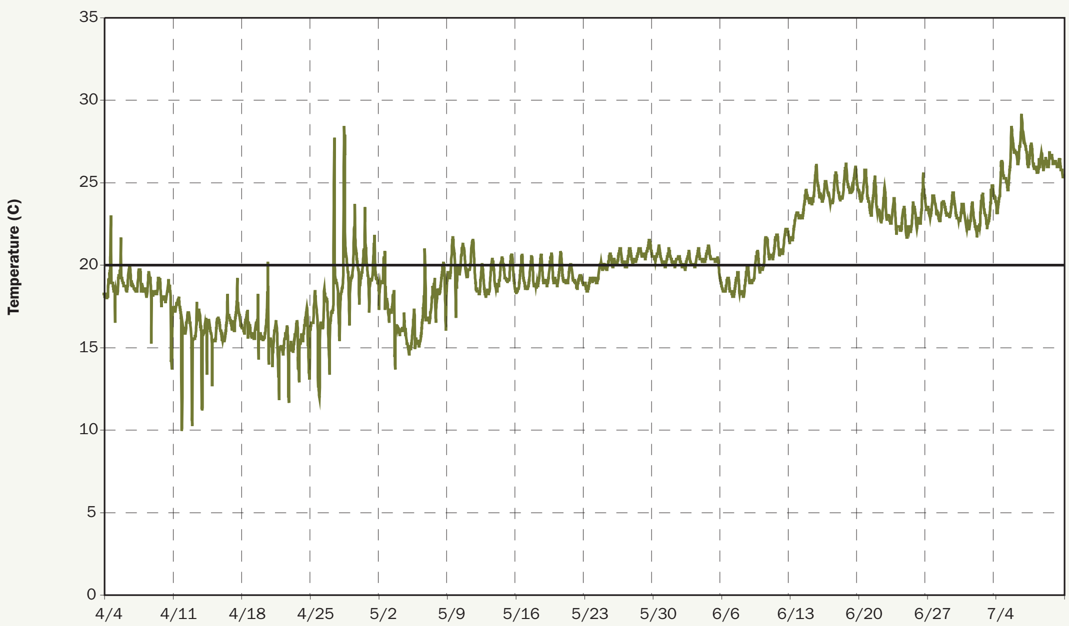
Appendix C-2
Hatchery 4
Water Temperature in Holding Tank



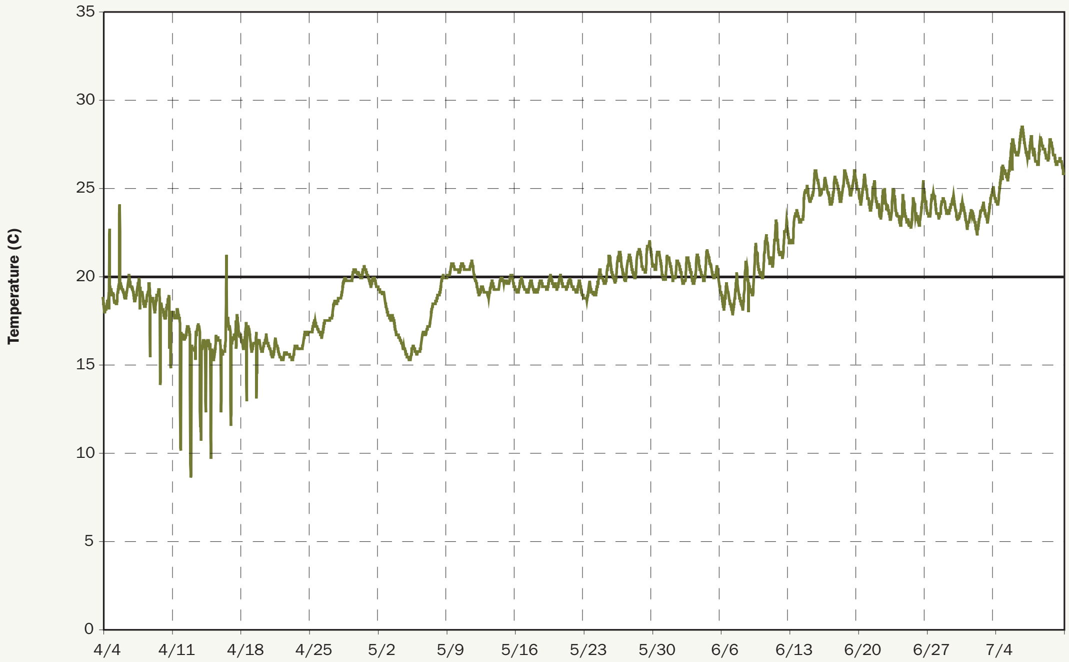
Appendix C-2
Durham Ferry



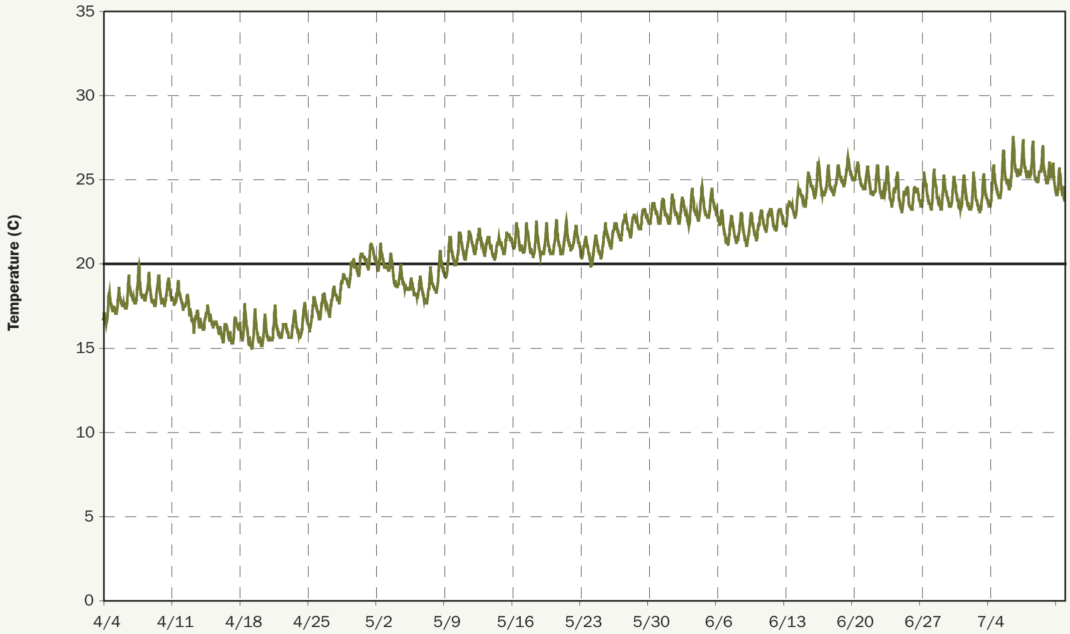
Appendix C-2
Old River at HORB



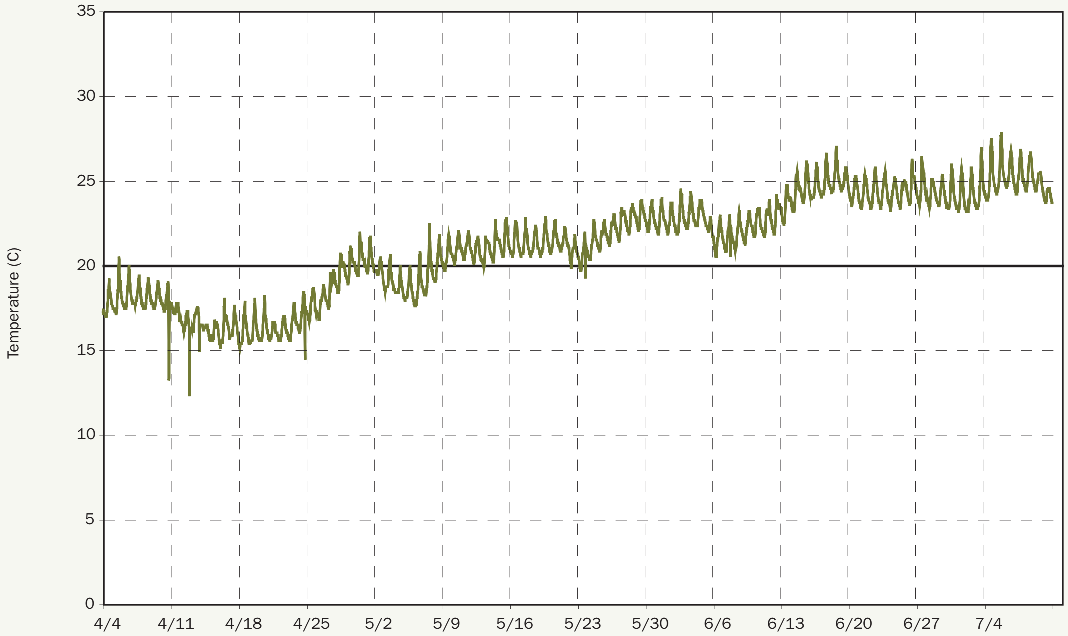
Appendix C-2
Dos Reis



Appendix C-2
Old River/Indian Slough Confluence



Appendix C-2
Werner Cut - Channel above Woodward Isle



Appendix C-3. Chinook salmon smolt conditon 48-hours post-release.

Release Location	CWT codes	Exam. Date	n	min FL	max FL	mean FL	river temp C	truck temp C	Delivery Time	Fish released	min scale loss	max scale loss	mean scale loss	color (% norm.)	Fin hemor-rhaging (% none)	Eyes (% norm.)	Gill color (% norm.)	Partial adclips (number)	Missing ad clips (number)	mortalities	comments or other abnormal-ities
Durham Ferry I	acoustic tagged	5/5/07	10	104	113	109	11.0	17.0	10:30	11:30	1.0	3.0	2.2	100	100	100	100	0	0	0	
Mossdale I	acoustic tagged	5/5/07	10	105	111	109.0	13.0	17.0	12:00	13:00	1.0	4.0	2.0	100	100	100	100	0	0	0	
MRH I	acoustic tagged	5/14/07	10	103	113	110.0			11:15		1.0	6.0	2.7	100	100	100	96	0	0	0	mortality; scale loss
Durham Ferry II	acoustic tagged	5/12/07	20	103	126	113.0	11.0	19.0	10:45	11:40	1.0	6.0	3.3	100	100.0	100.0	100.0	0.0	0.0	0	
Mossdale II	acoustic tagged	5/12/07	20	107	122	112.8	11.5	21.0	11:30	12:30	1.0	7.0	2.1	100	100.0	100.0	100.0	0.0	0.0	0	
MRH II	acoustic tagged	5/14/07	10	109	119	113.8			12:15		1.0	5.0	2.6	100	100.0	100.0	100.0	0.0	0.0	0	

Appendix C-4
Detections of acoustic-tagged salmon from May 3 & 4 releases upstream of the Head of Old River Barrier.

Release Dates: May 3 and May 4, 2007 Release Locations: Durham Ferry, Mossdale, Bowman Road, Stockton

Release Date	Release Time	Release Site	Tag Code	Upstream of HORB Date/Time	Bowman Road Date/Time	Stockton Date/Time	Turner cut Date/Time	R16 Date/Time	Mobile Monitoring: Near Stockton Date/Comment	Mobile Monitoring: Other Locations Date/Comment
5/3/07	11:30	Durham Ferry	3000	5/4/07 9:51	5/4/07 16:54			5/16/07 2:14		
5/3/07	11:30	Durham Ferry	3007	5/4/07 10:13	5/5/07 20:03					
5/3/07	11:30	Durham Ferry	3014	5/4/07 10:18	5/4/07 15:01	5/4/07 19:41				
5/3/07	11:30	Durham Ferry	3021	5/4/07 7:50	5/4/07 14:49			5/8/07 14:56	5/17-18,Tag Not Moving	
5/3/07	11:30	Durham Ferry	3035	5/4/07 4:03	5/4/07 10:53	5/5/07 21:14				
5/3/07	11:30	Durham Ferry	3042						5/17-18,Tag Not Moving	
5/3/07	11:30	Durham Ferry	3049	5/4/07 10:14	5/4/07 15:41	5/4/07 22:29			5/17-18,Tag Not Moving	
5/3/07	11:30	Durham Ferry	3056	5/6/07 12:00	5/7/07 0:43	5/7/07 11:13		5/10/07 19:40	5/17-18,Tag Not Moving	
5/3/07	11:30	Durham Ferry	3077	5/4/07 8:30	5/4/07 13:04	5/4/07 16:48				
5/3/07	11:30	Durham Ferry	3084	5/4/07 4:04	5/4/07 17:01					
5/3/07	11:30	Durham Ferry	3091	5/4/07 8:58	5/4/07 14:37		5/7/07 7:49			
5/3/07	11:30	Durham Ferry	3098	5/4/07 12:01	5/4/07 17:29				5/17-18,Tag Not Moving	
5/3/07	11:30	Durham Ferry	3105	5/4/07 4:42	5/4/07 13:22					
5/3/07	11:30	Durham Ferry	3112	5/4/07 13:15	5/4/07 17:10					
5/3/07	11:30	Durham Ferry	3119	5/4/07 0:34	5/4/07 5:19					
5/3/07	11:30	Durham Ferry	3126	5/4/07 4:08					5/17-18,Tag Not Moving	
5/3/07	11:30	Durham Ferry	3133	5/4/07 13:25	5/4/07 18:12	5/5/07 22:23			5/17-18,Tag Not Moving	
5/3/07	11:30	Durham Ferry	3140						5/17-18,Tag Not Moving	
5/3/07	11:30	Durham Ferry	3147	5/4/07 4:34	5/4/07 13:16					
5/3/07	11:30	Durham Ferry	3154	5/4/07 12:49	5/4/07 17:25	5/5/07 9:06		5/8/07 18:59	5/17-18,Tag Not Moving	
5/3/07	11:30	Durham Ferry	3182	5/4/07 2:16	5/4/07 10:20	5/4/07 14:47				
5/3/07	11:30	Durham Ferry	3189	5/4/07 4:51	5/4/07 11:54					
5/3/07	11:30	Durham Ferry	3196	5/4/07 14:14	5/5/07 8:02	5/5/07 13:22	5/8/07 6:28		5/17-18,Tag Not Moving	
5/3/07	11:30	Durham Ferry	3203	5/6/07 17:37	5/7/07 11:16	5/7/07 16:36			5/17-18,Tag Not Moving	
5/3/07	11:30	Durham Ferry	3210	5/4/07 6:25	5/4/07 12:24	5/4/07 15:28				
5/3/07	11:30	Durham Ferry	3217	5/4/07 13:00	5/4/07 17:27					
5/3/07	11:30	Durham Ferry	3231	5/4/07 10:55	5/4/07 16:00					
5/3/07	11:30	Durham Ferry	3238	5/4/07 15:46	5/4/07 23:13					
5/3/07	11:30	Durham Ferry	3245	5/4/07 11:36	5/4/07 18:00					
5/3/07	11:30	Durham Ferry	3252	5/4/07 21:20	5/5/07 10:27					
5/3/07	11:30	Durham Ferry	3259	5/4/07 13:51	5/4/07 18:18					
5/3/07	11:30	Durham Ferry	3266	5/4/07 6:00	5/4/07 13:37	5/4/07 17:38				
5/3/07	11:30	Durham Ferry	3280	5/4/07 12:30	5/4/07 16:25					
5/3/07	11:30	Durham Ferry	3287	5/4/07 14:23						
5/3/07	11:30	Durham Ferry	3294	5/4/07 13:54	5/4/07 18:20					5/8/07, CCFB
5/3/07	11:30	Durham Ferry	3301	5/5/07 10:29	5/5/07 15:51			5/8/07 16:49		
5/3/07	11:30	Durham Ferry	3308	5/4/07 14:39	5/4/07 19:57	5/5/07 18:38				
5/3/07	11:30	Durham Ferry	3315	5/4/07 8:08	5/4/07 14:00	5/4/07 18:17		5/9/07 7:02		
5/3/07	11:30	Durham Ferry	3322	5/4/07 12:39	5/4/07 16:21		5/6/07 6:11			
5/3/07	11:30	Durham Ferry	3350	5/4/07 13:46	5/6/07 10:38					
5/3/07	11:30	Durham Ferry	3357	5/4/07 11:43	5/4/07 16:13					
5/3/07	11:30	Durham Ferry	3378	5/4/07 3:11	5/4/07 11:09					
5/3/07	11:30	Durham Ferry	3392	5/4/07 1:01	5/4/07 8:39					
5/3/07	11:30	Durham Ferry	3399	5/4/07 13:16	5/4/07 18:16	5/5/07 11:26		5/9/07 9:01		
5/3/07	11:30	Durham Ferry	3413	5/4/07 8:15	5/4/07 13:44					
5/3/07	11:30	Durham Ferry	3427	5/4/07 1:51	5/4/07 10:01	5/4/07 13:40	5/6/07 8:41			
5/3/07	11:30	Durham Ferry	3434	5/4/07 3:47	5/4/07 12:40	5/4/07 19:11				
5/3/07	11:30	Durham Ferry	3441						5/17-18,Tag Not Moving	
5/3/07	11:30	Durham Ferry	3448	5/4/07 11:57	5/4/07 16:37			5/10/07 12:39		
5/3/07	11:30	Durham Ferry	3469	5/4/07 12:50	5/4/07 17:30	5/5/07 11:39				
5/3/07	11:30	Durham Ferry	3490	5/3/07 23:43	5/4/07 8:44					
5/3/07	11:30	Durham Ferry	3497	5/4/07 2:02	5/4/07 9:09					
5/3/07	11:30	Durham Ferry	3504	5/4/07 5:52	5/4/07 12:24					
5/3/07	11:30	Durham Ferry	3511	5/4/07 5:51	5/4/07 12:33					
5/3/07	11:30	Durham Ferry	3518	5/5/07 0:20	5/5/07 17:24	5/6/07 0:56				
5/3/07	11:30	Durham Ferry	3539	5/10/07 8:01						
5/3/07	11:30	Durham Ferry	3546	5/6/07 0:14	5/6/07 5:54					
5/3/07	11:30	Durham Ferry	3553	5/4/07 16:25	5/4/07 21:50	5/5/07 14:37		5/9/07 15:24		
5/3/07	11:30	Durham Ferry	3560	5/6/07 7:12	5/6/07 13:45					
5/3/07	11:30	Durham Ferry	3567	5/4/07 10:20	5/4/07 14:36	5/4/07 19:37				
5/3/07	11:30	Durham Ferry	3574	5/4/07 1:12	5/4/07 9:04		5/6/07 4:01			
5/3/07	11:30	Durham Ferry	3602	5/5/07 1:08	5/5/07 8:55	5/5/07 12:37				
5/3/07	11:30	Durham Ferry	3616	5/4/07 10:16	5/4/07 14:36					
5/3/07	11:30	Durham Ferry	3623	5/4/07 19:47	5/5/07 4:51					
5/3/07	11:30	Durham Ferry	3637	5/4/07 4:26	5/4/07 12:34		5/6/07 7:34			
5/3/07	11:30	Durham Ferry	3651	5/4/07 11:29	5/4/07 16:07					
5/3/07	11:30	Durham Ferry	3658	5/7/07 7:54	5/7/07 14:23	5/7/07 17:26				
5/3/07	11:30	Durham Ferry	3665	5/6/07 12:25	5/6/07 16:40	5/7/07 9:31				
5/3/07	11:30	Durham Ferry	3672	5/4/07 10:12	5/4/07 16:06					
5/3/07	11:30	Durham Ferry	3679	5/4/07 4:38	5/4/07 17:17					
5/3/07	11:30	Durham Ferry	3686	5/4/07 5:32	5/4/07 20:37					
5/3/07	11:30	Durham Ferry	3693	5/5/07 1:41	5/5/07 10:37	5/5/07 14:12				
5/3/07	13:00	Mossdale	3700	5/3/07 15:17	5/3/07 22:08					
5/3/07	13:00	Mossdale	3707	5/3/07 18:26	5/4/07 1:20					
5/3/07	13:00	Mossdale	3714	5/3/07 18:30	5/4/07 1:16					
5/3/07	13:00	Mossdale	3721	5/3/07 15:58	5/4/07 0:39					

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Appendix C-4
Detections of acoustic-tagged salmon from May 3 & 4 releases upstream of the Head of Old River Barrier.

Release Dates: May 3 and May 4, 2007 Relase Locations: Durham Ferry, Mossdale, Bowman Road, Stockton

Release Date	Release Time	Release Site	Tag Code	Upstream of HORB Date/Time	Bowman Road Date/Time	Stockton Date/Time	Turner cut Date/Time	R16 Date/Time	Mobile Monitoring Near Stockton Date/Comment	Mobile Monitoring Other Locations Date/Comment
5/3/07	13:00	Mossdale	3728	5/3/07 15:41	5/4/07 0:20					
5/3/07	13:00	Mossdale	3735	5/3/07 15:27	5/3/07 23:06			5/8/07 15:36		
5/3/07	13:00	Mossdale	3742	5/3/07 18:05	5/5/07 9:24	5/5/07 13:20				
5/3/07	13:00	Mossdale	3749	5/3/07 15:00	5/3/07 20:30					
5/3/07	13:00	Mossdale	3756	5/3/07 16:14	5/4/07 10:06	5/4/07 13:53				
5/3/07	13:00	Mossdale	3763	5/3/07 15:49	5/3/07 22:21	5/4/07 9:10				
5/3/07	13:00	Mossdale	3770	5/3/07 15:23	5/4/07 7:09					
5/3/07	13:00	Mossdale	3777	5/3/07 15:27	5/3/07 23:38	5/4/07 9:52		5/8/07 20:36		
5/3/07	13:00	Mossdale	3784	5/3/07 15:59	5/3/07 23:40	5/4/07 8:30				
5/3/07	13:00	Mossdale	3791	5/3/07 16:56	5/4/07 9:31	5/4/07 19:23				
5/3/07	13:00	Mossdale	3798	5/3/07 14:49	5/4/07 0:29			5/9/07 11:14		
5/3/07	13:00	Mossdale	3805	5/3/07 15:53	5/3/07 22:49					
5/3/07	13:00	Mossdale	3812	5/3/07 16:22	5/4/07 0:45	5/4/07 11:52				
5/3/07	13:00	Mossdale	3819	5/3/07 15:51	5/4/07 7:36					
5/3/07	13:00	Mossdale	3826	5/3/07 17:32						
5/3/07	13:00	Mossdale	3833	5/3/07 16:12	5/4/07 9:42					
5/3/07	13:00	Mossdale	3840	5/3/07 23:09	5/4/07 13:25	5/5/07 13:06				
5/3/07	13:00	Mossdale	3847	5/3/07 16:00	5/3/07 23:18					
5/3/07	13:00	Mossdale	3854	5/3/07 16:10	5/3/07 23:36	5/4/07 8:55				
5/3/07	13:00	Mossdale	3861	5/3/07 15:50	5/3/07 22:27					
5/3/07	13:00	Mossdale	3868	5/3/07 15:44	5/3/07 21:04	5/4/07 9:24				
5/3/07	13:00	Mossdale	3875	5/3/07 16:11	5/4/07 6:20	5/4/07 13:34				
5/3/07	13:00	Mossdale	3882	5/3/07 15:27						
5/3/07	13:00	Mossdale	3889	5/3/07 17:00	5/3/07 23:27					
5/3/07	13:00	Mossdale	3896	5/3/07 15:57	5/3/07 22:25	5/4/07 8:53				
5/3/07	13:00	Mossdale	3903	5/3/07 15:03	5/3/07 22:41	5/4/07 10:58				
5/3/07	13:00	Mossdale	3910	5/3/07 15:17	5/3/07 21:44	5/4/07 8:24	5/5/07 12:09			5/9/07 06:58, Hwy 4
5/3/07	13:00	Mossdale	3910	5/3/07 15:17	5/3/07 21:44	5/4/07 8:24	5/5/07 12:09			5/9/07 13:27, Tracy
5/3/07	13:00	Mossdale	3917	5/3/07 15:10	5/4/07 0:16					
5/3/07	13:00	Mossdale	3924	5/3/07 22:08	5/4/07 9:16					
5/3/07	13:00	Mossdale	3931	5/3/07 15:14	5/4/07 10:09					
5/3/07	13:00	Mossdale	3938	5/3/07 15:50	5/4/07 10:27			5/12/07 9:25		
5/3/07	13:00	Mossdale	3945	5/3/07 15:52	5/4/07 3:17	5/4/07 11:56				
5/3/07	13:00	Mossdale	3952	5/3/07 15:58	5/3/07 23:02	5/4/07 9:03		5/10/07 11:53		
5/3/07	13:00	Mossdale	3959	5/3/07 17:16	5/4/07 1:51					
5/3/07	13:00	Mossdale	3966	5/3/07 15:29	5/3/07 22:52					
5/3/07	13:00	Mossdale	3973	5/3/07 15:58						
5/3/07	13:00	Mossdale	3980	5/3/07 15:58	5/3/07 23:13					
5/3/07	13:00	Mossdale	3987	5/3/07 17:53						
5/3/07	13:00	Mossdale	3994	5/3/07 15:13						
5/3/07	13:00	Mossdale	4001	5/3/07 15:57	5/3/07 22:05	5/4/07 10:53				
5/3/07	13:00	Mossdale	4008	5/3/07 15:28	5/4/07 13:16	5/4/07 16:48				
5/3/07	13:00	Mossdale	4015	5/3/07 22:05	5/4/07 5:29	5/4/07 14:38	5/7/07 22:47			
5/3/07	13:00	Mossdale	4022	5/3/07 16:14	5/3/07 23:32					
5/3/07	13:00	Mossdale	4029	5/3/07 16:31	5/4/07 1:13					
5/3/07	13:00	Mossdale	4036	5/3/07 14:48						
5/3/07	13:00	Mossdale	4043	5/3/07 17:01	5/3/07 23:42					
5/3/07	13:00	Mossdale	4050	5/3/07 18:22	5/4/07 2:02					
5/3/07	13:00	Mossdale	4057	5/3/07 14:49	5/3/07 19:42	5/4/07 10:05				
5/3/07	13:00	Mossdale	4064	5/3/07 15:29	5/4/07 10:00	5/4/07 17:35				
5/3/07	13:00	Mossdale	4071	5/3/07 15:41	5/3/07 21:51	5/4/07 10:06				
5/3/07	13:00	Mossdale	4078	5/3/07 16:43	5/4/07 0:42	5/4/07 10:35				
5/3/07	13:00	Mossdale	4092	5/3/07 15:59						
5/3/07	13:00	Mossdale	4099	5/3/07 19:43	5/4/07 14:00					
5/3/07	13:00	Mossdale	4106	5/3/07 15:57	5/4/07 0:25	5/4/07 10:15				
5/3/07	13:00	Mossdale	4120	5/3/07 21:30	5/4/07 3:40			5/9/07 6:21		
5/3/07	13:00	Mossdale	4127	5/3/07 15:17	5/4/07 0:04	5/4/07 10:13				
5/3/07	13:00	Mossdale	4134	5/3/07 16:45						
5/3/07	13:00	Mossdale	4141	5/3/07 15:59	5/5/07 6:03					
5/3/07	13:00	Mossdale	4148	5/3/07 17:05	5/4/07 12:37			5/11/07 18:58		
5/3/07	13:00	Mossdale	4155	5/3/07 15:50						
5/3/07	13:00	Mossdale	4162	5/3/07 15:58	5/5/07 4:12					
5/3/07	13:00	Mossdale	4169	5/3/07 15:47	5/3/07 22:23					
5/3/07	13:00	Mossdale	4176	5/3/07 15:31	5/3/07 21:26	5/4/07 9:03			5/17-18,Tag Not Moving	
5/3/07	13:00	Mossdale	4183	5/3/07 17:41	5/4/07 0:37		5/5/07 7:20			
5/3/07	13:00	Mossdale	4190	5/3/07 23:38						
5/3/07	13:00	Mossdale	4197	5/3/07 15:19	5/4/07 9:33					
5/3/07	13:00	Mossdale	4204	5/3/07 15:10	5/3/07 20:12	5/4/07 9:06				
5/3/07	13:00	Mossdale	4211	5/3/07 15:46	5/3/07 21:19					
5/3/07	13:00	Mossdale	4218	5/3/07 16:04	5/4/07 0:58	5/5/07 17:38				
5/3/07	13:00	Mossdale	4225	5/3/07 15:52	5/4/07 0:42					
5/3/07	13:00	Mossdale	4232	5/3/07 19:28	5/4/07 1:47	5/4/07 10:35				
5/3/07	13:00	Mossdale	4239	5/3/07 17:14	5/5/07 9:53					
5/3/07	13:00	Mossdale	4246	5/3/07 21:12	5/4/07 7:10					
5/3/07	13:00	Mossdale	4253	5/3/07 15:58	5/3/07 21:57					

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Appendix C-4
Detections of acoustic-tagged salmon from May 3 & 4 releases upstream of the Head of Old River Barrier.

Release Dates: May 3 and May 4, 2007 Relase Locations: Durham Ferry, Mossdale, Bowman Road, Stockton

									Mobile Monitoring	
Release Date	Release Time	Release Site	Tag Code	Upstream of HORB Date/Time	Bowman Road Date/Time	Stockton Date/Time	Turner cut Date/Time	R16 Date/Time	Near Stockton Date/Comment	Other Locations Date/Comment
5/3/07	13:00	Mossdale	4260	5/3/07 15:27	5/3/07 22:08					
5/3/07	13:00	Mossdale	4267	5/3/07 15:40						
5/3/07	13:00	Mossdale	4274	5/3/07 18:16	5/4/07 9:37			5/9/07 4:38		
5/3/07	13:00	Mossdale	4281	5/3/07 15:27	5/3/07 22:09	5/4/07 10:36				
5/3/07	13:00	Mossdale	4288	5/3/07 15:33	5/3/07 22:19	5/4/07 8:22				
5/3/07	13:00	Mossdale	4302	5/3/07 18:38						
5/3/07	13:00	Mossdale	4309	5/3/07 18:56	5/4/07 13:03					
5/3/07	13:00	Mossdale	4316	5/3/07 16:09						
5/3/07	13:00	Mossdale	4323	5/3/07 16:27	5/3/07 23:25					
5/3/07	13:00	Mossdale	4330	5/3/07 15:04	5/4/07 0:28					
5/3/07	13:00	Mossdale	4337	5/3/07 15:54	5/3/07 23:22	5/4/07 9:11				
5/3/07	13:00	Mossdale	4344	5/3/07 15:10	5/3/07 23:49					
5/3/07	13:00	Mossdale	4351	5/3/07 14:57	5/3/07 22:05					
5/3/07	13:00	Mossdale	4358	5/3/07 16:20	5/3/07 23:25					
5/3/07	13:00	Mossdale	4365	5/3/07 17:01						
5/3/07	13:00	Mossdale	4372	5/3/07 15:59	5/3/07 23:20					
5/3/07	13:00	Mossdale	4379	5/3/07 15:51	5/3/07 23:15		5/7/07 11:30			
5/3/07	13:00	Mossdale	4386	5/3/07 15:57	5/4/07 1:36	5/4/07 11:47		5/9/07 17:40		
5/3/07	13:00	Mossdale	4393	5/3/07 16:23	5/4/07 9:42					
5/3/07	12:15	Bowman Rd.	5107			5/4/07 18:26				
5/3/07	12:15	Bowman Rd.	5142			5/4/07 18:59				
5/3/07	12:15	Bowman Rd.	5156			5/4/07 16:26				
5/3/07	12:15	Bowman Rd.	5163						5/17-18,Tag Not Moving	
5/3/07	12:15	Bowman Rd.	5177			5/5/07 9:56				
5/3/07	12:15	Bowman Rd.	5184			5/4/07 15:42				
5/3/07	12:15	Bowman Rd.	5196						5/17-18,Tag Not Moving	
5/3/07	12:15	Bowman Rd.	5198			5/6/07 21:20				
5/3/07	12:15	Bowman Rd.	5205			5/4/07 19:59				
5/3/07	12:15	Bowman Rd.	5219						5/17-18,Tag Not Moving	
5/3/07	12:15	Bowman Rd.	5233			5/4/07 16:19				
5/3/07	12:15	Bowman Rd.	5240			5/4/07 15:30				
5/3/07	12:15	Bowman Rd.	5247			5/4/07 18:25				
5/3/07	12:15	Bowman Rd.	5254			5/4/07 16:13				
5/3/07	12:15	Bowman Rd.	5261					5/6/07 7:21		
5/3/07	12:15	Bowman Rd.	5268			5/4/07 16:55				
5/3/07	12:15	Bowman Rd.	5282			5/4/07 15:41				
5/3/07	12:15	Bowman Rd.	5303			5/4/07 17:22				
5/3/07	12:15	Bowman Rd.	5317			5/4/07 17:00				
5/3/07	12:15	Bowman Rd.	5331			5/4/07 16:00				
5/3/07	12:15	Bowman Rd.	5352			5/4/07 19:58				
5/3/07	12:15	Bowman Rd.	5359					5/8/07 15:37		
5/3/07	12:15	Bowman Rd.	5373			5/4/07 19:33				
5/3/07	12:15	Bowman Rd.	5387			5/6/07 5:42				
5/3/07	12:15	Bowman Rd.	5401			5/4/07 18:41	5/7/07 17:09			
5/3/07	12:15	Bowman Rd.	5408			5/6/07 21:20			5/17-18,Tag Not Moving	
5/3/07	12:15	Bowman Rd.	5429					5/9/07 19:15		
5/3/07	12:15	Bowman Rd.	5527			5/4/07 18:12				
5/3/07	12:15	Bowman Rd.	5548			5/4/07 18:45				
5/3/07	12:15	Bowman Rd.	5583			5/4/07 16:04		5/8/07 20:28		
5/3/07	12:15	Bowman Rd.	5618			5/4/07 19:19				
5/3/07	12:15	Bowman Rd.	5632			5/4/07 16:38			5/17-18,Tag Not Moving	
5/3/07	12:15	Bowman Rd.	5688			5/4/07 16:36				
5/3/07	12:15	Bowman Rd.	5716			5/4/07 16:36				
5/3/07	12:15	Bowman Rd.	5751			5/4/07 17:17		5/9/07 13:00		
5/3/07	12:15	Bowman Rd.	5765			5/4/07 19:18				
5/3/07	12:15	Bowman Rd.	5786			5/4/07 18:48				
5/4/07	12:51	Stockton	5800				5/7/07 3:22			
5/4/07	12:51	Stockton	5898				5/6/07 8:22			
5/4/07	12:51	Stockton	6381				5/6/07 10:57			
5/4/07	12:51	Stockton	5912					5/9/07 6:31		
5/4/07	12:51	Stockton	5919					5/8/07 22:20		
5/4/07	12:51	Stockton	6003					5/9/07 17:07		
5/4/07	12:51	Stockton	6031					5/8/07 17:42		
5/4/07	12:51	Stockton	6038						5/17-18,Tag Not Moving	
5/4/07	12:51	Stockton	6059					5/8/07 21:25		
5/4/07	12:51	Stockton	6122					5/8/07 15:34		
5/4/07	12:51	Stockton	6171					5/9/07 7:28		
5/4/07	12:51	Stockton	6022						5/17-18,Tag Not Moving	
5/4/07	12:51	Stockton	6262						5/17-18,Tag Not Moving	
5/4/07	12:51	Stockton	6269						5/17-18,Tag Not Moving	
5/4/07	12:51	Stockton	6276						5/17-18,Tag Not Moving	
5/4/07	12:51	Stockton	6311					5/10/07 18:38		
5/4/07	12:51	Stockton	6367						5/17-18,Tag Not Moving	
5/4/07	12:51	Stockton	6458					5/8/07 21:25		

Appendix C-5
Detections of acoustic-tagged salmon released May 4 downstream of the Head of Old River Barrier.

Release Date: May 4, 2007 | **Release Location: Old River downtstream of HORB**

Release Date	Release Time	Release Site	Tag Code	Tracy Fish Facilities Date/Time	Clifton Court Inlet Date/Time	Skinner Fish Facilities Date/Time	Old River at Hwy 4 Date/Time
5/4/07	10:17	D/S of HORB	4400	5/6/07 6:04	5/9/07 5:47		
5/4/07	10:17	D/S of HORB	4407				5/6/07 18:40
5/4/07	10:17	D/S of HORB	4449	5/10/07 11:14	5/7/07 3:54		
5/4/07	10:17	D/S of HORB	4456				5/14/07 12:29
5/4/07	10:17	D/S of HORB	4477		5/6/07 13:10		
5/4/07	10:17	D/S of HORB	4505	5/10/07 0:26			
5/4/07	10:17	D/S of HORB	4512	5/5/07 23:07			
5/4/07	10:17	D/S of HORB	4519				5/11/07 5:14
5/4/07	10:17	D/S of HORB	4526				5/9/07 20:09
5/4/07	10:17	D/S of HORB	4547				5/7/07 15:03
5/4/07	10:17	D/S of HORB	4561	5/9/07 6:16			
5/4/07	10:17	D/S of HORB	4568		5/6/07 12:18		
5/4/07	10:17	D/S of HORB	4610	5/11/07 1:42			5/8/07 19:46
5/4/07	10:17	D/S of HORB	4617	5/7/07 14:02			
5/4/07	10:17	D/S of HORB	4631	5/9/07 6:51			5/7/07 18:14
5/4/07	10:17	D/S of HORB	4645				5/6/07 12:20
5/4/07	10:17	D/S of HORB	4659	5/8/07 1:26			
5/4/07	10:17	D/S of HORB	4673	5/9/07 12:38	5/7/07 4:29		5/6/07 16:20
5/4/07	10:17	D/S of HORB	4694				5/6/07 14:16
5/4/07	10:17	D/S of HORB	4701	5/8/07 0:40			5/7/07 15:18
5/4/07	10:17	D/S of HORB	4708	5/9/07 7:24			
5/4/07	10:17	D/S of HORB	4715	5/6/07 6:56			5/8/07 16:50
5/4/07	10:17	D/S of HORB	4722	5/5/07 23:13			5/6/07 16:44
5/4/07	10:17	D/S of HORB	4743		5/6/07 2:26	5/7/07 9:00	
5/4/07	10:17	D/S of HORB	4771	5/16/07 16:46			
5/4/07	10:17	D/S of HORB	4757		5/6/07 13:08		
5/4/07	10:17	D/S of HORB	4785		5/8/07 4:48	5/9/07 20:09	5/7/07 17:23
5/4/07	10:17	D/S of HORB	4799		5/9/07 5:48		
5/4/07	10:17	D/S of HORB	4834				5/7/07 10:31
5/4/07	10:17	D/S of HORB	4841		5/7/07 4:45		
5/4/07	10:17	D/S of HORB	4848		5/6/07 13:37		
5/4/07	10:17	D/S of HORB	4855	5/9/07 14:24			
5/4/07	10:17	D/S of HORB	4862				5/7/07 17:41
5/4/07	10:17	D/S of HORB	4869		5/6/07 11:49		
5/4/07	10:17	D/S of HORB	4883		5/6/07 2:52	5/9/07 7:50	
5/4/07	10:17	D/S of HORB	4897		5/8/07 4:18		
5/4/07	10:17	D/S of HORB	4904	5/7/07 11:37			
5/4/07	10:17	D/S of HORB	4932	5/6/07 5:40	5/9/07 5:54		5/8/07 18:08
5/4/07	10:17	D/S of HORB	4939	5/7/07 12:01			
5/4/07	10:17	D/S of HORB	4946				5/7/07 5:09
5/4/07	10:17	D/S of HORB	4988		5/6/07 13:11	5/7/07 6:18	
5/4/07	10:17	D/S of HORB	4995	5/5/07 19:58			5/6/07 15:03
5/4/07	10:17	D/S of HORB	5002		5/6/07 12:14		
5/4/07	10:17	D/S of HORB	5009				5/6/07 19:47
5/4/07	10:17	D/S of HORB	5016				5/7/07 14:00
5/4/07	10:17	D/S of HORB	5044	5/7/07 12:18			
5/4/07	10:17	D/S of HORB	5051	5/12/07 18:13			5/7/07 18:13
5/4/07	10:17	D/S of HORB	5065		5/7/07 13:20		
5/4/07	10:17	D/S of HORB	5072		5/7/07 14:15		5/6/07 15:43

Appendix C-6
Detections of acoustic-tagged salmon from May 10 & 11 releases upstream of the Head of Old River Barrier.

Release Dates: May 10 and May 11, 2007 Relase Locations: Durham Ferry, Mossdale, Bowman Road, Stockton										
									Mobile Monitoring	
Release Date	**Release Time**	**Release Site**	**Tag Code**	**Upstream of HORB Date/Time**	**Bowmand Road Date/Time**	**Stockton Date/Time**	**Turner Cut Date/Time**	**R16 Date/Time**	**Near Stockton Date/Comment**	**Other Locations Date/Comment**
5/10/07	11:40	Durham Ferry	3003	5/10/07 23:05						
5/10/07	11:40	Durham Ferry	3010					5/13/07 13:51		
5/10/07	11:40	Durham Ferry	3017						5/17-18, Tag Not Moving	
5/10/07	11:40	Durham Ferry	3031						5/17-18, Tag Not Moving	
5/10/07	11:40	Durham Ferry	3038	5/11/07 1:55	5/11/07 8:05	5/11/07 23:09			5/17-18, Tag Not Moving	
5/10/07	11:40	Durham Ferry	3045	5/11/07 13:15	5/11/07 20:31				5/17-18, Tag Not Moving	
5/10/07	11:40	Durham Ferry	3052	5/11/07 3:51	5/11/07 14:16	5/11/07 19:10			5/17-18, Tag Not Moving	
5/10/07	11:40	Durham Ferry	3059	5/11/07 9:29	5/11/07 18:26				5/17-18, Tag Not Moving	
5/10/07	11:40	Durham Ferry	3066	5/11/07 8:14						
5/10/07	11:40	Durham Ferry	3073	5/11/07 4:22	5/11/07 10:32	5/11/07 14:38				
5/10/07	11:40	Durham Ferry	3080	5/11/07 1:58	5/11/07 8:15	5/13/07 0:04			5/17-18, Tag Not Moving	
5/10/07	11:40	Durham Ferry	3087	5/11/07 1:23	5/11/07 11:29				5/17-18, Tag Not Moving	
5/10/07	11:40	Durham Ferry	3094						5/17-18, Tag Not Moving	
5/10/07	11:40	Durham Ferry	3101	5/11/07 11:24					5/17-18, Tag Not Moving	
5/10/07	11:40	Durham Ferry	3108	5/11/07 4:34	5/11/07 11:34				5/17-18, Tag Not Moving	
5/10/07	11:40	Durham Ferry	3115						5/17-18, Tag Not Moving	
5/10/07	11:40	Durham Ferry	3122	5/11/07 8:38						
5/10/07	11:40	Durham Ferry	3129	5/11/07 9:04	5/11/07 16:12				5/17-18, Tag Not Moving	
5/10/07	11:40	Durham Ferry	3136	5/11/07 1:27						
5/10/07	11:40	Durham Ferry	3143	5/11/07 7:07	5/11/07 12:25					
5/10/07	11:40	Durham Ferry	3150						5/17-18, Tag Not Moving	
5/10/07	11:40	Durham Ferry	3157						5/17-18, Tag Not Moving	
5/10/07	11:40	Durham Ferry	3171	5/11/07 1:29					5/17-18, Tag Not Moving	
5/10/07	11:40	Durham Ferry	3185						5/17-18, Tag Not Moving	
5/10/07	11:40	Durham Ferry	3192	5/11/07 0:20	5/11/07 8:35				5/17-18, Tag Not Moving	
5/10/07	11:40	Durham Ferry	3199	5/11/07 5:10						
5/10/07	11:40	Durham Ferry	3206					5/13/07 19:41		
5/10/07	11:40	Durham Ferry	3213	5/11/07 11:02	5/11/07 22:32			5/13/07 9:11		
5/10/07	11:40	Durham Ferry	3220	5/11/07 15:02						
5/10/07	11:40	Durham Ferry	3227	5/11/07 14:43	5/11/07 20:34			5/14/07 11:01		
5/10/07	11:40	Durham Ferry	3262	5/11/07 6:11	5/11/07 12:14					
5/10/07	11:40	Durham Ferry	3269	5/11/07 6:04						
5/10/07	11:40	Durham Ferry	3276	5/11/07 0:36	5/11/07 9:18					
5/10/07	11:40	Durham Ferry	3290	5/10/07 21:40						
5/10/07	11:40	Durham Ferry	3297	5/11/07 3:35	5/11/07 12:34				5/17-18, Tag Not Moving	
5/10/07	11:40	Durham Ferry	3311	5/11/07 0:01						
5/10/07	11:40	Durham Ferry	3332	5/11/07 1:06	5/11/07 7:39					
5/10/07	11:40	Durham Ferry	3339	5/11/07 4:57	5/11/07 13:00			5/13/07 9:29		
5/10/07	11:40	Durham Ferry	3360	5/11/07 3:27	5/11/07 16:12					
5/10/07	11:40	Durham Ferry	3367	5/11/07 2:11	5/11/07 9:16					
5/10/07	11:40	Durham Ferry	3374	5/11/07 0:49						
5/10/07	11:40	Durham Ferry	3381	5/11/07 1:54						
5/10/07	11:40	Durham Ferry	3409	5/11/07 2:19	5/11/07 8:43					
5/10/07	11:40	Durham Ferry	3437	5/11/07 5:00	5/11/07 10:54					
5/10/07	11:40	Durham Ferry	3444	5/11/07 1:17						
5/10/07	11:40	Durham Ferry	3465	5/11/07 9:00	5/11/07 14:38					
5/10/07	11:40	Durham Ferry	3472	5/11/07 8:52	5/11/07 18:00	5/11/07 21:47				
5/10/07	11:40	Durham Ferry	3493	5/11/07 5:31	5/11/07 11:22	5/12/07 17:13				
5/10/07	11:40	Durham Ferry	3500	5/11/07 11:29	5/11/07 18:23	5/12/07 8:58		5/13/07 19:03		
5/10/07	11:40	Durham Ferry	3507	5/11/07 3:39	5/11/07 10:28					
5/10/07	11:40	Durham Ferry	3521	5/11/07 8:29	5/11/07 13:34			5/13/07 18:03		
5/10/07	11:40	Durham Ferry	3535	5/11/07 10:17	5/11/07 17:32	5/12/07 8:25				
5/10/07	11:40	Durham Ferry	3549	5/11/07 14:41						
5/10/07	11:40	Durham Ferry	3556	5/10/07 23:05						
5/10/07	11:40	Durham Ferry	3577	5/11/07 8:03						
5/10/07	11:40	Durham Ferry	3584	5/11/07 11:44	5/11/07 19:12					
5/10/07	11:40	Durham Ferry	3591	5/11/07 4:47	5/11/07 19:08	5/12/07 2:41				
5/10/07	11:40	Durham Ferry	3598	5/11/07 8:54						
5/10/07	11:40	Durham Ferry	3612	5/11/07 4:32						
5/10/07	11:40	Durham Ferry	3619	5/10/07 21:29	5/11/07 3:04					
5/10/07	11:40	Durham Ferry	3633	5/11/07 7:33	5/11/07 13:49		5/13/07 8:06	5/12/07 19:05		
5/10/07	11:40	Durham Ferry	3640	5/11/07 0:41	5/11/07 8:21				5/17-18, Tag Not Moving	
5/10/07	11:40	Durham Ferry	3668	5/11/07 4:46						
5/10/07	11:40	Durham Ferry	3689	5/11/07 2:00	5/11/07 8:01				5/17-18, Tag Not Moving	
5/10/07	11:40	Durham Ferry	3696	5/11/07 10:16	5/11/07 21:46					
5/10/07	12:30	Mossdale	3703	5/10/07 16:24	5/10/07 21:30	5/11/07 5:12				
5/10/07	12:30	Mossdale	3710	5/10/07 16:54	5/10/07 21:32	5/11/07 5:25				
5/10/07	12:30	Mossdale	3717	5/10/07 15:06						
5/10/07	12:30	Mossdale	3724	5/10/07 18:57	5/11/07 0:12				5/17-18, Tag Not Moving	
5/10/07	12:30	Mossdale	3731	5/10/07 16:27						
5/10/07	12:30	Mossdale	3738	5/10/07 15:17	5/10/07 19:18			5/13/07 20:21		
5/10/07	12:30	Mossdale	3745	5/10/07 15:45	5/11/07 7:08		5/12/07 15:19			
5/10/07	12:30	Mossdale	3752	5/10/07 17:40						
5/10/07	12:30	Mossdale	3759	5/10/07 18:52	5/11/07 12:12					
5/10/07	12:30	Mossdale	3766	5/10/07 15:41	5/10/07 19:22					
5/10/07	12:30	Mossdale	3773	5/10/07 15:16	5/10/07 22:47					
5/10/07	12:30	Mossdale	3780	5/10/07 18:01	5/11/07 0:06		5/15/07 17:23	5/13/07 8:26		
5/10/07	12:30	Mossdale	3787	5/10/07 16:53	5/10/07 21:06					
5/10/07	12:30	Mossdale	3794	5/10/07 16:26						
5/10/07	12:30	Mossdale	3801	5/10/07 17:56	5/11/07 6:01	5/11/07 10:50	5/12/07 1:42			5/14/07, Hwy 4
5/10/07	12:30	Mossdale	3808	5/10/07 16:13	5/10/07 20:25					
5/10/07	12:30	Mossdale	3815	5/10/07 15:29						
5/10/07	12:30	Mossdale	3822	5/10/07 15:07	5/10/07 19:00	5/11/07 5:22			5/17-18, Tag Not Moving	
5/10/07	12:30	Mossdale	3829	5/10/07 16:26	5/10/07 20:08					
5/10/07	12:30	Mossdale	3836	5/10/07 16:00	5/10/07 23:29				5/17-18, Tag Not Moving	

continued on following page

Appendix C-6
Detections of acoustic-tagged salmon from May 10 & 11 releases upstream of the Head of Old River Barrier.

Release Dates: May 10 and May 11, 2007 Relase Locations: Durham Ferry, Mossdale, Bowman Road, Stockton

									Mobile Monitoring	
Release Date	Release Time	Release Site	Tag Code	Upstream of HORB Date/Time	Bowmand Road Date/Time	Stockton Date/Time	Turner Cut Date/Time	R16 Date/Time	Near Stockton Date/Comment	Other Locations Date/Comment
5/10/07	12:30	Mossdale	3843	5/10/07 16:19						
5/10/07	12:30	Mossdale	3850	5/10/07 17:28	5/12/07 4:53					
5/10/07	12:30	Mossdale	3857	5/10/07 15:57	5/10/07 19:31					
5/10/07	12:30	Mossdale	3871	5/10/07 16:16	5/11/07 3:12					
5/10/07	12:30	Mossdale	3878	5/10/07 17:06	5/11/07 6:24					
5/10/07	12:30	Mossdale	3885	5/10/07 16:54	5/10/07 22:06	5/11/07 8:04				
5/10/07	12:30	Mossdale	3892	5/10/07 16:00	5/10/07 20:01	5/11/07 5:46			5/17-18, Tag Not Moving	
5/10/07	12:30	Mossdale	3899	5/10/07 15:42	5/10/07 19:22	5/11/07 5:09		5/13/07 20:34		
5/10/07	12:30	Mossdale	3906	5/10/07 16:43	5/10/07 21:01	5/11/07 4:55				
5/10/07	12:30	Mossdale	3913	5/10/07 15:16	5/10/07 20:15	5/11/07 2:57	5/13/07 15:12	5/12/07 19:28		
5/10/07	12:30	Mossdale	3920	5/10/07 17:01						
5/10/07	12:30	Mossdale	3927	5/10/07 17:40	5/11/07 5:40			5/13/07 12:01		
5/10/07	12:30	Mossdale	3934	5/10/07 16:50	5/10/07 22:35	5/11/07 6:20			5/17-18, Tag Not Moving	
5/10/07	12:30	Mossdale	3948	5/10/07 16:47						
5/10/07	12:30	Mossdale	3955	5/10/07 16:54	5/10/07 21:30					
5/10/07	12:30	Mossdale	3962	5/10/07 15:57	5/10/07 19:28					
5/10/07	12:30	Mossdale	3969	5/10/07 16:46	5/10/07 21:42					
5/10/07	12:30	Mossdale	3976	5/10/07 15:43	5/10/07 19:53					
5/10/07	12:30	Mossdale	3983	5/10/07 15:39	5/10/07 19:55	5/11/07 7:06				
5/10/07	12:30	Mossdale	3990	5/10/07 18:41	5/11/07 0:50	5/11/07 11:02				
5/10/07	12:30	Mossdale	3997	5/10/07 17:34	5/11/07 0:42					
5/10/07	12:30	Mossdale	4004	5/10/07 16:54						
5/10/07	12:30	Mossdale	4011	5/10/07 17:54	5/11/07 3:39				5/17-18, Tag Not Moving	
5/10/07	12:30	Mossdale	4018	5/10/07 17:21	5/10/07 21:41	5/11/07 5:40				
5/10/07	12:30	Mossdale	4025	5/10/07 17:21						
5/10/07	12:30	Mossdale	4032	5/10/07 17:07	5/10/07 22:41				5/17-18, Tag Not Moving	
5/10/07	12:30	Mossdale	4039	5/10/07 16:39	5/10/07 22:08					
5/10/07	12:30	Mossdale	4046	5/10/07 15:07	5/10/07 19:17	5/12/07 13:50				
5/10/07	12:30	Mossdale	4053	5/10/07 18:56	5/11/07 1:01	5/11/07 15:10		5/13/07 12:04		
5/10/07	12:30	Mossdale	4060	5/10/07 15:28	5/10/07 19:47					
5/10/07	12:30	Mossdale	4074	5/10/07 15:06	5/10/07 20:08					
5/10/07	12:30	Mossdale	4081	5/10/07 17:16	5/10/07 21:36	5/11/07 7:37			5/17-18, Tag Not Moving	
5/10/07	12:30	Mossdale	4088	5/10/07 15:28						
5/10/07	12:30	Mossdale	4095	5/10/07 15:51	5/11/07 4:40				5/17-18, Tag Not Moving	
5/10/07	12:30	Mossdale	4102	5/10/07 16:25	5/10/07 20:32				5/17-18, Tag Not Moving	
5/10/07	12:30	Mossdale	4109	5/10/07 16:08			5/13/07 6:09	5/12/07 21:04		
5/10/07	12:30	Mossdale	4116	5/10/07 15:00						
5/10/07	12:30	Mossdale	4123	5/10/07 15:21	5/10/07 19:45		5/13/07 1:06			
5/10/07	12:30	Mossdale	4130	5/10/07 18:51	5/13/07 0:35					
5/10/07	12:30	Mossdale	4137	5/10/07 15:15	5/10/07 19:56	5/11/07 8:03			5/17-18, Tag Not Moving	
5/10/07	12:30	Mossdale	4144	5/10/07 17:22	5/10/07 21:56	5/11/07 20:11				
5/10/07	12:30	Mossdale	4151	5/10/07 16:33	5/10/07 20:43	5/11/07 23:35				
5/10/07	12:30	Mossdale	4158	5/10/07 15:58	5/10/07 19:29					
5/10/07	12:30	Mossdale	4165	5/10/07 15:01						
5/10/07	12:30	Mossdale	4179	5/10/07 16:54	5/10/07 21:50	5/11/07 5:57				
5/10/07	12:30	Mossdale	4186	5/10/07 16:00	5/10/07 21:35	5/11/07 6:09			5/17-18, Tag Not Moving	
5/10/07	12:30	Mossdale	4193	5/10/07 15:39	5/14/07 19:48					
5/10/07	12:30	Mossdale	4200	5/10/07 15:57	5/10/07 19:29					
5/10/07	12:30	Mossdale	4207	5/10/07 18:01						
5/10/07	12:30	Mossdale	4214	5/10/07 17:00	5/10/07 23:24			5/14/07 22:43		
5/10/07	12:30	Mossdale	4221	5/10/07 15:41	5/10/07 19:45				5/17-18, Tag Not Moving	
5/10/07	12:30	Mossdale	4228	5/10/07 15:40	5/10/07 20:05	5/11/07 4:52				
5/10/07	12:30	Mossdale	4235	5/10/07 15:39	5/10/07 20:29			5/13/07 20:55		
5/10/07	12:30	Mossdale	4242	5/10/07 15:06	5/10/07 19:43	5/11/07 4:48				
5/10/07	12:30	Mossdale	4249	5/10/07 16:54	5/10/07 21:47	5/11/07 5:47				
5/10/07	12:30	Mossdale	4256	5/10/07 17:01	5/10/07 21:21	5/11/07 4:31				
5/10/07	12:30	Mossdale	4263	5/10/07 18:29	5/11/07 0:02	5/13/07 1:18				
5/10/07	12:30	Mossdale	4270	5/10/07 16:42	5/10/07 21:57	5/11/07 10:30				
5/10/07	12:30	Mossdale	4277	5/10/07 20:34						
5/10/07	12:30	Mossdale	4284	5/10/07 15:06	5/10/07 20:20	5/12/07 21:11				
5/10/07	12:30	Mossdale	4291	5/10/07 15:07	5/10/07 19:00					
5/10/07	12:30	Mossdale	4298	5/10/07 15:57	5/10/07 19:34					
5/10/07	12:30	Mossdale	4305	5/10/07 15:05	5/10/07 21:32	5/11/07 7:00			5/17-18, Tag Not Moving	
5/10/07	12:30	Mossdale	4312	5/10/07 15:21	5/11/07 3:35					
5/10/07	12:30	Mossdale	4319	5/10/07 15:36	5/11/07 0:19		5/14/07 2:25			
5/10/07	12:30	Mossdale	4326	5/10/07 15:28	5/10/07 19:55					
5/10/07	12:30	Mossdale	4333	5/10/07 16:54	5/11/07 2:47					
5/10/07	12:30	Mossdale	4340	5/10/07 15:33	5/11/07 5:24			5/13/07 12:27		
5/10/07	12:30	Mossdale	4347	5/10/07 16:54	5/10/07 22:09	5/11/07 10:29		5/13/07 9:18		
5/10/07	12:30	Mossdale	4354	5/10/07 16:43	5/10/07 20:30			5/16/07 11:48		
5/10/07	12:30	Mossdale	4361	5/10/07 16:34						
5/10/07	12:30	Mossdale	4368	5/10/07 16:54	5/10/07 21:45	5/11/07 5:52		5/11/07 18:16		
5/10/07	12:30	Mossdale	4375	5/10/07 15:28	5/10/07 19:47	5/11/07 5:01				
5/10/07	12:30	Mossdale	4382	5/10/07 17:51						
5/10/07	12:30	Mossdale	4396	5/10/07 16:33						
5/11/07	12:05	Bowman Rd.	5110			5/11/07 18:41			5/17-18, Tag Not Moving	
5/11/07	12:05	Bowman Rd.	5117			5/19/07 21:47			5/17-18, Tag Not Moving	
5/11/07	12:05	Bowman Rd.	5131					5/13/07 20:01		
5/11/07	12:05	Bowman Rd.	5145						5/17-18, Tag Not Moving	
5/11/07	12:05	Bowman Rd.	5166			5/11/07 19:02				
5/11/07	12:05	Bowman Rd.	5229			5/11/07 20:08		5/13/07 9:00		
5/11/07	12:05	Bowman Rd.	5243						5/17-18, Tag Not Moving	
5/11/07	12:05	Bowman Rd.	5264			5/11/07 23:30				
5/11/07	12:05	Bowman Rd.	5285			5/15/07 20:50			5/17-18, Tag Not Moving	
5/11/07	12:05	Bowman Rd.	5313						5/17-18, Tag Not Moving	

continued on following page

Appendix C-6
Detections of acoustic-tagged salmon from May 10 & 11 releases upstream of the Head of Old River Barrier.

Release Dates: May 10 and May 11, 2007 Relase Locations: Durham Ferry, Mossdale, Bowman Road, Stockton

									Mobile Monitoring	
Release Date	**Release Time**	**Release Site**	**Tag Code**	**Upstream of HORB Date/Time**	**Bowmand Road Date/Time**	**Stockton Date/Time**	**Turner Cut Date/Time**	**R16 Date/Time**	**Near Stockton Date/Comment**	**Other Locations Date/Comment**
5/11/07	12:05	Bowman Rd.	5327						5/17-18, Tag Not Moving	
5/11/07	12:05	Bowman Rd.	5334						5/17-18, Tag Not Moving	
5/11/07	12:05	Bowman Rd.	5341				5/14/07 16:03	5/13/07 18:12		
5/11/07	12:05	Bowman Rd.	5348						5/17-18, Tag Not Moving	
5/11/07	12:05	Bowman Rd.	5362					5/13/07 21:21		
5/11/07	12:05	Bowman Rd.	5390			5/11/07 18:25			5/17-18, Tag Not Moving	
5/11/07	12:05	Bowman Rd.	5404			5/12/07 23:31				
5/11/07	12:05	Bowman Rd.	5411						5/17-18, Tag Not Moving	
5/11/07	12:05	Bowman Rd.	5418					5/14/07 20:24		
5/11/07	12:05	Bowman Rd.	5425					5/12/07 17:04		
5/11/07	12:05	Bowman Rd.	5432			5/11/07 19:43				
5/11/07	12:05	Bowman Rd.	5446			5/11/07 16:16				
5/11/07	12:05	Bowman Rd.	5453						5/17-18, Tag Not Moving	
5/11/07	12:05	Bowman Rd.	5460						5/17-18, Tag Not Moving	
5/11/07	12:05	Bowman Rd.	5474			5/11/07 15:47	5/13/07 15:59	5/13/07 12:39		
5/11/07	12:05	Bowman Rd.	5481			5/11/07 16:48				
5/11/07	12:05	Bowman Rd.	5502			5/11/07 15:47			5/17-18, Tag Not Moving	
5/11/07	12:05	Bowman Rd.	5516					5/13/07 19:32		
5/11/07	12:05	Bowman Rd.	5523			5/11/07 22:04				
5/11/07	12:05	Bowman Rd.	5530						5/17-18, Tag Not Moving	
5/11/07	12:05	Bowman Rd.	5537					5/12/07 20:55		
5/11/07	12:05	Bowman Rd.	5544						5/17-18, Tag Not Moving	
5/11/07	12:05	Bowman Rd.	5565			5/15/07 3:45				
5/11/07	12:05	Bowman Rd.	5579						5/17-18, Tag Not Moving	
5/11/07	12:05	Bowman Rd.	5593			5/12/07 15:30				
5/11/07	12:05	Bowman Rd.	5600			5/11/07 18:14			5/17-18, Tag Not Moving	
5/11/07	12:05	Bowman Rd.	5614					5/13/07 9:36		
5/11/07	12:05	Bowman Rd.	5628			5/11/07 18:20				
5/11/07	12:05	Bowman Rd.	5642			5/13/07 3:45			5/17-18, Tag Not Moving	
5/11/07	12:05	Bowman Rd.	5663			5/11/07 19:43			5/17-18, Tag Not Moving	
5/11/07	12:05	Bowman Rd.	5698					5/12/07 20:02		
5/11/07	12:05	Bowman Rd.	5677						5/17-18, Tag Not Moving	
5/11/07	12:05	Bowman Rd.	5684						5/17-18, Tag Not Moving	
5/11/07	12:05	Bowman Rd.	5691						5/17-18, Tag Not Moving	
5/11/07	12:05	Bowman Rd.	5705						5/17-18, Tag Not Moving	
5/11/07	12:05	Bowman Rd.	5719			5/13/07 17:24			5/17-18, Tag Not Moving	
5/11/07	12:05	Bowman Rd.	5754			5/13/07 10:06				
5/11/07	12:05	Bowman Rd.	5761			5/11/07 19:51				
5/11/07	12:05	Bowman Rd.	5782			5/12/07 6:02				
5/11/07	12:05	Bowman Rd.	5796			5/17/07 2:36			5/17-18, Tag Not Moving	
5/11/07	12:43	Stockton	5803						5/17-18, Tag Not Moving	
5/11/07	12:43	Stockton	5824						5/17-18, Tag Not Moving	
5/11/07	12:43	Stockton	5838					5/13/07 19:13		
5/11/07	12:43	Stockton	5845					5/12/07 17:57		
5/11/07	12:43	Stockton	5873						5/17-18, Tag Not Moving	
5/11/07	12:43	Stockton	5901						5/17-18, Tag Not Moving	
5/11/07	12:43	Stockton	5915						5/17-18, Tag Not Moving	
5/11/07	12:43	Stockton	5936					5/13/07 8:50		
5/11/07	12:43	Stockton	5943						5/17-18, Tag Not Moving	
5/11/07	12:43	Stockton	5950						5/17-18, Tag Not Moving	
5/11/07	12:43	Stockton	5971						5/17-18, Tag Not Moving	
5/11/07	12:43	Stockton	5978					5/12/07 8:16		5/13/07 21:12, Tracy
5/11/07	12:43	Stockton	5985						5/17-18, Tag Not Moving	
5/11/07	12:43	Stockton	5999						5/17-18, Tag Not Moving	
5/11/07	12:43	Stockton	6020					5/13/07 13:51		
5/11/07	12:43	Stockton	6062						5/17-18, Tag Not Moving	
5/11/07	12:43	Stockton	6083						5/17-18, Tag Not Moving	
5/11/07	12:43	Stockton	6090						5/17-18, Tag Not Moving	
5/11/07	12:43	Stockton	6097						5/17-18, Tag Not Moving	
5/11/07	12:43	Stockton	6111						5/17-18, Tag Not Moving	
5/11/07	12:43	Stockton	6118						5/17-18, Tag Not Moving	
5/11/07	12:43	Stockton	6174						5/17-18, Tag Not Moving	
5/11/07	12:43	Stockton	6181					5/13/07 9:54		
5/11/07	12:43	Stockton	6188						5/17-18, Tag Not Moving	
5/11/07	12:43	Stockton	6195						5/17-18, Tag Not Moving	
5/11/07	12:43	Stockton	6202						5/17-18, Tag Not Moving	
5/11/07	12:43	Stockton	6230						5/17-18, Tag Not Moving	
5/11/07	12:43	Stockton	6251						5/17-18, Tag Not Moving	
5/11/07	12:43	Stockton	6258						5/17-18, Tag Not Moving	
5/11/07	12:43	Stockton	6265						5/17-18, Tag Not Moving	
5/11/07	12:43	Stockton	6293					5/14/07 10:26		
5/11/07	12:43	Stockton	6300						5/17-18, Tag Not Moving	
5/11/07	12:43	Stockton	6307						5/17-18, Tag Not Moving	
5/11/07	12:43	Stockton	6314						5/17-18, Tag Not Moving	
5/11/07	12:43	Stockton	6321				5/13/07 6:25			
5/11/07	12:43	Stockton	6328					5/12/07 19:00		
5/11/07	12:43	Stockton	6342						5/17-18, Tag Not Moving	
5/11/07	12:43	Stockton	6384						5/17-18, Tag Not Moving	
5/11/07	12:43	Stockton	6391						5/17-18, Tag Not Moving	
5/11/07	12:43	Stockton	6405						5/17-18, Tag Not Moving	
5/11/07	12:43	Stockton	6412					5/13/07 19:40		
5/11/07	12:43	Stockton	6419				5/12/07 11:07			

Appendix C-7
Detections of acoustic-tagged salmon released May 11 downstream of the Head of Old River Barrier.

Release Date: May 11, 2007 **Release Location: Old River downtstream of HORB**

Release Date	Release Time	Release Site	Tag Code	Tracy Fish Facilities Date/Time	Clifton Court Inlet Date/Time	Skinner Fish Facilities Date/Time	Old River at Hwy 4 Date/Time
5/11/07	11:22	D/S of HORB	4403			5/13/07 15:58	
5/11/07	11:22	D/S of HORB	4424	5/14/07 14:32		5/18/07 16:06	5/13/07 20:41
5/11/07	11:22	D/S of HORB	4431	5/13/07 17:00			
5/11/07	11:22	D/S of HORB	4438	5/13/07 17:19			
5/11/07	11:22	D/S of HORB	4452	5/15/07 17:11			
5/11/07	11:22	D/S of HORB	4466	5/13/07 20:30			
5/11/07	11:22	D/S of HORB	4487			5/14/07 4:48	
5/11/07	11:22	D/S of HORB	4494	5/15/07 14:32			
5/11/07	11:22	D/S of HORB	4501	5/13/07 14:56			
5/11/07	11:22	D/S of HORB	4515	5/14/07 2:15			5/14/07 12:14
5/11/07	11:22	D/S of HORB	4522	5/13/07 14:40			
5/11/07	11:22	D/S of HORB	4529	5/15/07 11:01			
5/11/07	11:22	D/S of HORB	4536				5/13/07 21:50
5/11/07	11:22	D/S of HORB	4543				5/14/07 21:42
5/11/07	11:22	D/S of HORB	4564	5/15/07 1:08			
5/11/07	11:22	D/S of HORB	4585				5/13/07 17:36
5/11/07	11:22	D/S of HORB	4592	5/14/07 0:45			
5/11/07	11:22	D/S of HORB	4599	5/12/07 19:58			
5/11/07	11:22	D/S of HORB	4606	5/13/07 9:25			
5/11/07	11:22	D/S of HORB	4620				5/13/07 18:14
5/11/07	11:22	D/S of HORB	4669	5/13/07 14:51			
5/11/07	11:22	D/S of HORB	4683	5/13/07 0:00			
5/11/07	11:22	D/S of HORB	4704				5/14/07 1:40
5/11/07	11:22	D/S of HORB	4725	5/16/07 2:11			
5/11/07	11:22	D/S of HORB	4746	5/13/07 2:12			
5/11/07	11:22	D/S of HORB	4760	5/14/07 14:28			5/13/07 21:00
5/11/07	11:22	D/S of HORB	4781	5/12/07 19:11			
5/11/07	11:22	D/S of HORB	4802	5/15/07 14:09			
5/11/07	11:22	D/S of HORB	4809	5/18/07 17:34			
5/11/07	11:22	D/S of HORB	4830	5/13/07 11:58			
5/11/07	11:22	D/S of HORB	4837				5/14/07 18:39
5/11/07	11:22	D/S of HORB	4844	5/14/07 1:37			
5/11/07	11:22	D/S of HORB	4879	5/13/07 23:07			
5/11/07	11:22	D/S of HORB	4900	5/15/07 1:00			
5/11/07	11:22	D/S of HORB	4942	5/13/07 18:04			
5/11/07	11:22	D/S of HORB	5033	5/13/07 8:33			
5/11/07	11:22	D/S of HORB	5054	5/13/07 8:09			
5/11/07	11:22	D/S of HORB	5068				5/14/07 6:11
5/11/07	11:22	D/S of HORB	5082	5/14/07 15:08			
5/11/07	11:22	D/S of HORB	5096	5/16/07 18:38			

Appendix D

Field Standard Operating Procedure

Surgical Tag Implantation Procedures Used in VAMP Studies

Purpose

To provide guidelines and standard protocols for surgical tagging of juvenile salmonids for VAMP studies.

Area of Applicability

All staff involved in surgical tagging of juvenile salmonids for VAMP studies.

References

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Techniques, 2nd edition. American Fisheries Society 121-155.

Martinelli, T.L., H.C. Hansel, and R. S. Shively. 1998. Growth and physiological responses to surgical and gastric radio transmitter implantation techniques in subyearling Chinook salmon. Hydrobiologia 371/372: 79-87.

Summerfelt, R. C. and L. S. Smith. 1990. Anesthesia, surgery, and related techniques. Pages 213-272 in C. B. Schreck and P. B. Moyle, editors. Methods for fish biology. American Fisheries Society, Bethesda, Maryland.

Materials Needed

- Thermometer
- YSI 55 dissolved oxygen (DO) meter
- Acoustic tags and acoustic tag equipment
- Chlorhexidine solution (30mL/L D-H2O)
- Saline solution (7g/L D-H2O)
- Tricaine methanesulfonate (MS-222; 100g/L),
- Sodium bicarbonate solution (buffer; 100g/L)
- Stress coat - stock concentration and 25% solution (250mL/L D-H2O)
- 70% ethanol or isopropyl alcohol solution
- 19 L bucket(s) marked at 10 L and clearly labeled 'Anesthesia'
- 19 L perforated recovery buckets (7 L holding capacity)
- 19 L bucket clearly labeled 'Reject' for fish that are not tagged
- Pair of gravity feed containers marked at 10 L, and connected by rubber tubing with in-line shut-off valves – one labeled 'anesthesia' and one labeled 'freshwater'
- Syringes for measuring anesthetic, buffer, and stress coat
- Oxygen delivery system or bubblers
- Dip nets
- Nitrile gloves
- Scale measuring to the nearest 0.1 g
- Large plastic weigh boats
- Measuring board with ruler to the nearest millimeter
- Surgery table (tray with foam pad and groove cut)
- Trays for holding solutions used to disinfect surgical tools
- Needle drivers

- Forceps
- Scalpel handle and blades
- Oxytetracycline (100 mg/mL concentration)
- Pipette (2-20 microliter (_L) volume) and tips
- Sutures (size: 5-0 and 4-0) with an RB-1 needle
- Spray bottles for alcohol
- Timer(s)
- Sharps container
- Datasheets and writing tools

Procedures

1) Collection and Pre-Tag Holding

A. The pre-tag holding period begins once the fish are placed in holding tanks. Prior to tag implantation, the pre-tag holding period should be at least 12-36 h. Fish should not have access to food during the pre-tagging holding period.

B. Each species collected is held in a separate holding tank to reduce stress. Record the species and collection date on each pre-tag holding container.

2) Fish Size Criteria

A. Size of fish tagged is dependent on the type of tag being used. A maximum tag weight to body weight ratio of 5% is used to calculate minimum fish size.

3) Pre-Tag Preparations

A. Environmental conditions

i. Dissolved oxygen (DO): will be measured as percent saturation in a pre- and post-tag holding tank or raceway during each tag session.

1. Measurements will be taken using a YSI model 55 DO meter

2. DO concentrations in pre- and post-tag holding tanks should be between 80% and 130% saturation.

ii. Temperature: will be measured in °C in a pre- and post-tag holding tank during each tag session.

1. Changes in water temperature exceeding 2°C require tempering (Kelsch and Shields 1996). "Tempering" means "to bring to a suitable state by mixing in or adding a usually liquid ingredient". Therefore, prior to exposing fish to a new water source the fish holding temperature and the temperature of the new water source need to be measured to ensure that the difference between the two water sources is ≤ 2°C. If the temperature difference is > 2°C then water in the container holding fish should be tempered at a rate of 0.5°C/15 min until the temperature difference between the two water sources is ≤ 2°C. New source water should be added in small amounts multiple times over 15 min to gradually change the temperature by 0.5°C. Once the temperature difference between the two water sources is ≤ 2°C fish can be transferred to the new water source.

B. Setup of equipment

i. Tags should be programmed and prepared for implantation.

ii. Disinfect all tags in chlorhexidine solution and thoroughly rinse in saline. Line tags up near the surgery table.

iii. Prepare surgical table and equipment for use.

iv. Setup measuring board and scale

1. Ensure the scale is functioning properly. Scales should be calibrated at the start of the season, checked each week for accuracy, and recalibrated as necessary.

2. Put approximately 1-2 mL of diluted stress coat on the weigh boat and the measuring board.

C. Recovery buckets must be filled with untreated river water and supplied with oxygen or a bubbler just prior to tagging. The concentration of DO in recovery buckets should be between 120 and 150% saturation.

D. Administration of anesthetic: The effectiveness of MS-222 as an anesthetic varies with factors such as temperature and fish density. Adjustments of the anesthesia concentration should be based on the amount of time it takes for a fish to lose equilibrium (induction time).

i. Fill the anesthesia bucket with 10 L of untreated river water. As a starting concentration, add 7 mL (1 mL= 1 cc) of MS-222 stock solution. This will yield an anesthetic concentration of 70 mg/L.

ii. Fill both gravity feed containers with 10 L of untreated river water. Add 2 mL of MS-222 stock solution to the container marked anesthesia. This will yield an anesthetic concentration of 20 mg/L.

iii. For each mL of MS-222 added to a container, add the same amount of bicarbonate solution (buffer).

iv. Water in all containers (anesthesia and gravity feed) should be changed periodically to minimize dilution of anesthesia water and temperature changes and to ensure you do not run out of water during a surgery.

v. Add a small amount of diluted stress coat for each liter of water in the anesthesia, gravity feed, and recovery containers to protect fish from loss/damage to the slime layer.

vi. Containers should be filled and prepared just prior to tagging to avoid temperature changes.

4) Implantation of Tags

A. Anesthetizing fish

i. Net one fish from the pre-tag holding source and place directly into an anesthesia bucket. Secure the lid as soon as the fish is in the bucket. Start a timer to keep track of how long a fish has been in the anesthesia bucket.

1. Time of sedation for a fish should normally be 2 - 4 minutes, with an average time of about 3 minutes. If loss of equilibrium takes less than 1 min or greater than 5 min, reject that fish. If after sedating a few fish, they are consistently losing equilibrium in more or less time than typical, adjust the concentration of the anesthetic (up or down) in 0.5 ml increments of stock MS-222 solution.

2. Remove the lid after one minute to observe the fish for loss of equilibrium. Once the fish loses equilibrium, visually screen the fish for tags, fin clips, fungus, disease, descaling, bloated belly, or any obvious abnormalities. Make sure to keep the fish submerged during this examination. Relay any information to the data recorder.

3. Keep the fish in the water for an additional 30 - 60 sec after it has lost equilibrium.

4. Rejects - If the fish is unacceptable for tagging, place the fish in the bucket labeled Rejects, and relay the information to the data recorder.

B. Recording fish length and weight

i. Transfer the fish to the scale and weigh the fish to the nearest 0.1 g.

ii. Transfer the fish to the measuring board and measure the fork length to the nearest millimeter (mm).

iii. Data must be vocally relayed to the data recorder to avoid data errors. The data recorder should then record this information and repeat numbers back to avoid any miscommunication.

iv. Any fish that is dropped on the floor during this process must be rejected. A fish dropped on the table during surgery may still be tagged. If a fish is dropped on the floor after it is tagged, remove the tag and reject the fish.

C. Surgery

i. Place the fish on the surgery table ventral side up. Anesthesia should be administered through the gravity feed tubing as soon as the fish is on the surgery table. The tubing must be placed just inside the mouth so the water flows across the gills. If the flow is too low, the fish will flare its opercula and become agitated. Adjust the flow so that the gilling rate of the fish is steady. Use the in-line valve to control the flow of anesthesia, fresh water, or a mixture of both. Start with a constant flow of anesthesia and monitor the condition of the fish.

ii. Using a scalpel, make an incision, approximately 5 mm in length (dependent on tag size), about 3 mm away from and parallel to the mid-ventral line. Start your incision a few millimeters in front of the pelvic girdle, approximately 20% of the distance from the base of the pelvic fins to the base of the pectoral fins, and draw the blade toward the head of the fish. (For example, in Figure 1, the distance between the base of the pelvic and pectoral fins is ~45 mm, so the incision should start ~9 mm in front of the base of the pelvic fins.) The incision should be just deep enough to penetrate the peritoneum (the thin membrane separating the gut cavity from the musculature), avoiding the internal organs. The spleen is generally near the incision point, so pay close attention to the depth of the incision. Refer to Figure 1 for location of internal organs and Figure 2 for placement of incision. Avoid getting anesthesia water in the incision.

Figure 1
Lateral view of a juvenile salmonid, showing the location of internal organs.

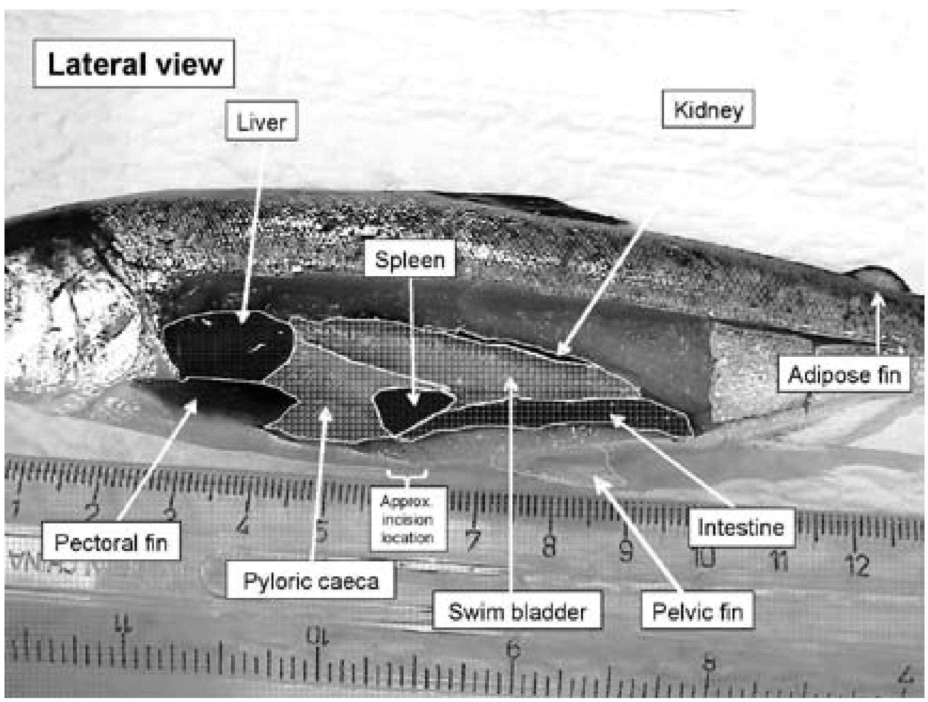
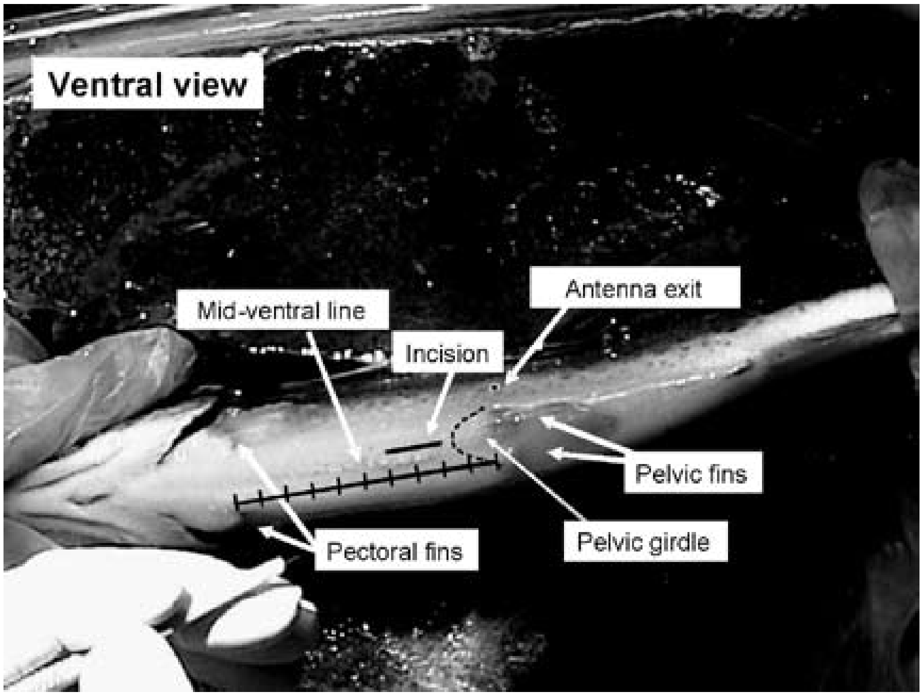


Figure 2
Ventral view of a juvenile salmonid, showing the location external organs and proper placement of incision and antenna exit (if applicable). This view corresponds to a left-handed surgeon's view and placement of the incision. For right-handed surgeons, the fish would be facing the right and the incision and antenna exit would be on the opposite side of the midline.



1. There is no exact specification for what size scalpel blade to use for each fish. We use a 5 mm blade for hatchery steelhead, which typically weigh more than 50.0 g. We use a 3 mm blade for smaller fish, such as yearling and subyearling Chinook salmon that typically weigh less than 50.0 g.

2. One scalpel blade can be used on about seven fish before it becomes dull. If the blade is pulling roughly or making jagged incisions, it needs to be changed prior to tagging the next fish.

3. Use forceps to open the incision to ensure you did not damage any internal organs or cause excessive bleeding. If you observe damage or think you damaged an organ, do not implant the tag, and reject that fish. Excessive bleeding should be noted on the datasheet.

iii. Gently push the tag into the body cavity, and position it so that it lies directly under the incision. This positioning will provide a barrier between the suture needle and internal organs. Through time the tag location will naturally move posterior in the fish.

iv. Use a pipette to administer oxytetracycline in the incision at a dosage of 50 mg/kg of body weight. Calculate the amount to administer for each fish using 1 _L of oxytetracycline for every 2 g of body weight (weight in g/2 = # of _L of oxytetracycline). For example, a 24.0 g fish would get 12 _L of oxytetracycline (Summerfelt and Smith 1990). Change the pipette tip after each fish.

v. Begin suturing the incision. Two or three interrupted stitches are used to close the incision, depending on the size of the tag and incision.

1. To make a stitch, lock the needle (at the end of the suture) in the needle drivers so the needle point faces you. Enter the outside edge of the incision on the side farthest from you and exit through the other edge of the incision, pulling the suture perpendicular through the two edges. The needle should enter and exit the skin as close to the edge of the incision as possible without tearing the skin (~ 2 mm from edge of incision). Pull the needle and suture through the skin to leave a tag end of about 2 - 3 cm of suture material protruding from the needle entrance location, then release the needle from the needle drivers. With your non-dominant hand, grasp the long end of the suture material (usually

with thumb and forefinger) at or below the needle, and make two forward wraps (i.e., away from your body) around the tip of the needle driver, which should be held in your dominant hand. With the two wraps still around the needle driver, grasp the short tag end of suture material with the needle driver and tighten the stitch by pulling the wraps off the needle driver and pulling both ends of suture material perpendicular to the incision. On the first knot, the dominant hand holding the needle driver should pull toward your body and the non-dominant hand should pull away from your body. Tighten the suture lightly, just so the edges of the incision meet, but do not overlap, pucker, or bulge the edges of the incision. The second knot is the same as the first, but in reverse order. On the second knot, grasp the long end of suture material with your non-dominant hand, make two reverse wraps (i.e., toward you body) around the end of the needle driver, grasp the short end of suture with the needle driver, and tighten the stitch. This time, the knot should be tightened by pulling your dominant hand (holding the needle drivers) away from you and your non-dominant hand toward you. The second knot can be slightly tighter than the first, again taking care not to overlap, pucker, or bulge the edges of the incision. The third knot is a repeat of the first and should be tightened snug to prevent the stitch from coming loose. This completes one stitch. Cut the suture with the needle drivers, leaving ends approximately 5 mm in length.

a. An alternative stitch consists of two knots, each with three wraps around the needle driver. The first knot consists of three forward wraps around the needle driver, and then is tightened by pulling the needle driver toward your body. The second is the same as the first, but in reverse order as described above.

b. When pulling a knot tight, be sure the knot lays flat and does not twist onto itself into a “balled-up” knot

2. There is no exact specification for what size suture to use. Generally, 4-0 suture is used for hatchery steelhead, which typically weigh greater than 50.0 g. For fish weighing less than 50.0 g, such as yearling and subyearling Chinook salmon, 5-0 suture is used.

3. Generally, a good time to switch the in-line valve on the gravity feed buckets to untreated river water is just prior to the last stitch. This initiates recovery from anesthesia as early as possible. However, if the fish appears to be inadequately gilling, provide a mixture or all fresh water as soon as possible. If the fish is too active to finish the surgery safely do not switch to fresh water, but maintain sedation.

4. If the incision is too long to close with two stitches, it is acceptable to add a 3rd stitch. Relay this information to the data recorder so they can note the extra stitch on the datasheet.

5. Because sutures are long, each individual suture (one packet) can be used on 2-4 fish. Rinse the suture material and the needle in the sanitizing solution used for instruments.

vi. Transfer the fish from the surgery table directly to a labeled recovery bucket. If a direct transfer is not possible, use a container filled with untreated river water to make the transfer.

vii. Between surgeries, the surgeon should prepare their tools for the next surgery. Disinfect the tools in chlorhexidine solution and rinse thoroughly with saline, load a new pipette tip, and ensure that the scalpel blade and suture are acceptable to use on the next fish.

viii. When all fish in a recovery bucket have spent 10 minutes in the bucket and gained equilibrium, transfer the bucket to the post-tag holding container (tank or raceway that has a constant flow of untreated river water).

5) Cleanup at the end of the tagging day

A. Wipe down all counter tops, scales and measuring boards with ethanol or isopropyl alcohol to disinfect.

B. Soak scalpels, catheters, forceps, and scissors in chlorhexidine solution for 15 minutes, rinse in saline solution, and thoroughly dry to prevent rusting.

C. Spray tagging platform (foam) with ethanol to disinfect.

D. Scrub needle drivers with a small brush and spray with ethanol or isopropyl alcohol.

E. Buckets should be rinsed thoroughly with untreated river water and placed upside down to dry. In addition, all buckets need to be cleaned weekly in accordance with Sterilization of 5 Gallon Buckets; FIE732.0.

APPROVED BY: ______________________________ DATE ______________

QUALITY ASSURANCE OFFICER

REVIEWED BY______________________________ DATE ______________

LABORATORY SUPERVISOR

SAN JOAQUIN RIVER AGREEMENT

2006 Annual Technical Report

San Joaquin River Group Authority

Figure 1-1
Sacramento – San Joaquin Estuary

Figure 2-1
Sacramento – San Joaquin Estuary

2006 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 Resource Control Board

in compliance with D-1641

January 2007

Table of Contents

Executive Summary 3

Chapter 1

Introduction 8

Experimental Design Elements 8

Chapter 2

VAMP Hydrologic Planning and Implementation 10

2006 VAMP Summary 10

VAMP Background and Description 11

Hydrologic Planning for 2006 VAMP 12

Implementation 16

Results of Operations 16

Summary of Historical VAMP Operations 17

Chapter 3

Additional Water Supply Arrangements and Deliveries 22

Merced Irrigation District 22

Oakdale Irrigation District 22

Chapter 4

Head of Old River Barrier 24

Background 24

Flow Measurements at and around Head of Old River 25

Old and San Joaquin Rivers Kodiak Trawling 28

Methods and Results 28

Discussion 34

Summary 37

Chapter 5

Salmon Smolt Survival Investigations 38

Merced River Hatchery Coded-Wire Tagging 38

VAMP Fish Releases 38

Water Temperature Monitoring 40

Short-Term Survival Study 40

Health and Physiology 44

Release Number Correction 45

Coded-Wire Tag Recovery Efforts 45

Transit Time 47

VAMP Chinook Salmon CWT Survival 48

Comparison with Past Years 51

The Role of Flow, Exports, and HORB 56

San Joaquin River Salmon Protection 63

Summary & Recommendations 68

Chapter 6

Complimentary Studies Related to the VAMP 72

Review of Juvenile Salmon Data 72

2006 Mossdale Trawl Summary 75

Monitoring the Migration of Juvenile Chinook Salmon Using Acoustic Telemetry 83

Survival Estimated for CWT Releases Made in the San Joaquin River Tributaries 88

Comparison of VAMP Releases with Sacramento River Delta Releases 90

Chapter 7

Conclusions and Recommendations 92

References Cited 94

Contributing Authors 94

Signatories to the San Joaquin River Agreement 95

Useful Web Pages 95

Acronyms and Abbreviations 96

Appendices 97

Executive Summary

The San Joaquin River Agreement (SJRA) and Vernalis Adaptive Management Plan (VAMP) 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). 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. 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).

High spring flows, exceeding the upper target flow objective of 7.000 cfs, prevented installation of the HORB in 2006 In addition low water temperatures at the Merced River Fish Hatchery delayed the growth of the hatchery fish used in the experiment causing the SJRA technical committee to recommend that the VAMP pulse flow period be moved from the default period of April 15 - May 15 to May 1 - May 31. Continued wet hydrologic conditions resulted in flood control releases on both the Tuolumne and Merced rivers; and excess water released from the Friant Dam on the Upper San Joaquin River. These conditions resulted in a gradual increase in Vernalis flow between May 1 and May 31.

The 2006 Annual Technical Report consolidates the annual SJRA Operations and the Vernalis Adaptive Management Plan (VAMP) Monitoring Reports. The VAMP 2006 program represents the seventh 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 VAMP program. Specifically, this 2006 report includes the

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following information on the implementation of the SJRA: the hydrologic chronicle; management of any additional SJRA water; flow and fisheries monitoring in the lower San Joaquin River, Old River, and Delta; results of the juvenile Chinook salmon smolt survival investigations; discussion of complementary investigations; and conclusions and recommendations.

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. In addition to providing improved protection for juvenile Chinook salmon emigrating from the San Joaquin River system, specific experimental objectives of VAMP 2006 included:

- Quantification of Chinook salmon smolt survival between Mossdale or Dos Reis, and Jersey Point using recaptures at Antioch and Chipps Island, under conditions of a San Joaquin River flow at Vernalis above 7,000 cfs, without an installed HORB, and SWP/CVP export rates of 1,500 and 6,000 cfs.
- Evaluation of the San Joaquin River – Old River flow split at the Head of Old River under the 2006 flow conditions without the installed HORB.
- Monitoring in Old River to evaluate the movement of salmon smolts into the Old River under the 2006 flow conditions without the installed HORB.
- Health and physiology testing of VAMP fish was conducted at the MRH and at Chipps Island to evaluate the incidence of disease.

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 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.

In planning for the VAMP the 2006 hydrologic conditions were similar to those of 2005. In the March 23 operation plan the existing a flow was forecasted to be between 6,110 and 6,610 cfs, thereby calling for a VAMP target flow of 7,000 cfs. This early forecast also indicated that the HORB could not safely be installed during 2006 due to flows exceeding 5,000 cfs in the San Joaquin River during the installation period. As wet conditions continued through the spring period, operators for New Don Pedro on the Tuolumne River and Lake McClure on the Merced River were required to initiate flood control operations. Due to continued wet conditions and the forecasted flood control operations on the Tuolumne and Merced rivers the subsequent operations plans forecasted an existing flow at Vernalis in excess of 7,000 cfs. By April 11 forecast of existing flow at Vernalis was projected to be about 25,880 cfs over the period of April 22 through May 22 and expected to increase. Additionally, the California Department of Fish and Game informed SJRA Technical Committee that low water temperatures at the Merced River Fish Hatchery were causing an apparent delay in the maturation of the salmon smolts. The SJRA Technical Committee recommended delaying the start of the VAMP pulse period until May 1 in an effort to provide smolt sized fish for the experiment. Also the study was modified to measure survival between Mossdale and Dos Reis and Jersey Point without a HORB. The release site at Durham Ferry was not used due to the flow being partially diverted into Paradise Cut, an overflow channel that leaves the San Joaquin River downstream of Durham Ferry but upstream of Mossdale.

VAMP experimental test conditions that have occurred over the past seven years are summarized below:

Year	VAMP Period	Average Vernalis Flow (cfs)	Average SWP/CVP Exports (cfs)	Head of Old River Barrier
2000	April 15-May 15	5,869	2,155	Installed
2001	April 20-May 20	4,220	1,420	Installed
2002	April 15-May 15	3,300	1,430	Installed
2003	April 15-May 15	3,235	1,446	Installed
2004	April 15-May 15	3,155	1,331	Installed
2005	May 1-May 31	10,390	2,986	Not Installed
2006	May 1-May 31	26,020	1,559/5,748 (a)	Not Installed

(a) Intended target export rate was 1,500 cfs (May 3-17) and 6,000 cfs (May 18-June 2)

Water temperature data were collected with a series of computerized recorders at the Merced River Fish Facility, in the transport trucks, at the release sites and throughout the lower San Joaquin River and Delta. Overall the average temperature at all sites ranged from 17 to 22 C.

Kodiak trawling was conducted in Old River in 2006, in addition to the usual sampling conducted in the San Joaquin River near Mossdale. Data from the two sites were compared to assess movement into the Old River during the VAMP period when there was no HORB installed. The ratio between the number of unmarked salmon and CWT salmon captured at the two locations was similar. It appears in May 2006, Salmon were diverted down Old River at a higher rate than the water flow. The hydraulic conditions at the San Joaquin/Old River split location may be contributing to a higher proportion of salmon entering the Old River.

In order to further verify the split of salmon at Old River and other South Delta channels, an acoustic telemetry tracking study was conducted in 2006. One hundred salmon smolts, with surgically implanted micro acoustic transmitters, were released and tracked for up to a 10-day period. Results from this effort also showed that in 2006, many of the ultrasonic tagged fish migrated into Old River.

Consistent with the VAMP experimental design, the 2006 effort included two mark-recapture studies performed in early and mid May to provide estimates of salmon survival however in 2006, they were at two different export conditions. The experimental design in past years included multiple release locations at Durham Ferry, Mossdale, and Jersey Point. In 2006, the releases were made at Mossdale and Dos Reis to better assess losses into upper Old River. The multiple recapture locations (Antioch, Chipps Island, SWP and CVP salvage operations, and in the ocean fisheries) were the same in 2006 as they have been in past years. The use of data from multiple release and recapture locations allows for a more thorough evaluation of juvenile Chinook salmon smolt survival as compared to recapture data from only one sampling location and/or one series of releases.

Chinook salmon smolt survival indices were calculated based on the number of marked salmon released and the number recaptured. Releases at Jersey Point serve as controls for releases at Mossdale and Dos Reis. Recapture data from Antioch, Chipps Island (for 2004-2006) and in the ocean fishery (releases made prior to 2004) thereby allowed calculation of survival estimates based on the ratio of recovery rates from marked salmon recaptured from upstream (Durham Ferry and Mossdale/Dos Reis) and downstream (Jersey Point) releases. Use of ratio estimates as part of the VAMP study design factors out the potential differential gear efficiency at Antioch and Chipps Island for each release group catch and differences in Ocean survival when the ocean recovery data is used as part of the ratio. These ratio estimates were used to evaluate relationships between salmon smolt survival and San Joaquin River flow and CVP and SWP exports with and without the HORB in place.

Survival of fish released at Mossdale during the high export period was extremely low and the lowest estimated since 2000.

The health of the CWT fish in 2006 was relatively good and PKD infection did not seem to be a problem as it may have been in 2003-2005. None of the VAMP fish recovered at Chipps Island had evidence of infection in their kidneys by the parasite that causes PKD in 2006.

Survival through the Delta does appear to be related to San Joaquin River flow at Vernalis, especially with the HORB in place. Relationships observed when there was no HORB in place are not clear, especially with the addition of the 2005 and 2006 data. At the high flows observed in 2006, we would have expected higher estimates.

The relationship of survival to exports is still difficult to detect based on the data gathered to date. The escapement data for adult salmon indicate that the flow/export ratio explains more of the variability in adult escapement than flow alone without the HORB, but the smolt survival data is too limited to detect these effects, if they are real. To further refine the relationship between survival and exports without the HORB, the survival experiments need to be conducted at a flow of 7,000 cfs with HORB installed at the two export levels, 1,500 and 3,000 cfs. We have not yet met these experimental conditions.

In addition to this recommendation, each previous technical report contained recommendations for future VAMP implementation. Key conclusions and recommendations resulting from the 2006 VAMP include:

- Survival from Durham Ferry and Mossdale/Dos Reis in 2003, 2004, 2005 and the second release group in 2006, was significantly less then prior years. Continued evaluation of survival rate versus flow and export rate is needed to detect differences in survival tests at extreme target levels (e.g. 7,000 cfs flow and 3,000 or 1,500 cfs exports), or equivalent high flow/export ratios are necessary.
- The flow data collected in 2005 and 2006 at San Joaquin River near Lathrop and the Head of Old River provided a useful evaluation of the flow split at the Head of Old River. Comparison of these 2005/2006 flow data against DWR-DSM2 modeling results should be conducted and may provide useful information.
- The Clifton Court Forebay was treated in early June with the aquatic herbicide Komeen, known to be toxic to salmon. While the treatment likely did not affect test fish, the treatment may have negatively affected natural smolts emigrating from the San Joaquin River in late May and early June.
- The numbers of CWT salmon, from Mossdale releases recovered at the SWP and CVP salvage facilities was less than prior years without an HORB. Only a few Mossdale and Dos Reis fish were recovered at the SWP and CVP salvage facilities in 2006.
- During the second release of experimental fish it was determined that the CWT lots were mixed between the Mossdale lots and Jersey Point lots resulting in not using the data from one tag group of the second Mossdale release and the need to adjust release numbers from the second Jersey Point release.
- The historical data indicates that the reach between Dos Reis and Jersey Point, in years when no HORB is installed, has the highest mortality. The relationship between the survival of the Dos Reis groups relative to the Jersey Point groups indicate that survival will improve as flows increase for smolts that remain within the main stem San Joaquin River when there is no HORB.

VAMP has been designed to evaluate opportunities to adaptively refine the VAMP test implementation conditions to: improve protection for juvenile Chinook salmon migrating from the San Joaquin River, and to improve the ability to detect differences in survival, if they exist, as a function of river flow and SWP/CVP export operations, and optimize the allocation of available water supplies each year.

The VAMP program should continue until smolt survival has been examined in relation to all target flow and export rates with an installed HORB. When completed the VAMP study will demonstrate the value of large-scale, long-duration, interdisciplinary experimental investigations that provide both protection to fishery resources while also providing important information that can be used to evaluate the performance and biological benefits of various management actions.

Chapter 1

Introduction

Actions associated with the Vernalis Adaptive Management Plan (VAMP) were implemented between May 1 and May 31, 2006 to protect juvenile Chinook salmon and evaluate the relationship between San Joaquin River flow and State Water Project (SWP) and federal Central Valley Project (CVP) water project exports on the survival of marked juvenile Chinook salmon migrating through the Sacramento – San Joaquin Delta. Initially the Delta Smelt workgroup recommended not installing the HORB but as the planning progressed the HORB could not be installed for the 2006 VAMP period due to high river flows. The VAMP period was postponed 15 days from previous years in an effort to maintain stable flows and to allow for maturation of the experimental fish. The water districts attempted to maintain stable flow in accordance with the SJRA throughout the May study period, however ongoing flood control activities limited the effort. Studies conducted in 2006, represent the seventh year of the VAMP experiment. Results from previous VAMP experiments are available in San Joaquin River Agreement Technical Reports, for each respective year. Similar 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 will describe the experimental design of VAMP, the hydrologic planning and implementation, the additional water supply arrangements and deliveries, fishery monitoring within the San Joaquin River and Old River in the absence of the Head of Old River Barrier (HORB), the salmon smolt survival investigation and complimentary studies related to VAMP. Conclusions and recommendations for future VAMP studies are also included.

Experimental Design Elements

The VAMP experimental design measures 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 2006, a total of 200,000 juvenile Chinook salmon were made available from the Merced River Hatchery (MRH) annual production for the VAMP survival studies. Chinook salmon survival indices under the experimental conditions are calculated based on the number of marked salmon released and the number recaptured. Absolute survival estimates and combined differential recovery rates (CDRR) are also calculated with the CDRR's used in relationships between survival and San Joaquin River flow and CVP and SWP exports.

As described the SJRA and 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 installation of the HORB. 2006 resulted in flow conditions that would not allow the HORB to be installed and made Vernalis flows difficult to control. The SJRA recognizes there may be years when the existing flow would be greater than 7,000 cfs, the HORB could not be in place due to high flows, and it may not be possible to maintain a constant flow rate at Vernalis. In such events of high flows the Technical Committee will develop an alternate plan pursuant to which those studies would be conducted under the SJRA as a VAMP experiment. This annual technical report describes the flow and HORB conditions encountered in 2006, the alternative experimental plan, and the findings.

With the high Vernalis flows and lack of the HORB the SJRA technical committee took advantage of these conditions in recommending two distinct levels of SWP/CVP export rates between the first and second release of test fish. A change in the export rate between the first and second half of the VAMP pulse period provided for the collection of survival estimates under two export/flow ratios without the HORB.

Due to a decline of the delta smelt population in the Bay-Delta estuary the delta Smelt workgroup recommended the HORB not be installed in 2006. Ultimately high flows in the San Joaquin River prohibited installation of the barrier. The 2006 VAMP experimental design included both multiple release locations (Mossdale, Dos Reis and Jersey Point), and multiple recapture locations (Antioch, Chipps Island, SWP and CVP salvage operations, and in the ocean fisheries; Figure 1-1, Inside Front Cover). Since the barrier was not installed Dos Reis was selected as an alternate

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release site immediately downstream of the HOR. The absence of the HORB in 2006 provided the opportunity to conduct Kodiak Trawls in both the San Joaquin River and Old River near the vicinity of the Head of Old River. Data from these fishery surveys has been used to assess the movement of juvenile Chinook salmon from the San Joaquin River (e.g., released upstream of Old River at Mossdale) into Old River when the HORB is not installed.

The use of data from multiple release and recapture locations allows for a more thorough evaluation of juvenile Chinook salmon survival as compared to recapture data from only one sampling location and/or one release location. The VAMP coded-wire tag (CWT) releases (Mossdale, Dos Reis and Jersey Point) and recapture locations (Antioch and Chipps Island, SWP and CVP salvage) are consistent with some previous years, providing a greater opportunity to assess salmon smolt survival over the range of Vernalis flows, SWP/CVP exports, and with and without the presence of the HORB. The recovery of marked fish in the ocean fishery also greatly improves the precision associated with the individual survival estimates, and improves confidence in detecting differences in salmon smolt survival as a function of Vernalis flows and SWP/CVP exports. The survival estimates prior to 2004 used in this report have been calculated based on recoveries at all three locations (Antioch, Chipps Island, and the ocean fishery). Releases at Jersey Point serve as controls for recaptures at Antioch, Chipps Island and the ocean fishery, thereby allowing the calculation of survival estimates based on the ratio of recovery rates from marked salmon recaptured from upstream (e.g., Mossdale and Dos Reis) and downstream (control release at Jersey Point) releases. The use of ratio estimates as part of the VAMP study design factors out the potential differential gear efficiency at Antioch and Chipps Island and ocean survival from ocean recoveries within and among years.

During the 2006 VAMP period an Acoustic Telemetry pilot study was conducted to evaluate the viability of using acoustic tagged fish and acoustic receivers to track San Joaquin River smolts. A total of 100 fish from the MRH were released at Mossdale and Dos Reis over the VAMP period. Five acoustic receivers located along the lower San Joaquin River, Old River, and in south Delta channels were used to track smolt movement throughout the south Delta.

A quality assurance/quality control program has been used as a routine part of VAMP tests, and includes quantifying the number of marked fish successfully clipped and tagged. In addition, the 2006 VAMP program continued use of the net pen studies and physiological testing to assess overall condition and health of marked fish used in VAMP experiments. Improvements were also made in 2006 relative to measuring flow in the San Joaquin River downstream of the confluence with Old River.

Chapter 2

VAMP Hydrologic Planning and Implementation

This section documents the planning and implementation undertaken by the Hydrology Group of the San Joaquin River Technical Committee (SJRTC) for the 2006 VAMP investigations. Implementation of VAMP is guided by the framework provided in the San Joaquin River Agreement (SJRA) and anticipated hydrologic conditions within the watershed. The planning and implementation activities were reduced due to the 2006 wet hydrology requiring no supplemental water to be provided and not allowing DWR to install the HORB

The Hydrology Group 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 2006, the agencies belonging to the Hydrology Group included: Merced Irrigation District (Merced), 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.

2006 VAMP Summary

Relatively full reservoirs as a result of wet conditions in 2005 combined with significant precipitation around the first of the year and again throughout March and into early April resulted in very high flow conditions in the San Joaquin River during the Spring of 2006. The mean daily flow in the San Joaquin River below the Stanislaus River exceeded 10,000 cfs in early March, increasing to 15,000 cfs at the end of March and peaking at 34,700 cfs on April 13. The flow remained above 30,000 cfs until the beginning of May, then slowly receded to around 20,000 cfs by the end of May. Since the flow during April and May exceeded the maximum VAMP target flow of 7,000 cfs no supplemental water was provided by the SJRGA agencies. Additionally, the flow in early April was significantly above the allowable installation flow threshold of 5000 cfs, therefore DWR was unable to install the temporary Head of Old River Barrier (HORB).

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. Operation conference calls were not conducted during the 2006 VAMP but contact was maintained with the operating entities to track reservoir releases. The Technical Committee placed an added emphasis on analyzing the flow and fish movement into Old River absent the HORB. Monitoring of real-time flow data was maintained throughout the planning and implementation phases.

VAMP Background and Description

This section provides information on the background and description of the water operations and factors to be considered when planning for the VAMP each year. Even with the high flow conditions during 2006 these factors continued to be considered in the planning process and implementation.

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

The VAMP provides for a 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 pulse 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 River, the Tuolumne River and the Stanislaus River.

As part of the development of the VAMP experimental design, the VAMP Hydrology and Biology Groups jointly 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 VAMP Hydrology and Biology Groups 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 technical committees 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.

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 technical committees 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 Hydrology and Biology Groups agreed to a target range variation of plus or minus 7% of the Vernalis flow target. It was recognized by the Hydrology and Biology Groups that these guidelines are not absolute conditions, but is to be used by the VAMP technical committees 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 Merced, OID, SSJID, SJRECWA, MID and TID members of the San Joaquin River Group Authority (SJRGA) agencies 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 Merced supplemental water would be provided on the Merced River from storage in Lake McClure and would be measured at the Cressey gage on the Merced River. 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 gage.

The target flow of 2,000 cubic feet per second (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 2000 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, as was the case in 2006, the Parties will exert their best efforts to maintain a stable flow during the VAMP pulse 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.

Table 2-2
San Joaquin Valley Water Year Hydrologic Year Classifications Used in VAMP

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

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 (off-ramp). These potential adjustments to the target flow are dependent on the hydrologic year type as defined by the SWRCB San Joaquin Valley Water Year Hydrologic Classification (60-20-20 classification), 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.

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 2006 VAMP

Hydrology Group Meetings

Beginning in February 2006, and continuing until early April, the Hydrology Group held three planning and coordination meetings (February 21, March 16 and April 11). The March 16 and April 11 meetings were joint meetings of the Hydrology and Biology Groups. 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 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 21 Hydrology Group meeting. The 90 percent exceedence forecast was indicating a VAMP target flow of 5,700 cfs and the 50 percent exceedence forecast was indicating a VAMP target flow of 7,000 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 that target. It also provides a forecast of the daily flows expected during the HORB installation period. In years like 2006 where the Existing Flow exceeds the maximum VAMP target flow, the daily operation plan is used to determine to what extent a stable flow can be provided during the VAMP pulse flow period. The daily operation plan calculates an estimated mean daily flow at Vernalis based on estimates 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 major tributaries.

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 above 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

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:

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)).

The forecast of the ungaged flow is the factor with the greatest uncertainty in the development of the daily operation plan. 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 pulse flow period is a reasonable estimate of the average ungaged flow for pulse 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 pulse flow period essentially equal to the value entering the pulse flow period.

The VAMP 31-day pulse flow period can occur anytime between April 1 and May 31. Factors that are considered in the determination of the timing of the VAMP pulse flow period include installation of HORB, availability of juvenile salmon at the MRH, and manpower and equipment availability for salmon releases and recapture. Until a specific start date is defined, a default pulse flow period of April 15 to May 15 is used for the VAMP operation planning.

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 classifications for 2004 and 2005 were “DRY” (VAMP numerical indicator of two) and “WET” (VAMP numerical indicator of five), respectively. Under these conditions there was no possibility of 2006 being an off-ramp year since the off-ramp criterion was already exceeded without including the current year’s numerical indicator. A “double-step” condition would occur if sum of the VAMP numerical indicators for the previous year and current year is equal to or greater than seven, with the current year’s indicator based on the 90% probability of exceedence forecast of the 60-20-20 water year classification. Due to the previous year being a “WET” year and the wet conditions in the current year, in the early planning it looked likely that 2006 would be a “double-step” year.

The initial daily operation plan was prepared on March 23. This daily operation plan looked at four scenarios based on two hydrologic conditions, dry and average, and two pulse flow periods, April 15 to May 15 and April 22 to May 22. These scenarios forecast “existing flows” ranging from 5,960 cfs to 6,610 cfs, all of which indicate a VAMP target flow of 7,000 cfs In this forecast Don Pedro Lake on the Tuolumne River and Lake McClure on the Merced River were expected to be making flood control releases and the Stanislaus River was expected to be at its institutional maximum of 1,500 cfs throughout the VAMP pulse flow period. This forecast also indicated that it was likely that the flow would be too high to allow for the safe installation of the Head of Old River Barrier (HORB). By the end of March it was apparent that the flows would be too great to allow for the installation of the HORB, and in all likelihood would continue to increase such that they would exceed the VAMP target flow of 7,000 cfs. Continually increasing runoff forecasts resulted in continually increasing forecasts

Table 2-3 Summary of Daily Operation Plans							
Phase	VAMP Forecast Date	DWR Runoff Forecast Date	VAMP Target Flow Period	Assumed Ungaged Flow at Vernalis (cfs)	Existing Flow (cfs)	VAMP Target Flow (cfs)	Supplemental Water Requirement (acre-feet)
Planning	3/23/06	3/14/06	April 15 - May 15	500	6,110	7,000	54,610
				1,000	6,610	7,000	23,870
			April 22 - May 22	500	5,960	7,000	63,790
				1,000	6,460	7,000	33,050
	3/27/06	3/21/06	April 15 - May 15	500	6,960	7,000	2,370
			April 22 - May 22	500	6,930	7,000	4,610
	4/3/06	3/28/06	April 15 - May 15	1,000	11,470	na	0
			April 22 - May 22	1,000	11,300	na	0
	4/11/06	4/1/06	April 22 - May 22	1,000	25,880	na	0
	4/18/06	4/11/06	April 22 - May 22	2,000	29,240	na	0
			May 1 - May 31	2,000	27,980	na	0
	4/25/06	4/18/06	May 1 - May 31	2,000	30,000	na	0

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?format=pre&period=31&site_no=11303500)
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?format=pre&period=31&site_no=11289650)
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?format=pre&period=31&site_no=11274000)

of flood control releases from Don Pedro Lake on the Tuolumne River, Lake McClure on the Merced River and Millerton Lake on the San Joaquin River such that by April 11 the daily operation forecast was looking at an existing flow of approximately 26,000 cfs. Due to the wet conditions and a need for the experiment fish to mature the SJRTC declared a VAMP pulse flow period of May 1 to May 31.

Table 2-3 provides a summary of the daily operation plans developed during the VAMP planning phase. The daily operation plans prepared during the VAMP planning phase are provided in Appendix A-1, Tables 1 through 12.

Tributary Flow Coordination

As previously noted, by early April the forecast existing flow was greater than the maximum VAMP target flow of 7,000 cfs. Under these conditions the tributary operations were coordinated to the degree possible to provide as stable a flow as possible during the VAMP pulse flow period. With this in mind the tributary operations prior to the VAMP were adjusted to the degree possible to maximize the very limited potential operational flexibility during the VAMP pulse flow period.

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Table 2-5
2006 Vernalis Adaptive Management Plan (VAMP)
Final Flows and Accounting of Supplemental Water Contributions
Target flow period: May 1 - May 31 * Target Flow: greater than 7,000 cfs

	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)			Upper SJR	Vernalis Ungaged	San Joaquin River at Vernalis		
Date	Existing Flow (cfs)	Observed Flow (cfs)	VAMP Supple-mental Water (cfs)	Existing Flow (cfs)	Observed Flow (cfs)	VAMP Supple-mental Water (cfs)	Existing Flow (cfs)	Observed Flow (cfs)	VAMP Supple-mental Water (cfs)	Observed Flow (cfs)	Observed Flow (cfs)	Existing Flow (cfs)	Observed Flow (cfs)	VAMP Supple-mental Water (cfs)
04/01/05	3,130	3,130		6,260	6,260		3,014	3,014		2,580	879	15,000	15,000	
04/02/05	2,980	2,980		6,440	6,440		3,019	3,019		2,680	1,232	16,200	16,200	
04/03/05	3,610	3,610		6,150	6,150		3,039	3,039		2,920	1,866	16,700	16,700	
04/04/05	6,990	6,990		3,650	3,650		3,303	3,303		2,380	1,631	16,900	16,900	
04/05/05	4,910	4,910		4,780	4,780		4,714	4,714		2,156	3,611	18,700	18,700	
04/06/05	4,970	4,970		5,640	5,640		5,776	5,776		8,771	7,757	20,700	20,700	
04/07/05	5,230	5,230		6,660	6,660		6,148	6,148		16,209	3,160	21,800	21,800	
04/08/05	5,190	5,190		7,020	7,020		4,379	4,379		18,238	(1,997)	23,100	23,100	
04/09/05	5,170	5,170		7,010	7,010		3,534	3,534		19,680	(6,587)	27,400	27,400	
04/10/05	5,110	5,110		6,990	6,990		3,504	3,504		19,401	(3,867)	31,000	31,000	
04/11/05	4,630	4,630		7,650	7,650		3,509	3,509		18,763	(3,314)	32,100	32,100	
04/12/05	4,540	4,540		8,100	8,100		3,868	3,868		18,163	(865)	34,200	34,200	
04/13/05	4,490	4,490		8,140	8,140		4,019	4,019		16,756	(332)	34,700	34,700	
04/14/05	4,480	4,480		7,890	7,890		3,995	3,995		15,308	(361)	34,400	34,400	
04/15/05	4,660	4,660		7,780	7,780		4,039	4,039		13,660	145	33,600	33,600	
04/16/05	4,550	4,550		7,740	7,740		4,062	4,062		12,950	1,017	32,700	32,700	
04/17/05	4,170	4,170		7,910	7,910		4,756	4,756		12,930	1,441	31,400	31,400	
04/18/05	4,010	4,010		8,590	8,590		5,495	5,495		12,710	1,088	30,500	30,500	
04/19/05	3,950	3,950		8,630	8,630		5,510	5,510		12,400	454	30,600	30,600	
04/20/05	4,010	4,010		8,820	8,820		5,507	5,507		12,180	(265)	30,700	30,700	
04/21/05	4,030	4,030		8,740	8,740		5,510	5,510		12,060	150	30,700	30,700	
04/22/05	4,010	4,010		8,850	8,850		5,522	5,522		11,980	143	30,600	30,600	
04/23/05	4,000	4,000		8,840	8,840		5,524	5,524		12,000	80	30,400	30,400	
04/24/05	4,000	4,000		8,980	8,980		5,548	5,548		12,060	18	30,400	30,400	
04/25/05	4,000	4,000		9,210	9,210		5,489	5,489		12,250	26	30,400	30,400	
04/26/05	4,170	4,170		9,170	9,170		5,527	5,527		12,210	12	30,600	30,600	
04/27/05	4,180	4,180		9,230	9,230		5,511	5,511		12,080	(49)	30,900	30,900	
04/28/05	4,250	4,250	0	9,180	9,180		5,508	5,508		11,890	93	31,000	31,000	
04/29/05	4,380	4,380	0	9,210	9,210	0	5,513	5,513	0	11,600	9	31,000	31,000	
04/30/05	4,500	4,500	0	9,250	9,250	0	5,514	5,514	0	11,380	42	30,800	30,800	
05/01/05	4,510	4,510	0	9,210	9,210	0	5,161	5,161	0	11,100	27	30,600	30,600	0
05/02/05	4,510	4,510	0	9,190	9,190	0	5,012	5,012	0	10,920	(124)	30,400	30,400	0
05/03/05	4,510	4,510	0	9,220	9,220	0	5,031	5,031	0	10,560	29	30,000	30,000	0
05/04/05	4,500	4,500	0	9,230	9,230	0	4,704	4,704	0	10,340	(32)	29,600	29,600	0
05/05/05	4,270	4,270	0	9,240	9,240	0	4,533	4,533	0	10,110	(221)	29,100	29,100	0
05/06/05	4,040	4,040	0	9,190	9,190	0	4,523	4,523	0	9,950	(284)	28,500	28,500	0
05/07/05	4,020	4,020	0	9,280	9,280	0	4,525	4,525	0	9,750	(383)	28,000	28,000	0
05/08/05	4,010	4,010	0	8,980	8,980	0	4,529	4,529	0	9,530	(333)	27,600	27,600	0
05/09/05	4,170	4,170	0	8,830	8,830	0	5,404	5,404	0	9,400	(395)	27,200	27,200	0
05/10/05	4,170	4,170	0	8,820	8,820	0	4,521	4,521	0	9,370	(259)	26,800	26,800	0
05/11/05	4,160	4,160	0	8,650	8,650	0	4,512	4,512	0	9,240	(1,144)	26,500	26,500	0
05/12/05	4,190	4,190	0	8,530	8,530	0	4,522	4,522	0	9,020	(581)	26,300	26,300	0
05/13/05	4,340	4,340	0	8,890	8,890	0	4,518	4,518	0	8,700	(472)	26,100	26,100	0
05/14/05	4,390	4,390	0	8,980	8,980	0	4,243	4,243	0	8,580	(232)	26,000	26,000	0
05/15/05	4,400	4,400	0	8,900	8,900	0	4,006	4,006	0	8,560	(498)	25,800	25,800	0
05/16/05	4,370	4,370	0	8,660	8,660	0	4,011	4,011	0	8,490	(643)	25,500	25,500	0
05/17/05	4,350	4,350	0	8,650	8,650	0	4,015	4,015	0	8,430	(656)	25,200	25,200	0
05/18/05	4,340	4,340	0	8,520	8,520	0	4,022	4,022	0	8,060	(561)	25,000	25,000	0
05/19/05	4,330	4,330	0	8,550	8,550	0	4,034	4,034	0	7,710	(665)	24,800	24,800	0
05/20/05	4,290	4,290	0	8,300	8,300	0	4,024	4,024	0	7,640	(452)	24,500	24,500	0
05/21/05	4,420	4,420	0	8,120	8,120	0	4,026	4,026	0	7,710	(334)	24,300	24,300	0
05/22/05	4,640	4,640	0	7,880	7,880	0	4,024	4,024	0	8,180	106	24,400	24,400	0
05/23/05	4,540	4,540	0	7,300	7,300	0	3,634	3,634	0	8,650	354	24,500	24,500	0
05/24/05	4,530	4,530	0	7,110	7,110	0	3,406	3,406	0	9,230	96	24,600	24,600	0
05/25/05	4,280	4,280	0	7,120	7,120	0	3,407	3,407	0	9,600	376	24,600	24,600	0
05/26/05	3,530	3,530	0	6,880	6,880	0	3,405	3,405	0	9,810	314	24,600	24,600	0
05/27/05	2,820	2,820	0	6,600	6,600	0	3,404	3,404	0	9,530	143	24,800	24,800	0
05/28/05	2,880	2,880	0	6,260	6,260	0	3,143	3,143	0	8,730	125	24,500	24,500	0
05/29/05	2,870	2,870		5,890	5,890	0	2,907	2,907	0	7,900	536	23,600	23,600	0
05/30/05	2,880	2,880		5,450	5,450	0	2,914	2,914		7,380	1,347	22,300	22,300	0
05/31/05	2,850	2,850		4,930	4,930		2,577	2,577		7,130	1,423	21,000	21,000	0
VAMP Period														
Average (cfs):	4,210	4,210		8,370	8,370		4,270	4,270		9,280	(110)	26,020	26,020	
Supplemental Water (ac-ft):			0			0			0					0

VAMP Period

Observed Flow Sources
Merced River at Cressey (CA DWR B05155): California DWR, Water Data Library, 9/8/06
Tuolumne River below LaGrange Dam near LaGrange (USGS 11289650): USGS, provisional data as of 9/8/06
Stanislaus River below Goodwin Dam: USBR, Goodwin Reservoir Daily Operations Report - OID/SSJID/Tri-Dams, 5/1/06 (April report) and 6/1/06 (May report)
San Joaquin River near Vernalis (USGS 11303500): USGS, provisional data as of 9/8/06

Delta Exports

The VAMP experimental design does not mandate specific magnitudes of reduced export rates when the existing flow at Vernalis is expected to exceed the maximum VAMP target flow rate of 7,000 cfs, but does provide the following suggested export rates.

Vernalis Flow	Suggested Export Rate
Up to 10,000 cfs	1,500 cfs or 3,000 cfs
Up to 15,000 cfs	2,250 cfs
Over 15,000 cfs	3,000 cfs

On April 25, 2006 the projected VAMP operation plan was discussed with the CalFed Operations Group. On April 28 the CalFed Water Operation Management Team (WOMT), which is made up of representatives from the DWR, USBR, USFWS, CDFG and NMFS, settled on a combined State and Federal export rate of 1,500 cfs for the first half of the VAMP pulse flow period (May 3 to May 17) and 6,000 cfs for the second half of the VAMP pulse flow period (May 18 to June 2). The period of reduced export pumping was slightly offset from the VAMP target flow period of May 1 to May 31 to allow both Mossdale releases a full 14 days to migrate through the system prior to changing the export rate.

Implementation

Operation Conference Calls

Due to the high flows in the San Joaquin River and the fact that the operation was being controlled by flood control considerations and not by the VAMP target flow, no operation conference calls were conducted in 2006.

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 quality. The 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.

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 August 1, 2006. 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 8, 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 26,020 cfs during the VAMP target flow period (May 1 – May 31). The flow showed a steady decline throughout the target flow period, ranging from a high of 30,600 cfs on May 1 to a low of 21,000 cfs on May 31, as shown in Figure 2-2. Figure 2-1 also shows the tributary contributions to the flow at Vernalis. Plots of the flow at the Merced River, Tuolumne River and Stanislaus River measurement points are provided in Figure 2-3. A tabulation of the observed mean daily flows during and around the VAMP target flow period is provided in Table 2-5.

The mean daily ungaged flow at Vernalis averaged -110 cfs during the VAMP target flow period, ranging from a minimum of -1,143 cfs to a maximum of 1,427 cfs. A plot of the ungaged flow is provided in Figure 2-4.

As noted previously, Millerton Lake on the San Joaquin River was making flood control releases during the VAMP target flow period. The Millerton Lake flood control operation resulted in a significant contribution of flow to the lower San Joaquin River as shown in Figure 2-5.

As previously stated, the combined CVP and SWP Delta export rate target was set at 1,500 cfs for the first half of the VAMP target flow period and 6,000 cfs for the second half. The observed exports, shown in Figure 2-6, averaged 1,559 cfs during the first half and 5,748 cfs during the second half.

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 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.

Due to the flood control operations in 2005 there were no SJRA storage impacts entering the 2006. No VAMP supplemental water was provided, so the 2006 VAMP operation had no impacts on reservoir storage. With and without SJRA storage and releases in 2006 for Lake McClure and Don Pedro Lake are shown in Figures 2-7 and 2-8, respectively.

Summary of Historical VAMP Operations

2006 marks the seventh year of VAMP operation in compliance with D-1641. A summary of the VAMP target flows for these first seven years is provided in Table 2-6. A summary of the SJRGA supplemental water contributions is provided in Table 2-7. 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 seven years of VAMP operation are provided in Appendix B-1, Figures 1 through 4.

Over the first seven 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
2006 VAMP: San Joaquin River near Vernalis
With Lagged Contributions from Primary Sources

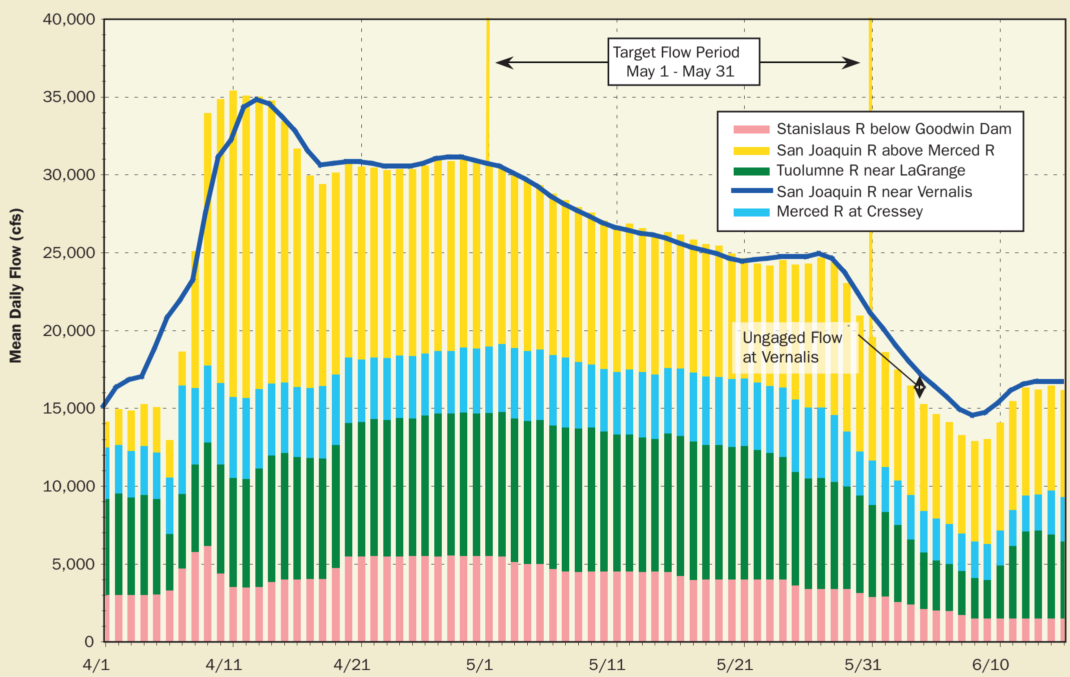


Figure 2-3
2006 VAMP: Flow at Tributary Measurement Points

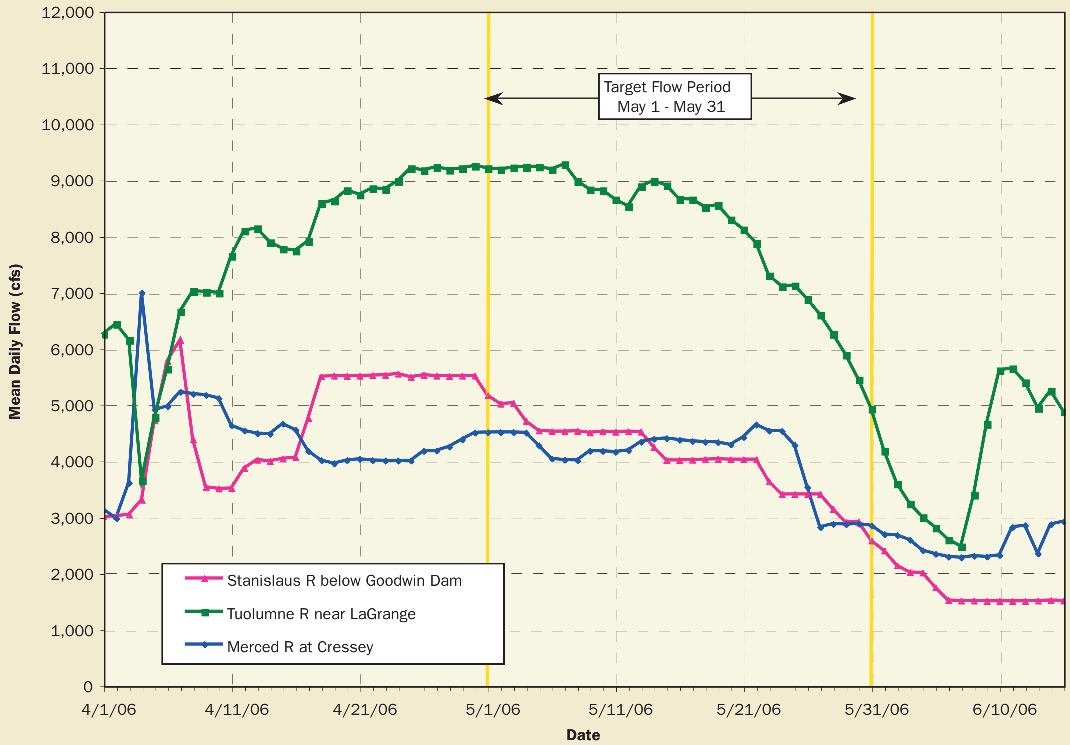


Figure 2-4
2006 VAMP - Ungaged Flow in San Joaquin River at Vernalis

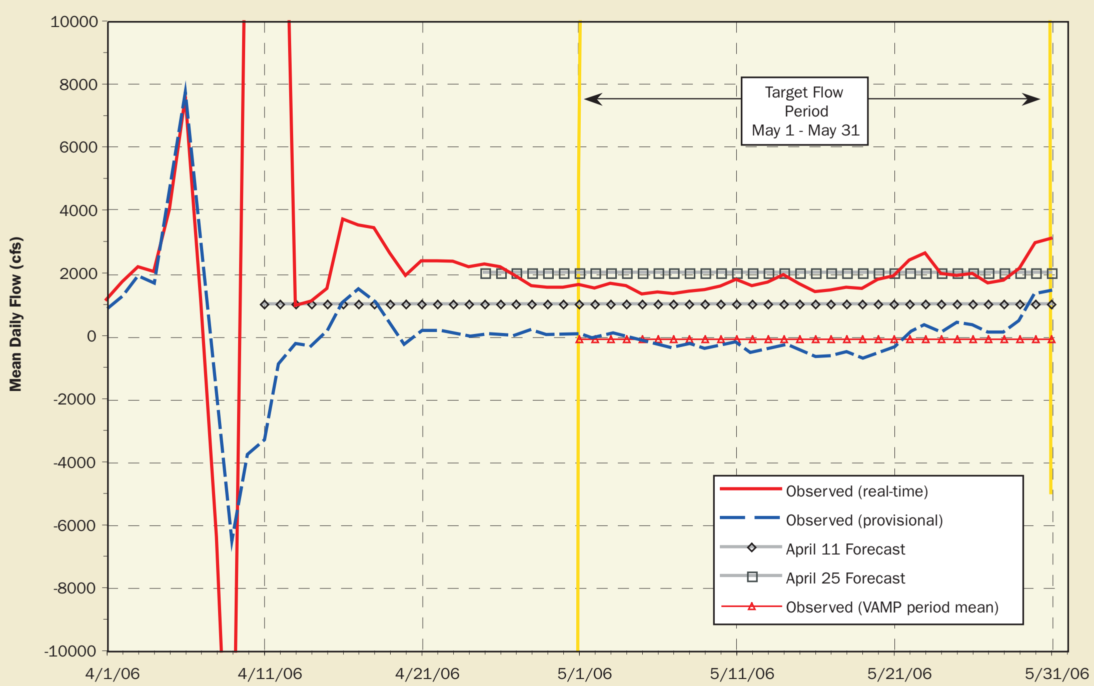


Figure 2-5
2006 VAMP - Upper San Joaquin River Flow

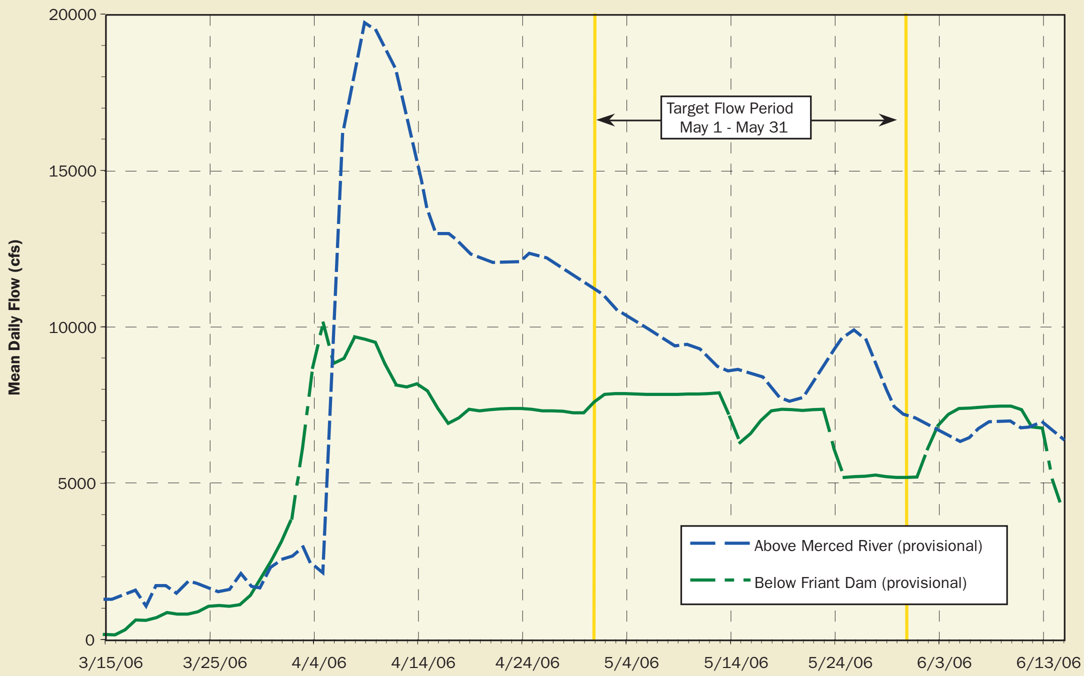


Figure 2-6
2006 VAMP - Federal and State Delta Exports

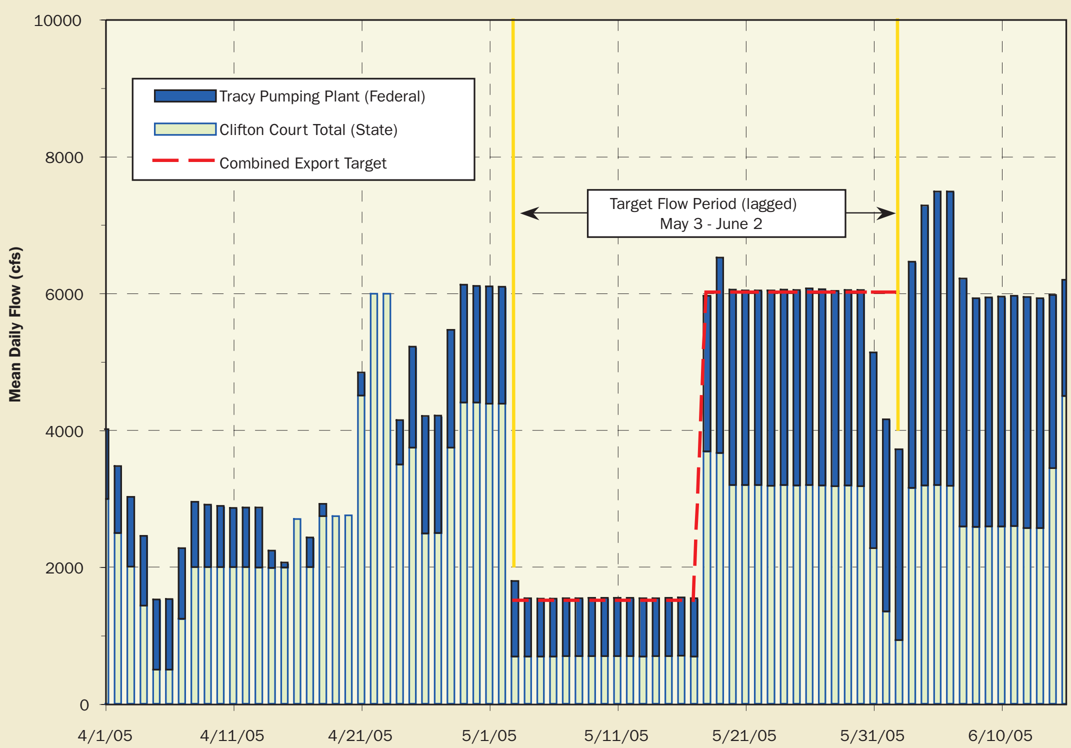


Figure 2-7
San Joaquin River Agreement Storage and Flow Impacts
Merced River - Lake McClure Storage and Release - 2006

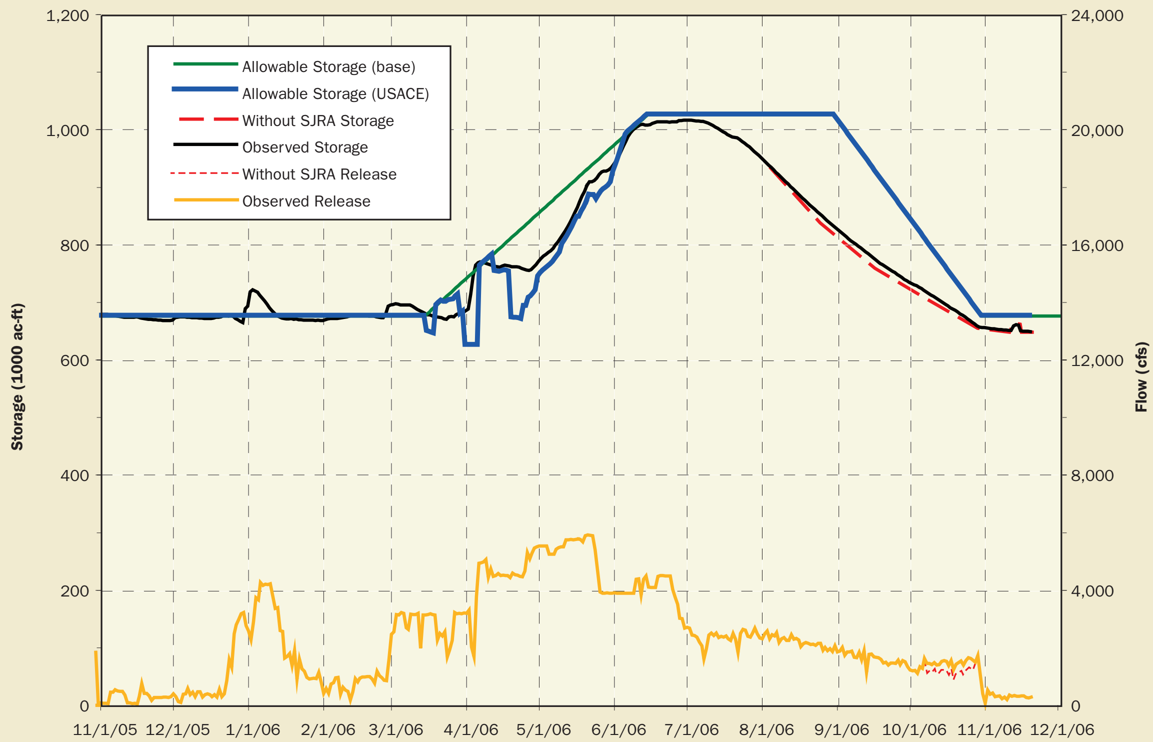


Figure 2-8
San Joaquin River Agreement Storage and Flow Impacts
Tuolumne River - New Don Pedro Reservoir Storage and Release - 2006

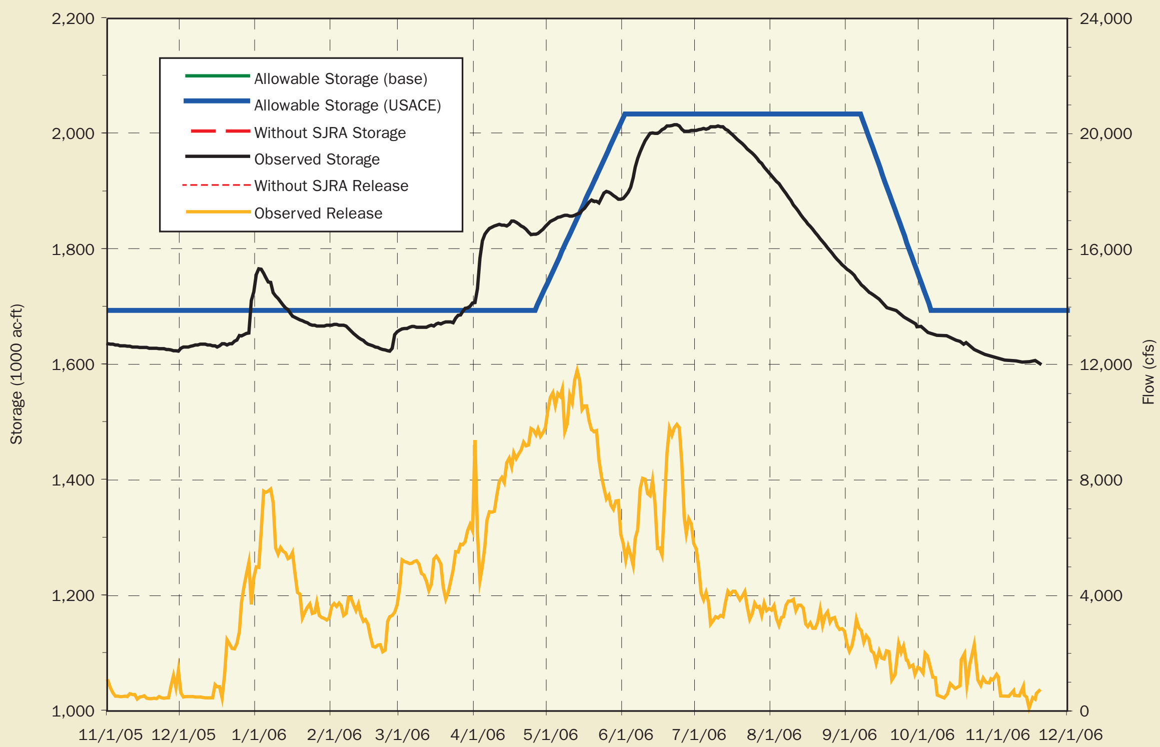


Table 2-6
Summary of VAMP Flows, 2000-2006

Year	60-20-20 Water Year Hydrologic Classification	VAMP Numerical Indicator	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	5,700	5,869	4,800	77,680	2,250	2,155
2001	Dry	2	4,450	4,224	2,909	78,650	1,500	1,420
2002	Dry	2	3,200	3,301	2,757	33,430	1,500	1,430
2003	Below Normal	3	3,200	3,235	2,290	58,065	1,500	1,446
2004	Dry	2	3,200	3,155	2,088	65,591	1,500	1,331
2005	Wet	5	>7,000	10,390	10,390	0	2,250	2,986 [a]
2006	Wet	5	>7,000	26,220/24,262 [b]	26,020	0	1,500/6,000	1,559/5,748 [b]

[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.

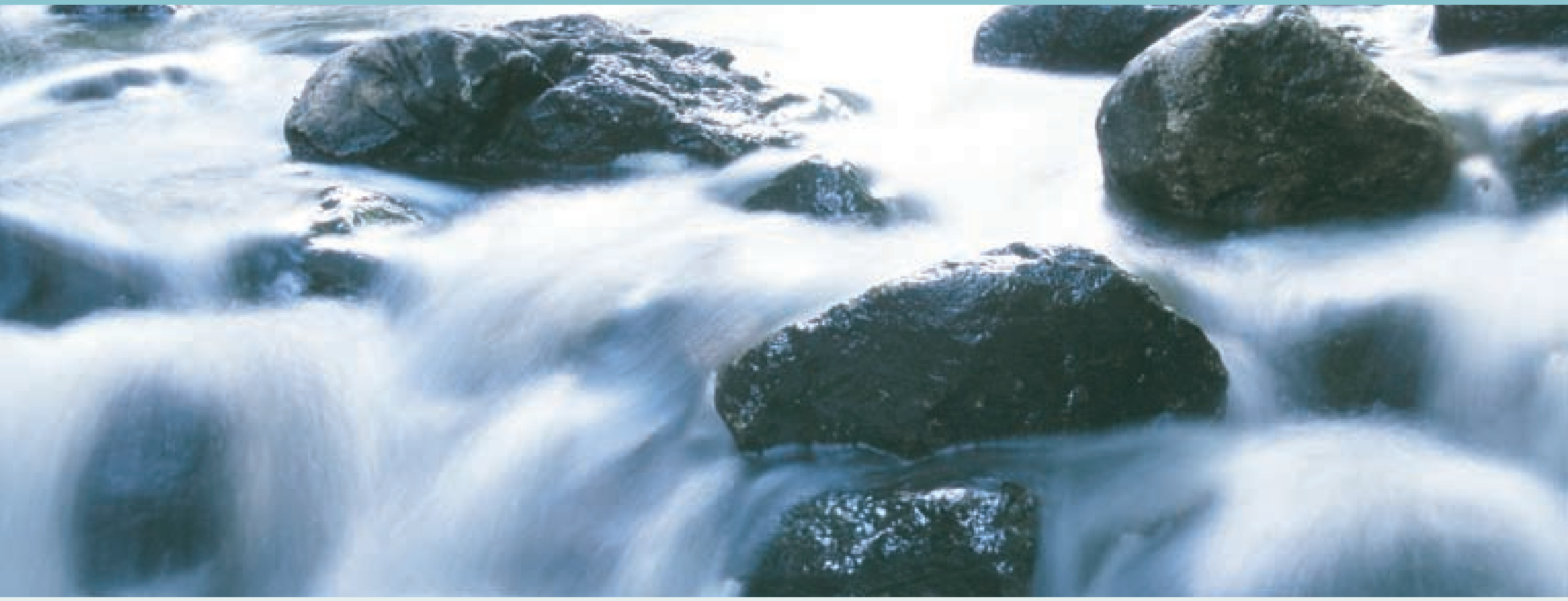
[b] “First fish release-recapture period”/”second fish release-recapture period”

Table 2-7
Summary of VAMP Supplemental Water Contributions, 2000-2006

Year	VAMP Supplemental Water (acre-feet)		Supplemental Water (acre feet) Merced ID	OID	SSJID	SJRECWA	MID	TID
2000	77,680	Observed:	46,750	(a)	(b)	8,280	15,200	7,450
	Division Agreement:	45,160	7,300	7,300	7,300	16,920	8,300	
	Deviation:	+ 1590	0	0	+ 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:	38,257	5,039	5,039	(c)	4,864.5	4,864.5
	Division Agreement:	38,065	5,000	5,000	5,000	5,000	5,000	
	Deviation:	+ 192	+ 39	+ 39	0	-135.5	-135.5	
2004	65,591	Observed:	42,680	5,880	5,880	(c)	5,575.5	5,575.5
	Division Agreement:	41,500	7,045.5	7,045.5	5,000	5,000	5,000	
	Deviation:	+ 1,180	- 1165.5	- 1165.5	0	+ 575.5	+ 575.5	
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	

Chapter 3

Additional Water Supply Arrangements and Deliveries



The SJRA includes a provision (Paragraph 8.4) stating that "Merced Irrigation District (Merced) 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." Pursuant to Paragraph 8.5 of the SJRA, "Oakdale Irrigation District (OID) shall sell 15,000 acre-feet of water to the USBR in every year of (the) Agreement…In addition to the 15,000 acre-feet, Oakdale will sell the difference between the water made available to VAMP under the SJRGA agreement and 11,000 acre-feet." This water 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 Merced ID.

The schedule for the 2006 Fall SJRA Transfer was finalized on September 27, 2006, with the transfer commencing on October 8, 2006. A daily summary table of the Merced 2006 Fall SJRA Transfer is provided as Table 3-1.

Oakdale Irrigation District

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

OID did not provide any supplemental water for the 2006 VAMP operation, therefore the amount of additional water purchased by the USBR from OID was 26,000 acre-feet (15,000 plus 11,000). 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.

Due to high storage levels and ongoing operations at New Melones Reservoir at the time of this writing the USBR has not scheduled the release of the 2006 OID additional water.

Table 3-1
2006 Merced Irrigation District SJRA Fall Water Transfer
Daily Summary (Final)

		Scheduled			Observed				
		Transfer Water			Observed Flow			Transfer Water	
Date	Base Flow (cfs) {1}	Daily Flow Rate (cfs) {2}	Cumulative Volume (ac-ft) {3}	Target Flow [1] (cfs) {4} = {1}+{2}	Merced R at Shaffer Bridge [PG&E] (cfs) {5}	Merced R at Cressey [DWR] (cfs) {6}	For Transfer [1] (cfs) {7}	Daily Flow Rate (cfs) {8} = {7}-{1}	Cumulative Volume (ac-ft) {9}
01-Oct-06	550	0	0	550	550	558	558	0	0
02-Oct-06	400	0	0	400	395	546	546	0	0
03-Oct-06	400	0	0	400	395	420	420	0	0
04-Oct-06	400	0	0	400	390	392	392	0	0
05-Oct-06	700	0	0	700	669	380	380	0	0
06-Oct-06	700	0	0	700	674	578	578	0	0
07-Oct-06	700	0	0	700	1,000	604	604	0	0
08-Oct-06	550	274	543	824	932	887	887	337	668
09-Oct-06	550	274	1,087	824	932	819	819	269	1,202
10-Oct-06	550	274	1,630	824	926	799	799	249	1,696
11-Oct-06	550	274	2,174	824	963	791	791	241	2,174
12-Oct-06	550	274	2,717	824	969	828	828	278	2,725
13-Oct-06	550	274	3,261	824	988	841	841	291	3,302
14-Oct-06	550	274	3,804	824	982	859	859	309	3,915
15-Oct-06	550	274	4,348	824	988	862	862	312	4,534
16-Oct-06	550	274	4,891	824	988	856	856	306	5,141
17-Oct-06	550	274	5,435	824	969	861	861	311	5,758
18-Oct-06	550	274	5,978	824	982	849	849	299	6,351
19-Oct-06	550	274	6,522	824	982	854	854	304	6,954
20-Oct-06	550	274	7,065	824	988	863	863	313	7,575
21-Oct-06	550	274	7,609	824	988	870	870	320	8,210
22-Oct-06	550	274	8,152	824	988	879	879	329	8,862
23-Oct-06	550	274	8,696	824	988	878	878	328	9,513
24-Oct-06	550	274	9,239	824	988	888	888	338	10,183
25-Oct-06	550	274	9,782	824	994	896	896	346	10,869
26-Oct-06	550	274	10,326	824	969	910	910	360	11,583
27-Oct-06	550	274	10,869	824	988	903	903	353	12,284
28-Oct-06	550	274	11,413	824	988	923	923	109	12,500
29-Oct-06	550	274	11,956	824	865	929	929		
30-Oct-06	550	185	12,323	735	669	816	816		
31-Oct-06	400	90	12,502	490	380	635	635		

[1]: The Technical Appendix to the San Joaquin River Group Division Agreement states that "[T]he Merced River at Shaffer Bridge…will be used for flows between 0 and 300 cfs. …[F]or the flows above 300 cfs, measurements will be provided at the gage on the Merc

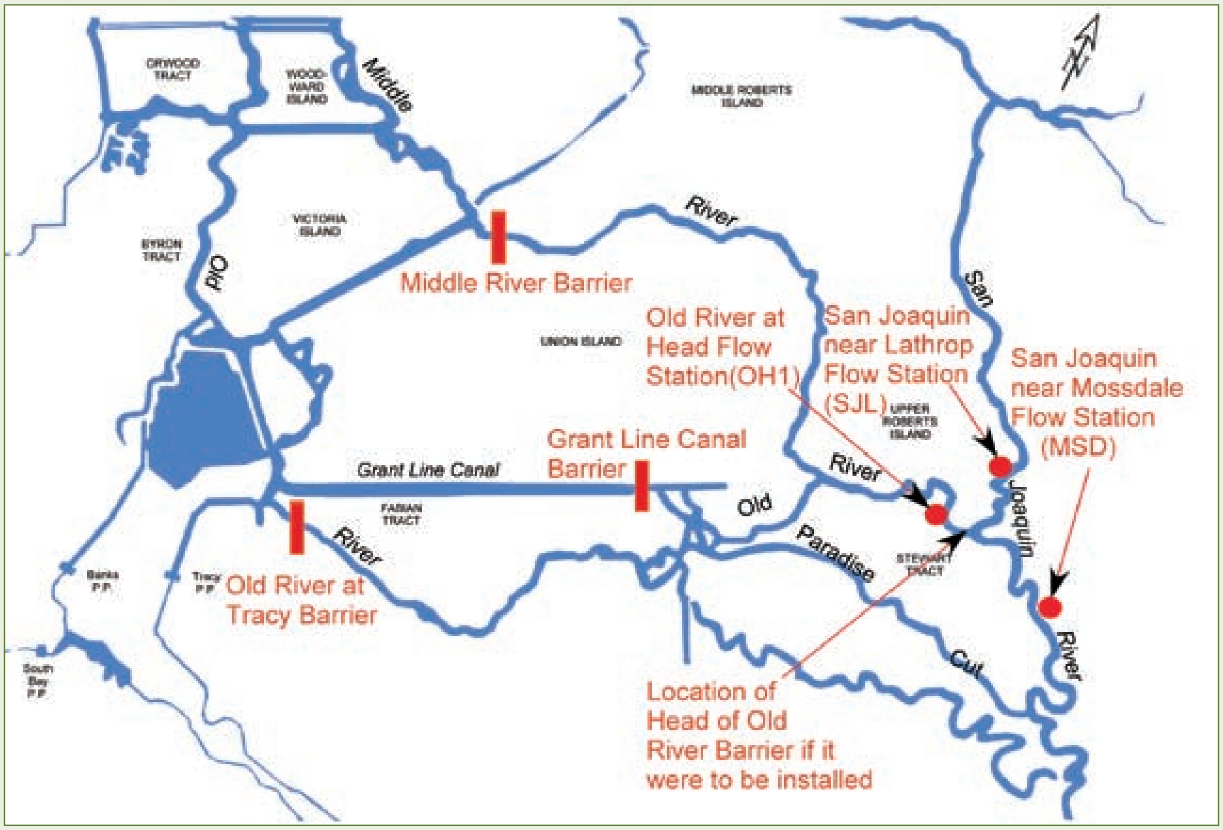
Chapter 4
Head of Old River Barrier

The spring temporary Head of Old River Barrier (HORB) was not installed in 2006 due to high flows in the San Joaquin River, nonetheless, monitoring near the HOR is performed as required by the permitting agencies and is one element of the monitoring program of the south delta Temporary Barriers Project (TBP). The TBP mitigates for low water levels in the south delta and improves water circulation and quality for agricultural purposes. Fishery sampling was conducted during the 2006 VAMP study period to determine the proportion of juvenile Chinook salmon that migrated into Old River in the absence of the HORB. Results of the 2006 monitoring tested the hypothesis that juvenile salmon migrate in direct proportion to a flow split. Results of the 2006 monitoring are briefly discussed below.

Background

The spring HORB was first constructed in 1992. Since then, the barrier has been installed in 1994, 1996, 1997 (w/two culverts), and between 2000 and 2004. In 2000-2004 the barrier was installed with six culverts. The HORB was not installed in 1993, 1995, 1998, 2005, and 2006 due to high San Joaquin River flows. The HORB was not installed in 1999 due to landowner access problems. The HORB, a key component of VAMP, is intended to increase San Joaquin River Chinook salmon smolt survival by preventing them from entering Old River.

Figure 4-1
South Delta Temporary Barriers



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Although the HORB was not installed in 2006, the three agricultural barriers (the Middle River barrier, the Old River near Tracy barrier, and the Grant Line Canal barrier) were installed by July 7, 2006, July 17, 2006, and July 20, 2006 respectively. Removal of the Middle River, Old River near Tracy, and Grant Line barriers was completed by November 18, December 13, and December 10, respectively. The agricultural barriers are installed to mitigate for low water surface elevations in south Delta region. Figure 4-1 shows the locations of the three agricultural barriers and the location of the HORB, if it were to be installed.

Flow Measurements at and Around the Head of Old River

DWR operates two Acoustic Doppler Current Meters (ADCM) in the vicinity of head of Old River, one in the San Joaquin River 1,500 feet downstream of Old River (San Joaquin River below Old River near Lathrop, SJL) and another in Old River 840 feet downstream of the head of Old River (Old River at Head, OH1). This year, a third acoustical Doppler was installed at the abutment of the Rail Road tracks near Mossdale (Figure 4-1). 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 flows for the April 1, 2006 through June 30, 2006 period for the three ADCMs as well as the flow split percentage of the total San Joaquin River flow between stations OH1 and SJL. Figures 4-2, 4-3, and 4-4 show the daily flow range and the mean for the Old River at head gage, the San Joaquin River below Old River gage, and the San Joaquin River at Mossdale gage respectively. The head of Old River gage reported missing data from April 1, 2006 till April 07, 2006 and from April 28, 2006 till May 1, 2006. All missing data are attributed to instrument malfunctioning or the lack of calibration at the site during that period.

At the HOR, during the 2006 VAMP period, an average of 54.3 percent of the flow entered the Old River compared to 51.3 percent during the 2005 VAMP period. However, the flow range at Vernalis in 2006 was 30,600 cfs to 21,000 cfs compared to a range of 7,700 cfs to 15,100 cfs in 2005. As is described below a portion of the higher 2006 flow entered Paradise Cut which was not the case in 2005. Until more data is collected no relationship between San Joaquin River flow and HOR flow can be made.

Table 4-2 shows the mean daily flow for the San Joaquin River gage at Mossdale and the San Joaquin River near Vernalis gage for the duration April 1, 2006 through June 30, 2006. When the flow in the San Joaquin River exceeds 18,000 cfs in the channel stretch between Vernalis and Mossdale; river water starts flowing over a flood-bypass weir (located approximately 12 miles downstream of Vernalis and about five miles upstream of the juncture with the Head of Old River) and into Paradise Cut which is a ditch with a dual purpose; irrigation and flood control-bypass channel conveying water from the San Joaquin River to Old River thereby easing the pressure on the levees located downstream of the weir. Figure 4-5 shows the San Joaquin River flow near Vernalis and at Mossdale as well as an estimation of the flow that was diverted into

Table 4-1
Flows in Old River at Head and San Joaquin River below Old River

Date	Old River at Head (OH1)			San Joaquin River below Old River (SJL)			San Joaquin River at Mossdale (MSD)			Flow Split (% of Total Flow)	
	Minimum Flow (cfs)	Maximum Flow (cfs)	Mean Flow (cfs)	Minimum Flow (cfs)	Maximum Flow (cfs)	Mean Flow (cfs)	Minimum Flow (cfs)	Maximum Flow (cfs)	Mean Flow (cfs)	OH1	SJL
4/1/2006				6,170	7,320	6,800	14,230	15,450	14,840		
4/2/2006				6,690	7,600	7,170	14,970	16,650	15,830		
4/3/2006				6,870	8,220	7,530	16,230	17,240	16,740		
4/4/2006				6,980	8,440	7,710	16,270	17,420	16,800		
4/5/2006				7,240	8,360	7,780	16,890	18,950	17,750		
4/6/2006				7,830	9,850	8,620	18,610	20,280	19,260		
4/7/2006	10,180	10,830	10,530	8,310	10,140	9,050	19,650	20,890	20,310	53.8%	46.2%
4/8/2006	10,290	11,330	10,710	8,610	10,440	9,650	20,370	22,390	21,230	52.6%	47.4%
4/9/2006	11,150	12,610	11,740	9,540	11,790	10,690	22,150	24,640	23,040	52.3%	47.7%
4/10/2006	12,210	13,430	12,750	11,360	13,150	12,130	24,190	26,090	25,210	51.2%	48.8%
4/11/2006	12,670	13,400	13,010	11,680	13,290	12,370	24,790	27,560	26,010	51.3%	48.7%
4/12/2006	13,120	14,440	13,770	12,500	15,100	13,710	26,630	28,730	27,700	50.1%	49.9%
4/13/2006	13,930	14,690	14,330	13,030	15,250	14,190	27,770	29,380	28,420	50.2%	49.8%
4/14/2006	13,940	14,790	14,400	12,460	15,190	13,850	27,140	28,900	28,000	51.0%	49.0%
4/15/2006	13,810	14,750	14,320	12,850	14,530	13,650	26,470	28,150	27,410	51.2%	48.8%
4/16/2006	13,460	14,330	13,880	12,220	14,390	13,360	25,770	28,050	26,820	51.0%	49.0%
4/17/2006	13,250	14,120	13,580	11,010	12,720	11,900	25,220	26,960	26,110	53.3%	46.7%
4/18/2006	12,940	13,770	13,320	10,480	12,540	11,460	24,280	25,870	25,200	53.8%	46.2%
4/19/2006	12,760	13,470	13,100	10,490	12,250	11,540	23,840	25,270	24,680	53.2%	46.8%
4/20/2006	12,890	13,750	13,260	11,100	12,070	11,560	23,760	25,670	24,670	53.4%	46.6%
4/21/2006	12,950	13,670	13,340	10,870	12,050	11,530	23,630	25,880	24,670	53.6%	46.4%
4/22/2006	12,830	13,590	13,200	10,930	12,130	11,530	23,520	25,210	24,370	53.4%	46.6%
4/23/2006	13,060	13,610	13,330	10,640	12,100	11,300	23,570	25,110	24,490	54.1%	45.9%
4/24/2006	12,940	13,440	13,220	11,070	12,160	11,640	23,450	25,030	24,260	53.2%	46.8%
4/25/2006	13,000	13,550	13,280	10,880	12,140	11,520	23,260	24,840	24,140	53.5%	46.5%
4/26/2006	12,780	13,630	13,290	10,830	12,240	11,500	23,060	24,840	24,040	53.6%	46.4%
4/27/2006	13,030	13,490	13,310	11,030	12,610	11,900	23,250	25,210	24,180	52.8%	47.2%
4/28/2006				11,310	12,640	11,950	23,660	25,620	24,590		
4/29/2006				11,270	12,680	11,950	23,730	26,110	24,640		
4/30/2006				11,480	12,900	12,050	23,680	25,370	24,520		
5/1/2006	13,050	13,720	13,340	11,590	12,650	12,170	23,570	25,500	24,620	52.3%	47.7%
5/2/2006	13,040	13,800	13,400	11,310	12,610	12,010	23,840	25,700	24,740	52.7%	47.3%
5/3/2006	12,950	13,650	13,340	10,980	12,610	11,850	23,360	25,010	24,140	53.0%	47.0%
5/4/2006	12,820	13,530	13,200	11,080	12,270	11,760	22,720	24,750	23,680	52.9%	47.1%
5/5/2006	12,780	13,430	13,130	10,960	12,360	11,630	22,500	24,030	23,430	53.0%	47.0%
5/6/2006	12,700	13,350	13,040	10,800	12,110	11,250	22,220	23,580	22,900	53.7%	46.3%
5/7/2006	12,380	13,040	12,660	10,670	11,900	11,440	21,490	23,570	22,620	52.5%	47.5%
5/8/2006	12,370	12,890	12,640	10,480	11,800	11,210	21,690	23,120	22,340	53.0%	47.0%
5/9/2006	12,310	12,830	12,550	10,450	11,590	11,030	21,280	23,300	22,320	53.2%	46.8%
5/10/2006	11,980	12,820	12,420	10,530	11,370	10,920	20,910	22,250	21,630	53.2%	46.8%
5/11/2006	11,840	12,700	12,220	9,820	11,190	10,610	20,560	22,620	21,440	53.5%	46.5%
5/12/2006	11,980	12,790	12,290	9,900	10,870	10,510	21,250	22,620	21,960	53.9%	46.1%
5/13/2006	11,990	12,580	12,360	9,860	10,870	10,340	20,990	22,620	21,830	54.4%	45.6%
5/14/2006	11,790	12,610	12,200	9,840	10,820	10,360	20,850	22,250	21,510	54.1%	45.9%
5/15/2006	11,640	12,720	12,200	9,430	11,000	10,190	20,650	22,920	21,650	54.5%	45.5%
5/16/2006	12,040	12,700	12,360	9,590	10,620	10,150	20,670	22,600	21,650	54.9%	45.1%
5/17/2006	11,970	12,500	12,270	9,840	10,800	10,200	20,520	22,340	21,590	54.6%	45.4%
5/18/2006	11,940	12,520	12,220	9,540	10,490	10,060	21,170	22,660	21,920	54.8%	45.2%
5/19/2006	11,600	12,530	12,160	9,460	10,630	10,030	21,240	22,560	21,780	54.8%	45.2%
5/20/2006	11,810	12,330	12,050	9,550	10,310	9,950	20,750	21,980	21,320	54.8%	45.2%
5/21/2006	11,570	12,130	11,870	9,440	10,290	9,900	20,110	21,610	20,840	54.5%	45.5%
5/22/2006	11,820	12,440	12,090	9,350	10,330	9,840	20,400	22,010	21,390	55.1%	44.9%
5/23/2006	11,660	12,420	12,030	9,410	10,360	9,950	20,230	22,260	21,240	54.7%	45.3%
5/24/2006	11,750	12,550	12,150	9,400	10,330	9,910	20,570	22,330	21,480	55.1%	44.9%
5/25/2006	11,980	12,500	12,260	9,140	10,030	9,550	20,750	22,240	21,390	56.2%	43.8%
5/26/2006	11,960	12,570	12,280	9,080	10,000	9,540	20,700	21,970	21,340	56.3%	43.7%
5/27/2006	11,990	12,610	12,270	9,140	10,550	9,750	20,450	22,470	21,610	55.7%	44.3%
5/28/2006	11,760	12,340	12,100	9,240	10,350	9,760	20,960	22,520	21,730	55.4%	44.6%
5/29/2006	11,490	12,230	11,910	8,930	10,130	9,600	20,110	21,980	21,270	55.4%	44.6%
5/30/2006	11,110	11,910	11,470	8,630	9,770	9,180	19,090	21,060	20,190	55.5%	44.5%
5/31/2006	10,790	11,370	11,090	8,010	9,210	8,750	18,250	20,300	19,160	55.9%	44.1%
6/1/2006	10,440	11,260	10,780	7,740	8,880	8,350	17,400	18,930	18,380	56.4%	43.6%
6/2/2006	10,160	10,830	10,530	7,530	8,190	7,860	16,930	18,210	17,510	57.3%	42.7%
6/3/2006	9,490	10,400	9,960	7,040	7,900	7,630	16,170	17,510	16,850	56.6%	43.4%
6/4/2006	9,210	9,950	9,550	6,850	7,440	7,140	15,230	16,530	16,000	57.2%	42.8%
6/5/2006	8,950	9,660	9,250	6,620	7,230	6,900	14,810	15,980	15,400	57.3%	42.7%
6/6/2006	8,640	9,180	8,930	6,160	6,890	6,540	14,070	15,410	14,770	57.7%	42.3%
6/7/2006	8,300	8,910	8,590	5,840	6,420	6,130	13,560	14,720	14,110	58.4%	41.6%
6/8/2006	8,150	8,710	8,390	5,410	6,160	5,850	13,220	13,990	13,590	58.9%	41.1%
6/9/2006	8,110	8,570	8,370	5,320	6,280	5,870	13,180	14,240	13,660	58.8%	41.2%
6/10/2006	8,380	8,880	8,660	5,350	6,420	6,010	13,870	15,300	14,540	59.0%	41.0%
6/11/2006	8,660	9,160	8,950	5,800	6,820	6,340	14,670	15,960	15,360	58.5%	41.5%
6/12/2006	8,930	9,460	9,190	6,010	6,910	6,560	15,100	16,420	15,900	58.3%	41.7%
6/13/2006	9,260	9,860	9,540	6,160	6,970	6,630	15,570	16,930	16,290	59.0%	41.0%
6/14/2006	9,550	10,000	9,790	6,350	7,190	6,730	16,050	17,100	16,440	59.3%	40.7%
6/15/2006	9,280	9,880	9,520	6,300	7,040	6,690	15,810	16,760	16,320	58.7%	41.3%
6/16/2006	9,040	9,530	9,260	6,260	6,990	6,700	15,550	16,740	16,200	58.0%	42.0%
6/17/2006	8,570	9,140	8,910	6,210	6,840	6,570	15,160	16,180	15,730	57.6%	42.4%
6/18/2006	8,230	8,770	8,510	5,870	6,530	6,260	14,890	15,840	15,340	57.6%	42.4%
6/19/2006	7,750	8,530	8,070	5,470	6,400	5,950	13,810	15,140	14,610	57.6%	42.4%
6/20/2006	7,390	7,910	7,600	5,130	5,900	5,540	13,010	14,180	13,610	57.8%	42.2%
6/21/2006	7,130	7,580	7,370	4,870	5,630	5,310	12,740	13,560	13,170	58.1%	41.9%
6/22/2006	7,340	7,910	7,680	4,760	5,690	5,350	12,920	14,310	13,610	58.9%	41.1%
6/23/2006	7,670	8,140	7,900	5,020	5,940	5,510	13,670	14,580	14,170	58.9%	41.1%
6/24/2006	7,740	8,300	7,990	5,170	6,050	5,660	13,940	14,980	14,550	58.5%	41.5%
6/25/2006	7,730	8,350	8,110	5,230	6,330	5,850	14,410	15,690	15,060	58.1%	41.9%
6/26/2006	7,950	8,480	8,290	5,560	6,490	6,060	15,100	16,060	15,560	57.8%	42.2%
6/27/2006	8,160	8,590	8,380	5,860	6,610	6,230	15,170	16,470	15,960	57.4%	42.6%
6/28/2006	7,980	8,550	8,270	5,880	6,600	6,200	15,280	16,250	15,830	57.2%	42.8%
6/29/2006	7,400	8,160	7,780	5,410	6,290	5,900	14,310	15,620	15,030	56.9%	43.1%
6/30/2006	7,220	7,580	7,430	4,930	5,850	5,470	13,510	14,770	14,060	57.6%	42.4%

No Data

Figure 4-2
Daily Flow Range - Old River at Head Gage, 2006

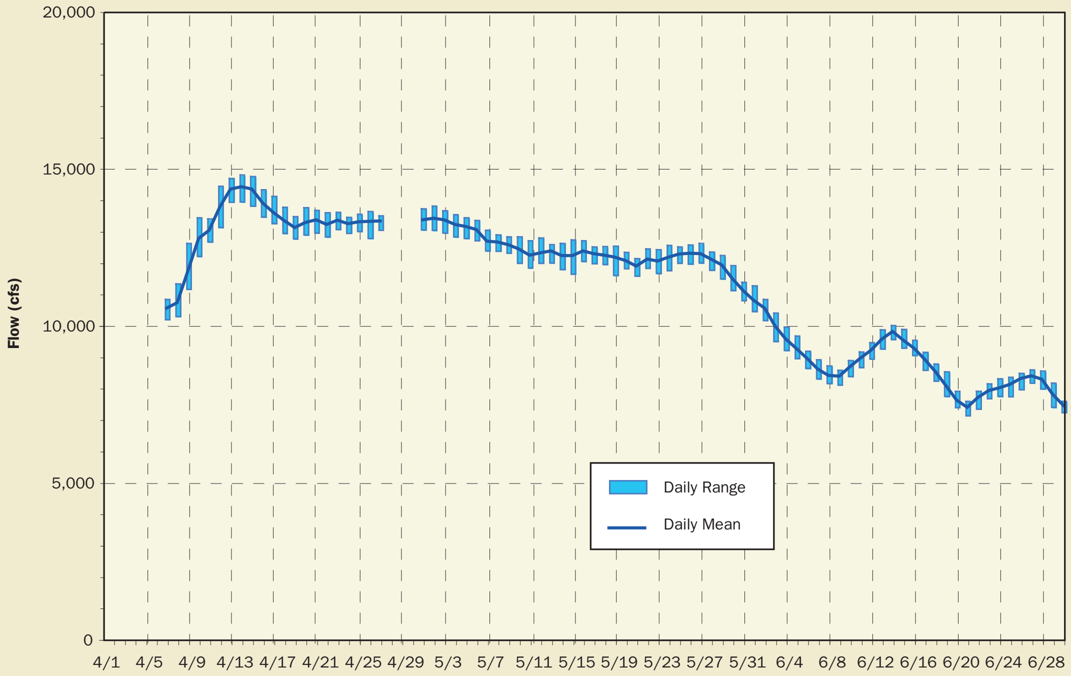
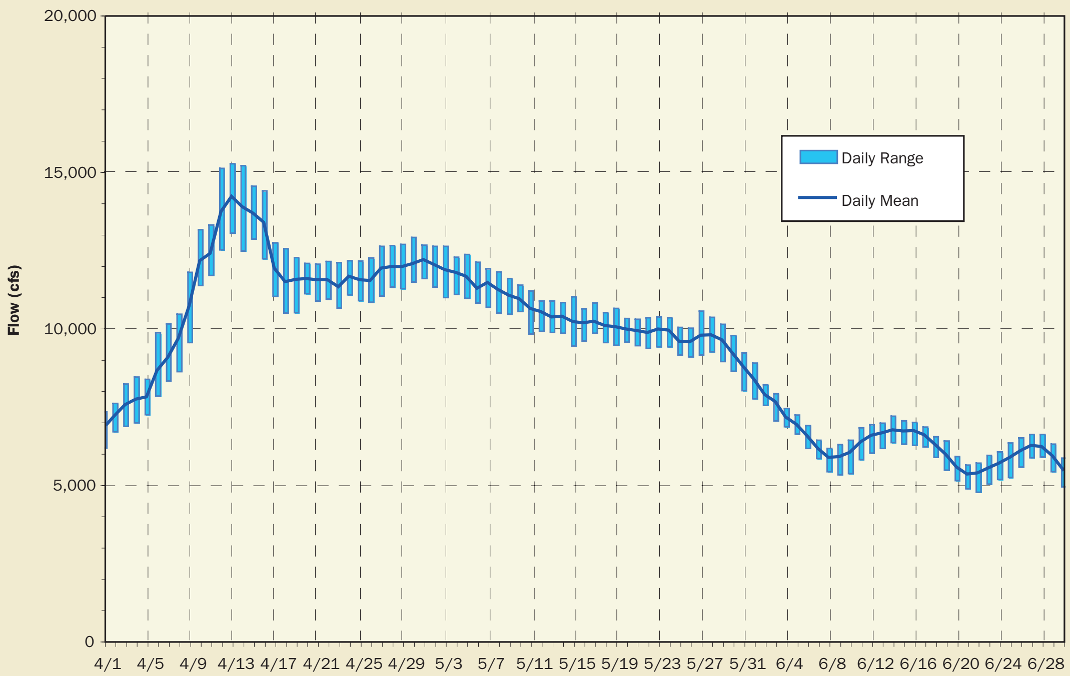


Figure 4-3
Daily Flow Range - San Joaquin River below Old River Gage, 2006



Paradise Cut. Since the test fish were released downstream of this location the flow diverted into Paradise Cut did not confound the analyses of the 2006 survival data.

DWR at the end of each year conducts a Delta Simulation Model 2 (DSM2) modeling run to be included in the yearly published South Delta Temporary Barriers Monitoring Report. As in 2005 data collected from the two ADCMs will be used to verify the flow split of the San Joaquin River and Old River at the confluence against the output generated using the model. In 2005, the flow split observed in the field during the period of April through June was 48.9 percent of the total flow for the San Joaquin River and 51.1 percent for the Old River at head. The output of the DSM2 model revealed a flow split of 47 percent and 53 percent respectively.

Seepage Monitoring

A seepage-monitoring program was initiated in April 2000, to evaluate the effects of HORB operations on seepage and groundwater on Upper Roberts Island. Although the HORB was not installed this year, DWR continued monitoring for seepage. Seepage was observed and recorded in April and May at Upper Roberts Island near and around the monitoring wells. A link to the continuous time series data in the water data library is available on the Internet.

Old and San Joaquin River Kodiak Trawling

As in 2005, the spring Head of Old River Barrier was not constructed in 2006 due to flows in excess of 5,000 cfs on the San Joaquin River. Consequently, there was no fish entrainment monitoring. As an alternative to the entrainment monitoring, the Department of Fish and Game towed a Kodiak trawl in Old River during the VAMP test period. The Old River Kodiak Trawl (ORKT) was conducted in a manner similar to the Mossdale Kodiak Trawl (MKT) which is conducted year-round on the San Joaquin River. Both trawls sampled for juvenile salmon during the first three weeks of May. Comparison of salmon catch between the two trawls may provide insights into salmon migration from the San Joaquin River into Old River.

Methods and Results

The ORKT and MKT used similar sampling gear and protocols. Fish were collected using a Kodiak trawl towed between two boats. Trawling took place in Old River, starting approximately two miles downstream of the head; and in the San Joaquin River, upstream of the head of Old River (Figure 4-6). The beginning of the 2006 ORKT sample site was about 0.8 miles downstream of the end of the 2005 sample site. The Kodiak trawl is 65 feet long, made of variable mesh (ranging from 0.5 inches stretch

Table 4-2
San Joaquin River and Old River Mean Daily Flows

Date	Mean Daily Flow (cfs)		
	San Joaquin River at Mossdale [A]	San Joaquin River near Vernalis [B]	Estimate of Flow Diverted to Paradise Cut [B] - [C]
4/1/06	14,840	15,000	
4/2/06	15,830	16,200	
4/3/06	16,740	16,700	
4/4/06	16,800	16,900	
4/5/06	17,750	18,700	950
4/6/06	19,260	20,700	1,440
4/7/06	20,310	21,800	1,490
4/8/06	21,230	23,100	1,870
4/9/06	23,040	27,400	4,360
4/10/06	25,210	31,000	5,790
4/11/06	26,010	32,100	6,090
4/12/06	27,700	34,200	6,500
4/13/06	28,420	34,700	6,280
4/14/06	28,000	34,400	6,400
4/15/06	27,410	33,600	6,190
4/16/06	26,820	32,700	5,880
4/17/06	26,110	31,400	5,290
4/18/06	25,200	30,500	5,300
4/19/06	24,680	30,600	5,920
4/20/06	24,670	30,700	6,030
4/21/06	24,670	30,700	6,030
4/22/06	24,370	30,600	6,230
4/23/06	24,490	30,400	5,910
4/24/06	24,260	30,400	6,140
4/25/06	24,140	30,400	6,260
4/26/06	24,040	30,600	6,560
4/27/06	24,180	30,900	6,720
4/28/06	24,590	31,000	6,410
4/29/06	24,640	31,000	6,360
4/30/06	24,520	30,800	6,280
5/1/06	24,620	30,600	5,980
5/2/06	24,740	30,400	5,660
5/3/06	24,140	30,000	5,860
5/4/06	23,680	29,600	5,920
5/5/06	23,430	29,100	5,670
5/6/06	22,900	28,500	5,600
5/7/06	22,620	28,000	5,380
5/8/06	22,340	27,600	5,260
5/9/06	22,320	27,200	4,880
5/10/06	21,630	26,800	5,170
5/11/06	21,440	26,500	5,060
5/12/06	21,960	26,300	4,340
5/13/06	21,830	26,100	4,270
5/14/06	21,510	26,000	4,490
5/15/06	21,650	25,800	4,150
5/16/06	21,650	25,500	3,850
5/17/06	21,590	25,200	3,610
5/18/06	21,920	25,000	3,080
5/19/06	21,780	24,800	3,020
5/20/06	21,320	24,500	3,180
5/21/06	20,840	24,300	3,460
5/22/06	21,390	24,400	3,010
5/23/06	21,240	24,500	3,260
5/24/06	21,480	24,600	3,120
5/25/06	21,390	24,600	3,210
5/26/06	21,340	24,600	3,260
5/27/06	21,610	24,800	3,190
5/28/06	21,730	24,500	2,770
5/29/06	21,270	23,600	2,330
5/30/06	20,190	22,300	2,110
5/31/06	19,160	21,000	1,840
6/1/06	18,380	20,000	1,620
6/2/06	17,510	18,900	1,390
6/3/06	16,850	17,900	1,050
6/4/06	16,000	17,000	1,000
6/5/06	15,400	16,300	
6/6/06	14,770	15,600	
6/7/06	14,110	14,800	
6/8/06	13,590	14,400	
6/9/06	13,660	14,600	
6/10/06	14,540	15,200	
6/11/06	15,360	16,000	
6/12/06	15,900	16,400	
6/13/06	16,290	16,600	
6/14/06	16,440	16,600	
6/15/06	16,320	16,600	
6/16/06	16,200	16,500	
6/17/06	15,730	16,000	
6/18/06	15,340	15,400	
6/19/06	14,610	14,700	
6/20/06	13,610	13,800	
6/21/06	13,170	13,400	
6/22/06	13,610	13,900	
6/23/06	14,170	14,300	
6/24/06	14,550	14,600	
6/25/06	15,060	15,000	
6/26/06	15,560	15,400	
6/27/06	15,960	15,800	
6/28/06	15,830	15,500	
6/29/06	15,030	14,400	
6/30/06	14,060	13,600	

Figure 4-4
Daily Flow Range - San Joaquin River at Mossdale, 2006

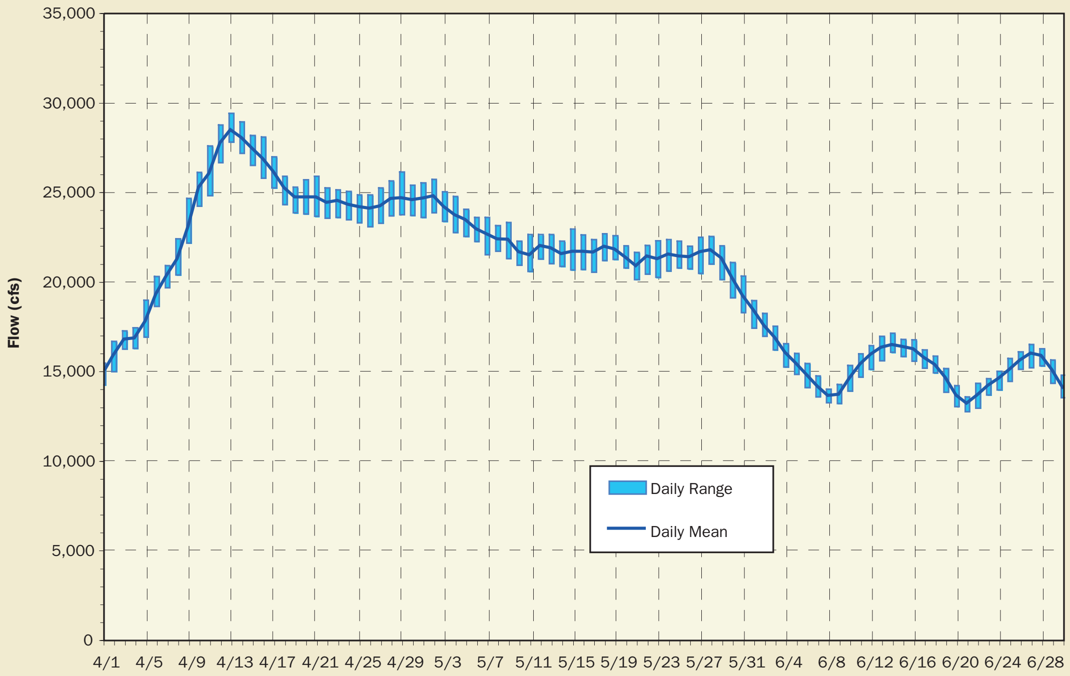
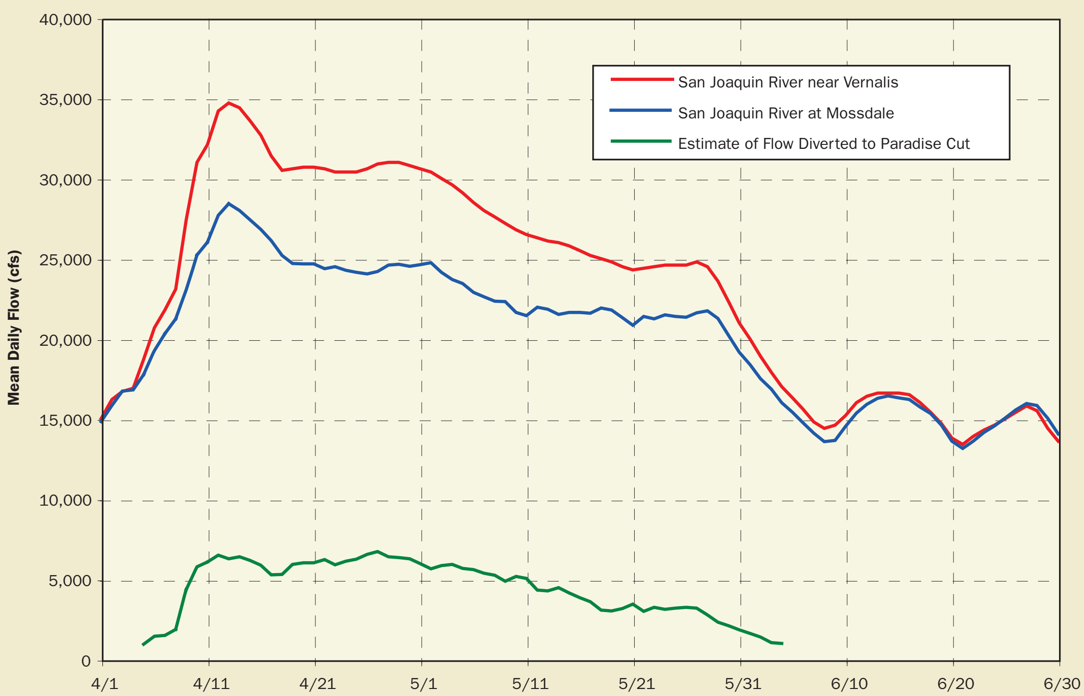


Figure 4-5
San Joaquin River Flow near Vernalis and at Mossdale, 2006



mesh at the cod-end to 2.0 inches mesh at the mouth), and has a mouth opening of 6.0 feet by 25 feet. The effective sampling area of the net was estimated at 134.5 ft^2 (USFWS 2003). All trawling was done during daylight hours, starting around 0800 hrs. Typically, the MKT and ORKT started and ended within a half hour of each other. The Kodiak trawl was towed against the current for 20 minutes. Although the boats and net faced upstream, the high flows carried the boats and net downstream. Due to the extremely high flows, only two tows were completed before the ORKT net was retrieved and reset upstream. For the ORKT, a total of 14 tows per day, five days a week, were conducted from May 3 through May 19. During this same time period, the MKT conducted 15 tows per day, seven days a week.

For the ORKT, all fish were counted and measured (fork length) to the nearest millimeter. All salmon were checked for a clipped adipose fin or spray dyed color-mark. Salmon with a clipped adipose fin were sacrificed for CWT reading. Although all the CWTs from the ORKT were read, not all the CWTs from the MKT were read and available at the writing of this section. Thus, for this comparison of the MKT and ORKT salmon catch, CWT salmon refers to all salmon with a clipped adipose fin. Because the number of salmon with a clipped adipose fin and no CWT is small, this should not significantly change the results. The unmarked salmon catch represents both hatchery and naturally spawned salmon. A flow meter was used to estimate the volume of water sampled. All sample statistics are reported as the mean ± standard deviation unless otherwise noted. The average volume of water sampled per tow by the MKT (395,969 ± 43,820 ft3) was greater than the ORKT (257,021 ± 32,203 ft3).

Table 4-3.
The raw abundance and composition of fishes caught in the Kodiak trawl in Old River (ORKT) and in the San Joaquin River (MKT) for trawls conducted weekdays, May 3-19, 2006. Chinook salmon catch is divided into CWT salmon, unmarked salmon, and color-marked salmon. Note: ORKT conducted 182 tows and the MKT conducted 196 tows.

Species	ORKT	MKT
Black Crappie	1	
Bluegill	5	
Brown Bullhead	1	
Common Carp	2	14
Goldfish		1
Golden Shiner		1
Inland Silverside		2
Redear Sunfish	1	2
Red Shiner		4
Sacramento Pikeminnow		2
Sacramento Sucker		1
Splittail	1	11
Steelhead	4	2
Threadfin shad	13	61
White Catfish	4	3
Chinook Salmon	**211**	**855**
CWT Salmon	54	238
Unmarked Salmon	130	547
Color-Marked Salmon	27	70
Total	**243**	**959**

The ORKT caught 243 fish, representing 10 species, in 186 tows during 13 days of sampling in Old River. The most abundant species was Chinook salmon (87 %) followed by threadfin shad (Table 4-3). Of the 211 salmon caught, 130 were unmarked, 54 were classified as CWT, and 27 had a color-mark. The MKT caught 959 fish, representing 13 species, in 196 tows during the same 13 days of sampling in the San Joaquin River. The most abundant species caught was Chinook salmon (89 %) followed by threadfin shad (Table 4-3). Of the 855 salmon caught, 547 were unmarked, 238 were classified as CWT, and 70 had a color-mark. A two sample t-test (degrees of freedom (df) = 964, Probability (P) = 0.03, t statistic = 2.17) indicated fork lengths for salmon (unmarked and CWT pooled) were significantly different between the MKT caught salmon (100.8 ± 8.2 mm) and the ORKT caught salmon (102.3 ± 8.0 mm).

As part of the VAMP salmon survival studies, roughly 50,000 CWT salmon were released at Mossdale on May 4 and 75,000 on May 19. On May 5, the ORKT caught four CWT salmon from the May 4 VAMP release. No CWT salmon were caught by the ORKT from the May 19 release. CWT salmon catch was the highest on May 17 in the San Joaquin River (Figure 4-7) and on May 18 in Old River (Figure 4-8). The highest unmarked catch occurred on May 18 in both rivers. To estimate salmon vulnerability to the Kodiak trawl, groups of color-marked salmon were released upstream of the MKT and ORKT on May 4, 11 and 18. On each of these dates, approximately 5,000 fish were released at the Mossdale boat ramp and approximately 2,000 fish were released at the head of Old River. The MKT caught marked fish from all three Mossdale releases while the ORKT only caught marked fish from the first and last Old River releases (Table 4-4).

Daily catch ratios of CWT to unmarked salmon were compared between trawls to determine if CWT salmon were migrating similarly to unmarked salmon into the Old

Figure 4-6
Map of the 2006 Kodiak trawl sample locations on Old and San Joaquin Rivers. The Old River Kodiak trawl sampled between letters A and B, and the Mossdale Kodiak trawl sampled between letters C and D.

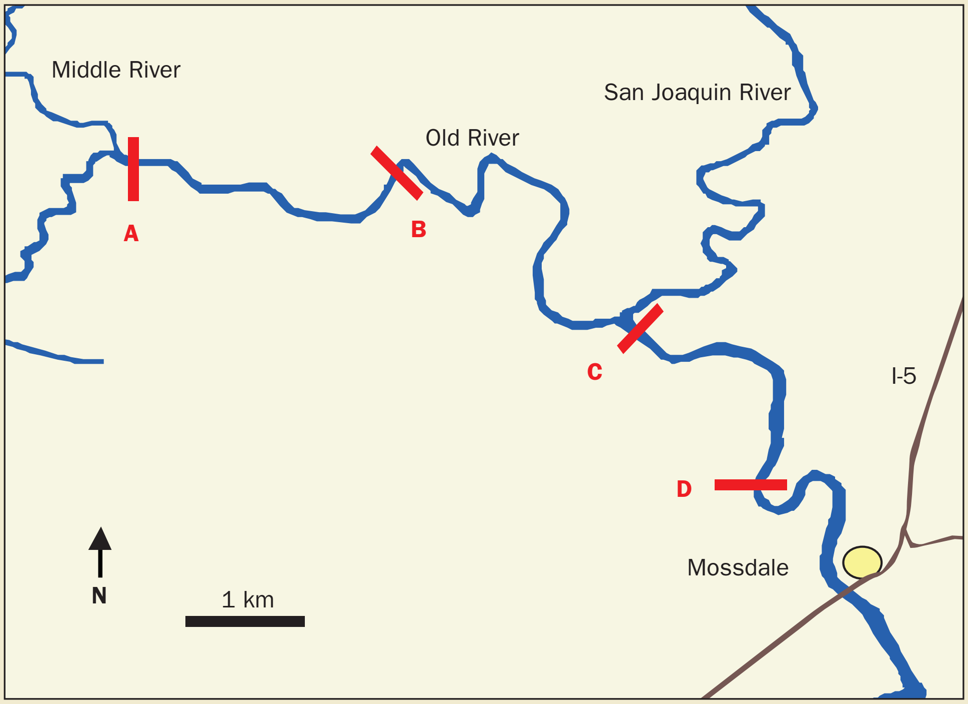


Figure 4-7
The total number of salmon by category (color-marked, coded wire tagged, and unmarked) caught in daily five hour Kodiak trawling sessions (150,000 m^3) in the San Joaquin River, 2006.

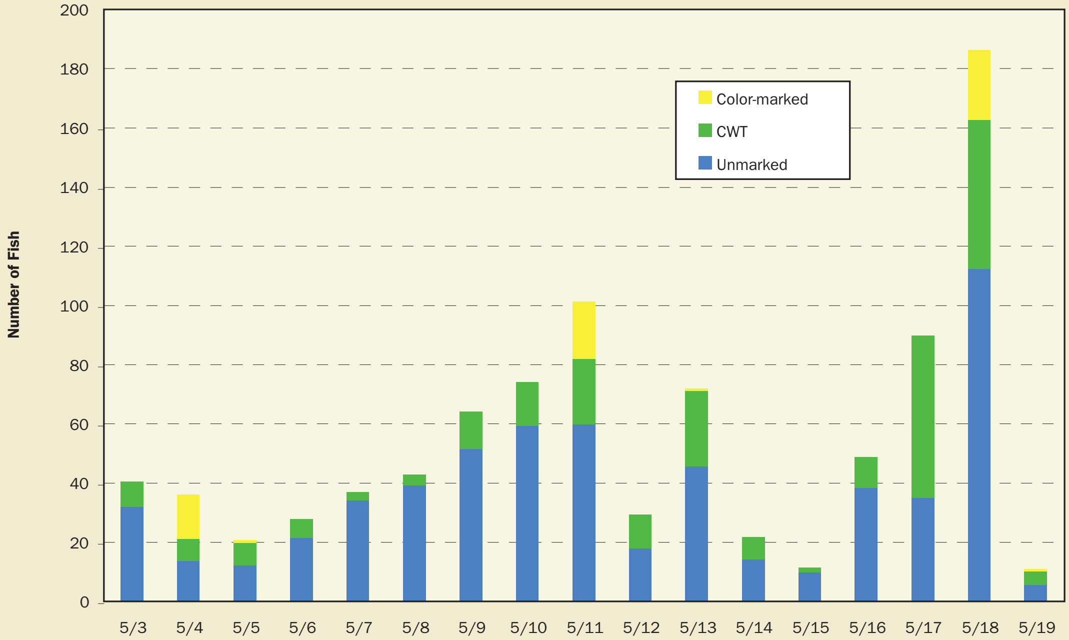


Figure 4-8
The total number of salmon by category (color-marked, coded wire tagged, and unmarked) caught in daily five hour Kodiak trawling sessions (150,000 m^3) in the Old River, 2006.
An "X" indicates no samples were collected.

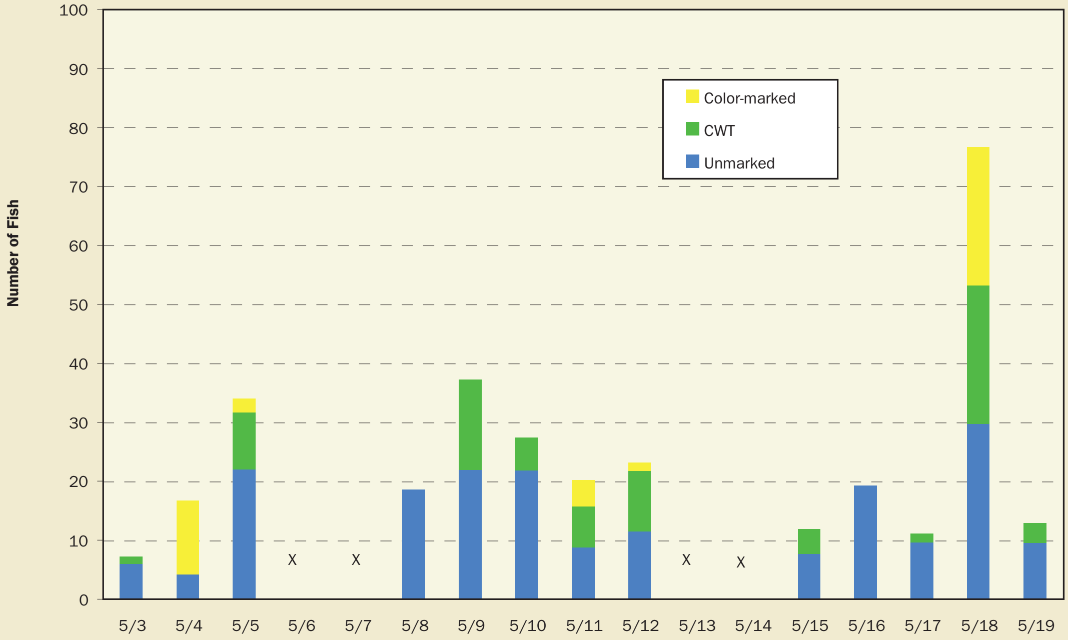
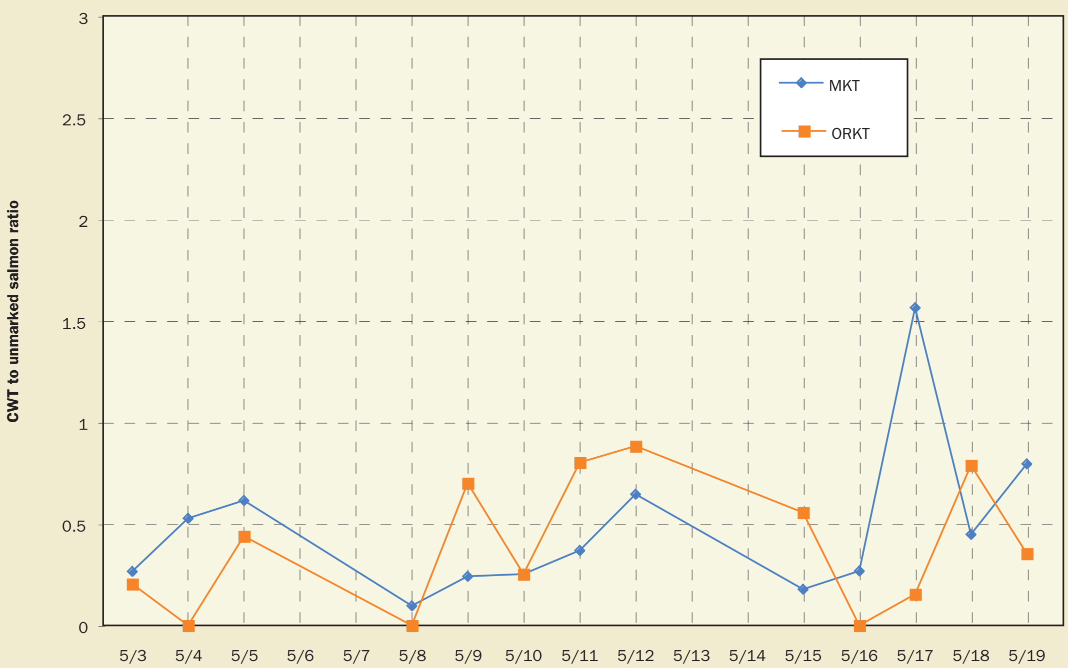


Figure 4-9
The ratio of CWT salmon to unmarked salmon caught in the Old River Kodiak trawl (ORKT) on Old River and the Mossdale Kodiak trawl (MKT) on the San Joaquin River, 2006.



River. The daily ratio of CWT salmon to unmarked salmon was similar between the ORKT and MKT (Figure 4-9). The daily ratios of CWT to unmarked salmon were converted to percentages (percent of the combined CWT and unmarked catch) and arcsine transformed before testing whether there was a significant difference between the ORKT and MKT. A paired two-tailed t-test (df = 12, P = 0.45, t statistic = 0.78) indicates no significant difference between the daily percent of CWT salmon caught in the ORKT and in the MKT.

Two different methods were used to calculate five-hour daily salmon abundance estimates in the San Joaquin River and Old River. These abundance estimates were used to estimate the percent of salmon migrating down Old River from the San Joaquin River. The abundance method based on flow (Af) is calculated by multiplying salmon density, calculated from the Kodiak trawl, by river flow and trawling duration (equation 1). The abundance estimate based on vulnerability (Av) is calculated by dividing the daily catch by the vulnerability estimate and standardizing the tow duration to 20 minutes (equation 2). For both methods, the 5 hour abundance estimates were standardized to 15 tows (5 hours of sampling) before they were compared to one another.

Equation 1:

$$A_f = \sum_{i=1}^{n} D_i * F_i * T_i$$

A_f = Abundance estimate based on flow and density
D = fish density (fish/m^3)
F = river flow (m^3/s) during sampling
T = trawling duration (s)
i = i^{th} tow
n = last tow with fish

Equation 2:

$$A_v = \sum_{i=1}^{n}(C_i/V)/(T_i/20)$$

A_v = Abundance estimate based on vulnerability
C = catch of Chinook salmon
V = vulnerability
T = tow duration (min)
i = i^{th} tow
n = number of tows

where:

$$V = \sum_{i=1}^{N}(Y_i/X_i)/N$$

V = vulnerability
Y = number of color-marked fish recaptured
X = number of color-marked fish released
N = number of releases
i = i^{th} release

The color-mark releases suggest the MKT flow abundance estimates were underestimating salmon abundance by one third and the ORKT flow abundance estimates were underestimating salmon abundance by one sixth (Table 4-4). Overall, the vulnerability abundance estimates were much higher than the flow abundance estimates, especially for Old River. Based on the flow method, on a daily average, 31 ± 29 % of the unmarked salmon, 32 ± 37 % of the CWT salmon, and 21 ± 11 % of the Mossdale released color-marked salmon estimated to be in the San Joaquin River migrated down Old River. Based on the vulnerability method,

Table 4-4
Color-marked salmon vulnerability results for the Mossdale and Old River Kodiak trawls. The catch in parenthesis for the Mossdale releases indicates the number of salmon caught by the ORKT. Abundance is the color-marked salmon abundance estimate based on flow method. Percent is how close the abundance estimate is to the actual number of marked salmon released.

				Mossdale Kodiak Trawl			
Date	**Released**	**Tows**	**Minutes**	**Catch**	**Vulnerability**	**Abundance**	**Percent**
5/4/06	4,998	11	220	17 (3)	0.0034	1,261	25%
5/11/06	4,999	13	260	25 (4)	0.0050	1,529	31%
5/18/06	4,990	4	80	25 (8)	0.0050	1,774	36%
Average	4,996			22 (5)	0.0045	1,521	30%
				Old River Kodiak Trawl			
Date	**Released**	**Tows**	**Minutes**	**Catch**	**Vulnerability**	**Abundance**	**Percent**
5/4/06	1,997	7	140	4	0.0020	296	15%
5/11/06	1,978			0		0	
5/18/06	1,989	5	100	5	0.0025	315	16%
Average	1,988			4.5	0.0023	203	15%

85 ± 87 % of the unmarked salmon, 78 ± 94 % of the CWT salmon, and 43 ± 17 % of the Mossdale released color-marked salmon estimated to be in the San Joaquin River migrated down Old River.

Flow data for the head of Old River (OH1) and San Joaquin River below Old River near Lathrop (SJL) was obtained from the California Department of Water Resources. Like last year, estimated flow on the San Joaquin River above Old River was calculated by summing flows from OH1 and SJL. From May 3 through May 19, river flow was slightly higher down Old River than down the San Joaquin River (Figure 4-10). During trawling, the percentage of water flowing down Old River ranged from 51 % (11,596 cfs) to 57 % (13,651 cfs), and averaged 54 % (12,113 cfs) ± 1 % (193 cfs).

Discussion

Despite high flows on Old River, which delayed the initial start date by two weeks, trawling went reasonably well. The delayed start limited our sampling to 13 days. Overall, the ORKT caught fewer fish and fewer fish species than the MKT. For both trawls, salmon were caught throughout the monitoring period and consisted of least 85 % of the total catch. Statistically, salmon caught in the ORKT were on average larger than salmon caught in the MKT; however, the couple of millimeter difference in length is probably not biologically significant and should not affect the catch comparison between trawls. Very few of the VAMP CWT salmon released at Mossdale were caught by either Kodiak trawls. The Mossdale VAMP releases were intentionally delayed to mid afternoon to avoid their capture by the Kodiak trawls. Interestingly, half of the CWT salmon caught by the ORKT were fish released for the Lower Merced River Survival Studies on April 26. These CWT salmon were caught throughout the two and half weeks of sampling in Old River.

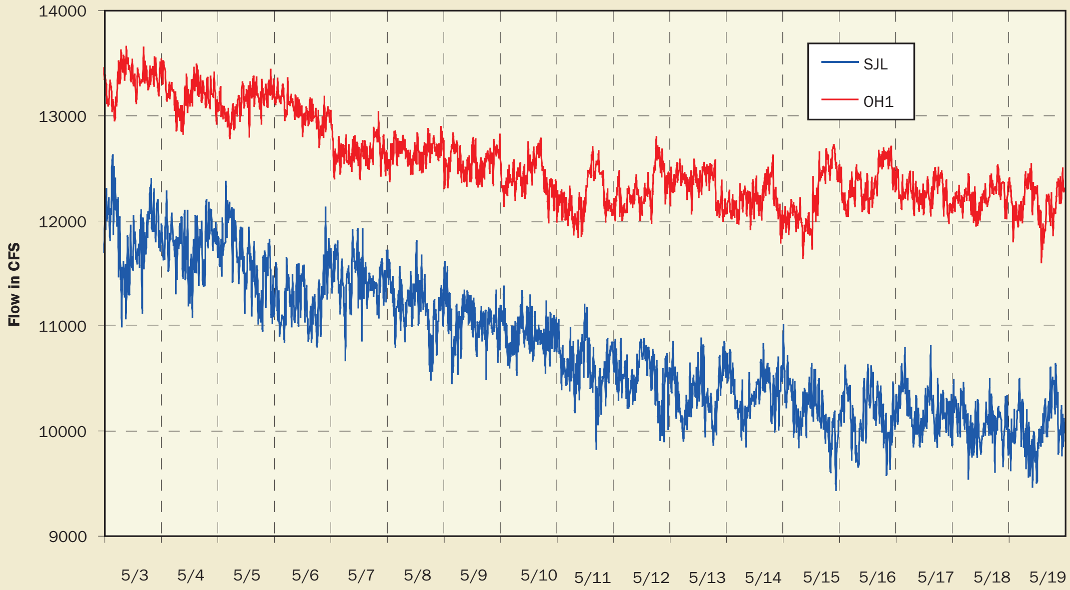
Direct comparisons between ORKT and MKT are difficult for a variety of reasons. Biases that can affect catch include the habitat (channel width, depth, and flow are not the same between and within the sample sites); the sporadic and uneven distribution of migrating salmon; boat and crew differences affecting how the Kodiak net is towed; and MKT and ORKT flow meters might have different calibrations which would effect water volume calculations. Using the ratio of CWT to unmarked salmon in each trawl minimizes some of these biases and other sampling differences. Although abundance estimates are calculated for both the Old and San Joaquin River, they will only be used to provide general insights to salmon migration into Old River.

The daily ratio of CWT to unmarked salmon was similar between the San Joaquin River and Old River. Like last year, CWT and unmarked salmon were migrating proportionally down Old River at the same rate. It appears the marking and subsequent release of CWT salmon in the tributaries does not affect their outmigration relative to the unmarked fish when they reach the Delta. However, there might be a difference for in-Delta releases of color-marked salmon. It appears color-marked salmon migrate down Old River at a lower rate overall than the unmarked and CWT salmon. However, when comparing salmon caught only on the three color-marked release days (May 4,11 and 18), color-marked salmon migrate down Old River at a slightly higher rate than the unmarked and CWT salmon. If color-marked fish

Table 4-5
Salmon abundance estimates in the San Joaquin River and Old River, for a 5 hour period, and the percent migrating down Old River. Abundancde estimates are based on two different methods of calculation: Abundance based on flow (A_f) and abundance based on vulnerability (A_v). Flow is the percent of the San Joaquin River flowing down Old River.

Unmarked Salmon							
	San Joaquin River		**Old River**		**Percent down Old River**		
Date	**A_f**	**A_v**	**A_f**	**A_v**	**Flow**	**A_f**	**A_v**
5/3/06	2,713	8,052	273	1,898	54%	10%	24%
5/4/06	1,163	3,355	189	1,423	53%	16%	42%
5/5/06	1,026	2,684	983	8,601	53%	96%	320%
5/8/06	3,170	9,171	795	6,167	53%	25%	67%
5/9/06	4,124	13,644	931	7,116	53%	23%	52%
5/10/06	4,721	15,433	924	7,591	53%	20%	49%
5/11/06	4,958	15,727	362	2,847	53%	7%	18%
5/12/06	1,385	4,250	480	3,795	54%	35%	89%
5/15/06	737	2,460	312	2,372	54%	42%	96%
5/16/06	2,925	8,947	804	6,167	55%	27%	69%
5/17/06	2,660	9,394	400	2,847	55%	15%	30%
5/18/06	8,450	26,841	1,227	8,065	55%	15%	30%
5/19/06	418	1,342	393	2,847	55%	94%	212%
Average					54%	31%	85%
Std dev					1%	29%	87%
CWT Salmon							
	San Joaquin River		**Old River**		**Percent down Old River**		
Date	**A_f**	**A_v**	**A_f**	**A_v**	**Flow**	**A_f**	**A_v**
5/3/06	724	2,237	56	474	54%	7%	21%
5/4/06	614	1,566	0	0	53%	0%	0%
5/5/06	631	1,789	432	3,345	53%	66%	187%
5/8/06	308	895	0	0	53%	0%	0%
5/9/06	1,001	3,579	652	5,219	53%	63%	146%
5/10/06	1,189	3,802	234	1,898	53%	19%	50%
5/11/06	1,827	5,871	290	2,372	53%	15%	40%
5/12/06	894	2,908	424	3,321	54%	46%	114%
5/15/06	131	447	174	1,423	54%	128%	318%
5/16/06	787	2,460	0	0	55%	0%	0%
5/17/06	4,162	14,539	61	474	55%	1%	3%
5/18/06	3,780	11,631	967	6,167	55%	25%	53%
5/19/06	332	1,118	139	949	55%	40%	85%
Average					54%	32%	78%
Std dev					1%	37%	94%
Color-marked							
	San Joaquin River		**Old River**		**Percent down Old River**		
Date	**A_f**	**A_v**	**A_f**	**A_v**	**Flow**	**A_f**	**A_v**
5/4/06	1,261	3,802	226	1,328	53%	18%	35%
5/11/06	1,529	5,592	173	1,771	53%	11%	32%
5/18/06	1,774	5,592	591	3,542	55%	33%	63%
Average					54%	21%	43%
Std dev					1%	11%	17%

Figure 4-10
Flow at the head of Old River (OH1) and near Lathrop on the San Joaquin River (SJL) during the 2006 Kodiak trawl survey. Flow recorded at 15 minute intervals.



releases were conducted everyday, they would probably show the same range in variability as the unmarked salmon migrating down Old River.

Salmon abundance in the San Joaquin River and Old River was calculated using two different methods. As in 2005, salmon abundance was calculated by multiplying salmon density by river flow and trawling duration. In 2006, abundance estimates were also calculated using the vulnerability results. Salmon abundance estimates for the two different methods gave vastly different results. Therefore, the average daily percentage of salmon calculated to be heading down Old River varied dramatically between the two methods. The color-marked vulnerability studies suggest the ORKT was underestimating salmon abundance to a larger degree than the MKT. The color-marked flow abundance estimates indicate the ORKT was only half as efficient as the MKT in catching juvenile salmon. The flow abundance estimates also tend to underestimate abundance when salmon are not evenly distributed in the water column. The vulnerability estimates likely give a better abundance estimate because they are based on net efficiency and the assumption that color-marked salmon distribute themselves similarly to the unmarked salmon.

The daily percentage of CWT and unmarked salmon heading down Old River is similar on most days. However, there is variability in the percentages among sampling days. Although flow in the San Joaquin River and Old River was relatively constant during the monitoring period, the variability around the mean for salmon migrating down Old River is large. If salmon always migrated in proportion to the flow split, and if we sampled consistently among days, we would expect low variability among the daily percentages of salmon migrating down Old River. The large observed variability could be due to the natural variability in salmon migration compounded by trawling biases and the extrapolated abundance estimate calculations.

As a general insight into salmon migration into Old River, average salmon abundance estimates were compared at different flows for three different years of Kodiak trawling. Based on the 1995, 2005 (San Joaquin River Group Authority 2006) and 2006 salmon abundance estimates for the San Joaquin and Old Rivers, it appears a higher percentage of salmon migrate down Old River at higher flows. When flow on the San Joaquin River upstream of the split was around 8,000 cfs (in 2005), 59 ± 51 % of the salmon went down Old River. At flows around 18,000 cfs (in 1995), 67 ± 13 % of the salmon headed down Old River. At flows around 23,000 cfs (2006), 78 ± 71 % of the salmon went down Old River. It must be noted that there is a lot of variability around the means and the overall relationship is probably not statistically significant. Also, differences in sampling location, sampling procedures and salmon abundance calculations among years contribute additional variability which further confounds the results.

If salmon truly head down Old River at a higher rate at higher flows, then the hydrology in front of the split with Old River might be a contributing factor. At higher flows, it appears the main current in the San Joaquin River is pushed towards the western bank and down Old River. As observational evidence, on May 4, 2006, while trawling in Old River, we noticed a steady ribbon of water hyacinth floating with the current. At the end of the day, on our trip back to the Mossdale boat ramp, we noticed that all the water hyacinth was heading down Old River and nothing was continuing down the San Joaquin River. The continuous ribbon of hyacinth revealed that the bend in the San Joaquin River, just upstream of the head of Old River, pushed the main current to the western side of the river and straight down Old River. Anything floating with the main current or west of the main current went down Old River.

Summary

Salmon were the most abundant species caught during the 13 days of Kodiak trawling in the San Joaquin River and Old River. Five-hour salmon abundance estimates were calculated for each river using two different methods. It appears abundance estimates based on vulnerability gives a better estimate than those based on density and flow. On an average daily basis, it appears about three-quarters of the salmon in the San Joaquin River migrated down Old River. During this time period, a little more than half of the San Joaquin River flow was heading down Old River. Although the daily variability in the data is large, it appears that in May 2006, salmon were going down Old River at a higher rate than water flow. The hydrology at the San Joaquin River and Old River split might be a contributing factor for increased salmon migration down Old River at higher flows. Any salmon following the main current will probably head down Old River. More research into the hydrology of this area will provide better insights into salmon migration down Old River.

Chapter 5
Salmon Smolt Survival Investigations

One of the primary objectives of the VAMP study, in addition to providing enhanced protection of juvenile Chinook salmon emigrating from the San Joaquin River system, is to determine the effects of San Joaquin River flows, SWP and CVP water exports, and HORB placement on survival of Chinook salmon smolts emigrating from the San Joaquin River through the Delta. As mentioned in previous chapters, the HORB was not installed in 2006. Therefore the VAMP study design was modified in 2006 to accommodate this change. This section describes the methods used to conduct the Chinook salmon smolt survival investigations and provides calculated survival indices, absolute survival estimates, and combined differential recovery rates for coded-wire tagged (CWT) Chinook salmon smolts released during the VAMP 2006 test period.

Merced River Fish Hatchery Coded-Wire Tagging

Merced River Fish Hatchery (MRH) supplied 200,000 CWT Chinook salmon smolts for the VAMP 2006 study. This was lower than requested due to lower than average adult returns to the hatchery and use of many of the MRH fish available for tributary studies. Salmon were coded wire tagged and marked with an adipose fin clip by a private contractor in March and April. Groups of fish were generally held separately by tag code, for approximately 27 days before release. Salmon were tagged with one of eight distinct tag codes. MRH examined sub-samples of tagged salmon to obtain estimates of mean size at release and CWT retention rates. CWT retention is typically high and all salmon from the sub-samples without a detected tag were sacrificed to verify the accuracy of the CWT detection process and to determine if these fish contained an undetected, non-magnetized tag. No sub-sampled fish were found to contain non-magnetized tags. Average tag retention documented by MRH was 97% and ranged from 94% to 100% (Table 5-1).

California Department of Fish and Game (Region 4) calculated the effective number released (ER) by tag code by first subtracting the pond loss at the hatchery (HL) from the total number tagged (TM) to obtain the hatchery release number (HR) (Table 5-1). Mortalities from the quality control (QCL), loading (LL) and transporting (TL) processes were then subtracted from the HR to obtain the number released at the site (SR). The number released at the site (SR) was then corrected for the tag retention rate (TRR) to obtain the number of fish with tags released at the site (ST). Finally, the fish with tags in the net pens (PT) that were sacrificed were subtracted from the site release with tags (ST) to obtain the effective release number (ER). The following formula restates how the effective number of fish released in each VAMP group was calculated.

HR= TM-HL

SR = HR – QCL –LL – TL

ST = SR* TRR

ER = ST-PT

VAMP Fish Releases

CWT salmon were released at three sites on five dates for the 2006 VAMP experiment (Table 5-2). CWT salmon with different tag codes were held separately at the hatchery and trucked in discrete tag lots to each release location. Releases occurred at Mossdale, Dos Reis, and Jersey Point for the first set of releases and at Mossdale and Jersey Point for the second set of releases. Transport and water temperatures at the time of release are listed in Table 5-2. The mean size of the fish released in each of the VAMP groups is also shown in Table 5-2.

Mossdale is located on the San Joaquin River upstream of the Head of the Old River (HOR)(Figure 1-1). For the first release, approximately 50,000 CWT salmon with two different tag codes were released at Mossdale. For the second release approximately 75,000 CWT salmon with three different tag codes were released at Mossdale.

Dos Reis is located downstream of the HOR (Figure 1-1), and was used as a release site in 2006 to help assess the mortality of marked salmon from the Mossdale release diverted into Old River. Just over 25,000 CWT salmon of one tag code were released during the first release. No releases were made at Dos Reis during the second set of releases.

Two releases of approximately 25,000 each were made at Jersey Point with one tag code per release. CWT salmon were released on a flood tide at Jersey Point to increase fish dispersion throughout the channel before they migrated downstream past Antioch and Chipps Island (recovery

Table 5-1
Chinook Salmon Smolt Release Data for VAMP, 2006

Release Site	CWT Code	Release Date	Total Marked TM	Mortalities Hatchery Loss (HL)	Hatchery rel. (HR)	Quality Control (QCL)	Load (LL)	Transport/ Plant (TL)	# Released at Site (SR)	Retention (TRR)	# Released at Site with tags (ST)	Fish in net pens w/ tags (PT)	Effective Release (ER)
Mossdale	06-47-13	5/4/06	25,992	92	25900	32	21	2	25,845	0.97	24,946	243	24,703
Mossdale	06-47-14	5/4/06	25,841	92	25749	34	27	3	25,685	0.96	24,534	219	24,315
Dos Reis	06-47-16	5/5/06	26,018	61	25957	25	27	1	25,904	1.00	25,904	302	25,602
Jersey Point	06-47-15	5/8/06	27,240	90	27150	30	23	3	27,094	0.98	26,417	225	26,192
Mossdale	06-47-21	5/19/06	25,917	49	25868	29	1	1	25,837	0.98	25,320	215	25,105
Mossdale	06-47-22	5/19/06	25,996	58	25938	38	6	1	25,893	0.94	24,225	217	24,008
Mossdale	06-47-23	5/19/06	25,765	43	25722	28	4	2	25,688	0.99	25,303	237	25,066
Jersey Point	06-47-24	5/22/06	25,941	51	25890	26	636	0	25,228	1.00	25,102	197	24,905
									Average	0.97			

Table 5-2
Chinook salmon smolt release data for VAMP 2006.

Release Date	Release Site	Tag Code	Effective Number Released	Size at release (in mm)	Transport Temperature (F)	River Temperature (F)
Release 1						
4-May-06	Mossdale	06-47-13	24703	80	53	64
4-May-06	Mossdale	06-47-14	24315	77	53	64
5-May-06	Dos Reis	06-47-16	25602	79	53	64
8-May-06	Jersey Point	06-47-15	26192	80	53	66
Release 2						
19-May-06	Mossdale	06-47-21	25105	89	55	67
19-May-06	Mossdale	06-47-22	24008	88	55	67
19-May-06	Mossdale	06-47-23	25066	89	55	67
22-May-06	Jersey Point	06-47-24	24905	87	55	67

sampling stations). Releases at other locations did not incorporate the tides for determining release times.

During the VAMP period in 2006, San Joaquin River flows were so high that part of the flow was diverted into Paradise Cut (a flood bypass). Paradise Cut flow leaves the San Joaquin River upstream of Mossdale, but downstream of Durham Ferry. To better compare results to other years, when San Joaquin flow was not diverted into Paradise Cut, the upstream release site was changed from Durham Ferry to Mossdale in 2006.

The study design in 2006 was intended to 1) estimate survival between Mossdale and Jersey Point under two different export levels and 2) determine if there was a difference in survival for smolts released at Mossdale versus those released at Dos Reis. The group released at Mossdale would have some of the group presumably diverted into upper Old River while those released at Dos Reis would generally stay on the mainstem San Joaquin River. Two sets of releases were made at Mossdale and Jersey Point to measure survival through the Delta at two exports levels, under similar and high San Joaquin River flow levels (approximately 25,000 cfs). Average daily exports were targeted to be 1500 cfs for the two weeks following the first release at Mossdale and 6000 cfs during the two weeks following the second Mossdale release. The number released for the first Mossdale group was reduced from 75,000 to 50,000 to provide 25,000 fish to be released at Dos Reis. It was anticipated, even with the low release numbers, that recovery numbers would be sufficient from both Mossdale and Dos Reis since survival has been relatively high in the past during similar high flow years. With the anticipation that survival might be lower under higher exports the Mossdale release numbers were kept at 75,000 for the second Mossdale release resulting in no Dos Reis release during the second set of releases.

Water Temperature Monitoring

Water temperature was monitored during the VAMP 2006 study using individual computerized temperature recorders (e.g., Onset Stowaway Temperature Monitoring/Data Loggers). 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-1and C-2). As part of the 2006 VAMP monitoring program additional temperature recorders were deployed in the south and central Delta (Appendix C-1) to provide geographic coverage for characterizing water temperature conditions while juvenile salmon emigrate from the lower San Joaquin River through the Delta.

Water temperature was recorded at 24-minute intervals throughout the period of the VAMP 2006 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. These temperature recorders were later transported with the juvenile salmon released at Mossdale (Appendix C-1).

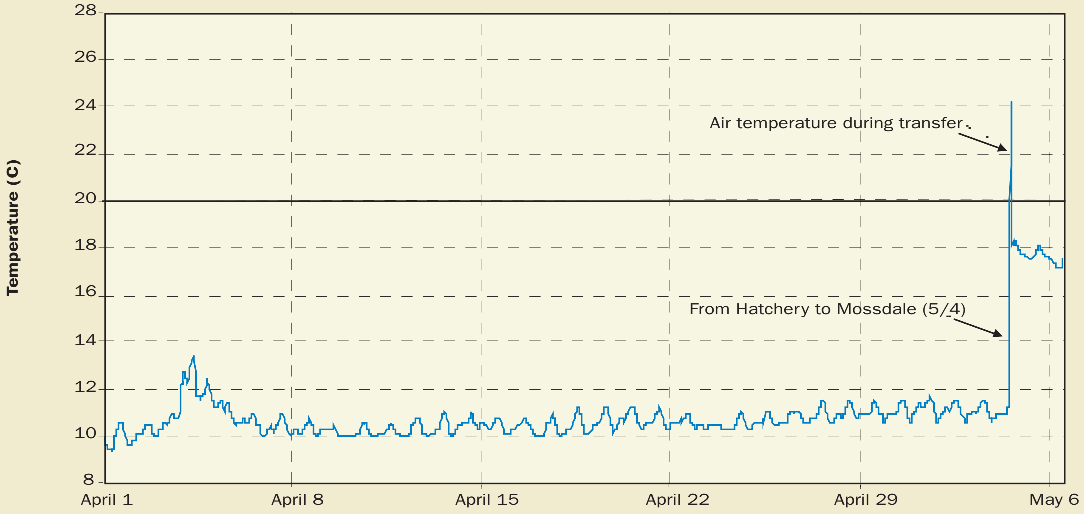
Results of water temperature monitoring within the MRH showed that juvenile Chinook salmon were reared in, and acclimated to, water temperatures of approximately 10°- 12° C (50° - 54° F) prior to release into the lower San Joaquin River (Figures 5-1 and 5-2). Results of water temperature monitoring at Durham Ferry, Dos Reis, 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. The water temperature logger deployed at the Mossdale release site could not be relocated and may have been lost to vandalism. 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, which is usually always the case. Water temperatures measured within the lower San Joaquin River and Delta (Figures 5-4 and 5-5; Appendix C-2) generally increased over time and may have reduced survival of emigrating juvenile Chinook salmon released as part of the VAMP 2006 investigations.

Short-Term Survival Study

A short term survival study was conducted as part of VAMP to determine if handling, transport, and release affected immediate (short-term) and 48-hour survival and general condition. A subset of approximately 225 CWT salmon were removed from the MRH truck and placed in net pens (volume ~ 1m^3; mesh size ~3 mm) before the remaining fish were released. Samples from each tag group were held in separate net pens.

Once placed into the pens, sub-samples of 25 fish from each pen were examined for swimming vigor then euthanized for measuring and documenting general condition. Each fish was measured (fork length to nearest 1 mm), weighed (to the nearest 0.1 g) and examined qualitatively in the field for percent scale loss, body color, fin hemorrhaging, eye quality, and gill coloration. Table 5-3 identifies the criteria used to define normal and abnormal conditions for these characteristics. Additionally, quality of adipose fin clip was documented. The sub-sampled fish were taken to the U.S. Fish and Wildlife Service, Stockton office (STFWO), for verification of tag code. After 48-hours post release, an additional 25 fish from each pen were measured, weighed, and examined for condition, as

Figure 5-1
Water Temperature Monitoring Merced River Fish Hatchery to Mossdale



5-2
Water Temperature Monitoring Merced River Fish Hatchery to Mossdale

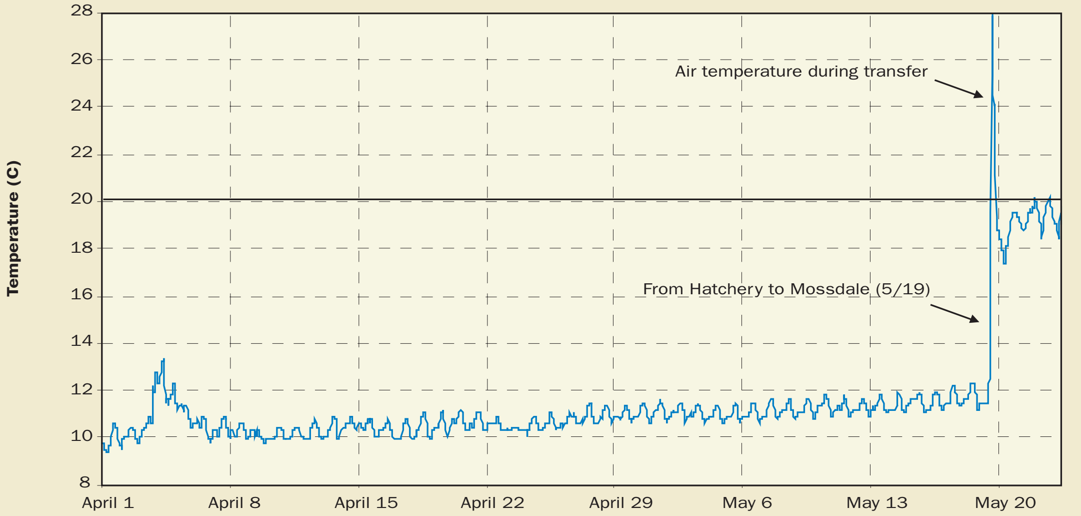


Figure 5-3
Water Temperature Monitoring Site 1 - Durham Ferry

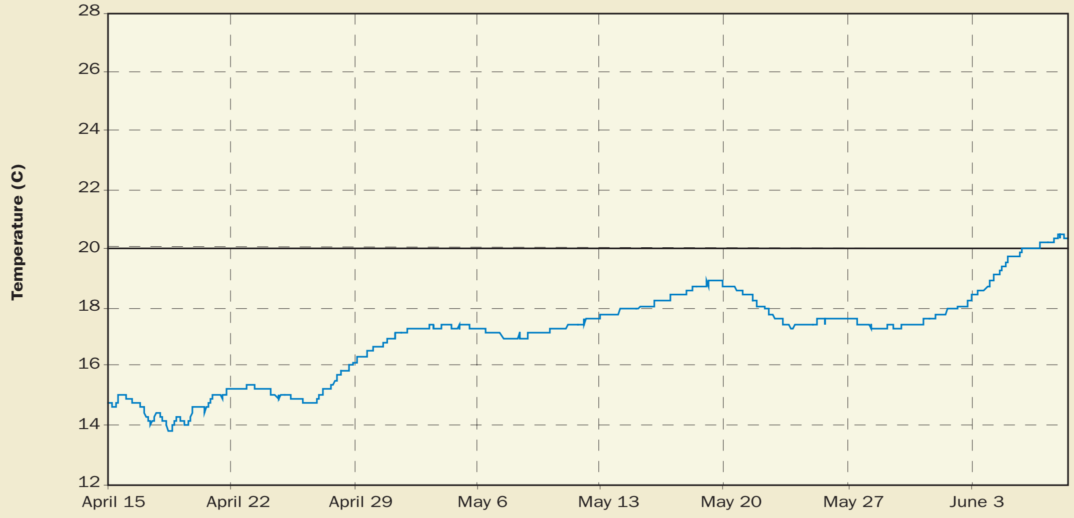


Figure 5-4
Site 3 - Dos Reis Water Temperature Monitoring

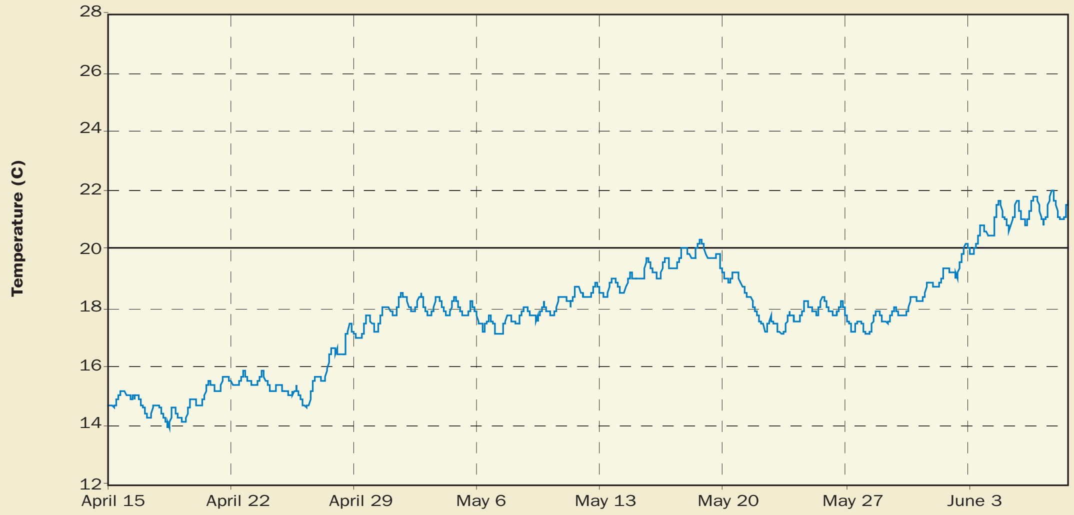


Figure 5-5

Site 10 - Chipps Island Water Temperature Monitoring

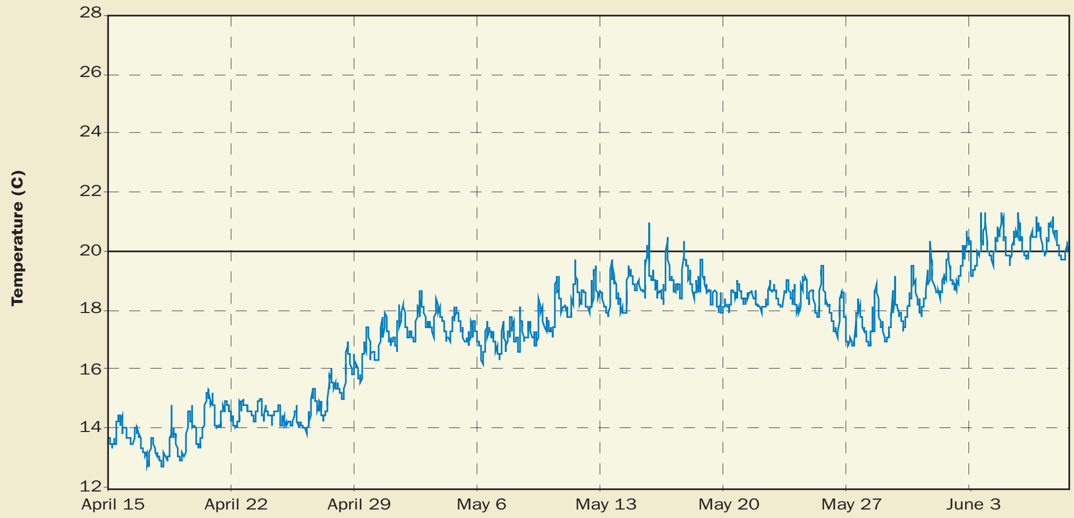


Table 5-3 Characteristics assessed for Chinook salmon smolt condition and short-term survival.		
Character	**Normal**	**Abnormal**
Percent Scale Loss	Lower relative numbers based on 0-100%	Higher relative number based on 0-100%
Body Color	High contrast dark dorsal surface and light sides	Low contrast dorsal surface 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)

described above. The remaining fish from each pen were examined for mortalities, euthanized, counted, measured, weighed, and returned to the STFWO for additional tag code verification.

Sub-samples of fish in the net pens immediately after release were generally in good condition (Appendix C-3a). All fish were swimming vigorously before being euthanized. Mean scale loss ranged from 3% for the second Mossdale release to 7% for the second Jersey Point release (average of all locations = 5.5%). Body color and gill color were normal for all fish examined except the second Jersey Point release. These fish were held for an additional 2 hours in the truck due to a flat tire; subsequently, body and gill color appeared pale. Fin hemorrhaging was observed in 4% of fish from the first Mossdale and second Jersey Point releases. Partial fin clips were observed at all sites and ranged from 8% to 16%.

Short-term survival (48-hours post-transport) was high (100%) within the net pens. Fish retained in the net pens for the 48-hour post release examination were swimming vigorously and generally in good condition (Appendix C-3b). Mean scale loss was (7%) and ranged from 5% to 12.5% after each of the 48-hour trials. Fish from all releases, except the second Jersey Point release had fin hemorrhaging. Fin hemorrhaging ranged from 4% to 16%. Fish from the second Jersey Point release had a high occurrence of abnormal body color (84%). No abnormal eye quality was detected in any fish. Pale gills were detected in 3% of fish from the second Mossdale release and 16% from the second Jersey Point release. No other fish had abnormal gill coloration. These data indicate that the fish used for the VAMP 2006 experiment were in good condition both initially and after 48 hours; and that handling, transport, and release should not have affected their survival.

Tag code discrepancies were found to have occurred between two tag codes used in the second set of releases; one of the mixed tag codes (06-47-23) was from the Mossdale release (May 19th), and the other was from the May 22nd Jersey Point release (06-47-24). The mixing was discovered when one of the 25 fish from the Mossdale net pen had a tag code associated with the Jersey Point release. To further evaluate the extent of the mixing, all fish kept from each of eight net pens were dissected to obtain the tags and identify tag codes. For the one Mossdale net pen, a total of 7 fish out of 212 contained tags with the Jersey Point tag code (06-47-24). For the Jersey Point net pen group, 32 of 222 were found to have a Mossdale tag code (06-47-23). In further discussion with Fish and Game it was determined that the mixing occurred when a screen at the hatchery was changed that separated the tag groups in the raceway. There was no evidence of mixing in the remaining six tag codes.

Health and Physiology

On April 25 2006, a subsample of 60 CWT juvenile Chinook salmon from tagged lots used in the 2006 VAMP study, were brought from the MRH to the U.S. Fish and Wildlife Service California-Nevada Fish Health Center (CA-NA FHC). Kidneys from these fish were collected aseptically for viral assay, culture of systemic bacteria and imprint smears to determine if *Renibacterium salmoninarum* was present. Posterior kidney from 20 salmon was processed to evaluate *Tetracapsuloides bryosalmonae* infection and kidney inflammation. This parasite has been detected in Merced River salmon for several decades (Hederick et al., 1986) and causes Proliferative Kidney Disease (PKD). A total of 14 of 60 kidney imprints contained low numbers of bacteria that resembled *R. salmoninarum*. While the fish were asymptomatic for Bacterial Kidney Disease (BKD), the 23% detection rate indicates that MRH juvenile Chinook contained a high number of *R. salmoninarum* infected fish. *R. salmoninarum* infections have been documented for MRH Chinook juveniles in previous years. It is unclear whether such infection later develops into clinical disease and is a health problem for the population.

In addition to examining MRH 2006 VAMP salmon prior to release, selected salmon recovered at Chipps Island were also examined for the presence of PKD. A subsample of 407 adipose fin clipped Chinook juveniles were collected in the Chipps Island trawl between 5 May and 18 June 2006. Kidney samples were collected from these fish by field personnel from the Stockton Fish and Wildlife Office. Imprints from 66 of these fish, which contained tags with VAMP tag codes, were screened for *T. brysalmonae*. The parasite *T. brysalmonae* was not detected in Chipps Island imprints, however, a number of imprints were observed to have been improperly fixed. If kidney imprints are collected in the future, it may be necessary to use rapid methanol fixation or provide additional training to field personnel. Based on the inability to detect *T. brysalmonae* in both histological and cytological sample types, this strongly suggests that the MRH juvenile Chinook population was not infected in 2006. A full report is available in Foott and Stone (2006).

Release Number Correction

The release number for the 2nd Jersey Point group has been corrected because of the tag code mixing at the hatchery, explained above. Information from the mixed Mossdale tag lot (6-47-23 tag code) has not been used for any analyses in this report. Only the two unmixed Mossdale tag codes were used from the 2nd release. We have corrected the Jersey Point release number based on the assumption that the proportion of those mixed in the total group is the same as the proportion mixed in the net pens. Without this assumption, there is no basis for correcting the release numbers. While this assumption is reasonable, there is no way of testing it.

The number of fish actually released at Jersey Point with a 6-47-24 tag code was estimated by subtracting those with the same tag code that were mistakenly released at Mossdale (925) from the effective release number (Table 5-4). We have assumed that the estimated number of survivors to Jersey Point (19) of the 925 released at Mossdale would have a negligible effect on our estimates of survival or recovery rate. The number of survivors was estimated by multiplying the number estimated to be released at Mossdale (925) by the survival rate to Jersey Point of the other (two unmixed) Mossdale tag groups released on the same day (Table 5-4). The estimated number of 06-47-24 tags released at Mossdale was obtained by multiplying the effective release number of the Jersey Point group (06-47-24) by the proportion of the tag code in the Mossdale net pen relative to the total in both net pens (Jersey Point and the one mixed Mossdale net pen). Numbers were standardized so that equal weight was given to both net pens, although due to rounding this adjustment did not change the number of tags estimated (7) with a 6-47-24 code in the Mossdale net pen. The proportion (0.0371) of 06-47-24 tags in the Mossdale net pen was estimated by dividing the standardized number found in the Mossdale net pen (7) by the standardized total in both net pens (197). The corrected effective release (CER) of the 06-47-24 tag code released at Jersey Point was estimated at 23980.

Coded-Wire Tag Recovery Efforts

Coded-wire tagged salmon were recaptured at Old River, Mossdale, Antioch, Chipps Island, and the Federal (Central Valley Project (CVP)) and State Water Projects (SWP) (Figure 1-1). CWT salmon recovered in California Department of Fish and Game (DFG) Kodiak trawls at Old River and Mossdale are discussed in Chapter 4. Juvenile Chinook salmon with an adipose fin clip caught at Antioch, Chipps Island and at the CVP and SWP fish facilities were sacrificed, labeled, and frozen for CWT processing by staff at Stockton Fish and Wildlife Office. DFG Region 4 staff processed CWT fish from Old River and Mossdale.

Table 5-4
Calculations to correct tag code mixing between 6-47-23 and 6-47-24 for VAMP studies in 2006

Net Pen Location	Net Pen Total	CWT Code 06-47-23	CWT Code 06-47-24	Percentage 6-47-23 in Net Pen at Mossdale
Mossdale	212	205	7	96.70%
Adjusted net pen sample Mossdale	222	215	7	
Jersey Point	222	32	190	
CWT Code	**Number in Tag Code**	**Proportion of Tag Code Released at JP**	**Proportion of Tag Code Released at Moss**	
06-47-24	24905	0.9629	0.0371	
CWT Code	**Estimated Number Released at Mossdale**	**Corrected Number Released at JP CE**	**Estimated Survival Mossdale to JP**	**Mossdale Release Fish Surviving to JP**
06-47-24	925	23980	2%	19

CWT processing consists of dissecting each tagged fish to obtain the 1-mm cylindrical tag from the snout. Tags are then placed under a dissecting microscope and the numbers are read and recorded in a database and archived. All tags were read twice, with any discrepancies resolved by a third reader. It should be noted that many CWT Chinook salmon are captured during the VAMP study; however a portion of these fish have been tagged for other studies and are not affiliated with the VAMP study. In order to identify tags related to VAMP, it is necessary to read all recovered tags.

Antioch Recapture Sampling

Fish sampling was conducted in the vicinity of Antioch on the lower San Joaquin River (Figure 1-1) using a Kodiak trawl, similar to previous years (since 2000). The Kodiak trawl has a graded stretch mesh, from 2-inch mesh at the mouth to 1/2-inch mesh at the cod-end. Its overall length is 65 feet, and the mouth opening is 6 feet deep and 25 feet wide. The net was towed between two skiffs, sampling in an upstream direction. Trawls were performed near the left bank, mid-channel, and right bank to sample CWT salmon emigrating from the San Joaquin River. Each sample was approximately 20 minutes in duration.

All captured fish were transferred immediately from the Kodiak trawl to buckets filled with river water, where they were held for processing. Data collected during each trawl included: species identification and fork length for each fish captured, tow start time and duration, and location in the channel. Any fish mortalities or injuries were documented to comply with the Endangered Species Act permit requirements. Juvenile Chinook salmon with an adipose fin clip were retained for later CWT processing while other fish were released at a location downstream of the sampling site immediately after identification, enumeration, and measurement.

Sampling at Antioch each day between 5:30 a.m. and 9:00 p.m. began May 5 and continued through May 31. In all, 680 Kodiak trawl samples were collected, for a total of 13,520 tow minutes. During sampling, 3,147 unmarked juvenile Chinook salmon were captured; 110 salmon with a coded wire tag were collected: 52 from VAMP releases (Table 5-5) and 57 from other hatchery releases. In addition, 59 delta smelt, 8 unmarked steelhead, and 8 adipose fin clipped steelhead were caught during sampling.

Chipps Island Recapture Sampling

Recovery efforts at Chipps Island were conducted using a mid-water trawl towed at the surface. The trawling net is 82 feet in length and has an opening that is 30 feet wide by 10 feet deep. Mesh size of the net is variable and ranges from 4-inch mesh at the mouth to 5/16-inch mesh at the cod end.

For VAMP 2006 trawling was conducted during two time periods per day, seven days per week from May 5, 2006 through June 17, 2006. Greater recoveries of Chinook salmon smolts have been reported during sunrise and sunset (Hanson Environmental, unpublished data).

Table 5-5
Chinook salmon smolt recovery information at Antioch, Chipps Island, and the fish facilities for VAMP 2006 releases.

				Antioch Recoveries						
Tag Code	**Release Site**	**Release Date**	**Corrected or Effective Release number**	**First Day Recovered**	**Last Day Recovered**	**Number Recovered**	**Recovery Effort (minutes sampled)**	**Percent of Time Sampled**	**Survival Index**	**Group index**
06-47-13	Mossdale		24,703	5/10/06	5/10/06	5	580	0.403	0.036	
06-47-14	Mossdale		24,315	5/11/06	5/16/06	4	3255	0.377	0.031	
	Total	**5/4/06**	**49,018**	**5/10/06**	**5/16/06**	**9**	**3835**	**0.380**		**0.035**
06-47-16	Dos Reis	5/5/06	25,602	5/10/06	5/12/06	3	1760	0.407	0.021	
06-47-15	Jersey Point	5/8/06	26,192	5/8/06	5/13/06	26	3245	0.376	0.190	
06-47-21	Mossdale		25,105	–	–	0	0	0.000	–	
06-47-22	Mossdale		24,008	–	–	0	0	0.000	–	
~~06-47-23~~	~~Mossdale~~		~~25,066~~	~~5/24/06~~	~~5/24/06~~	~~1~~	~~580~~	~~0.403~~	~~0.007~~	
	Total	**5/19/06**	**49,113**			**0**	~~**580**~~	~~**0.403**~~		**0.000**
06-47-24	Jersey Point	5/22/06	23,980	5/22/06	5/29/06	14	4160	0.363	0.116	

Mossdale group (6-47-23 tag code) not used in the analyses.

Therefore, the first shift began during sunrise and the second shift was completed during sunset in an attempt to increase the recovery of Chinook salmon smolts and reduce the variability in calculated survival indices and recovery rates. Two shifts a day have been conducted during the VAMP period since 1998. Each shift consisted of ten 20-minute tows conducted in the north, middle, and south sections of the channel parallel to the shore. Generally, three tows are conducted in each section of the channel with the section of the channel selected randomly for the last tow. After six weeks, the majority of VAMP Chinook salmon smolts have migrated past Chipps Island, so sampling was subsequently reduced. Ten morning tows were continued seven days per week between June 18 and June 24; and three days per week after June 25.

All fish retained in the cod end of the net were placed in aerated water collected from the sample site. All Chinook salmon smolts with an adipose fin clip were labeled and retained for later CWT processing. All other fish were identified to species, enumerated, and released. The fork length of each individual was measured to the nearest mm. As mentioned previously, some salmon were also processed in the field to determine if *T. bryosalmonae* were present. CWT salmon released for the VAMP 2006 study were recovered from Chipps Island between May 8 and May 29, 2006 (Table 5-5). A total of 53 juvenile Chinook salmon with tag codes used in the VAMP 2006 study were recaptured at Chipps Island; the majority being released at Jersey Point.

During this same time period, the catch included 10,695 unmarked Chinook salmon; 944 CWT Chinook salmon from non-VAMP studies; 179 delta smelt; 80 Sacramento splittail; 6 marked steelhead; and 12 unmarked steelhead.

CVP and SWP Salvage Recapture Sampling

CVP and SWP fish facilities salvage fish on a continuous basis. To estimate the total number of fish salvaged, sub-samples (raw salvage) are collected approximately every two hours. Expanded salvage is a calculated by expanding the raw salvage by the time sampled and provides an estimate of the total number of fish salvaged. Expanded salvage does not take into account the loss of Chinook salmon smolts at the facilities from pre-screen predation, screening, handling, and trucking. Raw and expanded CVP and SWP salvage estimates are reported in Table 5-5.

During VAMP 2006, salvage and expanded salvage was very low. This result is surprising in that the HORB was not installed which has in the past increased the number of CWT salmon observed in salvage (Brandes and McLain, 2001).

Transit Time

Recoveries of VAMP 2006 smolts were made at Antioch between May 10 and May 29 and at Chipps Island between May 8 and May 29 (Appendix C-4). Recoveries were made at the CVP and SWP fish facilities between May 4 and May 19 (Table 5-5); a few days earlier than at the other recovery locations.

Chipps Island Recoveries							Fish Facilities Recoveries Raw Salvage (Expanded Salvage)		
First Day Recovered	Last Day Recovered	Number Recovered	Recovery Effort (minutes sampled)	Percent of Time Sampled	Survival Index	Group index	CVP	SWP	Recovery Days
5/8/06	5/18/06	7	4400	0.278	0.133		0	2 (12)	5/4/06
5/11/06	5/12/06	2	800	0.278	0.038		0	1 (6)	5/4/06
5/8/06	**5/18/06**	**9**	**4400**	**0.278**		**0.086**			**5/4/06 - 5/4/06**
5/10/06	5/15/06	7	2400	0.278	0.128		0	0	–
5/9/06	5/16/06	58	3200	0.278	1.036		0	0	–
5/20/06	5/20/06	2	400	0.278	0.037		1 (12)	0	5/19/06
–	–	0	0	0.000	–		1 (12)	0	5/19/06
~~5/20/06~~	~~5/20/06~~	~~2~~	~~400~~	~~0.278~~	~~0.037~~		~~2 (24)~~	~~0~~	~~5/19/06~~
		2	**400**	**0.278**		**0.019**			**5/19/06 - 5/19/06**
5/23/06	5/28/06	44	2400	0.278	0.859		0	0	–

VAMP Chinook Salmon CWT Survival

Survival Indices

Survival indices were calculated for marked salmon released at Mossdale, Dos Reis and Jersey Point and recovered at Antioch and Chipps Island. Survival indices (SI) were calculated using the formula:

$$SI = (R / (ER*T*W))$$

where: R is the number recovered, ER is the effective number released, T is the fraction of time sampled, and W is the fraction of channel width sampled.

The fraction of the channel width sampled at Chipps Island (0.00769) was calculated by dividing the net width (30 feet) by the estimated channel width (3,900 feet). The fraction of the channel width sampled at Antioch (0.01388) was calculated in the same manner, with the net width being 25 feet and the channel width being 1,800 feet. The fraction of time sampled at both locations was calculated based on the number of minutes sampled between the first and last day of catching each particular tag code or group, divided by the total number of minutes in the time period. The fraction of time sampled for the VAMP 2006 release groups at Chipps Island was about 28%, while at Antioch it was about 40% (Table 5-5).

Survival indices were calculated for each tag code to provide a sense of the variability associated with the group survival index. To generate the group survival index, the recovery numbers and release numbers are combined for the tag codes within a release group.

Sampling at Antioch in 2006 was irregular between days (Appendix C-4) and potentially adds noise in estimating survival using the recoveries at Antioch. For instance, if the majority of the Mossdale group moves past Antioch on a day where more sampling occurs relative to the next day when the majority of Jersey Point fish pass, the Mossdale recovery rate would be potentially biased high relative to the recovery rate of the Jersey Point group. However, the timing of the Mossdale and Jersey Point groups past Antioch appears similar enough over the entire recovery period that there is probably no substantial bias however standardizing sampling effort between days could reduce the noise and variance associated with estimating survival (Appendix C-4). We will evaluate this source of noise in 2007.

Chinook Salmon Survival Estimates, and Differential and Combined Differential Recovery Rates

Survival indices are better put into context by evaluating absolute survival estimates and combined differential recovery rates (CDRR). Absolute survival estimates and CDRRs should be more robust for comparing survival between groups and years, since using ratios between upstream and downstream groups theoretically standardizes for differences in catch efficiency between recovery locations and years. As in past years, estimates of both absolute survival and CDRRs were calculated for CWT releases as part of VAMP 2006. The CDRR is similar to calculating absolute survival estimates, but does not expand estimates based on the fraction of the time and space sampled. The Differential Recovery Rate (DRR) is similar to the CDRR but only uses recoveries from one recovery location.

The CDRR and the absolute survival estimates should not be very different as (1) the fraction of the time sampled is similar between groups within a recovery location and (2) the fraction of space sampled at each recovery location is a constant. Neither would change the relative differences between groups. However, combining the recovery numbers from Antioch, Chipps Island and ocean fishery could result in different survival estimates between the two methods.

Absolute survival estimates (AS_i) are calculated by the formula:

$$AS_i = SI_u / SI_d$$

where: SI_u is the survival index of the upstream group (Mossdale or Dos Reis),

SI_d is the survival index of the downstream group (Jersey Point) and

i is either Antioch or Chipps Island.

Although referred to throughout this document as absolute survival estimates they are more aptly described as standardized or relative survival estimates.

The combined differential recovery rate (CDRR) is calculated by the formula:

$$CDRR = CRR_u / CRR_d$$

where: CRR_u is the combined recovery rate for the upstream group (Mossdale or Dos Reis),

CRR_d is the combined recovery rate for the downstream group (Jersey Point).

and the combined recovery rate (CRR) is estimated by the formula:

$$CRR = R_{C+A+O} / ER$$

where: R_{C+A+O} is the combined recoveries at Antioch, Chipps Island and in the ocean fishery of a CWT group,

and ER is the effective release number.

Recoveries are not available from each recovery location for all years so only those that are available have been used. For data obtained prior to 2000, no Antioch recoveries are available and for releases in 2004, 2005 and 2006 no ocean recoveries are available at this time.

This new approach of combining all recoveries to estimate survival was suggested by Dr. Ken Newman, statistician with the USFWS in Stockton. Since recovery rates in the past have been higher in the ocean fishery than in the Antioch and Chipps Island trawls, inclusion of the expanded ocean recoveries decreases the variance of the point estimates.

Standard errors were calculated for the CDRRs based on the Delta method and other methods developed by Ken Newman (K. Newman, personal communication). Plus or minus two standard errors are roughly equivalent to the 95% confidence intervals around the estimate. In comparing survival between reaches, the confidence intervals were used to determine if CDRRs were significantly different from one other. If the 95% confidence intervals overlapped, CDRRs were not considered statistically different from each other. If the 95% lower confidence level was less than zero it was truncated at zero, except in the case of the 95% confidence level around the difference in two point estimates.

Results:

Individual and group survival indices to Antioch and Chipps Island of the CWT salmon released as part of VAMP 2006 are shown in Table 5-5. Survival indices have been reported to three significant digits, but we realize indices are not likely that precise. Survival indices were not corrected for the number of CWT fish recovered in DFG sampling in Old River. Survival indices estimated for smolts released at Mossdale and Dos Reis were relatively low in 2006, especially for the 2nd group released at Mossdale. Jersey Point survival indices were much higher for estimates based on Chipps Island recoveries (1.04 and 0.86 respectively) whereas they were lower when based on Antioch recoveries (0.19 and 0.12).

As in past years, survival indices were higher using the Chipps Island recoveries than when using the Antioch recoveries. Also as in the past, the raw recovery numbers at Chipps Island and Antioch were similar, but once recoveries were expanded for effort, survival indices were much lower at Antioch, indicating that the greater sampling at Antioch is not translating into additional recoveries.

Survival estimates and CDRR's in 2006 are reported in Table 5-6. Survival was generally high between Mossdale and Dos Reis (Figure 5-6), indicating no difference in survival under the low export condition from part of the group being diverted into upper Old River. Survival from Mossdale to Jersey Point was relatively low for both sets of releases, but lower for the second release when exports were higher (Figure 5-7). However the confidence levels around the difference in the point estimates, under the two different export levels, included zero, indicating the difference was not statistically significant at the $p<0.05$ level. (Figure 5-7). While there is general relative agreement between CDRR point estimates based on Chipps Island and Antioch recoveries versus those using the Chipps Island, Antioch and ocean recoveries (next section), the variance generally lessens once the ocean recoveries are incorporated (Figure 5-8). Thus future recoveries in the ocean fishery may increase the precision of the point estimate of the difference between the two test conditions in 2006 such that the 95% confidence interval would no longer include zero and be statistically significant.

Between the first and second release at Mossdale, temperatures at release increased by 3 degrees F (Table 5-2). This increase in water temperature could account for at least part of the differences observed in survival between the two groups. One additional issue, associated with water temperature was the 2 degrees F difference between the first Mossdale and Jersey Point releases, whereas the water temperature at the two locations for the second release was the same (Table 5-2). The lower temperature may have benefited the first Mossdale group and increased its survival somewhat relative to the Jersey

Table 5-6
Absolute survival and combined differential recovery rates (CDRR) for VAMP 2006 releases.

Survival Reach	Release Date	Antioch Absolute survival	Chipps Island Absolute survival	CDRR
First release				
Mossdale to Dos Reis	4-May-06	1.67	0.67	0.94
Mossdale to Jersey Point	4-May-06	0.18	0.08	0.11
Dos Reis to Jersey Point	5-May-06	0.11	0.12	0.12
Second release				
Mossdale to Jersey Point	19-May-06	0.00	0.03	0.02

Figure 5-6
Combined Differential Recovery Rates (CDRR) (+ / -1 and 2 standard errors) of CWT smolts released at Mossdale (M) and Dos Reis (DR) and relative to those released at Jersey Point (JP) for the Dos Reis (DR/JP) and Mossdale (M/JP) first (1), second (2) release groups in 2006.

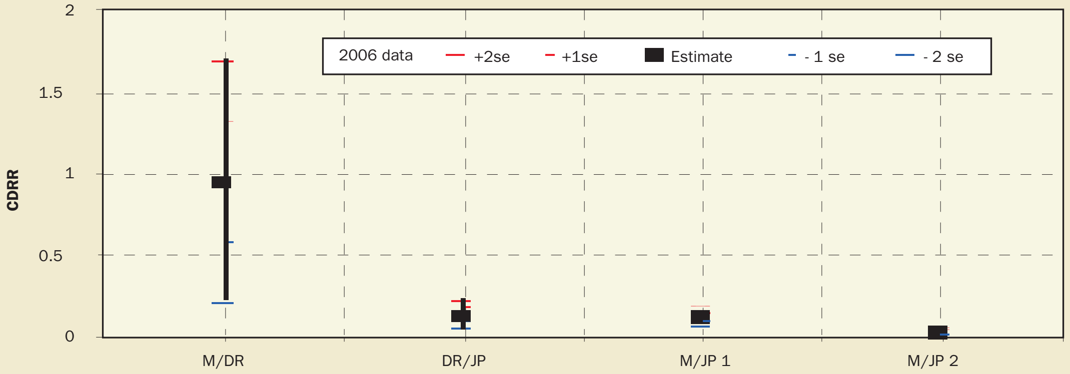


Figure 5-7
Combined Differential Recovery Rates (CDRR) (+ / -1 and 2 standard errors) of CWT smolts released at Mossdale (MD) relative to those released at Jersey Point for the first (1), second (2) release groups and the difference between the 1st and 2nd release groups at Mossdale in 2006.

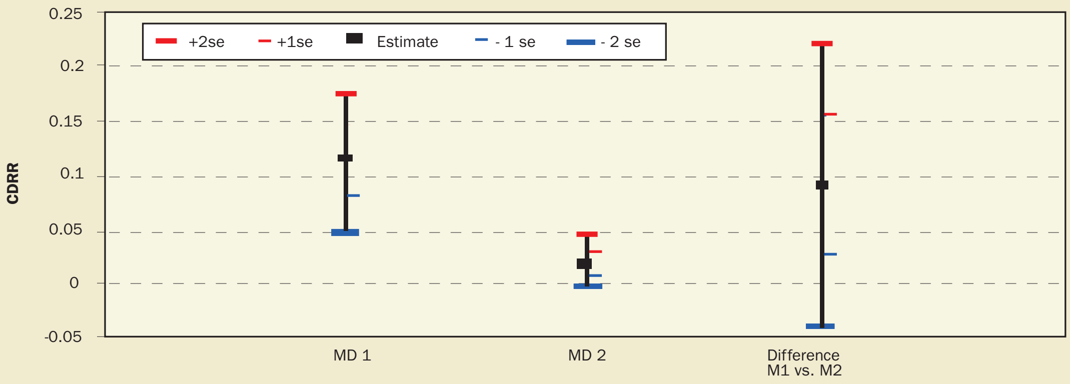
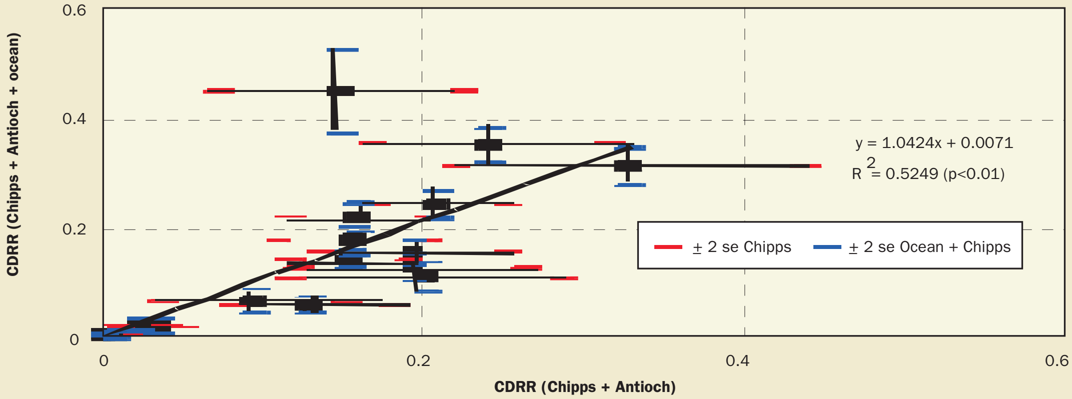


Figure 5-8
CDRR using Chipps Island and Antioch recoveries versus Chipps Island, Antioch and ocean fishery rrecoveries of the Mossdale or Durham Ferry and Jersey Point releases between 2000 and 2003.



Point group. While it is desirable to keep conditions as uniform as possible in these types of experiments, many of the factors are uncontrollable. Switching the export conditions between the two periods (and having the higher export condition first) would help alleviate some of these confounding issues, but due to logistical constraints could not be accommodated during this experiment.

Comparison with 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 2004. 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 2001 and partially available for CWT releases made from 2002 to 2004. 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 5-7. 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 (2000-2004). 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 (r^2=0.76), (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 VAMP releases for recoveries at Antioch, Chipps Island, and the ocean fishery.

Survival by Reach

In this section, Chinook salmon smolt survival in different reaches of the San Joaquin River will be evaluated using several years of data. These analyses help our understanding of survival through the south Delta. Initially, survival in the entire reach (Durham Ferry and Mossdale to Jersey Point) will be discussed. The second reach discussed is from Durham Ferry and Mossdale to Dos Reis. And lastly, the reach between Dos Reis and Jersey Point will be discussed. In this section we will only use CDRR's as our estimate of survival. Combined recoveries from Chipps Island and the ocean fishery are available for releases made between 1985 and 1999, combined recoveries from Chipps Island, Antioch and the ocean fishery are available for releases made between 2000 and 2003 and releases made between 2004 and 2006 only have Chipps Island and Antioch recoveries available.

Survival between Durham Ferry or Mossdale and Jersey Point

Smolt survival between Durham Ferry and Mossdale and Jersey Point has been low since 2003 (Figure 5-10). Even the higher flows in 2005 and 2006 did not increase survival to levels we saw in 2000, when flows were 5700 cfs and the barrier was installed. The survival of the first Mossdale and Dos Reis releases in 2006 appeared higher than for the other years since 2003, although it was not always significantly different at the 95% confidence interval.

The health of the CWT fish in 2006 was relatively good and PKD infection did not seem to be a problem as it may have been in 2003-2005. None of the VAMP fish recovered at Chipps Island had evidence of infection in their kidneys by the parasite that causes PKD in 2006. However, kidney imprints detected some (23%) of the VAMP fish at the hatchery were infected with Bacterial Kidney Disease, although they did not show clinical signs of the desease.

Survival between Durham Ferry and Mossdale

No releases were made at Durham Ferry in 2006 thus comparisons of survival rates between Durham Ferry and Mossdale for this year cannot be made. However, survival between Durham Ferry and Mossdale has been measured from 2000 to 2003 and is generally high using the combined Chipps Island, Antioch and ocean recoveries (Table 5-8). Survival was estimated to be high between Durham Ferry and Mossdale in 2004 using Chipps Island and Antioch recoveries alone. Only one release group in 2002 indicated possible mortality between the two locations but confidence intervals around the two point

Table 5-7
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 2004.

Release Year	San Joaquin River (Merced River Origin) TAG NO.	Release Number	Release Site	Release Date	Chipps Island Recovs.	Antioch Recovs.	Expanded Adult Ocean Recovs. (Age 1+ to 4+) Total	CHIPPS ISLAND	ANTIOCH	DRR or CDRR	OCEAN DRR
		Juvenile Salmon CWT 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 PT	3-May-96	39		186				
	Effective Release	94,870	DOS REIS		10		58	0.120		0.125	0.152
	Effective Release	46,190	JERSEY PT		39		186				
1997	062545	48,973	DOS REIS	27-Apr-97	9		180				
	062546	53,483	DOS REIS	27-Apr-97	7		168				
	062547	51,576	JERSEY PT	2-May-97	27		356				
	Effective Release	102,456	DOS REIS		16		348	0.290		0.298	0.492
	Effective Release	51,576	JERSEY PT		27		356				
	062548	46,674	DOS REIS	8-May-97	5		90	0.300		0.283	0.477
	062549	47,534	JERSEY PT	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 PT	20-Apr-98	87		110				
	61110813	25,673	JERSEY PT	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 PT		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 PT	21-Apr-99	34		334				
	062647	24,359	JERSEY PT	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 PT		59		721				
2000	06-45-63	24,457	DURHAM FERRY	17-Apr-00	11	11	246				
	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 PT	20-Apr-00	24	50	649				
	06-44-04	25,824	JERSEY PT	20-Apr-00	41	47	704				
	Effective Release	72,163	DURHAM FERRY		28	27	693	0.310	0.190	0.242	0.364
	Effective Release	46,249	MOSSDALE		18	30	381	0.310	0.330	0.329	0.313
	Effective Release	51,351	JERSEY PT		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	JERSEY PT	1-May-00	48	76	358				
	0601061002	24,661	JERSEY PT	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 PT		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 PT	4-May-01	50	156	470				
	06-44-35	24,993	JERSEY PT	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 PT		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 PT	11-May-01	17	43	243				
	06-44-42	25,466	JERSEY PT	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 PT		44	96	578				

Note: Ocean recoveries are based on data through 2005

Table 5-7
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 2004.

Release Year	San Joaquin River (Merced River Origin) TAG NO.	Release Number	Release Site	Release Date	Chipps Island Recovs.	Antioch Recovs.	Expanded Adult Ocean Recovs. (Age 1+ to 4+) Total	CHIPPS ISLAND	ANTIOCH	DRR or CDRR	OCEAN DRR
		Juvenile Salmon CWT Releases						Absolute Survival Estimates		Differential Recovery Rates	
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 PT	22-Apr-02	46	101	494				
	06-44-60	24,128	JERSEY PT	22-Apr-02	37	89	456				
	Effective Release	97,715	DURHAM FERRY		21	63	270	0.130	0.160	0.154	0.142
	Effective Release	50,787	MOSSDALE		13	42	145	0.150	0.210	0.194	0.147
	Effective Release	48,930	JERSEY PT		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 PT	30-Apr-02	18	43	307				
	06-44-81	22,880	JERSEY PT	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 PT		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 PT	25-Apr-03	57	71	253				
	Effective Release	74,449	DURHAM FERRY		3	6	19	0.019	0.015	0.023	0.025
	Effective Release	49,683	MOSSDALE		5	4	8	0.048	0.015	0.035	0.016
	Effective Release	24,414	JERSEY PT		57	71	253				
	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 PT	2-May-03	39	35	415				
	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 PT		39	35	415				
2004	06-27-52	23,440	DURHAM FERRY	22-Apr-04	0	1	0				
	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	0				
	06-45-80	22,911	JERSEY PT	26-Apr-04	25	22	14				
	Effective Release	92,265	DURHAM FERRY		3	2	0	0.030	0.020	0.026	0.000
	Effective Release	73,708	MOSSDALE		3	1	0	0.040	0.010	0.026	0.000
	Effective Release	22,911	JERSEY PT		25	22	14				
2005	06-46-72	23,414	DURHAM FERRY	2-May-05	5	0	0				
	06-46-73	23,193	DURHAM FERRY	2-May-05	2	2	0				
	06-46-74	23,660	DURHAM FERRY	2-May-05	4	3	0				
	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 PT	6-May-05	32	31	0				
	Effective Release	93,834	DURHAM FERRY		12	6	0	0.099	0.049	0.069	
	Effective Release	69,126	DOS REIS		3	7	0	0.035	0.110	0.052	
	Effective Release	22,767	JERSEY PT		32	31	0				
	06-45-84	22,777	DURHAM FERRY	9-May-05	2	1	0				
	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	0				
	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	0				
	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 PT	13-May-05	38	27	0				
	Effective Release	91,563	DURHAM FERRY		6	7	0	0.044	0.094	0.051	
	Effective Release	68,646	DOS REIS		6	7	0	0.058	0.127	0.068	
	Effective Release	23,231	JERSEY PT		38	27	0				

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 1996-2004.

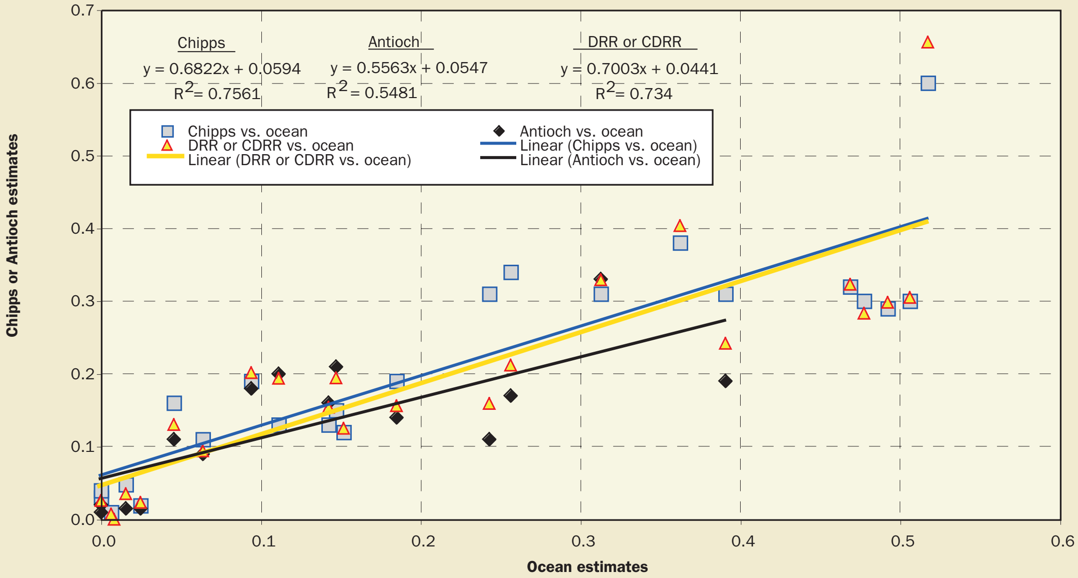
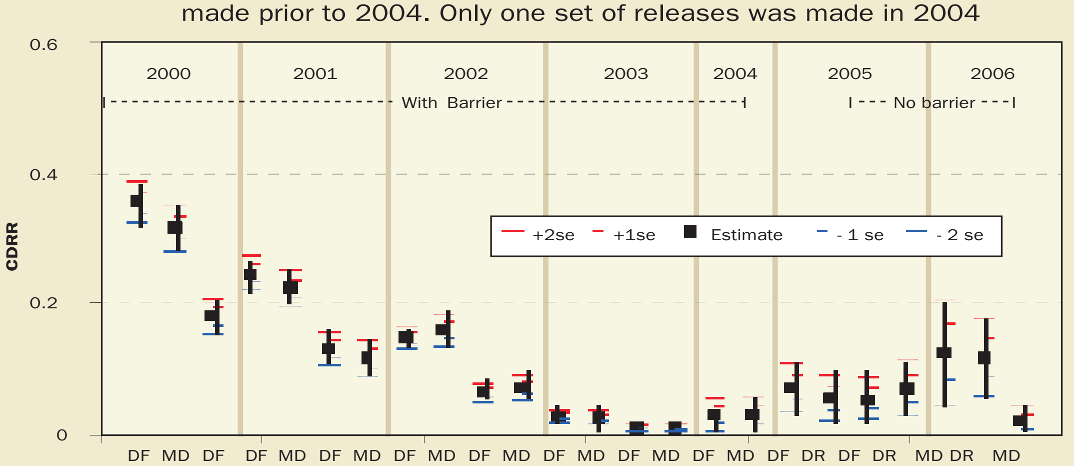


Figure 5-10
Combined Differential Recovery Rates (CDRR) (+/- 1 and 2 standard errors) of CWT smolts released at Durham Ferry (DF), Mossdale (MD) and Dos Reis (DR) relative to those released at Jersey Point for the first and second release groups in 2000- 2006. Recovery rates include recoveries from the ocean fishery for releases made prior to 2004. Only one set of releases was made in 2004



estimates in 2002 did not indicate significant differences at the 95% confidence level even with the ocean recoveries included. Releases of marked fish at both sites will allow detection of mortality between Durham Ferry and Mossdale if mortality becomes great enough to detect in the future.

Survival between Mossdale and Dos Reis

In 2006, releases were made to assess the difference in survival between a group released at Mossdale (which include a portion of the group that migrated down upper Old River) and one group released at Dos Reis (those released on the main-stem San Joaquin River downstream of upper Old River) during the low export condition. Survival between Mossdale and Jersey Point and Dos Reis and Jersey Point was similar for this first set of releases in 2006 (Figure 5-6).

A pilot ultrasonic tagging study (Chapter 6) and trawling in Old River compared to that at Mossdale (Chapter 4) indicated that most salmon migrated through Old River in 2006. If most of the coded wire tagged fish released at Mossdale in 2006 also primarily migrated into Old River under low exports and high flows, survival was similar between the two routes (between Old River and Jersey Point and, between Dos Reis and Jersey Point).

Nine additional paired releases have been made at Mossdale (or Durham Ferry in 2005) and Dos Reis in past years without the HORB in place. Five of these pairs produced ratios of survival between Mossdale and Dos Reis that were significantly less than 1.0 ($p<0.05$), indicating that in some years there was a significant difference in survival between the two groups (Table 5-9). Differences in survival between the two locations could be from a high proportion of the fish entering upper Old River and experiencing higher mortality via that migratory pathway, or from high mortality on the mainstem San Joaquin River between Mossdale and Dos Reis. The average survival between Mossdale or Durham Ferry and Dos Reis without a barrier in place was 0.73 (Table 5-9).

Only once were releases made at Mossdale and Dos Reis with the HORB in place. That was in 1997 and the point estimate of survival between the two locations was 1.29 using combined Chipps Island and ocean recoveries. These data reinforce that the temporary HORB on average provides protection to juvenile salmon migrating from the San Joaquin basin by reducing or preventing these fish from being drawn into upper Old River. It also indicates there was no detectable loss between Mossdale and Dos Reis with the barrier in place. If there truly is substantial mortality occurring now from predation in a hole on the San Joaquin River just downstream of upper Old River, as the ultrasonic data suggests in Chapter 6, we may consider releasing fish at Dos Reis and Mossdale when the barrier is in place in the future to assess this potential mortality source.

Survival between Dos Reis and Jersey Point

Survival in the reach from Dos Reis to Jersey Point in 2006 was much lower than survival from Mossdale to Dos Reis and similar to that between Mossdale and Jersey Point. This indicated that most of the mortality of the coded wire tagged salmon released at Mossdale occurred downstream of Dos Reis in 2006.

There have been 16 experiments where releases have been made at Dos Reis and Jersey Point, with three of these

Table 5-8
Combined differential recovery rates (CDRR) with recoveries from Antioch, Chipps Island, and in the ocean fishery for VAMP fish released at Durham Ferry and Mossdale between 2000 and 2004. Survival is between Durham Ferry and Mossdale. Ocean recoveries are not yet available for the release made in 2004.

YEAR	CDRR		Standard Error + / - 2 SE
	Antioch +Chipps Island +Ocean Recovery	Antioch +Chipps Island	
2000	1.15		
2001	1.11		
2001	1.10		
2002	0.92		
2002	0.65		0.58 - 1.19
2003	1.09		
2003	1.08		
2004		1.00	

made in 1997 with the HORB in place. The remaining data was gathered without the barrier in place between 1989 and 1991, 1995 and 1999 and during 2005 and 2006. CDRRs ranged between 0.05 and 0.79 and averaged 0.28 (Table 5-10). These historical data also indicate that the reach between Dos Reis and Jersey Point has the highest mortality. Additional data obtained in 1991, indicated that the highest salmon smolt mortality (lowest survival per mile) on the San Joaquin River between Dos Reis and Jersey Point occurred between Empire Tract (Figure 1-1) and the mouth of the Mokelumne River, although mortality between Dos Reis and Stockton, and between Stockton and Empire Tract was also high (Figure 1-1), (Brandes and McLain, 2001).

Survival between Old River and Jersey Point

No data has been gathered since 1990 to assess the differential survival for smolts migrating through upper Old River compared to those migrating on the mainstem San Joaquin River and released at Dos Reis. It has previously been published that survival appeared to be about twice that for smolts migrating down the mainstem San Joaquin versus those migrating down upper Old River, however differences were not statistically significant (Brandes and McLain, 2001).

In reanalyzing the data, using CDRR's, four of the seven years tested showed the 95% confidence interval around the ratio was significantly greater than 1.0 indicating the survival for smolts released at Dos Reis in those years was higher than for those released in upper Old River. (Table 5-11). The average ratio (Dos Reis to upper Old River) obtained by combining Chipps Island and ocean recoveries was similar to that reported in the past at 2.2 (Table 5-11). Confidence intervals around the mean of the ratio also indicated that the mean was significantly greater than 1.0, and survival was on average significantly higher for smolts released at Dos Reis compared to those released into upper Old River.

The Role of Flow, Exports and the Head of Old River Barrier on Smolt Survival Through the Delta

San Joaquin River flow and flow relative to exports between April 15 and June 15 was correlated to adult escapement in the San Joaquin basin 2 1/2 years later (SJRG 2003). Both relationships were statistically significant ($p<0.01$) with the ratio of flow to exports accounting for slightly more of the variability in escapement than flow alone ($r^2 = 0.58$ versus $r^2= 0.42$; SJRG 2003). These relationships were updated, refined to only include escapement from the San Joaquin tributaries and split between HORB and non-HORB years (SJRG, 2006) and still suggest that adult escapement in the San Joaquin basin is affected by flow in

Table 5-9
Combined Differential recovery rates (CDRR) for experimental fish released at Mossdale or Durham Ferry and Dos Reis between 1995 - 1999 and 2005 - 2006.
1995 - 1999 do not have Antioch recoveries. 2005 and 2006 do not have ocean recovery data available.
Survival reach is between Durham Ferry or Mossdale and Dos Reis
Those shaded are significantly different (95% confidence interval) from 1.0.

Year	Date	Release site	Chipps + ocean CDRR	Chipps + Antioch CDRR	
1995	17-Apr	Mossdale	0.99		
1995	5-May	Mossdale	0.31		
1995	17-May	Mossdale	0.44		
1996	30-Apr	Mossdale	0.37		
1998	16-Apr	Mossdale	1.05		
1998	23-Apr	Mossdale	0.42		
1999	19-Apr	Mossdale	0.69		
2005	2-May	Durham Ferry		1.32	
2005	9-May	Durham Ferry		0.75	
2006	4-May	Mossdale		0.94	
Average for all years					0.73

Table 5-10
Combined differential recovery rates (CDRR) using recoveries from Chipps Island and the ocean fishery or Chipps Island and Antioch to estimate survial between Dos Reis and Jersey Point between 1989 and 2005. Stock is either Feather River (FR) or Merced River (MR). The barrier was usually not installed (n) except in 1997(y).

Year	Date	Fish Stock	Barrier	CDRR Ocean + Chipps	CDRR Chipps + Antioch	
1989	20-Apr	FR	n	0.19		
1990	16-Apr	FR	n	0.05		
1990	2-May	FR	n	0.07		
1991	15-Apr	FR	n	0.12		
1995	17-Apr	FR	n	0.79		
1996	1-May	FR	n	0.11		
1996	1-May	MR	n	0.15		
1998	17-Apr	MR	n	0.40		
1998	24-Apr	FR	n	0.54		
1999	19-Apr	MR	n	0.53		
1997	29-Apr	FR	y	0.36		
1997	29-Apr	MR	y	0.48		
1997	8-May	MR	y	0.47		
2005	3-May	MR	n		0.05	
2005	10-May	MR	n		0.06	
2006	5-May	MR	n		0.12	
Average all years						0.28

Table 5-11
Ratio between CDRR of marked smolts released at Dos Reis (DR) and Upper Old River (UOR) between 1985 and 1990.

Year		Ratio	SE	+ 2 SE	- 2 SE
1985		0.99	0.01	1.00	0.97
1986		1.90	0.07	2.04	1.76
1987		2.48	0.13	2.74	2.22
1989		0.96	0.21	1.37	0.54
1989		4.35	1.08	6.50	2.20
1990		1.70	0.53	2.77	0.63
1990		3.17	1.05	5.28	1.07
	Mean	2.22		2.68	1.76

the San Joaquin River at Vernalis and flow relative to CVP and SWP exports during the spring months when juveniles migrate through the river and Delta to the ocean. These relationships serve as conceptual models of how smolt survival could vary with flows and exports.

VAMP was designed to further define these relationships by testing how San Joaquin River flows (7,000 cfs or less) at Vernalis and exports (1,500 to 3,000 cfs) at the SWP and CVP, with the HORB, affect smolt survival through the Delta. The HORB is assumed to improve survival based on studies conducted between 1985 and 1990 (Brandes and McLain, 2001) and discussed previously. The HORB barrier could not be installed during the VAMP in 2005 and 2006 as San Joaquin River flows exceeded 5,000 cfs during the scheduled installation period. Flows also exceeded maximum levels for operation of the HORB (7,000 cfs) in 2005 and 2006.

Survival of juvenile Chinook salmon emigrating from the San Joaquin River system has been evaluated within the framework established by the VAMP since the spring of 2000. The installation of the HORB is part of the VAMP experimental design when flows do not exceed 7,000 cfs. This year was the second year since 2000 that the HORB has not been installed and operated during the VAMP experiment, due to high flows. However, similar survival tests both with and without the HORB were conducted prior to 2000. The results of these earlier tests were also used to help define the relationships between flow and exports on smolt survival with and without the HORB in place.

Role of flow on salmon survival

To assess the relationship between San Joaquin River flows at Vernalis and smolt survival with and without the HORB survival (CDRRs), using recoveries from Chipps Island, Antioch and the ocean (if they were available), between Durham Ferry and/or Mossdale and Jersey Point from 1994- 2006 were plotted against San Joaquin River flows at Vernalis. Flows at Vernalis were 10 day averages for each release starting on the day of the Mossdale release or the day after the Durham Ferry release. Ten day averages were used to represent the flow variable since after 10 days most of the fish are far enough downstream (with some already recovered) that the flow at Vernalis is probably no longer important for that particular group migrating to Chipps Island. Flow data was obtained through DWR's DAYFLOW for past years (updated January 2004). San Joaquin flows downstream of Old River (SRL) between 1995 and 2004 were obtained from DWR from a model that simulated historical flows using DSM2 (T. Smith, DWR Personal Communication). SRL flow for 1994 was based on subtracting estimates of average daily flow in upper Old River from flow at Mossdale to obtain San Joaquin flows downstream of upper Old River. Average flows downstream of Dos Reis were for the 10 days starting on the day after the Dos Reis release. SRL and other flow and export data for 2005 and 2006 was obtained from Chapters 2 and 4 of this and last years (SJRG, 2006) annual report.

Role of flow with HORB on Salmon Survival

In the 2005 VAMP report (SJRG, 2006), it was reported that the CDRRs using the Chipps Island and Antioch recoveries of the Mossdale and Durham Ferry groups relative to the Jersey Point groups did increase with Vernalis flow with the HORB in place ($p<0.01$) (SJRG, 2006). It was also reported that the relationship between Vernalis flow and DRR using the ocean data with the HORB was also positive and statistically significant ($p<0.01$) (SJRG, 2006). The ocean data had fewer data points because recoveries were not yet available for the 2003-2005 releases.

For this year's evaluation, we have combined recoveries from Antioch, Chipps Island and in the ocean fishery to obtain one point estimate based on recoveries made to date from all three recovery locations. The relationship between these point estimates and San Joaquin River flow at Vernalis with the HORB in place is statistically significant ($p<0.01$) with flow accounting for 73% of the variability in survival (Figure 5 - 11).

Role of flow without HORB on Salmon Survival

Without the HORB in place, there was no clear relationship between the DRR/CDRR's and flow using the Chipps Island, Antioch and ocean recoveries for the Mossdale and Durham Ferry releases relative to the Jersey Point releases (Figure 5-12). The 2005 and 2006 data were much lower than what previous results had been at similar flow levels. It is not surprising that more variability is associated with smolt survival at any given flow at Vernalis without the HORB since the flow and proportion of marked fish moving into HOR varies more without the HORB.

To explore this issue further, we evaluated a group of test fish that were released on the mainstem San Joaquin River downstream of the head of Old River. The CDRR's of smolts released at Dos Reis relative to those released at Jersey Point were compared to estimates of San Joaquin flow downstream of the HOR. Most of the data were gathered when there was no HORB, but three data points (obtained in 1997) were gathered when the HORB was operating. The data indicated a weak relationship between survival and flow, but 2005 and 2006 were potential outliers (Figure 5-13). The relationship without these two years of data was highly significant and showed that survival from Dos Reis to Jersey Point did increase with San Joaquin River

Figure 5-11
CDRR (point estimates of survival) plus and minus 2 standard errors using Chipps Island, Antioch and ocean recoveries, for groups released at Mossdale or Durham Ferry and Jersey Point in 1994, 1997, 2000-2004 and average flow at Vernalis in cfs for 10 days starting the day of the Mossdale release or the day after the Durham Ferry release with HORB in place. Ocean recoveries are not yet available for 2004 releases.

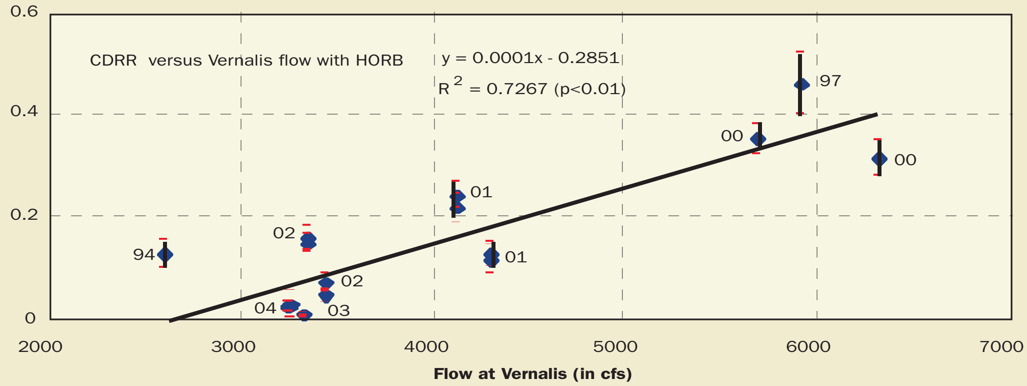


Figure 5-12
CDRR using combined Chipps Island, Antioch and ocean recoveries between Mossdale or Durham Ferry and Jersey Point and average flow at Vernalis in cfs for 10 days starting the day of the Mossdale release or the day after the Durham Ferry release without the HORB in place. Data in 2005 and 2006 only include recoveries from Antioch and Chipps Island.

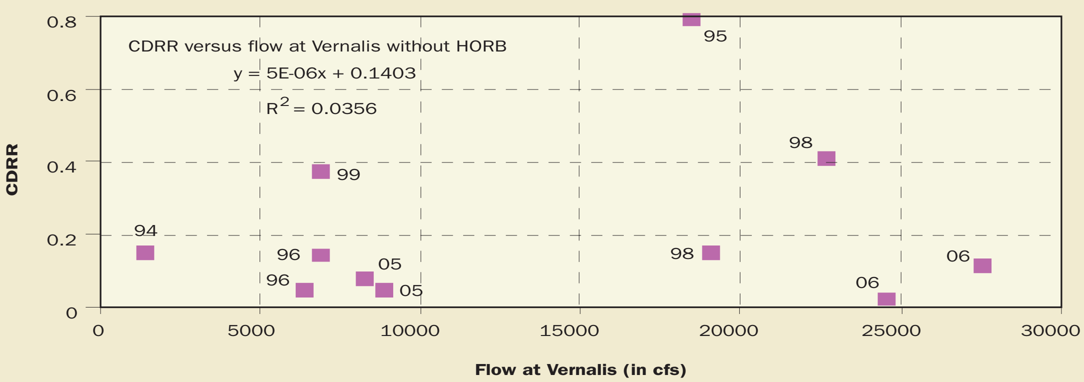
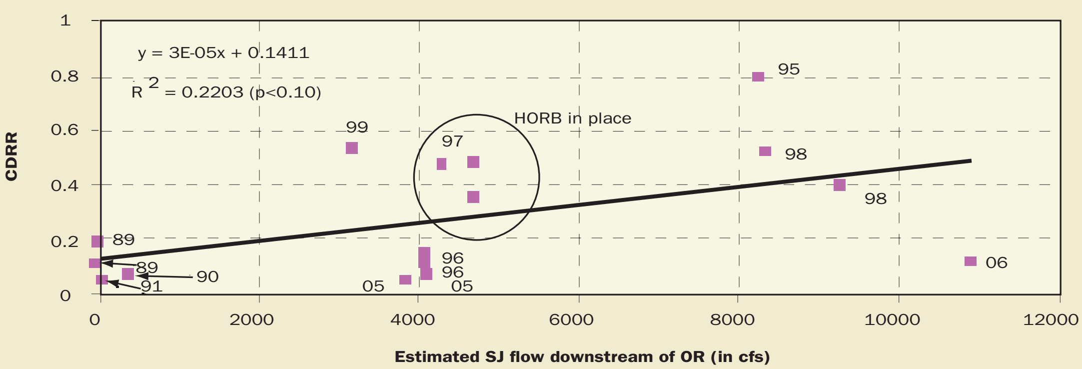


Figure 5-13
Survival between Dos Reis and Jersey Point (with recoveries at Chipps Island and the ocean fishery) with and without the HORB and estimated/modeled San Joaquin flows downstream of Old River between 1989 - 1991, 1995, - 1999, 2005 and 2006. 1997 data was gathered with the HORB in place. 2005 and 2006 data only has Chipps Island and Antioch recoveries available at this time.



flows downstream of the HOR ($p<0.01$ level) (Figure 5-14). It is unclear why 2005 and 2006 experiments resulted in such low survival compared to that observed in the past, although survival has been extremely low and lower than expected since 2003. It appears this trend has continued in 2005 and 2006 without the HORB in place, even though flows were higher.

The Role of Exports on Survival

Another goal of the VAMP program is to identify the role of exports on juvenile salmon survival through the Delta. VAMP limits CVP+SWP exports to between 1,500 and 3,000 cfs depending on the flow target, because of its dual protective purpose for naturally spawned juvenile salmon and to meet the terms of the delta smelt biological opinion. Prior to 1994, exports were generally much greater during this period. The VAMP design includes examining the role of exports with the HORB at flows of 7,000 cfs by experimenting at exports of 1,500 and 3,000 cfs. As conditions have not yet provided a 7,000 cfs flow with a HORB to test either export level, assessing the role of exports with a HORB is limited at this time.

In years when the HORB could not be installed it was recommended in the VAMP framework agreement to limit exports to either 1,500 or 3,000 cfs to make better comparisons with and without the HORB. In 2005, there was an attempt to measure survival with combined SWP/CVP pumping at 1,500 cfs for two weeks and then measure survival again at 3,000 cfs, but it was not implemented as one of the parties did not initially adjust pumping as proposed. In 2006, export levels were 1500 and 6000 cfs at high San Joaquin River flows (~25,000 cfs) for the two sets of VAMP releases. We were able to recommend such an experimental design because flows were deemed high enough to provide adequate protection for delta smelt even with the 6000 cfs exports. Results suggest the higher exports resulted in lower salmon smolt survival, but additional tests, especially with the higher export period, are needed to confirm this apparent benefit. Additional tests of this type may help us better identify the role of exports on smolt survival without the HORB in place.

Role of exports with HORB

The San Joaquin River flow relative to exports does not appear to explain the variability in smolt survival as well as flow alone from data obtained with the HORB in 1994, 1997 and between 2000 and 2004 (Figure 5-15). The flow/export variable is the 10-day mean for the ratio. Previous reports (SJRG 2006) have represented the ratio as the 10-day average of flow divided by the 10-day average of the export rate. One potential explanation for these results is that level of exports were low and did not vary enough during these experiments to provide a sufficient difference to be detected in our measurements of smolt survival. Exports ranged between 1,450 and 2,350 cfs during these experiments which is much lower than those incorporated into the adult escapement relationships. Another complication is that exports and San Joaquin River flows were correlated with higher exports observed during times of higher flows (Figure 5-16). It is also likely the relationship of exports to smolt survival is different with the HORB in place than when it is absent. While some of the juveniles that contributed to adult escapement may have benefited from the HORB in a few of the years, the HORB was not installed during the majority of the years incorporated into the adult relationships.

The next step would be to conduct a survival experiment at flows of 7,000 cfs with the HORB and vary exports (1,500 and 3,000 cfs) to better define the export effect on smolt survival with the HORB in place. Experimenting at flows of 7000 with a 1500 exports would help decouple the effects of flows and exports with the HORB in place (Figure 5-16).

Role of exports without HORB

The role of exports on smolt survival without the HORB in place is also difficult to identify at this time. As mentioned earlier, there was not a clear relationship between smolt survival and flow without the HORB (Figure 5-12). Regressions between the CDRR from Mossdale and Durham Ferry to Jersey Point using Chipps Island, Antioch and ocean recoveries also do not show a clear relationship with flow/export ratios (Figure 5-17). This is counter to our conceptual model based on the better relationship of flow/exports and San Joaquin basin escapement 2 1/2 years later than that when using flow alone. Similar limitations, to those with HORB, occur with this data. Exports have been limited to between 1400 and 3700 cfs, with the exception of 6000 cfs for the second experiment conducted in 2006. Conducting experiments as we did in 2006, where exports varied and flows were relatively constant may help us sort out the role of exports when the HORB is absent.

The Role of the HORB on survival through the Delta

One obvious result of the HORB on survival through the Delta has been the lower rate of salvage (and direct loss) for fish released at Durham Ferry and Mossdale when the HORB is installed. If one assumes densities are equal, direct loss should increase as exports increase. In 2006 very few individuals from either Mossdale group were salvaged in 2006. This could be a result of the extremely

Figure 5-14
Survival between Dos Reis and Jersey Point (with recoveries at Chipps Island and the ocean fishery) with and without the HORB and estimated/modeled San Joaquing flows downstream of Old River between 1989 - 1991, 1995 - 1999, 2005 and 2006. 1997 data was gathered with the HORB in place. 2005 and 2006 data has not been included.

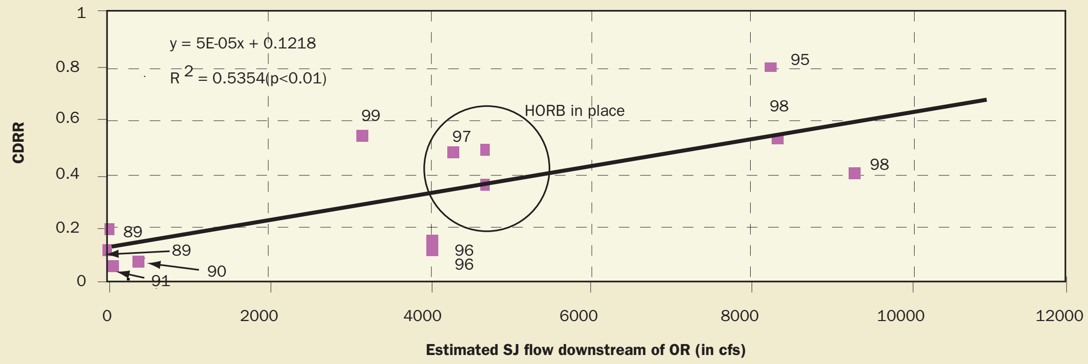


Figure 5-15
CDRR using Chipps Island, Antioch (2000 - 2004 only) and ocean recoveries (1994, 1997, 2000 - 2003), for groups released at Mossdale or Durham Ferry and Jersey Point and average flow at Vernalis/Exports in cfs for 10 days starting the day of the Mossdale release or the day after the Durham Ferry release with the HORB in place.

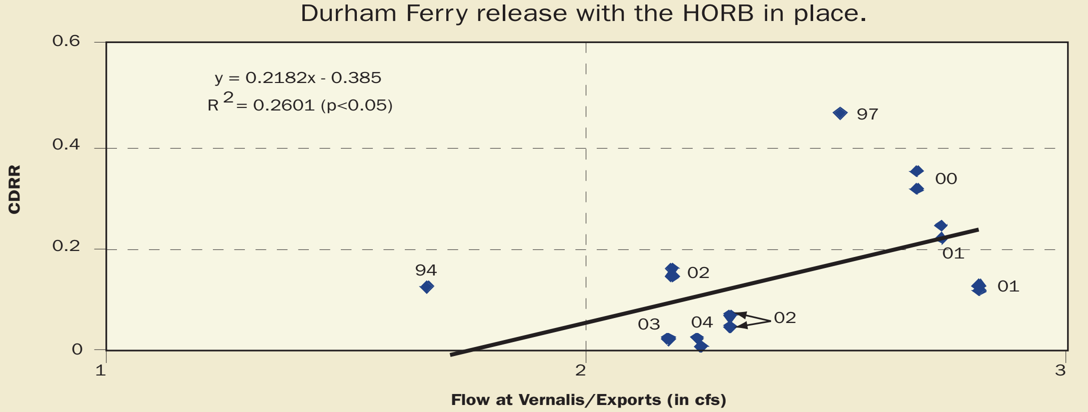


Figure 5-16
The relationship between flow and exports during VAMP tests with the HORB in place.

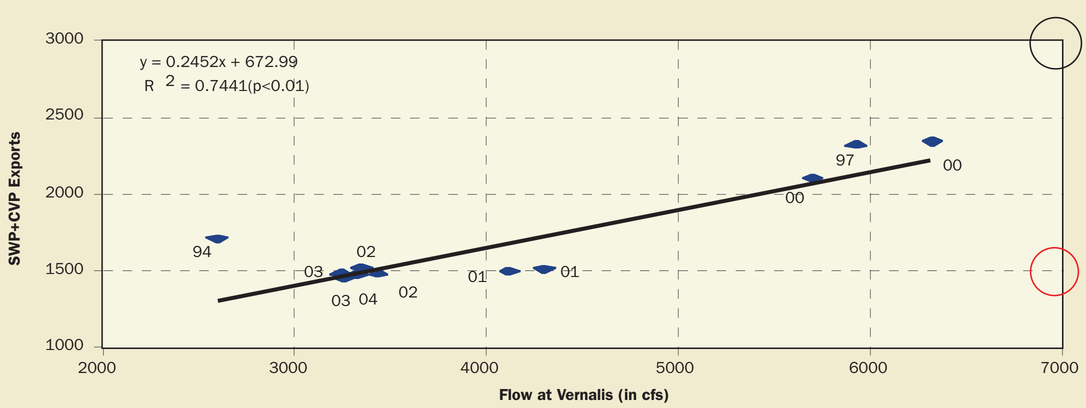


Figure 5-17
CDRR for fish released at Mossdale and Durham Ferry relative to Jersey Point between 1994 - 1996, 1998, 1999, 2005 and 2006 versus the mean Vernalis Flow/Export ratio for the 10 days after release without the HOR barrier.

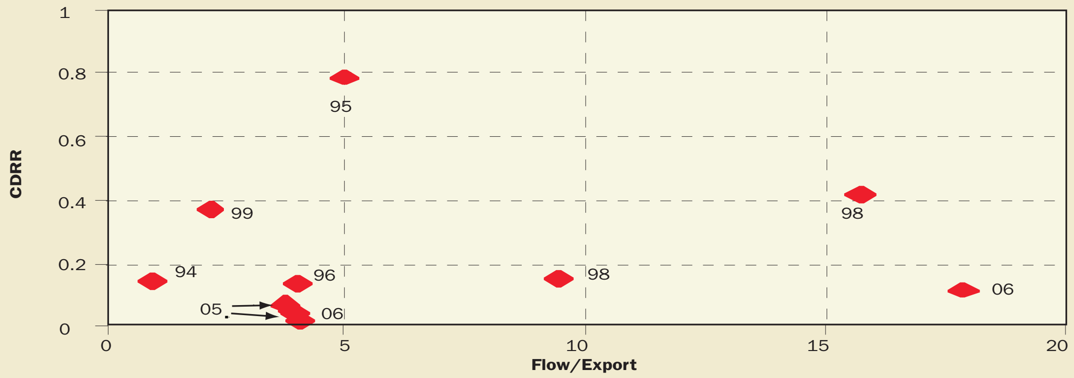


Figure 5-18
CDRR using combined Chipps Island,Antioch and ocean recoveries between Mossdale or Durham Ferry and Jersey Point and average flow at Vernalis in cfs for 10 days starting the day of the Mossdale release or the day after the Durham Ferry release with and without the HORB in place between 1994-2006. Data in 2004,2005 and 2006 only include recoveries from Antioch and Chipps Island.

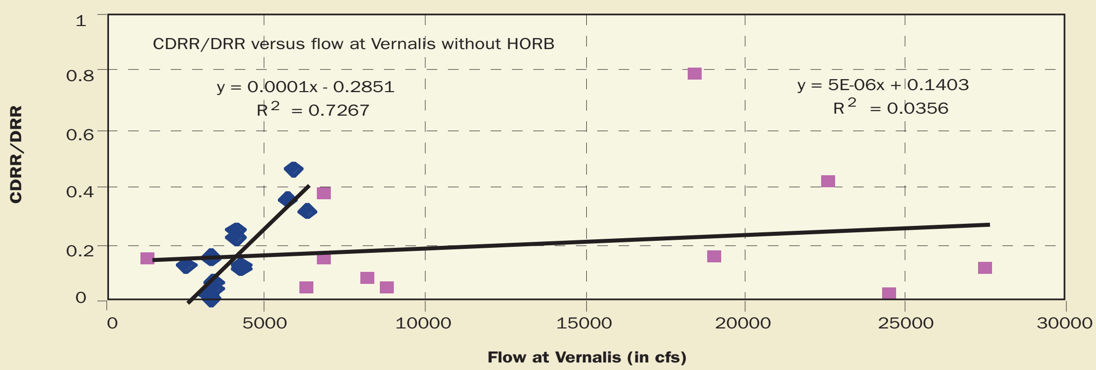
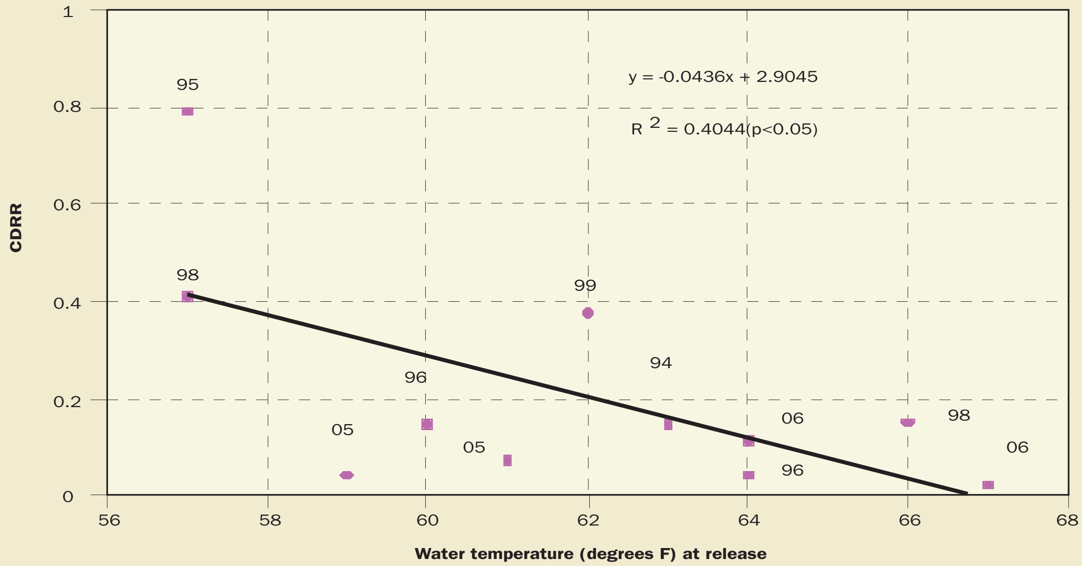


Figure 5-19
Combined Differential Recovery Rate (CDRR) for smolts released at Durham Ferry and Mossdale relative to those released at Jersey Point without the HORB versus water temperature at release site for smolts released at Durham Ferry and Mossdale.



high flows present in 2006. In contrast, several hundred of the Durham Ferry group, were salvaged in 2005 indicating a higher direct loss in 2005 compared to that in 2006.

Comparing the CDRRs with and without HORB data using the recoveries from Chipps Island, Antioch, and the ocean fishery, appears to indicate that there may be on average value in installing the HORB at flows between about 4,000 and 7,000 cfs (Figure 5-18).

The role of temperature on smolt survival

One parameter that appears to be confounding identification of the role of exports and flow is water temperature. Without the HORB, survival from Mossdale or Durham Ferry to Jersey Point was highest in the years that had the lowest temperature at release (Figure 5- 19). Water temperature at release was highest for the second group released in 2006 (Figure 5-19). Water temperature at release has also been shown to be an important factor in survival for smolts migrating through the Delta from the Sacramento basin (Newman, 2003).

Relationship of flow and exports to adult escapement 2 1/2 years later

The relationships between flow and flow/export ratio to escapement 2 1/2 years later have been shown in previous reports (SJRG, 2003 and SJRG, 2006). These data have been updated to include the most recent escapement (to 2005) and flow (to 2003) data (Figure 5-20 and 5-21). These revised and updated escapement data were obtained from the USFWS Anadromous Fish Restoration Program's website at http://www.delta.dfg.ca.gov/afrp. The flow/ export variable was also modified to reflect the mean of the daily ratios between April 15 and June 15. The previous relationship (SJRG, 2006) was based on the ratio of the average flow and export values for the two month period.

In determining whether flow or flow/exports was better at predicting escapement 2 1/2 years later, Ken Newman conducted a K-fold cross validation where K=5. Essentially this analysis breaks the data down into five random groups and uses data not used to fit the model to validate the model. In this analysis, Ken found that the total absolute prediction error was about 15% less using the model that incorporated the flow/export variable, indicating that it better predicts the data than the model using flow alone.

The benefit of examining these adult relationships is that there are more data gathered over a broader range of conditions than with smolt survival under the VAMP framework. These adult relationships would indicate that as you increase flows and decrease exports relative to flows there should be corresponding increases in smolt survival and adult escapement 2 1/2 years later. It is not surprising that there is some uncertainty and noise in these relationships because the escapement data does not incorporate the varying age classes within annual escapement, the impact of declining ocean harvest in recent years and the imprecision in the escapement estimates.

Summary

The smolt survival data obtained without the HORB do not show a clear relationship to flow, especially with the 2005 and 2006 data included. With the HORB in place we have demonstrated statistically significant relationships between smolt survival and flow at Vernalis and flow/exports, although exports are correlated to flow. The relationship between the survival of the Dos Reis groups relative to the Jersey Point groups indicate that survival will improve generally as flows increase for smolts migrating downstream on the main stem San Joaquin River. The role of exports on smolt survival within the VAMP (with HORB) and without a HORB is more difficult to define based on the limited data. To identify the role of exports with a HORB it is imperative that we measure survival with export rates at 1,500 and 3,000 cfs with San Joaquin River flows of 7,000 cfs. Experiments like those conducted in 2006 can help assess the role of exports without the HORB. It is unclear why smolt survival between 2003 and 2006 has been so low.

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 at Mossdale and in salvage at the CVP and SWP facilities were compared prior to and during the VAMP period.

Unmarked Salmon Recovered at Mossdale

The typical time period for VAMP (April 15 to May 15) was chosen based on historical data that indicated a high percentage of the juvenile salmon emigrating from the San Joaquin tributaries passed into the Delta at Mossdale during that time. In 2006, the VAMP period was delayed until May 1 due to flood conditions. The average catch per 10,000 cubic meters per day of unmarked juvenile salmon caught in Kodiak trawling at Mossdale during January through June is shown in Figure 5-22. Unmarked salmon do not have an adipose clip and can be juveniles from natural spawning or unmarked hatchery fish from the MRH. Unmarked smolt releases in 2006 at MRH were as follows: 65,000 on May 26, 75,000 on June 2, and 60,000 on June 4. There were less unmarked juvenile salmon passing Mossdale during the low export period than during the higher export period of VAMP (Figure 5-22). If results from this years VAMP are representative of survival for unmarked fish migrating through the Delta from Mossdale, those migrating during the latter half of May may have survived at a lower rate than those migrating earlier in the month. The size of the juvenile salmon captured in the Mossdale trawl during January through June is shown in Figure 5-23.

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 CWT recovery data for MRH smolts at the salvage facilities to provide some general indications as to the origin of the unmarked fish. However, 2006 had extended San Joaquin River flood conditions and no temporary spring barriers. It was estimated by DWR that nearly all water in the Clifton Court Forebay (CCF) of the SWP during mid-March through June was from the San Joaquin River (SJR); SJR water was also predominant in CCF during January to mid-March (based on Real Time Data and Forecasting Project Water Quality Weekly Reports from DWR Office of Water Quality). It may be assumed that CVP water sources were similar in 2006.

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 Clifton Court Forebay. 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.

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Figure 5-20
Vernalis flows (April 15 - June 15) versus escapement 2 1/2 years later in years with and without the HORB between 1951 and 2003.

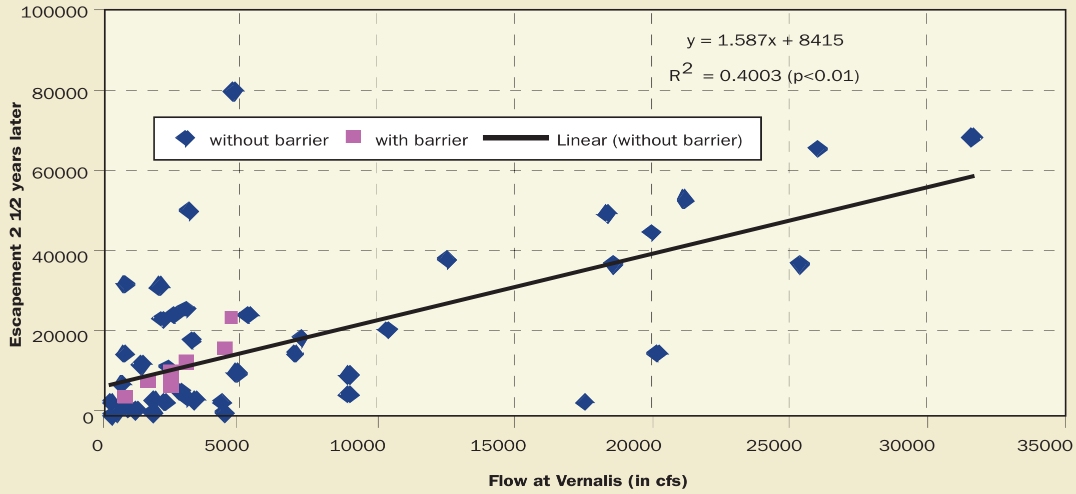


Figure 5-21
Vernalis flow/export ratio versus adult escpement 2 1/2 years later in years with and without the HORB in place between 1951 and 2003.

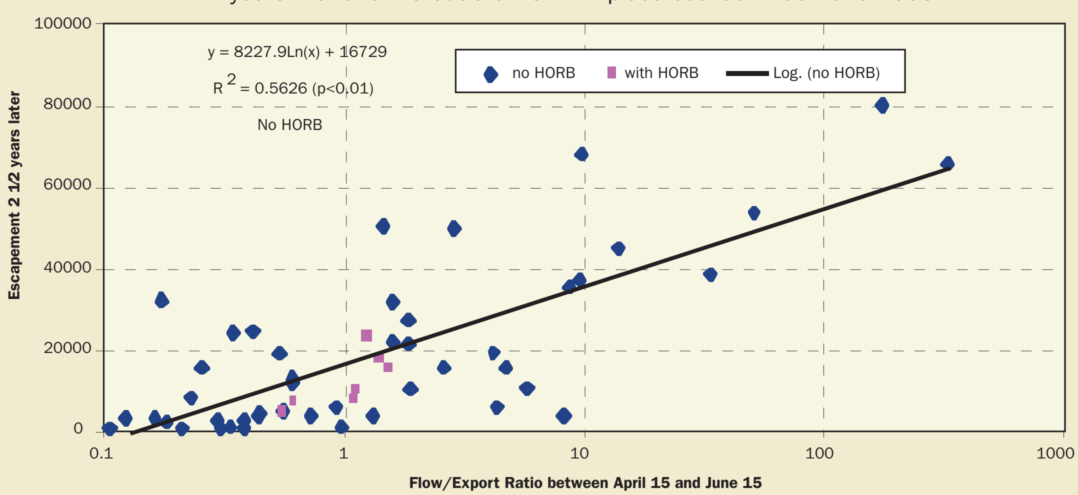


Figure 5-22
Average daily densities of unmarked salmon caught in the Mossdale Kodiak trawl.

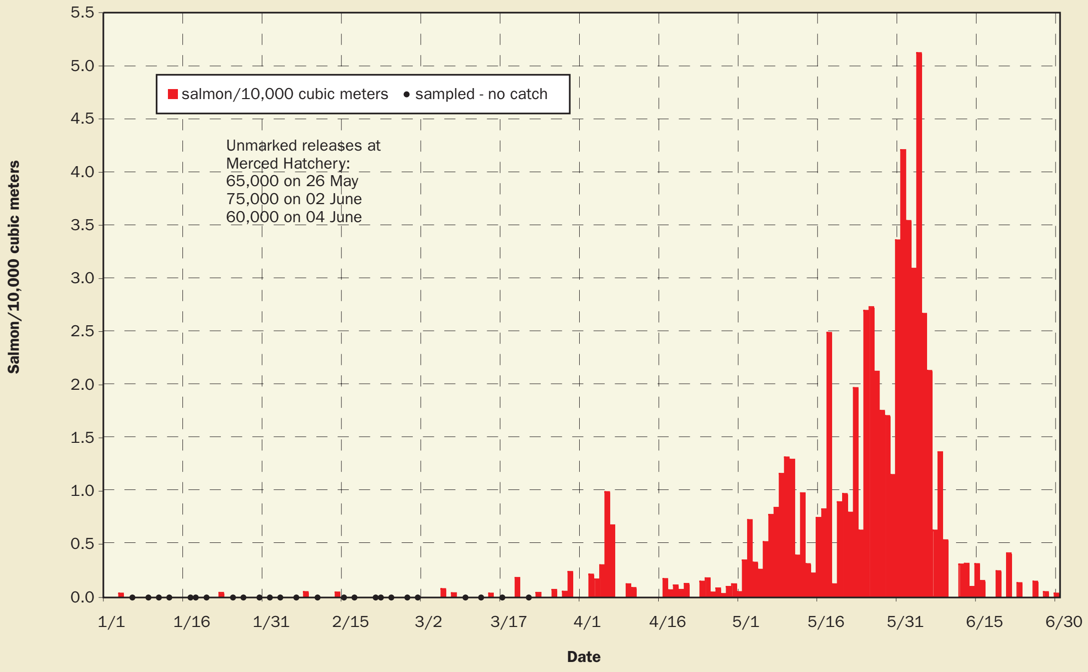


Figure 5-23
Mossdale Kodiak trawl individual daily forklengths of unmarked juvenile Chinook salmon, January through June 2006

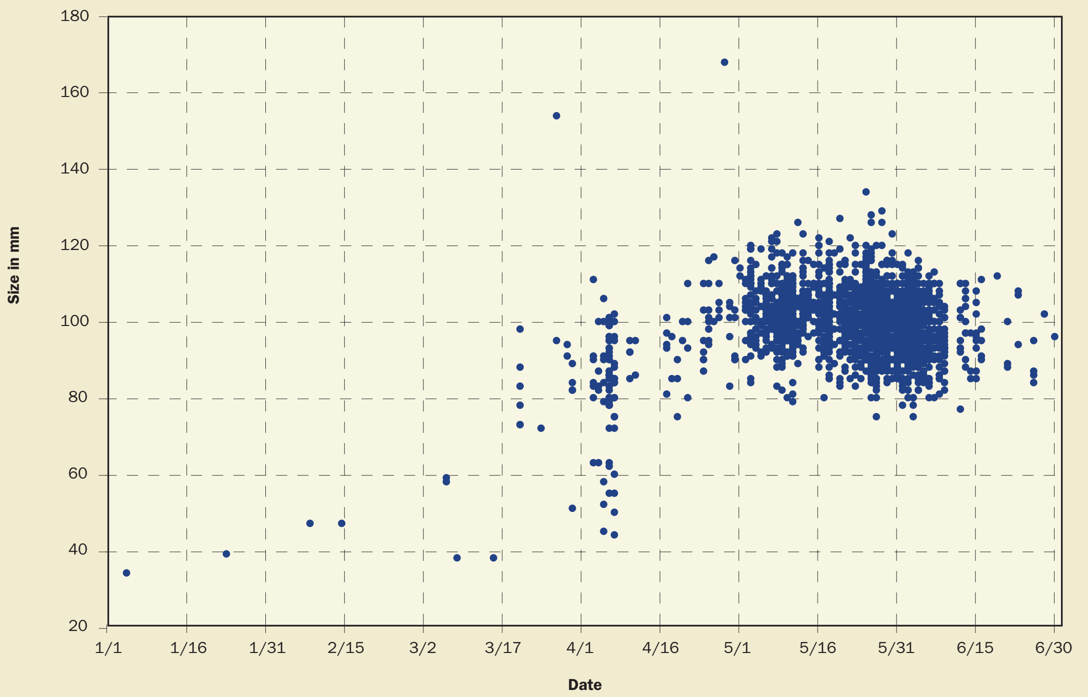


Figure 5-24
2006 CVP estimated salmon salvage and loss

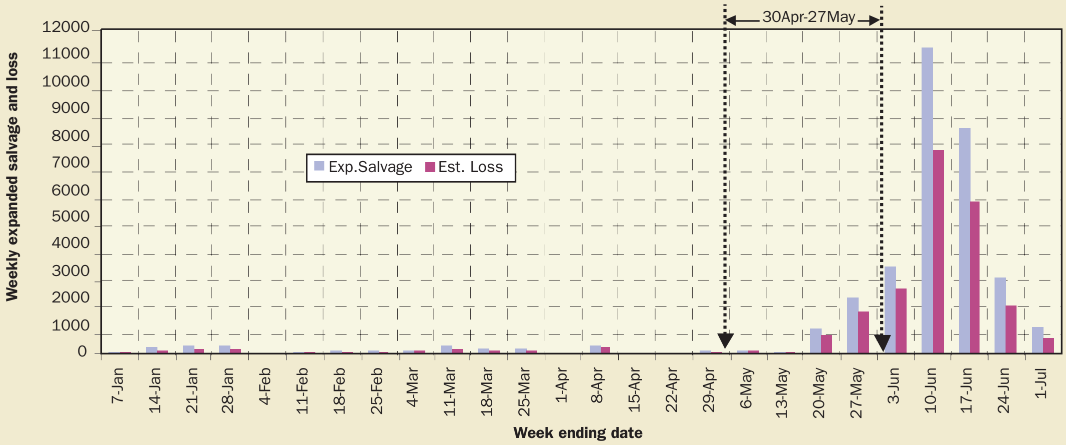


Figure 5-25
2006 SWP estimated salmon salvage and loss

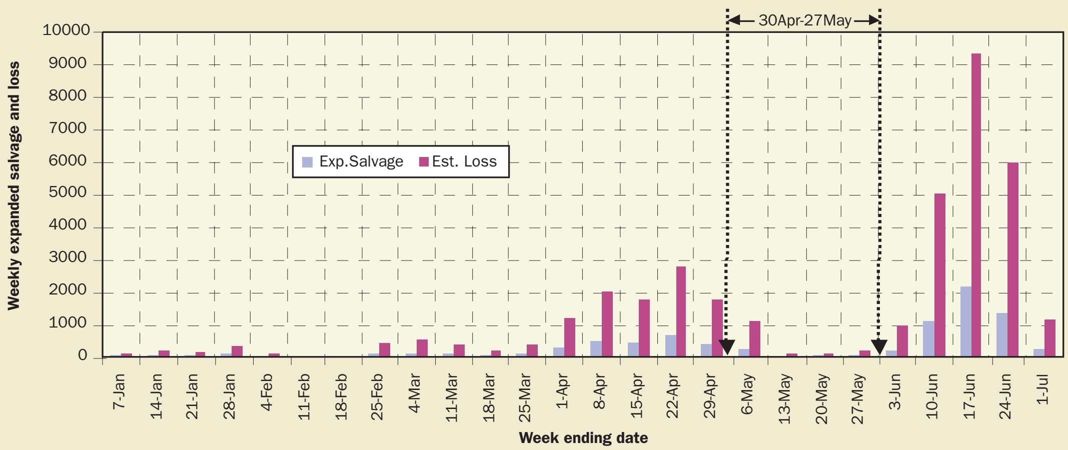
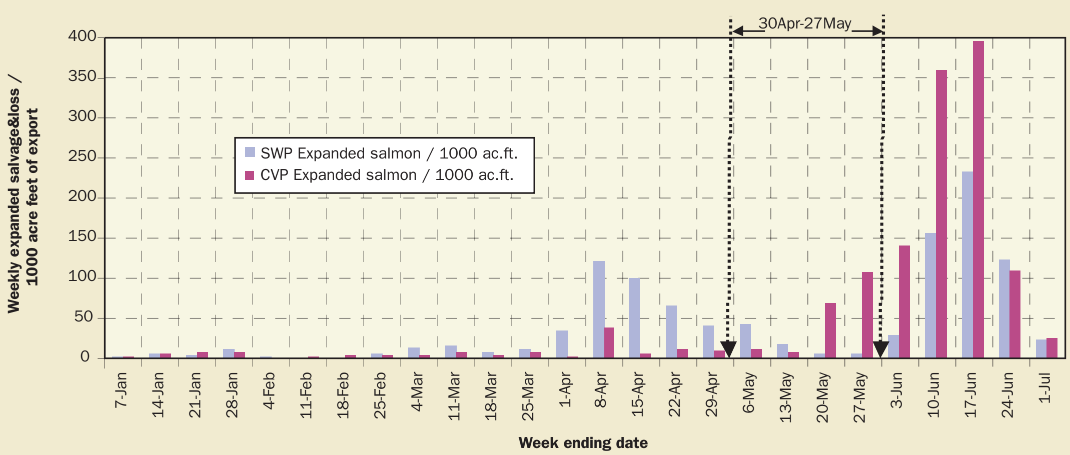


Figure 5-26
2006 SWP & CVP Combined salvage and loss density



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 pre-smolts), so their salvage numbers and estimated losses are underrepresented.

The weekly data covering the period of April 30 to May 27 approximated the 2006 VAMP period. A review of weekly data for January through June indicates that the highest CVP salvage and losses occurred in June, with the last half of May having increasing values (Figure 5-24). Highest SWP salvage and losses were also in June with a lesser peak from late March to early May (Figure 5-25). Salmon densities based on combined salvage and loss estimates at both facilities were highest in June, with an earlier peak from late March to early May, mainly at the SWP (Figure 5-26). CVP densities were also relatively high in the second half of May (Figure 5-26). The June CVP and SWP peaks occurred during a period of declining flow at Vernalis (Figure 5-27).

The size distribution of unmarked salmon during January through June in the Mossdale trawl (Figure 5-23) generally overlaps withthe size distribution of those salvaged at the fish facilities (Figure 5-28, Source E. Chappell, DWR). Based on comparisons with Mossdale data , it appears that some salmon salvaged prior to VAMP could have been from the San Joaquin basin (Figure 5-22).

Results of these analyses showed that the 2006 VAMP test period coincided with part of the peak period of San Joaquin River salmon smolt emigration. The largest daily peak of the production passing Mossdale occurred after VAMP ended (June 3).

Summary and Recommendations

The CDRRs measured for the first group released in 2006, under low exports, appeared higher than those obtained in 2003 – 2005 and for the 2006 group released under higher exports and higher temperature.

The health of the fish used in 2006 was generally good, but it is uncertain whether detection of Bacterial Kidney Disease (BKD) in a proportion of the fish may have affected their survival through the Delta.

There are significant relationships between smolt survival and San Joaquin River flow at Vernalis and flow/exports with the HORB, although exports and flows are correlated in the data. These relationships are found when combining all of the recoveries available (Chipps Island, Antioch and ocean fishery) for the Durham Ferry and Mossdale groups relative to the Jersey Point groups. There does not appear to be a clear relationship to flow when the HORB is absent. There is however, a statistically significant relationship between SJR flow/exports and adult escapement 2 1/2 years later.

To better determine relationships of smolt survival to exports and flow, certain conditions should be targeted during the remaining years of VAMP and in years when the HORB cannot be installed. Two of the conditions that need to be tested with the HORB are at exports at 1500 and 3000 cfs with San Joaquin River flows at 7000 cfs. In addition, the 7000 cfs flow and the 1500 export condition would be especially valuable in decoupling the effects of flow and exports with the HORB in place. More experiments, like those in 2006, should be conducted when the HORB cannot be installed to further refine and define the survival relationships to flow and exports without the HORB in place. If exports are to vary within a year, further consideration should be given to doing the high export rate with low temperatures first, to decouple the trend of higher flows, low exports and low temperatures for the first release and lower flows, higher exports and higher temperatures for the second release. Conducting field experiments where many parameters vary together, make isolating the role of a single variable more difficult.

Figure 5-27
2006 weekly export rates and Vernalis flow

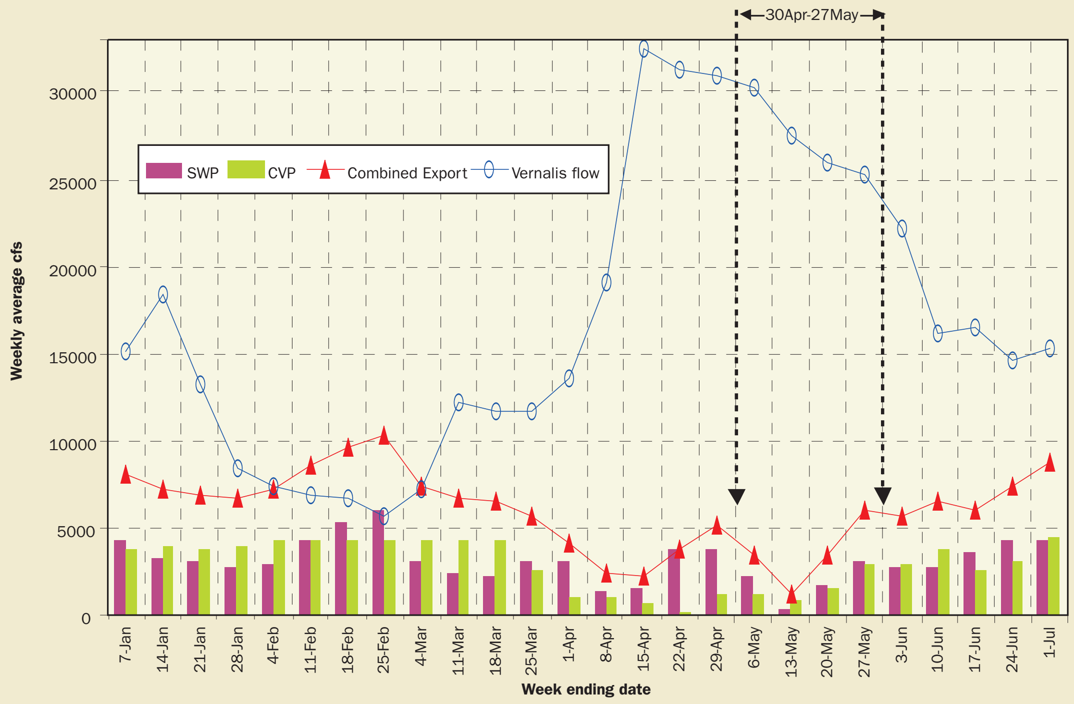
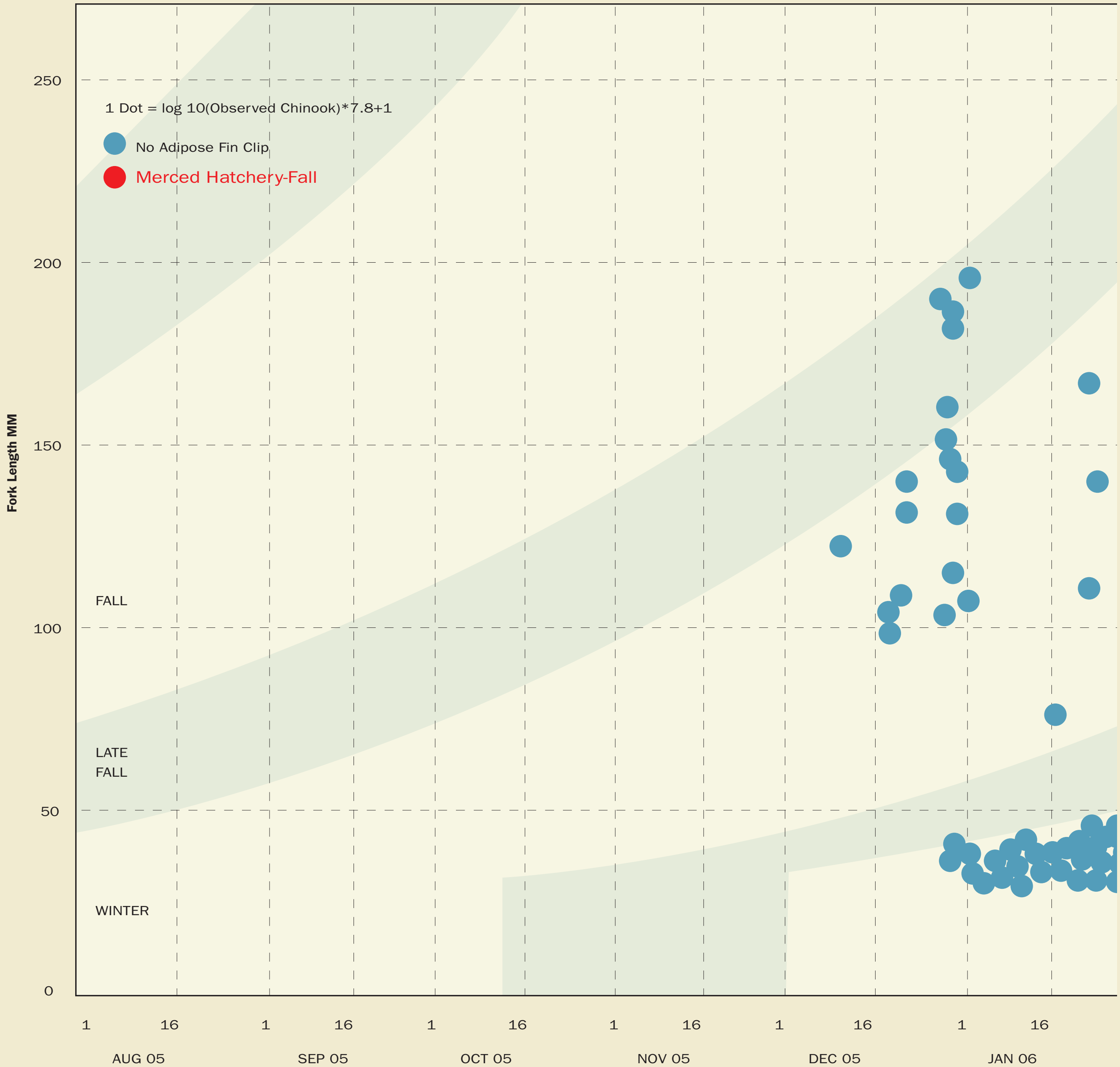
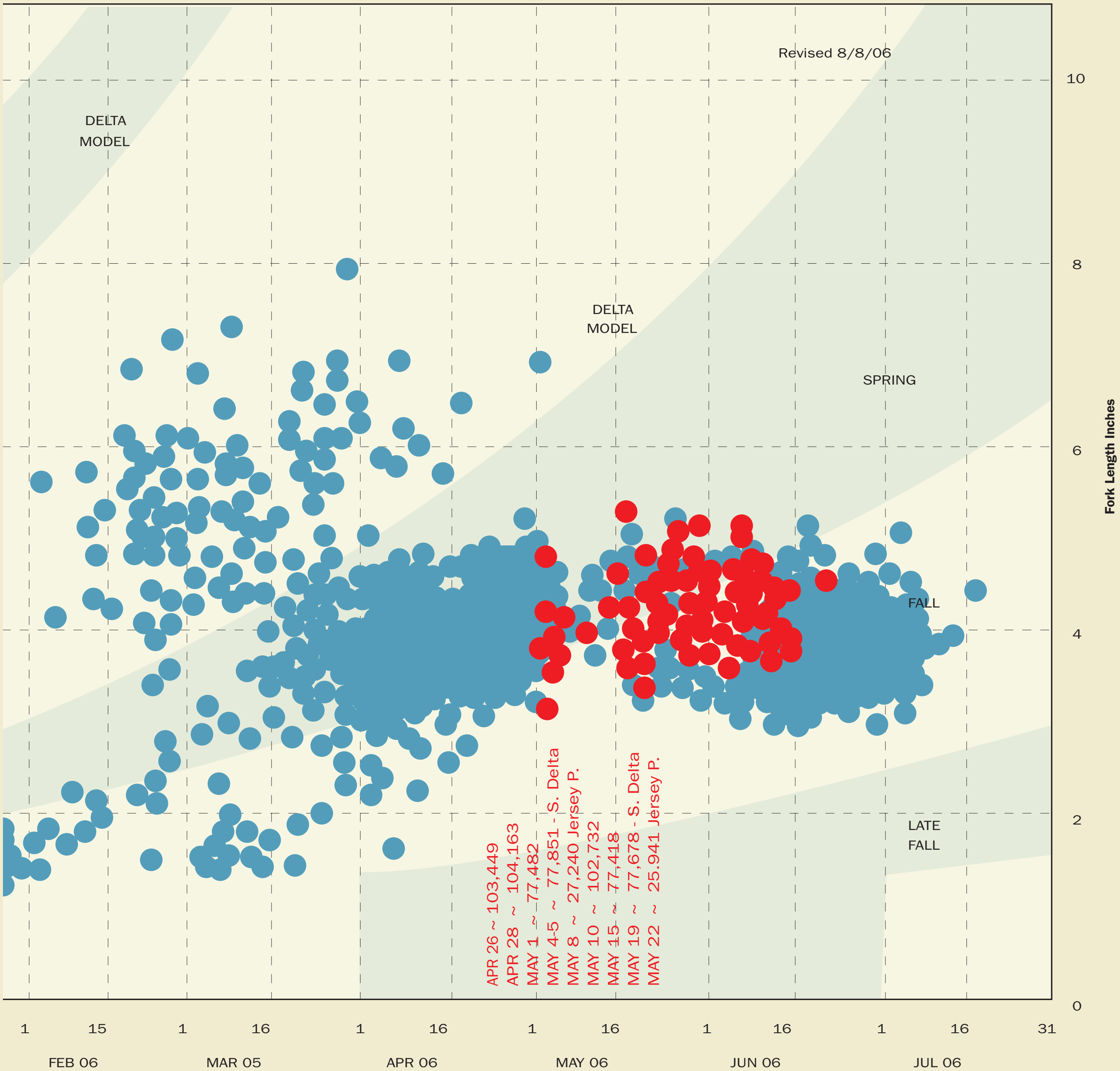


Figure 5-27
Observed Chinook salvage at the SWP and CVP
Delta Fish Facilities, August 2005 through July 2006.




Revised 8/8/06
DELTA
MODEL
DELTA
MODEL
SPRING
FALL
LATE
FALL
APR 26 ~ 103,449
APR 28 ~ 104,163
MAY 1 ~ 77,482
MAY 4-5 ~ 77,851 - S. Delta
MAY 8 ~ 27,240 Jersey P.
MAY 10 ~ 102,732
MAY 15 ~ 77,418
MAY 19 ~ 77,678 - S. Delta
MAY 22 ~ 25.941 Jersey P.
10
8
6
4
2
0
Fork Length Inches
1
15
1
16
1
16
1
16
1
16
1
16
31
FEB 06
MAR 05
APR 06
MAY 06
JUN 06
JUL 06

Chapter 6

Complimentary Studies Related to the VAMP

Throughout 2006 several fishery studies were conducted that were considered to be important to the overall understanding of the abundance and survival of juvenile salmon in the San Joaquin River basin. These are presented below to provide the reader with summary information on each study. More information can be obtained from each study manager or report author.

Review of Juvenile Salmon Data from the San Joaquin River Tributaries to the South Delta During January to Mid-July, 2006

Contributed by Tim Ford, Turlock and Modesto Irrigation Districts, and Andrea Fuller, 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 2006, rotary screw trapping was conducted near the confluences of the Stanislaus and Tuolumne Rivers with the San Joaquin River - no comparable monitoring occurred on the Merced River. Seining was also done in the SJR from below the 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. Stanislaus River RST monitoring was conducted at River Mile (RM) 9 (Caswell site) during 07 Mar – 14 Jul; and Tuolumne River RST monitoring was conducted at RM 5 (Grayson site) during 26 Jan – 22 Jun. Weekly seining during Jan-June was done at up to 8 sites from River Mile 51 (Dos Reis) to River Mile 83 (North of Tuolumne River) and 2 other sites were seined every 2 weeks from mid-January to mid-June 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 Head of Old River) during 03 Jan – 29 June (daily, except only 3 days/week prior to April). 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; flow at the Modesto gage was estimated by the sum of flow at La Grange the prior day and the flow of Dry Creek at Modesto and some flows at Merced River at Stevinson were estimated as the difference in flow between San Joaquin River at Newman and Fremont Ford Bridge.

Seasonal peaks in catch of fry in the Tuolumne River RST (Figure 6-2) occurred on January 28 and March 1. The first peak followed a decrease in flood releases and was very near the start of sampling, which could have missed an earlier peak. The peak during March coincided with a large rain event and increasing flood releases. However, similar to 2005, relatively few early fish were observed at the Mossdale trawl (Figure 6-3), and in the CVP (Figure 5-24) and SWP (Figure 5-25) salvage operations. Seasonal peak catch occurred at Mossdale during early June, coincident with peak smolt catches on the Tuolumne and Stanislaus (Figure 6-4) rivers and prior to the peak densities recorded at the salvage facilities (Fig. 5-26). Figure 6-5 shows that most fish observed prior to mid-March averaged <50 mm fork length (FL). Both the trawl and salvage are relatively less effective at capture of fry (salmon less than 50 mm long).

Average size in RST and trawl catch and salvage increased by late April to >80 mm FL at all locations (Figure 6-5). Migrants captured during the first half of June at Mossdale and in the salvage were on average approximately 10 mm larger than Stanislaus River smolts. By late June, all sampling in the tributaries and at Mossdale indicated very low abundance of juvenile salmon. Seining in the SJR only captured salmon prior to VAMP, with salmon <50 mm in fork length being present through March (Figure 6-6), with the highest densities recorded at Mossdale and/or Dos Reis in early March and early April. (Figure 6-7)

Figure 6-1
San Joaquin Basin Flows and Rainfall

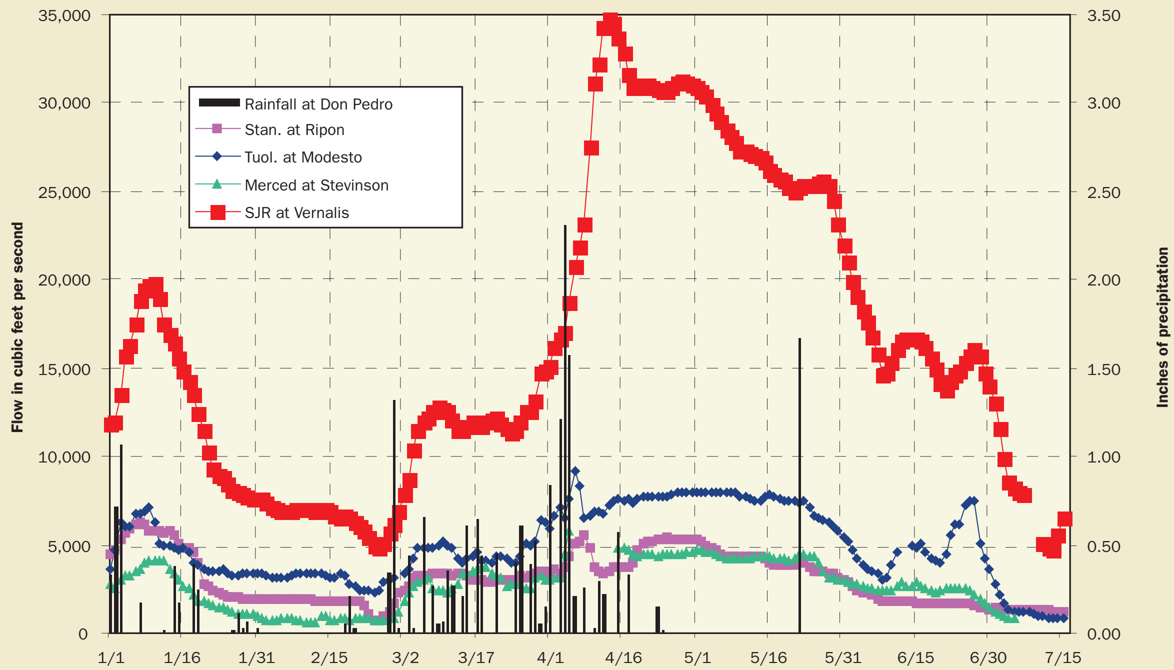


Figure 6-2
Tuolumne screw trap catch of unmarked juvenile Chinook salmon

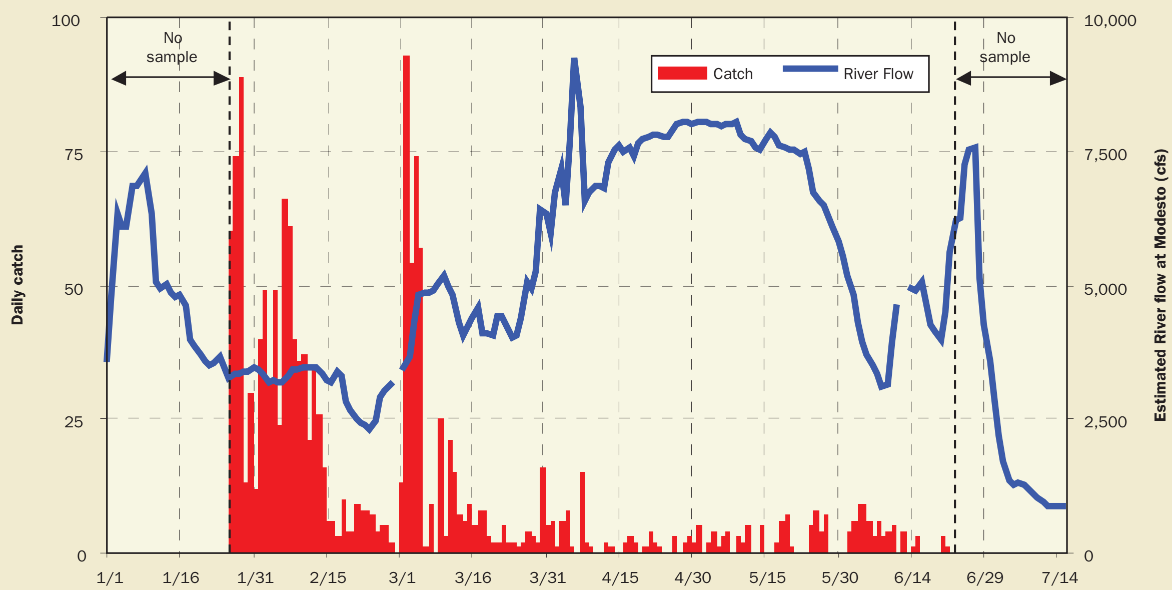


Figure 6-3
Mossdale kodiak trawl catch of unmarked juvenile Chinook salmon

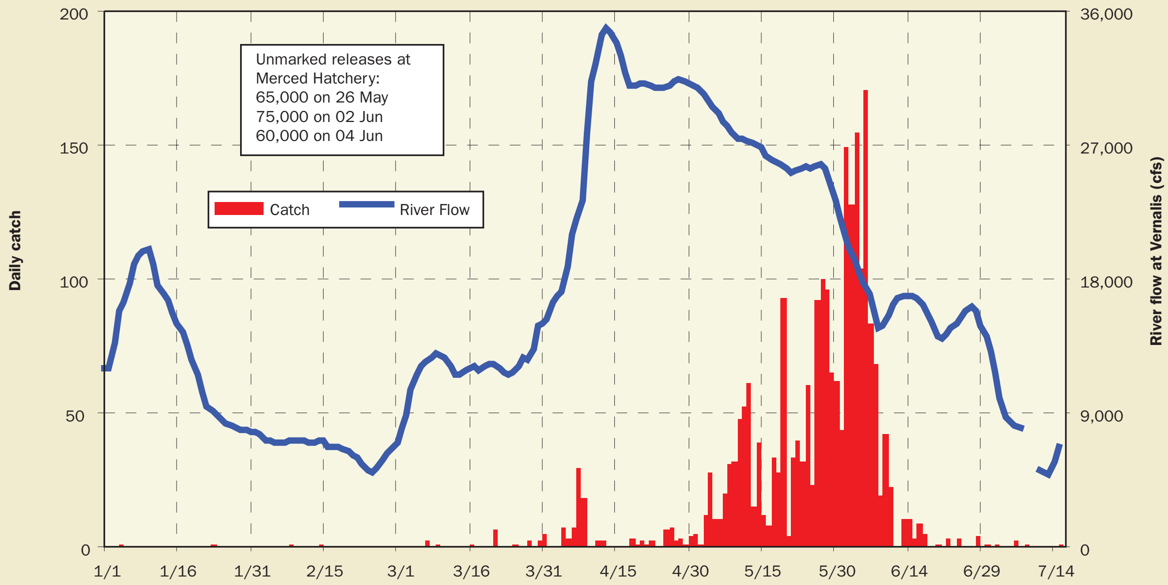
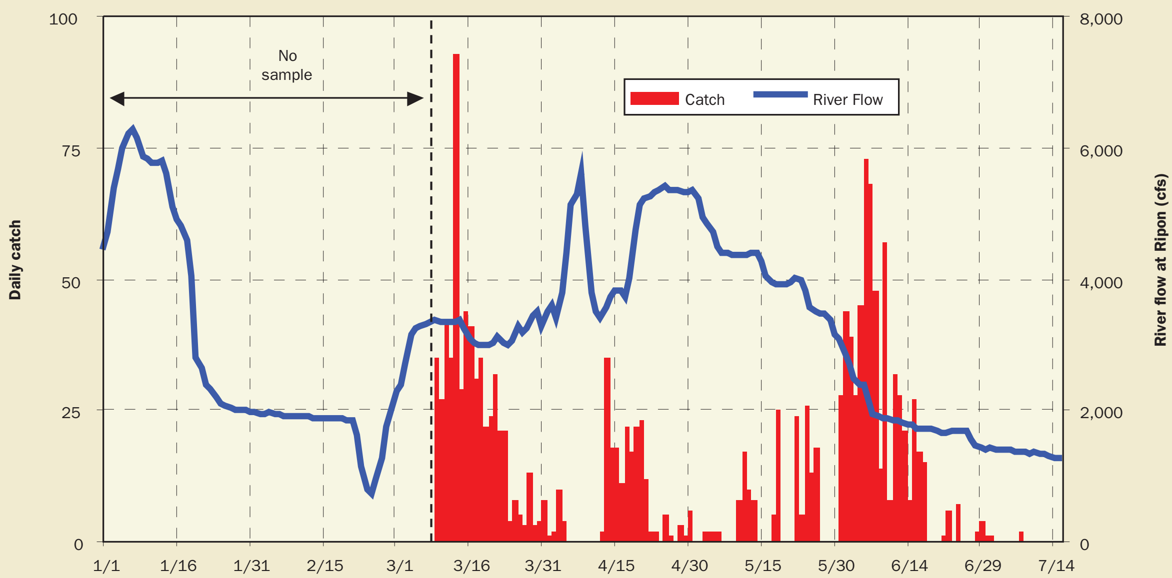


Figure 6-4
Stanislaus screw trap catch of unmarked juvenile Chinook salmon



It is apparent that much of the Tuolumne River juvenile salmon population migrated into the SJR during January to March as fry and pre-smolts. Although sampling did not occur near the mouth of the Stanislaus River prior to early March, many fry and pre-smolts outmigrated during the portion of March that was monitored. With early flood flows similar to the Tuolumne, it is also likely that much of the Stanislaus River juvenile population emigrated as fry and pre-smolts prior to the initiation of sampling as has been recorded during January and February of previous sampling years when flood releases occurred. Early migrants were not captured in high numbers at Mossdale or in the salvage, indicating that the juveniles may have remained in the lower San Joaquin above Mossdale and/or that relative efficiency of the trawl and salvage facilities for fry-sized salmon is less than for the RST. However, high densities have been recorded early in the season at those sites in other years (SJRGA, 2005); differences in density at Mossdale and salvage between years may also be influenced by the overall abundance of juveniles migrating from the tributaries as a result of varying parent runs.

To obtain more information on fry movement into the Delta, additional monitoring at the lower end of each of the three San Joaquin tributaries for the entire season (January through June) would be 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 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.

2006 Mossdale Trawl Summary

Contributed by Jason Guignard,
California Department of Fish and Game

Introduction

Monitoring for the fall-run chinook salmon smolt out-migrant population, in the San Joaquin drainage, is conducted two miles downstream of Mossdale Landing, Country Park (river mile 56), and upstream of the Old River confluence (Figure 6-8). The measurement of timing and production (indices and estimates) for the out-migrating fall-run Chinook salmon smolts have been monitored at this location since 1987 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.

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 3 to April 21, and then increased into 7 days a week from April 24 to May 28. The sampling effort was reduced to 5 days a week during May 29 to June 16. The entire sampling period was from April 3 to June 16, 2006 with a total of 62 sample days out of the study period of 75 days. All trawling occurred during daylight hours, starting around 0800 hours. A sampling day usually consisted of 15 tows at 20 minutes per tow, although the first three weeks and last two weeks of sampling had 10 tows per day. Due to high river level conditions, sampling was not performed between April 12-14. Sampling is also conducted 3 days per week between mid- June and April by the USFWS in Stockton.

Water temperature, turbidity, weather, beginning tow time and velocity were recorded for each tow. Velocity was recorded by using a digital flow meter model 2030R that is made by General Oceanics Inc. A Garmin GPSMap 172c was used to map the location of all sampling tows. This mapping was done in an attempt evaluate differences in catch rate throughout the sampling area (Figure 6-9). 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 as well as the California Department of Water Resources gauge at Mossdale.

All fish were identified to species and enumerated. The first 20 per tow of all species, except Chinook salmon, were also measured. Chinook salmon were checked for a clipped adipose fin and/or dye mark. All non-marked Chinook salmon were considered “natural” for the purpose of this study. All Chinook salmon were measured (fork length, mm). Chinook salmon that had a clipped adipose fin was measured, individually bagged, and labeled and saved for coded wire tag processing.

Flows averaging over 20,000 cfs in the spring of 2006 resulted in the daily operation of the trawl beginning at the upstream end of the sampling area. Although the boats and net faced upstream, the high flows carried the boats and net downstream. Typically, three tows were completed before the net was retrieved and reset upstream. The marked fish associated with the weekly vulnerability tests were released at the Mossdale boat ramp and coincided with the first tow of the day. Fish were released over a two hour period to allow the group to disperse through the reach.

Figure 6-5
Daily average forklength of unmarked juvenile Chinook salmon

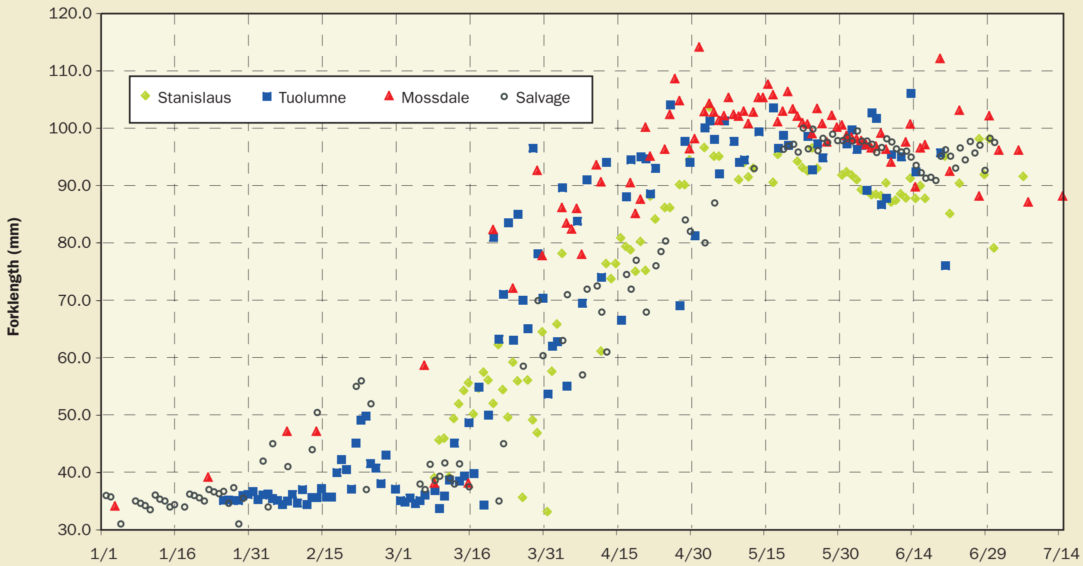


Figure 6-6
San Joaquin River salmon catch in 2006 seining by USFWS and TID/MID
from River Mile 51 (Dos Reis) to RM 90 (Laird)

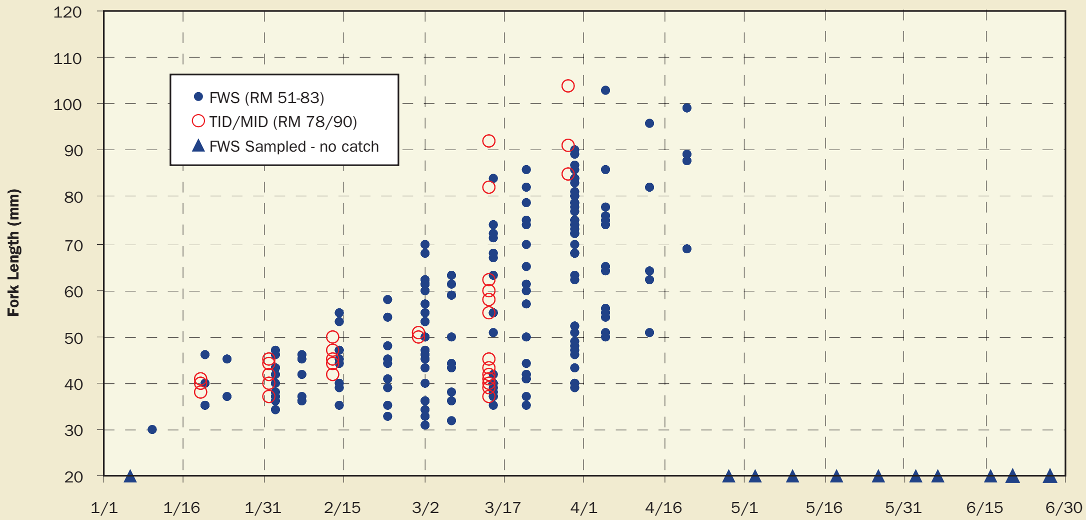


Figure 6-7
Salmon density in San Joaquin River seining from River Mile 51 (Dos Reis) to RM 90 (Laird) during January to June, 2006 - no catch in May and June.

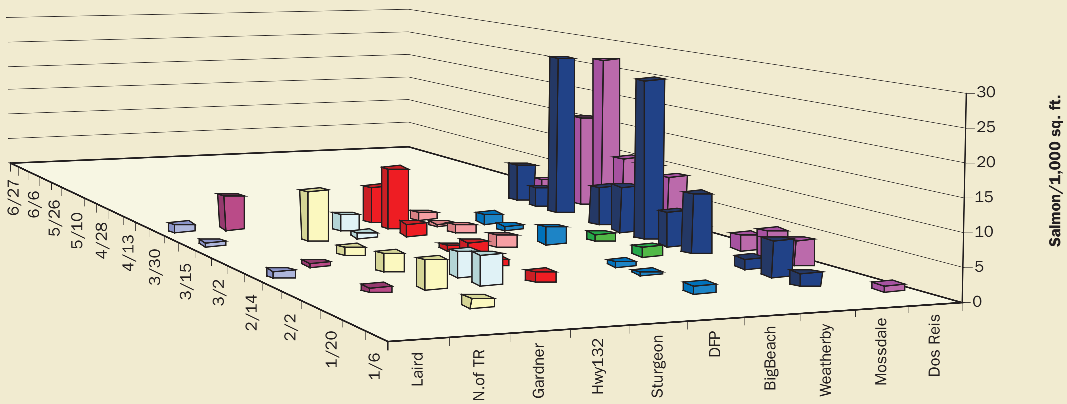


Figure 6-8
San Joaquin River and Delta.

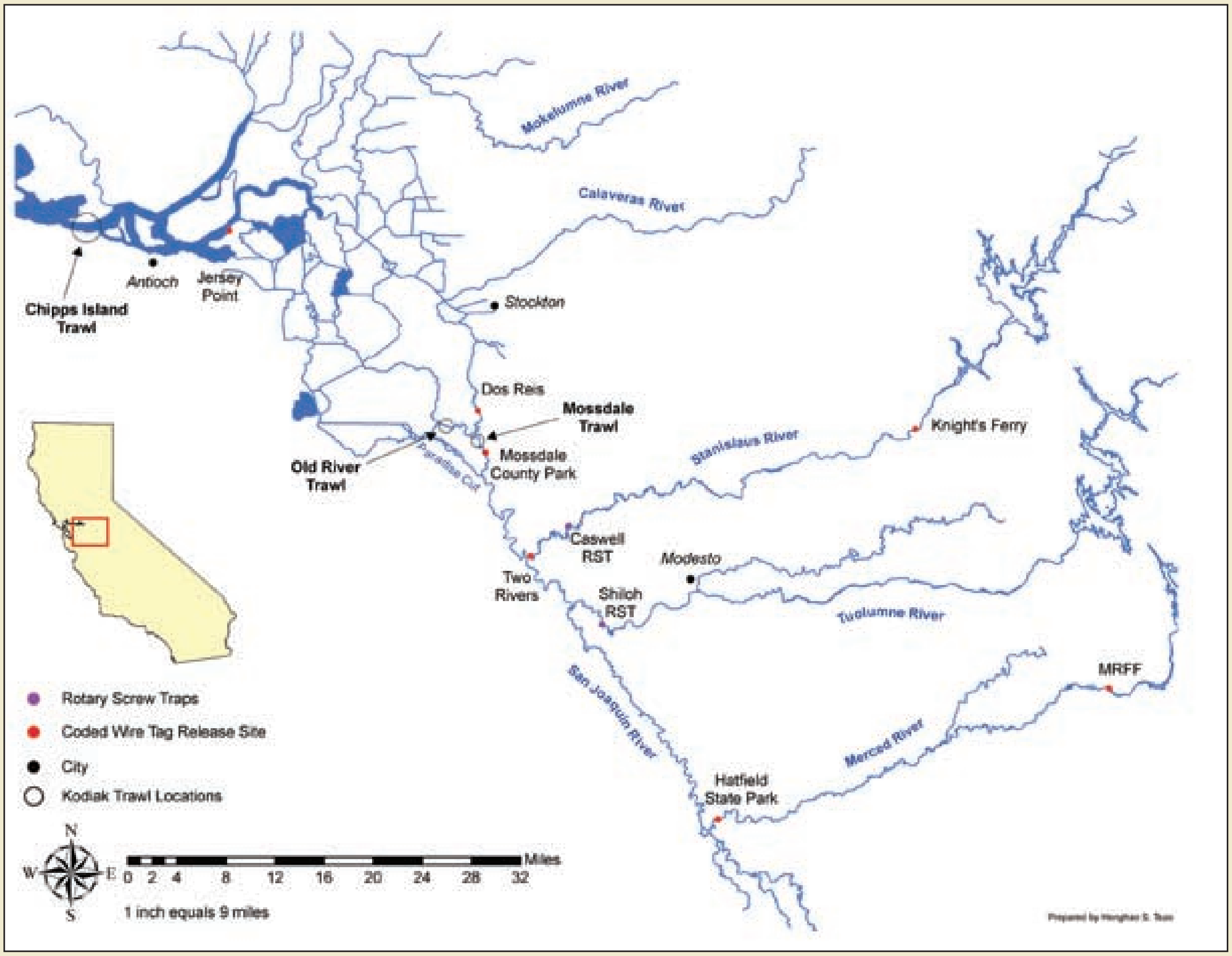


Figure 6-9
GPS tracks of all sampling tows and the corresponding catch of Chinook.

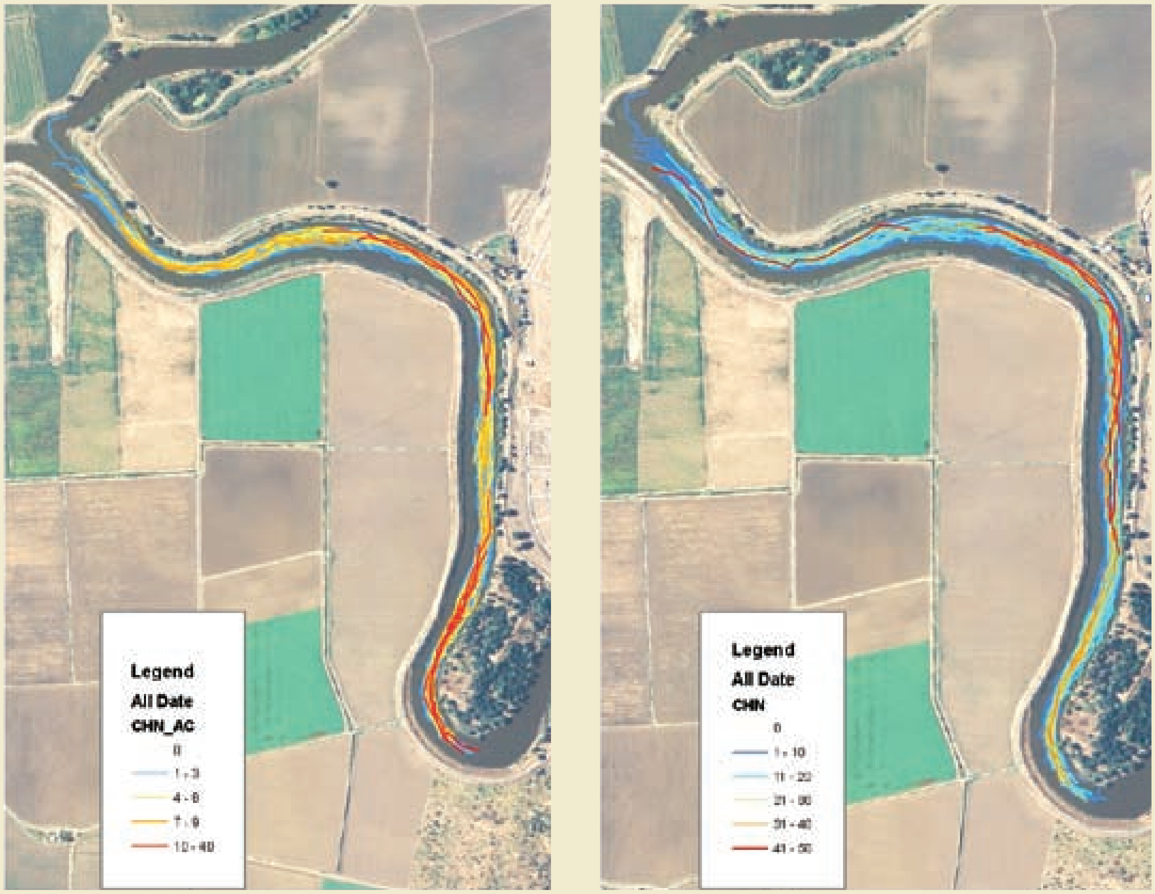
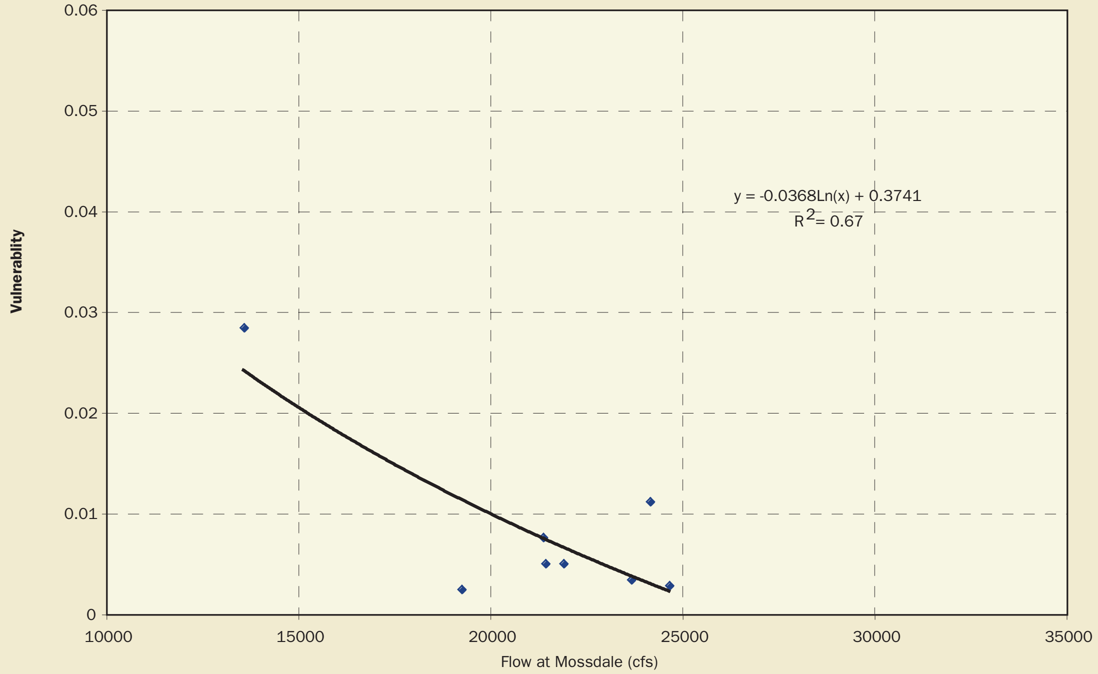


Figure 6-10
Natural Log of 2006 vulnerability tests vs. flow at Mossdale



High river flows resulted in some water being routed around Mossdale into Old River through Paradise Cut (Figure 6-8). Average mean daily flow through Paradise Cut between 4/1/2006 and 5/31/2006 was 5300 cfs.

The 2006 natural smolt production from the San Joaquin drainage was estimated by two different methods. The first method (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 Mossdale for a 5-hour index and expanded again for a 24-hour daily estimate. These daily average smolt densities were then expanded by multiplying by the daily mean flow recorded at Mossdale. Production for days not sampled within the study period were estimated by averaging smolt/ac-ft for the 2 days before and 2 days after the non-sampled period. Past smolt production estimates have been based on flows at Vernalis. Due to the flows through Paradise Cut, the 2006 production estimate utilized mean daily flow at Mossdale.

The second estimate (population ratio method), which we believe to be a more accurate estimate, due to the uneven distribution of smolts in the channel, was determined using the 8 dye marked vulnerability release groups (Table 6-1 and Figure 6-10). Production for days not sampled within the study period were estimated by averaging smolt catch and minutes towed for the 2 days before and 2 days after the non-sampled period.

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

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

$$E_I = \sum_{i=1}^{n=75}\left[\left(\frac{C_i}{V_{Ti}}\right)\left(V_{Pi}\right)\left(\frac{24}{5}\right)\right]$$

Where:

n = days in the index period

C = daily non-marked Chinook catch

V_T = daily volume of trawl sampled

V_P = daily 5-hour volume of water passing Mossdale

i = i^{th} 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 75 days.

Table 6-1
Dye marked smolt releases from Merced River Hatchery for vulnerability studies (released 975 meters upstream of the Kodiak trawl) in the san Joaquin River at Mossdale Landing, April through May, 2006.

Release Date/Time	Water Temp. (°C) Truck/River	Effective # Released	Number Recovered	Streamflow (cfs) at Mossdale	Beginning and Ending Recovery Time
6-Apr-06	10/ 13	2,056	5	19,263	10:31
9:18					11:50
20-Apr-06	10/ 14	4,986	14	24,672	9:50
9:03					11:08
27-Apr-06	11/ 15	5,027	56	24,177	9:27
8:35					11:40
4-May-06	11/ 16	4,998	17	23,679	8:26
7:32					12:58
11-May-06	12/ 17	4,999	25	21,445	8:52
8:00					14:14
18-May-06	12/ 19	4,990	25	21,919	8:31
7:34					9:48
25-May-06	12/ 17	4,994	38	21,388	8:42
7:51					10:43
*01-Jun-06	12/ 18.5	4,999	12	18,379	8:21
7:55					10:06
8-Jun-06	12/ 20	4,998	142	13,595	8:15
7:45					9:09

* Vulnerability test ommitted due to problems with trawl net

Kodiak Trawl Vulnerability Estimates (Population Ratio Method):

The vulnerability expansion production estimate (E_V) was used for 2001-2006 estimates, and is calculated as follow:

$$E_V = \sum_{i=1}^{N=75} \left\{ \left[\frac{(C_i/r)}{(T_i/300)} \right] \left(\frac{24}{5} \right) \right\}$$

Where:

r = population ratio

C = Daily non-marked Chinook catch

T = Tow Duration

i = i^{th} Day

N = number of days sampled

The population ratio (r) is calculated as follow:

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

Where:

n = number of vulnerability test groups

y = number of marked fish captured

x = number of marked fish released (effective release)

i = i^{th} Day

Estimated variance ( ) of r:

$$\hat{V}(r) = \hat{V}\left(\frac{\sum_{i=1}^{n} y_i}{\sum_{i=1}^{n} x_i} \right) = \left(\frac{N-n}{nN} \right) \left(\frac{1}{\mu_x^2} \right) s.d._r^2$$

N = number of days sampled

n = number of vulnerability test groups

y = number of marked fish captured

x = number of marked fish released (effective release)

i = i^{th} Day day

u_ = average of effective release

s.d. = standard deviation

The 95% confidence interval around this estimate was calculated as $r \pm 1.96\sqrt{\hat{V}(r)}$

The 1989-2000 estimates, are based on the number of actual non-adipose clipped Chinook salmon caught per tow and expanded by the natural log of all vulnerability tests (1989-2005). This number is then extrapolated out to a 5-hour index and a 24- hour seasonal estimate.

For the purpose of analysis, vulnerability to the trawl was assumed from the beginning of the first tow detected to the end of the last tow detected on the day of release. Detection of marked fish subsequent to 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 trawl), time vulnerable to the trawl and the percent vulnerability as related to flow were determined for each test group.

Results

Between April 3 and June 16, 2006 2,743 non-marked Chinook salmon smolts were captured in the Mossdale trawl. Daily capture of non-marked salmon ranged from 0 – 176 individuals with an average of 43. Average forklength of non-marked Chinook was 99.5 millimeters (mm) and ranged from 44 – 134 mm. A total of 543 adipose fin clipped Chinook were captured between May 3 and June 14, 2006. The average forklength of marked Chinook was 99.6 mm and ranged from 71 – 126 mm.

Smolt production estimates for the San Joaquin basin ranged between 848,394 using the smolt/ac-ft estimate and 1,808,143 using the trawl vulnerability estimate (Table 6-2). The trawl vulnerability extimate is thought to be more accurate than the smolt density index method because it should account for an uneven distribution of migrating smolts in the river channel. Trawl vulnerabilities were obtained by conducting mark-recapture tests each week. Release groups ranged from 2,056 – 5,027 dye marked juveniles. Juveniles were obtained from the Merced River Hatchery and were selected by size to match as closely as possible the size of wild fish being observed in the river at that time. The production estimate had a 95% confidence range of (1,749,531 – 1,866,755).

Eleven steelhead/ rainbow trout (RBT) were captured during the 2006 sampling period. All RBTs were measured and returned to the river. Average forklength was 271 mm, and all samples exhibited advanced stages of the smoltification process. Figure 6-12 shows the total number and average forklength of RBTs captured by the Mossdale Trawl from 1988 to 2006.

Figure 6-11
Expanded daily catch of non-marked Chinnok based on vulnerability estimates and flow at Mossdale, 2006

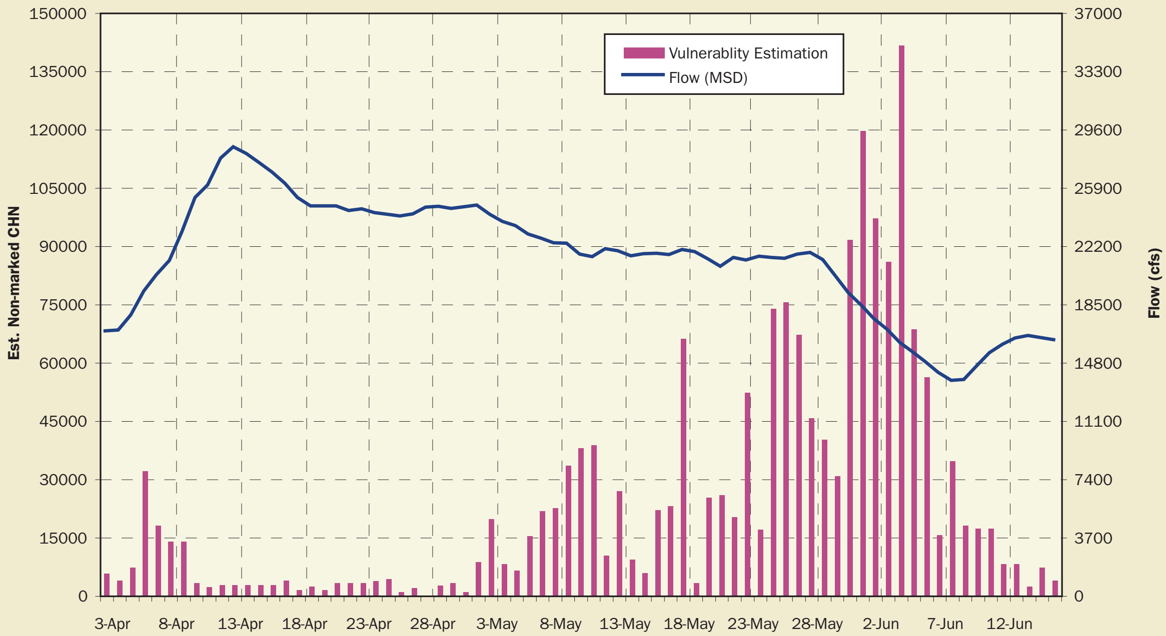


Figure 6-12
Annual rainbow trout/steelhead catch and average forklength at Mossdale

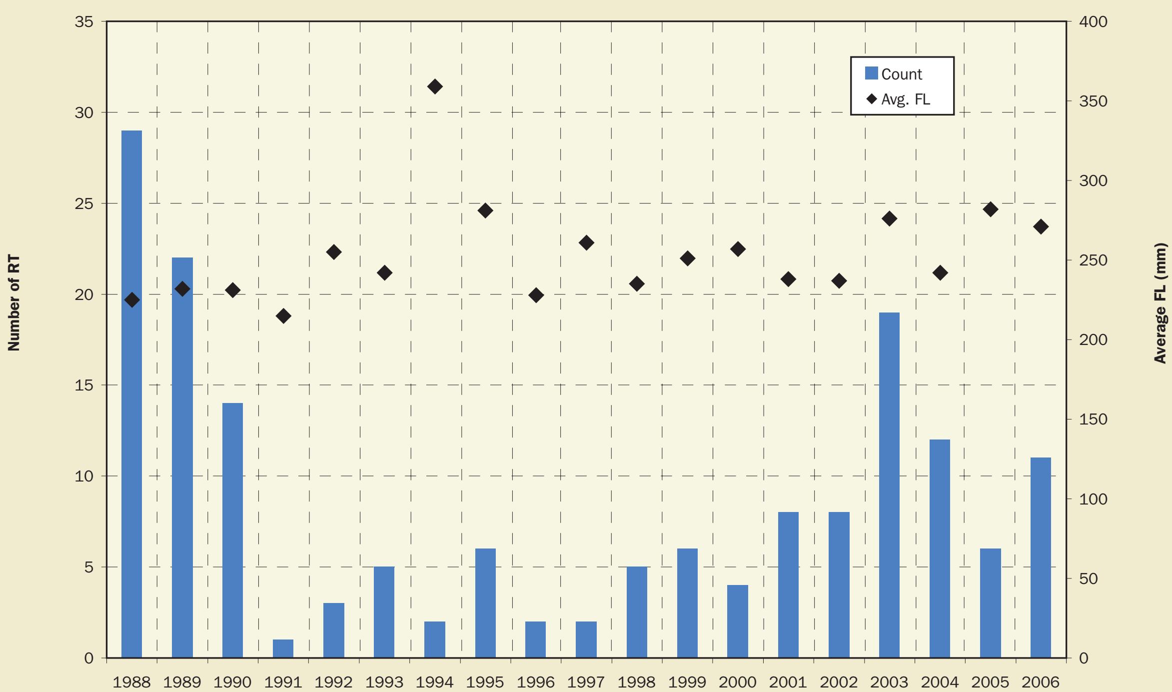


Table 6-2 Smolt Production seasonal estimates and sampling period for the duration of the study.				
Year	Sampling Period (Days)	Percentage of Day Sampled (%)	Smolt/ac-ft Estimate	Vulnerability Smolt Production Seasonal Estimate** (95% confidence range)
2006	75	85.3	848,394 + 12,888	1,808,143 : (1,749,531-1,866,755)
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.

** 2001-2006 production estimates based on the annual population ratio method, 1989-2000 estimates based on the natural log of all vulnerability tests (1989-2005).

2006 VAMP Pilot Study to Monitor the Migration of Juvenile Chinook Salmon Using Acoustic Telemetry

Contributed by Dave Vogel, Natural Resource Scientists, Inc.

Introduction

During the 2006 Vernalis Adaptive Management Program (VAMP), a pilot study was initiated to monitor the migration of juvenile Chinook salmon using acoustic telemetry. The study was prompted by interest from VAMP participants to determine if the applied technology would provide detailed information about the movements of juvenile salmon through the Delta. In particular, there was need to evaluate how lack of a barrier at the Old River/San Joaquin River flow split may affect juvenile salmon and determine migration pathways used by salmon at other locations further downstream in the San Joaquin River. The project was conducted as a short-term, small-scale pilot effort to evaluate if the equipment, techniques, and results would be valuable toward supplementing existing VAMP studies in future years. The following section provides a brief description of the results of the 2006 pilot study. Additional details will be provided in a separate technical report.

Summary of 2006 Pilot Study

The pilot study was conducted from May 8 through May 19, 2006, during high flow conditions. One hundred Merced Hatchery juvenile fall-run Chinook were used for the study. A request was made to the California Department of Fish and Game to include wild fish captured in the Merced River but was not approved. Miniature acoustic transmitters (0.8 grams) (Figure 6-13) were surgically implanted (Figure 6-14) inside the hatchery fish. Each transmitter was programmed to be individually identifiable based on sound transmission pulse width and repetition rate.

Acoustic receivers (Figure 6-15) capable of recording each acoustic-tagged salmon were deployed off the levee banks (Figure 6-16) or from California Department of Water Resources tide gauging stations to detect fish passing each site. The receivers electronically record the time when each fish is detected.

The acoustic-tagged salmon were released at Mossdale and Dos Reis in the lower San Joaquin and monitored with acoustic receivers placed at five locations shown in Figure 6-17.

Only five acoustic receivers were available for this pilot study and, therefore, data collection was limited by coverage in only some of the Delta channels where fish may migrate. Other important areas could not be included in the study (e.g., south Delta export facilities).

An initial release of 32 acoustic-tagged salmon was made at Mossdale on May 8, 2006. Originally, it was planned to release 100 fish on that date, but the remaining fish at the hatchery were slightly smaller than required for tag implantation. Therefore, the remaining fish were kept at the hatchery to acquire additional growth for tagging, then subsequently released on May 15, 2006.

First Fish Release (May 8, 2006) (Low Export Rate)

Of the 32 fish released at Mossdale on May 8, 2006, 25 fish (78%) were detected to have been diverted into Old River and 5 fish (16%) were detected to have migrated down the lower San Joaquin past the Brandt gauge. The fate of the remaining 2 fish is unknown, but, given the caveats

Figure 6-13
An acoustic transmitter

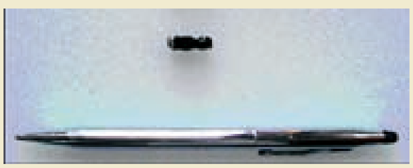


Figure 6-14
A juvenile Chinook salmon with a surgically implanted acoustic tag.

Figure 6-15
An acoustic (hydrophone) receiver, connection cable, output extender box, and 12-VDC marine batter.

Figure 6-16
Deployment of an acoustic receiver from a Delta levee.

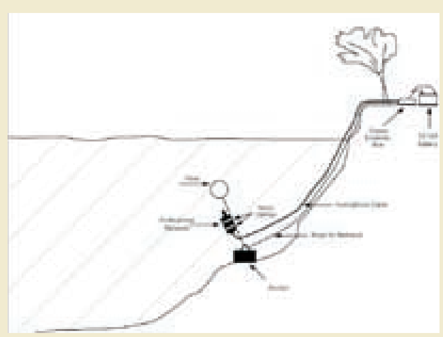
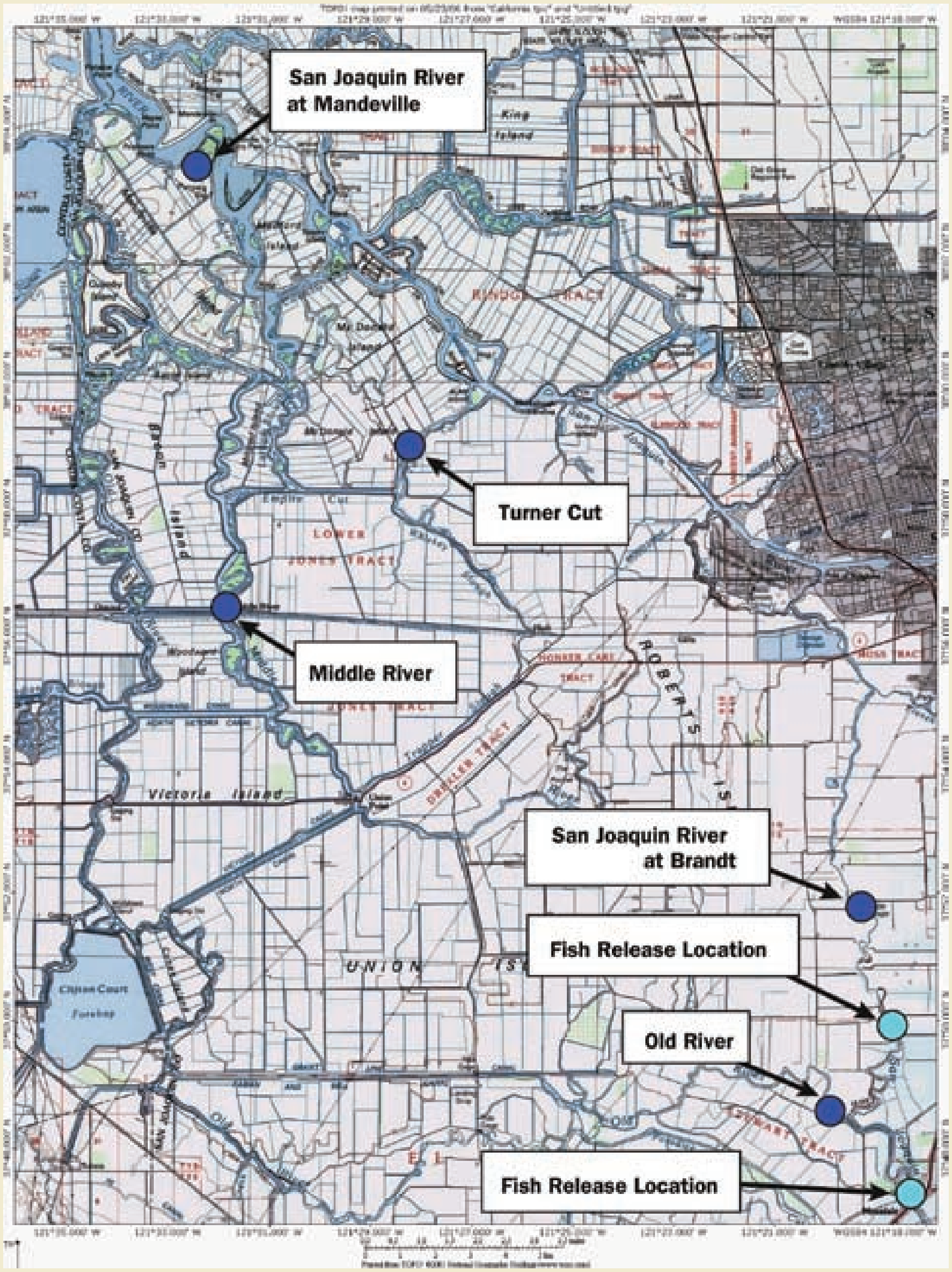


Figure 6-17
Release locations of acoustic-tagged juvenile salmon and deployment locations of acoustic receivers during May 2006.



described below, the fish were presumed to have been preyed upon because the transmitters were not detected at any receivers during the study period.

The proportionally high rate of fish diverted into Old River could not be explained by proportion of flow diverted. Based on preliminary flow data, Old River was diverting approximately 53% of the mainstem San Joaquin flow at the time the fish approached the flow split, but at least 78% of the fish were diverted into Old River. (Table 6-3)

Table 6-4
Acoustic tag detections following a release of 32 fish at Mossdale on May 8, 2006

# Detected in Old River	# Detected in San Joaquin River at Brandt Gauge	# Assumed Lost Due to Predation
25* (78%)	5 (16%)	2 (6%)

* Three of these fish were subsequently detected in Middle River

Second Fish Release (May 15, 2006)

Because such an unexpectedly high proportion of the fish were diverted into Old River during the first fish release, the second release was modified by releasing 35 fish at Mossdale and 33 fish at Dos Reis on May 15, 2006. Based on preliminary flow data, approximately 51% of the mainstem San Joaquin flow was diverted into Old River at the time fish approached the flow split, with 40% of fish released at Mossdale entering Old River (Table 6-4). Of the 33 fish release at Dos Reis, only 14 (42%) passed the first downstream receiver at the Brandt gauge (Table 6-5). The fate of the remaining 19 fish (58%) is unknown but the fish

Table 6-5
Acoustic tag detections following a release of 35 fish at Mossdale on May 15, 2006

# Detected in Old River	# Detected in San Joaquin River at Brandt Gauge	# Assumed Lost Due to Predation
14 * (40%)	11 (31%)	10 (29%)

* One of these fish was subsequently detected in Middle River and two of these fish were subsequently detected by mobile telemetry and assumed preyed upon.

Table 6-6
Acoustic tag detections following a release of 33 fish at Dos Reis on May 15, 2006

# Detected in San Joaquin River at Brandt Gauge	# Assumed Lost Due to Predations
14 (42%)	19 (58%)

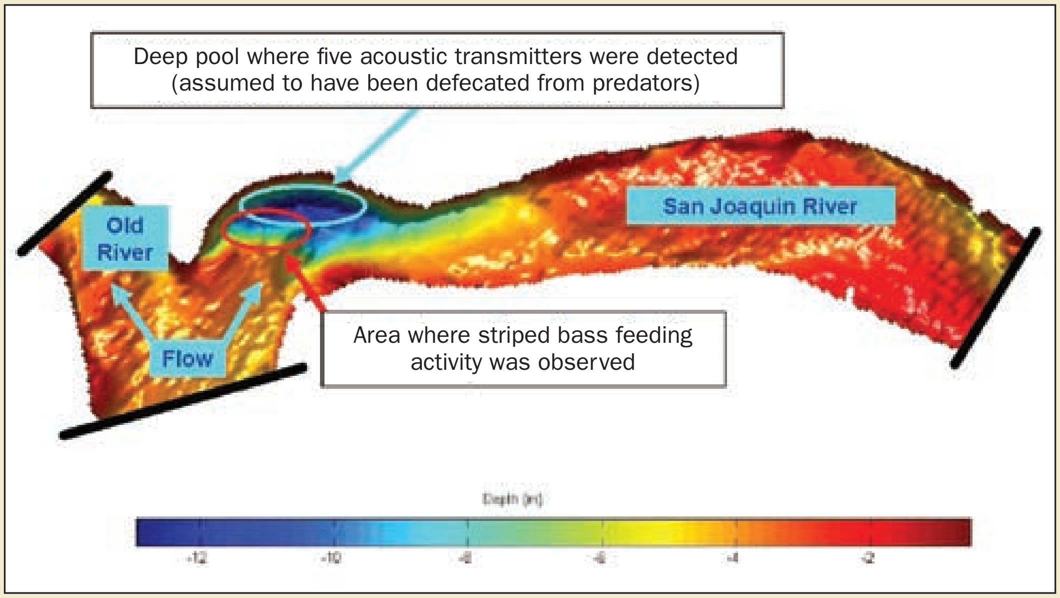
were assumed to be consumed by predators because the transmitters were not detected by any fixed-station receiver during the study period.

No fish were detected in Turner Cut or the lower San Joaquin River at Mandeville Island. The Turner Cut acoustic receiver had complete coverage of the cross-section of the river channel so no acoustic-tagged fish passing the site could have escaped detection. The Mandeville Island receiver had coverage of the majority of flow passing the site. Some flow passing around a side channel at the site could not be covered by the receiver and, therefore, it is possible some fish may have escaped detection. However, that circumstance is probably not likely based on fish behavior derived from extensive fish radio-telemetry in that region during prior studies. If those fish passing the Brandt gauge receiver took a long time (e.g., a week) to reach Turner Cut or Mandeville Island, it is also possible that the transmitter battery reached its useful life, estimated at about 10 days. However, based on past radio-telemetry studies on juvenile salmon in that region, fish movements past the area would be expected to be only several days.

Because of the limited number of acoustic receivers available for this pilot study, no data could be collected upstream of the two fish release sites. Therefore, it is possible (but not probable) that some acoustic-tagged salmon could have swam upstream during the period of study. It is more likely that some salmon were consumed by predatory fish that swam upstream escaping detection from any receiver. Notably, May is the peak upstream spawning migration period for striped bass spawning.

The fate of fish after diversion into Old River could not be determined from this study due to the limited number of acoustic receivers. However, four of the fish diverted into Old River were subsequently detected in Middle River

Figure 6-18
Plan-view, bathymetry of the Old River/San Joaquin River flow split (bathymetry graphic courtesy of Jon Burau and Aaron Blake, USGS).



near Bacon Island. Because of the small amount of flow diverted at the Old River/Middle River flow split, it is likely those fish moved west via Grant Line Canal or Fabian and Bell Canal, then north (past the south Delta export facilities) and subsequently moved across to Middle River through one of several interior Delta channels (e.g., Victoria Canal, Woodward Canal). A prior radio-telemetry study on juvenile salmon in this region demonstrated such migration pathways north of the export facilities.

On May 19, 2006, all five receivers were removed from Delta channels. One receiver was utilized as a "mobile" receiver in an attempt to locate transmitters that were not detected at either the Old River or lower San Joaquin River (Brandt) receiver sites. This was accomplished by hanging the receiver submerged off a boat and drifting the distance from just upstream of the Mossdale bridges to downstream of the location where the lower San Joaquin receiver had been deployed at the Brandt gauge. During this final mobile survey, 13 acoustic transmitters were located within the surveyed reach. Five transmitters were detected in a large, deep hole in the San Joaquin River adjacent to the Old River flow split (Figure 6-18). At that location, numerous striped bass were observed feeding. Eight additional transmitters were located further downstream near pump station structures in the river channel. All 13 transmitters were assumed to have been defecated from predatory fish that had consumed acoustic-tagged juvenile salmon, although this could not be confirmed.

Conclusions from the 2006 Pilot Study

- The equipment and techniques worked well, but the study was limited by the number of available acoustic receivers; additional receivers deployed at other locations throughout the Delta would maximize collection of data useful to determine the fate of salmon migrating through the Delta.
- A higher than anticipated number of fish were diverted into Old River; the proportion of fish diverted into Old River was higher than the proportion of flow diverted.
- Study results suggested a high rate of predation; future use of a mobile receiver would locate areas of predation.

Survival Estimated for CWT Releases Made in the San Joaquin Tributaries

Contributed by Pat Brandes, U.S. Fish and Wildlife Service

Coded wire tagged salmon from the MRH were released in the Merced and Stanislaus Rivers between April 26 and May 15, 2006 as part of independent (complimentary to VAMP) fishery investigations. Releases were made in the upper and lower reaches of the Merced (Merced River Hatchery and Hatfield State Park, respectively) and Stanislaus (Knights Ferry and Two Rivers) Rivers.

Survival indices to Antioch and Chipps Island of lower Merced releases made at Hatfield State Park and lower Stanislaus releases at Two Rivers include mortality down the mainstem San Joaquin River, as well as, through the Delta (Figure 6-8). Chipps Island survival indices of the lower Merced River and Two Rivers groups were comparable to survival indices from the 2006 VAMP releases made at Mossdale and Dos Reis. Only recoveries from a few of the upstream groups were made at Antioch. Survival indices using Chipps Island recoveries ranged between 0.019 – 0.077 (Table 6-7), while those for VAMP fish released at Mossdale and Dos Reis ranged from 0.019 to 0.128 (Table 5-5).

These data indicate that the low survival observed from the Mossdale and Dos Reis groups was common to those released upstream. It is also interesting to note that the first groups released on the Merced River had higher survival indices to Chipps Island than the 2nd group released later. This difference in survival could be related to the different export rates (and temperatures) during the two periods as was shown for the Mossdale groups and discussed in Chapter 5.

Survival indices were also generated for groups released on the upper Merced (MRH) and Stanislaus Rivers. Comparison of survival indices of groups released upstream and

Table 6-7
Smolt survial indcies for smolts released in the upper and lower reaches of the Merced and Stanislaus Rivers in 2006

							Antioch				
TagCode	**Release Site/Stock**	**Date**	**Truck Temp (F)**	**Release Temp (F)**	**Number Released**	**Average Size (mm)**	**First Day Recovered**	**Last Day Recovered**	**Number Recovered**	**Minutes Fished**	**Percent Sampled**
6-46-94	MRH		52	52	25533	87	–	–	0	–	–
6-46-95	MRH		52	52	26120	87	–	–	0	–	–
6-47-01	MRH		52	52	25382	87	5/6/06	5/6/06	1	200	0.139
6-47-02	MRH		52	52	26289	87	–	–	0	–	–
	Total	**4/26/06**			**103324**		**5/6/06**	**5/6/06**	**1**	**200**	**0.139**
6-47-03	Hatfield State Park		53.6	60.8	17645	88	5/7/06	5/10/06	2	2065	0.359
06-47-04	Hatfield State Park		52.7	57.2	17615	88	5/8/06	5/14/06	2	3760	0.373
06-47-05	Hatfield State Park		52.7	57.2	17684	88	5/11/06	5/17/06	4	3775	0.375
	Total	**5/1/06**			**52944**		**5/7/06**	**5/17/06**	**8**	**5840**	**0.369**
6-47-09	MRH		54	54	23433	81	–	–	0	–	–
6-47-10	MRH		54	54	23500	81	–	–	0	–	–
6-47-11	MRH		54	54	23255	81	–	–	0	–	–
06-47-12	MRH		54	54	23295	81	–	–	0	–	–
	Total	**5/10/06**			**93483**		**–**	**–**	**0**	**–**	**–**
06-47-06	Hatfield State Park		55.4	60.8	24700	87	–	–	0	–	–
06-47-07	Hatfield State Park		55.4	60.8	24232	87	5/24/06	5/24/06	1	580	0.403
06-47-08	Hatfield State Park		56.3	62.6	24181	87	–	–	0	–	–
	Total	**5/15/06**			**73113**		**5/24/06**	**5/24/06**	**1**	**580**	**0.403**
06-47-17	Knights Ferry		51.8	53.6	26089	73	–	–	0	–	–
06-47-18	Knights Ferry		51.8	53.6	25577	75	–	–	0	–	–
06-47-19	Knights Ferry		55.4	53.6	24575	75	–	–	0	–	–
	Total	**4/28/06**			**76241**		**–**	**–**	**0**	**–**	**–**
06-47-20	Two Rivers	5/2/06	52.7	57.2	24411	75	5/30/06	5/30/06	1	560	0.389

downstream and recovered at Chipps Island provides an estimate of survival through the Merced and Stanislaus Rivers. This is accomplished by dividing the upstream group survival index by the downstream survival index. For the two sets released on the Merced River, survival was estimated to range from 0.39 and 1.05, indicating survival down the Merced River was relatively high (Table 6-8). Survival through the Stanislaus River was lower and estimated at 0.23. (Table 6-8). These comparisons likely do not provide precise estimates of survival through the Merced and Stanislaus Rivers, but may be useful for distinguishing between high and low tributary survival. Ocean recoveries will be available for these groups in future years and will provide an additional source of recoveries of which to use to estimate survival through each tributary. It is also clear that in 2006, survival through the Delta was much lower between Mossdale and Jersey Point for the first and second groups (0.12 and 0.02, respectively) than it was down the Merced or Stanislaus rivers.

More of the CWT fish released in the San Joaquin tributaries were recovered at the CVP and SWP fish facilities than for the VAMP groups (Table 6-7). It also appeared there were more salvaged at the CVP during the later releases although unexpanded salvage was still generally low.

Table 6-8
Estmates of tributary survial in the Merced and Stanislaus Rivers in 2006

Release site	Release Date	Survival index	Tributary survival
Upper Merced	4/26/06	0.41	0.39
Hatfield State Park	5/1/06	0.106	
Upper Merced	5/10/06	0.02	1.05
Hatfield State Park	5/15/06	0.019	
Knights Ferry	4/28/06	0.018	0.23
Two Rivers	5/2/06	0.077	

		Chipps							CVP and SWP Salvage			
									Observed (unexpanded) salvage		Expanded salvage	
Survival Index	**Group Index**	**First Day Recovered**	**Last Day Recovered**	**Number Recovered**	**Minutes Fished**	**Percent Sampled**	**Survival Index**	**Group Index**	**SWP**	**CVP**	**SWP**	**CVP**
–		5/6/06	5/17/06	4	4800	0.278	0.073		0	3	0	60
–		–	–	0	–	–	–		2	1	12	12
0.020		5/27/06	5/27/06	1	400	0.278	0.071		0	2	0	24
–		5/15/06	5/31/06	4	6802	0.278	0.071		0	4	0	48
	0.005	**5/6/06**	**5/31/06**	**9**	**10402**	**0.278**		**0.041**				
0.023		5/8/06	5/14/06	3	2800	0.278	0.080		1	4	6	48
0.022		5/6/06	5/15/06	7	4000	0.278	0.186		2	2	9	24
0.044		5/7/06	5/24/06	2	7202	0.278	0.053		1	1	6	12
	0.030	**5/6/06**	**5/24/06**	**12**	**7602**	**0.278**		**0.106**				
–		6/1/06	6/1/06	1	400	0.278	0.020		1	6	12	72
–		5/31/06	5/31/06	1	400	0.278	0.020		0	5	0	96
–		6/1/06	6/1/06	1	400	0.278	0.020		1	3	12	48
–		6/1/06	6/1/06	1	400	0.278	0.020		1	4	12	72
	–	**5/31/06**	**6/1/06**	**4**	**800**	**0.278**		**0.020**				
–		5/29/06	5/29/06	1	400	0.278	0.019		2	8	12	108
0.007		5/29/06	6/1/06	2	1600	0.278	0.039		0	11	0	156
–		–	–	0	–	–	–		1	8	6	108
	0.002	**5/29/06**	**6/1/06**	**3**	**1600**	**0.278**		**0.019**				
–		–	–	0	–				0	11	0	219
–		5/30/06	5/30/06	1	400	0.278	0.018		0	9	0	252
–		5/28/06	6/11/06	2	5986	0.277	0.038		5	12	45	216
	–	**5/28/06**	**6/11/06**	**3**	**5986**	**0.277**		**0.018**				
0.008		5/10/06	6/6/06	4	11188	0.277	0.077		0	10	0	112

Comparison of VAMP Releases with Sacramento River Delta Releases

Contributed by Pat Brandes, U.S. Fish and Wildlife Service

As in previous years, marked fish from the Feather River were released on the Sacramento River near West Sacramento. Three groups were released to index survival through the Delta for juvenile salmon originating in the Sacramento basin. Comparison of survival between the Sacramento released fish and those released at Mossdale and Dos Reis provide insight on the variation in survival between basins. The average survival index in 2006 for the three separate groups of Feather River Hatchery smolts released on April 18, May 1, and May 17 was 0.53 similar to that measured in 2003 (0.51) and 2005 (0.46) and greater than that measured in 2004 (0.19). VAMP survival indices to Chipps Island for groups released at Mossdale and Dos Reis for the first release in 2006 were 0.086 and 0.128 respectively. The second release group, released at Mossdale under higher exports in 2006, had a survival index of 0.019. Survival indices for Durham Ferry, Mossdale and or Dos Reis were low for all three years between 2003 and 2005 and were estimated at about 0.05. These data indicate survival was lowest in both basins in 2004. Delta smolt survival in 2003, 2005 and 2006 for the Sacramento basin was similar between these years and much higher than for the VAMP fish released in the same years. Survival for the VAMP fish was low for all of these years, with the exception of some apparent improvement in 2006 under the low export condition.

Survival indices are typically higher for smolts migrating through the Delta from Sacramento than for smolts emigrating past Mossdale. It is unclear why this is the case although smolts entering the Delta from Mossdale are generally exposed to lower river flows than on the Sacramento River and smolts from the San Joaquin basin migrate in closer proximity to the CVP and SWP pumping plants. In 2006, San Joaquin stocks did not have PKD as they have had in the recent past, which may have decreased survival in some of the previous years. All of these factors and others may result in the lower survival detected through the Delta for juvenile salmon originating from the San Joaquin basin.

Chapter 7
Conclusions and Recommendations

The 2006 VAMP was implemented without the installation of the HORB due to high flow conditions described in Chapter 2. The start of the VAMP pulse flow period was delayed until May 1, with a resulting average flow between May 1 and May 31 of 26,020 cfs. Exports were separated in two rates of 1,559 cfs and 5,748 cfs for the period May 3 -17 and May 18 – June 2. Flow monitoring was conducted in the San Joaquin River downstream of the HOR and in the Old River. Kodiak trawling was again conducted in Old River in 2006, and compared with the regularly conducted sampling on the San Joaquin River at Mossdale. Estimates of juvenile Chinook salmon smolt survival were calculated based upon recoveries of CWT juvenile salmon produced in the MRH and released at Mossdale, Dos Reis, and Jersey Point. Marked salmon were recaptured in sampling at Mossdale, in Old River, at the SWP and CVP fish facilities, and at Antioch and Chipps Island. Based upon the data and experience gained during the VAMP 2006 investigations, 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.

Smolt survival in 2006 was low as it has been the past three years. There were greater flows in 2006 then in 2005 and we would have anticipated survival should have improved. Survival in 2006 for the first group releases (at low exports) was somewhat better than in 2005 although the second group released in 2006 (at high exports) was lower than in 2005 and more similar to that observed in 2003. The relationship of salmon survival to San Joaquin River flow has shown that survival increases as flows increase, with the HORB in place. This relationship is statistically significant when recovery from all available sources (Antioch, Chipps Island, and ocean fishery) are combined. The relationships are more variable comparing survival to flow without the HORB especially when including data from 2005 and 2006. Relationships of flow to adult escapement 2 1/2 years later, indicates these relationships are likely real and that survival is improved as flows and flows relative to exports increase.

The role of exports has been difficult to identify. During the 2006 test two distinct export rates were evaluated to collect more useful data. The role of exports will not be established with the HORB until at least two VAMP targets of 7,000 cfs flow with a HORB are obtained so that survival can be measured with exports at 1,500 and 3,000 cfs. The VAMP program provides increased flows at a wide range of flow and likely increases the survival of unmarked juvenile salmon migrating through the Delta during the VAMP period.

Table 7-1
Summary of VAMP 2006 conclusions and recommendations

CONCLUSIONS	RECOMMENDATIONS FOR 2007
Observed ungaged flows (accretions, depletions) between upstream measurement points and Vernalis varied significantly from those forecasted resulting in differences in forecasted and required supplemental flows.	Hydrology committee to continue refining estimates of ungaged flow and develop a management scheme to accommodate variability.
The flow data collected in 2006 at San Joaquin River near Lathrop and the Old River at Head provided useful information on the flow split at the Head of Old River	The 2005 and 2006 flow data should be compared against DWR-DSM2 modeling results. Continue to calibrate the stage and flow monitoring at the San Joaquin River near Lathrop station.
Short-term survival (48-hours post-transport) was high (99.9%) indicating that handling, transport, and release likely had no affect on short-term smolt survival.	Continue net pen studies and fish health inspections.
Some test fish obtained from Chipps Island Trawl to detect the presence of PKD were improperly fixed.	Recommend additional training of staff or different process for fixing of tissues used to detect presence of PKD.
The number of CWT salmon from Mossdale releases recovered at the SWP and CVP salvage facilities were much less than in prior years when there was no HORB.	Continue salvage monitoring to document direct losses at SWP/CVP export facilities.
VAMP has been designed to adaptively change within a few weeks, the VAMP test period each year	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.
Survival from Mossdale and Dos Reis in 2006 was lower with higher exports without the HORB installed.	It is anticipated that due to the decline in delta smelt the HORB will not be installed in the future. Continue to measure survival when there is no HORB to compare to past years and to better understand the role of flow and exports on survival without the HORB in place. The VAMP tests should be continued.
Further evaluation of survival rate versus export rate is needed. The VAMP is limited by lack of 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.
HOR Kodiak trawl, when the HORB is not installed, is an important component to understanding the distribution of out migrating salmon in the southern Delta.	Implement the HOR trawl during the spring out migration when the HORB is not installed.
Mossdale Kodiak trawl is an important component in determining distribution of juvenile salmon out migration from the San Joaquin basin.	Maintain the Mossdale Kodiak trawl at existing or higher level of effort throughout year.
During 2006 two CWT lots were mixed at MRH resulting in the need to correct release numbers to estimate survival.	Merced River Hatchery should safeguard against the mixing of CWT lots.
An Acoustic Telemetry pilot study was conducted in 2006 to determine the suitability to track the movement of out migrating salmon in the Lower San Joaquin River and southern Delta.	Implement a full-scale Acoustic Telemetry study to better understand the movement and survival of out migrating salmon from the San Joaquin River basin.
Complimentary studies to evaluate mechanisms affecting survival of fish from tributaries and across the Delta were conducted.	Encourage an expansion of complementary studies to provide additional information on factors and mechanisms affecting salmon survival.

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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

OAKDALE IRRIGATION DISTRICT*

SOUTH SAN JOAQUIN IRRIGATION DISTRICT*

MODESTO IRRIGATION DISTRICT*

TURLOCK IRRIGATION DISCTICT*

MERCED IRRIGATION DISTRICT*

SAN JOAQUIN RIVER EXCHANGE CONTRACTORS WATER AUTHORITY*

Central California Irrigation District
Firebaugh Canal Water District
Columbia Canal Company
Sal Luis Canal Company

FRIANT WATER USERS AUTHORITY*

PUBLIC UTILITIES COMMISSION OF THE CITY AND COUNTYOF SAN FRANCISCO*

NATURAL HERITAGE INSTITUTE

METROPOLITAN WATER DISTRTICT OF SOUTHERN CALIFORNIA

SAN LUIS AND DELTA-MENDOTA CANAL WATER AUTHORITY

SAN JOAQUIN RIVER GROUP AUTHORITY

*San Joaquin River Group Authority Members

2006 Useful Web Pages

Page 3 San Joaquin River Agreement
www.sjrg.org/agreement.htm

Page 3 SWRCB Decision 1641
www.waterrights.ca.gov/hearings/Decisions.htm

Page 8 VAMP Annual Technical Reports

www.sjrg.org

Page 8 VAMP Experimental Design

www.sjrg.org/agreement.htm

Page 14 San Joaquin River nr.Vernalis, USGS Daily
http://waterdata.usgs.gov/ca/nwis/dv?format=pre&period=1&site_no=11303500

San Joaquin River nr. Newman, USGS Daily
http://waterdata.usgs.gov/ca/nwis/dv?format=pre&period=31&site_no=11274000

Tuolumne River nr. LaGrange, USGS Daily
http://waterdata.usgs.gov/ca/nwis/dv?format=pre&period=31&site_no=11289650

Stanislaus River below Goodwin, USBR Daily
www.usbr.gov/mp/cvo/vungvari/gdwdop.pdf

Merced River at Cressey, CDEC Daily
http://cdec.water.ca.gov/cgi-progs/queryDgroups?s=fw2

Merced River nr. Stevinson, CDEC Daily
http://cdec.water.ca.gov/cgi-progs/queryDgroups?s=fw2

Page 24 Temporary Barrier Program
http://sdelta.water.ca.gov/web_pg/tempmesr.html

Page 28 Reclamation District 544 Seepage Monitoring Study
http://wdl.water.ca.gov/hydstra/index.cfm#GW

Page 64 CVP and SWP Salvage Data
www.iep.ca.gov

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

Regional Mark Information System
www.rmis.org

Page 63 U.S. Fish and Wildlife Service

Anadromous Fish Restoration Program
www.delta.dfg.ca.gov/afrp

Common Acronyms and Abbreviations

ADCP	Acoustic Doppler Current Profiler
Bay-Delta	Sacramento and San Joaquin Rivers San Francisco Bay Delta
CDEC	California Data Exchange Center
CDRR	Combined Differential Recovery Rate
CFS	Cubic Feet Per Second
CPUE	Catch Per Unit Effort
CRR	Combined Recovery Rate
CVP	Central Valley Project
CWT	Coded-Wire Tagged
D-1641	Water Rights Decision 1641 of the SWRCB
DFG	California Department of Fish and Game
DWR	California Department of Water Resources
GLC	Grant Line Canal
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
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
TBP	Temporary Barriers Project
TID	Turlock Irrigation District
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

Appendix Table of Contents

Appendix A

Hydrology and Operation Plans 98

A-1

Daily Operation Plan, Tables 1-12 99

A-2

Comparison of Real-time and Provisional Flows, Figures 1-8 111

Appendix B

Historical Data 115

B- Figure 1

Storage Impacts, 2000-2006 Lake McClure 116

B- Figure 2

Storage Impacts, 2000-2006 New Don Pedro Reservoir 116

B- Figure 3

Merced River below Crocker-Huffman Dam, 2000-2006 117

B- Figure 4

Tuolumne River below LaGrange Dam, 2000-2006 117

Appendix C

Chinook Salmon Survival Investigations 118

C-1 Water Temperature Monitoring Locations 119

C-2 Water Temperature Monitoring Data, Plots 1-19 121

C-3 Net Pen Sampling Results, Tables C-3a, C-3b 131

C-4 Coded Wire Tag Recovery Data 132

Appendix D

Errata for the Year 2005 Annual Technical Report 137

Appendix A
Hydrology and Operation Plans

Appendix A-1, Table 1

2006 VAMP DAILY OPERATION PLAN
March 23, 2006 (A) • LOW
Target Flow Period: April 15 - May 15 • Flow Target: greater than 7,000 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	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (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)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		(cfs)	(cfs)	(cfs)	
15-Mar-06	**11,700**				**11,700**	**1,583**	**966**	**2,849**			**2,849**	**4,060**	**4,060**		**4,060**	**3,005**	**3,005**			**3,005**	
16-Mar-06	**11,900**				**11,900**	**1,698**	**936**	**2,843**			**2,843**	**3,700**	**3,700**		**3,700**	**3,002**	**3,002**			**3,002**	
17-Mar-06	**12,000**				**12,000**	**1,792**	**612**	**2,939**			**2,939**	**3,380**	**3,380**		**3,380**	**3,009**	**3,009**			**3,009**	
18-Mar-06	**11,700**				**11,700**	**1,716**	**550**	**3,309**			**3,309**	**3,340**	**3,340**		**3,340**	**3,000**	**3,000**			**3,000**	
19-Mar-06	**11,900**				**11,900**	**2,454**	**630**	**2,409**			**2,409**	**3,900**	**3,900**		**3,900**	**3,004**	**3,004**			**3,004**	
20-Mar-06	**12,100**				**12,100**	**2,223**	**811**	**2,285**			**2,285**	**3,840**	**3,840**		**3,840**	**3,010**	**3,010**			**3,010**	
21-Mar-06	**12,200**				**12,200**	**1,986**	**505**	**2,407**			**2,407**	**3,740**	**3,740**		**3,740**	**3,014**	**3,014**			**3,014**	
22-Mar-06	**11,900**				**11,900**	**2,178**	**352**	**2,066**			**2,066**	**3,660**	**3,660**		**3,660**	**3,008**	**3,008**			**3,008**	
23-Mar-06								2,000			2,000										
24-Mar-06								2,000			2,000										
25-Mar-06								2,000			2,000										
26-Mar-06								1,500			1,500										
27-Mar-06								1,500			1,500										
28-Mar-06								1,500			1,500										
29-Mar-06								1,000			1,000										
30-Mar-06						779		1,000			1,000	3,120	3,120		3,120	2,500	2,500			2,500	
31-Mar-06						774		1,000			1,000	3,120	3,120		3,120	2,500	2,500			2,500	
01-Apr-06	7,899				7,899	769	500	850			850	2,850	2,850		2,850	2,500	2,500			2,500	
02-Apr-06	7,894				7,894	764	500	850			850	2,850	2,850		2,850	2,500	2,500			2,500	
03-Apr-06	7,619				7,619	759	500	850			850	2,850	2,850		2,850	2,500	2,500			2,500	
04-Apr-06	7,464				7,464	754	500	850			850	2,850	2,850		2,850	2,500	2,500			2,500	
05-Apr-06	7,459				7,459	748	500	850			850	2,850	2,850		2,850	2,500	2,500			2,500	
06-Apr-06	7,454				7,454	742	500	850			850	2,850	2,850		2,850	2,500	2,500			2,500	
07-Apr-06	7,448				7,448	736	500	850			850	2,850	2,850		2,850	2,500	2,500			2,500	
08-Apr-06	7,442				7,442	730	500	850			850	2,850	2,850		2,850	2,500	2,500			2,500	
09-Apr-06	7,436				7,436	724	500	850			850	2,850	2,850		2,850	2,500	2,500			2,500	
10-Apr-06	7,430				7,430	718	500	850			850	2,850	2,850		2,850	2,500	2,500			2,500	
11-Apr-06	7,424				7,424	712	500	850			850	2,850	2,850		2,850	2,500	2,500			2,500	
12-Apr-06	7,418				7,418	706	500	850	419	81	1,350	2,850	2,850		2,850	2,500	2,500			2,500	
13-Apr-06	7,412	0			7,412	700	500	850	419	81	1,350	2,850	2,850	110	2,960	1,500	1,500	0	0	1,500	
14-Apr-06	7,406	0			7,406	695	500	850	419	81	1,350	2,850	2,850	110	2,960	1,500	1,500	0	0	1,500	
15-Apr-06	6,400	610	0	1.21	7,010	690	500	850	419	81	1,350	2,850	2,850	110	2,960	1,500	1,500	0	0	1,500	
16-Apr-06	6,395	610	0	2.42	7,005	684	500	850	419	81	1,350	2,850	2,850	110	2,960	1,500	1,500	0	0	1,500	
17-Apr-06	6,390	610	0	3.63	7,000	679	500	850	449	81	1,380	2,850	2,850	110	2,960	1,500	1,500	0	0	1,500	
18-Apr-06	6,384	610	0	4.84	6,994	674	500	850	449	81	1,380	2,850	2,850	110	2,960	1,500	1,500	0	0	1,500	
19-Apr-06	6,379	610	0	6.05	6,989	669	500	850	449	81	1,380	2,850	2,850	110	2,960	1,500	1,500	0	0	1,500	
20-Apr-06	6,374	640	0	7.32	7,014	663	500	850	449	81	1,380	2,850	2,850	110	2,960	1,500	1,500	0	0	1,500	
21-Apr-06	6,369	640	0	8.59	7,009	658	500	850	449	81	1,380	2,850	2,850	120	2,970	1,500	1,500	0	0	1,500	
22-Apr-06	6,363	640	0	9.86	7,003	653	500	850	449	81	1,380	2,850	2,850	120	2,970	1,500	1,500	0	0	1,500	
23-Apr-06	6,358	650	0	11.15	7,008	648	500	850	449	81	1,380	2,850	2,850	120	2,970	1,500	1,500	0	0	1,500	
24-Apr-06	6,353	650	0	12.44	7,003	642	500	850	479	81	1,410	2,850	2,850	120	2,970	1,500	1,500	0	0	1,500	
25-Apr-06	6,348	650	0	13.73	6,998	637	500	850	479	81	1,410	2,850	2,850	120	2,970	1,500	1,500	0	0	1,500	
26-Apr-06	6,342	650	0	15.01	6,992	632	500	850	479	81	1,410	2,850	2,850	120	2,970	1,500	1,500	0	0	1,500	
27-Apr-06	6,337	680	0	16.36	7,017	627	500	850	479	81	1,410	2,850	2,850	120	2,970	1,500	1,500	0	0	1,500	
28-Apr-06	6,332	680	0	17.71	7,012	622	500	850	479	81	1,410	2,850	2,850	120	2,970	1,500	1,500	0	0	1,500	
29-Apr-06	6,327	680	0	19.06	7,007	616	500	850	479	81	1,410	2,850	2,850	120	2,970	1,500	1,500	0	0	1,500	
30-Apr-06	6,322	680	0	20.41	7,002	611	500	850	509	81	1,440	2,850	2,850	120	2,970	1,500	1,500	0	0	1,500	
01-May-06	6,316	680	0	21.76	6,996	606	500	850	509	81	1,440	2,350	2,350	620	2,970	1,500	1,500	0	0	1,500	
02-May-06	6,311	680	0	23.11	6,991	601	500	850	509	81	1,440	2,350	2,350	620	2,970	1,500	1,500	0	0	1,500	
03-May-06	5,806	1,210	0	25.51	7,016	595	500	850	509	81	1,440	2,350	2,350	620	2,970	1,500	1,500	0	0	1,500	
04-May-06	5,801	1,210	0	27.91	7,011	590	500	850	509	81	1,440	2,350	2,350	620	2,970	1,500	1,500	0	0	1,500	
05-May-06	5,795	1,210	0	30.31	7,005	585	500	850	509	81	1,440	2,350	2,350	620	2,970	1,500	1,500	0	0	1,500	
06-May-06	5,790	1,210	0	32.71	7,000	580	500	850	539	81	1,470	2,350	2,350	620	2,970	1,500	1,500	0	0	1,500	
07-May-06	5,785	1,210	0	35.11	6,995	574	500	850	539	81	1,470	2,350	2,350	620	2,970	1,500	1,500	0	0	1,500	
08-May-06	5,780	1,210	0	37.51	6,990	569	500	850	539	81	1,470	2,350	2,350	615	2,965	1,500	1,500	0	0	1,500	
09-May-06	5,774	1,240	0	39.97	7,014	564	500	850	539	81	1,470	2,350	2,350	610	2,960	1,500	1,500	0	0	1,500	
10-May-06	5,769	1,235	0	42.42	7,004	559	500	850	539	81	1,470	2,350	2,350	610	2,960	1,500	1,500	0	0	1,500	
11-May-06	5,764	1,230	0	44.86	6,994	553	500	850	539	81	1,470	2,350	2,350	610	2,960	1,500	1,500	0	0	1,500	
12-May-06	5,759	1,230	0	47.30	6,989	548	500	850	539	81	1,470	2,350	2,350	610	2,960	1,500	1,500	0	0	1,500	
13-May-06	5,753	1,230	0	49.74	6,983	543	500	850			850	2,350	2,350	610	2,960	1,500	1,500	0	0	1,500	
14-May-06	5,748	1,230	0	52.18	6,978	538	500	850			850	2,350	2,350		2,350	1,500	1,500			1,500	
15-May-06	5,743	1,230	0	54.61	6,973	533	500	850			850	2,350	2,350		2,350	1,500	1,500			1,500	
16-May-06	5,738	0	0		5,738	528	500	850			850	2,350	2,350		2,350	1,500	1,500			1,500	
17-May-06	5,733	0	0		5,733	523	500	850			850	2,350	2,350		2,350	1,500	1,500			1,500	
18-May-06	5,728	0	0		5,728	518	500	850			850	2,350	2,350		2,350	1,500	1,500			1,500	
19-May-06	5,723	0	0		5,723	513	500	850			850	2,350	2,350		2,350	1,500	1,500			1,500	
20-May-06	5,718	0	0		5,718	508	500	850			850	2,350	2,350		2,350	1,500	1,500			1,500	
21-May-06	5,713	0	0		5,713	503	500	850			850	2,350	2,350		2,350	1,500	1,500			1,500	
22-May-06	5,708	0	0		5,708	498	500	850			850	2,350	2,350		2,350	1,500	1,500			1,500	
23-May-06	5,703	0	0		5,703	493	500	850			850	2,350	2,350		2,350	1,500	1,500			1,500	
24-May-06	5,698	0	0		5,698	488	500	850			850	2,350	2,350		2,350	1,500	1,500			1,500	
25-May-06	5,693	0	0		5,693	483	500	850			850	2,350	2,350		2,350	1,500	1,500			1,500	
26-May-06	5,688	0	0		5,688	478	500	850			850	2,350	2,350		2,350	1,500	1,500			1,500	
27-May-06	5,683	0	0		5,683	473	500	850			850	2,350	2,350		2,350	1,500	1,500			1,500	
28-May-06	5,678	0	0		5,678	468	500	850			850	2,350	2,350		2,350	1,500	1,500			1,500	
29-May-06	5,673	0	0		5,673	463	500	850			850	2,350	2,350		2,350	1,500	1,500			1,500	
30-May-06	5,668	0	0		5,668	458	500	850			850	2,350	2,350		2,350	1,500	1,500			1,500	
31-May-06	5,663	0	0		5,663	453	500	850			850	2,350	2,350		2,350	1,500	1,500			1,500	
VAMP Period																					
Avg. (cfs):	6,112	888			7,000	622	500	850	482	81	1,413	2,640	2,640	325	2,966	1,500	1,500	0	0	1,500	
Supplemental Water (TAF):				54.61							29.63	4.98				20.00				0.00	

VAMP flow operation period

Appendix A-1, Table 2
2006 VAMP DAILY OPERATION PLAN
March 23, 2006 (B) • HIGH
Target Flow Period: April 15 - May 15 • Flow Target: greater than 7,000 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	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (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)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		(cfs)	(cfs)	(cfs)	
15-Mar-06	**11,700**				**11,700**	**1,583**	**966**	**2,849**			**2,849**	**4,060**	**4,060**		**4,060**	**3,005**	**3,005**			**3,005**	
16-Mar-06	**11,900**				**11,900**	**1,698**	**936**	**2,843**			**2,843**	**3,700**	**3,700**		**3,700**	**3,002**	**3,002**			**3,002**	
17-Mar-06	**12,000**				**12,000**	**1,792**	**612**	**2,939**			**2,939**	**3,380**	**3,380**		**3,380**	**3,009**	**3,009**			**3,009**	
18-Mar-06	**11,700**				**11,700**	**1,716**	**550**	**3,309**			**3,309**	**3,340**	**3,340**		**3,340**	**3,000**	**3,000**			**3,000**	
19-Mar-06	**11,900**				**11,900**	**2,454**	**630**	**2,409**			**2,409**	**3,900**	**3,900**		**3,900**	**3,004**	**3,004**			**3,004**	
20-Mar-06	**12,100**				**12,100**	**2,223**	**811**	**2,285**			**2,285**	**3,840**	**3,840**		**3,840**	**3,010**	**3,010**			**3,010**	
21-Mar-06	**12,200**				**12,200**	**1,986**	**505**	**2,407**			**2,407**	**3,740**	**3,740**		**3,740**	**3,014**	**3,014**			**3,014**	
22-Mar-06	**11,900**				**11,900**	**2,178**	**352**	**2,066**			**2,066**	**3,660**	**3,660**		**3,660**	**3,008**	**3,008**			**3,008**	
23-Mar-06								2,000			2,000										
24-Mar-06								2,000			2,000										
25-Mar-06								2,000			2,000										
26-Mar-06								1,500			1,500										
27-Mar-06								1,500			1,500										
28-Mar-06								1,500			1,500										
29-Mar-06								1,000			1,000										
30-Mar-06						779		1,000			1,000	3,120	3,120		3,120	2,500	2,500			2,500	
31-Mar-06						774		1,000			1,000	3,120	3,120		3,120	2,500	2,500			2,500	
01-Apr-06	8,399				8,399	769	1,000	850			850	2,850	2,850		2,850	2,500	2,500			2,500	
02-Apr-06	8,394				8,394	764	1,000	850			850	2,850	2,850		2,850	2,500	2,500			2,500	
03-Apr-06	8,119				8,119	759	1,000	850			850	2,850	2,850		2,850	2,500	2,500			2,500	
04-Apr-06	7,964				7,964	754	1,000	850			850	2,850	2,850		2,850	2,500	2,500			2,500	
05-Apr-06	7,959				7,959	748	1,000	850			850	2,850	2,850		2,850	2,500	2,500			2,500	
06-Apr-06	7,954				7,954	742	1,000	850			850	2,850	2,850		2,850	2,500	2,500			2,500	
07-Apr-06	7,948				7,948	736	1,000	850			850	2,850	2,850		2,850	2,500	2,500			2,500	
08-Apr-06	7,942				7,942	730	1,000	850			850	2,850	2,850		2,850	2,500	2,500			2,500	
09-Apr-06	7,936				7,936	724	1,000	850			850	2,850	2,850		2,850	2,500	2,500			2,500	
10-Apr-06	7,930				7,930	718	1,000	850			850	2,850	2,850		2,850	2,500	2,500			2,500	
11-Apr-06	7,924				7,924	712	1,000	850			850	2,850	2,850		2,850	2,500	2,500			2,500	
12-Apr-06	7,918				7,918	706	1,000	850	100	0	950	2,850	2,850		2,850	2,500	2,500			2,500	
13-Apr-06	7,912	0			7,912	700	1,000	850	100	0	950	2,850	2,850	0	2,850	1,500	1,500	0	0	1,500	
14-Apr-06	7,906	0			7,906	695	1,000	850	100	0	950	2,850	2,850	0	2,850	1,500	1,500	0	0	1,500	
15-Apr-06	6,900	100	0	0.20	7,000	690	1,000	850	100	0	950	2,850	2,850	0	2,850	1,500	1,500	0	0	1,500	
16-Apr-06	6,895	100	0	0.40	6,995	684	1,000	850	100	0	950	2,850	2,850	0	2,850	1,500	1,500	0	0	1,500	
17-Apr-06	6,890	100	0	0.60	6,990	679	1,000	850	150	0	1,000	2,850	2,850	0	2,850	1,500	1,500	0	0	1,500	
18-Apr-06	6,884	100	0	0.79	6,984	674	1,000	850	150	0	1,000	2,850	2,850	0	2,850	1,500	1,500	0	0	1,500	
19-Apr-06	6,879	100	0	0.99	6,979	669	1,000	850	150	0	1,000	2,850	2,850	0	2,850	1,500	1,500	0	0	1,500	
20-Apr-06	6,874	150	0	1.29	7,024	663	1,000	850	150	0	1,000	2,850	2,850	0	2,850	1,500	1,500	0	0	1,500	
21-Apr-06	6,869	150	0	1.59	7,019	658	1,000	850	150	0	1,000	2,850	2,850	0	2,850	1,500	1,500	0	0	1,500	
22-Apr-06	6,863	150	0	1.88	7,013	653	1,000	850	150	0	1,000	2,850	2,850	0	2,850	1,500	1,500	0	0	1,500	
23-Apr-06	6,858	150	0	2.18	7,008	648	1,000	850	150	0	1,000	2,850	2,850	0	2,850	1,500	1,500	0	0	1,500	
24-Apr-06	6,853	150	0	2.48	7,003	642	1,000	850	150	0	1,000	2,850	2,850	0	2,850	1,500	1,500	0	0	1,500	
25-Apr-06	6,848	150	0	2.78	6,998	637	1,000	850	150	0	1,000	2,850	2,850	0	2,850	1,500	1,500	0	0	1,500	
26-Apr-06	6,842	150	0	3.07	6,992	632	1,000	850	150	0	1,000	2,850	2,850	0	2,850	1,500	1,500	0	0	1,500	
27-Apr-06	6,837	150	0	3.37	6,987	627	1,000	850	150	0	1,000	2,850	2,850	0	2,850	1,500	1,500	0	0	1,500	
28-Apr-06	6,832	150	0	3.67	6,982	622	1,000	850	150	0	1,000	2,850	2,850	0	2,850	1,500	1,500	0	0	1,500	
29-Apr-06	6,827	150	0	3.97	6,977	616	1,000	850	200	0	1,050	2,850	2,850	0	2,850	1,500	1,500	0	0	1,500	
30-Apr-06	6,822	150	0	4.26	6,972	611	1,000	850	700	0	1,550	2,850	2,850	0	2,850	1,500	1,500	0	0	1,500	
01-May-06	6,816	150	0	4.56	6,966	606	1,000	850	700	0	1,550	2,350	2,350	0	2,350	1,500	1,500	0	0	1,500	
02-May-06	6,811	200	0	4.96	7,011	601	1,000	850	700	0	1,550	2,350	2,350	0	2,350	1,500	1,500	0	0	1,500	
03-May-06	6,306	700	0	6.35	7,006	595	1,000	850	700	0	1,550	2,350	2,350	0	2,350	1,500	1,500	0	0	1,500	
04-May-06	6,301	700	0	7.74	7,001	590	1,000	850	750	0	1,600	2,350	2,350	0	2,350	1,500	1,500	0	0	1,500	
05-May-06	6,295	700	0	9.12	6,995	585	1,000	850	750	0	1,600	2,350	2,350	0	2,350	1,500	1,500	0	0	1,500	
06-May-06	6,290	700	0	10.51	6,990	580	1,000	850	750	0	1,600	2,350	2,350	0	2,350	1,500	1,500	0	0	1,500	
07-May-06	6,285	750	0	12.00	7,035	574	1,000	850	750	0	1,600	2,350	2,350	0	2,350	1,500	1,500	0	0	1,500	
08-May-06	6,280	750	0	13.49	7,030	569	1,000	850	750	0	1,600	2,350	2,350	0	2,350	1,500	1,500	0	0	1,500	
09-May-06	6,274	750	0	14.98	7,024	564	1,000	850	750	0	1,600	2,350	2,350	0	2,350	1,500	1,500	0	0	1,500	
10-May-06	6,269	750	0	16.46	7,019	559	1,000	850	750	0	1,600	2,350	2,350	0	2,350	1,500	1,500	0	0	1,500	
11-May-06	6,264	750	0	17.95	7,014	553	1,000	850	750	0	1,600	2,350	2,350	0	2,350	1,500	1,500	0	0	1,500	
12-May-06	6,259	750	0	19.44	7,009	548	1,000	850	750	0	1,600	2,350	2,350	0	2,350	1,500	1,500	0	0	1,500	
13-May-06	6,253	750	0	20.93	7,003	543	1,000	850			850	2,350	2,350	0	2,350	1,500	1,500	0	0	1,500	
14-May-06	6,248	750	0	22.41	6,998	538	1,000	850			850	2,350	2,350		2,350	1,500	1,500			1,500	
15-May-06	6,243	750	0	23.90	6,993	533	1,000	850			850	2,350	2,350		2,350	1,500	1,500			1,500	
16-May-06	6,238	0	0		6,238	528	1,000	850			850	2,350	2,350		2,350	1,500	1,500			1,500	
17-May-06	6,233	0	0		6,233	523	1,000	850			850	2,350	2,350		2,350	1,500	1,500			1,500	
18-May-06	6,228	0	0		6,228	518	1,000	850			850	2,350	2,350		2,350	1,500	1,500			1,500	
19-May-06	6,223	0	0		6,223	513	1,000	850			850	2,350	2,350		2,350	1,500	1,500			1,500	
20-May-06	6,218	0	0		6,218	508	1,000	850			850	2,350	2,350		2,350	1,500	1,500			1,500	
21-May-06	6,213	0	0		6,213	503	1,000	850			850	2,350	2,350		2,350	1,500	1,500			1,500	
22-May-06	6,208	0	0		6,208	498	1,000	850			850	2,350	2,350		2,350	1,500	1,500			1,500	
23-May-06	6,203	0	0		6,203	493	1,000	850			850	2,350	2,350		2,350	1,500	1,500			1,500	
24-May-06	6,198	0	0		6,198	488	1,000	850			850	2,350	2,350		2,350	1,500	1,500			1,500	
25-May-06	6,193	0	0		6,193	483	1,000	850			850	2,350	2,350		2,350	1,500	1,500			1,500	
26-May-06	6,188	0	0		6,188	478	1,000	850			850	2,350	2,350		2,350	1,500	1,500			1,500	
27-May-06	6,183	0	0		6,183	473	1,000	850			850	2,350	2,350		2,350	1,500	1,500			1,500	
28-May-06	6,178	0	0		6,178	468	1,000	850			850	2,350	2,350		2,350	1,500	1,500			1,500	
29-May-06	6,173	0	0		6,173	463	1,000	850			850	2,350	2,350		2,350	1,500	1,500			1,500	
30-May-06	6,168	0	0		6,168	458	1,000	850			850	2,350	2,350		2,350	1,500	1,500			1,500	
31-May-06	6,163	0	0		6,163	453	1,000	850			850	2,350	2,350		2,350	1,500	1,500			1,500	
18-May-05	6,217	0	0		6,217	605	1,200	650			650	3,400	3,400		3,400	352	352			352	
VAMP Period																					
Avg. (cfs):	6,612	389			7,001	622	1,000	850	389	0	1,239	2,640	2,640	0	2,640	1,500	1,500	0	0	1,500	
Supplemental Water (TAF):				23.90							23.90	0.00				0.00				0.00	

VAMP flow operation period

Appendix A-1, Table 3
2006 VAMP DAILY OPERATION PLAN
March 23, 2006 (C) • LOW
Target Flow Period: April 22 - May 22 • Flow Target: greater than 7,000 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	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (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)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		(cfs)	(cfs)	(cfs)	
15-Mar-06	**11,700**				**11,700**	1,583	966	**2,849**			**2,849**	**4,060**	**4,060**		**4,060**	**3,005**	**3,005**			**3,005**	
16-Mar-06	**11,900**				**11,900**	1,698	936	**2,843**			**2,843**	**3,700**	**3,700**		**3,700**	**3,002**	**3,002**			**3,002**	
17-Mar-06	**12,000**				**12,000**	1,792	612	**2,939**			**2,939**	**3,380**	**3,380**		**3,380**	**3,009**	**3,009**			**3,009**	
18-Mar-06	**11,700**				**11,700**	1,716	550	**3,309**			**3,309**	**3,340**	**3,340**		**3,340**	**3,000**	**3,000**			**3,000**	
19-Mar-06	**11,900**				**11,900**	2,454	630	**2,409**			**2,409**	**3,900**	**3,900**		**3,900**	**3,004**	**3,004**			**3,004**	
20-Mar-06	**12,100**				**12,100**	2,223	811	**2,285**			**2,285**	**3,840**	**3,840**		**3,840**	**3,010**	**3,010**			**3,010**	
21-Mar-06	**12,200**				**12,200**	1,986	505	**2,407**			**2,407**	**3,740**	**3,740**		**3,740**	**3,014**	**3,014**			**3,014**	
22-Mar-06	**11,900**				**11,900**	2,178	352	**2,066**			**2,066**	**3,660**	**3,660**		**3,660**	**3,008**	**3,008**			**3,008**	
23-Mar-06								2,000			2,000										
24-Mar-06								2,000			2,000										
25-Mar-06								2,000			2,000										
26-Mar-06								1,500			1,500										
27-Mar-06								1,500			1,500										
28-Mar-06								1,500			1,500										
29-Mar-06								1,000			1,000										
30-Mar-06						779		1,000			1,000	3,120	3,120		3,120	2,500	2,500			2,500	
31-Mar-06						774		1,000			1,000	3,120	3,120		3,120	2,500	2,500			2,500	
01-Apr-06	7,899				7,899	769	500	850			850	2,850	2,850		2,850	2,500	2,500			2,500	
02-Apr-06	7,894				7,894	764	500	850			850	2,850	2,850		2,850	2,500	2,500			2,500	
03-Apr-06	7,619				7,619	759	500	850			850	2,850	2,850		2,850	2,500	2,500			2,500	
04-Apr-06	7,464				7,464	754	500	850			850	2,850	2,850		2,850	2,500	2,500			2,500	
05-Apr-06	7,459				7,459	748	500	850			850	2,850	2,850		2,850	2,500	2,500			2,500	
06-Apr-06	7,454				7,454	742	500	850			850	2,850	2,850		2,850	2,500	2,500			2,500	
07-Apr-06	7,448				7,448	736	500	850			850	2,850	2,850		2,850	2,500	2,500			2,500	
08-Apr-06	7,442				7,442	730	500	850			850	2,850	2,850		2,850	2,500	2,500			2,500	
09-Apr-06	7,436				7,436	724	500	850			850	2,850	2,850		2,850	2,500	2,500			2,500	
10-Apr-06	7,430				7,430	718	500	850			850	2,850	2,850		2,850	2,500	2,500			2,500	
11-Apr-06	7,424				7,424	712	500	850			850	2,850	2,850		2,850	2,500	2,500			2,500	
12-Apr-06	7,418				7,418	706	500	850			850	2,850	2,850		2,850	2,500	2,500			2,500	
13-Apr-06	7,412	0			7,412	700	500	850			850	2,850	2,850		2,850	2,500	2,500			2,500	
14-Apr-06	7,406	0			7,406	695	500	850			850	2,850	2,850		2,850	2,500	2,500			2,500	
15-Apr-06	7,400	0			7,400	690	500	850			850	2,850	2,850		2,850	2,500	2,500			2,500	
16-Apr-06	7,395	0			7,395	684	500	850			850	2,850	2,850		2,850	2,500	2,500			2,500	
17-Apr-06	7,390	0			7,390	679	500	850			850	2,850	2,850		2,850	2,500	2,500			2,500	
18-Apr-06	7,384	0			7,384	674	500	850			850	2,850	2,850		2,850	2,500	2,500			2,500	
19-Apr-06	7,379	0			7,379	669	500	850	579	81	1,510	2,850	2,850		2,850	2,500	2,500			2,500	
20-Apr-06	7,374	0			7,374	663	500	850	579	81	1,510	2,850	2,850	0	2,850	1,500	1,500	0	0	1,500	
21-Apr-06	7,369	0			7,369	658	500	850	579	81	1,510	2,850	2,850	0	2,850	1,500	1,500	0	0	1,500	
22-Apr-06	6,363	660	0	1.31	7,023	653	500	850	579	81	1,510	2,850	2,850	0	2,850	1,500	1,500	0	0	1,500	
23-Apr-06	6,358	660	0	2.62	7,018	648	500	850	579	81	1,510	2,850	2,850	0	2,850	1,500	1,500	0	0	1,500	
24-Apr-06	6,353	660	0	3.93	7,013	642	500	850	579	81	1,510	2,850	2,850	0	2,850	1,500	1,500	0	0	1,500	
25-Apr-06	6,348	660	0	5.24	7,008	637	500	850	579	81	1,510	2,850	2,850	0	2,850	1,500	1,500	0	0	1,500	
26-Apr-06	6,342	660	0	6.55	7,002	632	500	850	579	81	1,510	2,850	2,850	0	2,850	1,500	1,500	0	0	1,500	
27-Apr-06	6,337	660	0	7.85	6,997	627	500	850	579	81	1,510	2,850	2,850	0	2,850	1,500	1,500	0	0	1,500	
28-Apr-06	6,332	660	0	9.16	6,992	622	500	850	579	81	1,510	2,850	2,850	0	2,850	1,500	1,500	0	0	1,500	
29-Apr-06	6,327	660	0	10.47	6,987	616	500	850	579	81	1,510	2,850	2,850	0	2,850	1,500	1,500	0	0	1,500	
30-Apr-06	6,322	660	0	11.78	6,982	611	500	850	579	81	1,510	2,850	2,850	40	2,890	1,500	1,500	0	0	1,500	
01-May-06	6,316	660	0	13.09	6,976	606	500	850	579	81	1,510	2,350	2,350	560	2,910	1,500	1,500	0	0	1,500	
02-May-06	6,311	700	0	14.48	7,011	601	500	850	579	81	1,510	2,350	2,350	560	2,910	1,500	1,500	0	0	1,500	
03-May-06	5,806	1,220	0	16.90	7,026	595	500	850	579	81	1,510	2,350	2,350	560	2,910	1,500	1,500	0	0	1,500	
04-May-06	5,801	1,220	0	19.32	7,021	590	500	850	579	81	1,510	2,350	2,350	560	2,910	1,500	1,500	0	0	1,500	
05-May-06	5,795	1,220	0	21.74	7,015	585	500	850	579	81	1,510	2,350	2,350	560	2,910	1,500	1,500	0	0	1,500	
06-May-06	5,790	1,220	0	24.16	7,010	580	500	850	584	81	1,515	2,350	2,350	560	2,910	1,500	1,500	0	0	1,500	
07-May-06	5,785	1,220	0	26.58	7,005	574	500	850	589	81	1,520	2,350	2,350	560	2,910	1,500	1,500	0	0	1,500	
08-May-06	5,780	1,220	0	29.00	7,000	569	500	850	589	81	1,520	2,350	2,350	560	2,910	1,500	1,500	0	0	1,500	
09-May-06	5,774	1,225	0	31.43	6,999	564	500	850	619	81	1,550	2,350	2,350	560	2,910	1,500	1,500	0	0	1,500	
10-May-06	5,769	1,230	0	33.87	6,999	559	500	850	619	81	1,550	2,350	2,350	560	2,910	1,500	1,500	0	0	1,500	
11-May-06	5,764	1,230	0	36.31	6,994	553	500	850	619	81	1,550	2,350	2,350	560	2,910	1,500	1,500	0	0	1,500	
12-May-06	5,759	1,260	0	38.81	7,019	548	500	850	619	81	1,550	2,350	2,350	560	2,910	1,500	1,500	0	0	1,500	
13-May-06	5,753	1,260	0	41.31	7,013	543	500	850	619	81	1,550	2,350	2,350	560	2,910	1,500	1,500	0	0	1,500	
14-May-06	5,748	1,260	0	43.80	7,008	538	500	850	619	81	1,550	2,350	2,350	560	2,910	1,500	1,500	0	0	1,500	
15-May-06	5,743	1,260	0	46.30	7,003	533	500	850	619	81	1,550	2,350	2,350	560	2,910	1,500	1,500	0	0	1,500	
16-May-06	5,738	1,260	0	48.80	6,998	528	500	850	619	81	1,550	2,350	2,350	560	2,910	1,500	1,500	0	0	1,500	
17-May-06	5,733	1,260	0	51.30	6,993	523	500	850	619	81	1,550	2,350	2,350	560	2,910	1,500	1,500	0	0	1,500	
18-May-06	5,728	1,260	0	53.80	6,988	518	500	850	619	81	1,550	2,350	2,350	560	2,910	1,500	1,500	0	0	1,500	
19-May-06	5,723	1,260	0	56.30	6,983	513	500	850	619	81	1,550	2,350	2,350	560	2,910	1,500	1,500	0	0	1,500	
20-May-06	5,718	1,260	0	58.80	6,978	508	500	850			850	2,350	2,350	560	2,910	1,500	1,500	0	0	1,500	
21-May-06	5,713	1,260	0	61.30	6,973	503	500	850			850	2,350	2,350		2,350	1,500	1,500			1,500	
22-May-06	5,708	1,260	0	63.80	6,968	498	500	850			850	2,350	2,350		2,350	1,500	1,500			1,500	
23-May-06	5,703	0	0		5,703	493	500	850			850	2,350	2,350		2,350	1,500	1,500			1,500	
24-May-06	5,698	0	0		5,698	488	500	850			850	2,350	2,350		2,350	1,500	1,500			1,500	
25-May-06	5,693	0	0		5,693	483	500	850			850	2,350	2,350		2,350	1,500	1,500			1,500	
26-May-06	5,688	0	0		5,688	478	500	850			850	2,350	2,350		2,350	1,500	1,500			1,500	
27-May-06	5,683	0	0		5,683	473	500	850			850	2,350	2,350		2,350	1,500	1,500			1,500	
28-May-06	5,678	0	0		5,678	468	500	850			850	2,350	2,350		2,350	1,500	1,500			1,500	
29-May-06	5,673	0	0		5,673	463	500	850			850	2,350	2,350		2,350	1,500	1,500			1,500	
30-May-06	5,668	0	0		5,668	458	500	850			850	2,350	2,350		2,350	1,500	1,500			1,500	
31-May-06	5,663	0	0		5,663	453	500	850			850	2,350	2,350		2,350	1,500	1,500			1,500	
VAMP Period																					
Avg. (cfs):	5,962	1,038			7,000	585	500	850	594	81	1,525	2,527	2,527	363	2,890	1,500	1,500	0	0	1,500	
Supplemental Water (TAF):				63.80							36.52	4.98				22.29				0.00	

VAMP flow operation period

Appendix A-1, Table 4
2006 VAMP DAILY OPERATION PLAN
March 23, 2006 (D) • HIGH
Target Flow Period: April 22 - May 22 • Flow Target: greater than 7,000 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	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (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)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		(cfs)	(cfs)	(cfs)	
15-Mar-06	**11,700**				**11,700**	**1,583**	**966**	**2,849**			**2,849**	**4,060**	**4,060**		**4,060**	**3,005**	**3,005**			**3,005**	
16-Mar-06	**11,900**				**11,900**	**1,698**	**936**	**2,843**			**2,843**	**3,700**	**3,700**		**3,700**	**3,002**	**3,002**			**3,002**	
17-Mar-06	**12,000**				**12,000**	**1,792**	**612**	**2,939**			**2,939**	**3,380**	**3,380**		**3,380**	**3,009**	**3,009**			**3,009**	
18-Mar-06	**11,700**				**11,700**	**1,716**	**550**	**3,309**			**3,309**	**3,340**	**3,340**		**3,340**	**3,000**	**3,000**			**3,000**	
19-Mar-06	**11,900**				**11,900**	**2,454**	**630**	**2,409**			**2,409**	**3,900**	**3,900**		**3,900**	**3,004**	**3,004**			**3,004**	
20-Mar-06	**12,100**				**12,100**	**2,223**	**811**	**2,285**			**2,285**	**3,840**	**3,840**		**3,840**	**3,010**	**3,010**			**3,010**	
21-Mar-06	**12,200**				**12,200**	**1,986**	**505**	**2,407**			**2,407**	**3,740**	**3,740**		**3,740**	**3,014**	**3,014**			**3,014**	
22-Mar-06	**11,900**				**11,900**	**2,178**	**352**	**2,066**			**2,066**	**3,660**	**3,660**		**3,660**	**3,008**	**3,008**			**3,008**	
23-Mar-06								2,000			2,000										
24-Mar-06								2,000			2,000										
25-Mar-06								2,000			2,000										
26-Mar-06								1,500			1,500										
27-Mar-06								1,500			1,500										
28-Mar-06								1,500			1,500										
29-Mar-06								1,000			1,000										
30-Mar-06						779		1,000			1,000	3,120	3,120		3,120	2,500	2,500			2,500	
31-Mar-06						774		1,000			1,000	3,120	3,120		3,120	2,500	2,500			2,500	
01-Apr-06	8,399				8,399	769	1,000	850			850	2,850	2,850		2,850	2,500	2,500			2,500	
02-Apr-06	8,394				8,394	764	1,000	850			850	2,850	2,850		2,850	2,500	2,500			2,500	
03-Apr-06	8,119				8,119	759	1,000	850			850	2,850	2,850		2,850	2,500	2,500			2,500	
04-Apr-06	7,964				7,964	754	1,000	850			850	2,850	2,850		2,850	2,500	2,500			2,500	
05-Apr-06	7,959				7,959	748	1,000	850			850	2,850	2,850		2,850	2,500	2,500			2,500	
06-Apr-06	7,954				7,954	742	1,000	850			850	2,850	2,850		2,850	2,500	2,500			2,500	
07-Apr-06	7,948				7,948	736	1,000	850			850	2,850	2,850		2,850	2,500	2,500			2,500	
08-Apr-06	7,942				7,942	730	1,000	850			850	2,850	2,850		2,850	2,500	2,500			2,500	
09-Apr-06	7,936				7,936	724	1,000	850			850	2,850	2,850		2,850	2,500	2,500			2,500	
10-Apr-06	7,930				7,930	718	1,000	850			850	2,850	2,850		2,850	2,500	2,500			2,500	
11-Apr-06	7,924				7,924	712	1,000	850			850	2,850	2,850		2,850	2,500	2,500			2,500	
12-Apr-06	7,918				7,918	706	1,000	850			850	2,850	2,850		2,850	2,500	2,500			2,500	
13-Apr-06	7,912	0			7,912	700	1,000	850			850	2,850	2,850		2,850	2,500	2,500			2,500	
14-Apr-06	7,906	0			7,906	695	1,000	850			850	2,850	2,850		2,850	2,500	2,500			2,500	
15-Apr-06	7,900	0			7,900	690	1,000	850			850	2,850	2,850		2,850	2,500	2,500			2,500	
16-Apr-06	7,895	0			7,895	684	1,000	850			850	2,850	2,850		2,850	2,500	2,500			2,500	
17-Apr-06	7,890	0			7,890	679	1,000	850			850	2,850	2,850		2,850	2,500	2,500			2,500	
18-Apr-06	7,884	0			7,884	674	1,000	850			850	2,850	2,850		2,850	2,500	2,500			2,500	
19-Apr-06	7,879	0			7,879	669	1,000	850	150	0	1,000	2,850	2,850		2,850	2,500	2,500			2,500	
20-Apr-06	7,874	0			7,874	663	1,000	850	150	0	1,000	2,850	2,850	0	2,850	1,500	1,500	0	0	1,500	
21-Apr-06	7,869	0			7,869	658	1,000	850	150	0	1,000	2,850	2,850	0	2,850	1,500	1,500	0	0	1,500	
22-Apr-06	6,863	150	0	0.30	7,013	653	1,000	850	150	0	1,000	2,850	2,850	0	2,850	1,500	1,500	0	0	1,500	
23-Apr-06	6,858	150	0	0.60	7,008	648	1,000	850	150	0	1,000	2,850	2,850	0	2,850	1,500	1,500	0	0	1,500	
24-Apr-06	6,853	150	0	0.89	7,003	642	1,000	850	155	0	1,005	2,850	2,850	0	2,850	1,500	1,500	0	0	1,500	
25-Apr-06	6,848	150	0	1.19	6,998	637	1,000	850	200	0	1,050	2,850	2,850	0	2,850	1,500	1,500	0	0	1,500	
26-Apr-06	6,842	150	0	1.49	6,992	632	1,000	850	200	0	1,050	2,850	2,850	0	2,850	1,500	1,500	0	0	1,500	
27-Apr-06	6,837	155	0	1.80	6,992	627	1,000	850	200	0	1,050	2,850	2,850	0	2,850	1,500	1,500	0	0	1,500	
28-Apr-06	6,832	200	0	2.19	7,032	622	1,000	850	200	0	1,050	2,850	2,850	0	2,850	1,500	1,500	0	0	1,500	
29-Apr-06	6,827	200	0	2.59	7,027	616	1,000	850	200	0	1,050	2,850	2,850	0	2,850	1,500	1,500	0	0	1,500	
30-Apr-06	6,822	200	0	2.99	7,022	611	1,000	850	500	0	1,350	2,850	2,850	0	2,850	1,500	1,500	0	0	1,500	
01-May-06	6,816	200	0	3.38	7,016	606	1,000	850	500	0	1,350	2,350	2,350	203	2,553	1,500	1,500	0	0	1,500	
02-May-06	6,811	200	0	3.78	7,011	601	1,000	850	500	0	1,350	2,350	2,350	203	2,553	1,500	1,500	0	0	1,500	
03-May-06	6,306	703	0	5.17	7,009	595	1,000	850	500	0	1,350	2,350	2,350	203	2,553	1,500	1,500	0	0	1,500	
04-May-06	6,301	703	0	6.57	7,004	590	1,000	850	500	0	1,350	2,350	2,350	203	2,553	1,500	1,500	0	0	1,500	
05-May-06	6,295	703	0	7.96	6,998	585	1,000	850	500	0	1,350	2,350	2,350	203	2,553	1,500	1,500	0	0	1,500	
06-May-06	6,290	703	0	9.36	6,993	580	1,000	850	550	0	1,400	2,350	2,350	203	2,553	1,500	1,500	0	0	1,500	
07-May-06	6,285	703	0	10.75	6,988	574	1,000	850	550	0	1,400	2,350	2,350	203	2,553	1,500	1,500	0	0	1,500	
08-May-06	6,280	703	0	12.14	6,983	569	1,000	850	550	0	1,400	2,350	2,350	203	2,553	1,500	1,500	0	0	1,500	
09-May-06	6,274	753	0	13.64	7,027	564	1,000	850	550	0	1,400	2,350	2,350	203	2,553	1,500	1,500	0	0	1,500	
10-May-06	6,269	753	0	15.13	7,022	559	1,000	850	550	0	1,400	2,350	2,350	203	2,553	1,500	1,500	0	0	1,500	
11-May-06	6,264	753	0	16.63	7,017	553	1,000	850	550	0	1,400	2,350	2,350	203	2,553	1,500	1,500	0	0	1,500	
12-May-06	6,259	753	0	18.12	7,012	548	1,000	850	550	0	1,400	2,350	2,350	203	2,553	1,500	1,500	0	0	1,500	
13-May-06	6,253	753	0	19.61	7,006	543	1,000	850	550	0	1,400	2,350	2,350	203	2,553	1,500	1,500	0	0	1,500	
14-May-06	6,248	753	0	21.11	7,001	538	1,000	850	550	0	1,400	2,350	2,350	203	2,553	1,500	1,500	0	0	1,500	
15-May-06	6,243	753	0	22.60	6,996	533	1,000	850	550	0	1,400	2,350	2,350	203	2,553	1,500	1,500	0	0	1,500	
16-May-06	6,238	753	0	24.09	6,991	528	1,000	850	550	0	1,400	2,350	2,350	203	2,553	1,500	1,500	0	0	1,500	
17-May-06	6,233	753	0	25.59	6,986	523	1,000	850	550	0	1,400	2,350	2,350	203	2,553	1,500	1,500	0	0	1,500	
18-May-06	6,228	753	0	27.08	6,981	518	1,000	850	550	0	1,400	2,350	2,350	203	2,553	1,500	1,500	0	0	1,500	
19-May-06	6,223	753	0	28.57	6,976	513	1,000	850	550	0	1,400	2,350	2,350	203	2,553	1,500	1,500	0	0	1,500	
20-May-06	6,218	753	0	30.07	6,971	508	1,000	850			850	2,350	2,350	203	2,553	1,500	1,500	0	0	1,500	
21-May-06	6,213	753	0	31.56	6,966	503	1,000	850			850	2,350	2,350		2,350	1,500	1,500			1,500	
22-May-06	6,208	753	0	33.05	6,961	498	1,000	850			850	2,350	2,350		2,350	1,500	1,500			1,500	
23-May-06	6,203	0	0		6,203	493	1,000	850			850	2,350	2,350		2,350	1,500	1,500			1,500	
24-May-06	6,198	0	0		6,198	488	1,000	850			850	2,350	2,350		2,350	1,500	1,500			1,500	
25-May-06	6,193	0	0		6,193	483	1,000	850			850	2,350	2,350		2,350	1,500	1,500			1,500	
26-May-06	6,188	0	0		6,188	478	1,000	850			850	2,350	2,350		2,350	1,500	1,500			1,500	
27-May-06	6,183	0	0		6,183	473	1,000	850			850	2,350	2,350		2,350	1,500	1,500			1,500	
28-May-06	6,178	0	0		6,178	468	1,000	850			850	2,350	2,350		2,350	1,500	1,500			1,500	
29-May-06	6,173	0	0		6,173	463	1,000	850			850	2,350	2,350		2,350	1,500	1,500			1,500	
30-May-06	6,168	0	0		6,168	458	1,000	850			850	2,350	2,350		2,350	1,500	1,500			1,500	
31-May-06	6,163	0	0		6,163	453	1,000	850			850	2,350	2,350		2,350	1,500	1,500			1,500	
VAMP Period																					
Avg. (cfs):	6,462	538			7,000	585	1,000	850	407	0	1,257	2,527	2,527	131	2,658	1,500	1,500	0	0	1,500	
Supplemental Water (TAF):				33.05							25.00	0.00				8.05				0.00	

VAMP flow operation period

Appendix A-1, Table 5

2006 VAMP DAILY OPERATION PLAN
March 27, 2006 (A)
Target Flow Period: April 15 - May 15 • Flow Target: greater than 7,000 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	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (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)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		(cfs)	(cfs)	(cfs)	
15-Mar-06	**11,700**				**11,700**	1,583	966	**2,849**			**2,849**	**4,060**	**4,060**		**4,060**	**3,005**	**3,005**			**3,005**	
16-Mar-06	**11,900**				**11,900**	1,698	936	**2,843**			**2,843**	**3,700**	**3,700**		**3,700**	**3,002**	**3,002**			**3,002**	
17-Mar-06	**12,000**				**12,000**	1,792	612	**2,939**			**2,939**	**3,380**	**3,380**		**3,380**	**3,009**	**3,009**			**3,009**	
18-Mar-06	**11,700**				**11,700**	1,716	550	**3,309**			**3,309**	**3,340**	**3,340**		**3,340**	**3,000**	**3,000**			**3,000**	
19-Mar-06	**11,900**				**11,900**	2,454	630	**2,409**			**2,409**	**3,900**	**3,900**		**3,900**	**3,004**	**3,004**			**3,004**	
20-Mar-06	**12,100**				**12,100**	2,223	811	**2,285**			**2,285**	**3,840**	**3,840**		**3,840**	**3,010**	**3,010**			**3,010**	
21-Mar-06	**12,200**				**12,200**	1,986	505	**2,407**			**2,407**	**3,740**	**3,740**		**3,740**	**3,014**	**3,014**			**3,014**	
22-Mar-06	**11,900**				**11,900**	2,178	352	**2,066**			**2,066**	**3,660**	**3,660**		**3,660**	**3,008**	**3,008**			**3,008**	
23-Mar-06	**11,600**				**11,600**	2,129	175	**2,115**			**2,115**	**3,670**	**3,670**		**3,670**	**3,008**	**3,008**			**3,008**	
24-Mar-06	**11,400**				**11,400**	2,177	380	**2,080**			**2,080**	**3,910**	**3,910**		**3,910**	**3,005**	**3,005**			**3,005**	
25-Mar-06	**11,500**				**11,500**	2,063	450	**2,035**			**2,035**	**4,590**	**4,590**		**4,590**	**3,013**	**3,013**			**3,013**	
26-Mar-06	**12,000**				**12,000**	2,097	522	**1,867**			**1,867**	**4,580**	**4,580**		**4,580**	**3,009**	**3,009**			**3,009**	
27-Mar-06								1,500			1,500										
28-Mar-06								1,500			1,500										
29-Mar-06								1,000			1,000										
30-Mar-06						779		1,000			1,000	3,400	3,400		3,400	2,500	2,500			2,500	
31-Mar-06						774		1,000			1,000	3,400	3,400		3,400	2,500	2,500			2,500	
01-Apr-06	8,179				8,179	769	500	940			940	3,400	3,400		3,400	2,500	2,500			2,500	
02-Apr-06	8,174				8,174	764	500	940			940	3,400	3,400		3,400	2,500	2,500			2,500	
03-Apr-06	8,169				8,169	759	500	940			940	3,400	3,400		3,400	2,500	2,500			2,500	
04-Apr-06	8,104				8,104	754	500	940			940	3,400	3,400		3,400	2,500	2,500			2,500	
05-Apr-06	8,099				8,099	748	500	940			940	3,400	3,400		3,400	2,500	2,500			2,500	
06-Apr-06	8,094				8,094	742	500	940			940	3,400	3,400		3,400	2,500	2,500			2,500	
07-Apr-06	8,088				8,088	736	500	940			940	3,400	3,400		3,400	2,500	2,500			2,500	
08-Apr-06	8,082				8,082	730	500	940			940	3,400	3,400		3,400	2,500	2,500			2,500	
09-Apr-06	8,076				8,076	724	500	940			940	3,400	3,400		3,400	2,500	2,500			2,500	
10-Apr-06	8,070				8,070	718	500	940			940	3,400	3,400		3,400	2,500	2,500			2,500	
11-Apr-06	8,064				8,064	712	500	940			940	3,400	3,400		3,400	2,500	2,500			2,500	
12-Apr-06	8,058				8,058	706	500	940	0	0	940	3,400	3,400		3,400	2,500	2,500			2,500	
13-Apr-06	8,052	0			8,052	700	500	940	0	0	940	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
14-Apr-06	8,046	0			8,046	695	500	940	0	0	940	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
15-Apr-06	7,040	0	0	0.00	7,040	690	500	940	0	0	940	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
16-Apr-06	7,035	0	0	0.00	7,035	684	500	940	0	0	940	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
17-Apr-06	7,030	0	0	0.00	7,030	679	500	940	0	0	940	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
18-Apr-06	7,024	0	0	0.00	7,024	674	500	940	0	0	940	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
19-Apr-06	7,019	0	0	0.00	7,019	669	500	940	0	0	940	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
20-Apr-06	7,014	0	0	0.00	7,014	663	500	940	0	0	940	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
21-Apr-06	7,009	0	0	0.00	7,009	658	500	940	0	0	940	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
22-Apr-06	7,003	0	0	0.00	7,003	653	500	940	0	0	940	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
23-Apr-06	6,998	0	0	0.00	6,998	648	500	940	0	0	940	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
24-Apr-06	6,993	0	0	0.00	6,993	642	500	940	0	0	940	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
25-Apr-06	6,988	0	0	0.00	6,988	637	500	940	0	0	940	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
26-Apr-06	6,982	0	0	0.00	6,982	632	500	940	0	0	940	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
27-Apr-06	6,977	0	0	0.00	6,977	627	500	940	50	0	990	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
28-Apr-06	6,972	0	0	0.00	6,972	622	500	940	60	0	1,000	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
29-Apr-06	6,967	0	0	0.00	6,967	616	500	940	60	0	1,000	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
30-Apr-06	6,962	50	0	0.10	7,012	611	500	940	60	0	1,000	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
01-May-06	6,956	60	0	0.22	7,016	606	500	940	60	0	1,000	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
02-May-06	6,951	60	0	0.34	7,011	601	500	940	60	0	1,000	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
03-May-06	6,946	60	0	0.46	7,006	595	500	940	60	0	1,000	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
04-May-06	6,941	60	0	0.58	7,001	590	500	940	60	0	1,000	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
05-May-06	6,935	60	0	0.69	6,995	585	500	940	60	0	1,000	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
06-May-06	6,930	60	0	0.81	6,990	580	500	940	60	0	1,000	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
07-May-06	6,925	60	0	0.93	6,985	574	500	940	60	0	1,000	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
08-May-06	6,920	60	0	1.05	6,980	569	500	940	110	0	1,050	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
09-May-06	6,914	60	0	1.17	6,974	564	500	940	110	0	1,050	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
10-May-06	6,909	60	0	1.29	6,969	559	500	940	110	0	1,050	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
11-May-06	6,904	110	0	1.51	7,014	553	500	940	110	0	1,050	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
12-May-06	6,899	110	0	1.73	7,009	548	500	940	110	0	1,050	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
13-May-06	6,893	110	0	1.94	7,003	543	500	940			940	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
14-May-06	6,888	110	0	2.16	6,998	538	500	940			940	3,400	3,400		3,400	1,500	1,500			1,500	
15-May-06	6,883	110	0	2.38	6,993	533	500	940			940	3,400	3,400		3,400	1,500	1,500			1,500	
16-May-06	6,878	0	0		6,878	528	500	940			940	3,400	3,400		3,400	1,500	1,500			1,500	
17-May-06	6,873	0	0		6,873	523	500	940			940	3,400	3,400		3,400	1,500	1,500			1,500	
18-May-06	6,868	0	0		6,868	518	500	940			940	3,400	3,400		3,400	1,500	1,500			1,500	
19-May-06	6,863	0	0		6,863	513	500	940			940	3,400	3,400		3,400	1,500	1,500			1,500	
20-May-06	6,858	0	0		6,858	508	500	940			940	3,400	3,400		3,400	1,500	1,500			1,500	
21-May-06	6,853	0	0		6,853	503	500	940			940	3,400	3,400		3,400	1,500	1,500			1,500	
22-May-06	6,848	0	0		6,848	498	500	940			940	3,400	3,400		3,400	1,500	1,500			1,500	
23-May-06	6,843	0	0		6,843	493	500	940			940	3,400	3,400		3,400	1,500	1,500			1,500	
24-May-06	6,838	0	0		6,838	488	500	940			940	3,400	3,400		3,400	1,500	1,500			1,500	
25-May-06	6,833	0	0		6,833	483	500	940			940	3,400	3,400		3,400	1,500	1,500			1,500	
26-May-06	6,828	0	0		6,828	478	500	940			940	3,400	3,400		3,400	1,500	1,500			1,500	
27-May-06	6,823	0	0		6,823	473	500	940			940	3,400	3,400		3,400	1,500	1,500			1,500	
28-May-06	6,818	0	0		6,818	468	500	940			940	3,400	3,400		3,400	1,500	1,500			1,500	
29-May-06	6,813	0	0		6,813	463	500	940			940	3,400	3,400		3,400	1,500	1,500			1,500	
30-May-06	6,808	0	0		6,808	458	500	940			940	3,400	3,400		3,400	1,500	1,500			1,500	
31-May-06	6,803	0	0		6,803	453	500	940			940	3,400	3,400		3,400	1,500	1,500			1,500	
VAMP Period																					
Avg. (cfs):	6,962	39			7,000	622	500	940	39	0	979	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
Supplemental Water (TAF):				2.38							2.38	0.00				0.00				0.00	

VAMP flow operation period

Appendix A-1, Table 6

2006 VAMP DAILY OPERATION PLAN
March 27, 2006 (B)
Target Flow Period: April 22 - May 22 • Flow Target: greater than 7,000 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	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (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)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		(cfs)	(cfs)	(cfs)	
15-Mar-06	**11,700**				**11,700**	**1,583**	**966**	**2,849**			**2,849**	**4,060**	**4,060**		**4,060**	**3,005**	**3,005**			**3,005**	
16-Mar-06	**11,900**				**11,900**	**1,698**	**936**	**2,843**			**2,843**	**3,700**	**3,700**		**3,700**	**3,002**	**3,002**			**3,002**	
17-Mar-06	**12,000**				**12,000**	**1,792**	**612**	**2,939**			**2,939**	**3,380**	**3,380**		**3,380**	**3,009**	**3,009**			**3,009**	
18-Mar-06	**11,700**				**11,700**	**1,716**	**550**	**3,309**			**3,309**	**3,340**	**3,340**		**3,340**	**3,000**	**3,000**			**3,000**	
19-Mar-06	**11,900**				**11,900**	**2,454**	**630**	**2,409**			**2,409**	**3,900**	**3,900**		**3,900**	**3,004**	**3,004**			**3,004**	
20-Mar-06	**12,100**				**12,100**	**2,223**	**811**	**2,285**			**2,285**	**3,840**	**3,840**		**3,840**	**3,010**	**3,010**			**3,010**	
21-Mar-06	**12,200**				**12,200**	**1,986**	**505**	**2,407**			**2,407**	**3,740**	**3,740**		**3,740**	**3,014**	**3,014**			**3,014**	
22-Mar-06	**11,900**				**11,900**	**2,178**	**352**	**2,066**			**2,066**	**3,660**	**3,660**		**3,660**	**3,008**	**3,008**			**3,008**	
23-Mar-06	**11,600**				**11,600**	**2,129**	**175**	**2,115**			**2,115**	**3,670**	**3,670**		**3,670**	**3,008**	**3,008**			**3,008**	
24-Mar-06	**11,400**				**11,400**	**2,177**	**380**	**2,080**			**2,080**	**3,910**	**3,910**		**3,910**	**3,005**	**3,005**			**3,005**	
25-Mar-06	**11,500**				**11,500**	**2,063**	**450**	**2,035**			**2,035**	**4,590**	**4,590**		**4,590**	**3,013**	**3,013**			**3,013**	
26-Mar-06	**12,000**				**12,000**	**2,097**	**522**	**1,867**			**1,867**	**4,580**	**4,580**		**4,580**	**3,009**	**3,009**			**3,009**	
27-Mar-06								1,500			1,500										
28-Mar-06								1,500			1,500										
29-Mar-06								1,000			1,000										
30-Mar-06						779		1,000			1,000	3,400	3,400		3,400	2,500	2,500			2,500	
31-Mar-06						774		1,000			1,000	3,400	3,400		3,400	2,500	2,500			2,500	
01-Apr-06	8,179				8,179	769	500	940			940	3,400	3,400		3,400	2,500	2,500			2,500	
02-Apr-06	8,174				8,174	764	500	940			940	3,400	3,400		3,400	2,500	2,500			2,500	
03-Apr-06	8,169				8,169	759	500	940			940	3,400	3,400		3,400	2,500	2,500			2,500	
04-Apr-06	8,104				8,104	754	500	940			940	3,400	3,400		3,400	2,500	2,500			2,500	
05-Apr-06	8,099				8,099	748	500	940			940	3,400	3,400		3,400	2,500	2,500			2,500	
06-Apr-06	8,094				8,094	742	500	940			940	3,400	3,400		3,400	2,500	2,500			2,500	
07-Apr-06	8,088				8,088	736	500	940			940	3,400	3,400		3,400	2,500	2,500			2,500	
08-Apr-06	8,082				8,082	730	500	940			940	3,400	3,400		3,400	2,500	2,500			2,500	
09-Apr-06	8,076				8,076	724	500	940			940	3,400	3,400		3,400	2,500	2,500			2,500	
10-Apr-06	8,070				8,070	718	500	940			940	3,400	3,400		3,400	2,500	2,500			2,500	
11-Apr-06	8,064				8,064	712	500	940			940	3,400	3,400		3,400	2,500	2,500			2,500	
12-Apr-06	8,058				8,058	706	500	940			940	3,400	3,400		3,400	2,500	2,500			2,500	
13-Apr-06	8,052	0			8,052	700	500	940			940	3,400	3,400		3,400	2,500	2,500			2,500	
14-Apr-06	8,046	0			8,046	695	500	940			940	3,400	3,400		3,400	2,500	2,500			2,500	
15-Apr-06	8,040	0			8,040	690	500	940			940	3,400	3,400		3,400	2,500	2,500			2,500	
16-Apr-06	8,035	0			8,035	684	500	940			940	3,400	3,400		3,400	2,500	2,500			2,500	
17-Apr-06	8,030	0			8,030	679	500	940			940	3,400	3,400		3,400	2,500	2,500			2,500	
18-Apr-06	8,024	0			8,024	674	500	940			940	3,400	3,400		3,400	2,500	2,500			2,500	
19-Apr-06	8,019	0			8,019	669	500	940	10	0	950	3,400	3,400		3,400	2,500	2,500			2,500	
20-Apr-06	8,014	0			8,014	663	500	940	10	0	950	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
21-Apr-06	8,009	0			8,009	658	500	940	10	0	950	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
22-Apr-06	7,003	10	0	0.02	7,013	653	500	940	10	0	950	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
23-Apr-06	6,998	10	0	0.04	7,008	648	500	940	10	0	950	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
24-Apr-06	6,993	10	0	0.06	7,003	642	500	940	10	0	950	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
25-Apr-06	6,988	10	0	0.08	6,998	637	500	940	10	0	950	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
26-Apr-06	6,982	10	0	0.10	6,992	632	500	940	30	0	970	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
27-Apr-06	6,977	10	0	0.12	6,987	627	500	940	60	0	1,000	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
28-Apr-06	6,972	10	0	0.14	6,982	622	500	940	60	0	1,000	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
29-Apr-06	6,967	30	0	0.20	6,997	616	500	940	60	0	1,000	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
30-Apr-06	6,962	60	0	0.32	7,022	611	500	940	60	0	1,000	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
01-May-06	6,956	60	0	0.44	7,016	606	500	940	60	0	1,000	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
02-May-06	6,951	60	0	0.56	7,011	601	500	940	60	0	1,000	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
03-May-06	6,946	60	0	0.67	7,006	595	500	940	60	0	1,000	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
04-May-06	6,941	60	0	0.79	7,001	590	500	940	60	0	1,000	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
05-May-06	6,935	60	0	0.91	6,995	585	500	940	60	0	1,000	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
06-May-06	6,930	60	0	1.03	6,990	580	500	940	60	0	1,000	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
07-May-06	6,925	60	0	1.15	6,985	574	500	940	60	0	1,000	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
08-May-06	6,920	60	0	1.27	6,980	569	500	940	60	0	1,000	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
09-May-06	6,914	60	0	1.39	6,974	564	500	940	110	0	1,050	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
10-May-06	6,909	60	0	1.51	6,969	559	500	940	110	0	1,050	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
11-May-06	6,904	60	0	1.63	6,964	553	500	940	110	0	1,050	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
12-May-06	6,899	110	0	1.84	7,009	548	500	940	110	0	1,050	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
13-May-06	6,893	110	0	2.06	7,003	543	500	940	110	0	1,050	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
14-May-06	6,888	110	0	2.28	6,998	538	500	940	160	0	1,100	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
15-May-06	6,883	110	0	2.50	6,993	533	500	940	160	0	1,100	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
16-May-06	6,878	110	0	2.72	6,988	528	500	940	160	0	1,100	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
17-May-06	6,873	160	0	3.03	7,033	523	500	940	160	0	1,100	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
18-May-06	6,868	160	0	3.35	7,028	518	500	940	160	0	1,100	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
19-May-06	6,863	160	0	3.67	7,023	513	500	940	160	0	1,100	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
20-May-06	6,858	160	0	3.99	7,018	508	500	940			940	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
21-May-06	6,853	160	0	4.30	7,013	503	500	940			940	3,400	3,400		3,400	1,500	1,500			1,500	
22-May-06	6,848	160	0	4.62	7,008	498	500	940			940	3,400	3,400		3,400	1,500	1,500			1,500	
23-May-06	6,843	0	0		6,843	493	500	940			940	3,400	3,400		3,400	1,500	1,500			1,500	
24-May-06	6,838	0	0		6,838	488	500	940			940	3,400	3,400		3,400	1,500	1,500			1,500	
25-May-06	6,833	0	0		6,833	483	500	940			940	3,400	3,400		3,400	1,500	1,500			1,500	
26-May-06	6,828	0	0		6,828	478	500	940			940	3,400	3,400		3,400	1,500	1,500			1,500	
27-May-06	6,823	0	0		6,823	473	500	940			940	3,400	3,400		3,400	1,500	1,500			1,500	
28-May-06	6,818	0	0		6,818	468	500	940			940	3,400	3,400		3,400	1,500	1,500			1,500	
29-May-06	6,813	0	0		6,813	463	500	940			940	3,400	3,400		3,400	1,500	1,500			1,500	
30-May-06	6,808	0	0		6,808	458	500	940			940	3,400	3,400		3,400	1,500	1,500			1,500	
31-May-06	6,803	0	0		6,803	453	500	940			940	3,400	3,400		3,400	1,500	1,500			1,500	
VAMP Period																					
Avg. (cfs):	6,925	75			7,000	585	500	940	75	0	1,015	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
Supplemental Water (TAF):				4.62							4.62	0.00				0.00				0.00	

VAMP flow operation period

Appendix A-1, Table 7

2006 VAMP DAILY OPERATION PLAN
April 3, 2006 (A)
Target Flow Period: April 15 - May 15 • Flow Target: greater than 7,000 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	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (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)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		(cfs)	(cfs)	(cfs)	
15-Mar-06	**11,700**				**11,700**	**1,583**	**966**	**2,849**			**2,849**	**4,060**	**4,060**		**4,060**	**3,005**	**3,005**			**3,005**	
16-Mar-06	**11,900**				**11,900**	**1,698**	**936**	**2,843**			**2,843**	**3,700**	**3,700**		**3,700**	**3,002**	**3,002**			**3,002**	
17-Mar-06	**12,000**				**12,000**	**1,792**	**612**	**2,939**			**2,939**	**3,380**	**3,380**		**3,380**	**3,009**	**3,009**			**3,009**	
18-Mar-06	**11,700**				**11,700**	**1,716**	**550**	**3,309**			**3,309**	**3,340**	**3,340**		**3,340**	**3,000**	**3,000**			**3,000**	
19-Mar-06	**11,900**				**11,900**	**2,454**	**630**	**2,409**			**2,409**	**3,900**	**3,900**		**3,900**	**3,004**	**3,004**			**3,004**	
20-Mar-06	**12,100**				**12,100**	**2,223**	**811**	**2,285**			**2,285**	**3,840**	**3,840**		**3,840**	**3,010**	**3,010**			**3,010**	
21-Mar-06	**12,200**				**12,200**	**1,986**	**505**	**2,407**			**2,407**	**3,740**	**3,740**		**3,740**	**3,014**	**3,014**			**3,014**	
22-Mar-06	**11,900**				**11,900**	**2,178**	**352**	**2,066**			**2,066**	**3,660**	**3,660**		**3,660**	**3,008**	**3,008**			**3,008**	
23-Mar-06	**11,600**				**11,600**	**2,129**	**175**	**2,115**			**2,115**	**3,670**	**3,670**		**3,670**	**3,008**	**3,008**			**3,008**	
24-Mar-06	**11,400**				**11,400**	**2,177**	**380**	**2,080**			**2,080**	**3,910**	**3,910**		**3,910**	**3,005**	**3,005**			**3,005**	
25-Mar-06	**11,500**				**11,500**	**2,063**	**450**	**2,035**			**2,035**	**4,590**	**4,590**		**4,590**	**3,013**	**3,013**			**3,013**	
26-Mar-06	**12,000**				**12,000**	**2,097**	**522**	**1,867**			**1,867**	**4,580**	**4,580**		**4,580**	**3,009**	**3,009**			**3,009**	
27-Mar-06	**12,600**				**12,600**	**2,243**	**758**	**1,583**			**1,583**	**5,070**	**5,070**		**5,070**	**3,025**	**3,025**			**3,025**	
28-Mar-06	**12,500**				**12,500**	**1,595**	**876**	**2,584**			**2,584**	**5,070**	**5,070**		**5,070**	**3,043**	**3,043**			**3,043**	
29-Mar-06	**13,200**				**13,200**	**1,887**	**1,661**	**3,033**			**3,033**	**5,420**	**5,420**		**5,420**	**3,026**	**3,026**			**3,026**	
30-Mar-06	**14,700**				**14,700**	**1,855**	**1,728**	**2,877**			**2,877**	**6,050**	**6,050**		**6,050**	**3,014**	**3,014**			**3,014**	
31-Mar-06	**14,800**				**14,800**	**2,311**	**2,096**	**2,790**			**2,790**	**6,340**	**6,340**		**6,340**	**3,014**	**3,014**			**3,014**	
01-Apr-06	**15,100**				**15,100**	**2,574**	**2,147**	**2,972**			**2,972**	**6,110**	**6,110**		**6,110**	**3,014**	**3,014**			**3,014**	
02-Apr-06	**16,200**				**16,200**	**2,678**	**1,563**	**2,847**			**2,847**	**6,270**	**6,270**		**6,270**	**3,019**	**3,019**			**3,019**	
03-Apr-06	15,488				15,488	2,498	1,000	3,200			3,200	6,200	6,200		6,200	3,000	3,000			3,000	
04-Apr-06	15,939				15,939	2,318	1,000	3,200			3,200	5,400	5,400		5,400	3,000	3,000			3,000	
05-Apr-06	15,545				15,545	2,139	1,000	3,200			3,200	5,400	5,400		5,400	3,000	3,000			3,000	
06-Apr-06	14,918				14,918	1,959	1,000	3,200			3,200	5,400	5,400		5,400	3,000	3,000			3,000	
07-Apr-06	14,739				14,739	1,779	1,000	3,200			3,200	5,400	5,400		5,400	3,000	3,000			3,000	
08-Apr-06	14,559				14,559	1,599	1,000	3,200			3,200	5,400	5,400		5,400	3,000	3,000			3,000	
09-Apr-06	14,379				14,379	1,419	1,000	3,200			3,200	5,400	5,400		5,400	3,000	3,000			3,000	
10-Apr-06	14,199				14,199	1,239	1,000	3,200			3,200	5,400	5,400		5,400	3,000	3,000			3,000	
11-Apr-06	14,019				14,019	1,060	1,000	3,200			3,200	5,400	5,400		5,400	3,000	3,000			3,000	
12-Apr-06	13,839				13,839	880	1,000	3,200	0	0	3,200	5,400	5,400		5,400	3,000	3,000			3,000	
13-Apr-06	13,660	0			13,660	700	1,000	3,200	0	0	3,200	5,400	5,400	0	5,400	1,500	1,500	0	0	1,500	
14-Apr-06	13,480	0			13,480	695	1,000	3,200	0	0	3,200	5,400	5,400	0	5,400	1,500	1,500	0	0	1,500	
15-Apr-06	11,800	0	0	0.00	11,800	690	1,000	3,200	0	0	3,200	5,400	5,400	0	5,400	1,500	1,500	0	0	1,500	
16-Apr-06	11,795	0	0	0.00	11,795	684	1,000	3,200	0	0	3,200	5,400	5,400	0	5,400	1,500	1,500	0	0	1,500	
17-Apr-06	11,790	0	0	0.00	11,790	679	1,000	3,200	0	0	3,200	5,400	5,400	0	5,400	1,500	1,500	0	0	1,500	
18-Apr-06	11,784	0	0	0.00	11,784	674	1,000	3,200	0	0	3,200	5,400	5,400	0	5,400	1,500	1,500	0	0	1,500	
19-Apr-06	11,779	0	0	0.00	11,779	669	1,000	3,200	0	0	3,200	5,400	5,400	0	5,400	1,500	1,500	0	0	1,500	
20-Apr-06	11,774	0	0	0.00	11,774	663	1,000	3,200	0	0	3,200	5,400	5,400	0	5,400	1,500	1,500	0	0	1,500	
21-Apr-06	11,769	0	0	0.00	11,769	658	1,000	3,200	0	0	3,200	5,400	5,400	0	5,400	1,500	1,500	0	0	1,500	
22-Apr-06	11,763	0	0	0.00	11,763	653	1,000	3,200	0	0	3,200	5,400	5,400	0	5,400	1,500	1,500	0	0	1,500	
23-Apr-06	11,758	0	0	0.00	11,758	648	1,000	3,200	0	0	3,200	5,400	5,400	0	5,400	1,500	1,500	0	0	1,500	
24-Apr-06	11,753	0	0	0.00	11,753	642	1,000	3,200	0	0	3,200	5,400	5,400	0	5,400	1,500	1,500	0	0	1,500	
25-Apr-06	11,748	0	0	0.00	11,748	637	1,000	3,200	0	0	3,200	5,400	5,400	0	5,400	1,500	1,500	0	0	1,500	
26-Apr-06	11,742	0	0	0.00	11,742	632	1,000	3,200	0	0	3,200	5,400	5,400	0	5,400	1,500	1,500	0	0	1,500	
27-Apr-06	11,737	0	0	0.00	11,737	627	1,000	3,200	0	0	3,200	5,400	5,400	0	5,400	1,500	1,500	0	0	1,500	
28-Apr-06	11,732	0	0	0.00	11,732	622	1,000	3,200	0	0	3,200	5,400	5,400	0	5,400	1,500	1,500	0	0	1,500	
29-Apr-06	11,727	0	0	0.00	11,727	616	1,000	3,200	0	0	3,200	5,400	5,400	0	5,400	1,500	1,500	0	0	1,500	
30-Apr-06	11,722	0	0	0.00	11,722	611	1,000	3,200	0	0	3,200	5,400	5,400	0	5,400	1,500	1,500	0	0	1,500	
01-May-06	11,716	0	0	0.00	11,716	606	1,000	3,200	0	0	3,200	4,800	4,800	0	4,800	1,500	1,500	0	0	1,500	
02-May-06	11,711	0	0	0.00	11,711	601	1,000	3,200	0	0	3,200	4,800	4,800	0	4,800	1,500	1,500	0	0	1,500	
03-May-06	11,106	0	0	0.00	11,106	595	1,000	3,200	0	0	3,200	4,800	4,800	0	4,800	1,500	1,500	0	0	1,500	
04-May-06	11,101	0	0	0.00	11,101	590	1,000	3,200	0	0	3,200	4,800	4,800	0	4,800	1,500	1,500	0	0	1,500	
05-May-06	11,095	0	0	0.00	11,095	585	1,000	3,200	0	0	3,200	4,800	4,800	0	4,800	1,500	1,500	0	0	1,500	
06-May-06	11,090	0	0	0.00	11,090	580	1,000	3,200	0	0	3,200	4,800	4,800	0	4,800	1,500	1,500	0	0	1,500	
07-May-06	11,085	0	0	0.00	11,085	574	1,000	3,200	0	0	3,200	4,800	4,800	0	4,800	1,500	1,500	0	0	1,500	
08-May-06	11,080	0	0	0.00	11,080	569	1,000	3,200	0	0	3,200	4,800	4,800	0	4,800	1,500	1,500	0	0	1,500	
09-May-06	11,074	0	0	0.00	11,074	564	1,000	3,200	0	0	3,200	4,800	4,800	0	4,800	1,500	1,500	0	0	1,500	
10-May-06	11,069	0	0	0.00	11,069	559	1,000	3,200	0	0	3,200	4,800	4,800	0	4,800	1,500	1,500	0	0	1,500	
11-May-06	11,064	0	0	0.00	11,064	553	1,000	3,200	0	0	3,200	4,800	4,800	0	4,800	1,500	1,500	0	0	1,500	
12-May-06	11,059	0	0	0.00	11,059	548	1,000	3,200	0	0	3,200	4,800	4,800	0	4,800	1,500	1,500	0	0	1,500	
13-May-06	11,053	0	0	0.00	11,053	543	1,000	3,200			3,200	4,800	4,800	0	4,800	1,500	1,500	0	0	1,500	
14-May-06	11,048	0	0	0.00	11,048	538	1,000	3,200			3,200	4,800	4,800		4,800	1,500	1,500			1,500	
15-May-06	11,043	0	0	0.00	11,043	533	1,000	3,200			3,200	4,800	4,800		4,800	1,500	1,500			1,500	
16-May-06	11,038	0	0		11,038	528	1,000	3,200			3,200	4,800	4,800		4,800	1,500	1,500			1,500	
17-May-06	11,033	0	0		11,033	523	1,000	3,200			3,200	4,800	4,800		4,800	1,500	1,500			1,500	
18-May-06	11,028	0	0		11,028	518	1,000	3,200			3,200	4,800	4,800		4,800	1,500	1,500			1,500	
19-May-06	11,023	0	0		11,023	513	1,000	3,200			3,200	4,800	4,800		4,800	1,500	1,500			1,500	
20-May-06	11,018	0	0		11,018	508	1,000	3,200			3,200	4,800	4,800		4,800	1,500	1,500			1,500	
21-May-06	11,013	0	0		11,013	503	1,000	3,200			3,200	4,800	4,800		4,800	1,500	1,500			1,500	
22-May-06	11,008	0	0		11,008	498	1,000	3,200			3,200	4,800	4,800		4,800	1,500	1,500			1,500	
23-May-06	11,003	0	0		11,003	493	1,000	3,200			3,200	4,800	4,800		4,800	1,500	1,500			1,500	
24-May-06	10,998	0	0		10,998	488	1,000	3,200			3,200	4,800	4,800		4,800	1,500	1,500			1,500	
25-May-06	10,993	0	0		10,993	483	1,000	3,200			3,200	4,800	4,800		4,800	1,500	1,500			1,500	
26-May-06	10,988	0	0		10,988	478	1,000	3,200			3,200	4,800	4,800		4,800	1,500	1,500			1,500	
27-May-06	10,983	0	0		10,983	473	1,000	3,200			3,200	4,800	4,800		4,800	1,500	1,500			1,500	
28-May-06	10,978	0	0		10,978	468	1,000	3,200			3,200	4,800	4,800		4,800	1,500	1,500			1,500	
29-May-06	10,973	0	0		10,973	463	1,000	3,200			3,200	4,800	4,800		4,800	1,500	1,500			1,500	
30-May-06	10,968	0	0		10,968	458	1,000	3,200			3,200	4,800	4,800		4,800	1,500	1,500			1,500	
31-May-06	10,963	0	0		10,963	453	1,000	3,200			3,200	4,800	4,800		4,800	1,500	1,500			1,500	
VAMP Period																					
Avg. (cfs):	11,470	0			11,470	622	1,000	3,200	0	0	3,200	5,148	5,148	0	5,148	1,500	1,500	0	0	1,500	
Supplemental Water (TAF):				0.00							0.00	0.00				0.00				0.00	

VAMP flow operation period

Appendix A-1, Table 8

2006 VAMP DAILY OPERATION PLAN
April 3, 2006 (B)
Target Flow Period: April 22 - May 22 • Flow Target: greater than 7,000 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	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (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)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		(cfs)	(cfs)	(cfs)	
15-Mar-06	**11,700**				**11,700**	**1,583**	**966**	**2,849**			**2,849**	**4,060**	**4,060**		**4,060**	**3,005**	**3,005**			**3,005**	
16-Mar-06	**11,900**				**11,900**	**1,698**	**936**	**2,843**			**2,843**	**3,700**	**3,700**		**3,700**	**3,002**	**3,002**			**3,002**	
17-Mar-06	**12,000**				**12,000**	**1,792**	**612**	**2,939**			**2,939**	**3,380**	**3,380**		**3,380**	**3,009**	**3,009**			**3,009**	
18-Mar-06	**11,700**				**11,700**	**1,716**	**550**	**3,309**			**3,309**	**3,340**	**3,340**		**3,340**	**3,000**	**3,000**			**3,000**	
19-Mar-06	**11,900**				**11,900**	**2,454**	**630**	**2,409**			**2,409**	**3,900**	**3,900**		**3,900**	**3,004**	**3,004**			**3,004**	
20-Mar-06	**12,100**				**12,100**	**2,223**	**811**	**2,285**			**2,285**	**3,840**	**3,840**		**3,840**	**3,010**	**3,010**			**3,010**	
21-Mar-06	**12,200**				**12,200**	**1,986**	**505**	**2,407**			**2,407**	**3,740**	**3,740**		**3,740**	**3,014**	**3,014**			**3,014**	
22-Mar-06	**11,900**				**11,900**	**2,178**	**352**	**2,066**			**2,066**	**3,660**	**3,660**		**3,660**	**3,008**	**3,008**			**3,008**	
23-Mar-06	**11,600**				**11,600**	**2,129**	**175**	**2,115**			**2,115**	**3,670**	**3,670**		**3,670**	**3,008**	**3,008**			**3,008**	
24-Mar-06	**11,400**				**11,400**	**2,177**	**380**	**2,080**			**2,080**	**3,910**	**3,910**		**3,910**	**3,005**	**3,005**			**3,005**	
25-Mar-06	**11,500**				**11,500**	**2,063**	**450**	**2,035**			**2,035**	**4,590**	**4,590**		**4,590**	**3,013**	**3,013**			**3,013**	
26-Mar-06	**12,000**				**12,000**	**2,097**	**522**	**1,867**			**1,867**	**4,580**	**4,580**		**4,580**	**3,009**	**3,009**			**3,009**	
27-Mar-06	**12,600**				**12,600**	**2,243**	**758**	**1,583**			**1,583**	**5,070**	**5,070**		**5,070**	**3,025**	**3,025**			**3,025**	
28-Mar-06	**12,500**				**12,500**	**1,595**	**876**	**2,584**			**2,584**	**5,070**	**5,070**		**5,070**	**3,043**	**3,043**			**3,043**	
29-Mar-06	**13,200**				**13,200**	**1,887**	**1,661**	**3,033**			**3,033**	**5,420**	**5,420**		**5,420**	**3,026**	**3,026**			**3,026**	
30-Mar-06	**14,700**				**14,700**	**1,855**	**1,728**	**2,877**			**2,877**	**6,050**	**6,050**		**6,050**	**3,014**	**3,014**			**3,014**	
31-Mar-06	**14,800**				**14,800**	**2,311**	**2,096**	**2,790**			**1,000**	**6,340**	**6,340**		**6,340**	**3,014**	**3,014**			**3,014**	
01-Apr-06	**15,100**				**15,100**	**2,574**	**2,147**	**2,972**			**2,972**	**6,110**	**6,110**		**6,110**	**3,014**	**3,014**			**3,014**	
02-Apr-06	**16,200**				**16,200**	**2,678**	**1,563**	**2,847**			**2,847**	**6,270**	**6,270**		**6,270**	**3,019**	**3,019**			**3,019**	
03-Apr-06	15,488				13,698	2,498	1,000	3,200			3,200	6,200	6,200		6,200	3,000	3,000			3,000	
04-Apr-06	15,939				15,939	2,318	1,000	3,200			3,200	5,400	5,400		5,400	3,000	3,000			3,000	
05-Apr-06	15,545				15,545	2,139	1,000	3,200			3,200	5,400	5,400		5,400	3,000	3,000			3,000	
06-Apr-06	14,918				14,918	1,959	1,000	3,200			3,200	5,400	5,400		5,400	3,000	3,000			3,000	
07-Apr-06	14,739				14,739	1,779	1,000	3,200			3,200	5,400	5,400		5,400	3,000	3,000			3,000	
08-Apr-06	14,559				14,559	1,599	1,000	3,200			3,200	5,400	5,400		5,400	3,000	3,000			3,000	
09-Apr-06	14,379				14,379	1,419	1,000	3,200			3,200	5,400	5,400		5,400	3,000	3,000			3,000	
10-Apr-06	14,199				14,199	1,239	1,000	3,200			3,200	5,400	5,400		5,400	3,000	3,000			3,000	
11-Apr-06	14,019				14,019	1,060	1,000	3,200			3,200	5,400	5,400		5,400	3,000	3,000			3,000	
12-Apr-06	13,839				13,839	880	1,000	3,200			3,200	5,400	5,400		5,400	3,000	3,000			3,000	
13-Apr-06	13,660				13,660	700	1,000	3,200			3,200	5,400	5,400		5,400	3,000	3,000			3,000	
14-Apr-06	13,480				13,480	695	1,000	3,200			3,200	5,400	5,400		5,400	3,000	3,000			3,000	
15-Apr-06	13,300				13,300	690	1,000	3,200			3,200	5,400	5,400		5,400	3,000	3,000			3,000	
16-Apr-06	13,295				13,295	684	1,000	3,200			3,200	5,400	5,400		5,400	3,000	3,000			3,000	
17-Apr-06	13,290				13,290	679	1,000	3,200			3,200	5,400	5,400		5,400	3,000	3,000			3,000	
18-Apr-06	13,284				13,284	674	1,000	3,200			3,200	5,400	5,400		5,400	3,000	3,000			3,000	
19-Apr-06	13,279				13,279	669	1,000	3,200	0	0	3,200	5,400	5,400		5,400	3,000	3,000			3,000	
20-Apr-06	13,274				13,274	663	1,000	3,200	0	0	3,200	5,400	5,400	0	5,400	1,500	1,500	0	0	1,500	
21-Apr-06	13,269				13,269	658	1,000	3,200	0	0	3,200	5,400	5,400	0	5,400	1,500	1,500	0	0	1,500	
22-Apr-06	11,763	0	0	0.00	11,763	653	1,000	3,200	0	0	3,200	5,400	5,400	0	5,400	1,500	1,500	0	0	1,500	
23-Apr-06	11,758	0	0	0.00	11,758	648	1,000	3,200	0	0	3,200	5,400	5,400	0	5,400	1,500	1,500	0	0	1,500	
24-Apr-06	11,753	0	0	0.00	11,753	642	1,000	3,200	0	0	3,200	5,400	5,400	0	5,400	1,500	1,500	0	0	1,500	
25-Apr-06	11,748	0	0	0.00	11,748	637	1,000	3,200	0	0	3,200	5,400	5,400	0	5,400	1,500	1,500	0	0	1,500	
26-Apr-06	11,742	0	0	0.00	11,742	632	1,000	3,200	0	0	3,200	5,400	5,400	0	5,400	1,500	1,500	0	0	1,500	
27-Apr-06	11,737	0	0	0.00	11,737	627	1,000	3,200	0	0	3,200	5,400	5,400	0	5,400	1,500	1,500	0	0	1,500	
28-Apr-06	11,732	0	0	0.00	11,732	622	1,000	3,200	0	0	3,200	5,400	5,400	0	5,400	1,500	1,500	0	0	1,500	
29-Apr-06	11,727	0	0	0.00	11,727	616	1,000	3,200	0	0	3,200	5,400	5,400	0	5,400	1,500	1,500	0	0	1,500	
30-Apr-06	11,722	0	0	0.00	11,722	611	1,000	3,200	0	0	3,200	5,400	5,400	0	5,400	1,500	1,500	0	0	1,500	
01-May-06	11,716	0	0	0.00	11,716	606	1,000	3,200	0	0	3,200	4,800	4,800	0	4,800	1,500	1,500	0	0	1,500	
02-May-06	11,711	0	0	0.00	11,711	601	1,000	3,200	0	0	3,200	4,800	4,800	0	4,800	1,500	1,500	0	0	1,500	
03-May-06	11,106	0	0	0.00	11,106	595	1,000	3,200	0	0	3,200	4,800	4,800	0	4,800	1,500	1,500	0	0	1,500	
04-May-06	11,101	0	0	0.00	11,101	590	1,000	3,200	0	0	3,200	4,800	4,800	0	4,800	1,500	1,500	0	0	1,500	
05-May-06	11,095	0	0	0.00	11,095	585	1,000	3,200	0	0	3,200	4,800	4,800	0	4,800	1,500	1,500	0	0	1,500	
06-May-06	11,090	0	0	0.00	11,090	580	1,000	3,200	0	0	3,200	4,800	4,800	0	4,800	1,500	1,500	0	0	1,500	
07-May-06	11,085	0	0	0.00	11,085	574	1,000	3,200	0	0	3,200	4,800	4,800	0	4,800	1,500	1,500	0	0	1,500	
08-May-06	11,080	0	0	0.00	11,080	569	1,000	3,200	0	0	3,200	4,800	4,800	0	4,800	1,500	1,500	0	0	1,500	
09-May-06	11,074	0	0	0.00	11,074	564	1,000	3,200	0	0	3,200	4,800	4,800	0	4,800	1,500	1,500	0	0	1,500	
10-May-06	11,069	0	0	0.00	11,069	559	1,000	3,200	0	0	3,200	4,800	4,800	0	4,800	1,500	1,500	0	0	1,500	
11-May-06	11,064	0	0	0.00	11,064	553	1,000	3,200	0	0	3,200	4,800	4,800	0	4,800	1,500	1,500	0	0	1,500	
12-May-06	11,059	0	0	0.00	11,059	548	1,000	3,200	0	0	3,200	4,800	4,800	0	4,800	1,500	1,500	0	0	1,500	
13-May-06	11,053	0	0	0.00	11,053	543	1,000	3,200	0	0	3,200	4,800	4,800	0	4,800	1,500	1,500	0	0	1,500	
14-May-06	11,048	0	0	0.00	11,048	538	1,000	3,200	0	0	3,200	4,800	4,800	0	4,800	1,500	1,500	0	0	1,500	
15-May-06	11,043	0	0	0.00	11,043	533	1,000	3,200	0	0	3,200	4,800	4,800	0	4,800	1,500	1,500	0	0	1,500	
16-May-06	11,038	0	0	0.00	11,038	528	1,000	3,200	0	0	3,200	4,800	4,800	0	4,800	1,500	1,500	0	0	1,500	
17-May-06	11,033	0	0	0.00	11,033	523	1,000	3,200	0	0	3,200	4,800	4,800	0	4,800	1,500	1,500	0	0	1,500	
18-May-06	11,028	0	0	0.00	11,028	518	1,000	3,200	0	0	3,200	4,800	4,800	0	4,800	1,500	1,500	0	0	1,500	
19-May-06	11,023	0	0	0.00	11,023	513	1,000	3,200	0	0	3,200	4,800	4,800	0	4,800	1,500	1,500	0	0	1,500	
20-May-06	11,018	0	0	0.00	11,018	508	1,000	3,200			3,200	4,800	4,800	0	4,800	1,500	1,500	0	0	1,500	
21-May-06	11,013	0	0	0.00	11,013	503	1,000	3,200			3,200	4,800	4,800		4,800	1,500	1,500			1,500	
22-May-06	11,008	0	0	0.00	11,008	498	1,000	3,200			3,200	4,800	4,800		4,800	1,500	1,500			1,500	
23-May-06	11,003	0	0		11,003	493	1,000	3,200			3,200	4,800	4,800		4,800	1,500	1,500			1,500	
24-May-06	10,998	0	0		10,998	488	1,000	3,200			3,200	4,800	4,800		4,800	1,500	1,500			1,500	
25-May-06	10,993	0	0		10,993	483	1,000	3,200			3,200	4,800	4,800		4,800	1,500	1,500			1,500	
26-May-06	10,988	0	0		10,988	478	1,000	3,200			3,200	4,800	4,800		4,800	1,500	1,500			1,500	
27-May-06	10,983	0	0		10,983	473	1,000	3,200			3,200	4,800	4,800		4,800	1,500	1,500			1,500	
28-May-06	10,978	0	0		10,978	468	1,000	3,200			3,200	4,800	4,800		4,800	1,500	1,500			1,500	
29-May-06	10,973	0	0		10,973	463	1,000	3,200			3,200	4,800	4,800		4,800	1,500	1,500			1,500	
30-May-06	10,968	0	0		10,968	458	1,000	3,200			3,200	4,800	4,800		4,800	1,500	1,500			1,500	
31-May-06	10,963	0	0		10,963	453	1,000	3,200			3,200	4,800	4,800		4,800	1,500	1,500			1,500	
											VAMP Period										
Avg. (cfs):	11,298	0			11,298	585	1,000	3,200	0	0	3,200	5,013	5,013	0	5,013	1,500	1,500	0	0	1,500	
Supplemental Water (TAF):				0.00							0.00	0.00				0.00				0.00	

VAMP flow operation period

Appendix A-1, Table 9

2006 VAMP DAILY OPERATION PLAN
April 11, 2006
Target Flow Period: April 22 - May 22 • Flow Target: greater than 7,000 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	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (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)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		(cfs)	(cfs)	(cfs)	
15-Mar-06	**11,700**				**11,700**	**1,352**	**638**	**2,849**			**2,849**	**4,060**	**4,060**		**4,060**	**3,005**	**3,005**			**3,005**	
16-Mar-06	**11,900**				**11,900**	**1,407**	**956**	**2,843**			**2,843**	**3,700**	**3,700**		**3,700**	**3,002**	**3,002**			**3,002**	
17-Mar-06	**12,000**				**12,000**	**1,573**	**794**	**2,939**			**2,939**	**3,380**	**3,380**		**3,380**	**3,009**	**3,009**			**3,009**	
18-Mar-06	**11,700**				**11,700**	**1,684**	**742**	**3,309**			**3,309**	**3,340**	**3,340**		**3,340**	**3,000**	**3,000**			**3,000**	
19-Mar-06	**11,900**				**11,900**	**1,364**	**1,095**	**2,409**			**2,409**	**3,900**	**3,900**		**3,900**	**3,004**	**3,004**			**3,004**	
20-Mar-06	**12,100**				**12,100**	**1,892**	**1,137**	**2,285**			**2,285**	**3,840**	**3,840**		**3,840**	**3,010**	**3,010**			**3,010**	
21-Mar-06	**12,200**				**12,200**	**1,866**	**623**	**2,407**			**2,407**	**3,740**	**3,740**		**3,740**	**3,014**	**3,014**			**3,014**	
22-Mar-06	**11,900**				**11,900**	**1,674**	**749**	**2,066**			**2,066**	**3,660**	**3,660**		**3,660**	**3,008**	**3,008**			**3,008**	
23-Mar-06	**11,600**				**11,600**	**1,978**	**695**	**2,115**			**2,115**	**3,670**	**3,670**		**3,670**	**3,008**	**3,008**			**3,008**	
24-Mar-06	**11,400**				**11,400**	**1,952**	**651**	**2,080**			**2,080**	**3,910**	**3,910**		**3,910**	**3,005**	**3,005**			**3,005**	
25-Mar-06	**11,500**				**11,500**	**1,835**	**778**	**2,035**			**2,035**	**4,590**	**4,590**		**4,590**	**3,013**	**3,013**			**3,013**	
26-Mar-06	**12,000**				**12,000**	**1,776**	**1,018**	**1,867**			**1,867**	**4,580**	**4,580**		**4,580**	**3,009**	**3,009**			**3,009**	
27-Mar-06	**12,600**				**12,600**	**1,851**	**1,082**	**1,583**			**1,583**	**5,070**	**5,070**		**5,070**	**3,025**	**3,025**			**3,025**	
28-Mar-06	**12,500**				**12,500**	**2,262**	**1,100**	**2,584**			**2,584**	**5,070**	**5,070**		**5,070**	**3,043**	**3,043**			**3,043**	
29-Mar-06	**13,200**				**13,200**	**1,971**	**1,387**	**3,033**			**3,033**	**5,420**	**5,420**		**5,420**	**3,026**	**3,026**			**3,026**	
30-Mar-06	**14,700**				**14,700**	**1,795**	**2,742**	**2,877**			**2,877**	**6,050**	**6,050**		**6,050**	**3,014**	**3,014**			**3,014**	
31-Mar-06	**14,800**				**14,800**	**2,211**	**1,799**	**2,790**			**1,000**	**6,340**	**6,340**		**6,340**	**3,014**	**3,014**			**3,014**	
01-Apr-06	**15,100**				**15,100**	**2,444**	**1,208**	**2,972**			**2,972**	**6,110**	**6,110**		**6,110**	**3,014**	**3,014**			**3,014**	
02-Apr-06	**16,200**				**16,200**	**2,518**	**1,734**	**2,847**			**2,847**	**6,270**	**6,270**		**6,270**	**3,019**	**3,019**			**3,019**	
03-Apr-06	**16,700**				**16,700**	**2,733**	**2,342**	**3,513**			**3,513**	**6,020**	**6,020**		**6,020**	**3,039**	**3,039**			**3,039**	
04-Apr-06	**17,000**				**17,000**	**2,233**	**2,221**	**6,838**			**6,838**	**3,740**	**3,740**		**3,740**	**3,303**	**3,303**			**3,303**	
05-Apr-06	**18,700**				**18,700**	**2,796**	**4,061**	**4,830**			**4,830**	**4,800**	**4,800**		**4,800**	**4,714**	**4,714**			**4,714**	
06-Apr-06	**20,800**				**20,800**	**8,724**	**8,011**	**4,937**			**4,937**	**5,580**	**5,580**		**5,580**	**5,776**	**5,776**			**5,776**	
07-Apr-06	**21,900**				**21,900**	**15,426**	**2,752**	**5,219**			**5,219**	**6,470**	**6,470**		**6,470**	**6,148**	**6,148**			**6,148**	
08-Apr-06	**23,100**				**23,100**	**17,466**	**-1,810**	**5,183**			**5,183**	**6,790**	**6,790**		**6,790**	**4,379**	**4,379**			**4,379**	
09-Apr-06	**27,400**				**27,400**	**19,099**	**-5,581**	**5,157**			**5,157**	**6,780**	**6,780**		**6,780**	**3,534**	**3,534**			**3,534**	
10-Apr-06	**31,100**				**31,100**	**18,623**	**-2,754**	**5,102**			**5,102**	**6,760**	**6,760**		**6,760**	**3,504**	**3,504**			**3,504**	
11-Apr-06	32,000				32,000	17,174	-2,596	5,000			5,000	6,700	6,700		6,700	3,500	3,500			3,500	
12-Apr-06	32,000				32,000	16,000	-2,044	4,500			4,500	6,600	6,600		6,600	3,500	3,500			3,500	
13-Apr-06	32,476				32,476	15,500	0	4,500			4,500	6,600	6,600		6,600	3,500	3,500			3,500	
14-Apr-06	32,100				32,100	15,000	1,000	4,500			4,500	6,600	6,600		6,600	3,500	3,500			3,500	
15-Apr-06	31,100				31,100	14,500	1,000	4,500			4,500	6,600	6,600		6,600	3,500	3,500			3,500	
16-Apr-06	30,600				30,600	14,000	1,000	3,870			3,870	6,600	6,600		6,600	3,500	3,500			3,500	
17-Apr-06	30,100				30,100	13,500	1,000	3,820			3,820	6,600	6,600		6,600	5,500	5,500			5,500	
18-Apr-06	29,600				29,600	13,000	1,000	3,820			3,820	6,600	6,600		6,600	5,500	5,500			5,500	
19-Apr-06	30,470				30,470	12,500	1,000	3,810	0	0	3,810	6,600	6,600		6,600	5,500	5,500			5,500	
20-Apr-06	29,920				29,920	12,000	1,000	3,790	0	0	3,790	6,600	6,600	0	6,600	5,500	5,500	0	0	5,500	
21-Apr-06	29,420				29,420	11,867	1,000	3,790	0	0	3,790	6,600	6,600	0	6,600	5,500	5,500	0	0	5,500	
22-Apr-06	28,910	0	0	0.00	28,910	11,733	1,000	3,670	0	0	3,670	6,600	6,600	0	6,600	5,500	5,500	0	0	5,500	
23-Apr-06	28,757	0	0	0.00	28,757	11,600	1,000	3,650	0	0	3,650	6,600	6,600	0	6,600	5,500	5,500	0	0	5,500	
24-Apr-06	28,623	0	0	0.00	28,623	11,467	1,000	3,520	0	0	3,520	6,600	6,600	0	6,600	5,500	5,500	0	0	5,500	
25-Apr-06	28,370	0	0	0.00	28,370	11,333	1,000	3,570	0	0	3,570	6,600	6,600	0	6,600	5,500	5,500	0	0	5,500	
26-Apr-06	28,217	0	0	0.00	28,217	11,200	1,000	3,630	0	0	3,630	6,600	6,600	0	6,600	5,500	5,500	0	0	5,500	
27-Apr-06	27,953	0	0	0.00	27,953	11,067	1,000	3,620	0	0	3,620	6,600	6,600	0	6,600	5,500	5,500	0	0	5,500	
28-Apr-06	27,870	0	0	0.00	27,870	10,933	1,000	3,620	0	0	3,620	6,600	6,600	0	6,600	5,500	5,500	0	0	5,500	
29-Apr-06	27,797	0	0	0.00	27,797	10,800	1,000	3,620	0	0	3,620	6,600	6,600	0	6,600	5,500	5,500	0	0	5,500	
30-Apr-06	27,653	0	0	0.00	27,653	10,667	1,000	3,620	0	0	3,620	6,600	6,600	0	6,600	5,500	5,500	0	0	5,500	
01-May-06	27,520	0	0	0.00	27,520	10,533	1,000	2,850	0	0	2,850	6,000	6,000	0	6,000	5,500	5,500	0	0	5,500	
02-May-06	27,387	0	0	0.00	27,387	10,400	1,000	2,850	0	0	2,850	6,000	6,000	0	6,000	5,500	5,500	0	0	5,500	
03-May-06	26,653	0	0	0.00	26,653	10,267	1,000	2,850	0	0	2,850	6,000	6,000	0	6,000	5,500	5,500	0	0	5,500	
04-May-06	25,750	0	0	0.00	25,750	10,133	1,000	2,850	0	0	2,850	6,000	6,000	0	6,000	5,500	5,500	0	0	5,500	
05-May-06	25,617	0	0	0.00	25,617	10,000	1,000	2,850	0	0	2,850	6,000	6,000	0	6,000	5,500	5,500	0	0	5,500	
06-May-06	25,483	0	0	0.00	25,483	9,867	1,000	2,850	0	0	2,850	6,000	6,000	0	6,000	5,500	5,500	0	0	5,500	
07-May-06	25,350	0	0	0.00	25,350	9,733	1,000	2,850	0	0	2,850	6,000	6,000	0	6,000	5,500	5,500	0	0	5,500	
08-May-06	25,217	0	0	0.00	25,217	9,600	1,000	2,850	0	0	2,850	6,000	6,000	0	6,000	5,500	5,500	0	0	5,500	
09-May-06	25,083	0	0	0.00	25,083	9,467	1,000	2,850	0	0	2,850	6,000	6,000	0	6,000	5,500	5,500	0	0	5,500	
10-May-06	24,950	0	0	0.00	24,950	9,333	1,000	2,850	0	0	2,850	6,000	6,000	0	6,000	5,500	5,500	0	0	5,500	
11-May-06	24,817	0	0	0.00	24,817	9,200	1,000	2,850	0	0	2,850	6,000	6,000	0	6,000	5,500	5,500	0	0	5,500	
12-May-06	24,683	0	0	0.00	24,683	9,067	1,000	2,850	0	0	2,850	6,000	6,000	0	6,000	5,500	5,500	0	0	5,500	
13-May-06	24,550	0	0	0.00	24,550	8,933	1,000	2,850	0	0	2,850	6,000	6,000	0	6,000	5,500	5,500	0	0	5,500	
14-May-06	24,417	0	0	0.00	24,417	8,800	1,000	2,850	0	0	2,850	6,000	6,000	0	6,000	5,500	5,500	0	0	5,500	
15-May-06	24,283	0	0	0.00	24,283	8,667	1,000	2,850	0	0	2,850	6,000	6,000	0	6,000	5,500	5,500	0	0	5,500	
16-May-06	24,150	0	0	0.00	24,150	8,533	1,000	2,850	0	0	2,850	6,000	6,000	0	6,000	5,500	5,500	0	0	5,500	
17-May-06	24,017	0	0	0.00	24,017	8,400	1,000	2,850	0	0	2,850	6,000	6,000	0	6,000	5,500	5,500	0	0	5,500	
18-May-06	23,883	0	0	0.00	23,883	8,267	1,000	2,850	0	0	2,850	6,000	6,000	0	6,000	5,500	5,500	0	0	5,500	
19-May-06	23,750	0	0	0.00	23,750	8,133	1,000	2,850	0	0	2,850	6,000	6,000	0	6,000	5,500	5,500	0	0	5,500	
20-May-06	23,617	0	0	0.00	23,617	8,000	1,000	2,850			2,850	6,000	6,000	0	6,000	5,500	5,500	0	0	5,500	
21-May-06	23,483	0	0	0.00	23,483	7,850	1,000	2,850			2,850	6,000	6,000		6,000	5,500	5,500			5,500	
22-May-06	23,350	0	0	0.00	23,350	7,700	1,000	2,850			2,850	6,000	6,000		6,000	5,500	5,500			5,500	
23-May-06	23,200	0	0		23,200	7,550	1,000	2,850			2,850	6,000	6,000		6,000	5,500	5,500			5,500	
24-May-06	23,050	0	0		23,050	7,400	1,000	2,850			2,850	6,000	6,000		6,000	5,500	5,500			5,500	
25-May-06	22,900	0	0		22,900	7,250	1,000	2,850			2,850	6,000	6,000		6,000	5,500	5,500			5,500	
26-May-06	22,750	0	0		22,750	7,100	1,000	2,850			2,850	6,000	6,000		6,000	5,500	5,500			5,500	
27-May-06	22,600	0	0		22,600	6,950	1,000	2,850			2,850	6,000	6,000		6,000	5,500	5,500			5,500	
28-May-06	22,450	0	0		22,450	6,800	1,000	2,850			2,850	6,000	6,000		6,000	5,500	5,500			5,500	
29-May-06	22,300	0	0		22,300	6,650	1,000	2,850			2,850	6,000	6,000		6,000	5,500	5,500			5,500	
30-May-06	22,150	0	0		22,150	6,500	1,000	2,850			2,850	6,000	6,000		6,000	5,500	5,500			5,500	
31-May-06	22,000	0	0		22,000	6,350	1,000	2,850			2,850	6,000	6,000		6,000	5,500	5,500			5,500	
VAMP Period																					
Avg. (cfs):	25,876	0			25,876	10,000	1,000	3,163	0	0	3,163	6,213	6,213	0	6,213	5,500	5,500	0	0	5,500	
Supplemental Water (TAF):				0.00							0.00	0.00				0.00				0.00	

VAMP flow operation period

Appendix A-1, Table 10

2006 VAMP DAILY OPERATION PLAN
April 18, 2006 (A)
Target Flow Period: April 22 - May 22 • Flow Target: greater than 7,000 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	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (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)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		(cfs)	(cfs)	(cfs)	
15-Mar-06	**11,700**				**11,700**	**1,583**	**966**	**2,849**			**2,849**	**4,060**	**4,060**		**4,060**	**3,005**	**3,005**			**3,005**	
16-Mar-06	**11,900**				**11,900**	**1,698**	**936**	**2,843**			**2,843**	**3,700**	**3,700**		**3,700**	**3,002**	**3,002**			**3,002**	
17-Mar-06	**12,000**				**12,000**	**1,792**	**612**	**2,939**			**2,939**	**3,380**	**3,380**		**3,380**	**3,009**	**3,009**			**3,009**	
18-Mar-06	**11,700**				**11,700**	**1,716**	**550**	**3,309**			**3,309**	**3,340**	**3,340**		**3,340**	**3,000**	**3,000**			**3,000**	
19-Mar-06	**11,900**				**11,900**	**2,454**	**630**	**2,409**			**2,409**	**3,900**	**3,900**		**3,900**	**3,004**	**3,004**			**3,004**	
20-Mar-06	**12,100**				**12,100**	**2,223**	**811**	**2,285**			**2,285**	**3,840**	**3,840**		**3,840**	**3,010**	**3,010**			**3,010**	
21-Mar-06	**12,200**				**12,200**	**1,986**	**505**	**2,407**			**2,407**	**3,740**	**3,740**		**3,740**	**3,014**	**3,014**			**3,014**	
22-Mar-06	**11,900**				**11,900**	**2,178**	**352**	**2,066**			**2,066**	**3,660**	**3,660**		**3,660**	**3,008**	**3,008**			**3,008**	
23-Mar-06	**11,600**				**11,600**	**2,129**	**175**	**2,115**			**2,115**	**3,670**	**3,670**		**3,670**	**3,008**	**3,008**			**3,008**	
24-Mar-06	**11,400**				**11,400**	**2,177**	**380**	**2,080**			**2,080**	**3,910**	**3,910**		**3,910**	**3,005**	**3,005**			**3,005**	
25-Mar-06	**11,500**				**11,500**	**2,063**	**450**	**2,035**			**2,035**	**4,590**	**4,590**		**4,590**	**3,013**	**3,013**			**3,013**	
26-Mar-06	**12,000**				**12,000**	**2,097**	**522**	**1,867**			**1,867**	**4,580**	**4,580**		**4,580**	**3,009**	**3,009**			**3,009**	
27-Mar-06	**12,600**				**12,600**	**2,243**	**758**	**1,583**			**1,583**	**5,070**	**5,070**		**5,070**	**3,025**	**3,025**			**3,025**	
28-Mar-06	**12,500**				**12,500**	**1,595**	**876**	**2,584**			**2,584**	**5,070**	**5,070**		**5,070**	**3,043**	**3,043**			**3,043**	
29-Mar-06	**13,200**				**13,200**	**1,887**	**1,661**	**3,033**			**3,033**	**5,420**	**5,420**		**5,420**	**3,026**	**3,026**			**3,026**	
30-Mar-06	**14,700**				**14,700**	**1,855**	**1,728**	**2,877**			**2,877**	**6,050**	**6,050**		**6,050**	**3,014**	**3,014**			**3,014**	
31-Mar-06	**14,800**				**14,800**	**2,311**	**2,096**	**2,790**			**1,000**	**6,340**	**6,340**		**6,340**	**3,014**	**3,014**			**3,014**	
01-Apr-06	**15,100**				**15,100**	**2,444**	**1,208**	**2,972**			**2,972**	**6,110**	**6,110**		**6,110**	**3,014**	**3,014**			**3,014**	
02-Apr-06	**16,200**				**16,200**	**2,518**	**1,734**	**2,847**			**2,847**	**6,270**	**6,270**		**6,270**	**3,019**	**3,019**			**3,019**	
03-Apr-06	**16,700**				**16,700**	**2,733**	**2,342**	**3,513**			**3,513**	**6,020**	**6,020**		**6,020**	**3,039**	**3,039**			**3,039**	
04-Apr-06	**17,000**				**17,000**	**2,233**	**2,221**	**6,838**			**6,838**	**3,740**	**3,740**		**3,740**	**3,303**	**3,303**			**3,303**	
05-Apr-06	**18,700**				**18,700**	**2,796**	**4,061**	**4,830**			**4,830**	**4,800**	**4,800**		**4,800**	**4,714**	**4,714**			**4,714**	
06-Apr-06	**20,800**				**20,800**	**8,724**	**8,011**	**4,937**			**4,937**	**5,580**	**5,580**		**5,580**	**5,776**	**5,776**			**5,776**	
07-Apr-06	**21,900**				**21,900**	**15,426**	**2,752**	**5,219**			**5,219**	**6,470**	**6,470**		**6,470**	**6,148**	**6,148**			**6,148**	
08-Apr-06	**23,100**				**23,100**	**17,466**	**-1,810**	**5,183**			**5,183**	**6,790**	**6,790**		**6,790**	**4,379**	**4,379**			**4,379**	
09-Apr-06	**27,400**				**27,400**	**19,099**	**-5,581**	**5,157**			**5,157**	**6,780**	**6,780**		**6,780**	**3,534**	**3,534**			**3,534**	
10-Apr-06	**31,100**				**31,100**	**18,623**	**-2,754**	**5,102**			**5,102**	**6,760**	**6,760**		**6,760**	**3,504**	**3,504**			**3,504**	
11-Apr-06	**32,200**				**32,200**	**17,974**	**-2,396**	**4,618**			**4,618**	**7,340**	**7,340**		**7,340**	**3,509**	**3,509**			**3,509**	
12-Apr-06	**34,300**				**34,300**	**17,219**	**256**	**4,518**			**4,518**	**7,730**	**7,730**		**7,730**	**3,868**	**3,868**			**3,868**	
13-Apr-06	**34,800**				**34,800**	**15,911**	**875**	**4,465**			**4,465**	**7,770**	**7,770**		**7,770**	**4,019**	**4,019**			**4,019**	
14-Apr-06	**34,500**				**34,500**	**13,300**	**1,065**	**4,446**			**4,446**	**7,550**	**7,550**		**7,550**	**3,995**	**3,995**			**3,995**	
15-Apr-06	**33,700**				**33,700**	**12,160**	**1,482**	**4,619**			**4,619**	**7,450**	**7,450**		**7,450**	**4,039**	**4,039**			**4,039**	
16-Apr-06	**32,900**				**32,900**	**11,538**	**3,590**	**4,511**			**4,511**	**7,420**	**7,420**		**7,420**	**4,062**	**4,062**			**4,062**	
17-Apr-06	**31,700**				**31,700**	**11,520**	**3,605**	**4,130**			**4,130**	**7,600**	**7,600**		**7,600**	**4,756**	**4,756**			**4,756**	
18-Apr-06	30,639				30,639	11,330	3,000	4,000			4,000	8,500	8,500		8,500	5,500	5,500			5,500	
19-Apr-06	30,387				30,387	11,226	2,000	4,000	0	0	4,000	8,600	8,600		8,600	5,500	5,500			5,500	
20-Apr-06	31,460				31,460	11,122	2,000	4,000	0	0	4,000	8,700	8,700	0	8,700	5,500	5,500	0	0	5,500	
21-Apr-06	31,326				31,326	11,018	2,000	4,000	0	0	4,000	8,800	8,800	0	8,800	5,500	5,500	0	0	5,500	
22-Apr-06	31,322	0	0	0.00	31,322	10,914	2,000	4,000	0	0	4,000	8,900	8,900	0	8,900	5,500	5,500	0	0	5,500	
23-Apr-06	31,318	0	0	0.00	31,318	10,810	2,000	3,650	0	0	3,650	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
24-Apr-06	31,314	0	0	0.00	31,314	10,706	2,000	3,520	0	0	3,520	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
25-Apr-06	31,310	0	0	0.00	31,310	10,601	2,000	3,570	0	0	3,570	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
26-Apr-06	30,856	0	0	0.00	30,856	10,497	2,000	3,630	0	0	3,630	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
27-Apr-06	30,621	0	0	0.00	30,621	10,393	2,000	3,620	0	0	3,620	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
28-Apr-06	30,568	0	0	0.00	30,568	10,289	2,000	3,620	0	0	3,620	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
29-Apr-06	30,523	0	0	0.00	30,523	10,185	2,000	3,620	0	0	3,620	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
30-Apr-06	30,409	0	0	0.00	30,409	10,081	2,000	3,620	0	0	3,620	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
01-May-06	30,305	0	0	0.00	30,305	9,977	2,000	2,850	0	0	2,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
02-May-06	30,201	0	0	0.00	30,201	9,873	2,000	2,850	0	0	2,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
03-May-06	30,097	0	0	0.00	30,097	9,769	2,000	2,850	0	0	2,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
04-May-06	29,223	0	0	0.00	29,223	9,665	2,000	2,850	0	0	2,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
05-May-06	29,119	0	0	0.00	29,119	9,561	2,000	2,850	0	0	2,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
06-May-06	29,015	0	0	0.00	29,015	9,457	2,000	2,850	0	0	2,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
07-May-06	28,911	0	0	0.00	28,911	9,353	2,000	2,850	0	0	2,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
08-May-06	28,807	0	0	0.00	28,807	9,249	2,000	2,850	0	0	2,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
09-May-06	28,703	0	0	0.00	28,703	9,145	2,000	2,850	0	0	2,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
10-May-06	28,599	0	0	0.00	28,599	9,041	2,000	2,850	0	0	2,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
11-May-06	28,495	0	0	0.00	28,495	8,937	2,000	2,850	0	0	2,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
12-May-06	28,391	0	0	0.00	28,391	8,832	2,000	2,850	0	0	2,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
13-May-06	28,287	0	0	0.00	28,287	8,728	2,000	2,850	0	0	2,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
14-May-06	28,182	0	0	0.00	28,182	8,624	2,000	2,850	0	0	2,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
15-May-06	28,078	0	0	0.00	28,078	8,520	2,000	2,850	0	0	2,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
16-May-06	27,974	0	0	0.00	27,974	8,416	2,000	2,850	0	0	2,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
17-May-06	27,870	0	0	0.00	27,870	8,312	2,000	2,850	0	0	2,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
18-May-06	27,766	0	0	0.00	27,766	8,208	2,000	2,850	0	0	2,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
19-May-06	27,662	0	0	0.00	27,662	8,104	2,000	2,850	0	0	2,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
20-May-06	27,558	0	0	0.00	27,558	8,000	2,000	2,850			2,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
21-May-06	27,454	0	0	0.00	27,454	7,850	2,000	2,850			2,850	9,000	9,000		9,000	5,500	5,500			5,500	
22-May-06	27,350	0	0	0.00	27,350	7,700	2,000	2,850			2,850	9,000	9,000		9,000	5,500	5,500			5,500	
23-May-06	27,200	0	0		27,200	7,550	2,000	2,850			2,850	9,000	9,000		9,000	5,500	5,500			5,500	
24-May-06	27,050	0	0		27,050	7,400	2,000	2,850			2,850	9,000	9,000		9,000	5,500	5,500			5,500	
25-May-06	26,900	0	0		26,900	7,250	2,000	2,850			2,850	9,000	9,000		9,000	5,500	5,500			5,500	
26-May-06	26,750	0	0		26,750	7,100	2,000	2,850			2,850	9,000	9,000		9,000	5,500	5,500			5,500	
27-May-06	26,600	0	0		26,600	6,950	2,000	2,850			2,850	9,000	9,000		9,000	5,500	5,500			5,500	
28-May-06	26,450	0	0		26,450	6,800	2,000	2,850			2,850	9,000	9,000		9,000	5,500	5,500			5,500	
29-May-06	26,300	0	0		26,300	6,650	2,000	2,850			2,850	9,000	9,000		9,000	5,500	5,500			5,500	
30-May-06	26,150	0	0		26,150	6,500	2,000	2,850			2,850	9,000	9,000		9,000	5,500	5,500			5,500	
31-May-06	26,000	0	0		26,000	6,350	2,000	2,850			2,850	9,000	9,000		9,000	5,500	5,500			5,500	
VAMP Period																					
Avg. (cfs):	29,235	0			29,235	9,561	2,000	3,194	0	0	3,194	8,981	8,981	0	8,981	5,500	5,500	0	0	5,500	
Supplemental Water (TAF):				0.00							0.00	0.00				0.00				0.00	

VAMP flow operation period

Appendix A-1, Table 11

2006 VAMP DAILY OPERATION PLAN
April 18, 2006 (B)
Target Flow Period: May 1 - May 31 • Flow Target: greater than 7,000 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	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (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)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		(cfs)	(cfs)	(cfs)	
15-Mar-06	11,700				11,700	1,583	966	2,849			2,849	4,060	4,060		4,060	3,005	3,005			3,005	
16-Mar-06	11,900				11,900	1,698	936	2,843			2,843	3,700	3,700		3,700	3,002	3,002			3,002	
17-Mar-06	12,000				12,000	1,792	612	2,939			2,939	3,380	3,380		3,380	3,009	3,009			3,009	
18-Mar-06	11,700				11,700	1,716	550	3,309			3,309	3,340	3,340		3,340	3,000	3,000			3,000	
19-Mar-06	11,900				11,900	2,454	630	2,409			2,409	3,900	3,900		3,900	3,004	3,004			3,004	
20-Mar-06	12,100				12,100	2,223	811	2,285			2,285	3,840	3,840		3,840	3,010	3,010			3,010	
21-Mar-06	12,200				12,200	1,986	505	2,407			2,407	3,740	3,740		3,740	3,014	3,014			3,014	
22-Mar-06	11,900				11,900	2,178	352	2,066			2,066	3,660	3,660		3,660	3,008	3,008			3,008	
23-Mar-06	11,600				11,600	2,129	175	2,115			2,115	3,670	3,670		3,670	3,008	3,008			3,008	
24-Mar-06	11,400				11,400	2,177	380	2,080			2,080	3,910	3,910		3,910	3,005	3,005			3,005	
25-Mar-06	11,500				11,500	2,063	450	2,035			2,035	4,590	4,590		4,590	3,013	3,013			3,013	
26-Mar-06	12,000				12,000	2,097	522	1,867			1,867	4,580	4,580		4,580	3,009	3,009			3,009	
27-Mar-06	12,600				12,600	2,243	758	1,583			1,583	5,070	5,070		5,070	3,025	3,025			3,025	
28-Mar-06	12,500				12,500	1,595	876	2,584			2,584	5,070	5,070		5,070	3,043	3,043			3,043	
29-Mar-06	13,200				13,200	1,887	1,661	3,033			3,033	5,420	5,420		5,420	3,026	3,026			3,026	
30-Mar-06	14,700				14,700	1,855	1,728	2,877			2,877	6,050	6,050		6,050	3,014	3,014			3,014	
31-Mar-06	14,800				14,800	2,311	2,096	2,790			2,790	6,340	6,340		6,340	3,014	3,014			3,014	
01-Apr-06	15,100				15,100	2,444	1,208	2,972			2,972	6,110	6,110		6,110	3,014	3,014			3,014	
02-Apr-06	16,200				16,200	2,518	1,734	2,847			2,847	6,270	6,270		6,270	3,019	3,019			3,019	
03-Apr-06	16,700				16,700	2,733	2,342	3,513			3,513	6,020	6,020		6,020	3,039	3,039			3,039	
04-Apr-06	17,000				17,000	2,233	2,221	6,838			6,838	3,740	3,740		3,740	3,303	3,303			3,303	
05-Apr-06	18,700				18,700	2,796	4,061	4,830			4,830	4,800	4,800		4,800	4,714	4,714			4,714	
06-Apr-06	20,800				20,800	8,724	8,011	4,937			4,937	5,580	5,580		5,580	5,776	5,776			5,776	
07-Apr-06	21,900				21,900	15,426	2,752	5,219			5,219	6,470	6,470		6,470	6,148	6,148			6,148	
08-Apr-06	23,100				23,100	17,466	-1,810	5,183			5,183	6,790	6,790		6,790	4,379	4,379			4,379	
09-Apr-06	27,400				27,400	19,099	-5,581	5,157			5,157	6,780	6,780		6,780	3,534	3,534			3,534	
10-Apr-06	31,100				31,100	18,623	-2,754	5,102			5,102	6,760	6,760		6,760	3,504	3,504			3,504	
11-Apr-06	32,200				32,200	17,974	-2,396	4,618			4,618	7,340	7,340		7,340	3,509	3,509			3,509	
12-Apr-06	34,300				34,300	17,219	256	4,518			4,518	7,730	7,730		7,730	3,868	3,868			3,868	
13-Apr-06	34,800				34,800	15,911	875	4,465			4,465	7,770	7,770		7,770	4,019	4,019			4,019	
14-Apr-06	34,500				34,500	13,300	1,065	4,446			4,446	7,550	7,550		7,550	3,995	3,995			3,995	
15-Apr-06	33,700				33,700	12,160	1,482	4,619			4,619	7,450	7,450		7,450	4,039	4,039			4,039	
16-Apr-06	32,900				32,900	11,538	3,590	4,511			4,511	7,420	7,420		7,420	4,062	4,062			4,062	
17-Apr-06	31,700				31,700	11,520	3,605	4,130			4,130	7,600	7,600		7,600	4,756	4,756			4,756	
18-Apr-06	30,639				30,639	11,330	3,000	4,000			4,000	8,500	8,500		8,500	5,500	5,500			5,500	
19-Apr-06	30,387				30,387	11,226	2,000	4,000			4,000	8,600	8,600		8,600	5,500	5,500			5,500	
20-Apr-06	31,460				31,460	11,122	2,000	4,000			4,000	8,700	8,700		8,700	5,500	5,500			5,500	
21-Apr-06	31,326				31,326	11,018	2,000	4,000			4,000	8,800	8,800		8,800	5,500	5,500			5,500	
22-Apr-06	31,322				31,322	10,914	2,000	4,000			4,000	8,900	8,900		8,900	5,500	5,500			5,500	
23-Apr-06	31,318				31,318	10,810	2,000	3,650			3,650	9,000	9,000		9,000	5,500	5,500			5,500	
24-Apr-06	31,314				31,314	10,706	2,000	3,520			3,520	9,000	9,000		9,000	5,500	5,500			5,500	
25-Apr-06	31,310				31,310	10,601	2,000	3,570			3,570	9,000	9,000		9,000	5,500	5,500			5,500	
26-Apr-06	30,856				30,856	10,497	2,000	3,630			3,630	9,000	9,000		9,000	5,500	5,500			5,500	
27-Apr-06	30,621				30,621	10,393	2,000	3,620			3,620	9,000	9,000		9,000	5,500	5,500			5,500	
28-Apr-06	30,568				30,568	10,289	2,000	3,620	0	0	3,620	9,000	9,000		9,000	5,500	5,500			5,500	
29-Apr-06	30,523				30,523	10,185	2,000	3,620	0	0	3,620	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
30-Apr-06	30,409				30,409	10,081	2,000	3,620	0	0	3,620	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
01-May-06	30,305	0	0	0.00	30,305	9,977	2,000	2,850	0	0	2,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
02-May-06	30,201	0	0	0.00	30,201	9,873	2,000	2,850	0	0	2,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
03-May-06	30,097	0	0	0.00	30,097	9,769	2,000	2,850	0	0	2,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
04-May-06	29,223	0	0	0.00	29,223	9,665	2,000	2,850	0	0	2,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
05-May-06	29,119	0	0	0.00	29,119	9,561	2,000	2,850	0	0	2,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
06-May-06	29,015	0	0	0.00	29,015	9,457	2,000	2,850	0	0	2,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
07-May-06	28,911	0	0	0.00	28,911	9,353	2,000	2,850	0	0	2,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
08-May-06	28,807	0	0	0.00	28,807	9,249	2,000	2,850	0	0	2,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
09-May-06	28,703	0	0	0.00	28,703	9,145	2,000	2,850	0	0	2,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
10-May-06	28,599	0	0	0.00	28,599	9,041	2,000	2,850	0	0	2,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
11-May-06	28,495	0	0	0.00	28,495	8,937	2,000	2,850	0	0	2,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
12-May-06	28,391	0	0	0.00	28,391	8,832	2,000	2,850	0	0	2,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
13-May-06	28,287	0	0	0.00	28,287	8,728	2,000	2,850	0	0	2,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
14-May-06	28,182	0	0	0.00	28,182	8,624	2,000	2,850	0	0	2,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
15-May-06	28,078	0	0	0.00	28,078	8,520	2,000	2,850	0	0	2,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
16-May-06	27,974	0	0	0.00	27,974	8,416	2,000	2,850	0	0	2,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
17-May-06	27,870	0	0	0.00	27,870	8,312	2,000	2,850	0	0	2,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
18-May-06	27,766	0	0	0.00	27,766	8,208	2,000	2,850	0	0	2,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
19-May-06	27,662	0	0	0.00	27,662	8,104	2,000	2,850	0	0	2,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
20-May-06	27,558	0	0	0.00	27,558	8,000	2,000	2,850	0	0	2,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
21-May-06	27,454	0	0	0.00	27,454	7,850	2,000	2,850	0	0	2,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
22-May-06	27,350	0	0	0.00	27,350	7,700	2,000	2,850	0	0	2,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
23-May-06	27,200	0	0	0.00	27,200	7,550	2,000	2,850	0	0	2,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
24-May-06	27,050	0	0	0.00	27,050	7,400	2,000	2,850	0	0	2,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
25-May-06	26,900	0	0	0.00	26,900	7,250	2,000	2,850	0	0	2,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
26-May-06	26,750	0	0	0.00	26,750	7,100	2,000	2,850	0	0	2,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
27-May-06	26,600	0	0	0.00	26,600	6,950	2,000	2,850	0	0	2,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
28-May-06	26,450	0	0	0.00	26,450	6,800	2,000	2,850	0	0	2,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
29-May-06	26,300	0	0	0.00	26,300	6,650	2,000	2,850			2,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
30-May-06	26,150	0	0	0.00	26,150	6,500	2,000	2,850			2,850	9,000	9,000		9,000	5,500	5,500			5,500	
31-May-06	26,000	0	0	0.00	26,000	6,350	2,000	2,850			2,850	9,000	9,000		9,000	5,500	5,500			5,500	
VAMP Period																					
Avg. (cfs):	27,982	0			27,982	8,558	2,000	2,925	0	0	2,925	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
Supplemental Water (TAF):				0.00							0.00	0.00				0.00				0.00	

VAMP flow operation period

Appendix A-1, Table 12

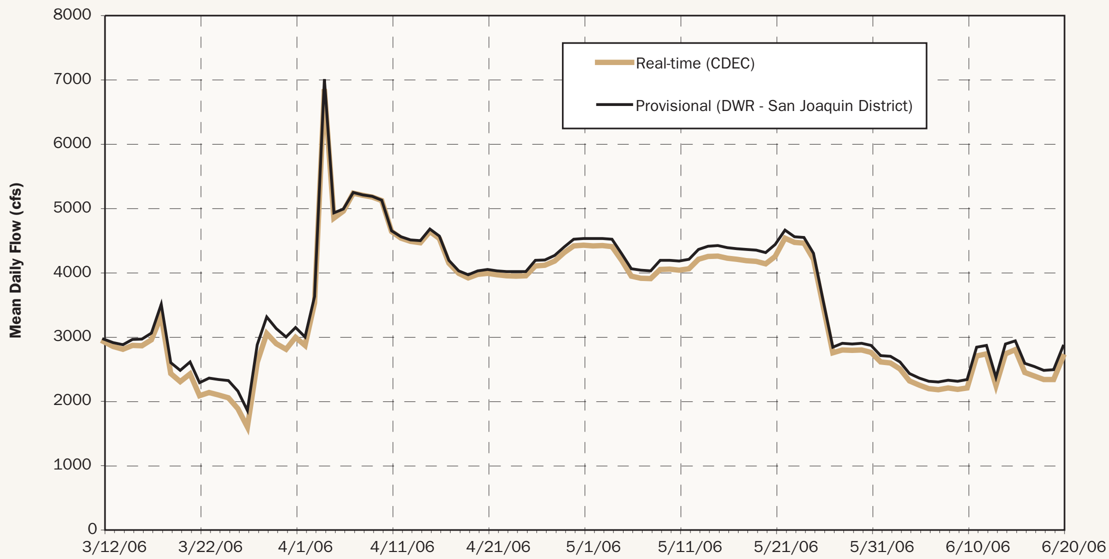
2006 VAMP DAILY OPERATION PLAN
April 25, 2006
Target Flow Period: May 1 - May 31 • Flow Target: greater than 7,000 cfs

Bold Numbers: observed real-time mean daily flows

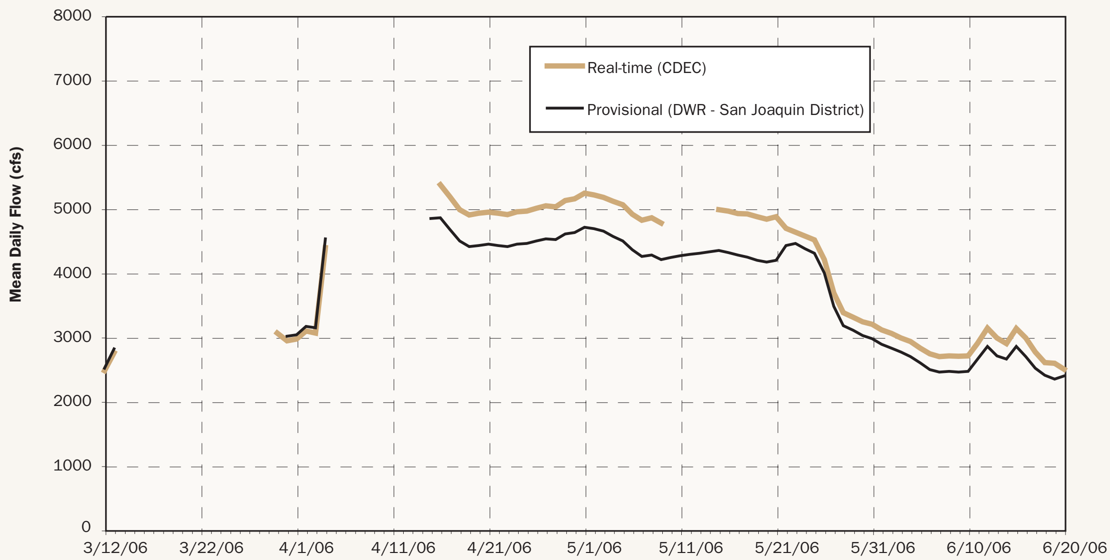
	San Joaquin River near Vernalis							Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus R blw Goodwin					
Date	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2 day lag)	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. 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)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		(cfs)	(cfs)	(cfs)	
15-Mar-06	11,700				11,700	1,583	966	2,849			2,849	4,060	4,060		4,060	3,005	3,005			3,005	
16-Mar-06	11,900				11,900	1,698	936	2,843			2,843	3,700	3,700		3,700	3,002	3,002			3,002	
17-Mar-06	12,000				12,000	1,792	612	2,939			2,939	3,380	3,380		3,380	3,009	3,009			3,009	
18-Mar-06	11,700				11,700	1,716	550	3,309			3,309	3,340	3,340		3,340	3,000	3,000			3,000	
19-Mar-06	11,900				11,900	2,454	630	2,409			2,409	3,900	3,900		3,900	3,004	3,004			3,004	
20-Mar-06	12,100				12,100	2,223	811	2,285			2,285	3,840	3,840		3,840	3,010	3,010			3,010	
21-Mar-06	12,200				12,200	1,986	505	2,407			2,407	3,740	3,740		3,740	3,014	3,014			3,014	
22-Mar-06	11,900				11,900	2,178	352	2,066			2,066	3,660	3,660		3,660	3,008	3,008			3,008	
23-Mar-06	11,600				11,600	2,129	175	2,115			2,115	3,670	3,670		3,670	3,008	3,008			3,008	
24-Mar-06	11,400				11,400	2,177	380	2,080			2,080	3,910	3,910		3,910	3,005	3,005			3,005	
25-Mar-06	11,500				11,500	2,063	450	2,035			2,035	4,590	4,590		4,590	3,013	3,013			3,013	
26-Mar-06	12,000				12,000	2,097	522	1,867			1,867	4,580	4,580		4,580	3,009	3,009			3,009	
27-Mar-06	12,600				12,600	2,243	758	1,583			1,583	5,070	5,070		5,070	3,025	3,025			3,025	
28-Mar-06	12,500				12,500	1,595	876	2,584			2,584	5,070	5,070		5,070	3,043	3,043			3,043	
29-Mar-06	13,200				13,200	1,887	1,661	3,033			3,033	5,420	5,420		5,420	3,026	3,026			3,026	
30-Mar-06	14,700				14,700	1,855	1,728	2,877			2,877	6,050	6,050		6,050	3,014	3,014			3,014	
31-Mar-06	14,800				14,800	2,311	2,096	2,790			2,790	6,340	6,340		6,340	3,014	3,014			3,014	
01-Apr-06	15,100				15,100	2,444	1,208	2,972			2,972	6,110	6,110		6,110	3,014	3,014			3,014	
02-Apr-06	16,200				16,200	2,518	1,734	2,847			2,847	6,270	6,270		6,270	3,019	3,019			3,019	
03-Apr-06	16,700				16,700	2,733	2,342	3,513			3,513	6,020	6,020		6,020	3,039	3,039			3,039	
04-Apr-06	17,000				17,000	2,233	2,221	6,838			6,838	3,740	3,740		3,740	3,303	3,303			3,303	
05-Apr-06	18,700				18,700	2,796	4,061	4,830			4,830	4,800	4,800		4,800	4,714	4,714			4,714	
06-Apr-06	20,800				20,800	8,724	8,011	4,937			4,937	5,580	5,580		5,580	5,776	5,776			5,776	
07-Apr-06	21,900				21,900	15,426	2,752	5,219			5,219	6,470	6,470		6,470	6,148	6,148			6,148	
08-Apr-06	23,100				23,100	17,466	-1,810	5,183			5,183	6,790	6,790		6,790	4,379	4,379			4,379	
09-Apr-06	27,400				27,400	19,099	-5,581	5,157			5,157	6,780	6,780		6,780	3,534	3,534			3,534	
10-Apr-06	31,100				31,100	18,623	-2,754	5,102			5,102	6,760	6,760		6,760	3,504	3,504			3,504	
11-Apr-06	32,200				32,200	17,974	-2,396	4,618			4,618	7,340	7,340		7,340	3,509	3,509			3,509	
12-Apr-06	34,300				34,300	17,219	256	4,518			4,518	7,730	7,730		7,730	3,868	3,868			3,868	
13-Apr-06	34,800				34,800	15,911	875	4,465			4,465	7,770	7,770		7,770	4,019	4,019			4,019	
14-Apr-06	34,500				34,500	13,300	1,065	4,446			4,446	7,550	7,550		7,550	3,995	3,995			3,995	
15-Apr-06	33,700				33,700	12,160	1,482	4,619			4,619	7,450	7,450		7,450	4,039	4,039			4,039	
16-Apr-06	32,900				32,900	11,538	3,590	4,511			4,511	7,420	7,420		7,420	4,062	4,062			4,062	
17-Apr-06	31,700				31,700	11,420	3,605	4,130			4,130	7,580	7,580		7,580	4,756	4,756			4,756	
18-Apr-06	30,900				30,900	11,322	3,261	3,970			3,970	8,190	8,190		8,190	5,495	5,495			5,495	
19-Apr-06	30,900				30,900	10,905	2,633	3,900			3,900	8,240	8,240		8,240	5,510	5,510			5,510	
20-Apr-06	31,000				31,000	10,679	1,863	3,955			3,955	8,420	8,420		8,420	5,507	5,507			5,507	
21-Apr-06	31,000				31,000	10,660	2,375	3,970			3,970	8,340	8,340		8,340	5,510	5,510			5,510	
22-Apr-06	30,900				30,900	10,580	2,394	3,948			3,948	8,440	8,440		8,440	5,522	5,522			5,522	
23-Apr-06	30,700				30,700	10,600	2,235	3,933			3,933	8,430	8,430		8,430	5,524	5,524			5,524	
24-Apr-06	30,700				30,700	10,655	2,188	3,927			3,927	8,560	8,560		8,560	5,548	5,548			5,548	
25-Apr-06	30,502				30,502	10,605	2,000	3,850			3,850	8,700	8,700		8,700	5,500	5,500			5,500	
26-Apr-06	30,696				30,696	10,555	2,000	3,850			3,850	9,000	9,000		9,000	5,500	5,500			5,500	
27-Apr-06	30,732				30,732	10,505	2,000	3,850			3,850	9,000	9,000		9,000	5,500	5,500			5,500	
28-Apr-06	30,905				30,905	10,454	2,000	3,850	0	0	3,850	9,000	9,000		9,000	5,500	5,500			5,500	
29-Apr-06	30,855				30,855	10,404	2,000	3,850	0	0	3,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
30-Apr-06	30,804				30,804	10,354	2,000	3,850	0	0	3,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
01-May-06	30,754	0	0	0.00	30,754	10,304	2,000	3,850	0	0	3,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
02-May-06	30,704	0	0	0.00	30,704	10,254	2,000	3,850	0	0	3,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
03-May-06	30,654	0	0	0.00	30,654	10,204	2,000	3,850	0	0	3,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
04-May-06	30,604	0	0	0.00	30,604	10,154	2,000	3,850	0	0	3,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
05-May-06	30,554	0	0	0.00	30,554	10,104	2,000	3,850	0	0	3,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
06-May-06	30,504	0	0	0.00	30,504	10,053	2,000	3,850	0	0	3,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
07-May-06	30,454	0	0	0.00	30,454	10,003	2,000	3,850	0	0	3,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
08-May-06	30,403	0	0	0.00	30,403	9,953	2,000	3,850	0	0	3,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
09-May-06	30,353	0	0	0.00	30,353	9,903	2,000	3,850	0	0	3,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
10-May-06	30,303	0	0	0.00	30,303	9,853	2,000	3,850	0	0	3,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
11-May-06	30,253	0	0	0.00	30,253	9,803	2,000	3,850	0	0	3,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
12-May-06	30,203	0	0	0.00	30,203	9,753	2,000	3,850	0	0	3,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
13-May-06	30,153	0	0	0.00	30,153	9,702	2,000	3,850	0	0	3,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
14-May-06	30,103	0	0	0.00	30,103	9,652	2,000	3,850	0	0	3,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
15-May-06	30,052	0	0	0.00	30,052	9,602	2,000	3,850	0	0	3,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
16-May-06	30,002	0	0	0.00	30,002	9,552	2,000	3,850	0	0	3,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
17-May-06	29,952	0	0	0.00	29,952	9,502	2,000	3,850	0	0	3,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
18-May-06	29,902	0	0	0.00	29,902	9,452	2,000	3,850	0	0	3,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
19-May-06	29,852	0	0	0.00	29,852	9,402	2,000	3,850	0	0	3,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
20-May-06	29,802	0	0	0.00	29,802	9,351	2,000	3,850	0	0	3,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
21-May-06	29,752	0	0	0.00	29,752	9,301	2,000	3,850	0	0	3,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
22-May-06	29,701	0	0	0.00	29,701	9,251	2,000	3,850	0	0	3,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
23-May-06	29,651	0	0	0.00	29,651	9,201	2,000	3,850	0	0	3,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
24-May-06	29,601	0	0	0.00	29,601	9,151	2,000	3,850	0	0	3,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
25-May-06	29,551	0	0	0.00	29,551	9,101	2,000	3,850	0	0	3,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
26-May-06	29,501	0	0	0.00	29,501	9,051	2,000	3,850	0	0	3,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
27-May-06	29,451	0	0	0.00	29,451	9,001	2,000	3,850	0	0	3,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
28-May-06	29,401	0	0	0.00	29,401	8,950	2,000	3,850	0	0	3,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
29-May-06	29,351	0	0	0.00	29,351	8,900	2,000	3,850			3,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
30-May-06	29,300	0	0	0.00	29,300	8,850	2,000	3,850			3,850	9,000	9,000		9,000	5,500	5,500			5,500	
31-May-06	29,250	0	0	0.00	29,250	8,800	2,000	3,850			3,850	9,000	9,000		9,000	5,500	5,500			5,500	
										VAMP Period											
Avg. (cfs):	30,002	0			30,002	9,652	2,000	3,850	0	0	3,850	9,000	9,000	0	9,000	5,500	5,500	0	0	5,500	
Supplemental Water (TAF):				0.00							0.00	0.00				0.00				0.00	

VAMP flow operation period

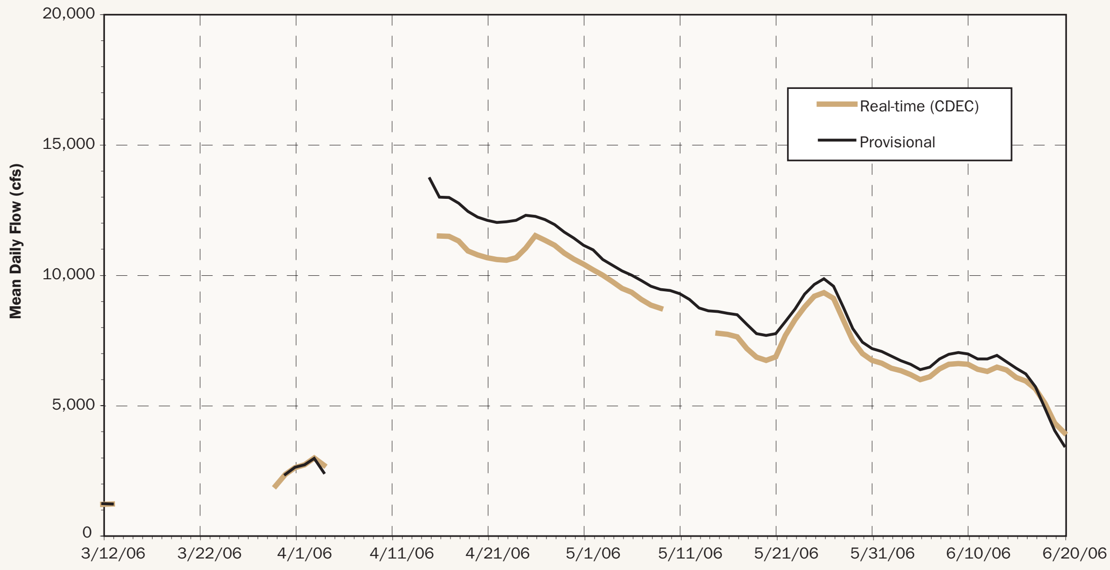
Appendix A-2, Figure 1
Merced River at Cressey



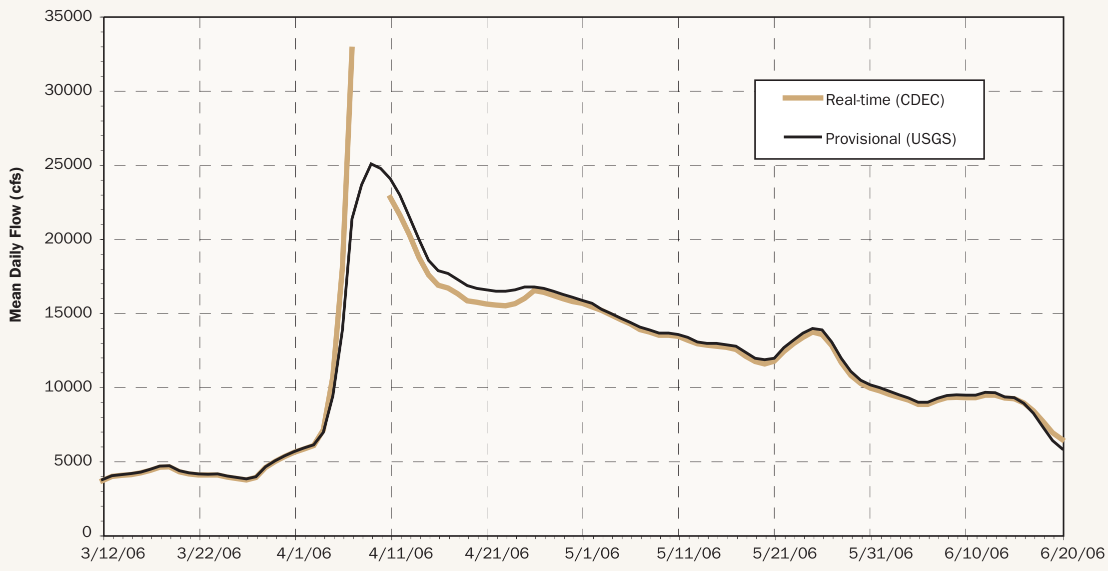
Appendix A-2, Figure 2
Merced River near Stevinson



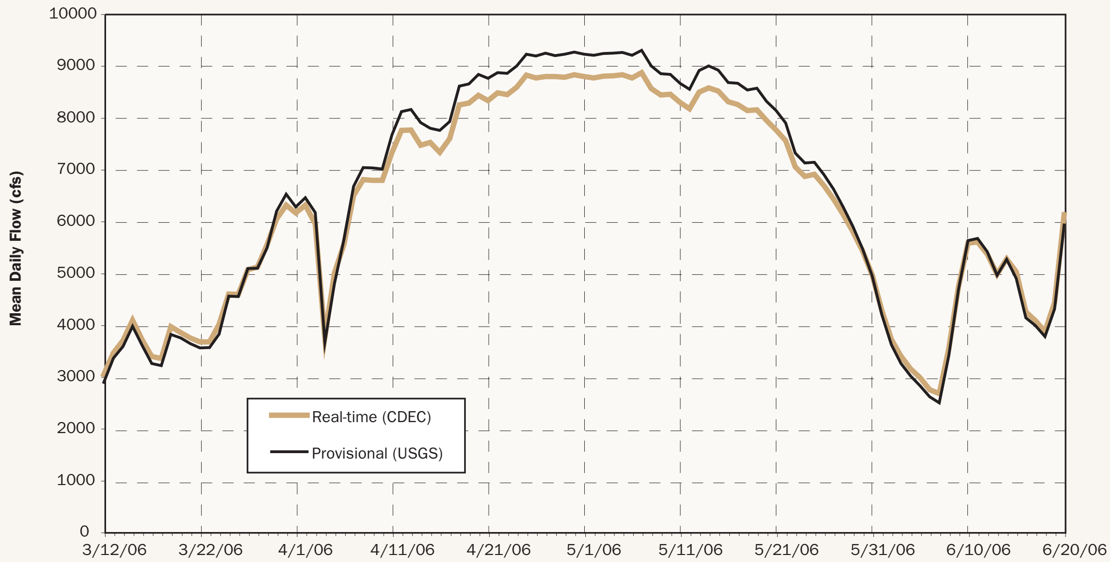
Appendix A-2, Figure 3
San Joaquin River above Merced River



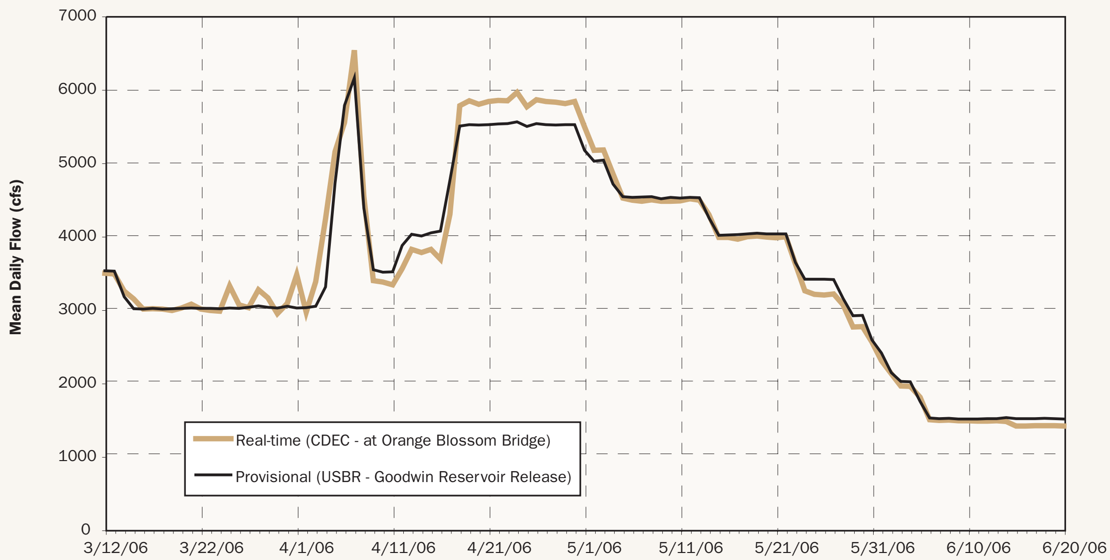
Appendix A-2, Figure 4
San Joaquin River near Newman



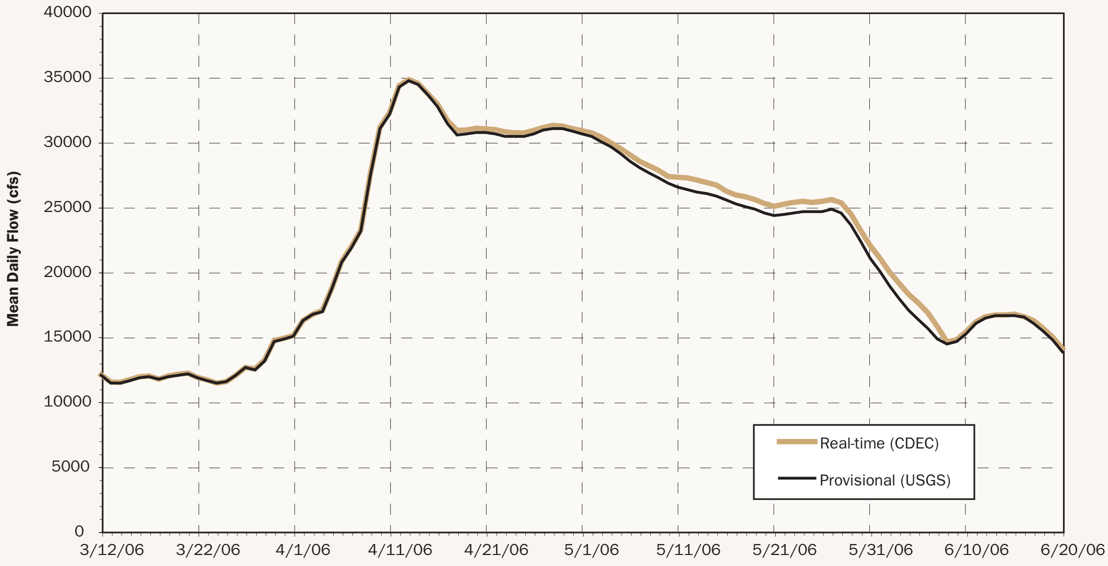
Appendix A-2, Figure 5
Tuolumne River below LaGrange Dam



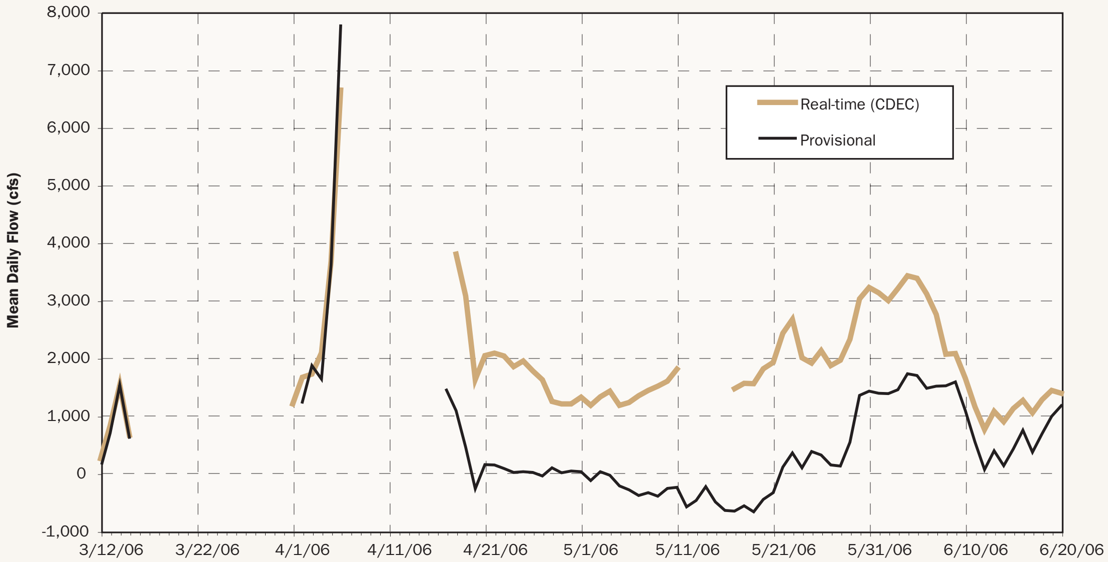
Appendix A-2, Figure 6
Stanislaus River below Goodwin Dam



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



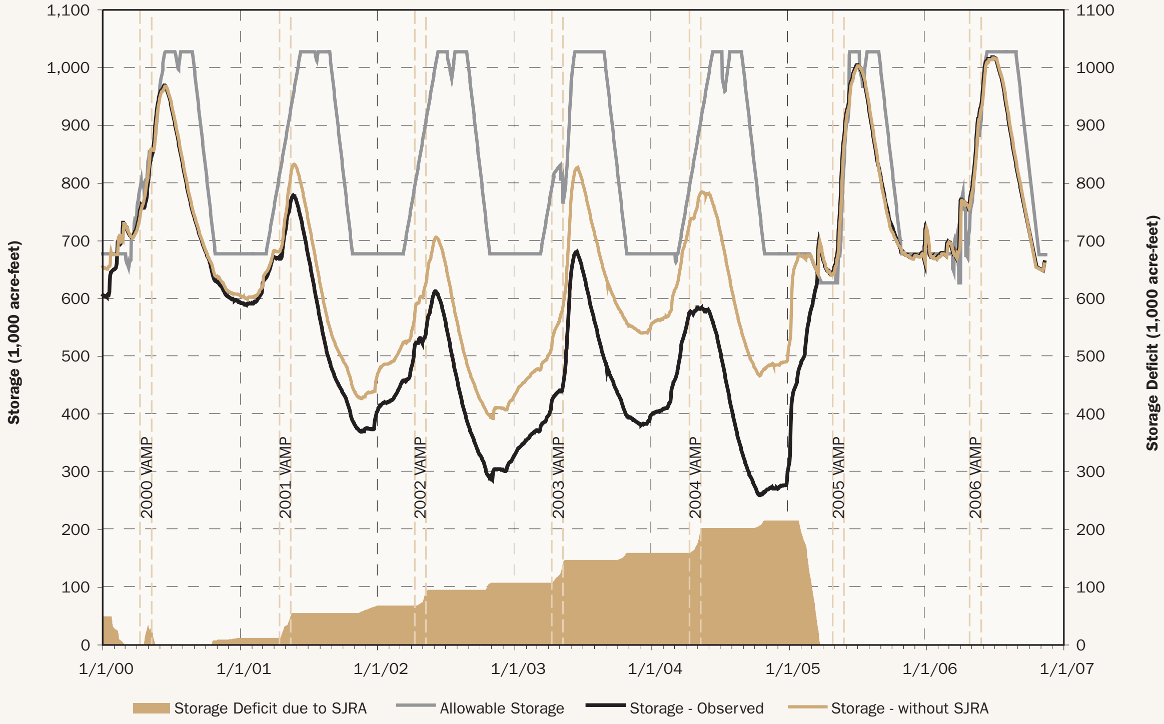
Appendix A-2, Figure 8
Ungaged Flow in San Joaquin River near Vernalis



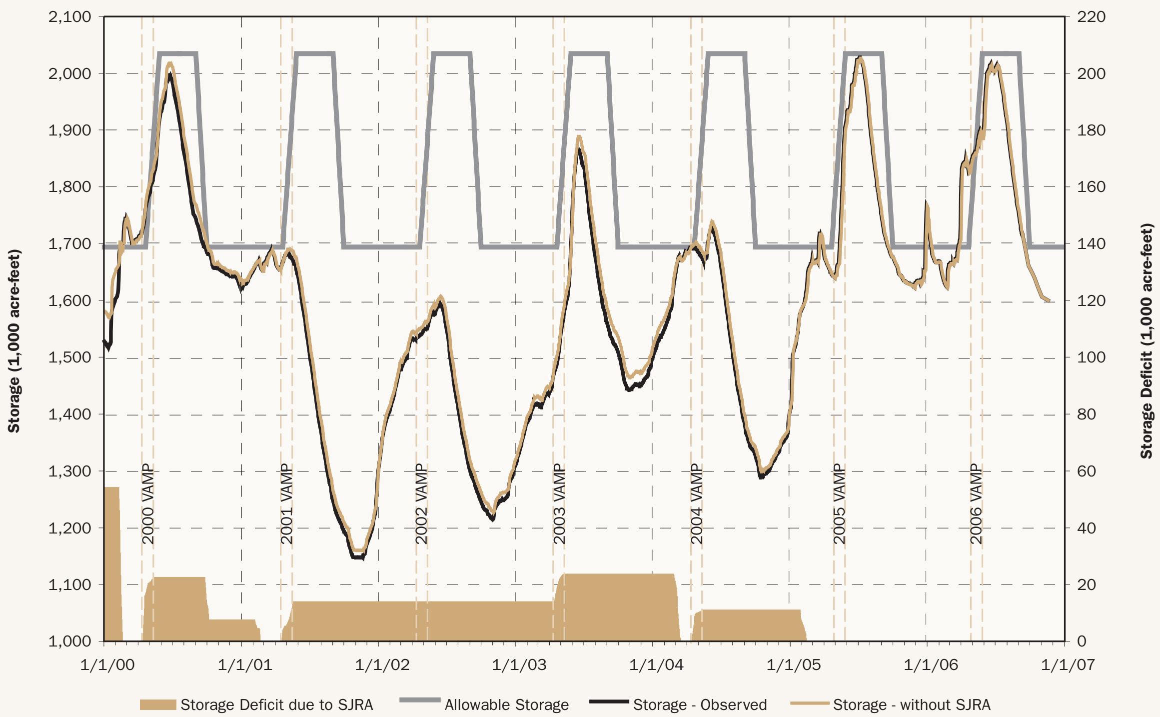
Appendix B

Historical Data

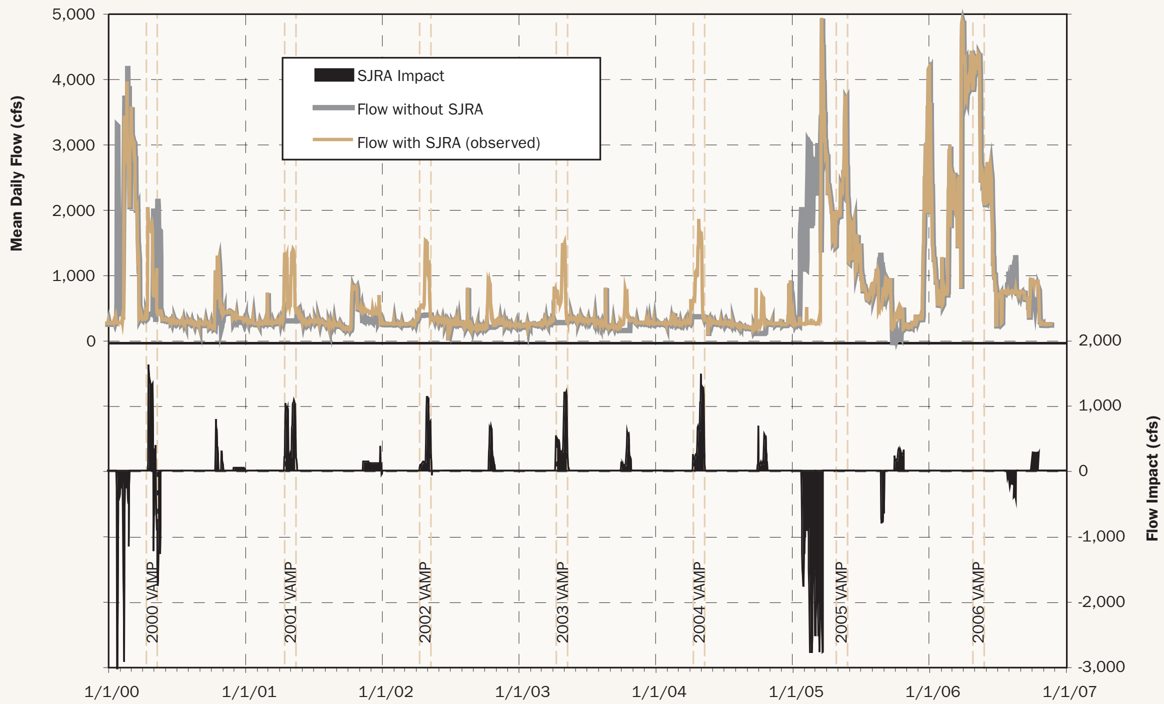
Appendix B-1, Figure 1
SJRA Storage Impacts, 2000-2006
Lake McClure (Merced River)



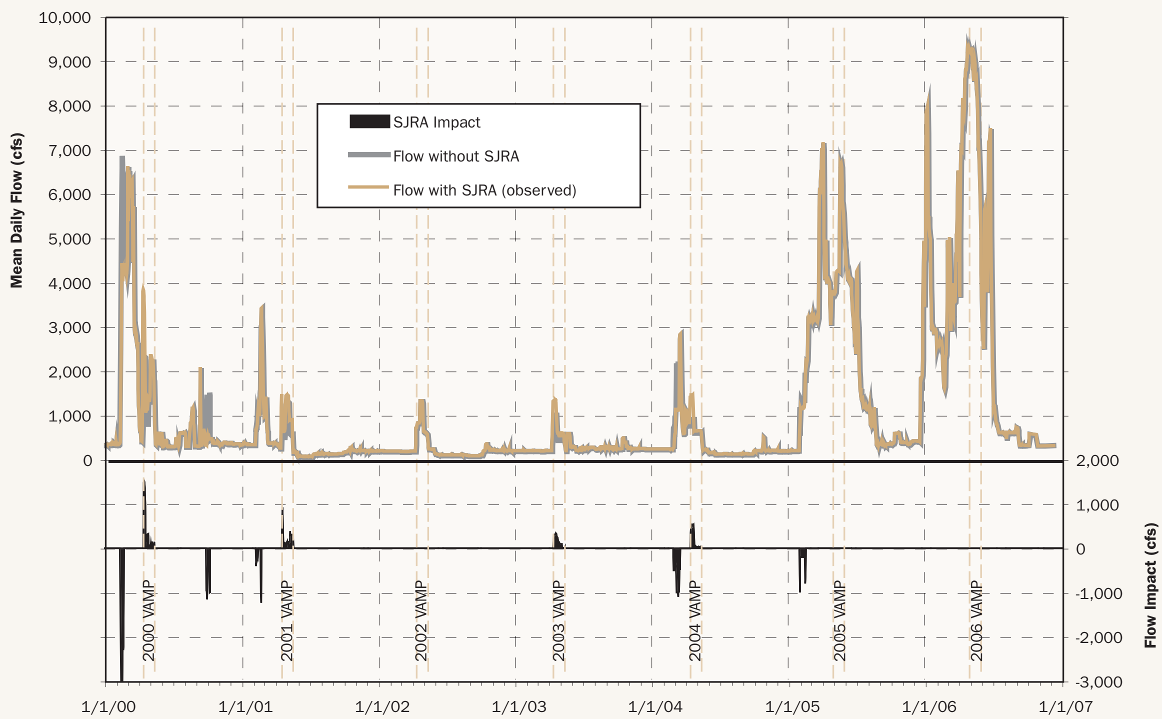
Appendix B-1, Figure 2
SJRA Storage Impacts, 2000-2006
New Don Pedro Reservoir (Tuolumne River)



Appendix B-1, Figure 3
Merced River below Crocker-Huffman Dam
2000-2006



Appendix B-1, Figure 4
Tuolumne River below LaGrange Dam
2000-2006



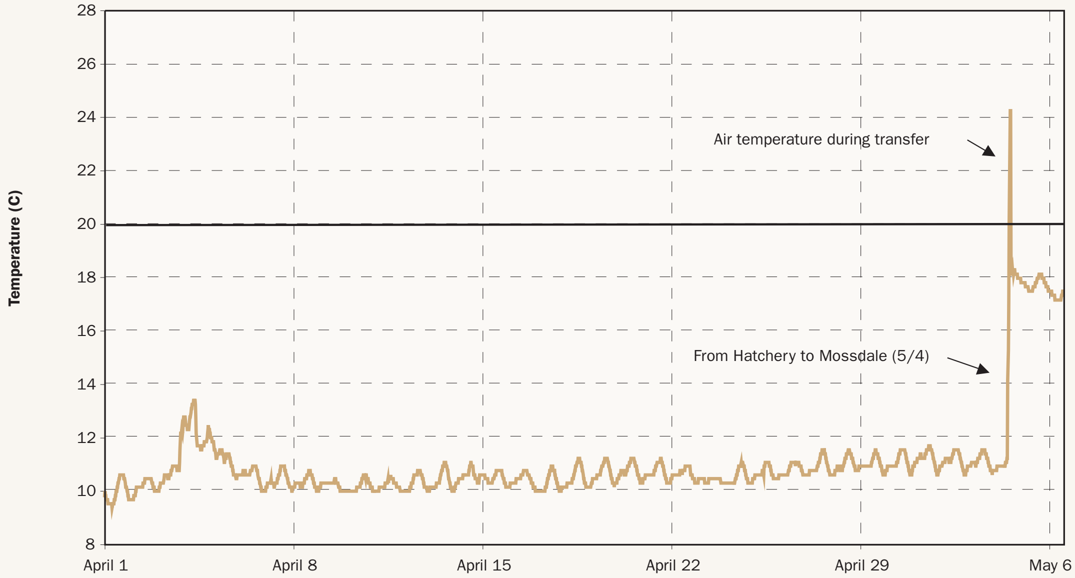
Appendix C
Chinook Salmon Survival Investigations

Appendix C-1
Water Temperature Monitoring Locations

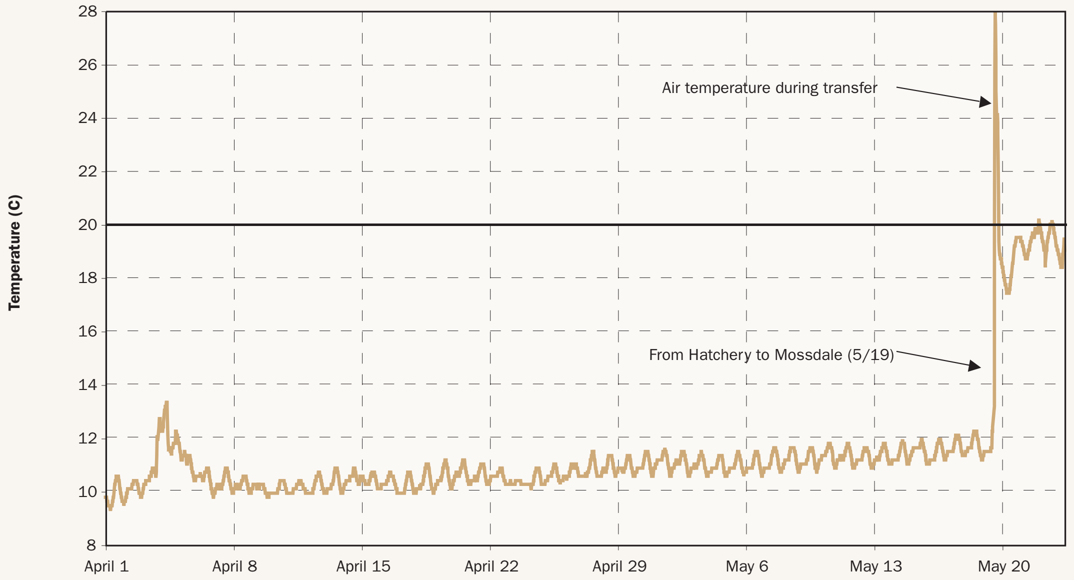
Appendix C-1
VAMP 2005 Water Temperature Monitoring

Site #	Logger Number	Temperature Monitoring Location	Lat	Long	Distance from Durham Ferry	Date Deployed	Date Retrieved	Notes
	551654	Merced River Hatcher - 1			n/a	3/27/06	5/23/06	
	562570	Merced River Hatcher - 2			n/a	3/27/06	5/23/06	
1	877664	Durham Ferry	N 37 41.381	W 121 15.657	n/a	4/4/06	6/8/06	
2	900627	Mossdale	N 37 47.180	W 121 18.425	11	4/4/06	6/8/06	Logger Lost
3	900626	Dos Reis	N 37 49.808	W 121 18.665	16	4/4/06	6/8/06	
4	900625	DWR Monitoring Station	N 37 51.869	W 121 19.376	19	4/4/06	6/8/06	
5a	900624	Confluence – Top	N 37 56.818	W 121 20.285	27	4/4/06	6/8/06	
5b	900615	Confluence- Bottom	N 37 56.818	W 121 20.285	27	4/4/06	6/8/06	
6	900616	Downstream of Channel Marker 30	N 37 59.776	W 121 25.569	33	4/4/06	6/8/06	
7	900617	"Q" Piling 1/2 mile upstream of channel marker 13	N 38 01.940	W 121 28.769	37	4/4/06	6/8/06	
8	877663	All Pro abandoned boat	N 38 04.522	W 121 34.413	45	4/4/06	6/8/06	Logger malfunction - no data
9	877667	Jersey Point USGS Gauging Station	N 38 03.172	W121 41.637	56	4/4/06	6/8/06	Logger Lost
10	877668	Chipps Island	N 38 03.084	W 121 55.463	72	4/4/06	6/8/06	
11	877666	Mokelumne River- Lighthouse Marina	N 38 06.334	W 121 34.213	40	na	6/8/06	Not deployed this year due to no Mokelumne releases
12	877669	Old River at HORB	N 37 48.457	W 121 19.872	13	4/4/06	6/8/06	
13	900619	Antioch Marina	N 38 01.147	W121 48.829	53	4/4/06	6/8/06	
14	900620	Turner Cut	N 37 59.468	W121 27.267	40	4/4/06	6/5/06	Logger Semi-Dewatered: Lying in very shallow water (2-3 inches)
15	877666	Holland Riverside Marina	N 37 58.323	W 121 34.887	42	4/18/06	6/5/06	
16	900618	Old River / Indian Slough Confluence	N 37 54.954	W 121 33.949	34	4/18/06	6/5/06	
17	900622	CCF Radial Gates	N 37 49.773	W 121 33.096	26	4/18/06	6/6/06	Fisher man said has been periodically dewatered by curious people.
18	822253	Grant Line Canal at Travy Blvd Bridge	N 37 49.143	W 121 27.026	21	4/18/06	6/6/06	Casing smashed, but logger present. Dewatered at somepoint.
19	900621	Middle River at Victoria Canal Confluence	N37 53.323	W121 29.334	32	4/18/06	6/6/06	
20	877665	Werner Cut: Channel above Woodward Isle	N 37 56.319	W 121 30.584	40	4/18/06	6/6/06	

Appendix C-2
Water Temperature Monitoring
Merced River Fish Hatchery to Mossdale



Appendix C-2
Water Temperature Monitoring
Merced River Fish Hatchery to Mossdale



Appendix C-2
Water Temperature Monitoring
Site 1 - Durham Ferry

Appendix C-2
Water Temperature Monitoring
Site 3 - Dos Reis

Appendix C-2
Water Temperature Monitoring
Site 4 - DWR Monitoring Station

Appendix C-2
Water Temperature Monitoring
Site 5a - Confluence - Top

Appendix C-2
Water Temperature Monitoring
Site 5b - Confluence - Bottom

Appendix C-2
Water Temperature Monitoring
Site 6 - Downstream of Channel Marker 30

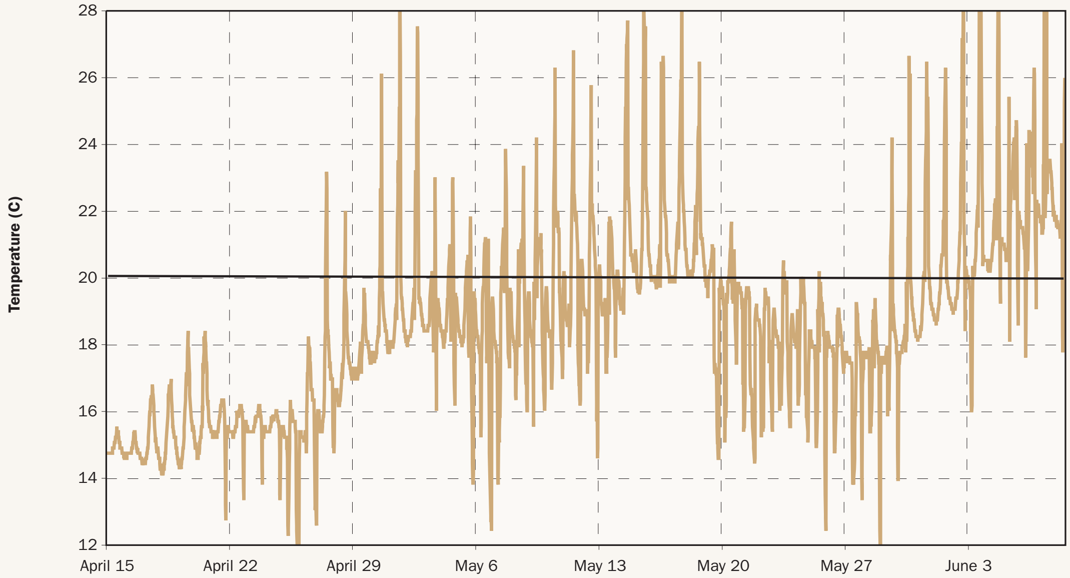
Appendix C-2
Water Temperature Monitoring
Site 7 - Upsteam of Channel Marker 13

Appendix C-2
Water Temperature Monitoring
Site 10 - Chipps Island

Appendix C-2
Water Temperature Monitoring
Site 12 - Old River at Head of Old River Barrier

Appendix C-2
Water Temperature Monitoring
Site 13 - Antioch Marina

Appendix C-2
Water Temperature Monitoring
Site 14 - Turner Cut



Appendix C-2
Water Temperature Monitoring
Site 15 - Holland Riverside Marina

Appendix C-2
Water Temperature Monitoring
Site 16 - Old River at Confluence with Indian Slough

Appendix C-2
Water Temperature Monitoring
Site 17 - CCF Radial Gates

Appendix C-2
Water Temperature Monitoring
Site 18 - Grant Line Canal At Tracy Blvd. Bridge

Appendix C-2
Water Temperature Monitoring
Site 19 - Middle River at the Confluence with Victoria Canal

Appendix C-2
Water Temperature Monitoring
Site 20 - Werner Cut; Channel above Woodward Isle

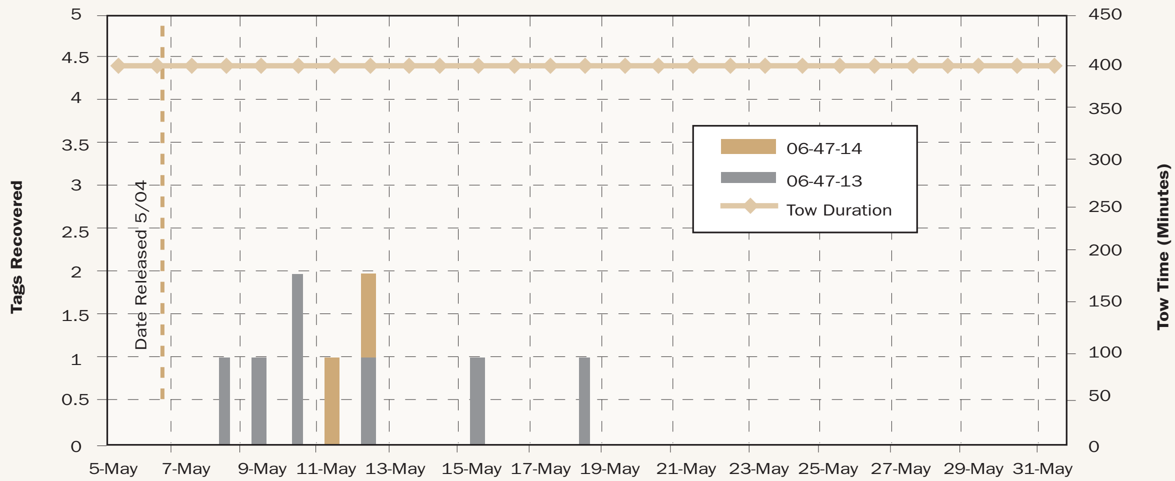
C-3a Chinook salmon smolt condition post-transport, immediately after VAMP 2006 releases.										
Release Site	Examination Date	Mean Fork Length (mm)	Mean Weight (g)	Vigor (%)	Mean Scale Loss (%)	Normal Body Color (%)	Fin Hemorrhaging (%)	Normal Eye Quality (%)	Normal Gill Color %	Complete Adclip (%)
Mossdale	5/4/06	85	7	100	6	100	2	100	100	88
Dos Reis	5/5/06	81	6	100	6	100	0	100	100	84
Jersey Point	5/8/06	86	7	100	5	100	0	100	100	92
Mossdale	5/19/06	92	9	100	5	100	12	100	100	87
Jersey Point	5/22/06	89	8	100	5	100	8	100	100	100

* % correct tag code of those that retained tags.

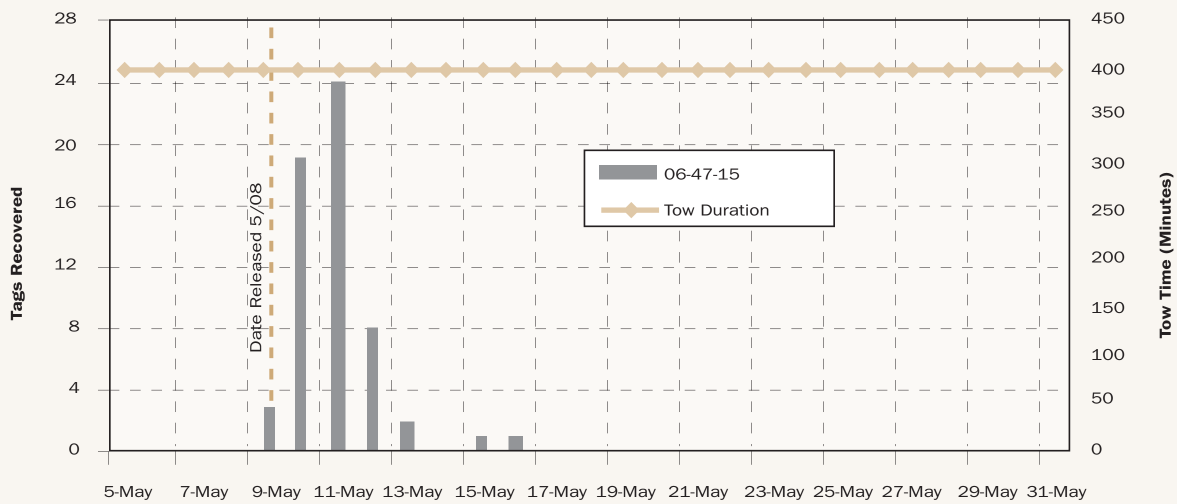
C-3b Chinook salmon smolt condition 48-hours post-release.											
Release Site	Examination Date	Mean Fork Length (mm)	Mean Weight (g)	Vigor (%)	Net Pen Mortalities	Mean Scale Loss (%)	Normal Body Color (%)	Fin Hemorrhaging (%)	Normal Eye Quality (%)	Normal Gill Color %	Complete Adclip (%)
Mossdale	5/6/06	86	7	100	0	8	100	0	100	100	86
Dos Reis	5/7/06	81	6	100	0	8	100	0	100	100	80
Jersey Point	5/10/06	86	7	100	0	6	100	12		100	92
Mossdale	5/21/06	93	9	100	0	7	100	16	100	97	95
Jersey Point	5/24/06	92	8	16**	0	7	16**	0	100	84	100

** Transport truck delayed for 2 1/2 hours due to flat tire; fish very pale (color, gills), vigor deminished.

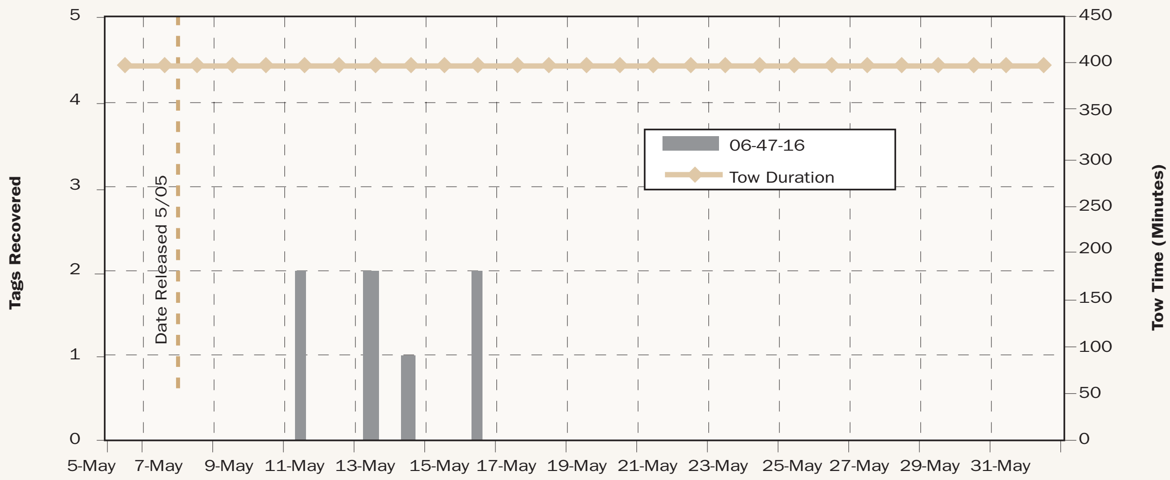
Appendix C-4, Figure 1
Chipps Island/Mossdale 1



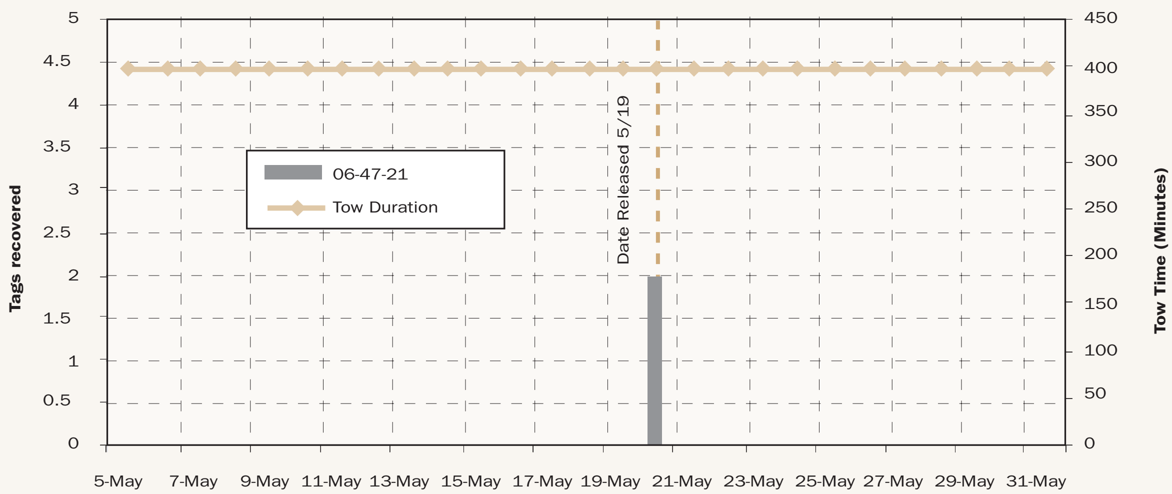
Appendix C-4, Figure 2
Chipps Island/Jersey Point 1



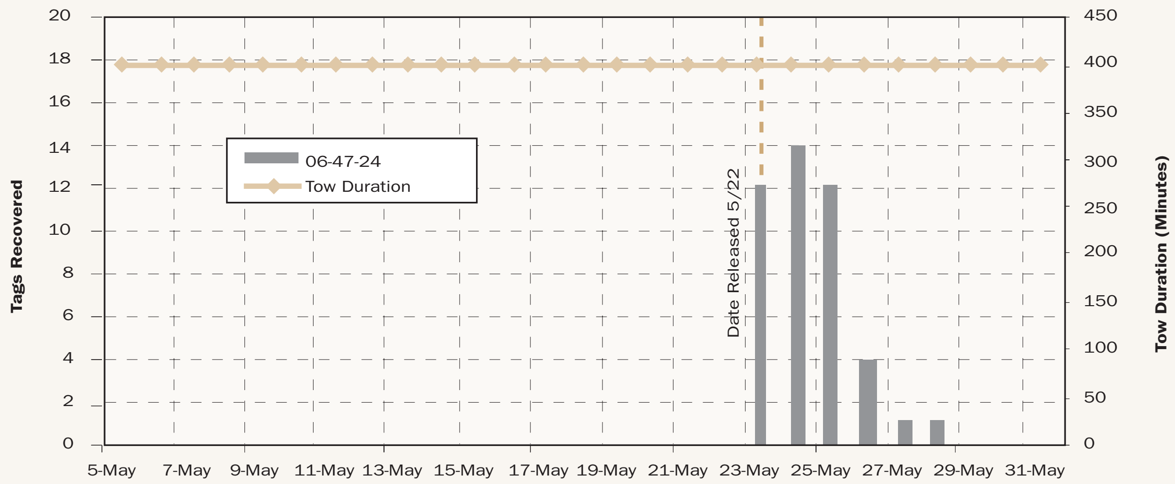
Appendix C-4, Figure 3
Chipps Island/Dos Reis 1



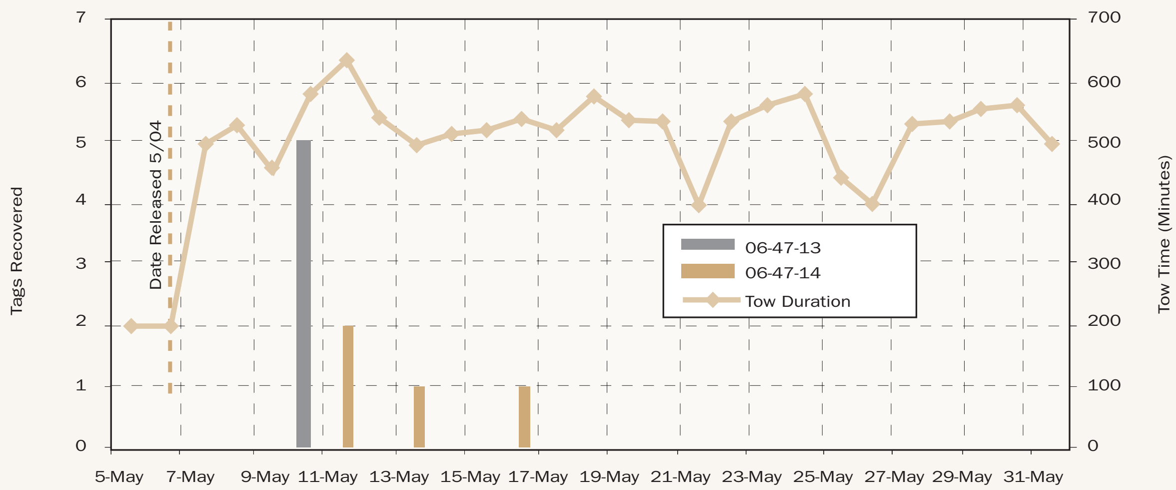
Appendix C-4, Figure 4
Chipps Island/Mossdale 2



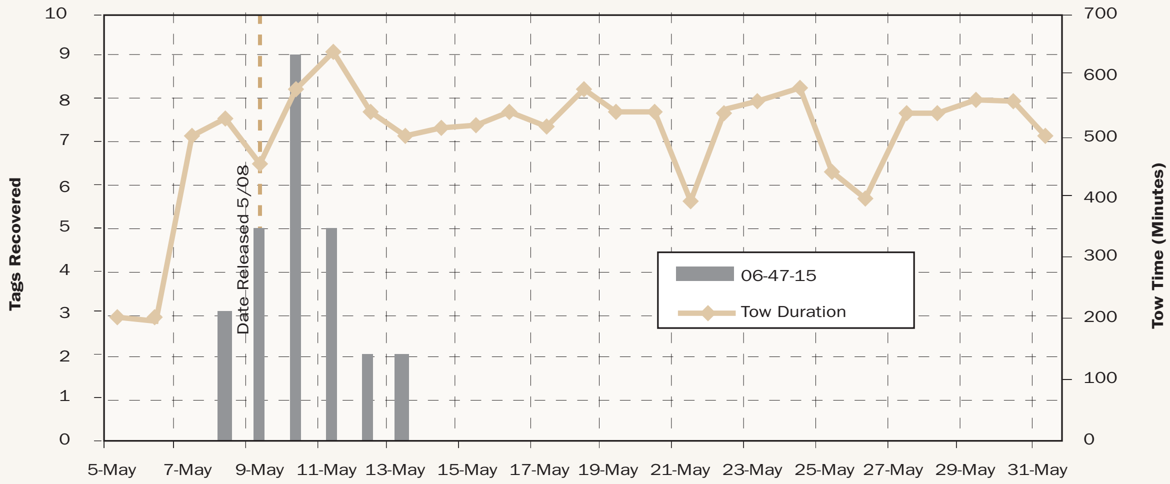
Apendix C-4, Figure 5
Chipps Island/Jersey Point 2



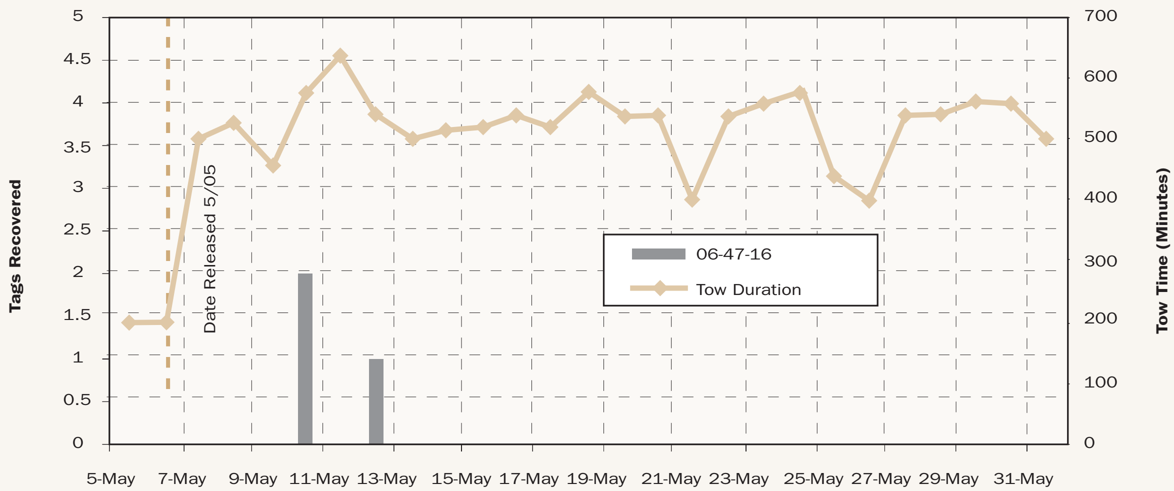
Appendix C-4, Figure 6
Antioch/Mossdale 1



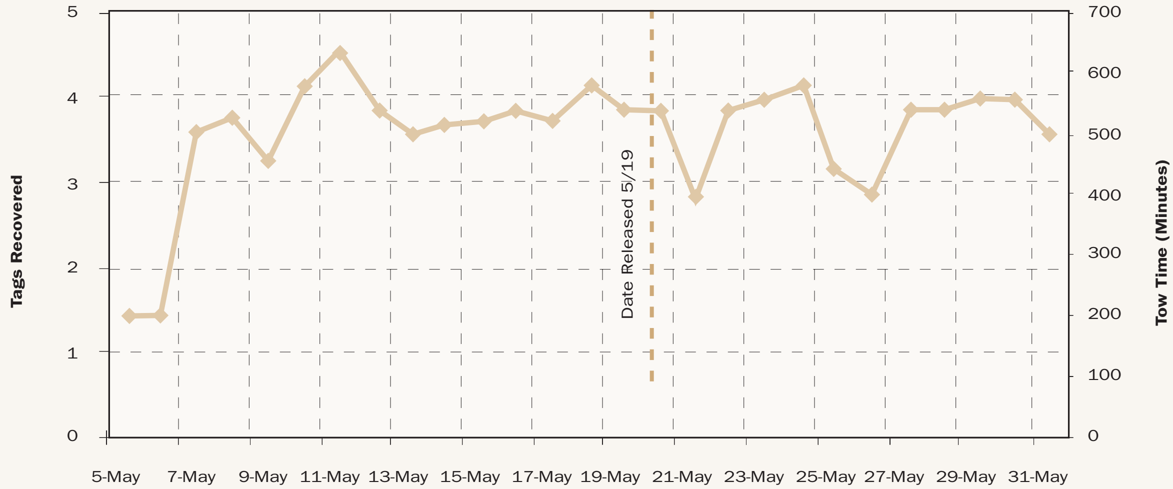
Appendix C-4, Figure 7
Antioch/Jersey Point 1



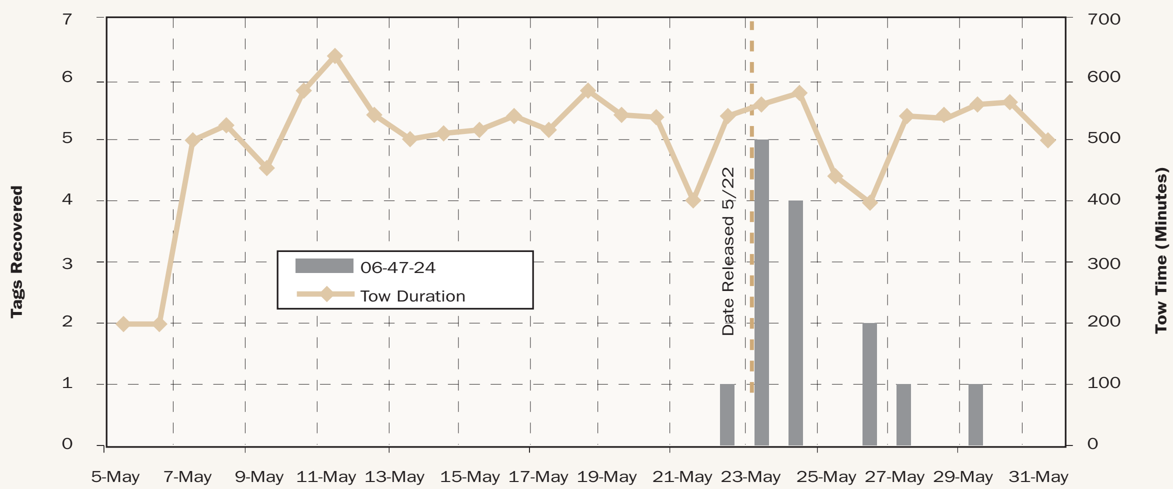
Appendix C-4. Figure 8
Antioch/Dos Reis 1



Appendix C-4, Figure 9
Antioch/Mossdale 2



Appendix C-4, Figure 10
Antioch/Jersey Point 2



Appendix Q

Errata for the Year 2005 Annual Technical Report

Page 43: Table 5-2: River temperature for the Durham Ferry group released on 5/2/05 should be 61.

Page 56: Table 5-6: This table includes several incorrect release and recovery numbers. Please refer to the 2006 Annual Report for correct numbers.

Page 66: In section " Role of exports without HORB", 4th sentence should read " The best relationship is a weakly significant multiple regression that includes flow and exports, with survival (using ocean recoveries) increasing as both flow and exports increase ($r=0.68$, $p<0.10$).

Page 80: Table 6-1: The row that contains "Total 4/20/05 123,072" should be deleted.

Page 88: In the equation for the Estimated variance ($\hat{V}$) of r, the symbol for the average of effective release should be "u".

San Joaquin River Group Authority

P.O. Box 4060 • Modesto, CA 95352 • (209) 526-7405 • fax (209) 526-7315

Modesto Irrigation District

Turlock Irrigation District

Oakdale Irrigation District

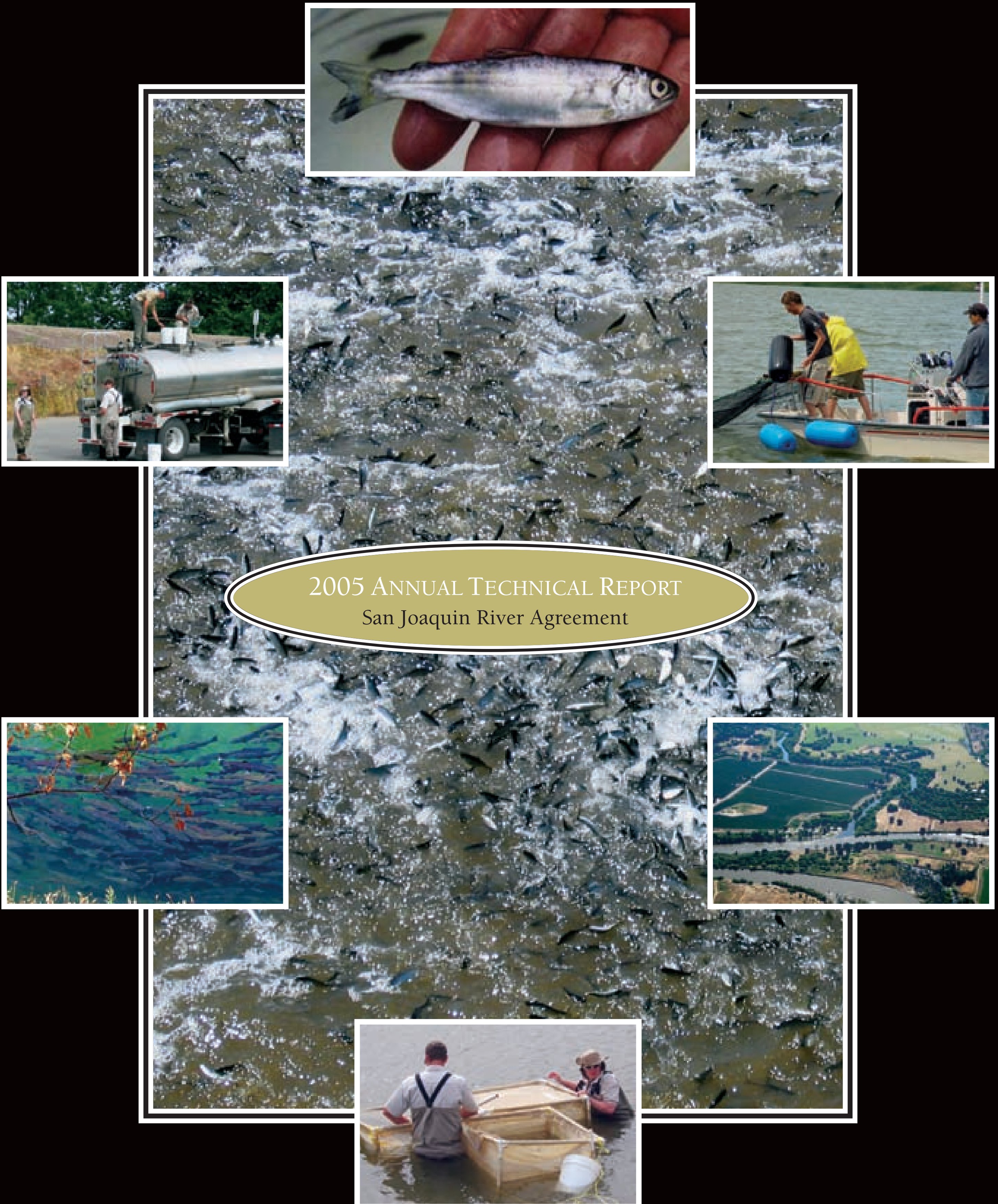
Merced Irrigation District

Friant Water Users Authority

City and County of San Francisco

South San Joaquin Irrigation District

San Joaquin River Exchange Contractors



2005 Annual Technical Report

San Joaquin River Agreement

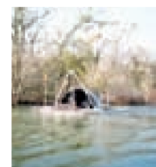
San Joaquin River Group Authority

Executive Summary

The San Joaquin River Agreement (SJRA) and Vernalis Adaptive Management Plan (VAMP) 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). 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. 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 VAMP experiment was modified in 2005 because high spring flows exceeded the upper target flow level of 7,000 cfs preventing the installation of the HORB. In addition, the SJRA technical committee recommended that the VAMP pulse flow period be moved from the default period of April 15 - May 15 to May 1 - May 31, when flows were anticipated to be more stable over the 31-day period. A continued wet hydrologic condition resulted in flood control releases on both the Tuolumne and Merced rivers; and excess water released from the Friant Dam on the Upper San Joaquin River. These conditions resulted in a gradual increase in Vernalis flow between May 1 and May 31.

The 2005 Annual Technical Report consolidates the annual SJRA Operations and the Vernalis Adaptive Management Plan (VAMP) Monitoring Reports. The VAMP 2005 program



represents the sixth 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 VAMP program. Specifically, this 2005 report includes the following information on the implementation of the SJRA: the hydrologic chronicle; management of the additional SJRA water; flow and fisheries monitoring in Old River; results of the juvenile Chinook salmon smolt survival investigations; discussion of complementary investigations; and conclusions and recommendations.

VAMP employs an adaptive management strategy to use current knowledge to protect Chinook salmon as they migrate through the Delta, while gathering information to allow more efficient protection in the future. In addition to providing improved protection for juvenile Chinook salmon emigrating from the San Joaquin River system, specific experimental objectives of VAMP 2005 included:

- Quantification of Chinook salmon smolt survival between Durham Ferry, Dos Reis, and Jersey Point using recapture locations at Antioch and Chipps Island, under conditions of a San Joaquin River flow at Vernalis above 7,000 cfs, without an installed HORB, and SWP/CVP export rates of 2,250 cfs.
- Evaluation of the San Joaquin River – Old River flow split at the Head of Old River under the 2005 flow conditions without the installed HORB.
- Monitoring in Old River to evaluate the movement of salmon smolts into the Old River under the 2005 flow conditions without the installed HORB.
- Health and physiology testing of VAMP fish over an extended period to evaluate disease, swimming performance, and saltwater adaptation.

VAMP 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 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 these experimental investigations and protection for juvenile salmon within the tributaries.

In planning for the VAMP, the March 23 operation plan forecasted an existing a flow of about 6,665 cfs, thereby calling for a VAMP target flow of 7,000 cfs. This early forecast also indicated that the HORB could not safely be installed during 2005 due to flows exceeding 5,000 cfs in the San Joaquin River during the installation period. As wet conditions continued through the spring period, operators for New Don Pedro on the Tuolumne River and Lake McClure on the Merced River were required to initiate flood control operations. Due to continued wet conditions and the forecasted flood control operations on the Tuolumne and Merced rivers the subsequent operations plans forecasted an existing flow at Vernalis in excess of 7,000 cfs. The SJRA Technical Committee recommended delaying the start of the VAMP pulse period from April 15 to May 1 in an effort to provide for increased stability of Vernalis flows. Additionally, the SJRA Technical Committee modified the experimental design to measure survival between Durham Ferry and Dos Reis and Jersey Point without a HORB.

VAMP experimental test conditions that have occurred over the past six years are summarized below:

Year	VAMP Period	Average Vernalis Flow (cfs)	Average SWP/CVP Exports (cfs)
2000	April 15-May 15	5,869	2,155
2001	April 20-May 20	4,220	1,420
2002	April 15-May 15	3,300	1,430
2003	April 15-May 15	3,235	1,446
2004	April 15-May 15	3,155	1,331
2005[a]	May 1 –May 31	10,390	2,986

[a] HORB not installed.

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Water temperature data were collected with a series of computerized recorders at the Merced River Fish Facility, in the transport trucks, and throughout the lower San Joaquin River and Delta. Overall the average temperature at all sites ranged from 19 to 22 C.

Kodiak trawling was conducted in Old River in 2005, in addition to the usual sampling conducted in the San Joaquin River near Mossdale. Data from the two sites were compared to assess movement into the Old River during the VAMP period when there is no HORB installed. The ratio between the number of unmarked salmon and CWT salmon captured at the two locations was similar. A daily average, over a 19 day period, of about 55 percent of the unmarked salmon and 64 percent of the CWT salmon migrated down the Old River. This estimate assumed efficiency of the two trawls was similar. We were not able to determine the relative efficiency between gears at the two locations so the true percentage of fish migrating into each channel is unknown.

Consistent with the VAMP experimental design, the 2005 effort included two mark-recapture studies performed in early May to provide estimates of salmon survival under similar flow and export conditions. The experimental design in past years included multiple release locations

at Durham Ferry, Mossdale, and Jersey Point. In 2005, the releases were made at Dos Reis instead of Mossdale to better assess losses into upper Old River. The multiple recapture locations (Antioch, Chipps Island, SWP and CVP salvage operations, and in the ocean fisheries) were the same in 2005 as they have been in past years. The use of data from multiple release and recapture locations allows for a more thorough evaluation of juvenile Chinook salmon smolt survival as compared to recapture data from only one sampling location and/or one series of releases.

Chinook salmon smolt survival indices were calculated based on the numbers of marked salmon released and the number recaptured. Releases at Jersey Point serve as controls for releases at Durham Ferry and Dos Reis. Recapture data from Antioch, Chipps Island and in the ocean fishery thereby allowed calculation of survival estimates based on the ratio of recovery rates or survival indices from marked salmon recaptured from upstream (Durham Ferry and Mossdale/Dos Reis) and downstream (Jersey Point) releases. Use of ratio estimates as part of the VAMP study design factors out the potential differential gear efficiency at Antioch and Chipps Island within and among years. It also factors out ocean survival when using the ocean recovery data. These ratio estimates were used to evaluate relationships between salmon smolt survival and San Joaquin River flow and CVP and SWP exports with and without the HORB in place.

The estimated survival of coded wire tagged (CWT) salmon released from Durham Ferry and Dos Reis was the third lowest measured since 2000. Samples of CWT salmon from the 2005 VAMP lots were collected and taken to the California-Nevada (CA-NV) Fish Health Center prior to the release dates for rearing and monitoring over an extended period. At the actual time of release the test fish appeared relatively healthy based on results of short-term survival studies and physiological examinations and should have performed adequately for outmigration assessment. However, 27 percent of the test fish held at the Fish

Health Center died due to Proliferative Kidney Disease (PDK) between 36 and 50 days after collection, indicating that survival may have been reduced from the effects of PKD after the fish passed Chipps Island. This reduction would not be reflected in the recapture data from Antioch and Chipps Island, but may be detected in future ocean recovery rates.

In 2005, the HORB was not installed and could have contributed to the low survival observed. Past evaluations have indicated that survival for salmon migrating through the Delta is lower when there is no HORB installed.

Survival through the Delta does appear to be related to San Joaquin River flow at Vernalis, especially with the HORB in place. Relationships observed when there was no HORB in place are more variable and not statistically significant, although both the ocean and trawl data show a similar trend of increased survival with increased flows.

The relationship of survival to exports is still difficult to detect based on the data gathered to date. The escapement data for adult salmon indicate that the flow/export ratio explains more of the variability in adult escapement than flow alone, but the smolt survival data is too limited to detect these effects, if they are real. To further refine the relationship between survival and flow or flow/export ratio, the survival experiments need to be conducted at a flow of 7,000 cfs with HORB installed at the two export levels, 1,500 and 3,000 cfs. We have not yet met these experimental conditions.

Conducting experiments when there is no HORB will further define and refine the relationship of survival to exports and flow.

In addition to this recommendation, each previous technical report contained recommendations for future VAMP implementation. Key conclusions and recommendations resulting from the 2005 VAMP include:

- Survival from Durham Ferry and Mossdale/Dos Reis in 2003, 2004, and 2005, was significantly less then prior years. Continued evaluation of survival rate versus flow and export rate is needed to detect differences in survival tests at extreme target levels (e.g. 7,000 cfs flow and 3,000 or 1,500 cfs exports), or equivalent high flow/export ratios are necessary.
- The flow data collected in 2005 at San Joaquin River near Lathrop and the Head of Old River provided a useful evaluation of the flow split at the Head of Old River. Comparison of these 2005 flow data against DWR-DSM2 modeling results should be conducted and may provide useful information.
- The Clifton Court Forebay was treated with the aquatic herbicide Komeen, known to be toxic to salmon, one day following the Durham Ferry release of test fish. DWR and USBR should coordinate operation and maintenance activities at the SWP and CVP export facilities with the VAMP technical groups.
- VAMP 2005 was the first time a sample of experimental fish were held at the CA-NV Fish Health Center for health evaluation, swimming performance testing, and saltwater adaptation testing. Such testing and evaluation should be continued in future years.
- The numbers of CWT salmon, from Durham Ferry releases recovered at the SWP and CVP salvage facilities were greater than prior years due to the lack of a HORB. Only a few Dos Reis fish were recovered at the SWP and CVP salvage facilities.
- VAMP has been designed to evaluate opportunities to adaptively refine the VAMP test implementation conditions to: improve protection for juvenile Chinook salmon migrating from the San Joaquin River, and to improve the ability to detect differences in survival, if they exist, as a function of river flow and SWP/CVP export operations, and optimize the allocation of available water supplies each year.

The VAMP program should continue until smolt survival has been examined in relation to all target flow and export rates with an installed HORB. When completed the VAMP study should demonstrate the value of large-scale, long-duration, interdisciplinary experimental investigations that provide both protection to fishery resources while also providing important information that can be used to evaluate the performance and biological benefits of various management actions.

1 Introduction

Actions associated with the Vernalis Adaptive Management Plan (VAMP) were implemented between May 1 and May 31, 2005 to protect juvenile Chinook salmon and evaluate the relationship between San Joaquin River flow and State Water Project (SWP) and federal Central Valley Project (CVP) water project exports, with the HORB installed, on the survival of marked juvenile Chinook salmon migrating through the Sacramento – San Joaquin Delta. Due to high river flows the HORB could not be installed for the 2005 VAMP period. The pulse flow period was postponed 15 days from previous years and in accordance with the SJRA the water districts attempted to maintain stable flow throughout the period. Studies conducted in 2005, represent the sixth year of the VAMP experiment. Results from previous VAMP experiments are available in San Joaquin River Agreement Technical Reports, for each respective year. Similar 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 will describe the experimental design of VAMP, the hydrologic planning and implementation, the additional water supply arrangements and deliveries, the Head of Old River Barrier (HORB) background, flow and seepage monitoring, Kodiak trawling in Old River, the salmon smolt survival investigation and complimentary studies related to VAMP. Conclusions and recommendations for future VAMP studies are also included.

EXPERIMENTAL DESIGN ELEMENTS

The VAMP experimental design measures 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 mid-April to mid-May juvenile salmon outmigration period that provide estimates of salmon survival under each set of conditions. During 2005, a total of 400,000 juvenile Chinook salmon were made available from the Merced River Fish Facility (MRFF) annual production for the VAMP survival studies. Chinook salmon survival indices under the experimental conditions are calculated based on the number of marked salmon released and the number recaptured. Absolute survival estimates and combined differential recovery rates are also calculated and used to assess relationships between survival and San Joaquin River flow and CVP and SWP exports.

Due to high flows in the San Joaquin River the HORB was not installed for the 2005 VAMP. The 2005 VAMP experimental design included both multiple release locations (Durham Ferry, Dos Reis, and Jersey Point), and multiple recapture locations (Antioch, Chipps Island, SWP and CVP salvage operations, and in the ocean fisheries; Figure 1-1). Two releases were made during the 2005 VAMP study at Durham Ferry, Dos Reis, and Jersey Point. Due to no HORB during the pulse flow period the Dos Reis release site was used in lieu of Mossdale to provide a better evaluation of smolt movement into the Old River. The use of data from multiple release and recapture locations allows for a more thorough evaluation of juvenile Chinook salmon survival as compared to recapture data from only one sampling location and/or one release location. The VAMP coded-wire tag (CWT) releases (Durham Ferry, Dos Reis, and Jersey Point) and recapture locations (Antioch and Chipps Island) are consistent with some previous years, providing a greater opportunity to assess salmon smolt survival over the range of Vernalis flows, SWP/CVP exports, and with and without the presence HORB. The recovery of marked fish at both Antioch and Chipps Island also improves the precision associated with the individual survival estimates, and improves confidence in detecting differences in salmon smolt survival as a function of Vernalis flows and SWP/CVP exports. Releases at Jersey Point serve as controls for recaptures at Antioch and Chipps Island, thereby allowing the calculation of survival estimates based on the ratio of survival indices from marked salmon recaptured from upstream (e.g., Durham Ferry and Dos Reis) and downstream (control release at Jersey Point) releases. The combined differential recovery rates are calculated in a similar manner after the number recovered from each trawl location is combined. The use of ratio estimates as part of the VAMP study design factors out the potential differential gear efficiency at Antioch and Chipps Island within and among years.

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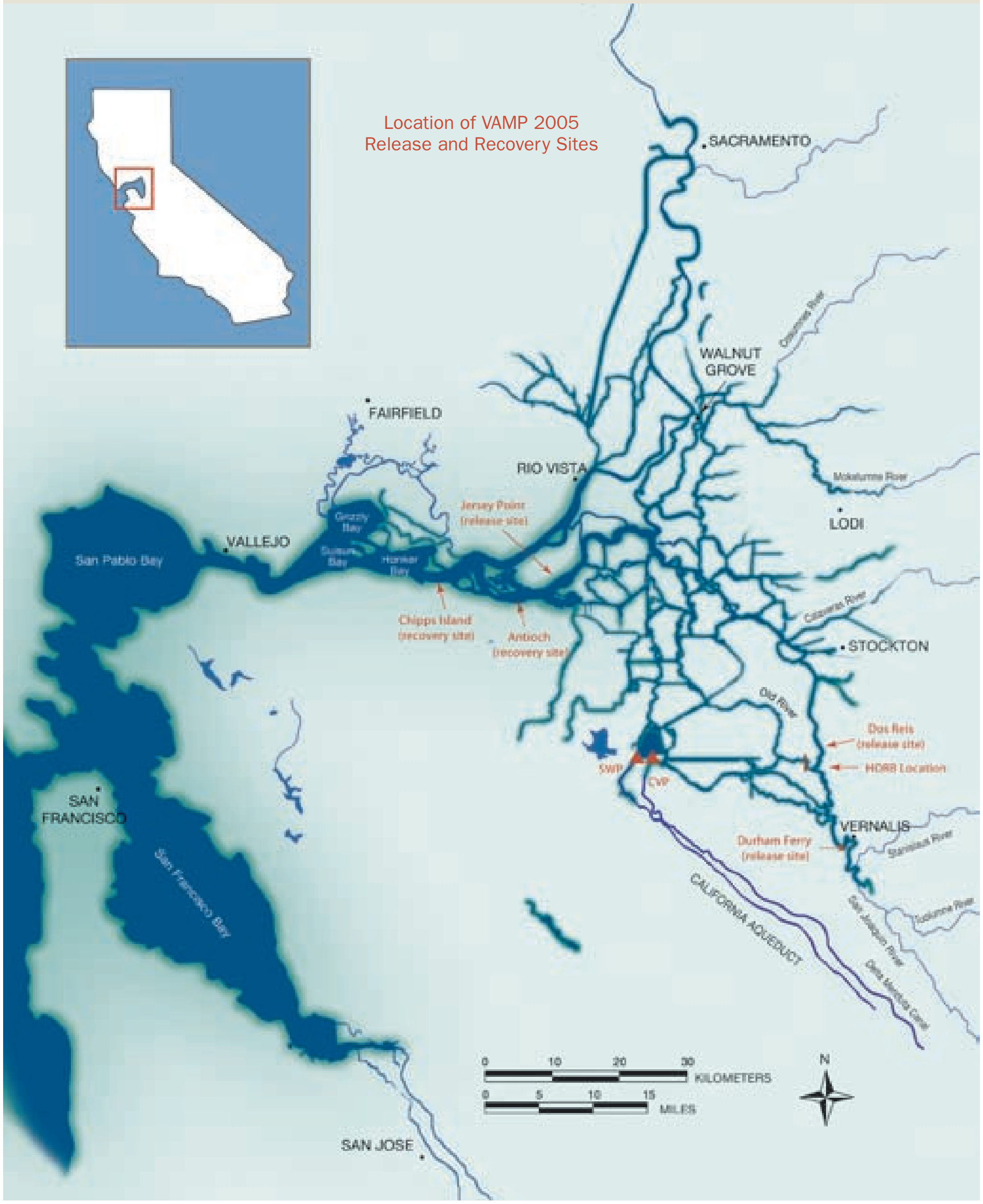
A quality assurance/quality control program has been used as a routine part of VAMP tests, and includes quantifying the number of marked fish successfully clipped and tagged. Coordination with the local landowner to curtail operation of an agricultural diversion pump located immediately downstream of Durham Ferry, coincident with the Durham Ferry release was continued in 2005. In addition, the 2005 VAMP program continued use of the net pen studies and physiological testing to assess overall condition and health of marked fish used in VAMP experiments. Improvements were also made in 2005 relative to measuring flow in the San Joaquin River downstream of the confluence with Old River. The absence of the HORB in 2005 provided the opportunity to conduct Kodiak Trawls in both the San Joaquin River and Old River near the vicinity of the Head of Old River.

Figure 1-1
Sacramento – San Joaquin Estuary



Chapter 2

VAMP Hydrologic Planning & Implementation

This section documents the planning and implementation undertaken by the Hydrology Group of the San Joaquin River Technical Committee (SJRTC) for the 2005 VAMP investigations. Implementation of VAMP is guided by the framework provided in the San Joaquin River Agreement (SJRA) and anticipated hydrologic conditions within the watershed.

The Hydrology Group 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 2005, the agencies belonging to the Hydrology Group included: Merced Irrigation District (Merced), 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 installation of the HORB and the planning of Delta exports consistent with the VAMP.

2005 VAMP SUMMARY

Generally wet conditions in the San Joaquin River basin and tributary basins resulted in relatively high flow conditions entering the Spring of 2005. Due to these high flows DWR was unable to install the temporary Head of Old River Barrier (HORB). Additionally, the flow in the San Joaquin River at Vernalis exceeded the maximum VAMP target flow of 7,000 cfs during the VAMP pulse flow period, therefore no supplemental water was provided by the SJRGA agencies.

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. Operation conference calls were not conducted during the 2005 VAMP but contact was maintained with the operating entities to track reservoir releases. The Technical Committee placed an added emphasis on analyzing the flow and fish movement into Old River absent the HORB. Monitoring of real-time flow data was maintained throughout the planning and implementation phases.

VAMP BACKGROUND AND DESCRIPTION

This section provides information on the background and description of the water operations and factors to be considered when planning for the VAMP each year. Even with the high flow conditions during 2005 these factors continued to be considered in the planning process and implementation.

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	

The VAMP provides for a 31-day pulse flow (target flow) at the Vernalis gage on the San Joaquin River (see 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 pulse 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 River, the Tuolumne River and the Stanislaus River.

As part of the development of the VAMP experimental design, the VAMP Hydrology and Biology Groups jointly 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 VAMP Hydrology and Biology Groups 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 technical committees 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.

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 technical committees 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 Hydrology and Biology Groups agreed to a target range variation of plus or minus 7% of the Vernalis flow target. It was recognized by the Hydrology and Biology Groups that these guidelines are not absolute conditions, but are to be used by the VAMP Hydrology and Biology workgroups to evaluate experimental test conditions and the potential effect of flow and export variation on our ability to detect and assess variation in juvenile Chinook salmon survival rates among VAMP test conditions.

Under the SJRA, the following San Joaquin River Group Authority (SJRGA) agencies have agreed to provide the supplemental water needed to achieve the VAMP target flows, limited to a maximum of 110,000 acre-feet: Merced, OID, SSJID, SJRECWA, MID and TID. The Merced supplemental water would be provided on the Merced River from storage in Lake McClure and would be measured at the Cressey gage on the Merced River. 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 New Don Pedro Reservoir and would be measured at the Tuolumne River below LaGrange Dam gage.

The target flow of 2,000 cubic feet per second (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 2000 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, as was the case in 2005, the Parties will exert their best efforts to maintain a stable flow during the VAMP pulse 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 (off-ramp). These potential adjustments to the target flow are dependent on the hydrologic year type as defined by the SWRCB San Joaquin Valley Water Year Hydrologic Classification (60-20-20 classification), 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 Classifications Used in VAMP

60-20-20 Water Year Classification	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 2005 VAMP

Hydrology Group Meetings

Beginning in February 2005, and continuing until early April, the Hydrology Group held three planning and coordination meetings (February 16, March 23 and April 11). The March 23 and April 11 meetings were joint meetings of the Hydrology and Biology Groups. 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 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 16 Hydrology Group meeting. The 90 percent exceedence forecast was indicating a VAMP target flow of 4,450 cfs and the 50 percent exceedence forecast was indicating a VAMP target flow of 5,700 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 that target. It also provides a forecast of the daily flows expected during the HORB installation period. In years like 2005 where the Existing Flow exceeds the maximum VAMP target flow, the daily operation plan is used to determine to what extent a stable flow can be provided during the VAMP pulse flow period. The daily operation plan calculates an estimated mean daily flow at

Vernalis based on estimates 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 major tributaries.

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 above 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

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:

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)).

The forecast of the ungaged flow is the factor with the greatest uncertainty in the development of the daily operation plan. 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 pulse flow period is a reasonable estimate of the average ungaged flow for pulse 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 pulse flow period essentially equal to the value entering the pulse flow period.

The VAMP 31-day pulse flow period can occur anytime between April 1 and May 31. Factors that are considered in the determination of the timing of the VAMP pulse flow period include installation of HORB, availability of juvenile salmon at the MRFF, and manpower and equipment availability for salmon releases and recapture. Until a specific start date is defined, a default pulse flow period of April 15 to May 15 is used for the VAMP operation planning.

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 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 classifications for 2003 and 2004 were “BELOW NORMAL” (VAMP numerical indicator of three) and “DRY” (VAMP numerical indicator of two), respectively. Under these conditions there was no possibility of 2005 being an off-ramp year since the off-ramp criterion was already exceeded without including the current year’s numerical indicator. A “double-step” condition would occur if sum of the VAMP numerical indicators for the previous year and current year is equal to or greater than seven, with the current year’s indicator based on the 90% probability of exceedence forecast of the 60-20-20 water year classification. This also was not a factor in 2005 since all indications during the planning phase were pointing to a VAMP target flow of 7,000 cfs or greater.

The initial daily operation plan was prepared on March 23. This forecast showed an existing flow of 6,665 cfs, indicating a VAMP target flow of 7,000 cfs. In this forecast New Don Pedro Reservoir on the Tuolumne River and Lake McClure on the Merced River were expected to be making flood control releases and the Stanislaus River was expected to be at its institutional maximum of 1,500 cfs throughout the VAMP pulse flow period. This forecast also indicated that it was likely that the flow would be too high to allow for the safe installation of the Head of Old River Barrier (HORB). Weighing all of these factors the SJRTC determined that delaying the start of the VAMP pulse flow period would increase the chances of installation of the HORB and declared a VAMP pulse flow period of May 1 to May 31. Hydrologic conditions continued to get wetter and by early April the daily operation plan forecasts were

Table 2-3
Summary of Daily Operation Plans

Phase	VAMP Forecast Date	VAMP Target Flow Period	Assumed Ungaged Flow at Vernalis (cfs)	Existing Flow (cfs)	VAMP Target Flow (cfs)	Supplemental Water needed to meet Target Flow (acre-feet)
Planning	March 23, 2005	April 15 - May 15	800	6,665	7,000	20,600
			1,200	7,465	na	0
	March 25, 2005	May 1 - May 31	800	6,811	7,000	11,610
			1,200	7,211	na	0
	April 5, 2005	May 1 - May 31	600	8,839	na	0
			1,200	9,439	na	0
	April 13, 2005	May 1 - May 31	600	6,764	7,000	14,520
			1,200	8,139	na	0
	April 21, 2005	May 1 - May 31	1,000	7,938	na	0
	April 28, 2005	May 1 - May 31	400	7,943	na	0

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?format=pre&period=31&site_no=11303500)
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?format=pre&period=31&site_no=11289650)
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?format=pre&period=31&site_no=11274000)

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

Date	Gage Height (ft)	Measured Flow (cfs)	Current Rating Shift Flow (cfs)	Percent Difference	Rating Shift Change
4/20/05 (11:30)	15.98	8,410	8,710	-3.4%	no
4/20/05 (12:19)	15.97	8,490	8,700	-2.4%	no
4/27/05 (10:57)	14.65	6,450	6,950	-7.2%	yes
5/3/05 (11:12)	15.71	8,360	7,780	7.5%	yes
5/10/05 (09:02)	16.24	9,000	8,740	3.0%	no
5/17/05 (10:08)	16.18	9,150	8,660	5.7%	yes

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indicating that the possibility of HORB installation had essentially been eliminated. It was also looking more likely that the existing flow would exceed the maximum VAMP target flow of 7,000 cfs. Continually increasing runoff forecasts resulted in continually increasing forecasts of flood control releases on the Tuolumne and Merced Rivers such that by April 28 the daily operation forecast was looking at an existing flow of approximately 8,000 cfs. Table 2-3 summarizes the various iterations of the daily operation plan during the VAMP planning phase, and demonstrates the evolutionary nature, of its development. The daily operation plans prepared during the VAMP planning phase are provided in Appendix A-1, Tables 1 through 10.

Tributary Flow Coordination

As previously noted, by late April the forecast existing flow was greater than the maximum VAMP target flow of 7,000 cfs. Under these conditions the tributary operations were coordinated to the degree possible to provide as stable a flow as possible during the VAMP pulse flow period. With this in mind the tributary operations prior to the VAMP were adjusted to the degree possible to maximize the very limited potential operational flexibility during the VAMP pulse flow period.

Delta Exports

The VAMP experimental design does not mandate specific magnitudes of reduced export rates when the existing flow at Vernalis is expected to exceed the maximum VAMP target flow rate of 7,000 cfs, but does provide the following suggested export rates.

Vernalis Flow	Suggested Export Rate
Up to 10,000 cfs	1,500 cfs or 3,000 cfs
Up to 15,000 cfs	2,250 cfs
Over 15,000 cfs	3,000 cfs

On March 30, April 15 and April 27 the projected VAMP operation plan was discussed with the CalFed Operations Group. On April 28, the CalFed Water Operation Management Team (WOMT), which is made up of representatives from the DWR, USBR, USFWS, CDFG and NMFS, settled on a combined State and Federal export rate of 1,500 cfs for the first half of May and 3,000 cfs for the second half of May. On May 4 the WOMT revised the combined export rate to 2,250 cfs for the VAMP period provided the Vernalis flow stayed in the vicinity of 8,000 cfs, and noted that the export rate reduction would be reassessed if the Vernalis flow increased significantly above 8,000 cfs.

IMPLEMENTATION

Operation Conference Calls

Due to the excess flow conditions and the fact that the operation was being controlled by flood control considerations and not by the VAMP target flow, the operation conference calls that had been conducted in previous years were not conducted in 2005.

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 quality. The 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.

Normally, the USGS makes monthly measurements of the flow at Vernalis to check the current rating shift. The real-time flows reported by the USGS and CDEC are dependent on the most current rating shift, therefore a new measurement and 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 20 and May 17. The results of these measurements are summarized in Table 2-5. There were no significant rating shifts during the 2005 VAMP operation 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 August 1, 2005. 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 8, to illustrate the differences between the real-time and the provisional data.

The mean daily flow at the Vernalis gage averaged 10,390 cfs during the May 1 – May 31 VAMP pulse flow period. The flow was relatively steady for the first 19 days of the pulse flow period, ranging from 7,500 cfs to 9,200 cfs. For the latter portion of the pulse flow period the flow at Vernalis

Table 2-6
2005 Vernalis Adaptive Management Plan (VAMP)
Final Flows and Accounting of Supplemental Water Contributions
Pulse flow period: May 1 - May 31 * Target Flow: greater than 7,000 cfs

	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)			Upper SJR	Vernalis Ungaged	San Joaquin River at Vernalis		
Date	Existing Flow (cfs)	Observed Flow (cfs)	VAMP Supple-mental Water (cfs)	Existing Flow (cfs)	Observed Flow (cfs)	VAMP Supple-mental Water (cfs)	Existing Flow (cfs)	Observed Flow (cfs)	VAMP Supple-mental Water (cfs)	Observed Flow (cfs)	Observed Flow (cfs)	Existing Flow (cfs)	Observed Flow (cfs)	VAMP Supple-mental Water (cfs)
04/01/05	4,190	4,190		7,010	7,010		229	229		2,460	500	15,100	15,100	
04/02/05	4,100	4,100		6,670	6,670		229	229		2,230	951	15,000	15,000	
04/03/05	3,810	3,810		6,870	6,870		229	229		2,010	781	15,000	15,000	
04/04/05	3,850	3,850		7,140	7,140		226	226		1,630	1,681	15,000	15,000	
04/05/05	3,600	3,600		6,990	6,990		229	229		1,410	1,491	14,700	14,700	
04/06/05	3,430	3,430		5,490	5,490		229	229		1,290	1,594	14,400	14,400	
04/07/05	3,270	3,270		5,020	5,020		226	226		1,090	921	13,400	13,400	
04/08/05	3,270	3,270		4,570	4,570		227	227		950	1,391	12,000	12,000	
04/09/05	3,240	3,240		4,050	4,050		225	225		910	1,734	11,500	11,500	
04/10/05	3,240	3,240		4,120	4,120		229	229		940	1,683	10,700	10,700	
04/11/05	3,200	3,200		4,830	4,830		232	232		940	1,945	10,400	10,400	
04/12/05	2,740	2,740		4,940	4,940		226	226		1,010	1,771	10,300	10,300	
04/13/05	2,660	2,660		4,010	4,010		227	227		980	1,558	10,800	10,800	
04/14/05	2,700	2,700		4,070	4,070		228	228		860	524	9,900	9,900	
04/15/05	2,720	2,720		3,950	3,950		231	231		770	1,363	9,320	9,320	
04/16/05	2,680	2,680		4,040	4,040		229	229		700	1,262	9,080	9,080	
04/17/05	2,630	2,630		4,050	4,050		342	342		650	1,359	9,010	9,010	
04/18/05	2,570	2,570		4,060	4,060		406	406		620	1,121	8,810	8,810	
04/19/05	2,500	2,500		4,030	4,030		403	403		610	1,028	8,750	8,750	
04/20/05	2,430	2,430		4,000	4,000		400	400		570	944	8,660	8,660	
04/21/05	2,380	2,380		3,980	3,980		404	404		550	767	8,380	8,380	
04/22/05	2,350	2,350		3,840	3,840		401	401		530	540	8,010	8,010	
04/23/05	2,250	2,250		3,520	3,520		402	402		470	366	7,730	7,730	
04/24/05	2,210	2,210		3,290	3,290		409	409		470	339	7,490	7,490	
04/25/05	2,060	2,060		3,020	3,020		414	414		530	448	7,190	7,190	
04/26/05	1,780	1,780		3,220	3,220		401	401		590	331	6,750	6,750	
04/27/05	1,600	1,600		3,680	3,680		405	405		610	316	6,490	6,490	
04/28/05	1,550	1,550		3,750	3,750		401	401		560	449	6,720	6,720	
04/29/05	1,510	1,510		3,760	3,760		1,285	1,285		550	485	6,960	6,960	
04/30/05	1,830	1,830		3,760	3,760		1,504	1,504		480	729	7,040	7,040	
05/01/05	1,980	1,980		3,770	3,770		1,498	1,498		430	375	7,520	7,520	0
05/02/05	1,930	1,930		3,770	3,770		1,504	1,504		440	716	7,970	7,970	0
05/03/05	1,380	1,380		3,750	3,750		1,499	1,499		630	592	8,120	8,120	0
05/04/05	1,340	1,340		3,770	3,770		1,500	1,500		650	166	7,860	7,860	0
05/05/05	1,820	1,820		3,760	3,760		1,519	1,519		520	(139)	7,670	7,670	0
05/06/05	1,970	1,970		3,740	3,740		1,518	1,518		420	610	7,910	7,910	0
05/07/05	1,950	1,950		3,760	3,760		1,505	1,505		570	1,051	8,190	8,190	0
05/08/05	1,960	1,960		3,980	3,980		1,503	1,503		620	912	8,410	8,410	0
05/09/05	2,000	2,000		4,230	4,230		1,507	1,507		680	825	8,630	8,630	0
05/10/05	1,990	1,990		4,220	4,220		1,501	1,501		750	817	8,870	8,870	0
05/11/05	2,000	2,000		4,230	4,230		1,501	1,501		830	553	8,930	8,930	0
05/12/05	1,990	1,990		4,220	4,220		1,507	1,507		970	409	8,880	8,880	0
05/13/05	1,970	1,970		4,230	4,230		1,501	1,501		1,020	389	8,940	8,940	0
05/14/05	2,010	2,010		4,250	4,250		1,501	1,501		970	343	9,040	9,040	0
05/15/05	2,010	2,010		4,250	4,250		1,504	1,504		910	329	9,070	9,070	0
05/16/05	2,040	2,040		4,240	4,240		1,505	1,505		840	239	8,930	8,930	0
05/17/05	2,370	2,370		4,230	4,230		1,500	1,500		870	106	8,780	8,780	0
05/18/05	2,460	2,460		4,510	4,510		1,504	1,504		1,200	175	8,770	8,770	0
05/19/05	2,430	2,430		5,580	5,580		1,506	1,506		1,580	560	9,200	9,200	0
05/20/05	2,410	2,410		6,620	6,620		1,504	1,504		1,890	616	10,200	10,200	0
05/21/05	2,410	2,410		6,580	6,580		1,507	1,507		2,160	274	11,400	11,400	0
05/22/05	2,360	2,360		6,620	6,620		1,503	1,503		2,480	(244)	12,200	12,200	0
05/23/05	2,320	2,320		6,640	6,640		1,505	1,505		2,840	143	12,800	12,800	0
05/24/05	2,690	2,690		6,590	6,590		1,506	1,506		3,140	87	13,100	13,100	0
05/25/05	2,700	2,700		6,180	6,180		1,503	1,503		3,420	155	13,500	13,500	0
05/26/05	2,670	2,670		5,830	5,830		1,506	1,506		3,950	244	13,800	13,800	0
05/27/05	3,050	3,050		5,760	5,760		1,501	1,501		4,450	7	13,800	13,800	0
05/28/05	3,590	3,590		5,640	5,640		1,507	1,507		4,900	214	14,200	14,200	0
05/29/05	3,860	3,860		5,560	5,560		1,504	1,504		5,330	219	14,600	14,600	0
05/30/05	3,940	3,940		5,330	5,330		1,433	1,433		5,820	103	15,200	15,200	0
05/31/05	3,930	3,930		5,070	5,070		1,340	1,340		6,300	(384)	15,600	15,600	0
							VAMP Period							
Average (cfs):	2,151	2,151		4,775	4,775		1,497	1,497		1,629	337	10,390	10,390	
Supplemental Water (ac-ft):			0			0			0					0

VAMP Period

Observed Flow Sources:
Merced River at Cressey (CA DWR B05155): California DWR, San Joaquin District, 8/24/05
Tuolumne River below LaGrange Dam near LaGrange (USGS 11289650): USGS, provisional data as of 8/1/05
Stanislaus River below Goodwin Dam: USBR, Goodwin Reservoir Daily Operations Report - OID/SSJID/Tri-Dams, 5/2/05 (April report) and 6/1/05 (May report)
San Joaquin River near Vernalis (USGS 11303500): USGS, provisional data as of 8/1/05

was impacted by flood releases from Friant Dam (Millerton Lake), reaching a VAMP period maximum of 15,600 cfs on May 31 as shown in Figure 2-2. Plots of the flow at the Merced River, Tuolumne River and Stanislaus River measurement points are provided in Figure 2-3. A tabulation of the observed mean daily flows during and around the VAMP period is provided in Table 2-6.

Near the end of April, just prior to the pulse flow period, the computed ungaged flow had dropped into the range of 400 to 600 cfs, so that a value of 400 cfs was used in the April 28 daily operation plan. The final accounting shows that the average ungaged flow during the VAMP pulse flow period was 284 cfs, with a minimum of -544 cfs and maximum of 741 cfs. A plot of the ungaged flow is provided in Figure 2-4.

Another unknown in the forecast equation similar to the ungaged flow is the flow in the San Joaquin River upstream of the Merced River. This unknown tends not to be as variable as the ungaged flow, but like the ungaged flow, it may be adjusted if the observed flow warrants it. During the 2005 VAMP the greatest uncertainty in regards to the San Joaquin River above Merced River flow was the potential for Friant Dam flood releases which could significantly affect this flow. As can be seen in Figure 2-5, the observed flow was slightly greater than the forecast for the first half of the pulse flow period due to the wet conditions in the basin. In mid-May it became necessary for Friant Dam to make significant flood control releases which resulted in the observed flow in the San Joaquin River above the Merced River significantly exceeding the forecasted flow as shown in Figure 2-5.

As previously stated, the combined CVP and SWP Delta export rate target was set at 2,250 cfs provided the Vernalis flow remained near 8,000 cfs. The export rate was held near the target rate for the first 25 days of the VAMP pulse flow period (see Figure 2-6) with an average of 2,260 cfs. However, due to the significant increase in the flow at Vernalis in the latter part of May, the DWR and USBR increased the combined export rate to between 6,000 and 7,000 cfs for the last five days in May. The resulting average combined export rate for the 31 day VAMP target flow data was 2,986 cfs.

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 New Don Pedro Reservoir. 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 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.

As of November 1, 2004, following the Fall 2004 SJRA water transfer, the cumulative impact of the SJRA on the storage in Lake McClure was a reduction of 215,197 acre-feet (see Table 2-7), assuming Merced I.D. diversions from the Merced River would have been the same both without and with the SJRA. It should be noted, however, that as a direct result of the SJRA, Merced I.D. has undertaken a number of conservation measures that have resulted

Table 2-7
Storage Impact History, Lake McClure (Merced River)

Calendar Year	VAMP Supplemental Water (acre-feet) [a]	Fall Supplemental Water (acre-feet)	SJRA Storage Impact Replenishment (acre-feet)	End of Year Cumulative Storage Impact (acre-feet)
2000	46,750	12,500	46,750 (May 2000)	-12,500
2001	43,146	12,496	0	-68,142
2002	27,120	12,470	0	-107,732
2003	39,586	12,500	0	-159,818
2004	42,879	12,500	0	-215,197
2005	0	12,500	215,197 (Jan.-Mar. 2005)	0 [b]

[a] Includes ramping flows.
[b] Fall Supplemental Water from re-opened flood-control release, therefore storage was not impacted.

Figure 2-2
2005 VAMP: San Joaquin River near Vernalis
With Lagged Contributions from Primary Sources

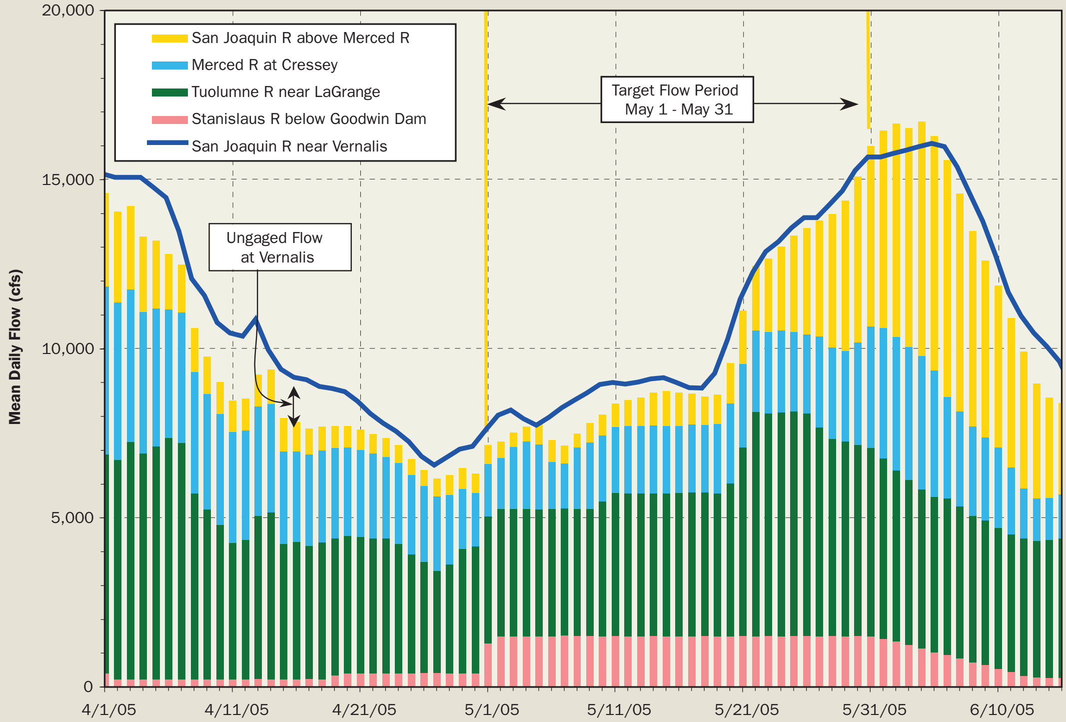


Figure 2-3
2005 VAMP: Flow at Tributary Measurement Points

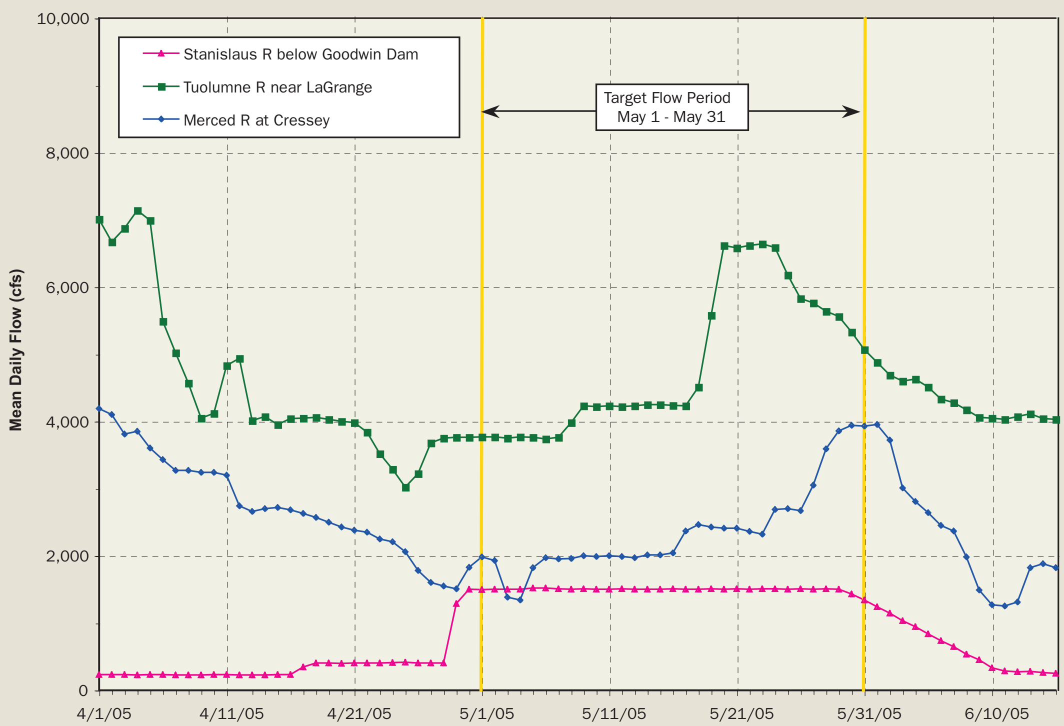


Figure 2-4
2005 VAMP - Ungaged Flow in San Joaquin River at Vernalis
Comparison of Forecasted and Observed

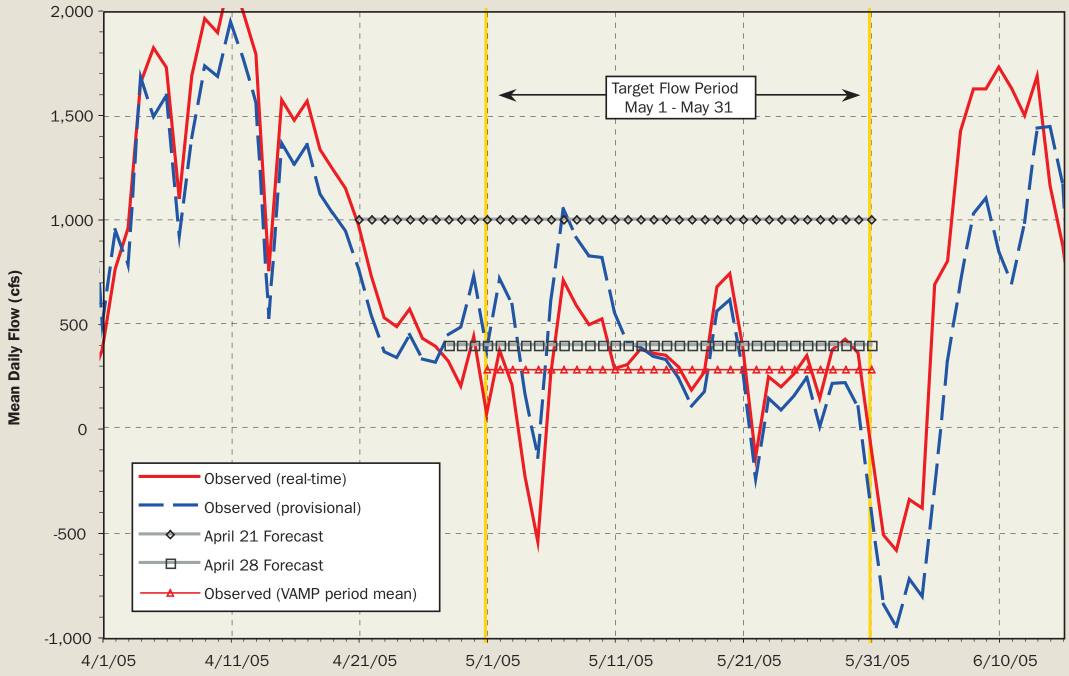


Figure 2-5
2005 VAMP - Upper San Joaquin River Flow
Comparison of Forecasted and Observed

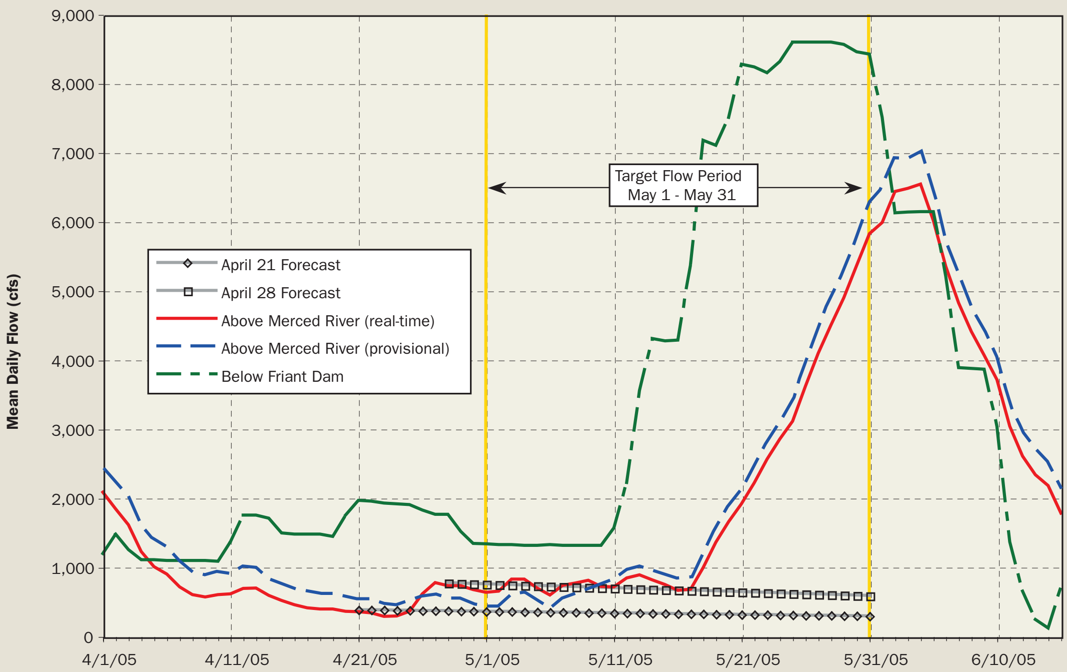


Figure 2-6
2005 VAMP - Federal and State Delta Exports

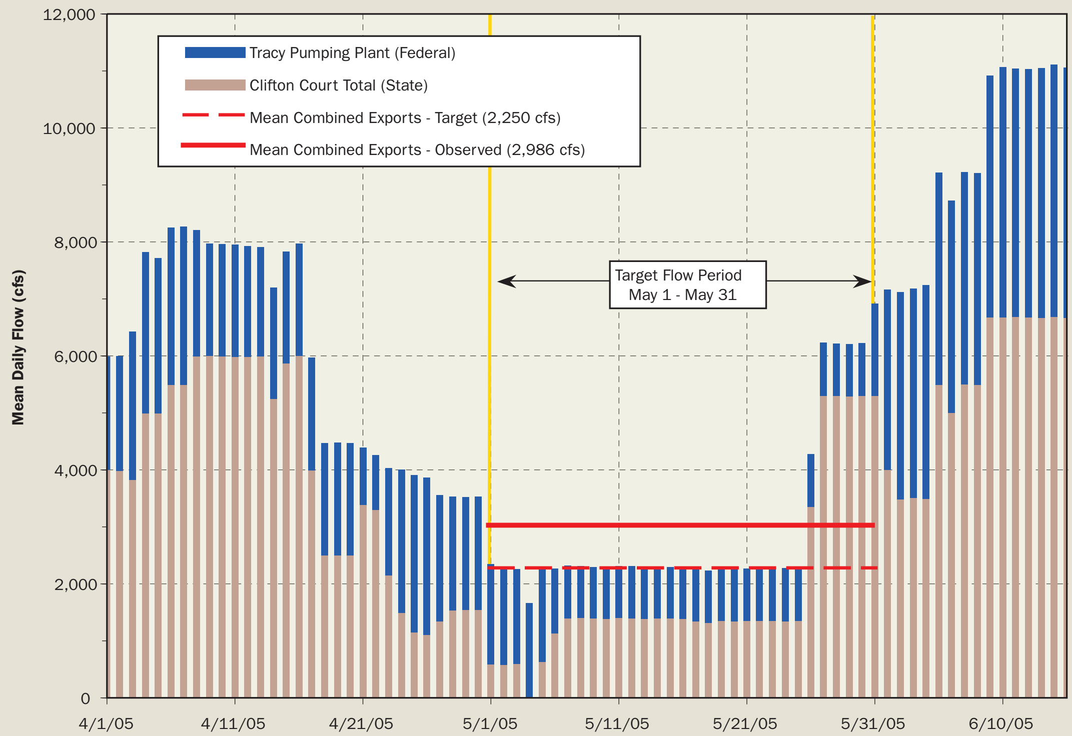
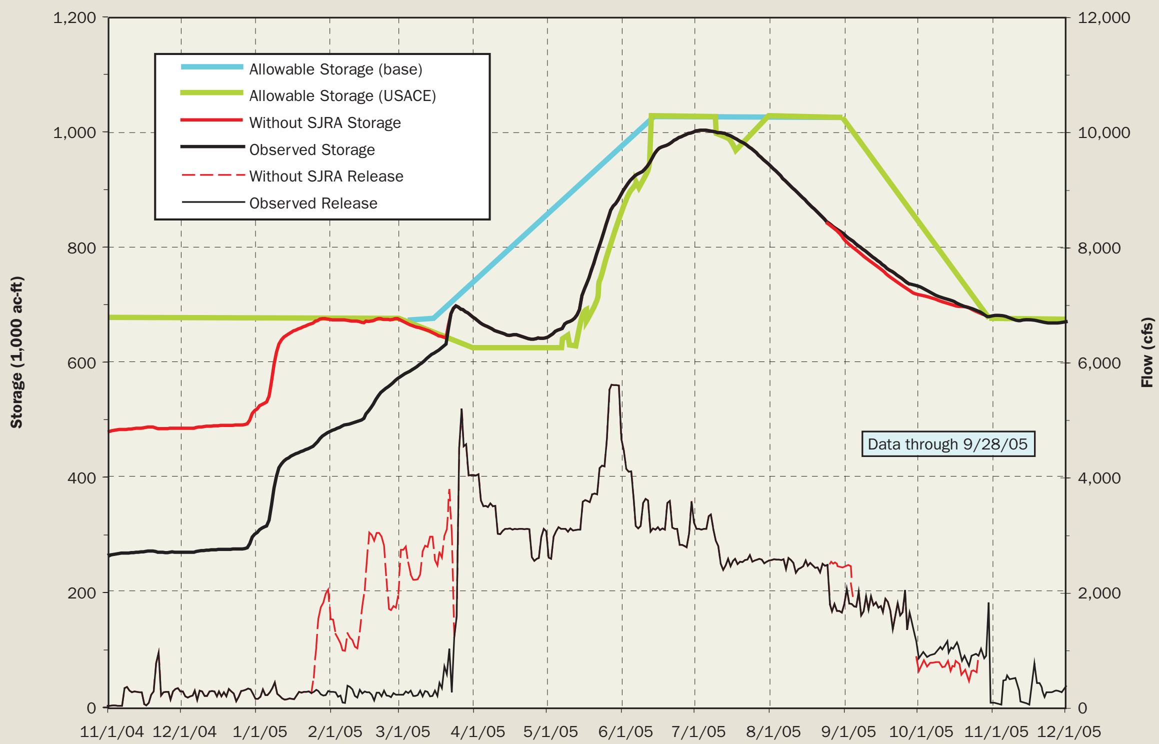


Figure 2-7
San Joaquin River Agreement Storage and Flow Impacts
Merced River - Lake McClure Storage and Release - 2005



in a reduced reliance on Merced River diversions. Any reductions in Merced River diversions would offset the 215,197 acre-foot storage impact. The impact of the conservation measures on Merced River diversions is in the process of being quantified and was not available at the time of publication of this report.

Assuming that the storage impact in Lake McClure was 215,197 acre-feet after the 2004 SJRA operation, the wet conditions in water year 2005 resulted in the complete replenishment of this water between January 25, 2005 and March 23, 2005 as shown in Figure 2-7. In compliance with D-1641, none of the following were in effect when this storage was replenished:

"(T)he USBR is releasing water from New Melones Reservoir for purpose of meeting the Vernalis salinity objective, or…Standard Permit Term 93 is in effect, or…salinity objectives at Vernalis are not being met."

Following the 2004 VAMP operation, the cumulative impact of the SJRA on storage in New Don Pedro Reservoir was a reduction of 11,151 acre-feet (see Table 2-8). This storage deficit was erased as a result of flood control operations in late January and early February 2005 as shown in Figure 2-8. This storage replenishment was also in compliance of the D-1641 terms noted above.

SUMMARY OF HISTORICAL VAMP OPERATIONS

2005 marks the sixth year of VAMP operation in compliance with D-1641. A summary of the VAMP target flows for these first six years is provided in Table 2-9. A summary of the SJRGA supplemental water contributions is provided in Table 2-10. The Hydrology Group monitors the cumulative impact of the SJRA on reservoir storage and stream flows. Plots of storage and flow impacts throughout the five years of VAMP operation are provided in Appendix D-1, Figures 1 through 4.

Over the first six 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.

Table 2-8
Storage Impact History, New Don Pedro Reservoir (Tuolumne River)

Calendar Year	VAMP Supplemental Water (acre-feet)	SJRA Storage Impact Replenishment (acre-feet)	End of Year Cumulative Storage Impact (acre-feet)
2000	22,651	14,955 (Sep.-Oct. 2000)	-7,696
2001	14,061	7,696 (Jan.-Feb. 2001)	-14,061
2002	0	0	-14,061
2003	9,729	0	-23,790
2004	11,151	23,790 (March 2004)	-11,151
2005	0	11,151 (Jan.-Feb. 2005)	0

Figure 2-8
San Joaquin River Agreement Storage and Flow Impacts
Tuolumne River - New Don Pedro Reservoir Storage and Release - 2005

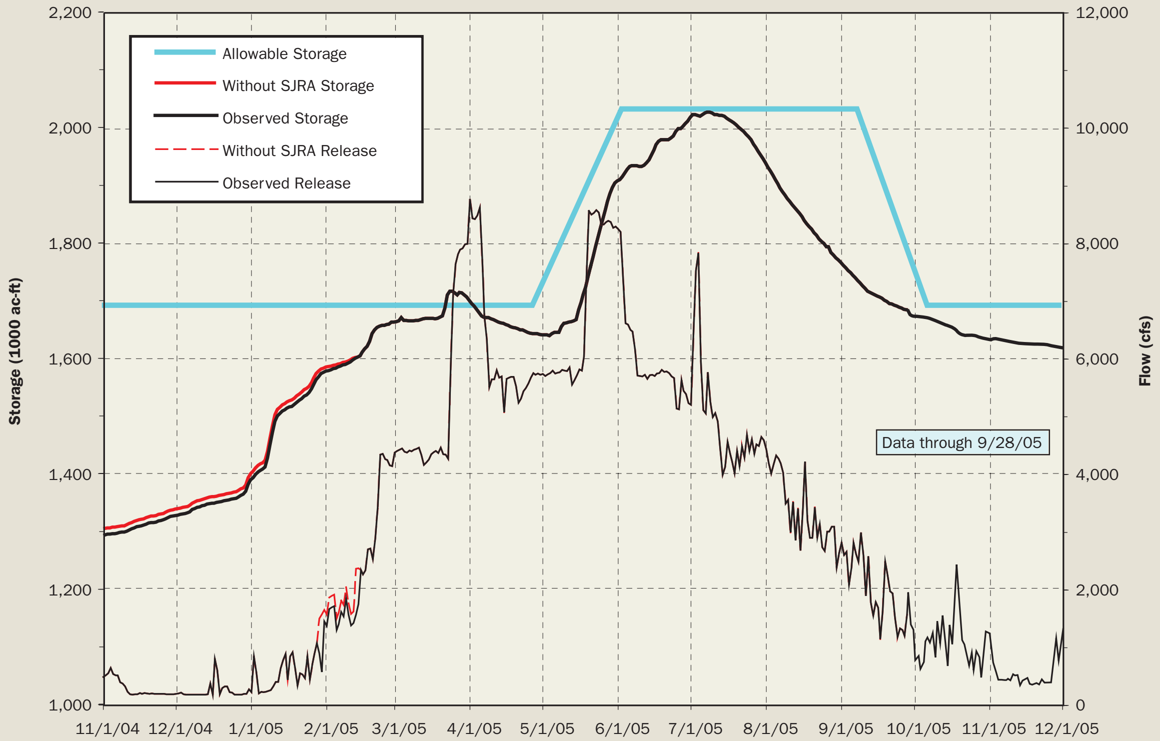


Table 2-9
Summary of VAMP Flows, 2000-2005

Year	60-20-20 Water Year Hydrologic Classification	VAMP Numerical Indicator	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	5,700	5,869	4,800	77,680	2,250	2,155
2001	Dry	2	4,450	4,224	2,909	78,650	1,500	1,420
2002	Dry	2	3,200	3,301	2,757	33,430	1,500	1,430
2003	Below Normal	3	3,200	3,235	2,290	58,065	1,500	1,446
2004	Dry	2	3,200	3,155	2,088	65,591	1,500	1,331
2005	Wet	5	>7,000	10,390	10,390	0	2,250	2,986 [a]

[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.

Table 2-10
Summary of VAMP Supplemental Water Contributions, 2000-2004

Year	VAMP Supplemental Water (acre-feet)		Supplemental Water (acre feet)					
			Merced ID	OID	SSJID	SJRECWA	MID	TID
2000	77,680	Observed:	46,750	(a)	(b)	8,280	15,200	7,450
		Division Agreement:	45,160	7,300	7,300	7,300	16,920	8,300
		Deviation:	+ 1590	0	0	+ 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:	38,257	5,039	5,039	(c)	4,864.5	4,864.5
		Division Agreement:	38,065	5,000	5,000	5,000	5,000	5,000
		Deviation:	+ 192	+ 39	+ 39	0	-135.5	-135.5
2004	65,591	Observed:	42,680	5,880	5,880	(c)	5,575.5	5,575.5
		Division Agreement:	41,500	7,045.5	7,045.5	5,000	5,000	5,000
		Deviation:	+ 1,180	- 1165.5	- 1165.5	0	+ 575.5	+ 575.5
2005	0	Observed:	0	0	0	0	0	0
		Division Agreement:	0	0	0	0	0	0
		Deviation:	0	0	0	0	0	0

Chapter 3

Additional Water Supply Arrangements & Deliveries

The SJRA includes a provision (Paragraph 8.4) stating that "Merced Irrigation District (Merced) 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." Pursuant to Paragraph 8.5 of the SJRA, "Oakdale Irrigation District (OID) shall sell 15,000 acre-feet of water to the USBR in every year of (the) Agreement…In addition to the 15,000 acre-feet, Oakdale will sell the difference between the water made available to VAMP under the SJRGA agreement and 11,000 acre-feet." This water 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

Paragraph 8.4 of the SJRA states that "Merced Irrigation District (Merced) 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." This 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 Merced ID.

The schedule for the 2005 Fall SJRA Transfer was finalized on September 26, 2005, with the transfer commencing on October 1, 2005. A daily summary table of the Merced 2005 Fall SJRA Transfer is provided as Table 3-1.

OAKDALE IRRIGATION DISTRICT

Pursuant to Paragraph 8.5 of the SJRA, "Oakdale Irrigation District (OID) shall sell 15,000 acre-feet of water to the USBR in every year of (the) Agreement…In addition to the 15,000 acre-feet, Oakdale will sell the difference between the water made available to VAMP under the SJRGA agreement and 11,000 acre-feet." This water is referred to as the Difference Water.

OID did not provide any supplemental water for the 2005 VAMP operation, therefore the amount of additional water purchased by the USBR from OID was 26,000 acre-feet (15,000 plus 11,000). 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 OID additional water was released from New Melones Reservoir by the USBR October 1, 2005, and December 1, 2005, as shown in Table 3-2.

Table 3-1
2005 Merced Irrigation District SJRA Fall Water Transfer
Daily Summary (Final)

		SCHEDULED			OBSERVED				
		Transfer Water			Observed Flow			Transfer Water	
Date	Base Flow (cfs) {1}	Daily Flow Rate (cfs) {2}	Cumulative Volume (ac-ft) {3}	Target Flow [A] (cfs) {4} = {1}+{2}	Merced R at Shaffer Bridge [PG&E] (cfs) {5}	Merced R at Cressey [DWR] (cfs) {6}	For Transfer [A] (cfs) {7}	Daily Flow Rate (cfs) {8} = {7}-{1}	Cumulative Volume (ac-ft) {9}
01-Oct-05	30	125	248	155	266	279	266	236	468
02-Oct-05	30	125	496	155	204	202	204	174	813
03-Oct-05	30	125	744	155	190	184	190	160	1,131
04-Oct-05	30	125	992	155	184	176	184	154	1,436
05-Oct-05	30	125	1,240	155	197	190	197	167	1,767
06-Oct-05	30	125	1,488	155	194	193	194	164	2,093
07-Oct-05	30	125	1,736	155	195	196	195	165	2,420
08-Oct-05	30	125	1,983	155	184	191	184	154	2,725
09-Oct-05	30	150	2,281	180	228	230	228	198	3,118
10-Oct-05	30	200	2,678	230	296	287	296	266	3,646
11-Oct-05	30	300	3,273	330	380	350	350	320	4,280
12-Oct-05	30	300	3,868	330	397	370	370	340	4,955
13-Oct-05	30	300	4,463	330	380	360	360	330	5,609
14-Oct-05	30	300	5,058	330	376	356	356	326	6,256
15-Oct-05	30	300	5,653	330	372	354	354	324	6,899
16-Oct-05	85	300	6,248	385	416	387	387	302	7,498
17-Oct-05	85	300	6,843	385	430	404	404	319	8,130
18-Oct-05	85	250	7,339	335	400	381	381	296	8,717
19-Oct-05	85	200	7,736	285	347	343	343	258	9,229
20-Oct-05	85	200	8,132	285	346	332	332	247	9,719
21-Oct-05	85	200	8,529	285	355	339	339	254	10,223
22-Oct-05	85	200	8,926	285	368	351	351	266	10,750
23-Oct-05	85	200	9,322	285	367	357	357	272	11,290
24-Oct-05	85	200	9,719	285	370	349	349	264	11,814
25-Oct-05	85	200	10,116	285	450	410	410	325	12,458
26-Oct-05	85	200	10,512	285	461	428	428	21	12,500
27-Oct-05	85	200	10,909	285	484	443	443		
28-Oct-05	85	200	11,306	285	503	463	463		
29-Oct-05	85	200	11,702	285	490	451	451		
30-Oct-05	85	200	12,099	285	496	455	455		
31-Oct-05	85	200	12,496	285	504	448	448		

[A]: The Technical Appendix to the San Joaquin River Group Division Agreement states that "[T]he Merced River at Shaffer Bridge…will be used for flows between 0 and 300 cfs. …[F]or the flows above 300 cfs, measurements will be provided at the gage on the Merced River located near Cressey.

Table 3-2
USBR Release of Oakdale Irrigation District SJRA Additional Water

Date	OID SJRA Additional Water		Date	OID SJRA Additional Water	
	Flow Rate (cfs)	Cumulative Volume (ac-ft)		Flow Rate (cfs)	Cumulative Volume (ac-ft)
01-Oct-05	125	248	01-Nov-05	125	18,744
02-Oct-05	125	496	02-Nov-05	125	18,992
03-Oct-05	125	744	03-Nov-05	125	19,240
04-Oct-05	125	992	04-Nov-05	125	19,488
05-Oct-05	125	1,240	05-Nov-05	125	19,736
06-Oct-05	125	1,488	06-Nov-05	125	19,983
07-Oct-05	125	1,736	07-Nov-05	125	20,231
08-Oct-05	125	1,983	08-Nov-05	125	20,479
09-Oct-05	125	2,231	09-Nov-05	125	20,727
10-Oct-05	125	2,479	10-Nov-05	125	20,975
11-Oct-05	125	2,727	11-Nov-05	125	21,223
12-Oct-05	125	2,975	12-Nov-05	125	21,471
13-Oct-05	125	3,223	13-Nov-05	125	21,719
14-Oct-05	125	3,471	14-Nov-05	125	21,967
15-Oct-05	125	3,719	15-Nov-05	125	22,215
16-Oct-05	125	3,967	16-Nov-05	125	22,463
17-Oct-05	125	4,215	17-Nov-05	125	22,711
18-Oct-05	375	4,959	18-Nov-05	125	22,959
19-Oct-05	775	6,496	19-Nov-05	125	23,207
20-Oct-05	775	8,033	20-Nov-05	125	23,455
21-Oct-05	775	9,570	21-Nov-05	125	23,702
22-Oct-05	775	11,107	22-Nov-05	125	23,950
23-Oct-05	775	12,645	23-Nov-05	125	24,198
24-Oct-05	775	14,182	24-Nov-05	125	24,446
25-Oct-05	775	15,719	25-Nov-05	125	24,694
26-Oct-05	525	16,760	26-Nov-05	125	24,942
27-Oct-05	275	17,306	27-Nov-05	125	25,190
28-Oct-05	225	17,752	28-Nov-05	125	25,438
29-Oct-05	125	18,000	29-Nov-05	125	25,686
30-Oct-05	125	18,248	30-Nov-05	125	25,934
31-Oct-05	125	18,496	01-Dec-05	50	26,033

4 Head of Old River Barrier

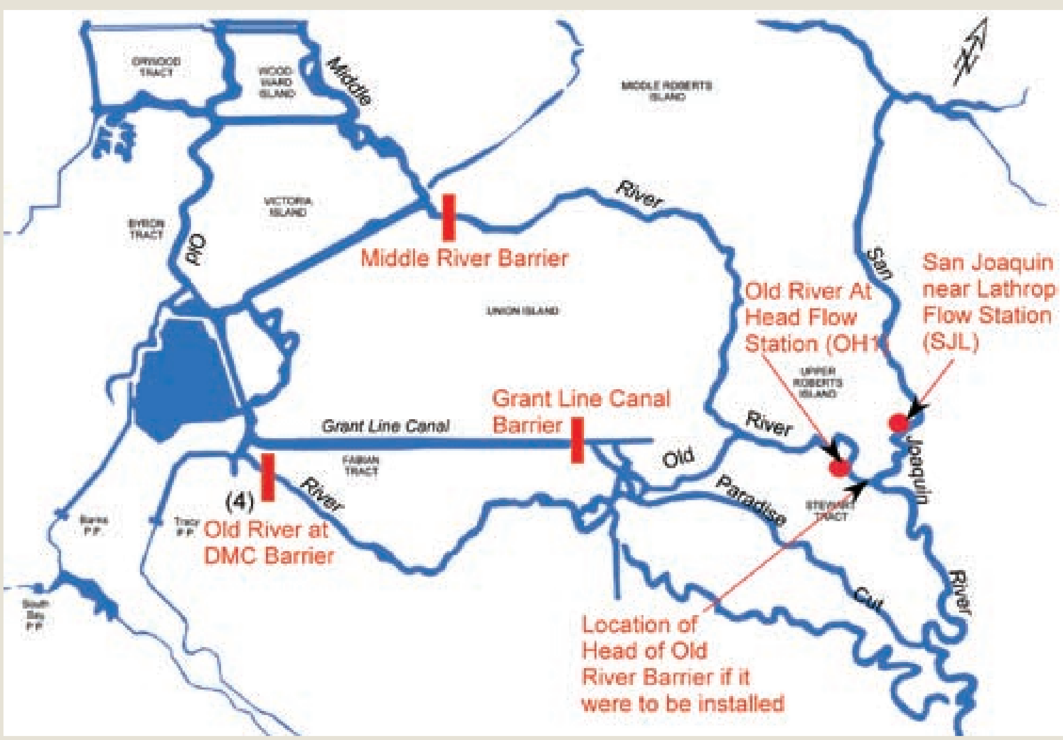
Installation of the spring temporary Head of Old River Barrier (HORB) was not performed in 2005 due to high flows in the San Joaquin River, nonetheless, the spring HORB is a component of the south delta Temporary Barriers Project (TBP). The TBP mitigates for low water levels in the south delta and improves water circulation and quality for agricultural purposes.

BACKGROUND

The spring HORB was first constructed in 1992. Since then, the barrier has been installed in 1994, 1996, 1997 (w/two culverts), and between 2000 and 2004. In 2000-2004 the barrier was installed with six culverts. The HORB was not installed in 1993, 1995, 1998, and 2005 due to high San Joaquin River flows. The HORB was not installed in 1999 due to landowner access problems. The HORB, a key component of VAMP, is intended to increase San Joaquin River Chinook salmon smolt survival by preventing them from entering Old River.

Although the HORB was not installed in 2005, the three agricultural barriers (the Grant Line Canal barrier, the Old River near Tracy barrier, and the Middle River barrier) were installed in mid-April and were removed at end of November 2005. Figure 4-1 shows the locations of the three agricultural barriers and the location of the HORB, if it were to be installed.

Figure 4-1
South Delta Temporary Barriers



FLOW MEASUREMENTS AT AND AROUND THE HEAD OF OLD RIVER

DWR operates two Acoustic Doppler Current Meters (ADCM) in the vicinity of the head of Old River, one in the San Joaquin River 1,500 feet downstream of Old River (San Joaquin River below Old River near Lathrop, SJL) and one in Old River 840 feet downstream of the head of Old River (Old River at Head, OH1) (Figure 4-1). 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 flows for the April 8, 2005 through June 30, 2005 period for the two ADCMs, along with the percentage of the total San Joaquin River flow at each ADCM. Figures 4-2 and 4-3 show plots of the daily minimum, maximum and mean flows for the two ADCMs. The San Joaquin River below Old River near Lathrop ADCM suffered from a technical glitch with the Handar data logger program resulting in a period of missing data from April 27, 2005 at 12:45 p.m. through April 29, 2005 at 1:45 p.m.

A comparison of the mean daily flow near Vernalis and the mean daily flow at Old River is presented in Table 4-2 and in Figure 4-4.

DWR at the end of each year conducts a Delta Simulation Model 2 (DSM2) modeling run to be included in the yearly published South Delta Temporary Barriers Monitoring Report. Data collected from the two ADCMs will be used to verify the flow split of the San Joaquin River and Old River at the confluence against that estimated using the model.

Seepage Monitoring

A seepage-monitoring program was initiated in April 2000, to evaluate the effects of HORB operations on seepage and groundwater on Upper Roberts Island. Although the HORB was not installed this year, DWR continued monitoring for seepage. In 2005 no seepage was observed at any of the monitoring sites despite the high flows in the San Joaquin River. Currently, DWR is in the process of completing the (2004-2005) seepage report.

Chapter 4

Table 4-1
Flows in Old River at Head and San Joaquin River below Old River

Date	Old River at Head (OH1)			San Joaquin River below Old River (SJL)			Flow Split (% of Total Flow)	
	Minimum Flow (cfs)	Maximum Flow (cfs)	Mean Flow (cfs)	Minimum Flow (cfs)	Maximum Flow (cfs)	Mean Flow (cfs)	OH1	SJL
4/1/2005								
4/2/2005								
4/3/2005								
4/4/2005								
4/5/2005								
4/6/2005								
4/7/2005								
4/8/2005	5,538	6,339	5,946	4,753	5,830	5,383	52.5%	47.5%
4/9/2005	5,279	5,822	5,558	4,593	5,525	5,151	51.9%	48.1%
4/10/2005	5,012	5,603	5,295	4,446	5,344	4,908	51.9%	48.1%
4/11/2005	4,732	5,315	5,056	4,119	5,020	4,693	51.9%	48.1%
4/12/2005	4,616	5,212	4,968	4,085	4,931	4,611	51.9%	48.1%
4/13/2005	4,794	5,335	5,119	4,219	5,187	4,766	51.8%	48.2%
4/14/2005	4,570	5,308	4,889	4,213	4,891	4,636	51.3%	48.7%
4/15/2005	4,208	4,828	4,563	3,896	4,579	4,290	51.5%	48.5%
4/16/2005	4,201	4,637	4,446	3,772	4,472	4,127	51.9%	48.1%
4/17/2005	4,044	4,557	4,327	3,617	4,428	4,043	51.7%	48.3%
4/18/2005	3,984	4,518	4,229	3,559	4,340	4,013	51.3%	48.7%
4/19/2005	3,878	4,355	4,146	3,519	4,258	3,918	51.4%	48.6%
4/20/2005	3,809	4,415	4,143	3,333	4,154	3,785	52.3%	47.7%
4/21/2005	3,677	4,311	4,020	3,154	4,105	3,685	52.2%	47.8%
4/22/2005	3,477	4,114	3,882	2,986	4,023	3,557	52.2%	47.8%
4/23/2005	3,287	4,128	3,719	2,763	3,848	3,451	51.9%	48.1%
4/24/2005	3,163	4,083	3,644	2,668	3,806	3,384	51.9%	48.1%
4/25/2005	3,079	4,010	3,550	2,523	3,770	3,300	51.8%	48.2%
4/26/2005	2,838	3,723	3,348	2,229	3,595	3,110	51.8%	48.2%
4/27/2005	2,527	3,623	3,193					
4/28/2005	2,570	3,645	3,199					
4/29/2005	2,870	3,703	3,359					
4/30/2005	2,862	3,702	3,378	2,532	3,781	3,284	50.7%	49.3%
5/1/2005	3,135	3,898	3,517	2,826	3,969	3,434	50.6%	49.4%
5/2/2005	3,352	3,970	3,716	3,156	4,087	3,631	50.6%	49.4%
5/3/2005	3,513	4,075	3,821	3,195	4,092	3,727	50.6%	49.4%
5/4/2005	3,466	4,096	3,768	3,155	4,092	3,712	50.4%	49.6%
5/5/2005	3,259	3,946	3,642	3,041	4,003	3,552	50.6%	49.4%
5/6/2005	3,293	4,047	3,713	2,864	4,043	3,589	50.9%	49.1%
5/7/2005	3,352	4,219	3,838	2,967	4,178	3,713	50.8%	49.2%
5/8/2005	3,442	4,322	3,935	3,115	4,260	3,809	50.8%	49.2%
5/9/2005	3,473	4,381	4,029	3,003	4,421	3,823	51.3%	48.7%
5/10/2005	3,663	4,509	4,165	3,372	4,473	4,008	51.0%	49.0%
5/11/2005	3,761	4,524	4,204	3,535	4,498	4,080	50.7%	49.3%
5/12/2005	3,850	4,523	4,207	3,613	4,549	4,096	50.7%	49.3%
5/13/2005	3,945	4,523	4,252	3,642	4,554	4,125	50.8%	49.2%
5/14/2005	4,038	4,502	4,282	3,735	4,489	4,133	50.9%	49.1%
5/15/2005	4,070	4,442	4,258	3,677	4,476	4,097	51.0%	49.0%
5/16/2005	4,022	4,426	4,237	3,643	4,392	4,097	50.8%	49.2%
5/17/2005	3,928	4,387	4,158	3,535	4,348	4,040	50.7%	49.3%
5/18/2005	3,726	4,289	4,066	3,422	4,314	3,960	50.7%	49.3%
5/19/2005	3,806	4,410	4,220	3,380	4,485	4,084	50.8%	49.2%
5/20/2005	4,220	4,837	4,540	3,652	4,738	4,335	51.2%	48.8%
5/21/2005	4,638	5,387	5,079	4,050	5,192	4,751	51.7%	48.3%
5/22/2005	5,175	5,808	5,528	4,460	5,489	5,096	52.0%	48.0%
5/23/2005	5,421	6,058	5,802	4,739	5,696	5,315	52.2%	47.8%
5/24/2005	5,557	6,231	5,966	4,742	5,800	5,433	52.3%	47.7%
5/25/2005	5,705	6,370	6,086	4,852	5,932	5,570	52.2%	47.8%
5/26/2005	5,770	6,580	6,265	5,009	6,090	5,639	52.6%	47.4%
5/27/2005	6,045	6,549	6,358	5,080	6,101	5,719	52.6%	47.4%
5/28/2005	6,124	6,654	6,401	5,356	6,268	5,865	52.2%	47.8%
5/29/2005	6,345	6,788	6,577	5,619	6,381	5,965	52.4%	47.6%
5/30/2005	6,498	7,027	6,786	5,846	6,420	6,141	52.5%	47.5%
5/31/2005	6,788	7,110	6,931	5,806	6,469	6,204	52.8%	47.2%
6/1/2005	6,755	7,126	6,948	5,830	6,504	6,238	52.7%	47.3%
6/2/2005	6,822	7,198	7,023	5,917	6,611	6,270	52.8%	47.2%
6/3/2005	7,005	7,276	7,160	5,906	6,635	6,297	53.2%	46.8%
6/4/2005	7,076	7,417	7,214	5,944	6,773	6,406	53.0%	47.0%
6/5/2005	7,091	7,427	7,261	5,922	6,969	6,476	52.9%	47.1%
6/6/2005	7,062	7,472	7,255	5,996	6,849	6,469	52.9%	47.1%
6/7/2005	6,812	7,400	7,056	6,092	6,738	6,409	52.4%	47.6%
6/8/2005	6,415	6,961	6,691	5,898	6,583	6,207	51.9%	48.1%
6/9/2005	6,200	6,676	6,399	5,561	6,232	5,931	51.9%	48.1%
6/10/2005	5,777	6,324	5,983	5,222	5,876	5,642	51.5%	48.5%
6/11/2005	5,332	5,897	5,597	4,933	5,581	5,314	51.3%	48.7%
6/12/2005	4,844	5,375	5,105	4,762	5,359	5,050	50.3%	49.7%
6/13/2005	4,689	5,143	4,872	4,566	5,147	4,829	50.2%	49.8%
6/14/2005	4,460	4,898	4,663	4,322	4,899	4,609	50.3%	49.7%
6/15/2005	4,293	4,764	4,520	4,035	4,686	4,445	50.4%	49.6%
6/16/2005	3,877	4,497	4,192	3,727	4,470	4,145	50.3%	49.7%
6/17/2005	3,669	4,290	3,890	3,251	4,269	3,831	50.4%	49.6%
6/18/2005	3,389	4,007	3,704	2,925	4,128	3,616	50.6%	49.4%
6/19/2005	3,196	3,897	3,623	2,607	4,048	3,504	50.8%	49.2%
6/20/2005	3,163	4,024	3,577	2,494	4,029	3,419	51.1%	48.9%
6/21/2005	2,794	3,843	3,294	2,085	3,915	3,241	50.4%	49.6%
6/22/2005	2,617	3,473	3,154	2,054	3,850	3,172	49.9%	50.1%
6/23/2005	2,637	3,616	3,262	1,922	3,791	3,111	51.2%	48.8%
6/24/2005	2,794	3,902	3,299	1,665	3,710	3,001	52.4%	47.6%
6/25/2005	2,499	3,773	3,083	1,587	3,505	2,880	51.7%	48.3%
6/26/2005	2,511	3,518	2,936	1,574	3,377	2,768	51.5%	48.5%
6/27/2005	2,392	3,200	2,804	1,815	3,260	2,688	51.1%	48.9%
6/28/2005	2,371	3,300	2,792	1,443	3,179	2,575	52.0%	48.0%
6/29/2005	2,596	3,296	2,820	1,097	3,114	2,512	52.9%	47.1%
6/30/2005	2,319	3,153	2,790	1,237	3,219	2,559	52.2%	47.8%

Missing Data

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

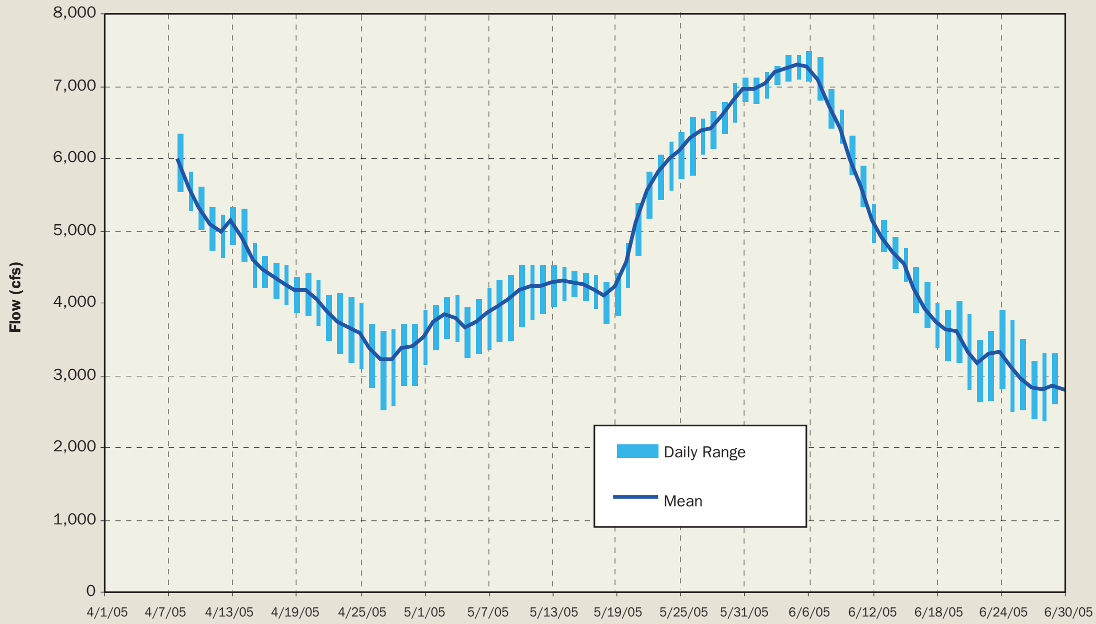


Figure 4-3
Daily Flow Range - San Joaquin River below Old River Gage

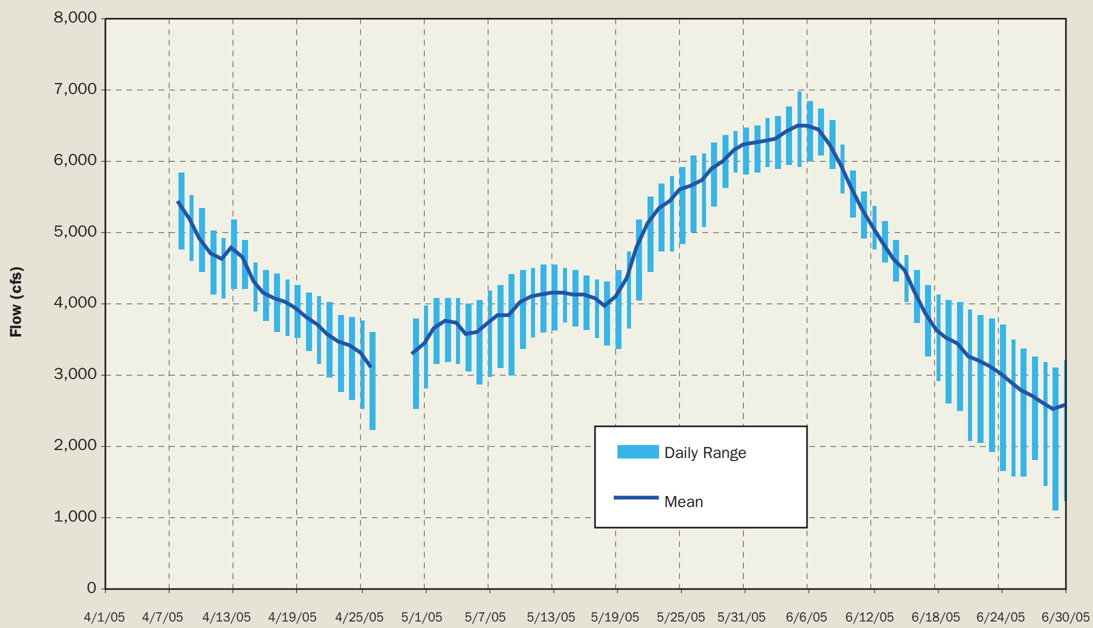


Table 4-2
San Joaquin River and Old River Mean Daily Flows

Date	Mean Daily Flow (cfs)			
	Old River at Head [A]	San Joaquin River below Old River [B]	San Joaquin River at Old River [C]=[A]+[B]	San Joaquin River near Vernalis [D]
4/8/2005	5,946	5,383	11,329	12,000
4/9/2005	5,558	5,151	10,709	11,400
4/10/2005	5,295	4,908	10,203	10,600
4/11/2005	5,056	4,693	9,749	10,200
4/12/2005	4,968	4,611	9,579	10,200
4/13/2005	5,119	4,766	9,886	10,600
4/14/2005	4,889	4,636	9,524	9,690
4/15/2005	4,563	4,290	8,853	9,090
4/16/2005	4,446	4,127	8,573	8,840
4/17/2005	4,327	4,043	8,370	8,740
4/18/2005	4,229	4,013	8,242	8,530
4/19/2005	4,146	3,918	8,064	8,450
4/20/2005	4,143	3,785	7,928	8,360
4/21/2005	4,020	3,685	7,705	8,160
4/22/2005	3,882	3,557	7,439	7,840
4/23/2005	3,719	3,451	7,170	7,620
4/24/2005	3,644	3,384	7,028	7,420
4/25/2005	3,550	3,300	6,850	7,160
4/26/2005	3,348	3,110	6,458	6,730
4/27/2005	3,193			6,500
4/28/2005	3,199			6,800
4/29/2005	3,359			7,090
4/30/2005	3,378	3,284	6,662	7,200
5/1/2005	3,517	3,434	6,951	7,720
5/2/2005	3,716	3,631	7,347	8,180
5/3/2005	3,821	3,727	7,549	8,320
5/4/2005	3,768	3,712	7,480	8,070
5/5/2005	3,642	3,552	7,194	7,890
5/6/2005	3,713	3,589	7,302	8,130
5/7/2005	3,838	3,713	7,551	8,400
5/8/2005	3,935	3,809	7,744	8,610
5/9/2005	4,029	3,823	7,852	8,820
5/10/2005	4,165	4,008	8,173	9,060
5/11/2005	4,204	4,080	8,284	9,110
5/12/2005	4,207	4,096	8,303	9,070
5/13/2005	4,252	4,125	8,377	9,130
5/14/2005	4,282	4,133	8,414	9,220
5/15/2005	4,258	4,097	8,355	9,250
5/16/2005	4,237	4,097	8,334	9,120
5/17/2005	4,158	4,040	8,198	8,970
5/18/2005	4,066	3,960	8,026	8,940
5/19/2005	4,220	4,084	8,305	9,340
5/20/2005	4,540	4,335	8,875	10,200
5/21/2005	5,079	4,751	9,830	11,400
5/22/2005	5,528	5,096	10,624	12,100
5/23/2005	5,802	5,315	11,116	12,600
5/24/2005	5,966	5,433	11,400	13,000
5/25/2005	6,086	5,570	11,656	13,200
5/26/2005	6,265	5,639	11,904	13,500
5/27/2005	6,358	5,719	12,077	13,500
5/28/2005	6,401	5,865	12,267	13,800
5/29/2005	6,577	5,965	12,542	14,200
5/30/2005	6,786	6,141	12,926	14,700
5/31/2005	6,931	6,204	13,136	15,100
6/1/2005	6,948	6,238	13,186	15,000
6/2/2005	7,023	6,270	13,293	15,100
6/3/2005	7,160	6,297	13,458	15,200
6/4/2005	7,214	6,406	13,619	15,300
6/5/2005	7,261	6,476	13,737	15,400
6/6/2005	7,255	6,469	13,724	15,300
6/7/2005	7,056	6,409	13,466	14,700
6/8/2005	6,691	6,207	12,898	13,900
6/9/2005	6,399	5,931	12,330	13,200
6/10/2005	5,983	5,642	11,625	12,200
6/11/2005	5,597	5,314	10,911	11,300
6/12/2005	5,105	5,050	10,155	10,600
6/13/2005	4,872	4,829	9,701	10,100
6/14/2005	4,663	4,609	9,272	9,770
6/15/2005	4,520	4,445	8,964	9,350
6/16/2005	4,192	4,145	8,338	8,640
6/17/2005	3,890	3,831	7,720	8,020
6/18/2005	3,704	3,616	7,320	7,710
6/19/2005	3,623	3,504	7,127	7,540
6/20/2005	3,577	3,419	6,995	7,370
6/21/2005	3,294	3,241	6,535	6,920
6/22/2005	3,154	3,172	6,326	6,720
6/23/2005	3,262	3,111	6,373	6,800
6/24/2005	3,299	3,001	6,300	6,620
6/25/2005	3,083	2,880	5,963	6,270
6/26/2005	2,936	2,768	5,704	6,010
6/27/2005	2,804	2,688	5,492	5,740
6/28/2005	2,792	2,575	5,367	5,560
6/29/2005	2,820	2,512	5,333	5,650
6/30/2005	2,790	2,559	5,349	5,680

Missing data

OLD RIVER AND SAN JOAQUIN RIVER KODIAK TRAWLING

Since the spring HORB was not constructed this year, there was no fish entrainment monitoring at the HORB. As an alternative to the entrainment monitoring, the Department of Fish and Game (DFG) towed a Kodiak trawl in Old River during the VAMP test period. The Old River Kodiak Trawl (ORKT) was conducted in a similar manner to the Mossdale Kodiak Trawl (MKT) which is conducted year-round on the San Joaquin River. Both trawls sampled on a daily basis during the first three weeks of May. Comparison of salmon catch between the two trawls may provide insights into salmon migration from the San Joaquin River into Old River.

METHODS AND RESULTS

The ORKT and MKT used similar sampling gear and protocols. Fish were collected using a Kodiak trawl towed between two boats. Trawling took place in Old River, downstream of the head, and in the San Joaquin River, upstream of the head of Old River (Figure 4-5). The Kodiak trawl is 19.8 m long, made of variable mesh (ranging from 1.27 cm stretch mesh at the cod-end to 5.08 cm mesh at the mouth), and has a mouth opening of 1.83 m by 7.62 m. The effective sampling area of the net was estimated at 12.5 m^2 (USFWS 2003). All trawling occurred during daylight hours, starting around 0800 hrs. Typically, the MKT and ORKT started within a half hour of each other and ended within an hour of each other. The Kodiak trawl was towed against the current for 20 minutes. Although the boats and net faced upstream, the high flows carried the boats and net downstream. Typically, five tows were completed before the ORKT net was retrieved and reset upstream. A total of 15 tows per day, seven days a week, were attempted from May 2 through May 20. Boat troubles and a snagged net resulted in two days with fewer than 15 tows in Old River.

For the ORKT, all fish were counted and measured (fork length) to the nearest millimeter. All salmon were checked for a clipped adipose fin or spray dyed color-mark. Salmon with a clipped adipose fin were sacrificed for CWT reading. For this comparison of the MKT and ORKT salmon catch, CWT salmon refers to all salmon with a clipped adipose fin. The unmarked salmon catch represents both hatchery and naturally spawned salmon. A flow meter was used to estimate the volume of water sampled. All sample statistics are reported as the mean ± standard deviation unless otherwise noted. The average volume of water sampled per tow by the MKT (10,520 ± 2,216 m^3) was greater than the ORKT (7,224 ± 1,074 m^3). Catch-per-unit-effort (CPUE) for both trawling efforts was standardized to the number of salmon per 10,000 m^3. CPUE was calculated by dividing the catch by the volume (m^3) of water sampled and then multiplying the result by 10,000.

Figure 4-4
San Joaquin River Flow near Vernalis and at Old River

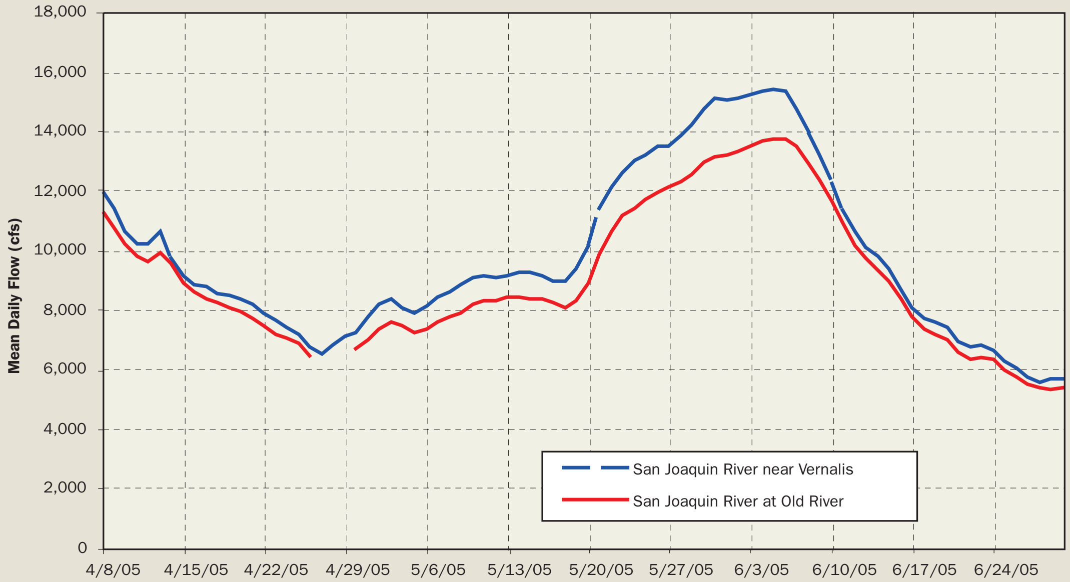
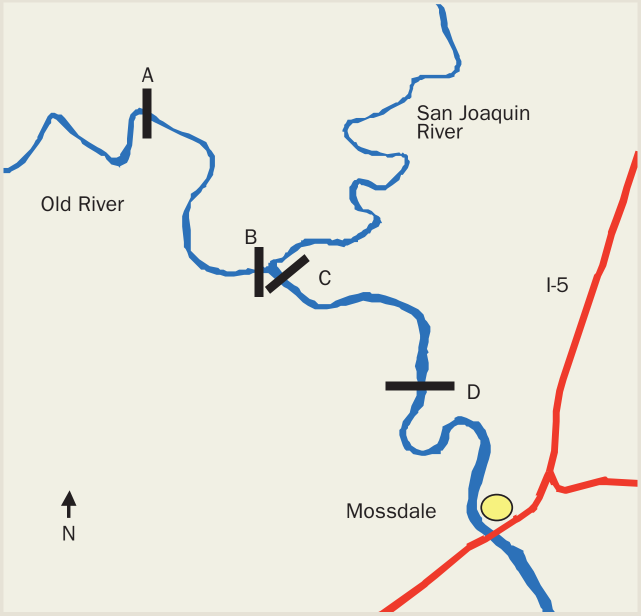


Figure 4-5
Map of the 2005 Kodiak trawl sample locations on Old and San Joaquin Rivers. The Old River Kodiak trawl sampled between letters A and B, and the Mossdale Kodiak trawl sampled between letters C and D.



The ORKT caught approximately 1,000 fish, representing 14 species, in 276 tows during the 19 day sampling period in Old River. The most abundant species was Chinook salmon followed by splittail (*Pogonichthys macrolepidotus*) (Table 4-3). Of the 709 salmon caught, 370 were unmarked, 318 were classified as CWT, and 21 had a color-mark. A two-tailed t-test (degrees of freedom (df) = 686, Probability (P) < 0.01, t statistic = 10.0) indicated fork lengths for unmarked salmon (95 ± 7.9 mm) were significantly larger than CWT salmon fork lengths (89 ± 6.9 mm).

The MKT caught approximately 4,500 fish, representing 17 species, in 285 tows during the same 19 day sampling period in the San Joaquin River. The most abundant species caught was splittail followed by Chinook salmon (Table 4-3).

Table 4-3
The raw abundance and composition of fishes caught in the Kodiak trawl in Old River (ORKT) and in the San Joaquin River (MKT) for trawls conducted May 2-20, 2005. Chinook salmon catch is divided into CWT salmon, unmarked salmon, and color-marked salmon.

Species	ORKT	MKT
Bigscale Logperch	1	
Black Crappie	1	1
Bluegill	6	1
Carp	11	2
Channel Catfish	2	1
Goldfish		7
Golden Shiner		6
Inland Silverside	1	9
Largemouth Bass		3
Redear Sunfish	2	2
Red Shiner		3
Sacramento Blackfish		2
Sacramento Pikeminnow	1	5
Sacramento Sucker	1	
Splittail	218	2,917
Steelhead	4	4
Striped Bass	3	
Threadfin shad	28	61
White Catfish	27	5
Chinook Salmon	**709**	**1,534**
CWT Salmon	318	466
Unmarked Salmon	370	812
Color-Marked Salmon	21	256
Total	**1,015**	**4,563**

Of the 1,534 salmon caught, 812 were unmarked, 466 were classified as CWT, and 256 had a color-mark. The mean length for unmarked salmon was 95 ± 9.8 mm for the 19 day sampling period. The mean unmarked salmon CPUEs in the MKT, from March through June, were highest during the VAMP period (Figure 4-6).

As part of the VAMP salmon survival studies, roughly 100,000 CWT salmon were released at Durham Ferry on two occasions. The effective number of CWT salmon released was estimated at 93,833 on May 2 and 91,563 on May 9. CWT salmon catch was the highest on May 3 in both Old River (Figure 4-7) and San Joaquin River (Figure 4-8). Overall, ORKT recaptured very few of the Durham Ferry released salmon. More salmon were recaptured from the May 2 release (77 salmon) than from the May 9 release (21 salmon).

To determine if CWT salmon were migrating similarly to unmarked salmon into the Old River, their daily ratios were compared between trawls. The daily ratio of CWT salmon to unmarked salmon was similar between the ORKT and MKT, although CWT salmon were proportionally higher in the ORKT during the VAMP salmon releases (Figure 4-9). The daily ratios of CWT to unmarked salmon were converted to percentages (percent of the combined CWT and unmarked catch) and arcsine transformed before testing whether there was a significant difference between the ORKT and MKT. A paired two-tailed t-test (df = 18, P = 0.13, t statistic = -1.60) indicates no significant difference in the daily percent of CWT salmon caught between the ORKT and MKT.

In order to compare salmon abundance between the San Joaquin River and Old River, salmon densities (calculated from the Kodiak trawls) were expanded by river flow and trawling duration. The following equation was used:

E = estimated number of salmon
D = fish density (fish/m^3)
F = river flow (m^3/s) during sampling
T = trawling time (s)
i = i^{th} tow
n = last tow with fish

$$E = \sum_{i=1}^{n} D_i * F_i * T_i$$

To determine how well this equation estimates salmon abundance in the San Joaquin River, abundance estimates for color-marked salmon were calculated and compared to the number of color-marked fish released. Eight groups of color-marked fish were released at Mossdale as part of DFG Region IV's MKT vulnerability study (see chapter 6). It was assumed all color-marked fish released upstream of the MKT, at Mossdale, passed the MKT while they were

Figure 4-6
The average daily densities of unmarked salmon caught
in the Mossdale Kodiak trawl on the San Joaquin River.

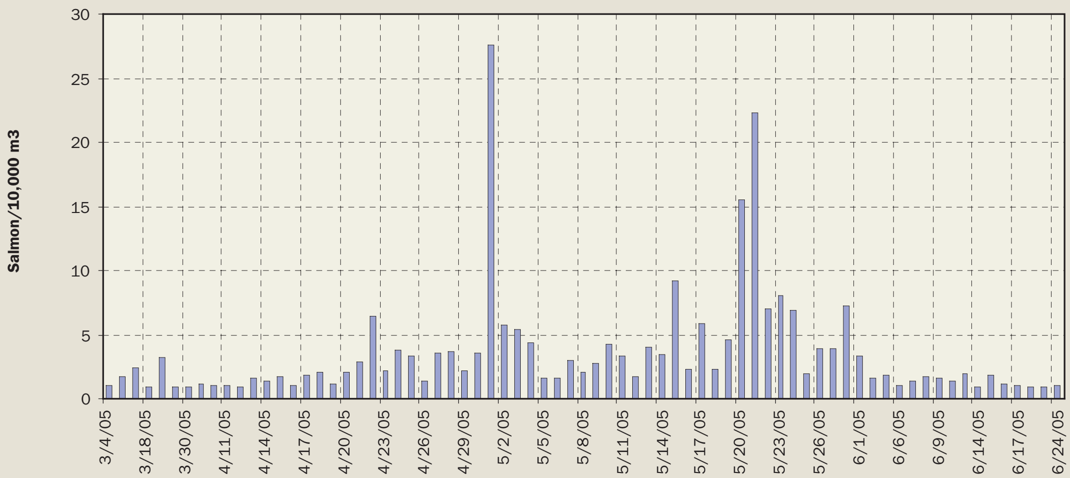


Figure 4-7
The total number of salmon by category (color-marked, coded wire tagged, and unmarked)
caught in daily five hour Kodiak trawling sessions (150,000 m³) in the San Joaquin River.

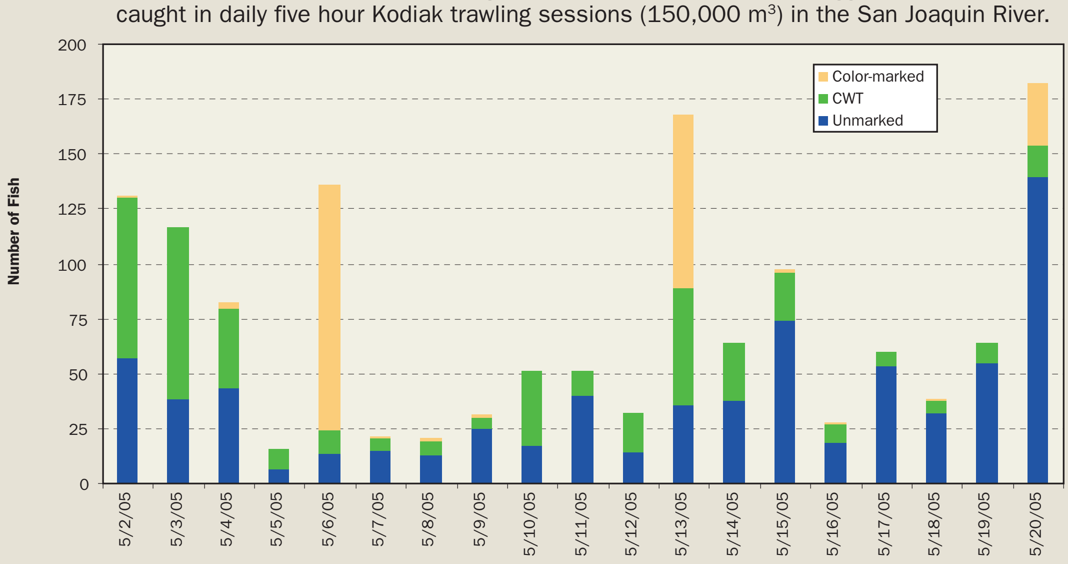


Figure 4-8

The total number of salmon by category (color-marked, coded wire tagged, and unmarked) caught in daily five hour Kodiak trawling sessions (150,000 m³) in Old River.

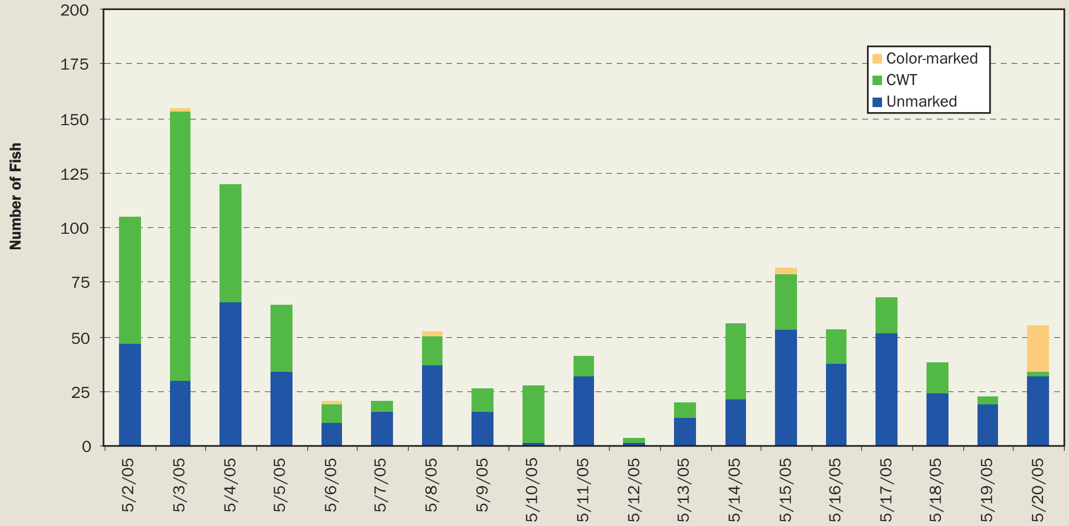
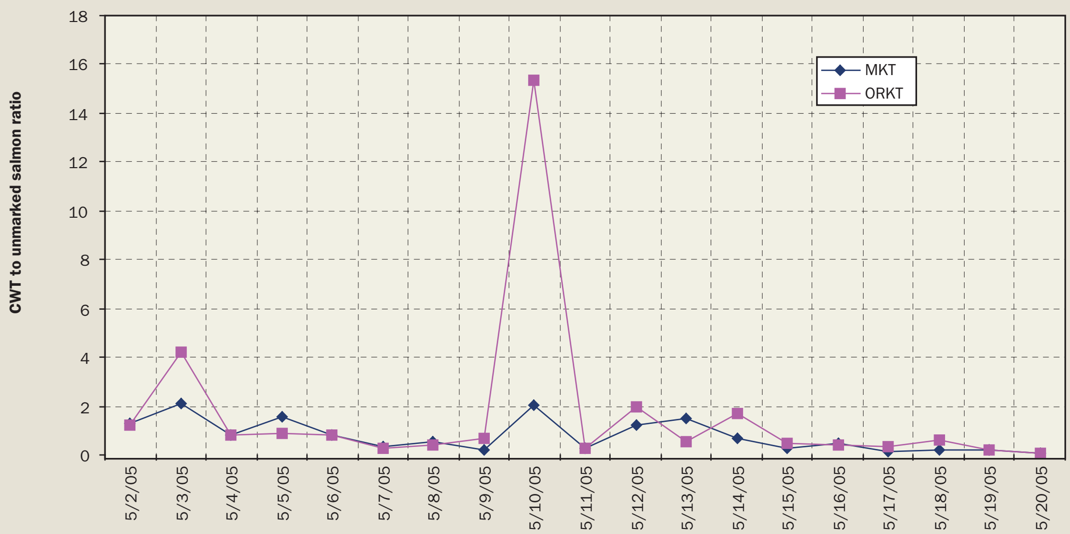


Figure 4-9

The ratio of CWT salmon to unmarked salmon caught in the Old River Kodiak trawl (ORKT) on Old River and the Mossdale Kodiak trawl (MKT) on the San Joaquin River.



trawling. Three of the color-mark groups were released when both MKT and ORKT were sampling. The estimated number of color-marked fish passing the MKT ranged from 6 % to 138 % of the color-marked salmon released upstream of the trawl, and averaged 50 % ± 38 % (Table 4-4). ORKT only caught color-marked salmon from the May 20 release (Table 4-5).

Flow data for the head of Old River (OH1) and San Joaquin River below Old River near Lathrop (SJL) was obtained from the California Data Exchange Center (http://cdec.water.ca.gov). Estimated flow on the San Joaquin River above Old River was calculated by summing flows from OH1 and SJL. The flow was split approximately equally between Old River and the San Joaquin River from May 2 through May 20 (Figure 4-10). The percent of water flowing down Old River ranged from 47 % (3,259 cfs) to 58 % (4,387 cfs), and averaged 51 % (4,060 cfs) ± 2 % (292 cfs).

As a general comparison of flows and fish between Old and San Joaquin Rivers, a daily five hour salmon abundance estimate was calculated for both CWT and unmarked salmon. The salmon abundance estimate was calculated using the previously mentioned equation; however, all daily 20 minute tows (n = 15) were used in the calculation. On a daily average, 55 ± 61 % of the unmarked salmon and 64 ± 43 % of the CWT salmon estimated in the San Joaquin River migrated down Old River (Table 4-6).

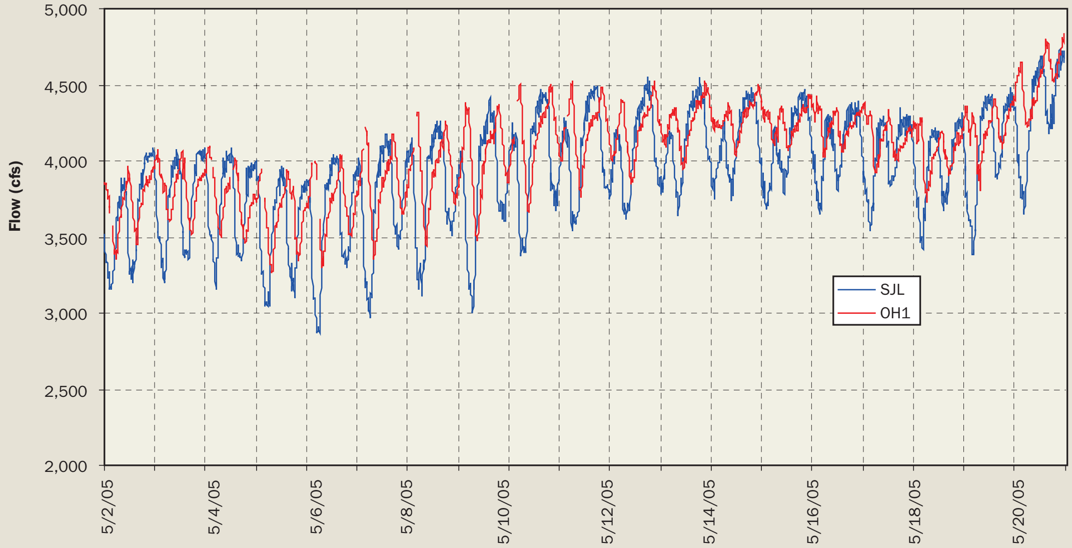
Table 4-4
The estimated number of color-marked salmon passing the Mossdale Kodiak trawl compared to the actual number of color-marked salmon released upstream of the trawl. Estimates based on salmon densities as calculated by the Mossdale Kodiak trawl multiplied by river flow (while trawling) and trawling duration. Percent is how close the estimated number is to the color-marked release number.

Date	Flow (cfs)	Density (salmon/m3)	Estimate	Released	Percent
4/6/05	12,800	0.000100	130	2,036	6%
4/15/05	8,518	0.000767	1,997	5,068	39%
4/22/05	7,077	0.001300	938	2,000	47%
4/29/05	6,337	0.000778	1,507	5,000	30%
5/6/05	7,301	0.003700	2,754	2,003	138%
5/13/05	7,882	0.001580	2,116	5,000	42%
5/20/05	8,910	0.000933	848	2,001	42%
5/27/05	11,576	0.000540	1,062	2,000	53%

Table 4-5
Total raw catch (first nine tows only) in the Mossdale and Old River Kodiak trawls, by tow and time, for three color-marked salmon releases on the San Joaquin River at Mossdale Landing. The asterisk in the Old River column indicates when the net was reset upstream.

	RedUC/Do (5/6/2005)		RedUC (5/13/2005)		RedLC (5/20/2005)	
Tow	Mossdale Catch Time	Old River Catch Time	Mossdale Catch Time	Old River Catch Time	Mossdale Catch Time	Old River Catch Time
1	0 (8:12)	0 (8:04)	0 (8:29)	0 (8:23)	0 (8:08)	0 (7:35)
2	72 (8:35)	0 (8:29)	6 (8:53)	0 (8:47)	0 (8:32)	0 (8:01)
3	59 (8:59)	0 (8:54)	19 (9:17)	0 (9:12)	25 (8:55)	0 (8:26)
4	3 (9:23)	0 (9:18)	53 (9:40)	0 (9:37)	2 (9:17)	0 (8:51)
5	0 (9:46)	0 (9:42)	1 (10:05)	0 (10:02)	2 (9:41)	0 (9:32)*
6	0 (10:10)	0 (10:06)	2 (10:41)	0 (10:55)*	0 (10:04)	12 (9:50)
7	0 (10:33)	0 (10:53)*	0 (11:04)	0 (11:20)	0 (10:28)	0 (10:15)
8	0 (10:57)	0 (11:17)	0 (11:28)	0 (11:45)	0 (10:51)	5 (10:46)
9	0 (11:20)	0 (11:42)	0 (11:51)	0 (12:10)	0 (11:26)	0 (11:26)*
Total catch	134	0	81	0	29	17

Figure 4-10
Flow at the head of Old River (OH1) and near Lathrop on the San Joaquin River (SJL) during the 2005 Kodiak trawl survey.



DISCUSSION

For the most part, trawling went well in Old River. Boat engine problems resulted in eight missed tows on the first day and a snagged net resulted in one missed tow on another day. MKT was able to complete all their tows during this time period.

Direct comparisons between ORKT and MKT are difficult for a variety of reasons. Biases that can affect catch include the habitat (channel width, depth and flow are not the same between and within the sample sites), the sporadic and uneven distribution of migrating salmon, boat and crew differences affecting how the Kodiak net is towed, and MKT and ORKT flow meters might have different calibrations which would effect water volume calculations. Using the ratio of CWT to unmarked salmon in each trawl minimizes some of these biases and other sampling differences, and allows the two rivers to be compared with some certainty. Although direct CPUE comparisons and abundance estimates are presented here, they are to provide general insights to salmon movement and must be viewed with caution.

To determine if marked salmon had a similar migration rate into Old River as unmarked salmon, the daily percent of CWT salmon was compared between the two rivers. Proportionally, CWT and unmarked salmon were migrating down Old River at the same rate. It appears the marking and subsequent release does not affect salmon outmigration relative to the unmarked fish. Although during the Durham Ferry releases, a higher proportion of CWT went down Old River compared to unmarked salmon. There might be some differences for the Durham Ferry released salmon. Once the CWT salmon results from the MKT are available, the Durham Ferry salmon catch can be compared to the other CWT salmon catches to specifically find if there is a migration difference into Old River for in-delta salmon releases.

It is not possible to determine the total number of Durham Ferry released CWT salmon that migrated down Old River. The ORKT caught very few salmon (combined, less than 0.05 %) from the two Durham Ferry releases. The 2002-2004 results from the 24 hour entrainment studies at the HORB indicate salmon released around noon at Durham Ferry start reaching the head of Old River in about 12 hours. Consequently, entrainment of Durham Ferry salmon is highest (63 ± 20 %) during the first night following a fish release. Only 16 ± 15 % of the total Durham Ferry salmon entrainment occurs during the following day. Extrapolating the ORKT day results to include the nighttime period would greatly underestimate the number of Durham Ferry fish migrating down Old River.

ORKT and the MKT salmon abundance estimates were calculated using the same method. Salmon abundance was estimated by multiplying salmon density by river flow and trawling duration. Although the abundance estimates based on the MKT vulnerability study might be more accurate, this method was not used since no vulnerability study was conducted in Old River. However, the color-marked salmon vulnerability study releases were used to provide information on the accuracy of the MKT salmon abundance estimates. The range in the accuracy of the eight estimates (Table 4-4) might be caused by several factors, such as the uneven distribution of salmon as they migrate downstream, the variability in trawling, and the ability to detect the color-mark on recaptured fish. On average, it appeared the MKT underestimated the color-marked fish by half. Thus, a correction factor could be used with these calculations to get a better estimate of outmigrating salmon.

The ORKT would probably have a smaller correction factor compared to the MKT. Since the channel is narrower in Old River than it is in the San Joaquin River, ORKT sampled a larger percentage of the channel width. The resulting calculated fish densities in Old River might be closer to the actual densities than the densities calculated in the San Joaquin River. Consequently, salmon catch in the MKT would be adjusted upward to a greater degree than in the ORKT. Adjusting both the MKT and ORKT for catch efficiencies would probably decrease the daily calculated percentages of salmon heading down Old River that are presented in Table 4-6.

Color-marked salmon released for the MKT vulnerability study were not recaptured by the ORKT on two of the three releases that occurred while ORKT was sampling. The most likely reason for the zero catch is that the net was being moved back upstream while the marked fish were migrating down Old River. Based on the timing of the MKT catch and the time ORKT caught color-marked fish in Old River, the boats trawling in Old River reached the end of the sampling area and picked up the net before the color-marked fish arrived. The net was then reset upstream (around 1100 hrs) after the color-marked fish entered Old River. This means that an approximately 1.5 mile stretch of river is not sampled as the net is moved back upstream. Any fish in this section of the stream will pass by undetected. On May 20, when color-marked fish were caught, the net was reset upstream earlier (0930 hrs). The ORKT was sampling near the head when marked fish entered Old River.

An attempt was made to estimate the number of salmon migrating down Old and San Joaquin River during the trawling periods. For these comparisons, it was assumed catch efficiency was the same between the ORKT and MKT.

Table 4-6
Estimated total number of unmarked and CWT salmon in a section of the San Joaquin upstream of Old River and at the head of Old River, for a 5 hour period per day, and the percent migrating down Old River. Estimates based on salmon densities from the Kodiak trawls multiplied by river flow and trawling duration.

	San Joaquin River		Old River		Percent down Old River		
Date	Unmarked	CWT	Unmarked	CWT	Flow	Unmarked	CWT
5/2/05	1,411	1,811	600	739	52%	43%	41%
5/3/05	994	2,061	390	1,633	51%	39%	79%
5/4/05	1,133	947	862	709	50%	76%	75%
5/5/05	158	244	423	382	49%	267%	157%
5/6/05	340	280	131	111	49%	39%	40%
5/7/05	400	136	201	61	48%	50%	45%
5/8/05	334	186	471	176	48%	141%	95%
5/9/05	670	138	208	137	49%	31%	99%
5/10/05	460	950	23	350	49%	5%	37%
5/11/05	1,095	321	432	132	49%	39%	41%
5/12/05	389	487	17	33	50%	4%	7%
5/13/05	993	1,476	181	100	50%	18%	7%
5/14/05	1,050	738	299	504	51%	29%	68%
5/15/05	2,059	621	765	361	51%	37%	58%
5/16/05	518	233	534	232	51%	103%	100%
5/17/05	1,491	193	738	234	51%	50%	121%
5/18/05	874	169	331	199	50%	38%	118%
5/19/05	1,581	279	275	56	50%	17%	20%
5/20/05	4,292	434	491	29	50%	11%	7%
Mean					50%	55%	64%
Standard Deviation					1%	61%	43%

As previously mentioned, the catch efficiency is probably different between the two trawls. Although we can correct for the MKT estimates based on the color-marked salmon releases, we have no correction for ORKT; thus, neither catch was adjusted. These abundance estimates are probably underestimating, to a different degree, the actual number of salmon in each river. When catch is adjusted for flow, it appears on a daily basis that a little more than half of the salmon in the San Joaquin River turn down Old River. During this time period, half of the San Joaquin River flow was also heading down Old River. In general terms, it appears salmon are going with the flow.

When comparing the ORKT and MKT salmon abundance estimates, the daily percentage of CWT and unmarked salmon heading down Old River is similar on most days. These results are similar to the previously mentioned CWT to unmarked salmon percent analysis. However, there is some variability among sampling days. If salmon always migrated in proportion to the flow split, we would expect low variability among the daily percentages of salmon migrating down Old River. However, the variability around the mean for both unmarked and CWT is large, e.g. ranges from 4 % to 267 % for unmarked salmon. The reason for this variability could be due to the natural variability in salmon migration which might then be compounded by trawling biases.

The 2005 flow-catch results differ from the 1995 Real-Time Monitoring (RTM) Program's Kodiak trawling results on the San Joaquin River at Dos Reis and head of Old River. RTM trawling indicated salmon densities were higher, except on one sampling day, in Old River than in the San Joaquin River (IEP 1996). In order to more accurately compare the 1995 RTM results to the 2005 Kodiak trawl results, the raw data from the 1995 Dos Reis and Old River trawls were obtained from the USFWS. The 1995 data was then analyzed using the same methods that were used on the

2005 data. For the 1995 trawling, it was assumed the catch efficiencies were the same between rivers. River flows at OH1 and SJL during the 1995 Kodiak trawling period (8 days) were estimated by using Vernalis flows and equating it to OH1 and SJL flows through regression analyses. On average, flows at OH1 were calculated at 9,971 ± 462 (95 % confidence interval) cfs and at SJL 8,812 ± 658 (95 % confidence interval) cfs. An estimated 53 % of the San Joaquin River flow went down Old River. When salmon density is expanded by flow, it appears on a daily average, 66 ± 17 % of the unmarked salmon and 70 ± 18 % of the CWT salmon migrated down Old River. These percentages are higher than the 2005 percentages for Old River. This could be due to the higher flows in 1995, compared to 2005, which might change downstream migration routes.

The RTM results also might be affected by the order in which Dos Reis and Old River were sampled. A single crew conducted five tows at Dos Reis and Old River. The Old River site was always sampled first, in the morning, and Dos Reis was sampled afterwards, late morning to midday. The higher 1995 salmon densities in Old River could be due to higher salmon activity and vulnerability in the morning than during midday. The 2005 Kodiak trawl results indicate more salmon are caught in the morning than midday. Salmon (unmarked and CWT combined) were 171 % more numerous in the first five tows than in the next five tows (tows 6 – 10) in the ORKT. In the MKT, salmon were 117 % more numerous in the first five tows than in the next five tows. If a single crew is to sample both rivers, the river sampled first should alternate to overcome any morning sampling bias.

In conclusion, direct comparisons of expanded salmon abundance estimates between the ORKT and MKT were difficult due to the unknown catch efficiency of the ORKT. Although the catch efficiencies between the ORKT and MKT are probably different, they were assumed to be similar for some of the analyses. Thus, some of these results must be viewed with caution. Proportionally, there is no statistical difference on a daily basis between CWT and unmarked salmon heading down Old River. CWT and unmarked salmon are moving into Old River at a similar rate. The flow split between the San Joaquin River and Old River was 50-50. It appears juvenile salmon migrate down Old River in proportion to the flow: about half of the flow and roughly half of the salmon went down Old River. However, there was a lot of variability among the daily percentages of salmon heading down Old River. This variability might be due to natural variability in salmon migration patterns which are magnified by sampling biases and the subsequent abundance calculations. Salmon migration down Old River might also change at different river flows and pumping rates at the state and federal water projects. More data is needed to elucidate the relationship between flow and catch in Old and San Joaquin rivers.

If Kodiak trawling is conducted in future years, due to no HORB installation, VAMP should release some of their fish at Mossdale. Salmon released at Mossdale, in the morning, would pass the Kodiak trawls in larger numbers than

salmon released at Durham Ferry. This would substantially increase the CWT salmon catch in the ORKT and MKT, and might make comparisons between the two rivers a little easier. The ability to adjust catch in the ORKT based on salmon vulnerability (catch efficiency) would improve the estimate and comparison of salmon abundance to the San Joaquin River. In order for any vulnerability studies to be conducted for the ORKT, the sample site would have to be moved at least two miles downstream, and likely three to four miles, to find a suitable trawling reach. A sample site further downstream would allow time for color-marked salmon released near the head to adjust to Old River flows.

Chapter 5

Salmon Smolt Survival Investigations

A primary objective of the VAMP study is to determine the effects of San Joaquin River flows, SWP and CVP water exports, and HORB installation on survival of juvenile Chinook salmon smolts emigrating from the San Joaquin River through the Delta. As mentioned in previous chapters, the HORB was not installed in 2005. Therefore the VAMP study was modified to accommodate these differences from past studies. This section describes the methods used to conduct the Chinook salmon smolt survival investigations and estimates survival indices, absolute survival estimates, and combined differential recovery rates for coded-wire tagged (CWT) juvenile Chinook salmon smolts released during the VAMP 2005 test period. The information gathered in 2005 was used in conjunction with past data to assess the relationships between smolt survival, river flow and CVP/SWP exports with and without the HORB. Relationships using escapement (adult salmon returning to the rivers to spawn) are also discussed.

MERCED RIVER FISH FACILITY CODED-WIRE TAGGING

Merced River Fish Facility (MRFF) supplied over 400,000 CWT Chinook salmon smolts for the VAMP 2005 study. Salmon were CWT and marked with an adipose fin clip by MRFF personnel between late March and mid-April 2005 and were generally held for approximately 27 days before release. Salmon were tagged with one of 16 distinct tag codes, depending upon where the fish were to be released. MRFF examined sub-samples of tagged salmon to estimate CWT retention rates. Average tag retention documented by MRFF was 92% and ranged from 86% to 95%. CWT detection is typically high and all salmon from the sub-samples without a detected tag were sacrificed to verify the accuracy of the CWT detection process and to determine if these fish contained an undetected, non-magnetized tag. No sub-sampled fish were found to contain non-magnetized tags.

To better estimate juvenile salmon survival through the Delta, survival estimates incorporate a measure of the VAMP Effective Number (ER) of fish that were tagged and released which accounts for tag retention rate and fish mortalities. The ER was calculated by multiplying the mortalities from the estimated number of fish transported by the tag retention rate which was then subtracted from the Hatchery Effective Number (Table 5-1).

ER = H - (M * TR) where:

H = Hatchery Effective Number of CWT salmon transported. This value incorporates mortalities at the hatchery and during release and the MRFF tag retention rate.

M = number of fish sacrificed for the short-term survival studies. For the Durham Ferry and Dos Reis releases, the total numbers of fish sacrificed were divided among the tag codes based on the proportion of hatchery effective number.

TR = CWT retention rate determined at the MRFF.

VAMP FISH RELEASES

Two sets (Release 1 and Release 2) of CWT salmon were released at three sites on six dates for the 2005 VAMP experiment (Table 5-1). Releases occurred at Durham Ferry, Dos Reis, and Jersey Point. Transport and water temperatures at the time of release are listed in Table 5-2.

Durham Ferry is located on the San Joaquin River upstream of the Head of the Old River (HOR). Due to high water and poor road condition, releases were made at the top of the levee at Durham Ferry. Over 90,000 CWT salmon with four different codes were released on each occasion at Durham Ferry.

Table 5-1
Chinook Salmon Smolt Release Data for VAMP 2005

Release Date	Release Site	Tag Code	Hatchery Effective Number	Fish Sacrificed for Short-Term Survival Exp.	Tag Retention Rate	Effective Number of Fish Sacrificed for Short-Term	VAMP Effective Number Released
Release 1							
2-May-05	Durham Ferry	06-46-72	23,533	127	0.94	119	23,414
2-May-05	Durham Ferry	06-46-73	23,311	126	0.94	118	23,193
2-May-05	Durham Ferry	06-46-74	23,780	128	0.94	120	23,660
2-May-05	Durham Ferry	06-46-75	23,687	128	0.94	120	23,567
Summary			**94,311**	**508**	**0.94**	**478**	**93,833**
3-May-05	Dos Reis	06-45-91	22,823	163	0.91	148	22,675
3-May-05	Dos Reis	06-46-97	22,444	160	0.89	142	22,302
3-May-05	Dos Reis	06-46-98	24,310	173	0.93	161	24,149
Summary			**69,577**	**496**		**452**	**69,125**
6-May-05	Jersey Point	06-45-88	**23,186**	**450**	**0.93**	**419**	**22,767**
Release 2							
9-May-05	Durham Ferry	06-45-84	22,874	107	0.91	97	22,777
9-May-05	Durham Ferry	06-45-85	23,066	108	0.91	98	22,968
9-May-05	Durham Ferry	06-45-86	23,110	108	0.91	98	23,012
9-May-05	Durham Ferry	06-45-87	22,903	107	0.91	97	22,806
Summary			**91,953**	**429**	**0.91**	**390**	**91,563**
10-May-05	Dos Reis	06-45-89	21,574	152	0.86	131	**21,443**
10-May-05	Dos Reis	06-45-90	23,913	169	0.94	158	**23,755**
10-May-05	Dos Reis	06-46-99	23,602	167	0.93	154	**23,448**
Summary			**69,089**	**488**		**443**	**68,646**
13-May-05	Jersey Point	06-47-00	**23,562**	**348**	**0.95**	**331**	**23,231**

Table 5-2
Water Temperature During Transport and Release

Release Site	Release Date	Transport Temperature (F)	River Temperature (F)
Durham Ferry	2-May-05	52	60
Dos Reis	3-May-05	55	63
Jersey Point	6-May-05	52	64
Durham Ferry	9-May-05	52	59
Dos Reis	10-May-05	52	59
Jersey Point	13-May-05	55	66

Dos Reis is located on the San Joaquin River downstream of the HOR, and was used as a release site, in lieu of Mossdale (which is upstream of HOR) in 2005 to assess the mortality of marked salmon diverted in HOR. Additionally, the release at Dos Reis was made on an ebb tide to reduce the likelihood of salmon being pushed upstream into HOR. Just fewer than 70,000 CWT salmon of three tag codes were released on each occasion at Dos Reis.

Jersey Point serves as a "control site" to standardize survival rates since fish released at Jersey Point do not migrate through the Delta and they are released just upstream of the Antioch and Chipps Island revocery locations. CWT salmon were released on a flood tide at Jersey Point to increase fish dispersion throughout the channel before reaching Antioch and Chipps Island (recovery sampling stations). CWT salmon from one tag code were released on each occasion (22,767 and 23,231 CWT salmon, respectively) at Jersey Point.

During the 2005 VAMP study, CWT salmon with different tag codes were held separately at the hatchery except for the fish released at Durham Ferry. During transport it was necessary to combine tag codes from the Dos Reis release, as well. Once the hatchery truck arrived at a release site, approximately 450 salmon were removed for the short-term survival study (see below). The remaining fish were then immediately released.

WATER TEMPERATURE MONITORING

Water temperature was monitored during the VAMP 2005 study using individual computerized temperature recorders (e.g., Onset Stowaway Temperature Monitoring/Data Loggers). 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 smolts released as part of these tests (Appendix C-1). Water temperature was recorded at 24-minute intervals throughout the period of the VAMP 2005 investigations. Water temperatures were also recorded within the hatchery raceways at the MRFF coincident with the period when juvenile Chinook salmon were being tagged and held. These temperature recorders were later transported with the juvenile salmon released at Durham Ferry.

Results of water temperature monitoring within the Merced River Fish Facility showed that juvenile Chinook salmon were reared in, and acclimated to, water temperatures of approximately 9.7°- 11.8° C (49.5° - 53.2° F) prior to release into the lower San Joaquin River (Figures 5-1 and 5-2). Results of water temperature monitoring at Durham Ferry and Jersey Point following the VAMP 2005 releases are shown in Figures 5-3 and 5-4. This water temperature monitoring showed that water temperatures at the release locations and throughout the lower San Joaquin River and Delta (Appendix C-2) were higher than those at the hatchery, which is generally the case. Water temperatures measured within the lower San Joaquin River and Delta (Figures 5-3 and 5-4) were within a range considered to be suitable (< 20 C; 68 F) for Chinook salmon smolts and would not be expected to result in adverse effects or reduced survival of emigrating juvenile Chinook salmon released as part of the VAMP 2005 investigations.

SHORT-TERM SURVIVAL STUDY

Two groups of CWT salmon were removed from the MRFF fish transport truck before each release to determine if handling, transport, and release affected short-term, 48-hour survival and general condition. The goal was to place 225 CWT fish into each of 2 net pens (volume ~ 1m^3; mesh size ~3 mm); however, all numbers were approximated when the fish were removed from the MRFF truck in an attempt to reduce handling stress. As mentioned previously, tag codes were mixed during transport and therefore fish were not kept in separate net pens by distinct tag codes.

Once placed into the pens, sub-samples of 25 fish from each pen were examined for swimming vigor then euthanized for measuring and documenting general condition of transported fish. Each fish was measured for fork length (to nearest 1 mm), weighed (to the nearest 0.1 g) and examined qualitatively for percent scale loss, body color, fin hemorrhaging, eye quality, and gill coloration. For the purposes of the 2005 VAMP study, Table 5-3 defines normal and abnormal conditions for these characteristics. Additionally, quality of adipose fin clip was documented. The sub-sampled fish were taken to the U.S. Fish and Wildlife Service, Stockton office (STFWO), for verification of tag code. After 48-hours, an additional 25 fish from each pen were measured, weighed, and examined for condition, as described above. The remaining fish from each pen were examined for mortalities, euthanized, counted, measured, weighed, and returned to STFWO for later tag code verification, if necessary.

Post transport fish were generally in good condition (Appendix C-3a). All fish were swimming vigorously before being euthanized. Mean scale loss ranged from 2% at the second Jersey Point release up to 12% at the second Durham Ferry release (average of all locations = 5%). Body color and gill color were normal for all fish examined. No fin hemorrhaging was detected in any of the fish. Only one salmon (2%) from the first Jersey Point release had eye

Figure 5-1
Merced River Fish Hatchery to Durham Ferry

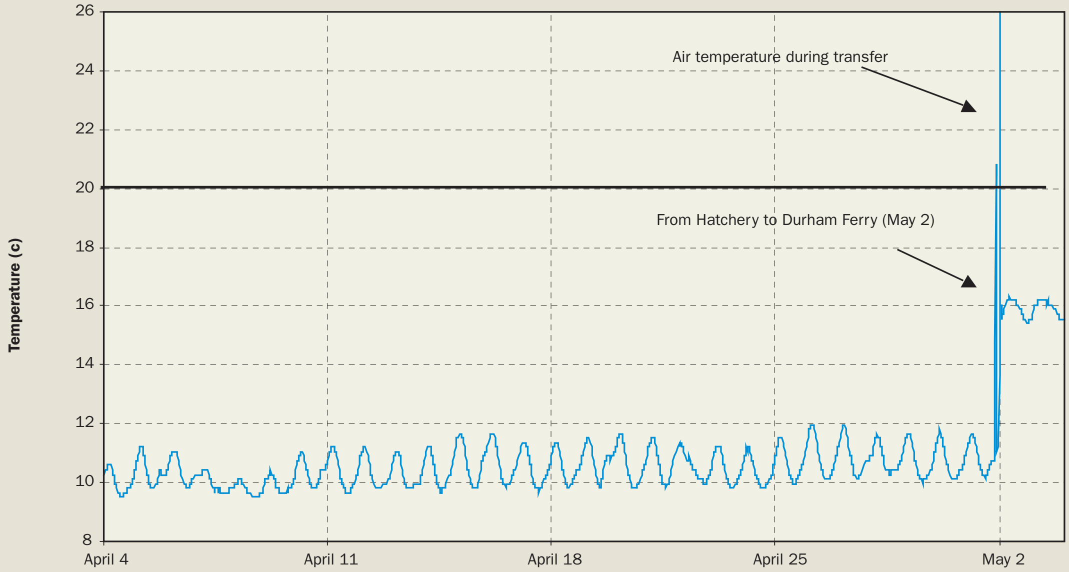


Figure 5-2
Merced River Fish Hatchery to Durham Ferry

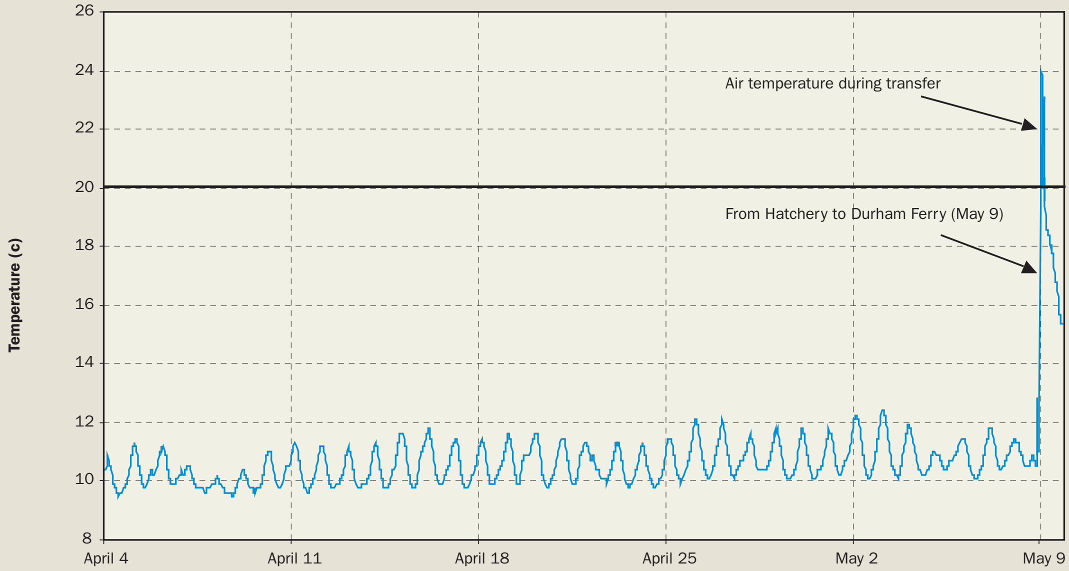
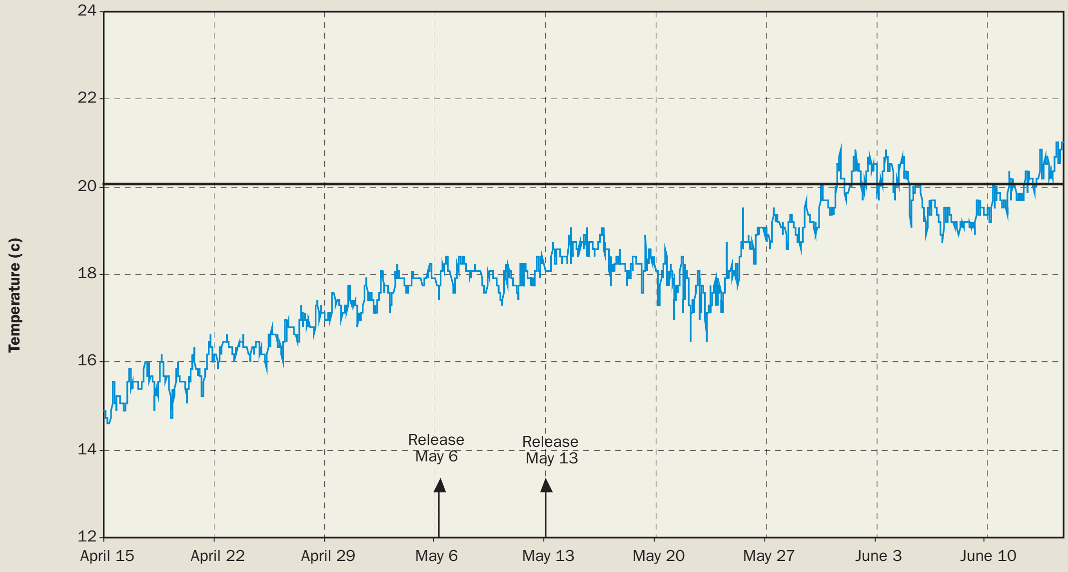


Figure 5-3
Site 1 - Durham Ferry

Figure 5-4
Site 9 - USGS Gauging Station at Jersey Point - Top



hemorrhaging. No errant CWT codes were detected in the 2005 VAMP salmon sub-samples, therefore no additional CWT verification was completed. Adipose fins were completely removed from an average of 85% (range of 74% to 94%) of the CWT salmon.

Short-term survival (48-hours post-transport) was high (99.9%) with only three mortalities (all from the first release at Durham Ferry) within the net pens. Fish retained in the net pens for the 48-hour post release examination were swimming vigorously and generally in good condition (Appendix C-3b). Mean scale loss was (6%) at each site and ranged from 3% to 9% after each of the 48-hour trials. Few fish from the first set of releases had abnormal body color: 4 % from Durham Ferry, 2% from Dos Reis, and 2% from Jersey Point. Abnormal body color was not detected for any of the salmon from the second set of releases. Only 2% of the fish from the first Jersey Point release had fin hemorrhaging. Abnormal eye quality was detected in 4% of the Dos Reis and 2% of the Jersey Point fish from the first release. Abnormal eye quality was detected in 2% of the fish from each of the second releases at Durham Ferry and Dos Reis. Pale gills were detected in 2% of the fish from the second Dos Reis release. No other fish had abnormal gill coloration. These data indicate that the fish used for the 2005 VAMP experiment were in good general condition initially and after 48 hours, and that handling, transport, and release should not have affected their survival.

HEALTH AND PHYSIOLOGY

Juvenile Chinook salmon from tagged lots used in the 2005 VAMP study, were brought from the MRFF to the U.S. Fish and Wildlife Service California-Nevada Fish Health Center (CA/NA FHC) six days prior to the first VAMP release and reared for 50 days at water temperatures similar to the San Joaquin River (14.5 to 19.6 C). At the time of transport, a fish health inspection showed that the population was generally healthy but had a low prevalence of an early stage infection by the myxosporean parasite, *Tetracapsula bryosalmonae*. This parasite has been detected in Merced River salmon for several decades (Hederick et al., 1986) and causes Proliferative Kidney Disease (PKD). The level of clinical PKD, as demonstrated by a combined kidney lesion and anemia score, markedly increased starting at 29 days post-exposure (dpe). A total of 76 study salmon (27% cumulative mortality) died due to PKD beginning at 36 dpe through the final sample at 50 dpe. Time post-exposure and disease state correlated with a decline in both hematocrit and plasma magnesium as well as an elevation in circulating white blood cell number and plasma protein concentration. There was no observed PKD effect on time to exhaustion during a 120-minute swim challenge until 50 dpe. Smolt development measurements indicated that the study fish were in an advanced stage of smoltification. Similar to swim performance, saltwater adaptation was not impaired until 50 dpe.

In addition to examining 2005/VAMP salmon maintained at the CA/NV FHC, selected salmon recovered at Chipps Island were also examined for the presence of PKD. While in the field, CWT salmon were dissected to remove the kidney and make kidney imprints on glass slides. *Tetracapsula bryosalmonae* was observed in 40% (17 of 43) of the kidney imprints collected from VAMP salmon recovered in the Chipps Island trawl. From the laboratory experiments, severe disease was not detected until 29 dpe which was chronologically after the last VAMP coded wire tag recovery at Chipps Island on 27 May 2005. These results indicate that while PKD was prevalent in VAMP out-migrating salmon, it may not have reduced VAMP recoveries. However PKD could be a significant mortality factor for VAMP salmon smolts during their early seaward entry phase (past all VAMP recovery stations). A full report is available in Foott et al.,(2005).

Table 5-3
Smolt Condition Characteristics Assessed for Short Term Survival Studies

Character	Normal	Abnormal
Percent Scale Loss	Lower relative numbers based on 0-100%	Higher relative number based on 0-100%
Body Color	High contrast dark dorsal surface and light sides	Low contrast dorsal surface 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)

CODED-WIRE TAG RECOVERY EFFORTS

Coded-wire tagged salmon were recaptured at Old River, Mossdale, Antioch, Chipps Island, and the Federal (Central Valley Project (CVP)) and State Water Projects (SWP)(Figure 1-1). CWT salmon recovered in California Department of Fish and Game (DFG) Kodiak trawls at Old River and Mossdale are not discussed in this chapter. Juvenile Chinook salmon with an adipose fin clip caught at all of the sampling locations (except Old River and Mossdale) were sacrificed, labeled, and frozen for CWT processing by staff at STFWO. DFG Region 4 staff processed CWT fish from Old River and Mossdale.

CWT processing consists of dissecting each tagged fish to obtain the 1-mm cylindrical tag from the snout. Tags were then placed under a dissecting microscope and the numbers were read and recorded in a database and archived. All tags were read twice, with any discrepancies resolved by a third reader. All tags were archived for future reference. It should be noted that many CWT Chinook salmon are captured during the VAMP study; however some of these fish may be tagged for other studies and are not affiliated with the VAMP study. VAMP releases comprise a small portion of the total tagged salmon released in the Sacramento and San Joaquin system. In order to identify tags related to VAMP, it is necessary to read all recovered tags.

Table 5-4
Recovery information at Antioch, Chipps Island, and the fish facilities for VAMP releases in 2005.

			Antioch Recoveries							
Tag Code	**Release Site**	**Release Date**	**Effective Number Released**	**First Day Recovered**	**Last Day Recovered**	**Number Recovered**	**Recovery Effort (minutes sampled)**	**Percent of Channel Sampled**	**Survival Index**	**Group Index**
06-46-72	Durham Ferry		23,414	–	–	0	–	–	–	
06-46-73	Durham Ferry		23,193	5/5/05	5/7/05	2	1,555	0.360	0.016	
06-46-74	Durham Ferry		23,660	5/5/05	5/24/05	3	10,283	0.357	0.024	
06-46-75	Durham Ferry		23,567	5/10/05	5/10/05	1	555	0.385	0.007	
	Total	**5/2/05**	**93,833**	**5/5/05**	**5/24/05**	**6**	**10,283**	**0.357**		**0.013**
06-45-91	Dos Reis		22,675	5/9/05	5/13/05	3	2,423	0.337	0.026	
06-46-97	Dos Reis		22,302	5/17/05	5/17/05	1	580	0.403	0.007	
06-46-98	Dos Reis		24,149	5/10/05	5/11/05	3	953	0.331	0.025	
	Total	**5/3/05**	**69,125**	**5/9/05**	**5/17/05**	**7**	**3,332**	**0.257**		**0.028**
06-45-88	Jersey Point	5/6/05	22,767	5/7/05	5/12/05	31	2,874	0.333	0.263	
06-45-84	Durham Ferry		22,777	5/15/05	5/15/05	1	500	0.347	0.008	
06-45-85	Durham Ferry		22,968	5/17/05	5/17/05	1	580	0.403	0.007	
06-45-86	Durham Ferry		23,012	5/14/05	5/16/05	3	1,420	0.329	0.026	
06-45-87	Durham Ferry		22,806	5/19/05	5/20/05	2	1,154	0.401	0.014	
	Total	**5/9/05**	**91,563**	**5/14/05**	**5/20/05**	**7**	**2,772**	**0.275**		**0.020**
06-45-89	Dos Reis		21,443	5/16/05	5/19/05	5	2,100	0.365	0.039	
06-45-90	Dos Reis		23,755	5/15/05	5/18/05	2	2,020	0.351	0.016	
06-46-99	Dos Reis		23,448	–	–	0	–	–	–	
	Total	**5/10/05**	**68,646**	**5/15/05**	**5/19/05**	**7**	**1,972**	**0.274**		**0.027**
06-47-00	Jersey Point	5/13/05	23,231	5/14/05	5/19/05	27	3,140	0.363	0.212	

* One fish was excluded due to inaccurate data.

Antioch Recapture Sampling

Fish sampling was conducted in the vicinity of Antioch on the lower San Joaquin River (Figure 1-1) using a Kodiak trawl. The Kodiak trawl has a graded stretch mesh, from 2-inch mesh at the mouth to 1/2-inch mesh at the cod-end. Its overall length is 65 feet, and the mouth opening is 6 feet deep and 25 feet wide. The net was towed between two skiffs, sampling in an upstream direction. Trawls were performed near the left bank, within the mid-channel, and near the right bank to sample for CWT salmon emigrating from the San Joaquin River. Each sample was approximately 20 minutes in duration.

All captured fish were transferred immediately from the Kodiak trawl to buckets filled with river water, where they were held for processing. Data collected during each trawl included: species identification and fork length for each fish captured, tow start time and duration, and location in the channel. Any fish mortalities or injuries were documented to comply with the Endangered Species Act permit requirements. Juvenile Chinook salmon with an adipose fin clip were retained for later CWT processing while other fish were released at a location downstream of the sampling site immediately after identification, enumeration, and measurement.

Sampling at Antioch began May 4 and continued through May 31. Each day between 5:30 a.m. and 9:00 p.m., anywhere from 6 to 30 tows were conducted. In all, 633 Kodiak trawl samples were collected, for a total of 12,528

Chipps Island Recoveries							Fish Facilities Recoveries Raw Salvage (Expanded Salvage)		
First Day Recovered	Last Day Recovered	Number Recovered	Recovery Effort (minutes sampled)	Percent of Channel Sampled	Survival Index	Group Index	CVP	SWP	Recovery Days
5/5/05	5/11/05	5	2,608	0.259	0.099		38 (456)	5 (27)	
5/10/05	5/12/05	2	1,152	0.267	0.038		25 (300)	2 (9)	
5/9/05	5/19/05	4	4,132	0.261	0.079		37 (444)	7 (39)	
5/7/05	5/7/05	1	400	0.278	0.018		19 (228)	4 (24)	
5/5/05	**5/19/05**	**12**	**5,732**	**0.265**		**0.058**			**05/3 - 05/24**
5/11/05	5/11/05	1	400	0.278	0.019		0	0	
5/11/05	5/11/05	1	400	0.278	0.018		0*	1 (6)	
5/12/05	5/12/05	1	352	0.244	0.020		0	0	
5/11/05	**5/12/05**	**3**	**752**	**0.261**		**0.019**			**05/15**
5/8/05	5/15/05	32	2,960	0.257	0.634		0	0	–
5/15/05	5/26/05	2	4,772	0.276	0.037		16 (192)	19 (102)	
5/12/05	5/12/05	1	352	0.244	0.021		6 (72)	15 (84)	
5/15/05	5/27/05	3	5,172	0.276	0.056		14 (168)	17 (93)	
–	–	0	–	–	–		7 (84)	9 (48)	
5/12/05	**5/27/05**	**6**	**6,324**	**0.274**		**0.028**			**05/10 - 05/31**
5/14/05	5/16/05	3	1,200	0.278	0.055		0	1 (6)	
5/17/05	5/18/05	2	772	0.268	0.038		0	0	
5/17/05	5/17/05	1	372	0.258	0.020		0	0	
5/14/05	**5/18/05**	**6**	**1,972**	**0.274**		**0.037**			**05/17**
5/14/05	5/20/05	38	2,772	0.275	0.711		0	0	–

tow minutes. During sampling, 5,127 unmarked juvenile Chinook salmon were captured; 248 salmon with a coded wire tag were collected, 97 from VAMP releases (Table 5-4) and 151 from other hatchery releases. In addition, 363 delta smelt, 12 unmarked steelhead, and 6 adipose fin clipped steelhead were caught during sampling.

Chipps Island Recapture Sampling

Recovery efforts at Chipps Island were conducted using a mid-water trawl towed at the surface. The trawling net is 82 feet in length and has an opening that is 30 feet wide by 10 feet deep. Mesh size of the net is variable and ranges from 4-inch mesh at the mouth to 5/16-inch mesh at the cod end. To keep the mouth of the net open, the net has floating aluminum hydrofoils on the top bridles and has steel depressors and a weighted lead line attached to the bottom bridles.

For VAMP 2005 trawling was conducted twice per day, seven days per week from May 3, 2005 through June 11, 2005. In past studies, greater recoveries of juvenile Chinook salmon smolts have been reported during sunrise and sunset (Hanson Environmental, unpublished data), therefore, the first shift began during sunrise and the second shift was completed during sunset in an attempt to increase the recovery of juvenile Chinook salmon smolts and reduce the variability in survival indices. Each shift consisted of ten 20-minutes tows conducted in the north, middle, and south sections of the channel parallel to the shore. After six weeks the majority of VAMP juvenile Chinook salmon smolts had migrated past Chipps Island, so sampling was subsequently reduced. Ten morning tows were continued seven days per week between June 12 and June 19; five days per week between June 20 and July 1; and three days per week after July 5.

All fish retained in the cod end of the net are placed in aerated water collected from the sample site. All juvenile Chinook salmon smolts with an adipose fin clip were labeled and retained for later CWT processing. All other fish were identified to species, and enumerated, and released. The fork length of each individual was measured to the nearest mm for most of the catch. As mentioned previously, some salmon were also processed in the field to determine if *T. bryosalmonae* were present. A total of 59 juvenile Chinook salmon with tag codes used in the VAMP 2005 study were recaptured at Chipps Island, with the majority having been released at Jersey Point. During this same time period, the catch included 11,111 unmarked Chinook salmon; 628 CWT Chinook salmon from non-VAMP studies; 101 Delta smelt; 130 Sacramento splittail; 23 marked steelhead; and 21 unmarked steelhead.

CVP and SWP Salvage Recapture Sampling

CVP and SWP fish facilities salvage fish on a continuous basis. To estimate the total number of fish salvaged, sub-samples (raw salvage) are collected approximately every two hours. The number of marked salmon collected during the sub-sampling (raw salvage) is reported in Table 5-4. Expanded salvage is a calculation based on the raw salvage collected and the time sampled and provides an estimate of the total number of fish salvaged. Expanded salvage does not take into account the indirect loss of juvenile salmon smolts at the facilities as it does not include any loss associated with pre-screening predation, screening, handling, and trucking. Expanded CVP and SWP salvage estimates are also reported in Table 5-4.

During VAMP 2005, expanded salvage was greater than salvage from releases at Durham Ferry in 2004 (CVP = 84; SWP = 12). The increase in salvage for VAMP 2005 was not surprising since the HORB was not installed. The installation of HORB reduces the number of fish observed at the fish facilities. Only a few juvenile salmon smolts that were released at Dos Reis and no smolts released at Jersey Point were observed in the raw salvage. The low salvage of smolts released at Dos Reis was anticipated as these fish are released downstream of the Head of Old River on an outgoing tide and would not be expected to be drawn through Old River into the fish facilities. The Jersey Point releases are downstream of all connections to Old River, but are released on an ebb tide to facilitate disbursement. Though in past years a few salmon released at Jersey Point have been observed, they are generally not expected at the salvage facilities.

TRANSIT TIME

The recoveries of the VAMP smolts collected in 2005 were made at Antioch between May 5 and May 24 and over a similar time period at Chipps Island between May 5 and May 27 (Appendix C-4). Recoveries were made at the CVP and SWP fish facilities between May 3 and May 31 (Table 5-4), a few days earlier and later than at the other recovery locations. All recoveries were made prior to the end of the VAMP period.

VAMP CHINOOK SALMON CWT SURVIVAL

Survival Indices

Survival indices were calculated to estimate survival to Antioch and Chipps Island for marked salmon released at Durham Ferry, Dos Reis and Jersey Point. Survival indices (SI) were calculated using the formula:

$$SI = (R / (ER*T*W))$$

where: R is the number recovered, ER is the effective number released, T is the fraction of time sampled, and W is the fraction of channel width sampled.

The fraction of the channel width sampled at Chipps Island (0.00769) was calculated by dividing the net width (30 feet) by the estimated channel width (3,900 feet). The fraction of the channel width sampled at Antioch (0.01388) was calculated in the same manner, with the net width being 25 feet and the channel width being 1,800 feet. The fraction of time sampled at both locations was calculated based on the number of minutes sampled between the first and last day of catching each particular tag code or group, divided by the total number of minutes in the time period. The fraction of time sampled for the VAMP 2005 release groups at Chipps Island was about 28%, while at Antioch it was about 37% (Table 5-4).

Survival indices were calculated for each tag code to provide a sense of the variability associated with the group survival index. To generate the group survival index, the recovery numbers and release numbers are combined for the tag codes within a release group.

Chinook Salmon Survival Estimates, and Differential and Combined Differential Recovery Rates

Survival is further put into context by estimating absolute survival estimates and combined differential recovery rates (CDRR). Absolute survival estimates and CDRRs should be more robust for comparing survival between groups, recovery locations, and years, since using ratios between upstream and downstream groups theoretically standardizes for differences in catch efficiency between recovery locations and years. As in past years, both estimates of absolute survival and CDRRs were calculated for CWT releases as part of VAMP 2005. An additional estimate of survival, differential recovery rates (DRR) was also used for recoveries made in the ocean fishery, two to four years following release, for groups released in past years. DRR are also used when only the Chipps Island recovery location was used, as was the case prior to 2000.

Absolute survival estimates (AS_i) are calculated by the formula:

$$AS_i = SI_u / SI_d$$

where: SI_u is the survival index of the upstream group (Durham Ferry or Dos Reis), SI_d is the survival index of the downstream group (Jersey Point) and i is either Antioch or Chipps Island.

Although referred to throughout this document as absolute survival estimates they are more aptly described as standardized or relative survival estimates.

The combined recovery rate (CRR) is estimated by the formula:

$$CRR = R_{C+A} / ER$$

where: R_{C+A} is the combined recoveries at Antioch and Chipps Island of a CWT group, and ER is the effective release number.

The combined differential recovery rate (CDRR) is calculated by the formula:

$$CDRR = CRR_u / CRR_d$$

where: CRR_u is the combined recovery rate for the upstream group (Durham Ferry, Mossdale or Dos Reis), and CRR_d is the combined recovery rate for the downstream group (Jersey Point).

The CDRR and DRR are other ways to estimate survival between the upstream and downstream release locations. It is similar to calculating absolute survival estimates, but does not expand estimates based on the fraction of the time and space sampled.

The CDRR and the absolute survival estimates should not be very different as (1) the fraction of the time sampled is similar between groups within a recovery location and (2) the fraction of space sampled at each recovery location is a constant. Neither would change the relative differences between groups. However, combining the recovery numbers from Antioch and Chipps Island could result in different survival estimates between the two methods.

Variance and standard errors were calculated for the CDRR and DRRs based on the Delta method recommended by Dr. Ken Newman. Plus or minus two standard errors are roughly equivalent to the 95% confidence intervals around the estimate. Plus or minus one standard error equates to roughly the 68% confidence intervals for normally distributed data (Ken Newman, University of St. Andrews, Scotland, personal communication). In comparing survival between reaches, the confidence intervals were used to determine if CDRRs were significantly different from each other. If the 95% confidence intervals overlapped, CDRRs were not considered statistically different from each other. Confidence intervals using the lower level of confidence (68%) are also included.

Results:

Individual and group survival indices to Antioch and Chipps Island of the CWT salmon released as part of VAMP 2005 are shown in Table 5-4. Survival indices have been reported to three significant digits, but we realize indices are not likely that precise. Survival indices were not corrected for the number of CWT fish recovered in DFG sampling at Mossdale or in Old River.

The survival indices were low and ranged between 0.013 and 0.063 for the Durham Ferry and Dos Reis groups using either recoveries at Antioch or Chipps Island. We would have expected the Dos Reis survival indices to be greater than those for the Durham Ferry groups, but this was not the case for the first group recovered at Chipps Island (Table 5-4). The group survival index to Chipps Island for the first Durham Ferry group was 0.063 and for the first Dos Reis group was 0.022. This result could be due to the low recovery numbers and inherent variability in the survival indices.

One compounding factor experienced in 2005, was the application of Komeen in Clifton Court Forebay on May 3, a day after our first Durham Ferry release. Komeen is a chemical herbicide containing copper that is known to be toxic to salmon (J. Stuart, NOAA Fisheries, personal communication). During the application period there were no flows into or out of Clifton Court Forebay for 48 hours (DWR, Delta Field Division, personal communication). The SWP exports directly out of Clifton Court Forebay. The first Durham Ferry released fish was observed at the CVP on May 3, indicating that some of the CWT fish released at Durham Ferry may have been diverted into Clifton Court Forebay before the gates were closed on May 3rd which in turn could have reduced their survival. The first Durham Ferry fish was not observed at the SWP until May 8th. Although the first group released at Durham Ferry did not have consistently lower survival indices, than the second Durham Ferry release, to Antioch and Chipps Island, it is uncertain whether this treatment lessened the survival of the first group released at Durham Ferry. We have requested further communication from DWR regarding the timing of when these herbicide applications are scheduled to avoid this potential problem in the future.

The control groups released at Jersey Point had greater survival than those fish released at Durham Ferry or Dos Reis. The survival index of the first Jersey Point group was 0.263 at Antioch and 0.634 at Chipps Island. The second Jersey Point release had survival indices of 0.212 at Antioch and 0.711 at Chipps Island.

In general, higher survival indices were estimated using the Chipps Island recoveries. As in past years, the raw recovery rate at Chipps Island and Antioch was similar, but once recoveries were expanded for effort, indices indicated that recoveries were much lower at Antioch, indicating that the greater sampling at Antioch is not translating into additional recoveries.

Survival indices for releases made at Durham Ferry and Dos Reis were low relative to releases made at Jersey Point

Table 5-5 Absolute survival and Combined Differential Recovery Rates (CDRR) for VAMP releases in 2005				
Survival Reach	**Release Date**	**Antioch Absolute Survival**	**Chipps Island Absolute Survival**	**CDRR**
First release				
Durham Ferry to Jersey Point	2-May-05	0.049	0.099	0.069
Dos Reis to Jersey Point	3-May-05	0.11	0.035	0.052
Second release				
Durham Ferry to Jersey Point	9-May-05	0.094	0.044	0.051
Dos Reis to Jersey Point	10-May-05	0.127	0.058	0.068

using either set of recovery numbers (Table 5-4). This is especially clear when looking at absolute survival rates and CDRR's (Table 5-5).

The CDRR's for the Durham Ferry groups relative to the Jersey Point groups were 0.069 and 0.051 for the first and second releases, respectively. The Dos Reis to Jersey Point CDRR estimates were 0.052 for the first and 0.068 for the second release (Table 5-5). Confidence intervals around each of the estimates suggested estimates were not significantly different for the two groups even though fish released at Durham Ferry are thought to incur additional mortality since it is roughly 15 miles farther upstream than Dos Reis and there was no HORB (Figure 5-5).

The pooled CDRRs of the two Dos Reis groups was 0.060. The pooled CDRR of the Durham Ferry groups was also 0.060. Further pooling of both sets resulted in the CDRR being 0.060. Plus and minus one and two standard errors of the estimates were also calculated and are shown in Figure 5-5.

COMPARISON WITH PAST YEARS

Ocean Recovery Information

Ocean recovery data of CWT salmon groups can provide another independent estimate of the ratio of recovery rate of an upstream release group relative to a downstream release group. Differential recovery rates using ocean recovery information can be compared with absolute survival estimates based on survival indices and the differential **(DRR)** or combined differential recovery rates **(CDRR)** of juvenile salmon recovered at Chipps Island and Chipps Island and Antioch, respectively. The ocean data may be more reliable due to the 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 2004. 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 2000 and partially available for CWT releases made from 2001 to 2003.

Differential recovery rates based on ocean recoveries, Chipps Island recoveries or combined Antioch and Chipps Island recoveries for salmon produced at the MRFF 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 (2000-2003). Releases have been made at several locations: Durham Ferry, Mossdale, Dos Reis, and Jersey Point. The Chipps Island and Antioch survival estimates and CDRR (Antioch and Chipps Island recoveries summed) or DRR (Chipps Island recoveries only) are graphed in relation to the differential recovery rate using the ocean recovery information in Figure 5-6.

Results of this comparative analysis of survival estimates and differential recovery rates for Chinook salmon produced in the MRFF show: (1) there is general agreement between absolute survival estimates based on juvenile CWT salmon recoveries at Chipps Island and the DRR or CDRR using recoveries at Chipps Island or Chipps Island and Antioch and the DRR using adult recoveries from the ocean fishery (r^2=0.71 and r^2 = 0.67), (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 VAMP releases for recoveries at Antioch, Chipps Island, and the ocean fishery.

Figure 5-5
Combined Differential Recovery Rates (CDRR) (+/- 1 and 2 standard errors) of CWT smolts released at Durham Ferry (DF/JP) and Dos Reis (DR/JP) relative to those released at Jersey Point for the first (1), second (2) and combined release groups (1&2) in 2005.

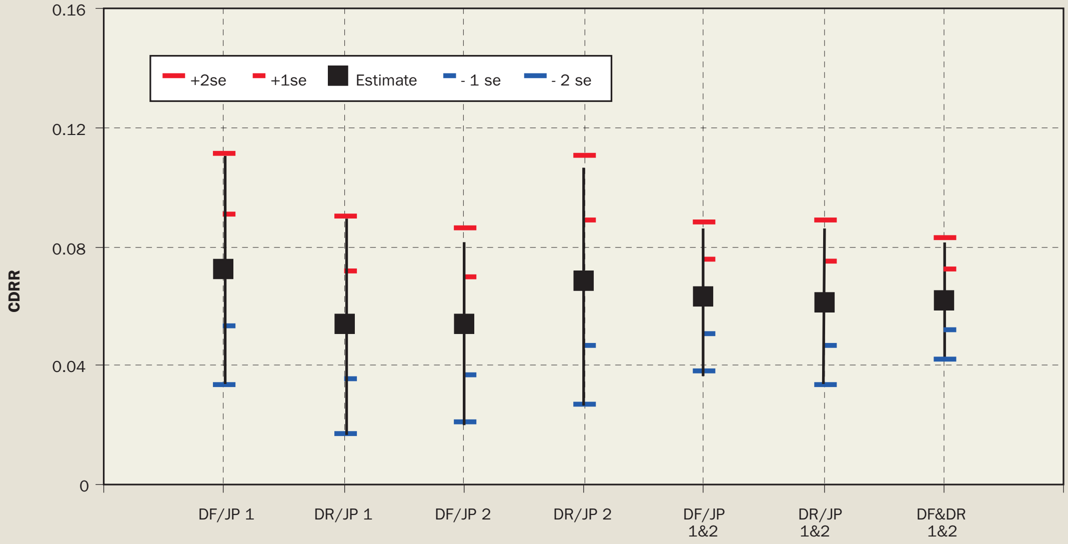
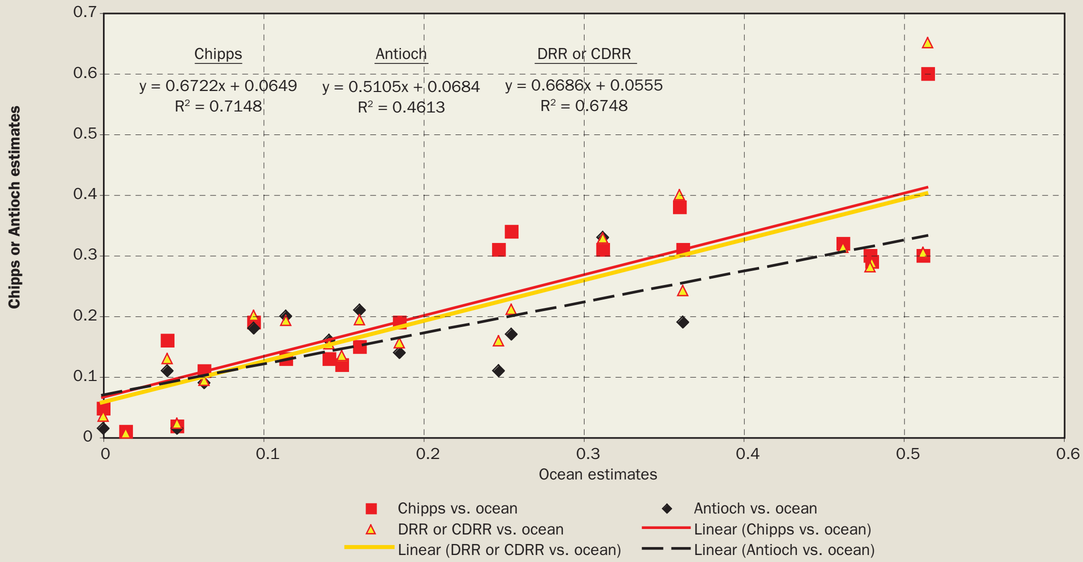


Figure 5-6
Comparison of Antioch and Chipps Island absolute survival estimates and differential or combined differential recovery rates compared to differential ocean recovery rates for 1996-2003.



Chapter 5

Table 5-6
Survival indices based on Chipps Island, Antioch, and ocean recoveries of Merced River Fish Facility salmon released as part of South Delta studies (1996 - 1999) and VAMP (2000 - 2003).

Release Year	San Joaquin River (Merced River origin) Tag Number	Release Number	Release Site	Release Date	Chipps Island Recovs.	Antioch Recovs.	Expanded Adult Ocean Recovs. (Age 1+ to 4+) Total	Chipps Island	Antioch	DRR or CDRR	Ocean Catch
		Juvenile Salmon CWT Releases						Absolute Survival Estimates		Differential Recovery Rates	
1996	H61110412	25,633	DOS REIS	01MAY96	2		3				
	H61110413	28,192	DOS REIS	01MAY96	3		37				
	H61110414	18,533	DOS REIS	01MAY96	1		8				
	H61110415	36,037	DOS REIS	01MAY96	5		10				
	H61110501	53,337	JERSEY PT	03MAY96	39		187				
	Effective Release	107,961	DOS REIS		11		58	0.120		0.135	0.149
	Effective Release	51,737	JERSEY PT		39		187				
1997	H62545	50,695	DOS REIS	29APR97	9		183				
	H62546	55,315	DOS REIS	29APR97	7		167				
	H62547	51,588	JERSEY PT	02MAY97	27		355				
	Effective Release	106,010	DOS REIS		16		350	0.290		0.288	0.480
	Effective Release	51,588	JERSEY PT		27		355				
	H62548	46,728	DOS REIS	08MAY97	5		91	0.300		0.281	0.479
	H62549	47,254	JERSEY PT	12MAY97	18		192				
1998	61110809	26,465	MOSSDALE	16APR98	25		61				
	61110810	25,264	MOSSDALE	16APR98	31		40				
	61110811	25,926	MOSSDALE	16APR98	32		58				
	61110806	26,215	DOS REIS	17APR98	33		47				
	61110807	26,366	DOS REIS	17APR98	23		35				
	61110808	24,792	DOS REIS	17APR98	34		61				
	61110812	24,598	JERSEY PT	20APR98	87		110				
	61110813	25,673	JERSEY PT	20APR98	100		91				
	Effective Release	77,655	MOSSDALE		88		159	0.300		0.305	0.512
	Effective Release	77,373	DOS REIS		90		143	0.320		0.313	0.462
	Effective Release	50,271	JERSEY PT		187		201				
1999	062642	24,715	MOSSDALE	19APR99	8		128				
	062643	24,725	MOSSDALE	19APR99	15		134				
	062644	25,433	MOSSDALE	19APR99	13		132				
	062645	25,014	DOS REIS	19APR99	20		151				
	062646	24,841	DOS REIS	19APR99	19		225				
	0601110815	24,927	JERSEY PT	21APR99	34		338				
	062647	24,193	JERSEY PT	21APR99	25		381				
	Effective Release	74,873	MOSSDALE		36		394	0.380		0.400	0.360
	Effective Release	49,855	DOS REIS		39		376	0.600		0.651	0.515
	Effective Release	49,120	JERSEY PT		59		719				
2000	06-45-63	24,457	DURHAM FERRY	17-Apr-00	11	11	245				
	06-04-01	23,529	DURHAM FERRY	17-Apr-00	7	6	214				
	06-04-02	24,177	DURHAM FERRY	17-Apr-00	10	10	229				
	06-44-01	23,465	MOSSDALE	18-Apr-00	9	14	206				
	06-44-02	22,784	MOSSDALE	18-Apr-00	9	16	174				
	06-44-03	25,527	JERSEY PT	20-Apr-00	24	50	646				
	06-44-04	25,824	JERSEY PT	20-Apr-00	41	47	706				
	Effective Release	72,163	DURHAM FERRY		28	27	688	0.310	0.190	0.242	0.362
	Effective Release	46,249	MOSSDALE		18	30	380	0.310	0.330	0.329	0.312
	Effective Release	51,351	JERSEY PT		65	97	1352				
	601060914	23,698	DURHAM FERRY	28-Apr-00	7	8	46				
	601060915	26,805	DURHAM FERRY	28-Apr-00	5	15	44				
	0601110814	23,889	DURHAM FERRY	28-Apr-00	10	8	70				
	0601061001	25,572	JERSEY PT	1-May-00	48	76	356				
	0601061002	24,661	JERSEY PT	1-May-00	30	76	228				
	Effective Release	74,392	DURHAM FERRY		22	31	160	0.190	0.140	0.156	0.185
	Effective Release	50,233	JERSEY PT		78	152	584				
2001	06-44-29	23,354	DURHAM FERRY	30-Apr-01	14	28	95				
	06-44-30	22,837	DURHAM FERRY	30-Apr-01	22	30	155				
	06-44-31	22,491	DURHAM FERRY	30-Apr-01	17	18	110				
	06-44-32	23,000	MOSSDALE	1-May-01	17	18	123				
	06-44-33	22,177	MOSSDALE	1-May-01	14	15	107				
	06-44-34	24,443	JERSEY PT	4-May-01	50	156	464				
	06-44-35	24,992	JERSEY PT	4-May-01	61	173	553				
	Effective Release	68,682	DURHAM FERRY		53	76	360	0.340	0.170	0.211	0.255
	Effective Release	45,177	MOSSDALE		31	33	230	0.310	0.110	0.159	0.247

Table 5-6
Survival indices based on Chipps Island, Antioch, and ocean recoveries of Merced River Fish Facility salmon released as part of South Delta studies (1996 - 1999) and VAMP (2000 - 2003).

Release Year	San Joaquin River (Merced River origin) Tag Number	Release Number	Release Site	Release Date	Chipps Island Recovs.	Antioch Recovs.	Expanded Adult Ocean Recovs. (Age 1+ to 4+) Total	Chipps Island	Antioch	DRR or CDRR	Ocean Catch
		Juvenile Salmon CWT Releases						Absolute Survival Estimates		Differential Recovery Rates	
	Effective Release	49,435	JERSEY PT		111	329	1017				
	06-44-36	24,025	DURHAM FERRY	7-May-01	2	8	17				
	06-44-37	24,029	DURHAM FERRY	7-May-01	5	11	47				
	06-44-38	24,177	DURHAM FERRY	7-May-01	2	10	28				
	06-44-39	23,878	MOSSDALE	8-May-01	4	8	25				
	06-44-40	25,308	MOSSDALE	8-May-01	4	11	27				
	06-44-41	25,909	JERSEY PT	11-May-01	17	43	243				
	06-44-42	25,465	JERSEY PT	11-May-01	27	53	332				
	Effective Release	72,231	DURHAM FERRY		9	29	92	0.130	0.200	0.193	0.114
	Effective Release	49,186	MOSSDALE		8	19	52	0.190	0.180	0.201	0.094
	Effective Release	51,374	JERSEY PT		44	96	575				
2002	06-44-71	23,920	DURHAM FERRY	18-Apr-02	4	11	30				
	06-44-72	25,176	DURHAM FERRY	18-Apr-02	9	20	84				
	06-44-73	23,872	DURHAM FERRY	18-Apr-02	4	12	65				
	06-44-74	24,747	DURHAM FERRY	18-Apr-02	4	20	61				
	06-44-57	25,515	MOSSDALE	19-Apr-02	6	13	72				
	06-44-58	25,272	MOSSDALE	19-Apr-02	7	29	70				
	06-44-59	24,802	JERSEY PT	22-Apr-02	46	101	461				
	06-44-60	24,128	JERSEY PT	22-Apr-02	37	89	394				
	Effective Release	97,715	DURHAM FERRY		21	63	240	0.130	0.160	0.154	0.141
	Effective Release	50,787	MOSSDALE		13	42	142	0.150	0.210	0.194	0.160
	Effective Release	48,930	JERSEY PT		83	190	855				
2002	06-44-70	24,680	DURHAM FERRY	25-Apr-02	3	6	18				
	06-44-75	24,659	DURHAM FERRY	25-Apr-02	5	2	17				
	06-44-76	24,783	DURHAM FERRY	25-Apr-02	3	4	8				
	06-44-77	24,381	DURHAM FERRY	25-Apr-02	4	6	4				
	06-44-78	24,519	MOSSDALE	26-Apr-02	2	3	23				
	06-44-79	24,820	MOSSDALE	26-Apr-02	3	4	14				
	06-44-80	24,032	JERSEY PT	30-Apr-02	18	43	282				
	06-44-81	22,880	JERSEY PT	30-Apr-02	28	32	278				
	Effective Release	98,503	DURHAM FERRY		15	18	47	0.160	0.110	0.130	0.040
	Effective Release	49,339	MOSSDALE		5	7	37	0.110	0.090	0.094	0.063
	Effective Release	46,912	JERSEY PT		46	75	560				
2003	06-02-82	24,563	DURHAM FERRY	21-Apr-03	0	1	5				
	06-02-83	26,036	DURHAM FERRY	21-Apr-03	2	4	0				
	06-27-42	24,179	DURHAM FERRY	21-Apr-03	1	1	8				
	06-27-48	24,706	MOSSDALE	22-Apr-03	2	2	0				
	06-27-43	25,480	MOSSDALE	22-Apr-03	3	2	0				
	06-27-44	24,649	JERSEY PT	25-Apr-03	57	71	93				
	Effective Release	74,778	DURHAM FERRY		3	6	13	0.019	0.015	0.023	0.046
	Effective Release	50,186	MOSSDALE		5	4	0	0.048	0.015	0.035	0.000
	Effective Release	24,649	JERSEY PT		57	71	93				
2003	06-27-45	24,815	DURHAM FERRY	28-Apr-03	0	0	0				
	06-27-46	25,319	DURHAM FERRY	28-Apr-03	0	0	0				
	06-27-47	24,758	DURHAM FERRY	28-Apr-03	0	0	0				
	06-27-49	24,219	MOSSDALE	29-Apr-03	0	0	3				
	06-27-50	24,505	MOSSDALE	29-Apr-03	1	0	0				
	06-27-51	25,950	JERSEY PT	2-May-03	39	36	115				
	Effective Release	74,892	DURHAM FERRY		0	0	0			0.000	0.000
	Effective Release	48,724	MOSSDALE		1	0	3	0.010		0.007	0.014
	Effective Release	25,950	JERSEY PT		39	36	115				

Note: Ocean recoveries are based on data through 2004.

Survival by Reach

In this section, Chinook salmon smolt survival in different reaches of the San Joaquin River will be evaluated between years. These analyses help our understanding of survival through the Delta for VAMP. Initially, survival in the entire reach (Durham Ferry or Mossdale to Jersey Point) will be discussed. Then the entire reach will be broken down by section and discussed further. The second reach discussed will be between Durham Ferry and Mossdale. The third reach is between Durham Ferry (or Mossdale) and Dos Reis. And lastly, the reach between Dos Reis and Jersey Point will be discussed. In this section we will only use CDRR or DRR as our estimate of survival. Data gathered prior to 2000 do not have any Antioch recoveries thus DRR's have been calculated using Chipps Island recoveries alone.

Survival between Durham Ferry or Mossdale and Jersey Point

Smolt survival between Durham Ferry and Jersey Point was low in 2005, as it was in 2003 and 2004. The 2005 survival estimates (0.07 and 0.05) were higher than those obtained in 2003 (0.023, and 0.0) and 2004 (0.026), but still low. The confidence intervals indicate that pooled survival between 2005 and 2004 was not significantly different (Figure 5-7). The pooled estimate in 2003 was the lowest measured to date with a HORB in place. Both the 2003 and 2004 data were much lower than other VAMP years (with the HORB in place) which started in 2000 (Table 5-7). The 2005 data was greater than that gathered in 1994 (0.0) when the HORB was not installed.

Table 5-7
Pooled, Combined Differential Recovery Rate (CDRR) and standard errors for CWT salmon released at Mossdale, Dos Reis and Durham Ferry in relation to those released at Jersey Point between 2000 and 2005.

Year	CDRR	Standard Error
2000	0.187	0.019
2001	0.191	0.014
2002	0.151	0.013
2003	0.019	0.005
2004	0.026	0.010
2005	0.060	0.010

The health of the CWT fish in 2005 may account for some of the low survival observed in 2005. While the fish appeared healthy at the hatchery prior to release, they had a low level of PKD infection. The disease progressed in test fish taken back to the CA/NV Fish Health Center, with severe occurrence observed after 29 days. Forty percent of the VAMP fish recovered at Chipps Island had evidence of infection in their kidneys by the parasite that causes PKD. It is not clear whether these levels of low initial infection rates may have affected our survival estimates to Antioch and Chipps Island in 2005. The CA/NV Fish Health Center concluded that while PKD in the VAMP fish may not have affected their survival to Chipps Island it may affect their long-term survival.

In 2003 and 2004, VAMP experimental fish also had PKD. We hypothesized that the PKD alone did not cause the higher mortality since infection and severe infection rates were not as high as they had been in 2001 when survival was greater (SJRG, 2005). However, the high level of PKD infection in combination with the lower flows in 2003 and 2004 may have differentially increased the mortality of upstream released VAMP fish since Jersey Point groups also had PKD but survived at a higher rate. This hypotheses seems supported by the work conducted by the CA/NV FHC in 2005, that indicated that PKD infection and its effects get worse over time and that a longer migration period (due to the lower flows and further distance than those released at Jersey Point) could have resulted in less smolts surviving to Chipps Island in 2003 and 2004.

Survival between Durham Ferry and Mossdale

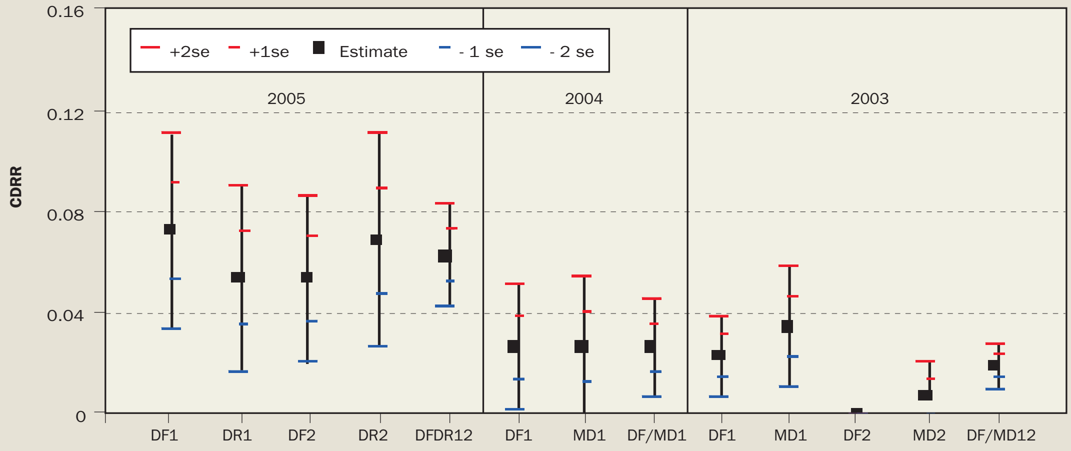
No releases were made at Mossdale in 2005 thus comparisons of survival rates between Durham Ferry and Mossdale cannot be made. However, survival between Durham Ferry and Mossdale between 2000 and 2004 has been generally high using both the Chipps Island and Antioch recoveries as well as the ocean recoveries (Table 5-8). Releases of marked fish at both sites will allow detection of mortality between Durham Ferry and Mossdale if mortality becomes great enough to detect in the future.

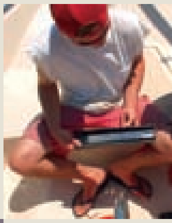
Table 5-8
Combined Differential Recovery Rates and Differential Recovery Rates for recoveries at Chipps and Antioch and in the ocean fishery for VAMP fish released at Durham Ferry and Mossdale between 2000 and 2004.

Year	CDRR Chipps and Antioch	DRR Ocean
2000	0.733	1.17
2001	1.325	1.04
2001	0.958	1.19
2002	0.794	0.93
2002	1.377	0.65
2003	0.667	
2003	0	
2004	0.998	

Figure 5-7

Combined Differential Recovery Rates (CDRR) (+ / - 1 and 2 standard errors) of CWT smolts released at Durham Ferry (DF), Mossdale (MD) and Dos Reis (DR) relative to those released at Jersey Point for the first (1), second (2) and combined release groups in 2003, 2004 and 2005. Only one set of releases was made in 2004.





Survival between Durham Ferry (or Mossdale) and Dos Reis

In 2005, releases were made at Durham Ferry and Dos Reis. However, the differences in survival between the two sites and Jersey Point in 2005 were not consistently or significantly different from each other (Figure 5-5). In past years, releases have also been made at Dos Reis and prior to 2005, were paired with comparable releases at Mossdale without the HORB in place. Average survival between Mossdale or Durham Ferry and Dos Reis was 0.71 using the Chipps Island recoveries (and Antioch recoveries in 2005) whereas it was 0.65 using the ocean recoveries (Table 5-9). However, there were two out of the nine instances using the Chipps Island recoveries and one instance using the ocean recoveries where the Mossdale or Durham Ferry groups survived at a higher rate than the Dos Reis groups. Low recovery rates, especially at Chipps Island and Antioch, may hinder our ability to consistently see differences even if they do exist.

Table 5-9
Differential Recovery Rates (and Combined Differential Recovery Rates in 2005) for experimental fish released at Mossdale (or Durham Ferry) and Dos Reis between 1995 and 2005.

MD/DF- DR	Release Date	CI	Ocean
1995	17-Apr	1.26	0.99
1995	5-May	0.31	0.51
1995	17-May	0.44	0.71
1996	30-Apr	0.33	0.38
1998	16-Apr	0.94	1.07
1998	23-Apr	0.4	0.22
1999	19-Apr	0.62	0.7
2005	2-May	1.36	
2005	9-May	0.76	
Average		0.71	0.65

Only once were releases made at Mossdale and Dos Reis with the HORB in place. That was in 1997 and estimates of survival between the two locations were 1.02 using Chipps Island recoveries and 1.29 using ocean recoveries. These data further reinforce that the temporary HORB provides protection to juvenile salmon migrating from the San Joaquin basin by reducing or preventing these fish from being drawn into upper Old River.

Survival between Dos Reis and Jersey Point

Survival in the reach from Dos Reis to Jersey Point in 2005, was much lower than survival from Durham Ferry to Dos Reis. This indicates that most of the juvenile salmon mortality occurs in the lower reach of the Delta. This finding is consistent in all years.

There have been 15 experiments where releases have been made at Dos Reis and Jersey Point, with three of these made in 1997 with the HORB in place. Data was gathered in the spring between 1989 and 1991, 1995 and 1999 and during 2005 without the HORB in place. Survival for the non-HORB years, using CDRR or DRR at Chipps Island (and Antioch recoveries in 2005) ranged between 0.03 and 0.66 and averaged 0.20. For ocean recoveries the DRR ranged between 0.05 and 0.83 and averaged 0.36 (Table 5-10). These data indicate that survival from Dos Reis to Jersey Point is generally low but has been relatively high some years. The highest survival was observed in 1995, 1997, 1998 and 1999.

Table 5-10
CDRR and DRR for survvial between Dos Reis (DR) and Jersey Point (JP) between 1989 and 2005. Stock is either Feather River (FR) or Merced River (MR). The HORB was usually not installed (n) except in 1997 (y).

Year	Release Date	CI DRR or CI and Antioch CDRR	Stock	HORB	DRR Ocean
1989	20-Apr	0.16	FR	n	0.2
1990	16-Apr	0.06	FR	n	0.05
1990	2-May	0.03	FR	n	0.08
1991	15-Apr	0.09	FR	n	0.13
1995	17-Apr	0.31	FR	n	0.83
1996	1-May	0.06	FR	n	0.11
1996	1-May	0.12	MR	n	0.15
1998	17-Apr	0.32	MR	n	0.47
1998	24-Apr	0.28	FR	n	0.77
1999	19-Apr	0.66	MR	n	0.52
1997	29-Apr	0.18	FR	y	0.37
1997	29-Apr	0.3	MR	y	0.492
1997	8-May	0.28	MR	y	0.485
2005	3-May	0.05	MR	n	
2005	10-May	0.07	MR	n	
Average		0.20			0.36

THE ROLE OF FLOW, EXPORTS AND THE HEAD OF OLD RIVER BARRIER ON SMOLT SURVIVAL THROUGH THE DELTA

San Joaquin River flow and flow relative to exports between April 15 and June 15 was correlated to adult escapement in the San Joaquin basin 2 1/2 years later (SJRG 2003). Both relationships were statistically significant ($p<0.01$) with the ratio of flow to exports accounting for slightly more of the variability in escapement than flow alone ($r^2 = 0.58$ versus $r^2= 0.42$; SJRG 2003). These relationships suggest that adult escapement in the San Joaquin basin is affected by flow in the San Joaquin River at Vernalis and exports by the CVP and SWP during the spring months when juveniles migrate through the river and Delta to the ocean. These relationships serve as conceptual models of how smolt survival would vary with flows and exports.

VAMP was designed to further define these relationships by testing how San Joaquin River flows (7,000 cfs or less) at Vernalis and exports (1,500 to 3,000 cfs) at SWP and CVP, with the HORB, affect smolt survival through the Delta. The HORB is assumed to improve survival based on studies conducted between 1985 and 1990 (Brandes and McLain, 2001). These studies indicated that smolts released on the San Joaquin River downstream of the HOR survived at about twice the rate of those released in the Old River. And while those data were not statistically significant, placing a temporary barrier at the Head of Old River appeared to be a management action that would improve survival through the Delta for smolts originating from the San Joaquin basin. The HORB barrier cannot be installed when the San Joaquin River flows exceed 5,000 cfs during the scheduled installation period, and would potentially need to be removed if the San Joaquin River flows were to exceed 7,000 cfs.

Survival of juvenile Chinook salmon emigrating from the San Joaquin River system has been evaluated within the framework established by the VAMP since the spring of 2000. The installation of the HORB is assumed as part of the VAMP experimental design. This year was the first year since 2000 that the HORB has not been in place during the VAMP experiment. However, similar survival tests both with and without the HORB were conducted prior to 2000. The results of these earlier tests were also used to help define the relationships between flow and exports on smolt survival with and without the HORB in place.

Role of flow on salmon survival

To assess the relationship between San Joaquin River flows at Vernalis and smolt survival with and without the HORB, CDRRs using recoveries at Chipps Island and Antioch as our estimate of survival between Durham Ferry and Mossdale and Jersey Point data from 1994- 2005 were plotted. In the past the CDRRs of all Durham Ferry and Mossdale releases within a year were pooled, as they were not significantly different from each other at the 95% confidence level. To increase our sample size, each separate estimate was used in this year's evaluation. Prior to combining the data from both locations, regression lines comparing the CDRR/DRR's to Vernalis flow were evaluated from both locations independently. The results indicated that the variances and the regression lines from the two locations were not statistically different. Thus the CDRR/DRR data from both Mossdale and Durham Ferry releases were plotted together in the various relationships discussed below.

Flows at Vernalis were 10 day averages for each release starting on the day of the Mossdale release (in previous years) or the day after the Durham Ferry release. Ten day averages were used to represent the flow variable since after 10 days most of the fish are far enough downstream (with some already recovered) that the flow at Vernalis is probably no longer important for that particular group migrating to Chipps Island. Flow data was obtained through DWR's DAYFLOW for past years (updated January 2004). San Joaquin flows downstream of Old River prior to 2005 were obtained from DWR from a model that simulated historical flows using DSM2 (T. Smith, DWR Personal Communication). Flow data for 2005 was obtained from Chapters 2 and 4 of this report. A request has been made to DWR to compare measured flows to those predicted by the model for the spring of 2005.

Role of flow with HORB on Salmon Survival

The CDRR/DRRs using the Chipps Island and Antioch recoveries of the Mossdale and Durham Ferry groups relative to the Jersey Point groups did increase with Vernalis flow with the HORB in place ($p<0.01$; Figure 5-8).

The relationship between Vernalis flow and DRR using the ocean data with the HORB was also positive and statistically significant ($p<0.01$; Figure 5-9). The ocean data has fewer data points because recoveries are not yet available for the 2004 and 2005 releases.

Figure 5-8
CDRR or DRR using Chipps Island and Antioch recoveries between Mossdale or Durham Ferry and Jersey Point with the HORB in place and average flow at Vernalis in cfs for 10 days starting the day of the Mossdale release or the day after the Durham Ferry release.

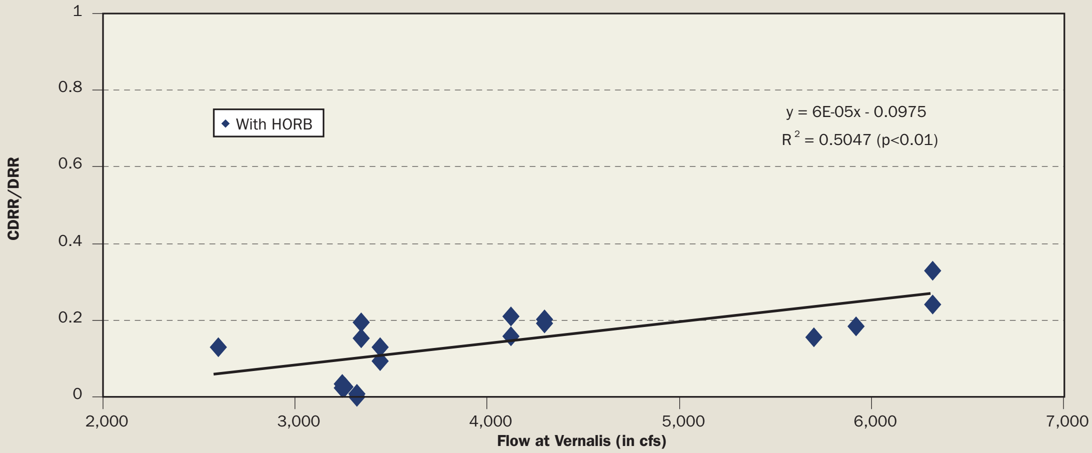


Figure 5-9
DRR using ocean recoveries, between Mossdale or Durham Ferry and Jersey Point and average flow at Vernalis in cfs for 10 days starting the day of the Mossdale release or the day after the Durham Ferry release with the HORB in place.

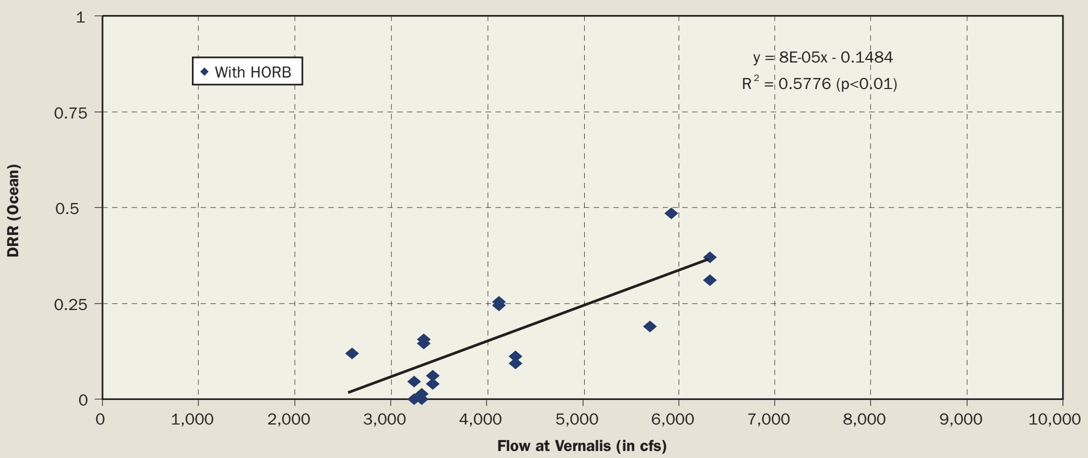
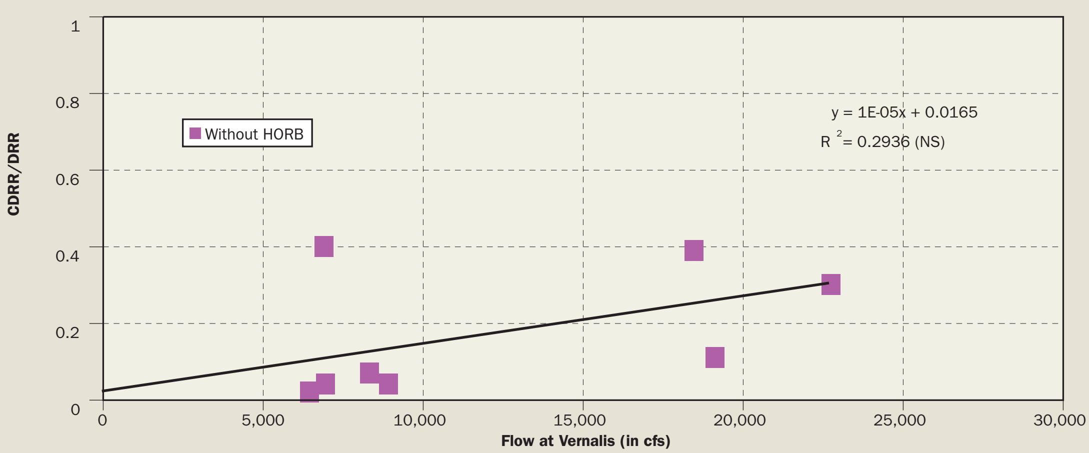


Figure 5-10
CDRR or DRR using Chipps Island and Antioch recoveries between Mossdale or Durham Ferry and Jersey Point and average flow at Vernalis in cfs for 10 days starting the day of the Mossdale release or the day after the Durham Ferry release without the HORB in place.



Role of flow without HORB on Salmon Survival

Without the HORB in place, the regression line of the DRR/CDRR's using the Chipps Island and Antioch recoveries of the Mossdale and Durham Ferry to Jersey Point survival increased with flow, but the relationship was not statistically significant (Figure 5-10).

The relationship using the ocean data without the HORB had a higher r^2 value than the one obtained using the Chipps Island and Antioch data, but was still not statistically significant (Figure 5-11). The two relationships were similar indicating that increasing flow may improve survival of the Mossdale and Durham Ferry groups relative to the Jersey Point groups without the HORB in place.

It is not surprising that there is more variability associated with smolt survival at any given flow at Vernalis without the HORB since the flow and proportion of marked fish moving into HOR varies more without the HORB.

To explore this issue further, we evaluated a group of test fish that "stayed" on the mainstem San Joaquin River and were not diverted into upper Old River. The CDRR/DRR's of smolts released at Dos Reis relative to those released at Jersey Point were compared to modeled San Joaquin flow downstream of the HOR. Three data points were gathered when the HORB was installed in 1997. The Chipps Island/Antioch data indicated a possible relationship between survival and flow, but one year (1999) was an obvious outlier (Figure 5-12). The relationship using the ocean recovery data showed that survival from Dos Reis to Jersey Point did increase with San Joaquin flows downstream of the HOR and it was statistically significant at the $p<0.01$ level (Figure 5-13). The 1999 data was no longer an outlier indicating that perhaps the Jersey Point group was biased low due to some missed sampling at Chipps Island that spring, as hypothesized in an earlier report (Brandes, 2000). This relationship indicated that survival is increased as flow increases on the mainstem San Joaquin River downstream of Old River, for the fish staying on the mainstem San Joaquin River when there is no HORB in place.

The Role of Exports on Survival

Another goal of the VAMP program is to identify the role of exports on juvenile salmon survival through the Delta. VAMP limits CVP+SWP exports to between 1,500 and 3,000 cfs depending on the flow target, because of its dual protective purpose. Historically, exports were generally much greater during this period. The VAMP design was intended to identify the role of exports with the HORB at flows of 7,000 cfs by experimenting at exports of 1,500 and 3,000 cfs. Conditions have not provided a 7,000 cfs flow with a HORB to test either export level. These limitations have made assessing the role of exports using the VAMP data difficult at this time.

In years when the HORB could not be installed it was recommended in the VAMP framework agreement to limit exports to either 1,500 or 3,000 cfs to make better comparisons with and without the HORB. In 2005, an agreement to have combined SWP/CVP pumping at 1,500 cfs for two weeks and then 3,000 cfs for the following two weeks was established and fish releases were to be made at each export level. However this agreement was not implemented as one of the parties did not initially adjust pumping as proposed. The failure to adjust pumping rates resulted in a combined pumping of approximately 2,250 cfs when marked fish were first released. A resolution was then implemented to maintain pumping at this rate for the full VAMP period. Pumping was approximately 2,250 cfs for the first 26 days of the 31 day VAMP period. Starting on May 26, exports increased gradually because the continued implementation of the reduced export level was increasing the costs (Environmental Water Account debt) to levels unacceptable to the implementing agencies.

Role of exports with HORB

Exports do not appear to explain additional variability in smolt survival over that using flow alone, in data obtained with the HORB in 1994, 1997 and between 2000 and 2004. This is counter to our conceptual model based on the better relationship of flow/exports and San Joaquin basin escapement 2 1/2 years later between 1951 and 2002 than that when using flow alone. In the recovery data from Chipps Island and Antioch (CDRR and DRR) with the HORB installed, regression analyses did show a relationship between the Durham Ferry and Mossdale data and flow/export ratios (Figure 5-14). However, the p value (0.02) indicated lower significance than the regression using flow alone ($p<0.01$) (Figure 5-8).

The ocean recovery data, while only available for releases prior to 2002, does show a trend of increasing survival with higher flow/export ratios but the relationship is not as statistically significant ($p<0.10$; Figure 5-15). Again, the relationship using flow alone was stronger (Figure 5-9).

One limitation in these experiments is the extremely narrow range of exports (1,450 to 2,350 cfs) during these smolt survival experiments with the HORB – a narrower range than in the VAMP design and much more narrow than the range of export levels observed since 1951 used in the adult escapement relationships. This narrow range may be why we can not detect a better smolt survival relationship using the flow/export ratio variable than when using flow alone with the HORB in place.

Figure 5-11
DRR using ocean recoveries, between Mossdale or Durham Ferry and Jersey Point and average flow at Vernalis in cfs for 10 days starting the day of the Mossdale release or the day after the Durham Ferry release with and without the HORB in place.

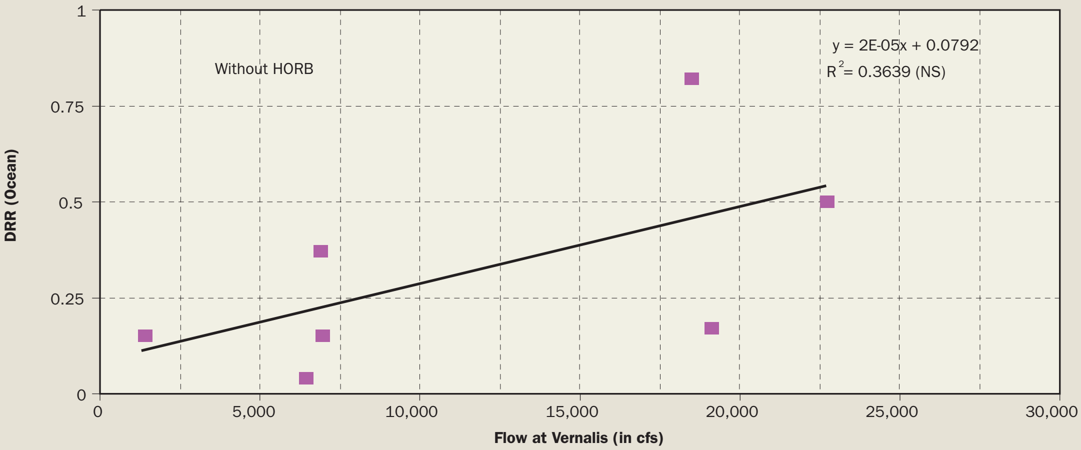


Figure 5-12
Survival between Dos Reis and Jersey Point (using recoveries at Chipps or Chipps and Antioch) with and without the HORB and modeled San Joaquin flows downstream of Old River. 1997 data was gathered with the HORB in place.

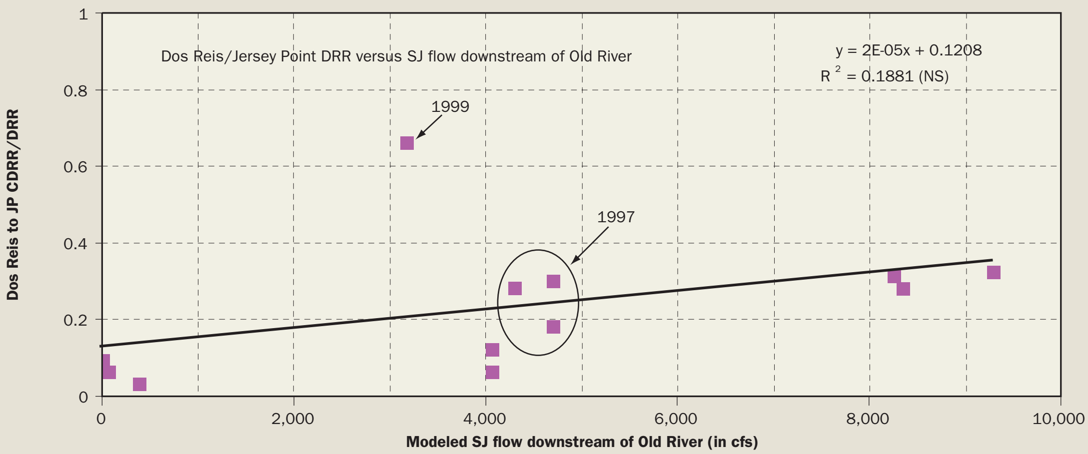


Figure 5-13
Ocean DRR of survival between Dos Reis and Jersey Point with and without a HORB and San Joaquin flows downstream of Old River. 1997 data was gathered with the HORB in place.

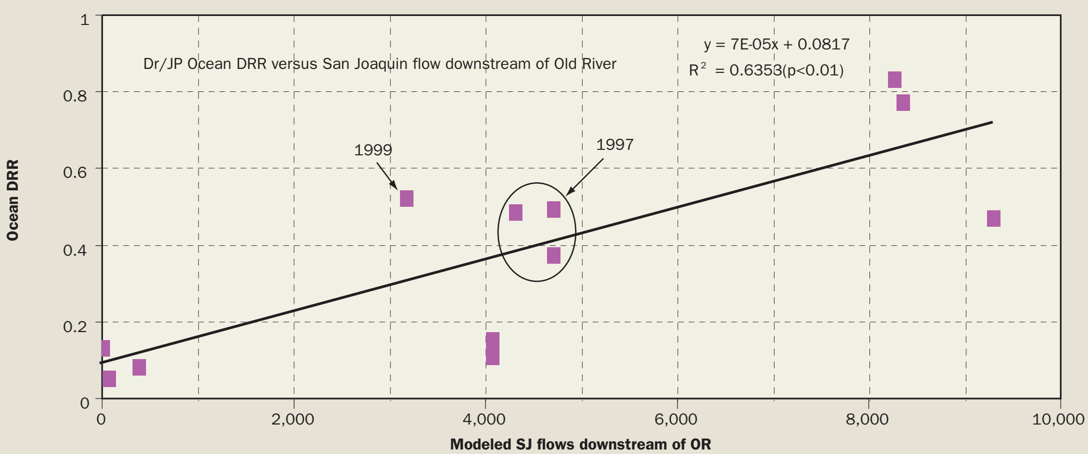


Figure 5-14
The survival between Durham Ferry or Mossdale and Jersey Point (CDRR/DRR) using Antioch and or Chipps Island recoveries and the Vernalis flow/export ratio for the 10 days after the Mossdale release. The data is gathered in years when there was a HORB in place.

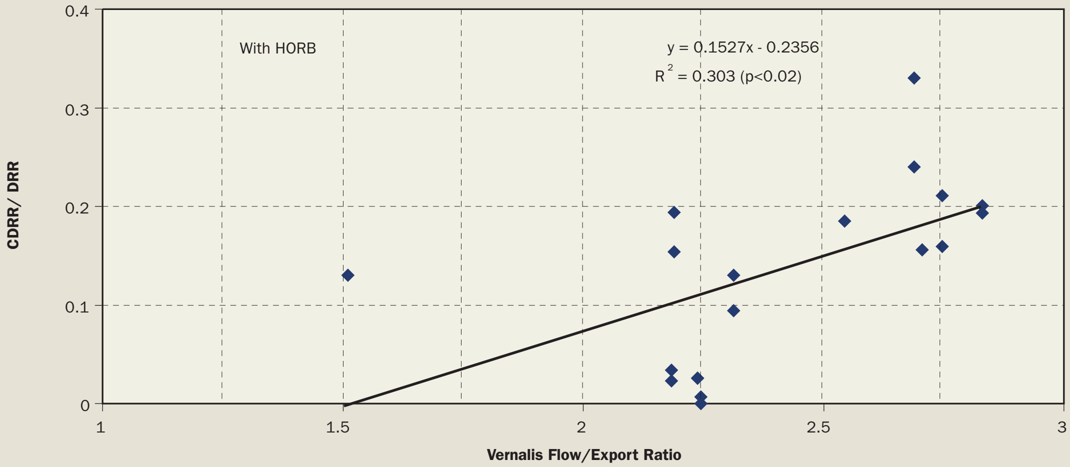


Figure 5-15
Ocean DRR of fish released at Durham Ferry or Mossdale and Jersey Point versus mean Vernalis flow/export ratio 10 days after release with the HORB in place.

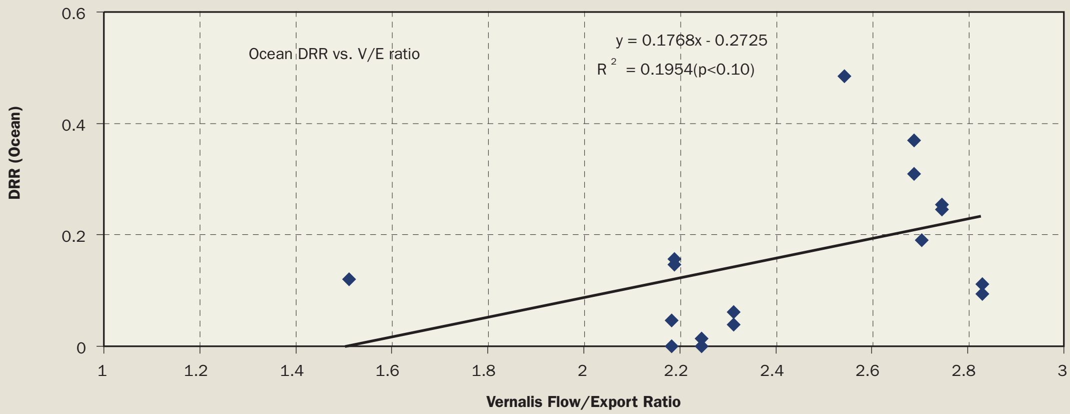
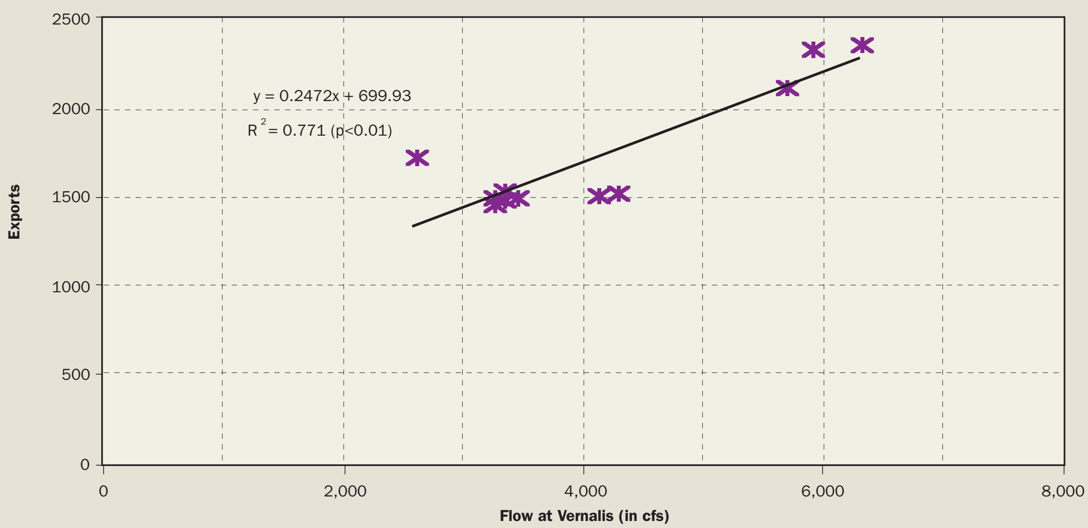


Figure 5-16
The relationship between San Joaquin River flows at Vernalis and CVP+SWP Exports during VAMP smolt survival tests conducted with the HORB in years between 1994 and 2004.



Additional analyses by Dean Marston of California Deparment of Fish and Game found that the CDRR and DRR's increased as exports increased in simple linear regressions (r^2 = 0.47 – Chipps and Anitoch recoveries, and r^2 = 0.69 – ocean recoveries) of the Mossdale groups relative to the Jersey Point groups, using both Antioch and Chipps Island and ocean recoveries. But when the exports and flow values used in these regressions were regressed against each other, there was a strong relationship between flow and exports (r^2 = 0.77) indicating that in general the experiments conducted with the HORB at the lower flows had lower exports and experiments at the higher flows had higher exports (Figure 5-16). It is problematic to identify the respective roles of each variable when the two variables tested are linked in this way.

Our next step is to experiment at flows of 7,000 cfs with the HORB and vary exports (1,500 and 3,000 cfs) to better define the export affect, independent of flow, on smolt survival.

Role of exports without HORB

The role of exports on smolt survival without the HORB in place is even more difficult to identify at this time. As mentioned earlier, relationships of smolt survival without the HORB with flow alone were not statistically significant (Figures 5-10 and 5-11). Regressions of exports to smolt survival without the HORB were weakly or not statistically significant (Figure 5-17) using both the Chipps Island and Antioch and ocean recoveries, but both relationships indicated survival increased as exports increased. The best relationship is a weakly significant multiple regression that includes flow and exports, with survival (using ocean recoveries) increasing as both flow and exports increase ($p<0.68$, $p<0.10$). In these data flows and exports were not correlated to each other (r^2 =0.0142), but the export range was limited to between 1400 and 3700 cfs. It is possible that increasing exports in this range decreases residence time in Old river such that survival for those smolts moving into Old River have higher survival. These findings are counter to our hypothesis that survival decreases as exports increase relative to flow.

Regressions between the DRR from Mossdale and Durham Ferry using Chipps Island and Antioch and ocean recoveries did not show a relationship with flow/export ratios (Figure 5-18) – but again these data are limited in the range of export values tested. The adult escapement data which incorporates a larger range in export values indicates a positive and strongly statistically significant relationship ($p<0.01$) with flow/exports without the HORB but we are not able to detect this same relationship with the smolt survival data we have gathered to date. As in the with HORB data, it will be important to continue these experiments in the future and to measure survival at different export levels at the same flows without the HORB.

The Role of the HORB on survival through the Delta

One obvious result of the HORB on survival through the Delta is the lower salvage (and direct loss) for fish released at Durham Ferry and Mossdale when the HORB is installed. In 2005, several hundred of the Durham Ferry group, were salvaged indicating a higher loss compared to previous years because the HORB was not in place.

Comparing the with and without HORB data, using the Chipps Island and Antioch data, appears to indicate that there is value in installing the HORB at flows between about 3,000 and 6,000 cfs (Figure 5-19a). The benefit, using the ocean data, seems less apparent but may improve survival between flows of 4,000 and 6,000 cfs (Figure 5-19b).

Relationship of flow and exports to adult escapement 2 1/2 years later

The relationships between flow and flow/exports to escapement (all year classes) 2 1/2 years later have been shown in previous reports (SJRGA, 2003). In this section of the report, we will present revised escapement data (includes all age classes) which only includes escapement from the Stanislaus, Tuolumne and Merced rivers. Previous estimates included escapement in the Mokelumne, Calaveras and Consumnes rivers as well. In addition, the data has been updated to include the most recent escapement (to 2004) and flow (to 2002) data. These revised and updated escapement data were obtained from the USFWS Anadromous Fish Restoration Program's website at http://www.delta.dfg.ca.gov/afrp/index/asp.

These updated escapement data for the years of 1953 to 2004 was divided into two groups: the first group includes data gathered in those years when the HORB was in place for at least 2 weeks during the smolt out-migration period (April 15 to June 15) 2 1/2 years earlier and the second group includes escapement data for those years when there was no HORB. These relationships using both sets of data continue to show that escapement is significantly ($p<0.01$) correlated to Vernalis flows (Figure 5-20) and Vernalis flows/CVP+SWP exports continues to explain more of the variability in adult escapement than when using flow alone when there was no HORB in place (Figure 5-21). In addition, escapement was significantly correlated to Vernalis flows minus exports (Figure 5-22). The highest r^2 value for the years when there was a HORB in place was for the relationship between adult escapement and flow. This may reflect the relatively low exports in the years the HORB has

Figure 5-17

Chipps Island DRR or Chipps Island and Antioch DRR and ocean DRR for CWT smolts released at Mossdale or Durham Ferry relative to those released at Jersey Point versus combined SWP+CVP mean exports for the 10 days after release in years between 1994 and 2005 when there was no HORB in place.

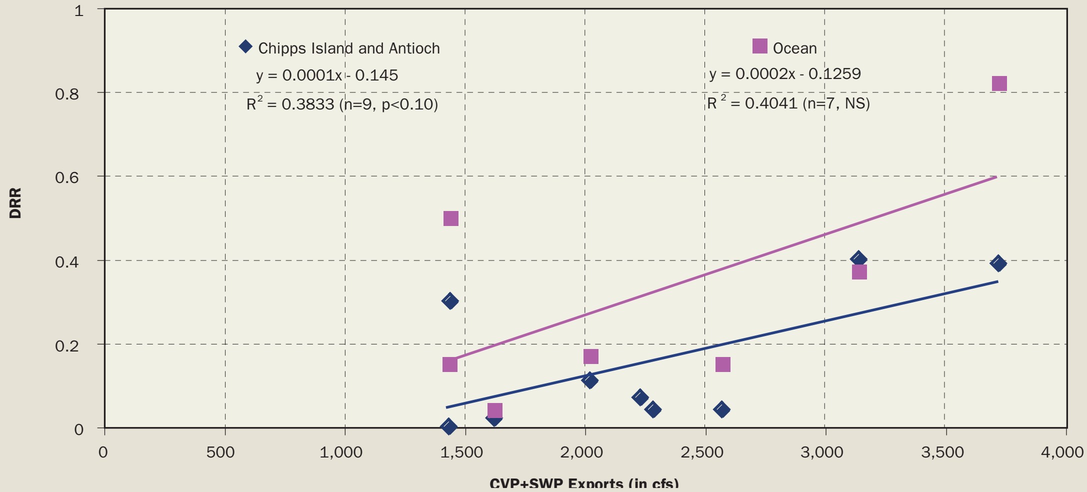


Figure 5-18

Ocean DRR's and Antioch and/or Chipps Island CDRR's or DRR's for fish released at Mossdale and Jersey Point versus the mean Flow/Export ratio for the 10 days after release without the HOR barrier.

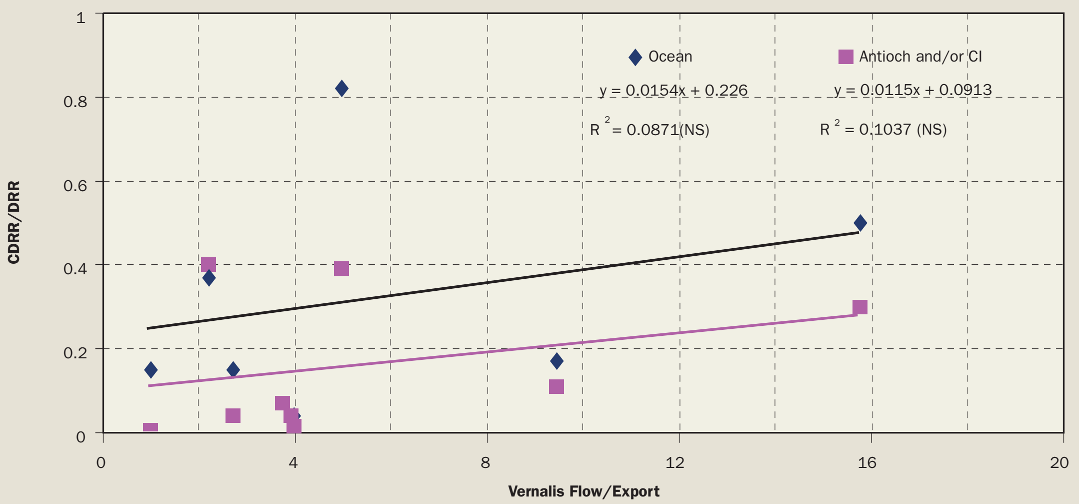
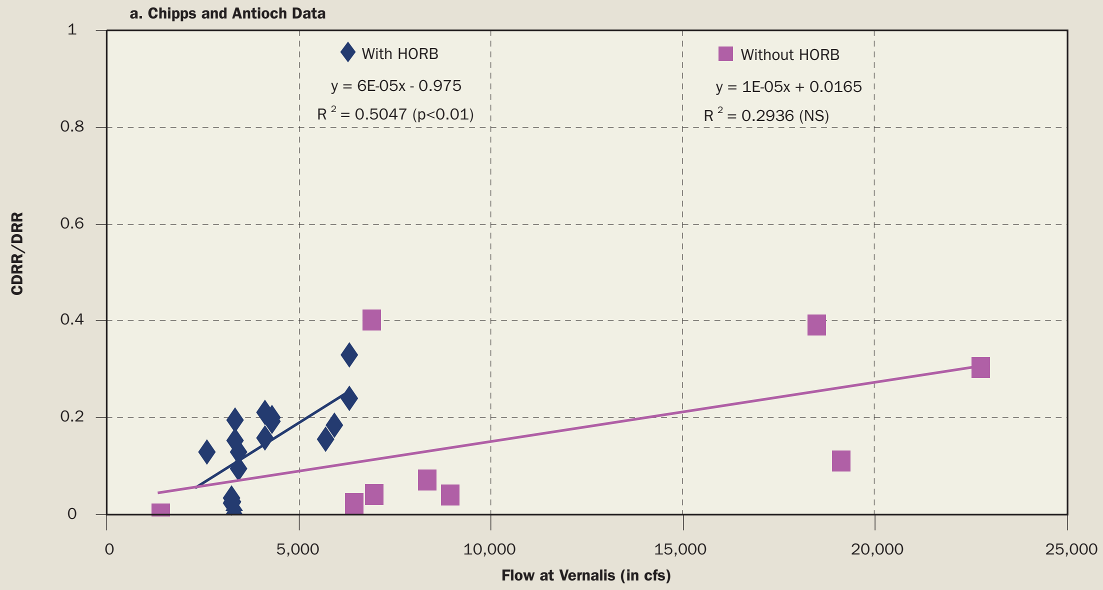


Figure 5-19
CDRR or DRR using Chipps Island and Antioch recoveries between Mossdale or Durham Ferry and Jersey Point and average flow at Vernalis in cfs.



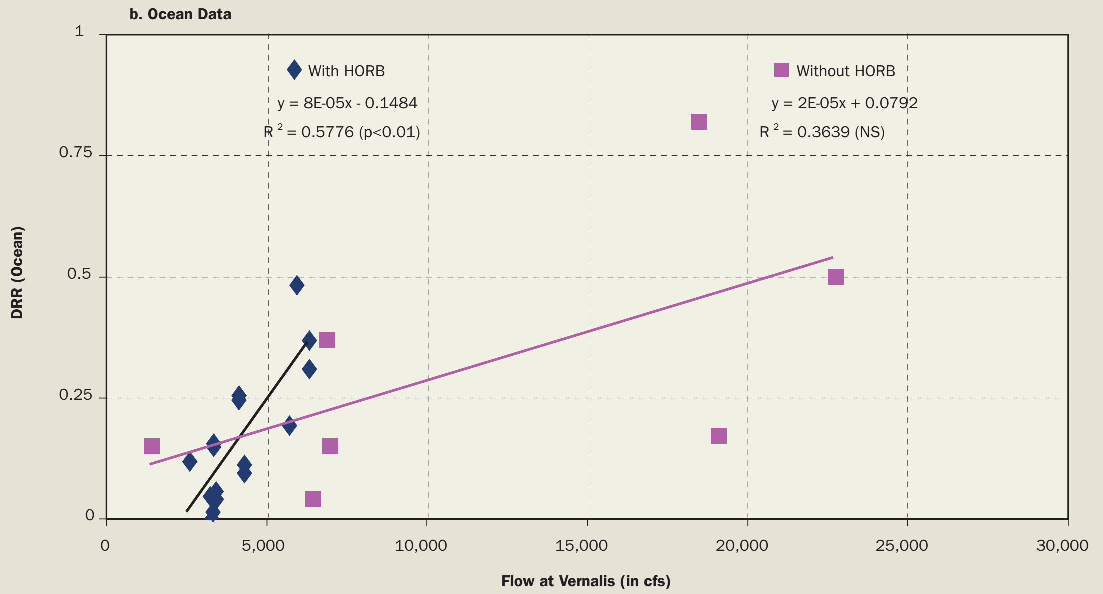


Figure 5-20

Vernalis flows versus escapement 2 1/2 years later in years with and without the HORB.

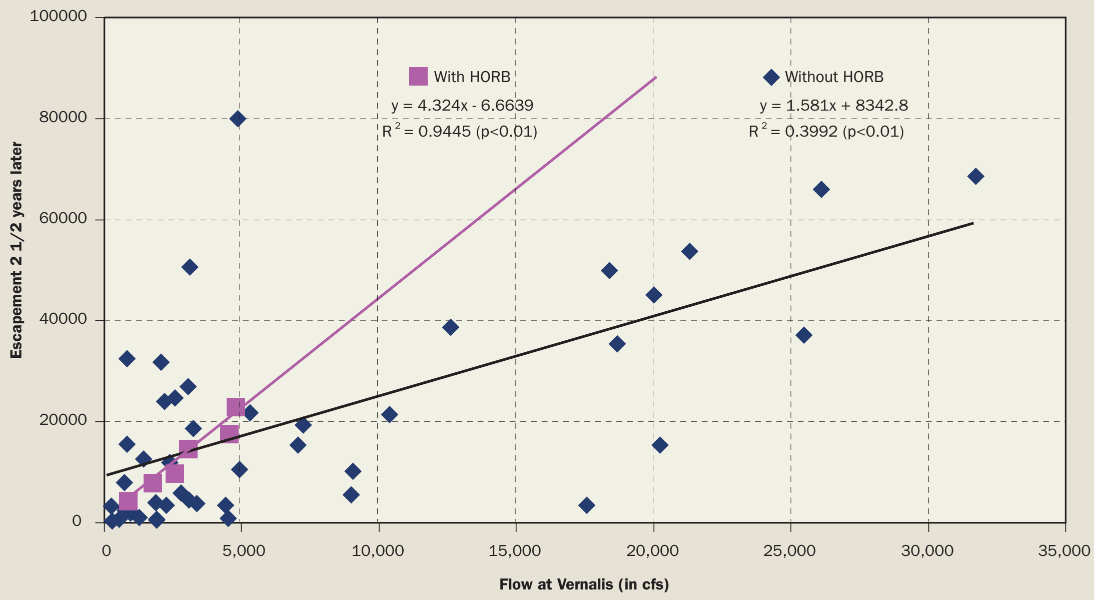
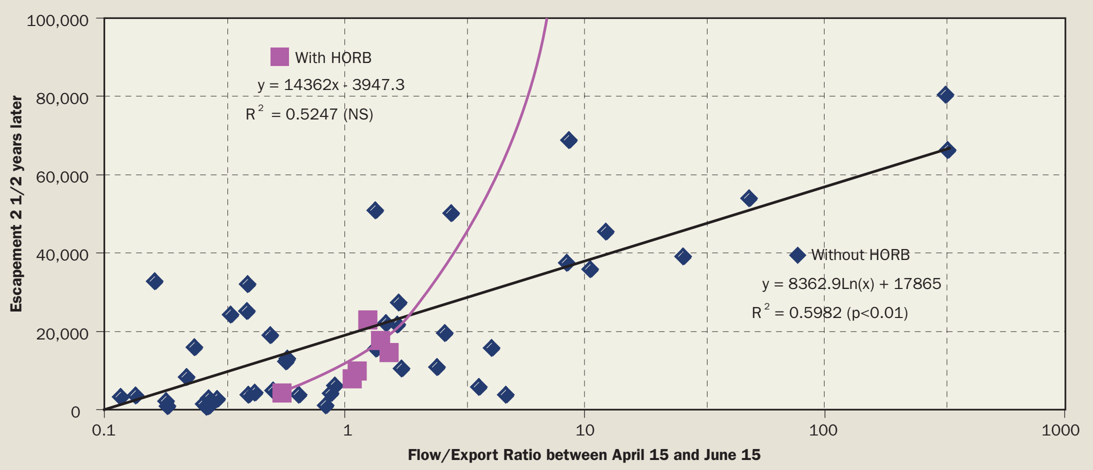


Figure 5-21

Vernalis flow/export ratio versus adult escapement 2 1/2 years later in years with and without the HORB in place.



been in place and the greater effect over a broader range of flow relative to exports on escapement when there wasn't a HORB.

In a multiple regression correlating escapement to flows and exports, exports did not provide any additional predictive power to the model than using flow alone. It is not clear why escapement without the HORB is better predicted using the flow/export ratio than flow alone in simple linear regressions, but in a multiple regression, exports do not explain any additional variability in escapement in all years between 1953 and 2004 over that of flow alone. The with and without HORB data was not partitioned in the multiple regression analyses and may explain some of these differences.

In addition, the ratio of exports to flow (opposite of the flow to export ratio) has been used in the past to estimate the amount of flow diverted into HOR when there is no HORB installed (Jim Snow, DWR, personal communication). It is likely the amount of flow diverted affects the proportion of smolts diverted into HOR. The smolts diverted into HOR would likely be more affected by project exports which in turn would affect their overall smolt survival through the Delta and sequential adult returns 2 1/2 years later. This relationship between the ratio of exports/flow and the proportion of flow diverted into Old River may help explain why we see relationships with the flow/export ratio to adult escapement but do not find that exports account for any additional variability in a multiple regression analyses with flow.

The benefit of examining these adult relationships is that there is more data gathered over a broader range than for smolt survival under the VAMP framework. These adult relationships would indicate that as you increase flows and decrease exports relative to flows there should be corresponding increases in smolt survival and adult escapement 2 1/2 years later. So while we cannot yet see a significant relationship of flow/exports to smolt survival with the limited data gathered to date, these data would suggest there is a relationship and it predicts adult escapement better than flow alone when there is no HORB. The relationship of flow alone to data gathered with the HORB may reflect the lack of variability in exports with the HORB in place during these experiments as mentioned previously.

When comparing the relationships of escapement and flow with and without the HORB we find that the HORB may have increased escapement between average flows of about 3,000 to 5,000 cfs (Figures 5-20). However, it is not clear that the with and without HORB regression lines are different from one another. Using the relationships of escapement, to evaluate the benefits of the HORB, are imprecise because the HORB wasn't in place for the entire migration period of the juvenile salmon that returned to spawn 2 1/2 years later. This is only one of the sources of noise in the escapement data. Additional data are needed to confirm this apparent benefit. Returns based on cohort estimates (specific year classes) would provide an important refinement to this assessment, as the assumption that the majority of spawners are 3-year old fish is known to be inaccurate.

Summary

With the HORB in place we have established statistically significant relationships between smolt survival and flow at Vernalis. These relationships are found using the Chipps Island and Antioch smolt recovery data and the ocean recovery data. The smolt survival data obtained without the HORB show a trend of increasing survival as flows increase but relationships are weaker and not statistically significant. The relationship between ocean recovery rates of the Dos Reis groups relative to the Jersey Point groups indicate that survival improves as flows increase for smolts that remain within the mainstem San Joaquin River when there is no HORB. The role of exports on smolt survival within the VAMP (with HORB) and without a HORB is more difficult to define based on the limited data. It is imperative that we measure the two export rate conditions (1,500 and 3,000 cfs) at flows of 7,000 cfs with a HORB in place so that the uncertainty can be resolved. Additional data should also be gathered without the HORB. Finally, the relationships with adult escapement infer that survival through the Delta can be improved with 1) increased flow when there is a HORB, 2) increased flow/export ratios when HORB is not installed, and 3) with a HORB at flows between 3,000 and 5,000 cfs.

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.

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

Figure 5-22
Relationship between San Joaquin flow minus exports between April 15 and June 15 and adult escapement 2 1/2 years later with and without the HORB in place.

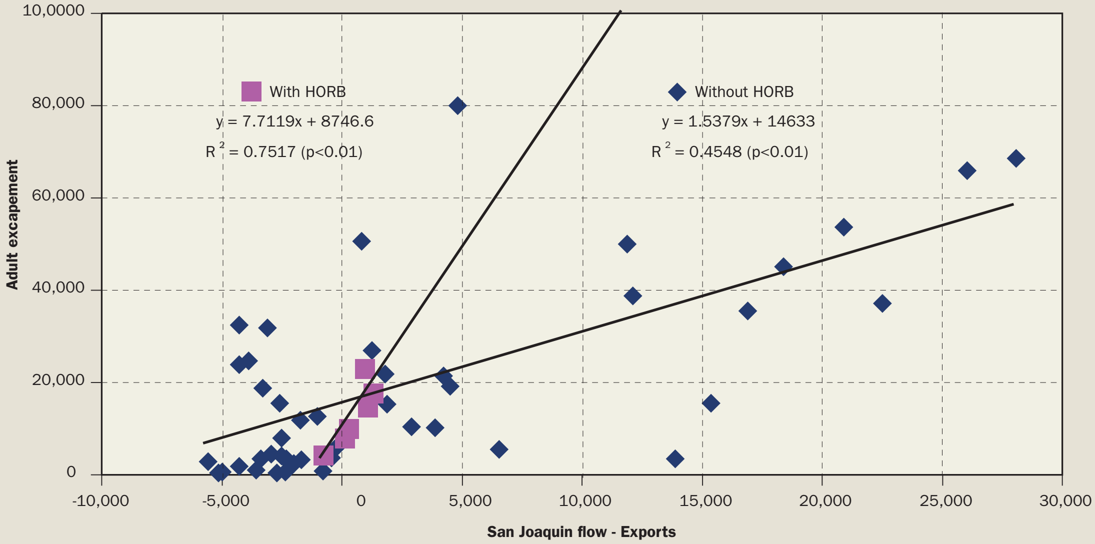


Figure 5-23
The average daily densities of unmarked salmon caught in the Mossdale Kodiak trawl on the San Joaquin River and the percent of smolts protected during the pre-VAMP and VAMP periods.

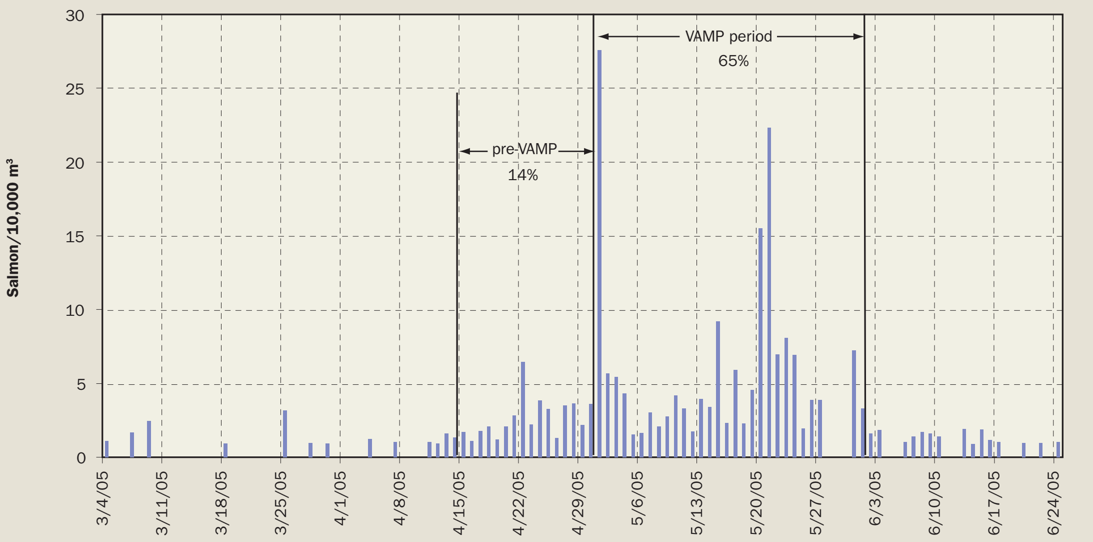


Figure 5-24
Mossdale Kodiak trawl individual daily forklengths of all unmarked juvenile Chinook salmon, March 15 through June 30, 2005.

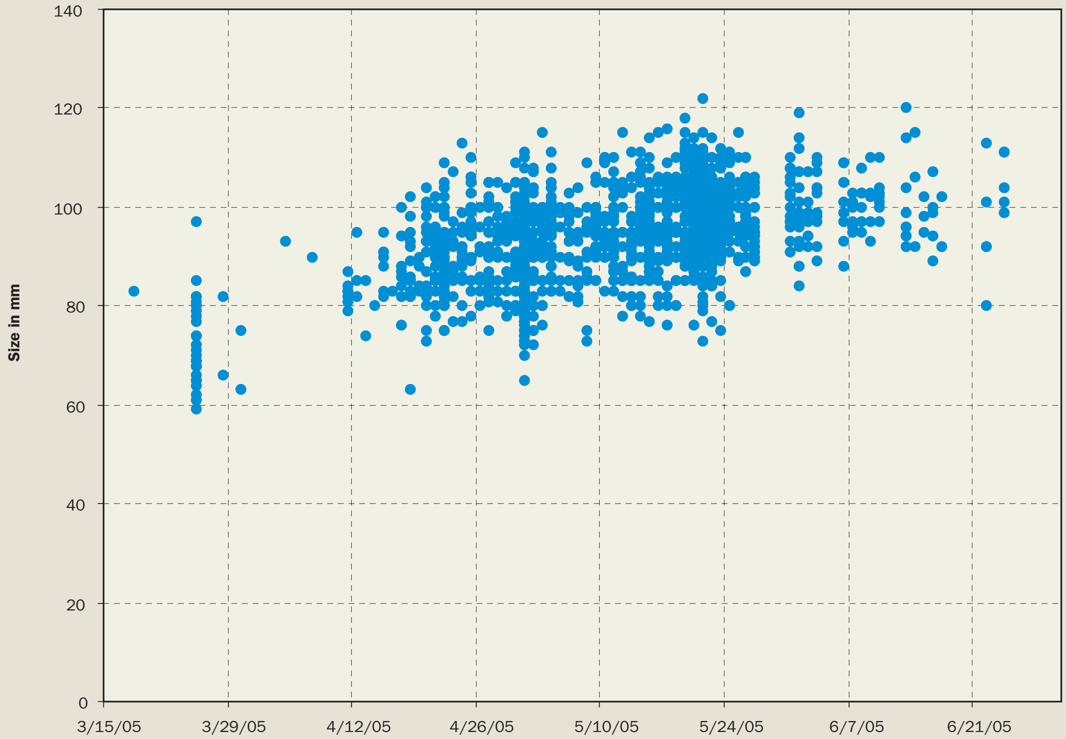
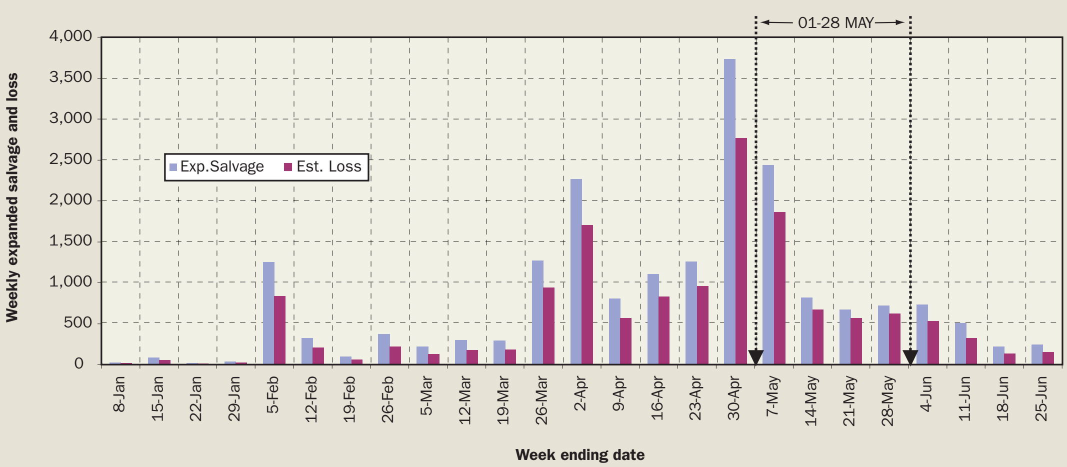
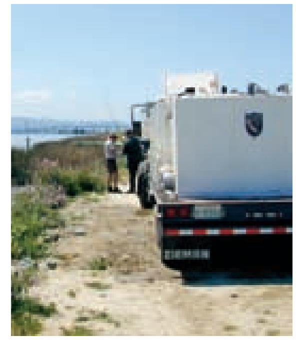
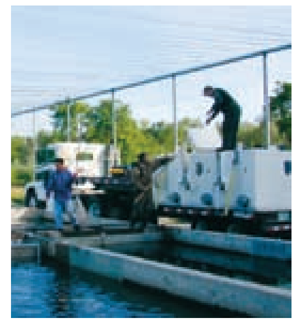


Figure 5-25
2005 CVP Estimated Salmon Salvage and Loss







Unmarked Salmon Recovered at Mossdale

The typical time period for VAMP (April 15 to May 15) was chosen based on historical data that indicated a high percentage of the juvenile salmon smolts emigrating from the San Joaquin tributaries passed into the Delta at Mossdale during that time. In 2005, the VAMP period was delayed until May 1 with the intent of providing more stability in the river flows at Vernalis. The average catch per 10,000 cubic meters per day of unmarked juvenile salmon caught in Kodiak trawling at Mossdale between March 15 and June 30, 2005 is shown in Figure 4-6. Unmarked salmon do not have an adipose clip and could be juveniles from natural spawning or unmarked fish released from the MRFF.

Approximately 65% of the unmarked catch that passed Mossdale between March 15 and June 30 passed during this years VAMP period (May 1 – June 1) (Figure 5-23). The range has varied between 31 and 76% in the pervious VAMP years since 2000 (SJRG, 2005). The pre- VAMP shoulder on VAMP that restricted exports between April 18 and May 1 provided protection to an additional 14% of the population in 2005 (Figure 5- 23). The size of the juvenile salmon migrating past Mossdale between March 15 and June 30, 2005 is shown in Figure 5-24.

Salmon Salvage and Losses at Delta Export Pumps

Fish salvage operations at the CVP and SWP export facilities capture unmarked salmon and transport them by tanker truck for release 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 CWT recovery data for MRFF smolts at the salvage facilities to provide some general indications as to the origin of the unmarked fish.

The 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 Clifton Court Forebay. The CVP losses are about six to eight times less, per salvaged salmon, than for the SWP. The loss estimates do not include any indirect mortality in the Delta due to water export operations, or any additional mortality associated with trucking and handling, or post-release predation.

Density of salmon at the fish facilities is represented by the combined number of salvage and losses estimated per acre-foot of water pumped. This approach provides more comparable densities at each facility than density values based only on salvage estimates that were used previously, due to the different calculation of associated losses at each location. 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.

The weekly data covering the period of May 1 to May 28 approximated the 2005 VAMP period. A review of weekly data for January through June indicates that the highest CVP salvage and loss occurred from late April to early May. Lesser peaks occurred between late March and early April and in early February (Figure 5-25). Highest SWP salvage and loss were in late April with a sustained broad peak from mid-May to mid-June (Figure 5-26). The primary CVP and SWP peaks occurred during an extended period of late March to mid-June when combined CVP and SWP weekly export rates were equal to, or exceeded by Vernalis flow (Figure 5-27).

Salmon densities at the CVP facilities were highest in late April to early May, with an earlier peak in late March (Figure 5-28). Densities at the SWP facilities were highest in the second half of May and were elevated from mid-April through early June (Figure 5-28).

The size distribution of unmarked salmon during mid-March through May in the Mossdale trawl (Figure 5-24) was a subset of the size distribution of those salvaged at the fish facilities (Figure 5-29, Source E. Chappell, DWR). Based on comparisons with Mossdale data (Table 4-2), it appears that some salmon salvaged prior to VAMP could have been from the San Joaquin basin.

Results of these analyses showed that the 2005 VAMP test period and the pre-VAMP curtailment in exports for Delta smelt coincided with much of the peak period of San Joaquin River salmon smolt emigration. Reductions in SWP and CVP exports and increased San Joaquin River flow likely provided improved conditions for salmon survival through the Delta.

SUMMARY AND RECOMMENDATIONS

The survival estimates and CDRRs measured in 2005 were low and similar to those estimated in 2003 and 2004. One of the reasons 2005 survival was low was due to the fact that there was no HORB installed. We would have predicted higher survival if the HORB had been installed.

The health of the fish used in 2005 was again somewhat suspect and improving their condition should be discussed with those responsible for fish production in the basin. Specifically, factors that could reduce the incidence of the parasite that causes PKD should be identified. The CA/NV FHC has shown PKD is also in the wild population in the San Joaquin basin. The survival indices were consistently low for all of the marked fish released from MRFF, with the exception of those released at Jersey Point. However, the survival of fish released at Jersey Point may have been reduced after they passed Chipps Island because they also had PKD but in general were recovered sooner then those released upstream.

There are statistically significant relationships of smolt survival and flow with the HORB. These relationships are found using the Chipps Island and Antioch recoveries of the Durham Ferry and Mossdale groups relative to the Jersey Point groups and when using ocean recoveries. Escapement 2 1/2 years later was also significantly ($p<0.01$) correlated to San Joaquin River flow at Vernalis with a HORB.

There is also a trend of increasing smolt survival with San Joaquin River flow without the HORB but the relationships are not statistically significant. There is however, a statistically significant relationship between spring flows without a HORB and adult escapement 2 1/2 years later. Without a HORB the best predictor of escapement is the flow/export ratio.

To better determine relationships of smolt survival to exports and flow, certain conditions should be targeted during the remaining years of VAMP and in years when the HORB cannot be installed. Two of the conditions that need to be tested are at exports at 1,500 and 3,000 cfs with San Joaquin River flows at 7,000 cfs with the HORB in place. In addition, the 7,000 cfs flow and the 1,500 export condition would achieve the highest inflow to export ratio (4.7) within the VAMP design and provide a larger ratio to test. Unless these extremes are tested soon, the length of the study may need to be extended. Furthermore, more data should be obtained when the HORB cannot be installed to further refine and define the survival relationships to flow and exports without the HORB in place.

Figure 5-26
2005 SWP Estimated Salmon Salvage and Loss

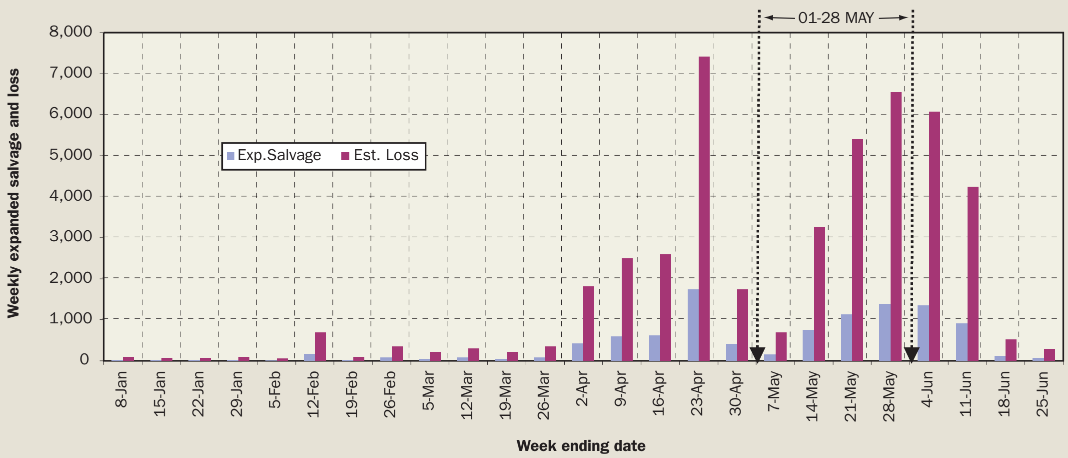


Figure 5-27
2005 Weekly Export Rates and Vernalis Flow

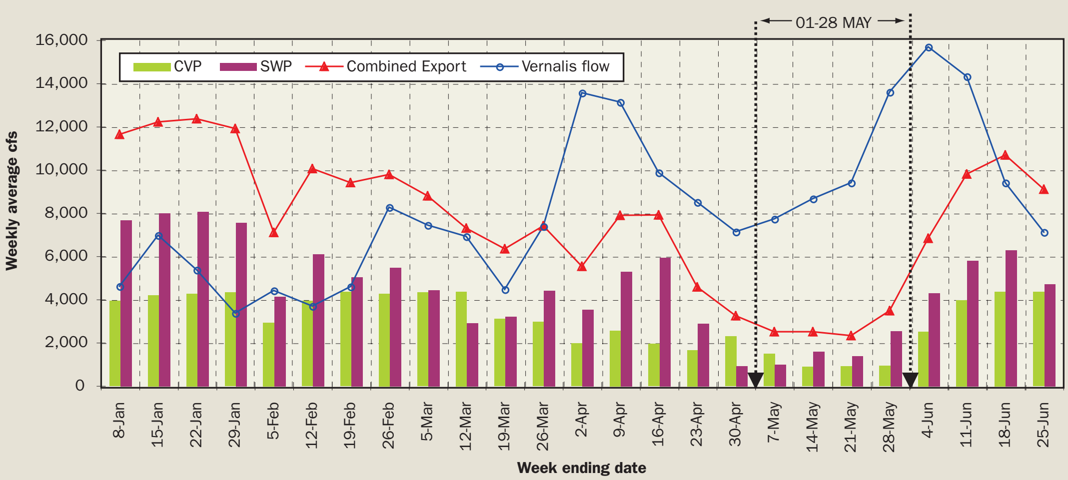


Figure 5-28
2005 CVP & SWP Combined Salvage and Loss Density

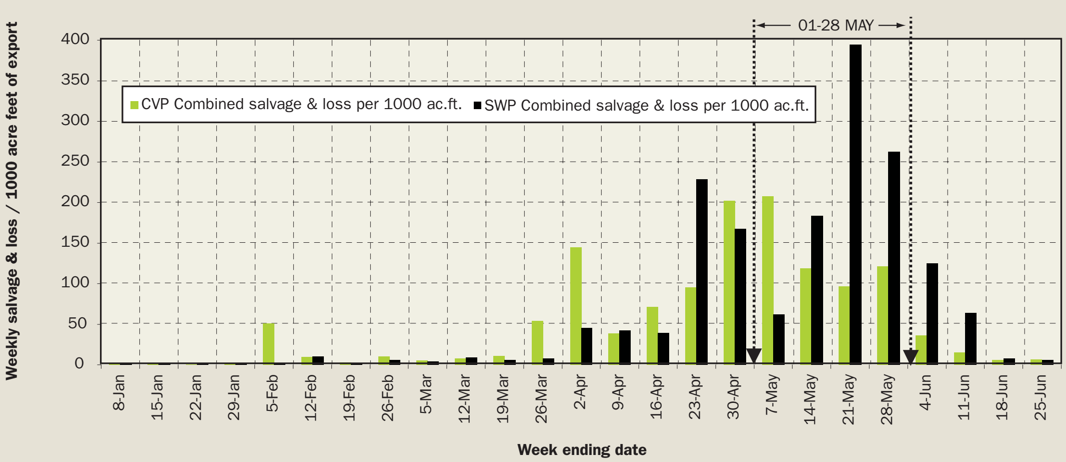
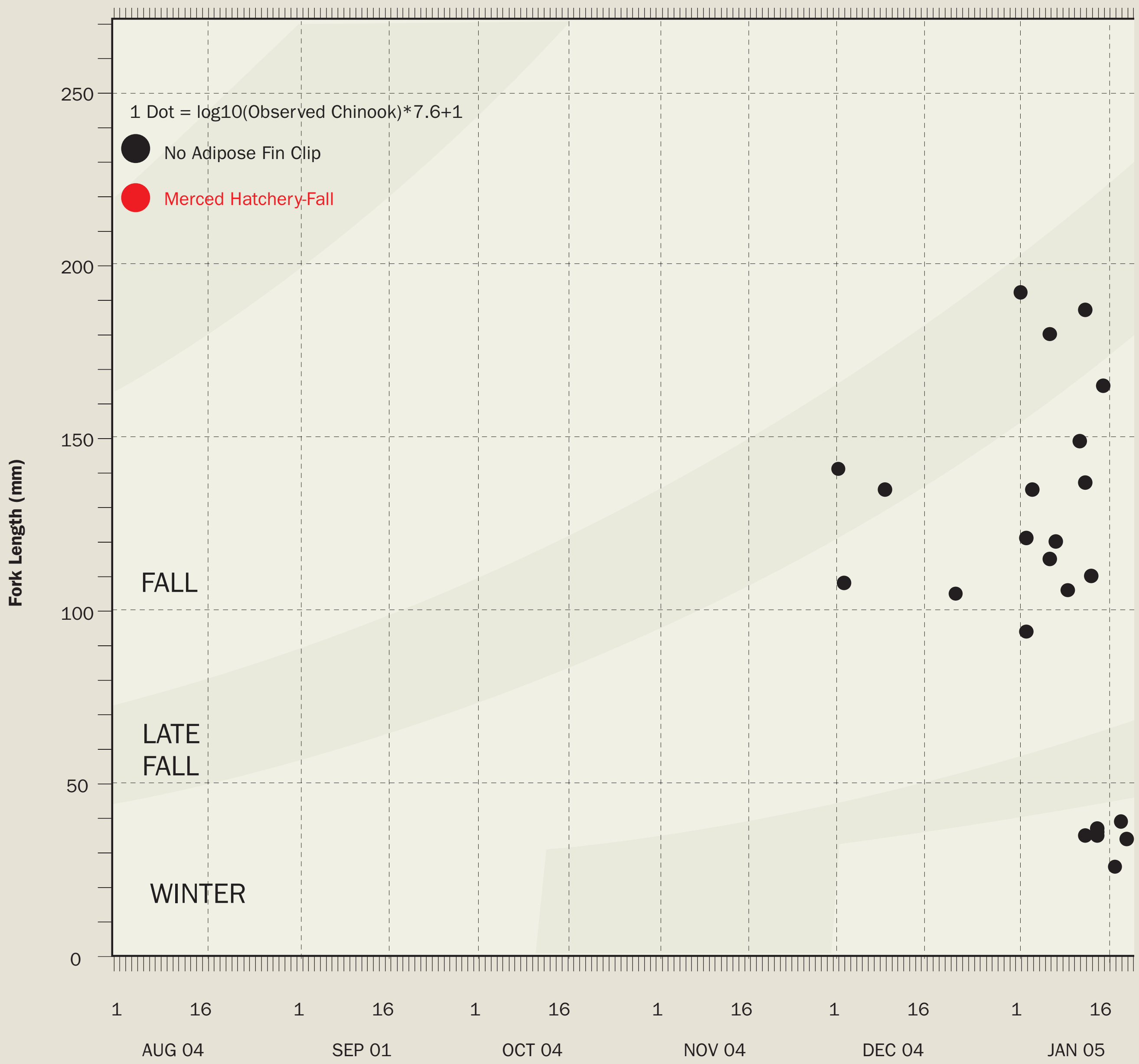
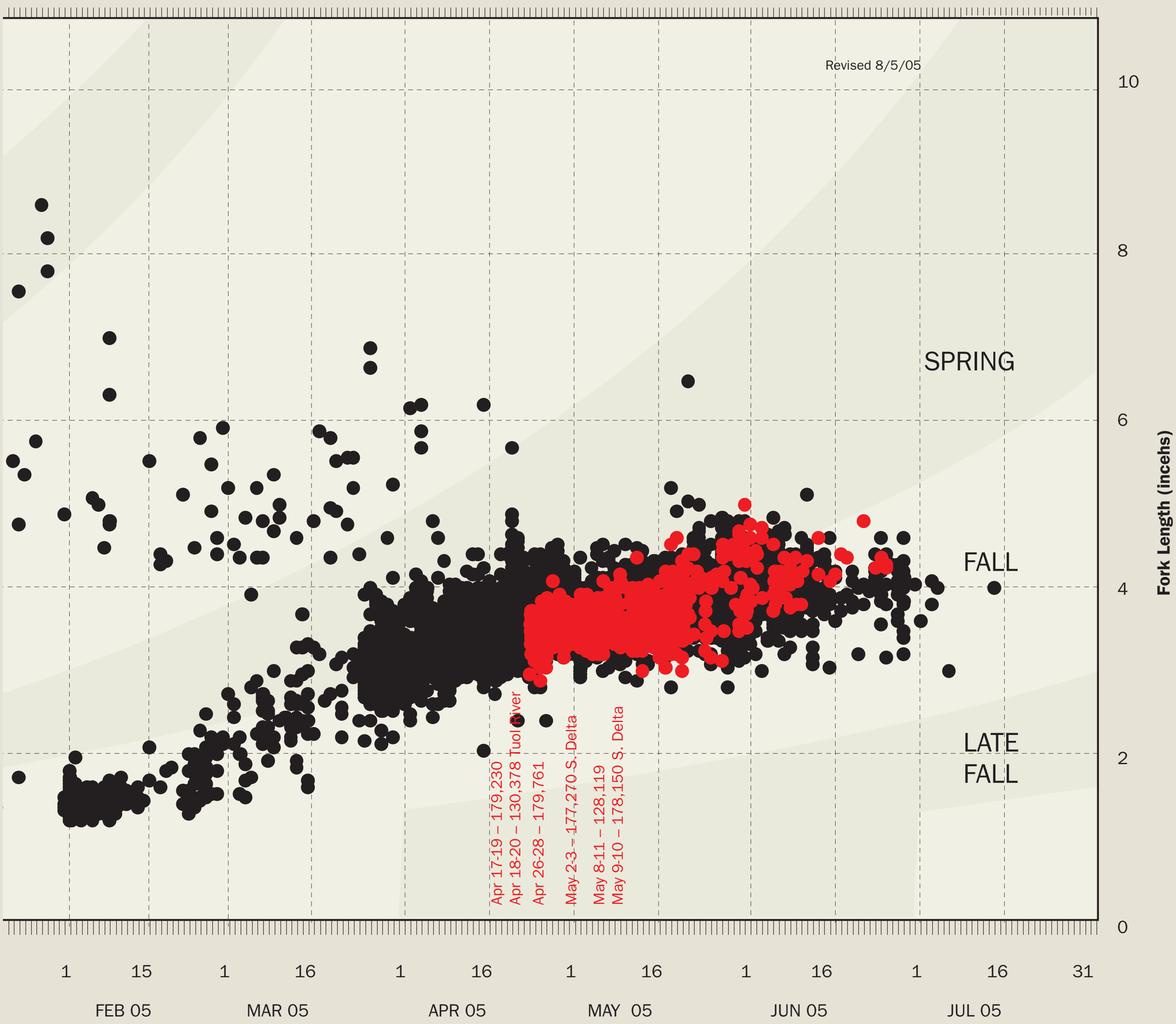


Figure 5-29
Observed Chinoook Salvate at SWP & CVP
Delta Fish Facilities 8/1/04 Through 7/31/05





Revised 8/5/05
SPRING
FALL
LATE FALL
Apr 17-19 – 179,230
Apr 18-20 – 130,378 Tuol River
Apr 26-28 – 179,761
May 2-3 – 177,270 S. Delta
May 8-11 – 128,119
May 9-10 – 178,150 S. Delta
Fork Length (incehs)
10
8
6
4
2
0
1
15
1
16
1
16
1
16
1
16
1
16
31
FEB 05
MAR 05
APR 05
MAY 05
JUN 05
JUL 05

Chapter 6

6 Complimentary Studies Related to the VAMP

Throughout 2005 several fishery studies were conducted that were considered to be important to the overall understanding of the abundance and survival in the San Joaquin River basin. These are presented below to provide the reader with summary information on each study. More information can be obtained from each study manager or report author.

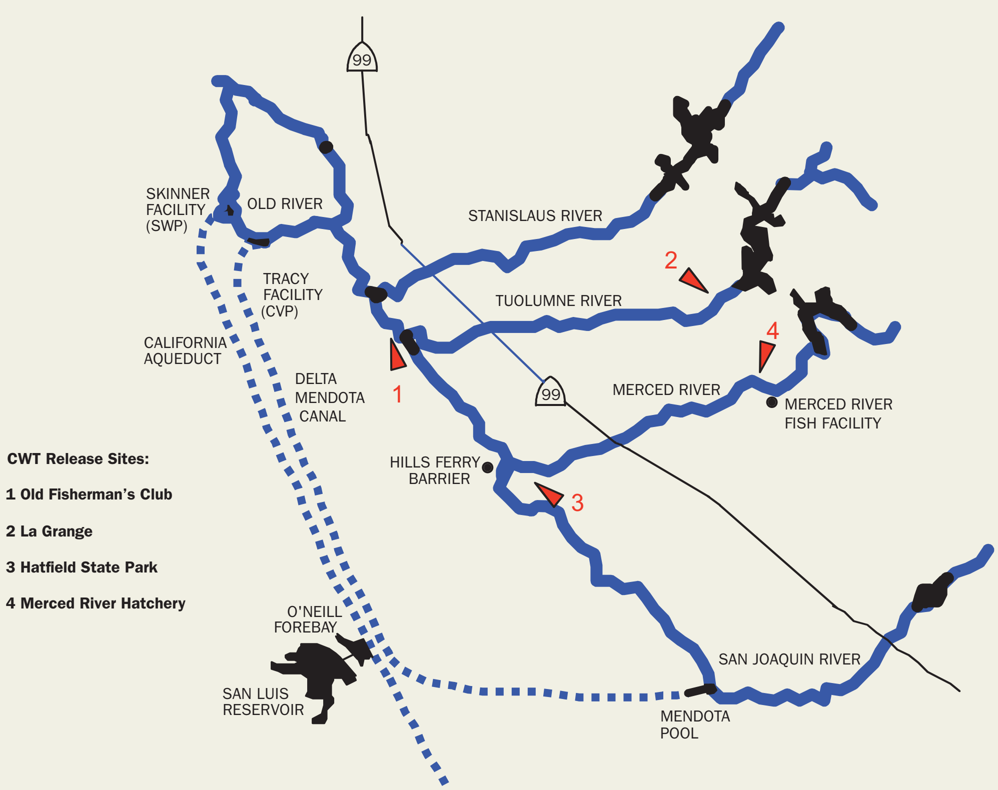
SURVIVAL ESTIMATED FOR CWT RELEASES MADE IN THE SAN JOAQUIN TRIBUTARIES

Contributed by Pat Brandes, U.S. Fish and Wildlife Service

Coded wire tagged salmon from the MRFF were released in the Merced River between April 17 and May 11, 2005 as part of an independent (complimentary to VAMP) fishery investigation. Releases were made in the upper and lower reaches of the Merced River (Merced Hatchery and Hatfield State Park, respectively). One set was also released in the Tuolumne (La Grange) and in the mainstem San Joaquin River just downstream of the confluence with the Tuolumne River (Old Fisherman's Club) (Figure 6-1).

Survival indices to Antioch and Chipps Island of lower Merced releases made at Hatfield State Park and San Joaquin River releases (Old Fisherman's Club) include

Figure 6-1
CWT release sites for releases made in the Merced, Tuolumne and San Joaquin Rivers in 2005



mortality down the mainstem San Joaquin River, as well as through the Delta. Chipps Island survival indices of the lower Merced River and Old Fisherman's Club groups were comparable to survival indices from the 2005 VAMP releases made at Durham Ferry and Dos Reis. Survival indices using Chipps Island recoveries ranged between 0.010 – 0.077 (Table 6-1), while those for VAMP fish released at Dos Reis and Durham Ferry ranged from 0.022 to 0.063 (Table 5-4). No recoveries were made at Antioch.

These data would indicate that the variables that affected the survival of Durham Ferry and Dos Reis released VAMP fish in 2005 also affected survival of the lower Merced River and Old Fisherman's Club release groups. Mortality was not as great for the Jersey Point groups. This same pattern was also detected in 2003 and 2004 (SJRG, 2004).

Survival indices were also generated for the upstream Merced River releases (MRFF) and for those groups released in the upper Tuolumne. Comparison of survival indices to Chipps Island of groups released upstream and downstream provides an estimate of survival through the tributary. This is accomplished by dividing the Chipps Island upstream group survival index by the downstream survival index. For the three sets released on the Merced River, survival was estimated to range from 0.42 to 1.2, indicating survival through the tributary was high (Table 6-2). Survival through the Tuolumne River was also high and was calculated to be 1.2 (Table 6-2). Estimates of over one are likely due to the variance associated with low recoveries of both the upper and lower release groups. These comparisons likely do not provide precise estimates of survival through the Merced and Tuolumne rivers, but may be useful for distinguishing between high and low survival. Ocean recoveries will be available for these groups in future years and will provide an additional means to estimate survival through each tributary.

COMPARISON OF VAMP RELEASES WITH SACRAMENTO RIVER DELTA RELEASES

Contributed by Pat Brandes, U.S. Fish and Wildlife Service

As in previous years, marked fish from the Feather River were released on the Sacramento River near Sacramento (Figure 1-1). Three groups were released to index survival through the Delta for juvenile salmon originating in the Sacramento basin. Comparison of these groups to VAMP releases tell us how survival has varied between basins. The average survival index in 2005 for the three separate groups of Feather River Hatchery smolts released on April 15, April 29 and May 16 was 0.46, similar to that measured in 2003 (0.51) and greater than that measured in 2004 (0.19). VAMP survival for groups released at Durham Ferry, Mossdale and Dos Reis were low for all three years and was estimated to be less than about 0.05. From a relative scale survival was lower through the Sacramento River delta in 2004 than in 2005 or 2003, whereas with the VAMP fish survival was low for all three years. This indicates that perhaps different variables are controlling survival in the two basins since relative survival between years within each of the basins do not follow similar patterns.

Survival indices are typically higher for smolts migrating through the Delta from Sacramento than for smolts migrating from Mossdale. It is unclear why this is the case, although smolts entering the Delta from Mossdale are exposed to lower river flows and higher temperatures than on the Sacramento River. Smolts from the San Joaquin basin migrate in closer proximity to the CVP and SWP pumping plants, and are more subjected to subsequent altered Delta flow patterns. Sacramento stocks also do not have PKD. All of these factors and others probably result in the lower survival through the Delta for juvenile salmon originating from the San Joaquin basin.

2005 MOSSDALE TRAWL SUMMARY

Contributed by Tim Heyne,
California Department of Fish and Game

Introduction

Monitoring for the fall-run Chinook salmon smolt out-migrant population in the San Joaquin drainage is located two miles downstream of Mossdale Landing Country Park (river mile 56), and upstream of the Old River confluence (Figure 6-1). The timing and measurement of out-migrant production (indices and estimates) of fall-run Chinook salmon smolts have been monitored at Mossdale on the San Joaquin River since 1987 to:

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

2) Develop smolt production trend information,

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

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

Table 6-1
Chipps Island VAMP Tag Summary, Survival Calculations and Expanded Fish Facility Recoveries for Tagged Fish

							Antioch				
TagCode	Release Site/Stock	Date	Truck Temp (F)	Release Temp (F)	Number Released	Average Size (mm)	First Day Recovered	Last Day Recovered	Number Recovered	Minutes Fished	Percent Sampled
06-46-76	Merced Hatchery (MRFF)		N/P	N/P	25,067	N/P	–	–	0	–	–
06-46-77	Merced Hatchery (MRFF)		N/P	N/P	25,141	N/P	–	–	0	–	–
06-46-78	Merced Hatchery (MRFF)		N/P	N/P	24,384	N/P	–	–	0	–	–
06-46-79	Merced Hatchery (MRFF)		N/P	N/P	24,996	N/P	–	–	0	–	–
	Total	**04/17/05**			**99,558**				**0**		
06-46-80	Hatfield (MRFF)		N/P	N/P	24,278	N/P	–	–	0	–	–
06-46-81	Hatfield (MRFF)		N/P	N/P	23,647	N/P	5/8/05	5/8/05	1	471	0.3271
06-46-82	Hatfield (MRFF)		N/P	N/P	23,733	N/P	–	–	0	–	–
	Total	**04/19/05**			**71,658**		**5/8/05**	**5/8/05**	**1**	**471**	**0.327**
05-51-36	La Grange (MRFF)	04/18/05	N/P	N/P	75,696	N/P	5/5/05	5/23/05	5	9,743	0.3561
05-11-69	Old Fisherman's Cl (MRFF)	04/20/05	N/P	N/P	47,376	N/P	5/5/05	5/9/05	2	2,416	0.3356
	Total	**04/20/05**			**123,072**						
06-46-83	Merced Hatchery (MRFF)		N/P	N/P	25,157	N/P	–	–	0	–	–
06-46-84	Merced Hatchery (MRFF)		N/P	N/P	25,029	N/P	–	–	0	–	–
06-46-85	Merced Hatchery (MRFF)		N/P	N/P	25,107	N/P	–	–	0	–	–
06-46-86	Merced Hatchery (MRFF)		N/P	N/P	24,553	N/P	5/21/05	5/21/05	1	560	0.3889
	Total	**04/26/05**			**99,846**		**5/21/05**	**5/21/05**	**1**	**560**	**0.389**
06-46-87	Hatfield (MRFF)		N/P	N/P	23,345	N/P	5/7/05	5/7/05	1	540	0.375
06-46-88	Hatfield (MRFF)		N/P	N/P	24,315	N/P	5/5/05	5/20/05	2	8,163	0.3543
06-46-89	Hatfield (MRFF)		N/P	N/P	23,338	N/P	5/10/05	5/16/05	2	3,453	0.3426
	Total	**04/28/05**			**70,998**		**5/5/05**	**5/20/05**	**5**	**8,163**	**0.3543**
06-46-92	Merced Hatchery (MRFF)		N/P	N/P	25,029	N/P	–	–	0	–	–
06-46-93	Merced Hatchery (MRFF)		N/P	N/P	25,009	N/P	–	–	0	–	–
06-46-96	Merced Hatchery (MRFF)		N/P	N/P	25,312	N/P	–	–	0	–	–
	Total	**05/08/05**			**75,350**				**0**		
06-46-90	Hatfield (MRFF)		N/P	N/P	22,868	N/P	5/18/05	5/18/05	1	560	0.3889
06-46-91	Hatfield (MRFF)		N/P	N/P	22,739	N/P	–	–	0	–	–
	Total	**05/11/05**			**45,607**		**5/18/05**	**5/18/05**	**1**	**560**	**0.389**

Table 6-2
Absolute survival estimates based on survival indices to Chipps Island for survival through the Merced and Tuolumne Rivers in 2005.

Date	Merced	Hatfield	Tributary Survival
4/17-4/19/2005	0.032	0.077	0.42
4/26-4/28/2005	0.024	0.071	0.33
5/8-5/11/2005	0.012	0.010	1.2
Date	**La Grange**	**Old Fishermans Club**	**Tributary Survival**
4/18-4/20/2005	0.047	0.038	1.2

intensity was 5 days a week from April 4 to April 10, and then increased into 7 days a week from April 11 to May 27. The sampling effort was reduced to 5 days a week during May 28 to June 17, and then to 3 days a week during the last 2 weeks. The entire sampling period was from April 4 to July 1, 2005 with a total of 72 sample days out of study period of 89 days. A sampling day usually consisted of 15 tows at 20 minutes per tow, although the first two weeks and last five weeks of sampling had 10 tows per day. Due to hazardous weather conditions, there were only 7 tows on

		Chipps Island										
Survival Index	Group Index	First Day Recovered	Last Day Recovered	Number Recovered	Minutes Fished	Percent Sampled	Survival Index	Group Index	Salvage CVP	Numbers SWP	Expanded CVP	Expanded SWP
–		04/26/05	05/28/05	2	11,532	0.243	0.041		11	7	132	27
–		05/10/05	05/10/05	1	400	0.278	0.018		19	6	228	24
–		–	–	0	–	–	–		12	6	144	24
–		04/29/05	04/30/05	3	400	0.139	0.108		9	6	108	27
		04/26/05	**05/28/05**	**6**	**11,532**	**0.243**		**0.032**				
–		04/30/05	05/05/05	3	1,800	0.208	0.073		19	7	228	42
0.009		04/26/05	05/05/05	2	2,600	0.181	0.057		9	5	108	21
–		05/06/05	05/06/05	1	400	0.278	0.019		11	5	132	27
	0.004	**04/26/05**	**05/06/05**	**6**	**3,000**	**0.189**		**0.077**				
0.013		04/27/05	05/26/05	7	10,532	0.244	0.047		29	39	349	210
0.008		05/03/05	05/17/05	4	5,732	0.265	0.038		37	29	444	141
–		–	–	0	–	–	–		5	1	60	3
–		05/03/05	05/23/05	2	8,132	0.269	0.038		5	8	60	36
–		05/06/05	05/25/05	3	7,732	0.268	0.056		1	4	12	24
0.007				0					4	8	48	36
	0.002	**05/03/05**	**05/25/05**	**5**	**8,932**	**0.27**		**0.024**				
0.008		05/07/05	05/07/05	1	400	0.278	0.018		9	1	108	6
0.015		05/02/05	05/26/05	4	9,532	0.265	0.074		11	0	132	0
0.017		05/03/05	05/16/05	3	5,360	0.266	0.058		9	1	108	6
	0.013	**05/02/05**	**05/26/05**	**8**	**9,532**	**0.265**		**0.071**				
–		06/07/05	06/07/05	1	400	0.278	0.018		2	12	24	63
–		06/05/05	06/05/05	1	400	0.278	0.018		5	9	60	48
–		–	–	0	–	–	–		1	16	12	90
		06/05/05	**06/07/05**	**2**	**1,200**	**0.278**		**0.012**				
0.007		05/24/05	05/24/05	1	400	0.278	0.018		7	10	86	54
–		–	–	0	–	–	–		5	6	61	33
	0.004	**05/24/05**	**05/24/05**	**1**	**400**	**0.278**		**0.010**				

April 8, 2005. Sampling is also conducted 3 days per week between July and April by the USFWS in Stockton.

Water temperature, turbidity, weather, beginning tow time and velocity were recorded for each tow. Velocity was recorded by using a digital flow meter model 2030R that is made by General Oceanics Inc. The daily river flow data that is used in this report had been measured by U.S. Geological Survey mean daily stream flow gauge at Vernalis. 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 a clipped adipose fin and/or dye mark. All non-marked Chinook salmon were considered "natural" for the purpose of this study. The first 50 natural and dye mark Chinook salmon, for each tow, were measured (fork length, mm) and the excess tallied without measurement. Every Chinook salmon that had a clipped adipose fin was measured, individually bagged, and labeled and saved for coded wire tag processing.

Flows averaging over 10,000 cfs in the spring of 2005 resulted in the daily operation of the trawl beginning at the upstream end of the sampling area. The weekly vulnerability tests released at the Mossdale boat ramp were done to coincide with the first tow of the day. The first vulnerability test conducted on April 6 was not used in the analysis due to problems with the net.

The 2005 natural smolt production from the San Joaquin drainage was estimated by two different methods. The first 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 were then expanded by multiplying with the daily mean flow recorded at Vernalis. Production estimates for days not sampled within the study period were assigned by averaging smolt/ac-ft for the days before and after the day not sampled.

The second estimate, which we believe to be a more accurate estimate, due to the uneven distribution of smolts in the channel, was determined using the 8 dye marked vulnerability release groups (Table 6-3 and Figure 6-2). Production estimates for days not sampled within the study period were assigned by averaging smolt caught and minutes towed for the days before and after the day not sampled.

Smolt Production Index Calculation:

The natural smolt index estimates (EI) is calculated as follow:

$$E_I = \sum_{i=1}^{n=89}\left[\left(\frac{C_i}{V_{Ti}}\right)\left(V_{Pi}\right)\left(\frac{24}{5}\right)\right]$$

Where:

n = days in the index period

C = daily non-marked Chinook catch

V_T = daily volume of trawl sampled

V_P = daily 5-hour volume of water passing Mossdale

i = i^{th} 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 89 days.

Table 6-3
Dye marked smolt releases from Merced River Hatchery for vulnerability studies (released 975 meters upstream of the Kodiak trawl) in the San Joaquin River at Mossdale Landing, April through May, 2005.

Release Date/Time	Water Temp. (°C) Truck/River	Effective # Released	Number Recovered	Streamflow (cfs)	Beginning And Ending Recovery Time
*06APR05 08:20	-/-	2,031	3	13,700	09:54 10:41
15APR05 09:15	9.5/14	5,060	71	9,242	09:48 13:10
22APR05 08:11	10.5/14	1,975	47	8,163	09:16 10:04
29APR05 07:59	11/14	4,988	64	6,882	09:41 12:49
06MAY05 08:00	11/14.5	1,997	134	7,847	08:35 09:23
13MAY05 08:20	11/15	4,999	79	8,744	08:53 09:17
20MAY05 07:57	11.5/15	2,001	29	10,190	08:55 09:14
27MAY05 08:07	13/15	1,948	28	14,062	08:37 11:08

*Vulnerability test omitted due to problems with trawl net.

Kodiak Trawl Vulnerability Estimates:

The vulnerability expansion production estimates (EV) is calculated as follow:

$$E_V = \sum_{i=1}^{N=89}\left\{\left[\frac{(C_i/r)}{(T_i/300)}\right]\left(\frac{24}{5}\right)\right\}$$

Where:

r = population ratio

C = Daily non-marked Chinook catch

T = Tow Duration

i = i^{th} day

N = number of days sampled

The population ratio (r) is calculated as follow:

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

Where:

n = number of vulnerability test groups

y = number of marked fish captured

x = number of marked fish released (effective release)

i = i^{th} day

Estimated variance ($\hat{V}$) of r:

$$\hat{V}(r) = \hat{V}\left(\frac{\sum_{i=1}^{n} y_i}{\sum_{i=1}^{n} x_i}\right) = \left(\frac{N-n}{nN}\right)\left(\frac{1}{\mu_x^2}\right) s.d._r^2$$

Where:

N = number of days sampled

n = number of vulnerability test groups

y = number of marked fish captured

x = number of marked fish released (effective release)

i = i^{th} day

_ = average of effective release

s.d. = standard deviation

Standard deviation (s.d.) is calculated as follow:

$$s.d._r = \sqrt{\frac{\sum_{i=1}^{n}(y_i - rx_i)^2}{n-1}}$$

Where:

n = number of vulnerability test groups

y = number of marked fish captured

x = number of marked fish released (effective release)

i = i^{th} day

95% Confidence Interval (C.I.) is calculated as follow:

$$C.I. = r \pm 1.96\sqrt{\hat{V}(r)}$$

Where:

r = population ratio of what?

(r) = variance of population ratio

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

Results

Between April 4 and July 1, 2005 2,294 non-marked Chinook salmon smolts were captured in the Mossdale trawl. Daily capture of non-marked salmon ranged from 0 – 363 individuals with an average of 32.

Smolt production estimates for the San Joaquin basin ranged between 363,800 using method 1 and 621,403 using method 2 (Table 6-4). The first method used a smolt density index to expand daily catch. The standard deviation using this method was +/-_14,700.

The second method used trawl efficiency (vulnerability) to expand daily catch (Figure 6-3). This method is thought to be more accurate than the smolt density index method because it should account for an uneven distribution of migrating smolts in the river channel. Trawl vulnerabilities were obtained by conducting mark-recapture tests each week. Release groups ranged from 1,948 – 5,060 dye

Figure 6.2
Vulnerability of Test Group vs. Flow

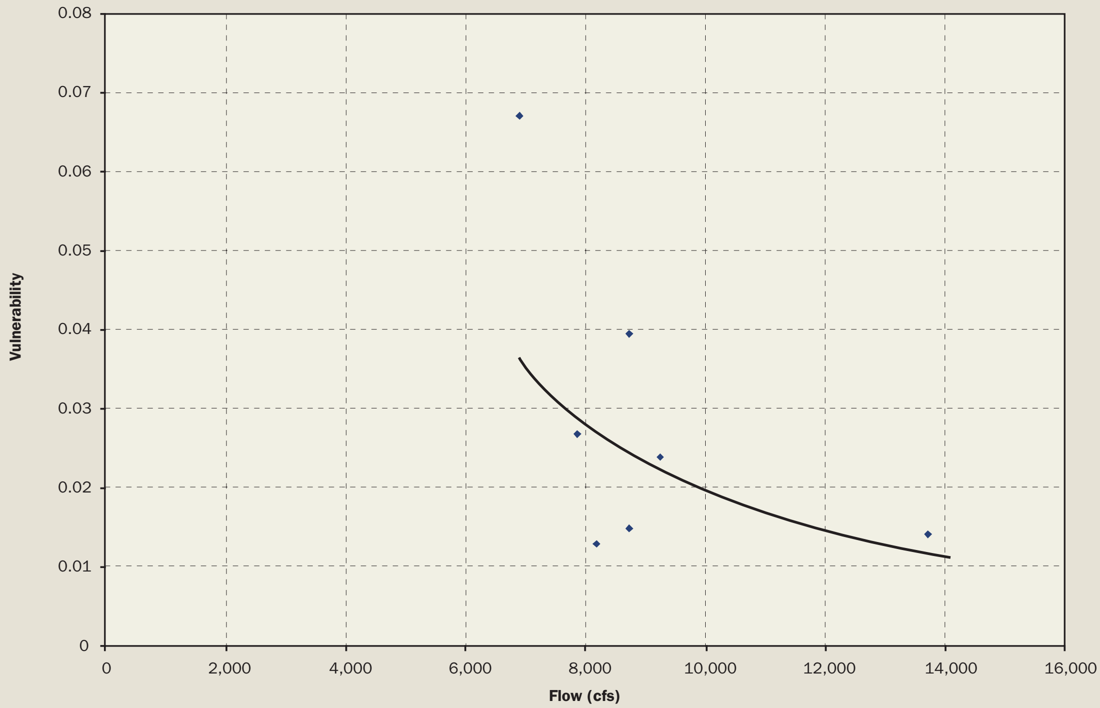
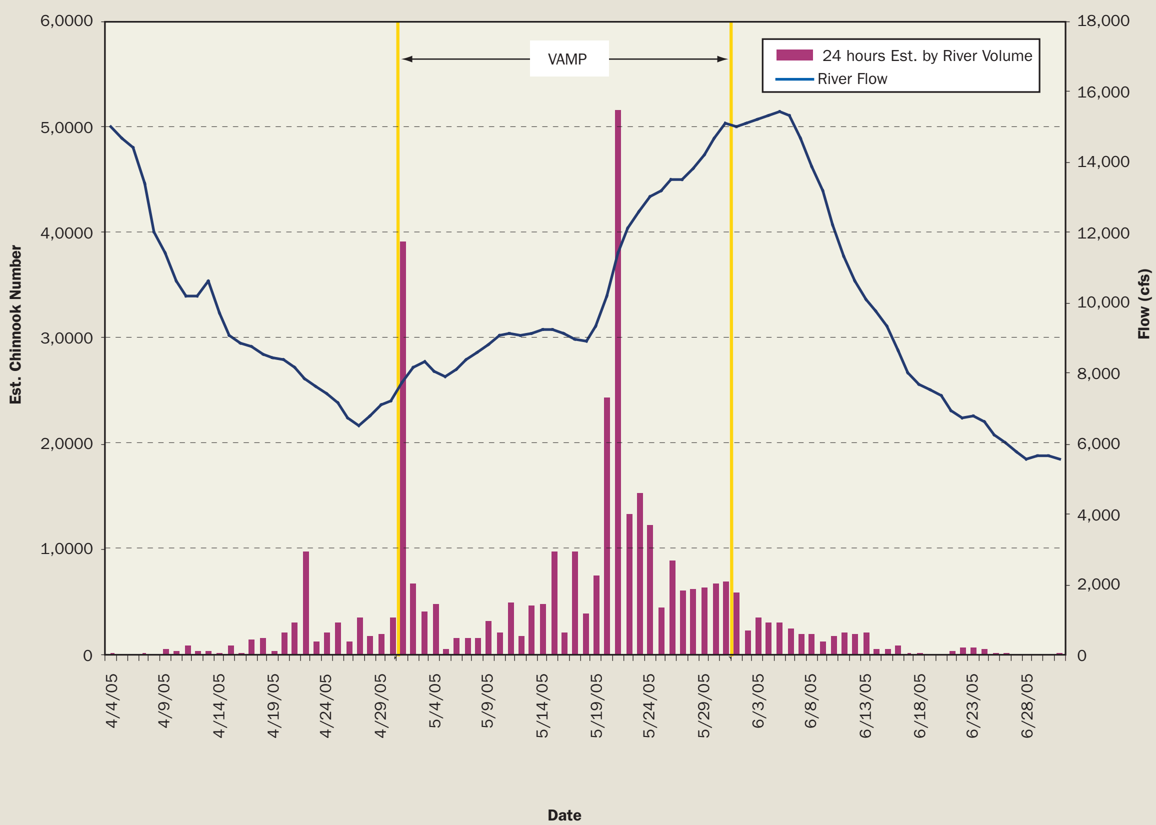


Figure 6.3
Daily Production Estimates (expanded using vulnerability testing) vs. Flow



marked juveniles. Juveniles were obtained from the Merced River Hatchery and were selected by size to match as closely as possible the size of wild fish being observed in the river at that time. The production estimate had a 95% confidence range of 388,884 – 1,119,550). Production of San Joaquin River basin smolts in 2005 was roughly twice that of the production in 2004.

This doubling in production occurred in spite of the number of spawning salmon the fall before being roughly equivalent in both years (~10,000). The main difference between the two years was a more than doubled spring outflow.

REVIEW OF JUVENILE SALMON DATA FROM THE SAN JOAQUIN RIVER TRIBUTARIES TO THE SOUTH DELTA DURING JANUARY TO JUNE, 2005

Contributed by Tim Ford, Turlock and Modesto Irrigation Districts, and Andrea Fuller, S. P. Cramer and Associates

The VAMP includes protective measures for San Joaquin River (SJR) smolts during a 31 day window 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

Table 6-4
Smolt production seasonal estimates with corresponding smolt/ac-ft. estimates and sampling period for the duration of the study.

Year	Sampling Period (Days)	Smolt/ac-ft Estimate 1=1,000	Vulnerability Smolt Production Seasonal Estimate (95% confidence range)
2005	89	363,800 + 14,700	621,403 : (388,884-1,119,550)**
2004	61	92,500 + 66,500	333,080
2003	88	107,500 + 60,300	550,446
2002	75	229,100. + 557,100	733,839
2001	*	*	848,488
2000	72	211,100 + 181,900	484,703
1999	86	*	438,979
1998	80	*	2,844,637
1997	67	*	635,517
1996	75	*	1,155,319
1995	46	*	3,361,384
1994	48	*	453,245
1993	51	*	269,035
1992	33	*	280,395
1991	39	*	538,005
1990	55	*	263,932
1989	50	*	4,241,862

Note: Data from 1989 – 2004 is cited from Annual Performance Report Federal Aid in Sport Fish Restoration Act. Project No. 26, Job No. 4, Table 1.

*Estimates are currently being analyzed.

**Analysis of 2005 production estimate was performed by the method described in the body of the report. All previous years have a production estimate that is based on a regressive relation of flow and vulnerability that uses data from all test years except 2005. Confidence limits are currently being developed for those estimates.

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 2005, rotary screw trapping was conducted on the Stanislaus River to document juvenile outmigration throughout the season; on the Tuolumne River during roughly half of the outmigration season; and no monitoring occurred on the Merced River. This review briefly presents data from the rotary screw traps fished in the Stanislaus and Tuolumne rivers during 2005 to identify the movement of juvenile salmon from the tributaries into the mainstem San Joaquin River relative to observations at the Mossdale Trawl and in salvage.

Stanislaus River rotary screw trap (RST) monitoring was conducted at River Mile (RM) 9 (Caswell site) during 05 Jan - 16 Jun; and Tuolumne River RST monitoring was conducted at RM 5 (Grayson site) during 01 Apr - 16 Jun. Trawling was conducted in the San Joaquin River at Mossdale near RM 54 (downstream of the tributaries, and upstream of the Head of Old River) during 03 Jan – 29 June (daily, except only 3 days/week prior to April). 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.

Several local runoff events between January and March were associated with significant rainfall periods (Figure 6-4). The seasonal peak catch of fry in the Stanislaus River RST (Figure 6-5) followed a late January storm event. However, relatively few early fish were observed at the Mossdale trawl (Figure 6-6), and SWP (Figure 5-24) salvage operations; more were found in the CVP salvage (Figures 5-23 and 5-26). Figure 6-7 shows that most fish observed prior to mid-February averaged <40 mm fork length (FL). Average size increased by mid- April to >80 mm FL in all areas (Figure 6-7), coincident to increased daily catch on the Tuolumne River (Figure 6-8) and also the highest densities observed at Mossdale (Figure 6-6) and the CVP/SWP (Figure 5-26). By mid-June, all sampling indicated very low abundance of juvenile salmon marking the end of the 2005 outmigration season.

It appears from the Stanislaus data that in 2005, much of juvenile salmon population migrated into the SJR, as fry and pre-smolts, between January to April. These early migrants were not captured in high densities at Mossdale but appear to have arrived in the CVP salvage, indicating that at least some fry moved into the Delta; relative efficiency of the trawl and salvage facilities for fry size salmon may be less than for the RST. However, even though fry were not observed at Mossdale in high densities during 2005, high densities have been recorded early in the season at this site in other years (SJRGA, 2005); and differences in density at Mossdale between years may also be influenced by the overall abundance of juveniles migrating from the tributaries as a result of fluctuating escapement.

To obtain more information on fry movement into the Delta, additional monitoring at the lower end of each of the three San Joaquin tributaries for the entire season (January through June) would be a high priority. Further evaluation of the trawl efficiency on different sized juvenile salmon might also be useful. These data would help to refine existing protective measures, if warranted, and to identify potential needs for additional protective measures targeting a larger proportion of the juvenile salmon population migrating from the San Joaquin tributaries.

FLORIDONE EXPOSURE TO EMIGRATING JUVENILE FALL RUN CHINOOK SALMON

Contributed by Jeff Stuart, National Marine Fisheries Service

In April 2005, the California Department of Boating and Waterways (DBW) in conjunction with the U.S. Department of Agriculture-Agricultural Research Service (USDA-ARS) applied the herbicide fluridone to waters of the Delta for the control of the non-native invasive weed *Egeria densa*. The National Marine Fisheries Service (NMFS) permitted this early season application of herbicide to the waters of Franks Tract, Sandmound Slough, and Disappointment Slough under the authority of their Section 7 Biological Opinion for the *Egeria densa* Control Program. Applications to these restricted areas were determined by NMFS to present a reduced level of exposure to juvenile salmonids during their spring emigration through the Delta. As part of the terms and conditions for this early season application, NMFS required DBW and the USDA-ARS to examine the level of fluridone exposure to emigrating juvenile fall-run Chinook salmon through the levels of fluridone found in their body tissues.

NMFS, in cooperation with the U.S. Fish and Wildlife Service (USFWS), the California Department of Fish and Game (DFG), and the Vernalis Adaptive Management Plan (VAMP) stakeholders, gathered coded wire tagged (CWT) fall-run Chinook salmon from monitoring trawls at Chipps Island, Antioch, Mossdale, and Sherwood Harbor to look for exposure to the fluridone herbicide during their downstream migration. The reading of the CWTs allow for the direct measurement of time spent in the water since release, the location of release, and the origins of these fish. These fish

Figure 6-4
San Joaquin Basin Flows and Rainfall

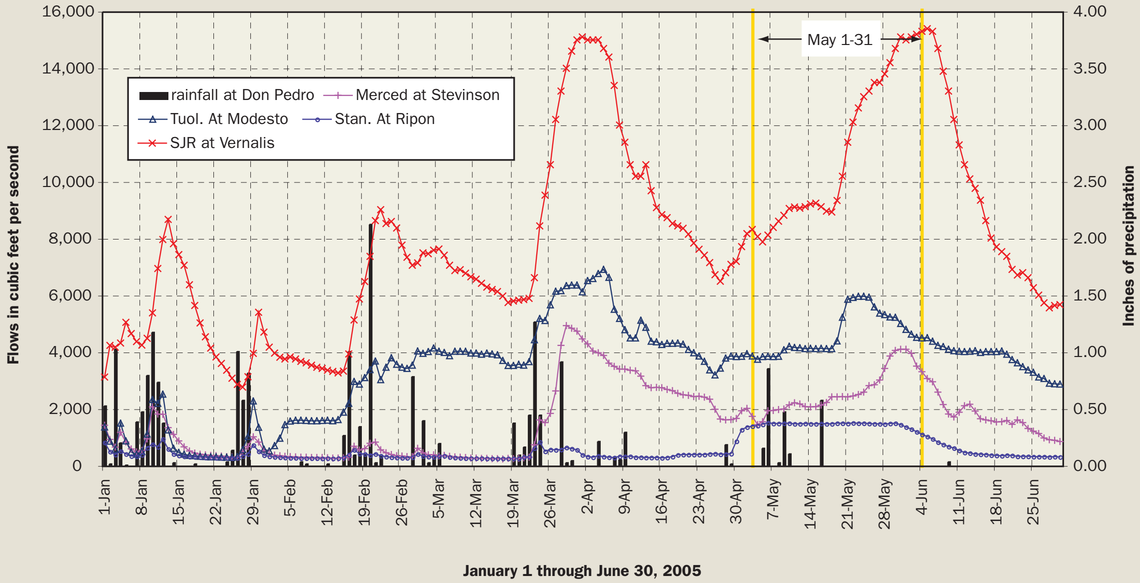


Figure 6-5
Stanislaus rotary screw trap daily catch of all unmarked juvenile Chinook salmon.

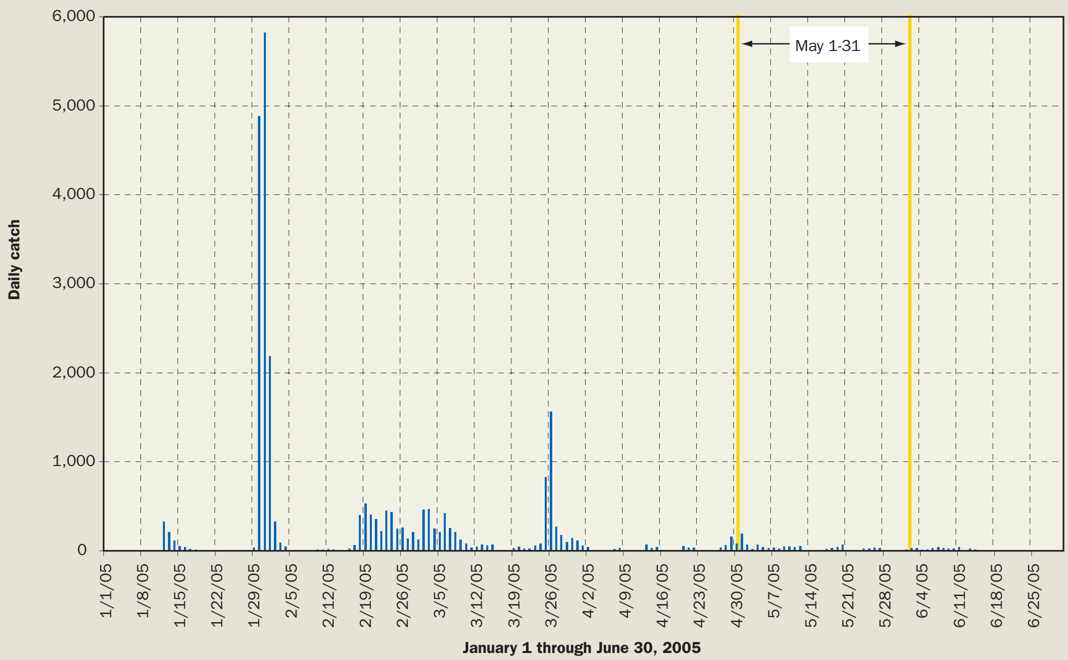


Figure 6-6
Mossdale Kodiak trawl mean daily catch per minute of all unmarked juvenile Chinook salmon.

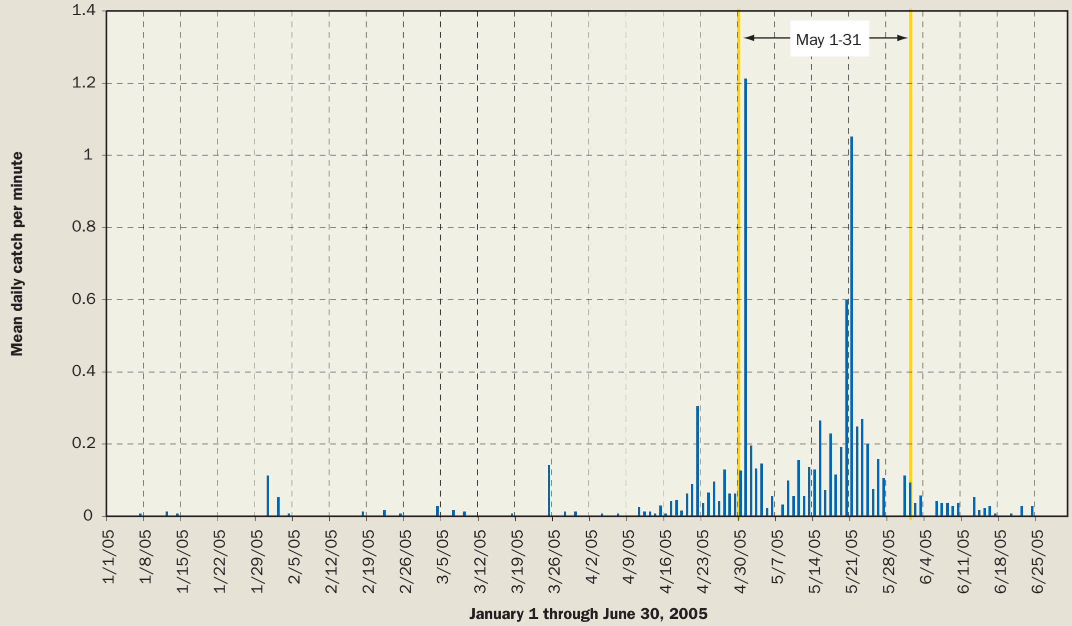


Figure 6-7
Daily average forklength of unmarked juvenile Chinook salmon.

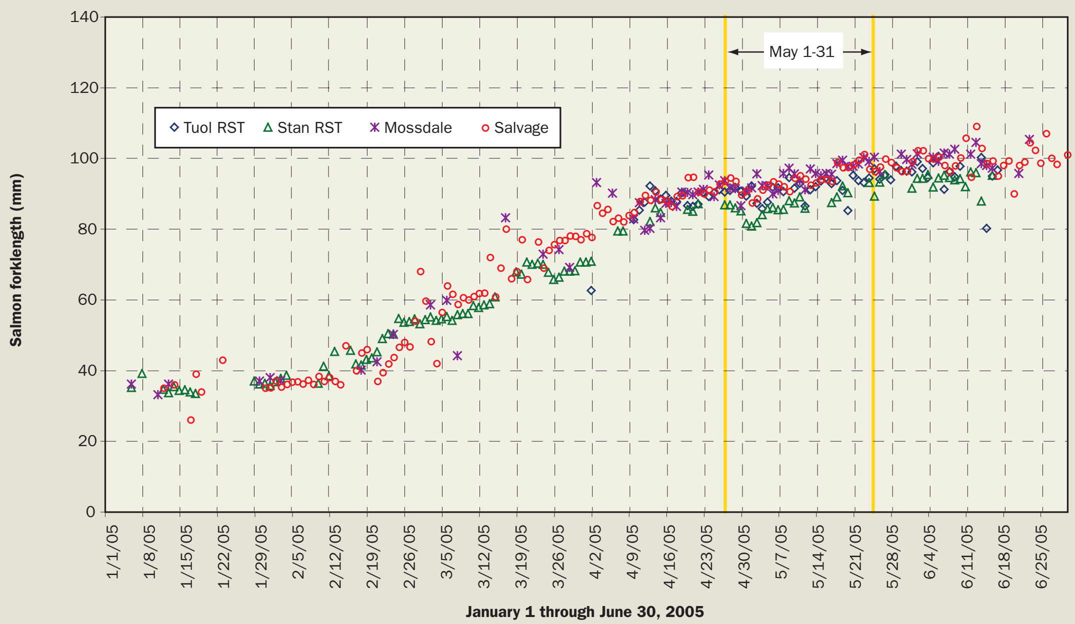
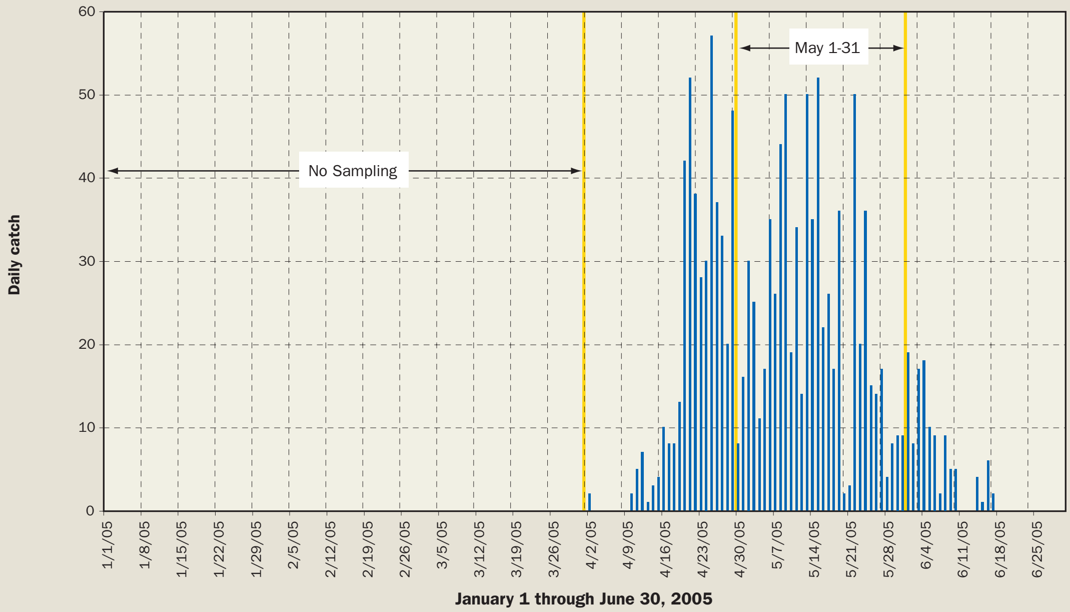


Figure 6-8
Tuolumne rotary screw trap daily catch of all unmarked juvenile Chinook salmon.



will be processed and whole body homogenates analyzed by DFG staff at the Water Pollution Control Laboratory for residues of the parent fluridone compound and the daughter metabolite compound, hydroxyl-fluridone. NMFS hypothesizes that fish migrating through the San Joaquin River system have a higher likelihood of encountering the fluridone compound than those which migrate down the Sacramento River system. Prior to entrance into the Delta from the San Joaquin River, fish should not have had any exposure history to the fluridone compound. Fish sampled at Mossdale should therefore not have any fluridone residues in their body, while those fish from the Merced Hatchery recovered at Antioch and Chipps Island should at least have the potential to have fluridone residues in their body, based on their predicted migration path through the Delta. Samples which are found to have residues of fluridone or its daughter metabolite indicate that the fish have moved through areas being treated for *Egeria densa*. Chinook salmon recovered at Sherwood Harbor on the Sacramento River have not yet entered the Delta, and like fish from Mossdale, should not have any fluridone residues in their body tissues. Fish recovered at Chipps Island were predominantly from the Sacramento River basin (Feather River hatchery). NMFS hypothesizes that most of these fish should migrate down the Sacramento River channel to Chipps Island before capture in the monitoring trawls and should therefore not have any fluridone or its metabolite in their body tissues. Should these Sacramento River origin fish show fluridone residues, then their migration path would necessitate that they moved through the Central Delta and into the San Joaquin River system prior to their capture at Chipps Island.

NMFS will use the fluridone body tissue burdens in their future analysis of exposure risks to emigrating salmonids in the Delta. The results of the data will facilitate developing future application windows to reduce or eliminate exposure risk to listed salmonids in the Delta from weed control programs.

Chapter 7

Conclusions and Recommendations

The 2005 VAMP was implemented without the installation of the HORB due to high flow conditions described in Chapter 2. The start of the VAMP pulse flow period was delayed until May 1, with a resulting average flow between May 1 and May 31 of 10,390 cfs and average exports of 2,986 cfs. Flow monitoring was conducted in the San Joaquin River and in the Old River both at locations downstream of the Head of Old River. New Kodiak trawling was conducted in Old River in 2005, and compared with the regularly conducted sampling on the San Joaquin River at Mossdale. Estimates of juvenile Chinook salmon smolt survival were calculated based upon recoveries of CWT juvenile salmon produced in the MRFF and released at Durham Ferry, Dos Reis, and Jersey Point. Marked salmon were recaptured in sampling at Mossdale, in Old River, at the SWP and CVP fish facilities, and at Antioch and Chipps Island. Based upon the data and experience gained during the VAMP 2005 investigations, 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.

Smolt survival in 2005 was low, as it was in 2003 and 2004. Although there were greater flows in 2005 which should have improved survival, the HORB was not installed. Survival in 2005 was in the range observed previously without a HORB. The relationship of salmon survival to San Joaquin River flow has shown that survival increases as flows increase, with the HORB in place. These relationships are statistically significant using both the trawl and ocean recovery information. The relationships are more variable comparing survival to flow without the HORB. However, the trend of increasing survival as flows increase is apparent using both sets of recovery information though relationships are not statistically significant. Relationships of flow to adult escapement 2 1/2 years later, indicates these relationships are likely real and that survival is improved as flows increase.

The role of exports has been difficult to identify given that the two VAMP targets to identify the relationship have not yet been obtained. The role of exports will not be established until at least two VAMP targets of 7,000 cfs flow with a HORB are obtained so that survival can be measured with exports at 1,500 and 3,000 cfs. The VAMP program provides increased flows (compared to without VAMP flows) and likely increases the survival of unmarked juvenile salmon migrating through the Delta during the VAMP period.

Table 7-1
Summary of VAMP 2005 Conclusions and Recommendations

CONCLUSIONS	RECOMMENDATIONS FOR 2006
Observed ungaged flows (accretions, depletions) between upstream measurement points and Vernalis varied significantly from those forecasted resulting in differences in forecasted and required supplemental flows.	Hydrology committee to refine estimates of ungaged flow and develop a management scheme to accommodate variability.
The flow data collected in 2005 at San Joaquin River near Lathrop and the Old River at Head provided useful information on the flow split at the Head of Old River.	The 2005 flow data should be compared against DWR-DSM2 modeling results. Continue to calibrate the stage and flow monitoring at the San Joaquin River near Lathrop station.
DWR treated the Clifton Court Forebay with the aquatic herbicide Komeen, known to be toxic to salmon, one day following the Durham Ferry release of test fish. This could have affected the survival of this group.	DWR and USBR should coordinate operation and maintenance activities at the SWP and CVP export facilities with the VAMP Biology and Hydrology Groups.
Short-term survival (48-hours post-transport) was high (99.9%) indicating that handling, transport, and release likely had no affect on short-term smolt survival.	Continue short-term survival studies and fish condition inspections.
Physiological studies provided useful information on fish health and condition. Fish pathologists concluded that fish were infected with PKD and while recoveries at Chipps Island many not be affected, there are implications for long-term survival.	Recommend continued health and disease monitoring to compare within and between year trends. Begin discussions on how to reduce PKD in San Joaquin basin juvenile salmon.
A sampling of fish were held at the CA/NV Fish Health Center for post-release health evaluation, swim performance testing, saltwater adaptation testing.	Recommend continued post-release evaluation in future years.
The number of CWT salmon from Durham Ferry releases recovered at the SWP and CVP salvage facilities were greater then prior years likely due to no HORB. Few Dos Reis fish were recovered at the SWP and CVP salvage facilities.	Continue salvage monitoring to document direct losses at SWP/CVP export facilities.
VAMP has been designed to adaptively change within a few weeks, the VAMP test period each year.	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.
Survival from Durham Ferry and Dos Reis in 2005 was low and similar to some prior years when the HORB was not installed.	Continue to measure survival when there is no HORB to compare to past years and to better understand the role of flow on survival without the HORB in place. Install the HORB when flows are 7,000 cfs or less to improve survival through the Delta. The VAMP tests should be continued.
Further evaluation of survival rate versus export rate is needed. The VAMP is limited by data at the target conditions of 7,000 cfs flow with a HORB with exports at 1,500 or 3,000 cfs.	Evaluate the possibility of amending the San Joaquin River Agreement to achieve needed test conditions of 7,000 cfs flow with a HORB at exports of 1,500 or 3,000 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.
Mossdale Kodiak trawl is an important component in determining distribution of juvenile salmon out migration from the San Joaquin basin.	Maintain the Mossdale Kodiak trawl at existing effort throughout year.
Some complimentary studies to evaluate mechanisms affecting survival of fish from tributaries and across the Delta were conducted.	Encourage an expansion of complementary studies to provide additional information on factors and mechanisms affecting salmon survival.

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MERCED IRRIGATION DISTRICT*

SAN JOAQUIN RIVER EXCHANGE
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Sal Luis Canal Company

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SAN LUIS AND DELTA-MENDOTA CANAL WATER AUTHORITY

SAN JOAQUIN RIVER GROUP AUTHORITY

*San Joaquin River Group Authority Members

2005 Useful Web Pages

Page 3 San Joaquin River Agreement
www.sjrg.org/agreement.htm

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

Page 8 VAMP Annual Technical Reports
www.sjrg.org

Page 8 VAMP Experimental Design
www.sjrg.org/agreement.htm

Page 14 Operation Monitoring, CDEC Hourly
http://cdec.water.ca.gov/cgi-progs/queryGroup?s=fw1

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

Vernalis USGS Real-Time
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Vernalis, USGS Daily
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http://cdec.water.ca.gov/cgi-progs/queryDgroups?s=fw2

Page 28 Temporary Barrier Program
http://sdelta.water.ca.gov/web_pg/tempmesr.html

Page 29 Reclamation District 544 Seepage Monitoring Study
http://sdelta.water.ca.gov/web_pg/tempmesr.html

Page 63 CVP and SWP Salvage Data
www.iep.ca.gov

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

Pacifica States Marine Fisheries Commission
Regional Mark Information System
www.rmis.org

Common Acronyms and Abbreviations

ADCP	Acoustic Doppler Current Profiler
Bay-Delta	Sacramento and San Joaquin Rivers San Francisco Bay Delta
CDEC	California Data Exchange Center
CDRR	Combined Differential Recovery Rate
CFS	Cubic Feet Per Second
CPUE	Catch Per Unit Effort
CRR	Combined Recovery Rate
CVP	Central Valley Project
CWT	Coded-Wire Tagged
D-1641	Water Rights Decision 1641 of the SWRCB
DFG	California Department of Fish and Game
DWR	California Department of Water Resources
GLC	Grant Line Canal
HOR	Head of Old River
HORB	Head of Old River Barrier
Merced	Merced Irrigation District
MID	Modesto Irrigation District
MR	Middle River
MRFF	Merced River Fish Facility
MSL	Mean Sea Level
NOAA	National Oceanic and Atmospheric Administration Fisheries
OID	Oakdale Irrigation District
ORT	Old River at Tracy
PKD	Proliferative Kidney Disease
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
TBP	Temporary Barriers Project
TID	Turlock Irrigation District
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

Appendix Table of Contents

APPENDIX A

Hydrology and Operation Plans 96

A-1
Daily Operation Plan, Tables 1-10 97

A-2
Comparison of Real-time and Provisional Flows, Figures 1-8 107

APPENDIX B

Historic Data 111

B- Figure 1
Storage Impacts, 2000-2005 Lake McClure 112

B- Figure 2
Storage Impacts, 2000-2005 New Don Pedro Reservoir 112

B- Figure 3
Merced River below Crocker-Huffman Dam, 2000-2005 113

B- Figure 4
Tuolumne River below LaGrange Dam, 2000-2005 113

APPENDIX C

Chinook Salmon Survival Investigations 114

C-1 Water Temperature Monitoring Locations 115

C-2 Water Temperature Monitoring Data, Plots 1-10 117

C-3 Net Pen Sampling Results, Tables C-3a, C-3b 122

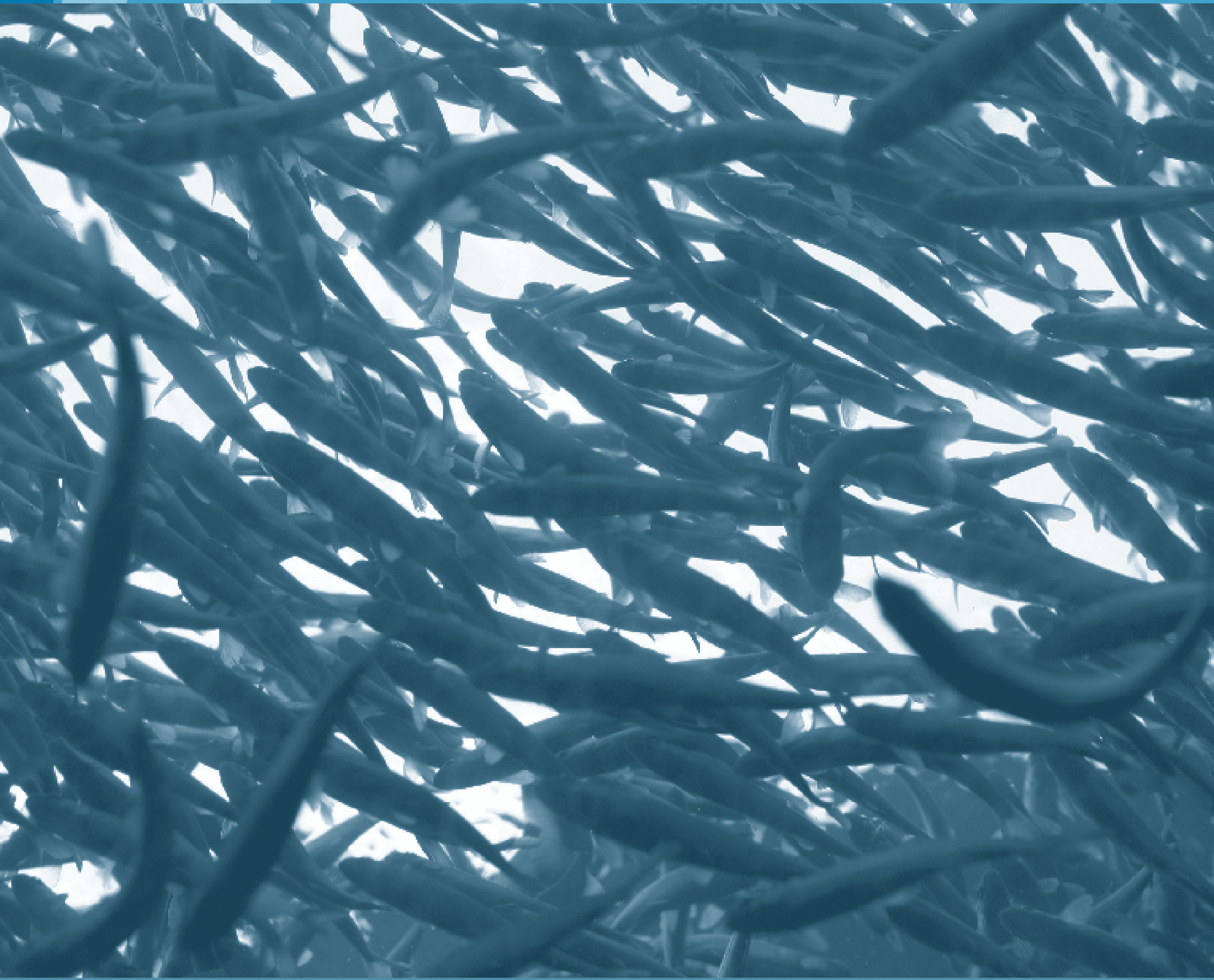
C-4 Coded Wire Tag Recovery Data 123

APPENDIX D

Errata for the Year 2004 Annual Technical Report 129

Appendix A

Appendix A
Hydrology and Operation Plans



Appendix A-1, Table 1

2005 VAMP DAILY OPERATION PLAN

March 23, 2005 (A) • Low

Target Flow Period: April 15 - May 15 • Flow Target: greater than 7,000 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	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (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)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		(cfs)	(cfs)	(cfs)	
15-Mar-05	**6,260**				**6,260**	**1,278**	**1,183**	**285**			**285**	**3,140**	**3,140**		**3,140**	**229**	**229**			**229**	
16-Mar-05	**6,180**				**6,180**	**1,234**	**1,201**	**275**			**275**	**3,140**	**3,140**		**3,140**	**229**	**229**			**229**	
17-Mar-05	**6,040**				**6,040**	**1,181**	**1,110**	**276**			**276**	**3,120**	**3,120**		**3,120**	**229**	**229**			**229**	
18-Mar-05	**5,820**				**5,820**	**1,163**	**932**	**274**			**274**	**3,150**	**3,150**		**3,150**	**229**	**229**			**229**	
19-Mar-05	**5,800**				**5,800**	**1,163**	**995**	**292**			**292**	**3,190**	**3,190**		**3,190**	**228**	**228**			**228**	
20-Mar-05	**5,750**				**5,750**	**1,151**	**932**	**322**			**322**	**3,170**	**3,170**		**3,170**	**226**	**226**			**226**	
21-Mar-05	**5,850**				**5,850**	**1,246**	**995**	**335**			**335**	**3,160**	**3,160**		**3,160**	**226**	**226**			**226**	
22-Mar-05	**5,880**				**5,880**	**1,535**	**1,041**	**356**			**356**	**3,120**	**3,120**		**3,120**	**245**	**245**			**245**	
23-Mar-05																					
24-Mar-05																					
25-Mar-05																					
26-Mar-05																					
27-Mar-05																					
28-Mar-05								650													
29-Mar-05								650													
30-Mar-05						879		650				3,000	3,000			225	225				
31-Mar-05						874		650				3,000	3,000			225	225				
01-Apr-05	5,554					869	800	650			650	3,000	3,000		3,000	225	225			225	
02-Apr-05	5,549					864	800	650			650	3,000	3,000		3,000	225	225			225	
03-Apr-05	5,544					859	800	650			650	3,000	3,000		3,000	225	225			225	
04-Apr-05	5,539				5,539	854	800	650			650	3,000	3,000		3,000	225	225			225	
05-Apr-05	5,534				5,534	848	800	650			650	3,000	3,000		3,000	225	225			225	
06-Apr-05	5,529				5,529	842	800	650			650	3,000	3,000		3,000	225	225			225	
07-Apr-05	5,523				5,523	836	800	650			650	3,000	3,000		3,000	225	225			225	
08-Apr-05	5,517				5,517	830	800	650			650	3,000	3,000		3,000	225	225			225	
09-Apr-05	5,511				5,511	824	800	650			650	3,000	3,000		3,000	225	225			225	
10-Apr-05	5,505				5,505	818	800	650			650	3,000	3,000		3,000	225	225			225	
11-Apr-05	5,499				5,499	812	800	650			650	3,000	3,000		3,000	225	225			225	
12-Apr-05	5,493				5,493	806	800	650	270	0	920	3,000	3,000		3,000	225	225			225	
13-Apr-05	5,487	0			5,487	800	800	650	270	0	920	3,000	3,000	0	3,000	1,500	1,500	0	0	1,500	
14-Apr-05	5,481	0			5,481	794	800	650	270	0	920	3,000	3,000	0	3,000	1,500	1,500	0	0	1,500	
15-Apr-05	6,750	270	0	0.54	7,020	789	800	650	270	0	920	3,000	3,000	0	3,000	1,500	1,500	0	0	1,500	
16-Apr-05	6,744	270	0	1.07	7,014	783	800	650	270	0	920	3,000	3,000	0	3,000	1,500	1,500	0	0	1,500	
17-Apr-05	6,739	270	0	1.61	7,009	777	800	650	270	0	920	3,000	3,000	0	3,000	1,500	1,500	0	0	1,500	
18-Apr-05	6,733	270	0	2.14	7,003	772	800	650	270	0	920	3,000	3,000	0	3,000	1,500	1,500	0	0	1,500	
19-Apr-05	6,727	270	0	2.68	6,997	766	800	650	270	0	920	3,000	3,000	0	3,000	1,500	1,500	0	0	1,500	
20-Apr-05	6,722	270	0	3.21	6,992	760	800	650	270	0	920	3,000	3,000	0	3,000	1,500	1,500	0	0	1,500	
21-Apr-05	6,716	270	0	3.75	6,986	755	800	650	320	0	970	3,000	3,000	0	3,000	1,500	1,500	0	0	1,500	
22-Apr-05	6,710	270	0	4.28	6,980	749	800	650	320	0	970	3,000	3,000	0	3,000	1,500	1,500	0	0	1,500	
23-Apr-05	6,705	270	0	4.82	6,975	743	800	650	320	0	970	3,000	3,000	0	3,000	1,500	1,500	0	0	1,500	
24-Apr-05	6,699	320	0	5.45	7,019	738	800	650	320	0	970	3,000	3,000	0	3,000	1,500	1,500	0	0	1,500	
25-Apr-05	6,693	320	0	6.09	7,013	732	800	650	320	0	970	3,000	3,000	0	3,000	1,500	1,500	0	0	1,500	
26-Apr-05	6,688	320	0	6.72	7,008	726	800	650	320	0	970	3,000	3,000	0	3,000	1,500	1,500	0	0	1,500	
27-Apr-05	6,682	320	0	7.36	7,002	721	800	650	320	0	970	3,000	3,000	0	3,000	1,500	1,500	0	0	1,500	
28-Apr-05	6,676	320	0	7.99	6,996	715	800	650	320	0	970	3,000	3,000	0	3,000	1,500	1,500	0	0	1,500	
29-Apr-05	6,671	320	0	8.63	6,991	709	800	650	320	0	970	3,000	3,000	0	3,000	1,500	1,500	0	0	1,500	
30-Apr-05	6,665	320	0	9.26	6,985	704	800	650	370	0	1,020	3,000	3,000	0	3,000	1,500	1,500	0	0	1,500	
01-May-05	6,659	320	0	9.90	6,979	698	800	650	370	0	1,020	3,000	3,000	0	3,000	1,500	1,500	0	0	1,500	
02-May-05	6,654	320	0	10.53	6,974	692	800	650	370	0	1,020	3,000	3,000	0	3,000	1,500	1,500	0	0	1,500	
03-May-05	6,648	370	0	11.27	7,018	687	800	650	370	0	1,020	3,000	3,000	0	3,000	1,500	1,500	0	0	1,500	
04-May-05	6,642	370	0	12.00	7,012	681	800	650	370	0	1,020	3,000	3,000	0	3,000	1,500	1,500	0	0	1,500	
05-May-05	6,637	370	0	12.73	7,007	675	800	650	370	0	1,020	3,000	3,000	0	3,000	1,500	1,500	0	0	1,500	
06-May-05	6,631	370	0	13.47	7,001	670	800	650	410	0	1,060	3,000	3,000	0	3,000	1,500	1,500	0	0	1,500	
07-May-05	6,625	370	0	14.20	6,995	664	800	650	410	0	1,060	3,000	3,000	0	3,000	1,500	1,500	0	0	1,500	
08-May-05	6,620	370	0	14.94	6,990	658	800	650	410	0	1,060	3,000	3,000	0	3,000	1,500	1,500	0	0	1,500	
09-May-05	6,614	410	0	15.75	7,024	653	800	650	410	0	1,060	3,000	3,000	0	3,000	1,500	1,500	0	0	1,500	
10-May-05	6,608	410	0	16.56	7,018	647	800	650	410	0	1,060	3,000	3,000	0	3,000	1,500	1,500	0	0	1,500	
11-May-05	6,603	410	0	17.38	7,013	641	800	650	410	0	1,060	3,000	3,000	0	3,000	1,500	1,500	0	0	1,500	
12-May-05	6,597	410	0	18.19	7,007	636	800	650	395	0	1,045	3,000	3,000	0	3,000	1,500	1,500	0	0	1,500	
13-May-05	6,591	410	0	19.00	7,001	630	800	650			650	3,000	3,000	0	3,000	1,500	1,500	0	0	1,500	
14-May-05	6,586	410	0	19.81	6,996	625	800	650			650	3,000	3,000		3,000	352	352			352	
15-May-05	6,580	395	0	20.60	6,975	620	800	650			650	3,000	3,000		3,000	352	352			352	
16-May-05	5,427	0	0		5,427	615	800	650			650	3,000	3,000		3,000	352	352			352	
17-May-05	5,422	0	0		5,422	610	800	650			650	3,000	3,000		3,000	352	352			352	
18-May-05	5,417	0	0		5,417	605	800	650			650	3,000	3,000		3,000	352	352			352	
VAMP Period																					
Avg. (cfs):	6,665	335			7,000	715	800	650	335	0	985	3,000	3,000	0	3,000	1,500	1,500	0	0	1,500	
Suppl. Water (TAF):		20.60							20.60	0.00				0.00				0.00			

VAMP flow operation period

Appendix A-1, Table 2

2005 VAMP DAILY OPERATION PLAN
March 23, 2005 (B) • High
Target Flow Period: April 15 - May 15 • Flow Target: greater than 7,000 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	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (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)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		(cfs)	(cfs)	(cfs)	
15-Mar-05	**6,260**				**6,260**	**1,278**	**1,183**	**285**			**285**	**3,140**	**3,140**		**3,140**	**229**	**229**			**229**	
16-Mar-05	**6,180**				**6,180**	**1,234**	**1,201**	**275**			**275**	**3,140**	**3,140**		**3,140**	**229**	**229**			**229**	
17-Mar-05	**6,040**				**6,040**	**1,181**	**1,110**	**276**			**276**	**3,120**	**3,120**		**3,120**	**229**	**229**			**229**	
18-Mar-05	**5,820**				**5,820**	**1,163**	**932**	**274**			**274**	**3,150**	**3,150**		**3,150**	**229**	**229**			**229**	
19-Mar-05	**5,800**				**5,800**	**1,163**	**995**	**292**			**292**	**3,190**	**3,190**		**3,190**	**228**	**228**			**228**	
20-Mar-05	**5,750**				**5,750**	**1,151**	**932**	**322**			**322**	**3,170**	**3,170**		**3,170**	**226**	**226**			**226**	
21-Mar-05	**5,850**				**5,850**	**1,246**	**995**	**335**			**335**	**3,160**	**3,160**		**3,160**	**226**	**226**			**226**	
22-Mar-05	**5,880**				**5,880**	**1,535**	**1,041**	**356**			**356**	**3,120**	**3,120**		**3,120**	**245**	**245**			**245**	
23-Mar-05																					
24-Mar-05																					
25-Mar-05																					
26-Mar-05																					
27-Mar-05																					
28-Mar-05																					
29-Mar-05								650													
30-Mar-05						879		650				3,400	3,400			225	225				
31-Mar-05						874		650				3,400	3,400			225	225				
01-Apr-05	6,354					869	1,200	650			650	3,400	3,400		3,400	225	225			225	
02-Apr-05	6,349					864	1,200	650			650	3,400	3,400		3,400	225	225			225	
03-Apr-05	6,344					859	1,200	650			650	3,400	3,400		3,400	225	225			225	
04-Apr-05	6,339				6,339	854	1,200	650			650	3,400	3,400		3,400	225	225			225	
05-Apr-05	6,334				6,334	848	1,200	650			650	3,400	3,400		3,400	225	225			225	
06-Apr-05	6,329				6,329	842	1,200	650			650	3,400	3,400		3,400	225	225			225	
07-Apr-05	6,323				6,323	836	1,200	650			650	3,400	3,400		3,400	225	225			225	
08-Apr-05	6,317				6,317	830	1,200	650			650	3,400	3,400		3,400	225	225			225	
09-Apr-05	6,311				6,311	824	1,200	650			650	3,400	3,400		3,400	225	225			225	
10-Apr-05	6,305				6,305	818	1,200	650			650	3,400	3,400		3,400	225	225			225	
11-Apr-05	6,299				6,299	812	1,200	650			650	3,400	3,400		3,400	225	225			225	
12-Apr-05	6,293				6,293	806	1,200	650	0	0	650	3,400	3,400		3,400	225	225			225	
13-Apr-05	6,287	0			6,287	800	1,200	650	0	0	650	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
14-Apr-05	6,281	0			6,281	794	1,200	650	0	0	650	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
15-Apr-05	7,550	0	0	0.00	7,550	789	1,200	650	0	0	650	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
16-Apr-05	7,544	0	0	0.00	7,544	783	1,200	650	0	0	650	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
17-Apr-05	7,539	0	0	0.00	7,539	777	1,200	650	0	0	650	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
18-Apr-05	7,533	0	0	0.00	7,533	772	1,200	650	0	0	650	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
19-Apr-05	7,527	0	0	0.00	7,527	766	1,200	650	0	0	650	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
20-Apr-05	7,522	0	0	0.00	7,522	760	1,200	650	0	0	650	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
21-Apr-05	7,516	0	0	0.00	7,516	755	1,200	650	0	0	650	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
22-Apr-05	7,510	0	0	0.00	7,510	749	1,200	650	0	0	650	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
23-Apr-05	7,505	0	0	0.00	7,505	743	1,200	650	0	0	650	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
24-Apr-05	7,499	0	0	0.00	7,499	738	1,200	650	0	0	650	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
25-Apr-05	7,493	0	0	0.00	7,493	732	1,200	650	0	0	650	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
26-Apr-05	7,488	0	0	0.00	7,488	726	1,200	650	0	0	650	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
27-Apr-05	7,482	0	0	0.00	7,482	721	1,200	650	0	0	650	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
28-Apr-05	7,476	0	0	0.00	7,476	715	1,200	650	0	0	650	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
29-Apr-05	7,471	0	0	0.00	7,471	709	1,200	650	0	0	650	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
30-Apr-05	7,465	0	0	0.00	7,465	704	1,200	650	0	0	650	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
01-May-05	7,459	0	0	0.00	7,459	698	1,200	650	0	0	650	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
02-May-05	7,454	0	0	0.00	7,454	692	1,200	650	0	0	650	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
03-May-05	7,448	0	0	0.00	7,448	687	1,200	650	0	0	650	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
04-May-05	7,442	0	0	0.00	7,442	681	1,200	650	0	0	650	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
05-May-05	7,437	0	0	0.00	7,437	675	1,200	650	0	0	650	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
06-May-05	7,431	0	0	0.00	7,431	670	1,200	650	0	0	650	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
07-May-05	7,425	0	0	0.00	7,425	664	1,200	650	0	0	650	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
08-May-05	7,420	0	0	0.00	7,420	658	1,200	650	0	0	650	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
09-May-05	7,414	0	0	0.00	7,414	653	1,200	650	0	0	650	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
10-May-05	7,408	0	0	0.00	7,408	647	1,200	650	0	0	650	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
11-May-05	7,403	0	0	0.00	7,403	641	1,200	650	0	0	650	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
12-May-05	7,397	0	0	0.00	7,397	636	1,200	650	0	0	650	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
13-May-05	7,391	0	0	0.00	7,391	630	1,200	650			650	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
14-May-05	7,386	0	0	0.00	7,386	625	1,200	650			650	3,400	3,400		3,400	352	352			352	
15-May-05	7,380	0	0	0.00	7,380	620	1,200	650			650	3,400	3,400		3,400	352	352			352	
16-May-05	6,227	0	0		6,227	615	1,200	650			650	3,400	3,400		3,400	352	352			352	
17-May-05	6,222	0	0		6,222	610	1,200	650			650	3,400	3,400		3,400	352	352			352	
18-May-05	6,217	0	0		6,217	605	1,200	650			650	3,400	3,400		3,400	352	352			352	
									VAMP Period												
Avg. (cfs):	7,465	0			7,465	715	1,200	650	0	0	650	3,400	3,400	0	3,400	1,500	1,500	0	0	1,500	
Supp. Water (TAF):		0.00							0.00	0.00				0.00				0.00			

VAMP flow operation period

Appendix A-1, Table 3
2005 VAMP DAILY OPERATION PLAN
March 25, 2005 (A) • Low
Target Flow Period: May 1 - May 31 • Flow Target: greater than 7,000 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	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (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)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		(cfs)	(cfs)	(cfs)	
15-Mar-05	**6,260**				**6,260**	**1,278**	**1,183**	**285**			**285**	**3,140**	**3,140**		**3,140**	**229**	**229**			**229**	
16-Mar-05	**6,180**				**6,180**	**1,234**	**1,201**	**275**			**275**	**3,140**	**3,140**		**3,140**	**229**	**229**			**229**	
17-Mar-05	**6,040**				**6,040**	**1,181**	**1,110**	**276**			**276**	**3,120**	**3,120**		**3,120**	**229**	**229**			**229**	
18-Mar-05	**5,820**				**5,820**	**1,163**	**932**	**274**			**274**	**3,150**	**3,150**		**3,150**	**229**	**229**			**229**	
19-Mar-05	**5,800**				**5,800**	**1,163**	**995**	**292**			**292**	**3,190**	**3,190**		**3,190**	**228**	**228**			**228**	
20-Mar-05	**5,750**				**5,750**	**1,151**	**932**	**322**			**322**	**3,170**	**3,170**		**3,170**	**226**	**226**			**226**	
21-Mar-05	**5,850**				**5,850**	**1,246**	**995**	**335**			**335**	**3,160**	**3,160**		**3,160**	**226**	**226**			**226**	
22-Mar-05	**5,880**				**5,880**	**1,535**	**1,041**	**356**			**356**	**3,120**	**3,120**		**3,120**	**245**	**245**			**245**	
23-Mar-05	**6,540**				**6,540**	**1,502**	**1,586**	**1,774**			**1,774**	**3,170**	**3,170**		**3,170**	**232**	**232**			**232**	
24-Mar-05	**8,230**				**8,230**	**1,789**	**2,995**	**1,769**			**1,769**	**4,230**	**4,230**		**4,230**	**301**	**301**			**301**	
25-Mar-05																					
26-Mar-05																					
27-Mar-05																					
28-Mar-05																					
29-Mar-05																					
30-Mar-05																					
31-Mar-05																					
01-Apr-05						869	800	1,220			1,220	3,400	3,400		3,400	225	225			225	
02-Apr-05						864	800	1,220			1,220	3,400	3,400		3,400	225	225			225	
03-Apr-05						859	800	1,220			1,220	3,400	3,400		3,400	225	225			225	
04-Apr-05	6,509				6,509	854	800	1,220			1,220	3,400	3,400		3,400	225	225			225	
05-Apr-05	6,504				6,504	848	800	1,220			1,220	3,400	3,400		3,400	225	225			225	
06-Apr-05	6,499				6,499	842	800	1,220			1,220	3,400	3,400		3,400	225	225			225	
07-Apr-05	6,493				6,493	836	800	1,220			1,220	3,400	3,400		3,400	225	225			225	
08-Apr-05	6,487				6,487	830	800	1,220			1,220	3,400	3,400		3,400	225	225			225	
09-Apr-05	6,481				6,481	824	800	1,220			1,220	3,400	3,400		3,400	225	225			225	
10-Apr-05	6,475				6,475	818	800	1,220			1,220	3,400	3,400		3,400	225	225			225	
11-Apr-05	6,469				6,469	812	800	1,220			1,220	3,400	3,400		3,400	225	225			225	
12-Apr-05	6,463				6,463	806	800	1,220			1,220	3,400	3,400		3,400	225	225			225	
13-Apr-05	6,457				6,457	800	800	1,220			1,220	3,400	3,400		3,400	225	225			225	
14-Apr-05	6,451				6,451	794	800	1,220			1,220	3,400	3,400		3,400	225	225			225	
15-Apr-05	6,445				6,445	789	800	1,220			1,220	3,400	3,400		3,400	225	225			225	
16-Apr-05	6,439				6,439	783	800	1,220			1,220	3,400	3,400		3,400	225	225			225	
17-Apr-05	6,434				6,434	777	800	1,220			1,220	3,400	3,400		3,400	225	225			225	
18-Apr-05	6,428				6,428	772	800	1,220			1,220	3,400	3,400		3,400	225	225			225	
19-Apr-05	6,422				6,422	766	800	1,220			1,220	3,400	3,400		3,400	225	225			225	
20-Apr-05	6,417				6,417	760	800	1,220			1,220	3,400	3,400		3,400	225	225			225	
21-Apr-05	6,411				6,411	755	800	1,220			1,220	3,400	3,400		3,400	225	225			225	
22-Apr-05	6,405				6,405	749	800	1,220			1,220	3,400	3,400		3,400	225	225			225	
23-Apr-05	6,400				6,400	743	800	1,220			1,220	3,400	3,400		3,400	225	225			225	
24-Apr-05	6,394				6,394	738	800	1,220			1,220	3,400	3,400		3,400	225	225			225	
25-Apr-05	6,388				6,388	732	800	1,220			1,220	3,400	3,400		3,400	225	225			225	
26-Apr-05	6,383				6,383	726	800	1,220			1,220	3,400	3,400		3,400	225	225			225	
27-Apr-05	6,377				6,377	721	800	1,220			1,220	3,400	3,400		3,400	225	225			225	
28-Apr-05	6,371				6,371	715	800	1,220	120	0	1,340	3,400	3,400		3,400	225	225			225	
29-Apr-05	6,366				6,366	709	800	1,220	120	0	1,340	2,700	2,700	0	2,700	1,500	1,500	0	0	1,500	
30-Apr-05	6,360				6,360	704	800	1,220	120	0	1,340	2,700	2,700	0	2,700	1,500	1,500	0	0	1,500	
01-May-05	6,929	120	0	0.24	7,049	698	800	1,180	120	0	1,300	2,700	2,700	0	2,700	1,500	1,500	0	0	1,500	
02-May-05	6,924	120	0	0.48	7,044	692	800	1,180	120	0	1,300	2,700	2,700	0	2,700	1,500	1,500	0	0	1,500	
03-May-05	6,918	120	0	0.71	7,038	687	800	1,180	160	0	1,340	2,700	2,700	0	2,700	1,500	1,500	0	0	1,500	
04-May-05	6,872	120	0	0.95	6,992	681	800	1,180	160	0	1,340	2,700	2,700	0	2,700	1,500	1,500	0	0	1,500	
05-May-05	6,867	120	0	1.19	6,987	675	800	1,180	160	0	1,340	2,700	2,700	0	2,700	1,500	1,500	0	0	1,500	
06-May-05	6,861	160	0	1.51	7,021	670	800	1,180	160	0	1,340	2,700	2,700	0	2,700	1,500	1,500	0	0	1,500	
07-May-05	6,855	160	0	1.82	7,015	664	800	1,180	160	0	1,340	2,700	2,700	0	2,700	1,500	1,500	0	0	1,500	
08-May-05	6,850	160	0	2.14	7,010	658	800	1,180	200	0	1,380	2,700	2,700	0	2,700	1,500	1,500	0	0	1,500	
09-May-05	6,844	160	0	2.46	7,004	653	800	1,180	200	0	1,380	2,700	2,700	0	2,700	1,500	1,500	0	0	1,500	
10-May-05	6,838	160	0	2.78	6,998	647	800	1,180	200	0	1,380	2,700	2,700	0	2,700	1,500	1,500	0	0	1,500	
11-May-05	6,833	200	0	3.17	7,033	641	800	1,180	200	0	1,380	2,700	2,700	0	2,700	1,500	1,500	0	0	1,500	
12-May-05	6,827	200	0	3.57	7,027	636	800	1,180	200	0	1,380	2,700	2,700	0	2,700	1,500	1,500	0	0	1,500	
13-May-05	6,821	200	0	3.97	7,021	630	800	1,180	200	0	1,380	2,700	2,700	0	2,700	1,500	1,500	0	0	1,500	
14-May-05	6,816	200	0	4.36	7,016	625	800	1,180	200	0	1,380	2,700	2,700	0	2,700	1,500	1,500	0	0	1,500	
15-May-05	6,810	200	0	4.76	7,010	620	800	1,180	200	0	1,380	2,700	2,700	0	2,700	1,500	1,500	0	0	1,500	
16-May-05	6,805	200	0	5.16	7,005	615	800	1,180	220	0	1,400	2,700	2,700	0	2,700	1,500	1,500	0	0	1,500	
17-May-05	6,800	200	0	5.55	7,000	610	800	1,180	220	0	1,400	2,700	2,700	0	2,700	1,500	1,500	0	0	1,500	
18-May-05	6,795	200	0	5.95	6,995	605	800	1,180	220	0	1,400	2,700	2,700	0	2,700	1,500	1,500	0	0	1,500	
19-May-05	6,790	220	0	6.39	7,010	600	800	1,180	220	0	1,400	2,700	2,700	0	2,700	1,500	1,500	0	0	1,500	
20-May-05	6,785	220	0	6.82	7,005	595	800	1,180	220	0	1,400	2,700	2,700	0	2,700	1,500	1,500	0	0	1,500	
21-May-05	6,780	220	0	7.26	7,000	590	800	1,180	220	0	1,400	2,700	2,700	0	2,700	1,500	1,500	0	0	1,500	
22-May-05	6,775	220	0	7.70	6,995	585	800	1,180	220	0	1,400	2,700	2,700	0	2,700	1,500	1,500	0	0	1,500	
23-May-05	6,770	220	0	8.13	6,990	580	800	1,180	220	0	1,400	2,700	2,700	0	2,700	1,500	1,500	0	0	1,500	
24-May-05	6,765	220	0	8.57	6,985	575	800	1,180	220	0	1,400	2,700	2,700	0	2,700	1,500	1,500	0	0	1,500	
25-May-05	6,760	220	0	9.00	6,980	570	800	1,180	220	0	1,400	2,700	2,700	0	2,700	1,500	1,500	0	0	1,500	
26-May-05	6,755	220	0	9.44	6,975	565	800	1,180	220	0	1,400	2,700	2,700	0	2,700	1,500	1,500	0	0	1,500	
27-May-05	6,750	220	0	9.88	6,970	560	800	1,180	220	0	1,400	2,700	2,700	0	2,700	1,500	1,500	0	0	1,500	
28-May-05	6,745	220	0	10.31	6,965	555	800	1,180	220	0	1,400	2,700	2,700	0	2,700	1,500	1,500	0	0	1,500	
29-May-05	6,740	220	0	10.75	6,960	550	800	1,180			1,180	2,700	2,700	0	2,700	1,500	1,500	0		1,500	
30-May-05	6,735	220	0	11.19	6,955	545	800	1,180			1,180	2,700	2,700		2,700	352	352			352	
31-May-05	6,730	220	0	11.62	6,950	540	800	1,180			1,180	2,700	2,700		2,700	352	352			352	
VAMP Period																					
Avg. (cfs):	6,811	189			7,000	627	800	1,184	189	0	1,373	2,700	2,700	0	2,700	1,500	1,500	0	0	1,500	
Suppl. Water (TAF):		11.62							11.62	0.00				0.00				0.00			

VAMP flow operation period

Appendix A-1, Table 4

2005 VAMP DAILY OPERATION PLAN
March 25, 2005 (B) • High
Target Flow Period: May 1 - May 31 • Flow Target: greater than 7,000 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	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (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)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		(cfs)	(cfs)	(cfs)	
15-Mar-05	**6,260**				**6,260**	**1,278**	**1,183**	**285**			**285**	**3,140**	**3,140**		**3,140**	**229**	**229**			**229**	
16-Mar-05	**6,180**				**6,180**	**1,234**	**1,201**	**275**			**275**	**3,140**	**3,140**		**3,140**	**229**	**229**			**229**	
17-Mar-05	**6,040**				**6,040**	**1,181**	**1,110**	**276**			**276**	**3,120**	**3,120**		**3,120**	**229**	**229**			**229**	
18-Mar-05	**5,820**				**5,820**	**1,163**	**932**	**274**			**274**	**3,150**	**3,150**		**3,150**	**229**	**229**			**229**	
19-Mar-05	**5,800**				**5,800**	**1,163**	**995**	**292**			**292**	**3,190**	**3,190**		**3,190**	**228**	**228**			**228**	
20-Mar-05	**5,750**				**5,750**	**1,151**	**932**	**322**			**322**	**3,170**	**3,170**		**3,170**	**226**	**226**			**226**	
21-Mar-05	**5,850**				**5,850**	**1,246**	**995**	**335**			**335**	**3,160**	**3,160**		**3,160**	**226**	**226**			**226**	
22-Mar-05	**5,880**				**5,880**	**1,535**	**1,041**	**356**			**356**	**3,120**	**3,120**		**3,120**	**245**	**245**			**245**	
23-Mar-05	**6,540**				**6,540**	**1,502**	**1,586**	**1,774**			**1,774**	**3,170**	**3,170**		**3,170**	**232**	**232**			**232**	
24-Mar-05	**8,230**				**8,230**	**1,789**	**2,995**	**1,769**			**1,769**	**4,230**	**4,230**		**4,230**	**301**	**301**			**301**	
25-Mar-05																					
26-Mar-05																					
27-Mar-05																					
28-Mar-05																					
29-Mar-05																					
30-Mar-05																					
31-Mar-05																					
01-Apr-05						869	1,200	1,220			1,220	3,400	3,400		3,400	225	225			225	
02-Apr-05						864	1,200	1,220			1,220	3,400	3,400		3,400	225	225			225	
03-Apr-05						859	1,200	1,220			1,220	3,400	3,400		3,400	225	225			225	
04-Apr-05	6,909				6,909	854	1,200	1,220			1,220	3,400	3,400		3,400	225	225			225	
05-Apr-05	6,904				6,904	848	1,200	1,220			1,220	3,400	3,400		3,400	225	225			225	
06-Apr-05	6,899				6,899	842	1,200	1,220			1,220	3,400	3,400		3,400	225	225			225	
07-Apr-05	6,893				6,893	836	1,200	1,220			1,220	3,400	3,400		3,400	225	225			225	
08-Apr-05	6,887				6,887	830	1,200	1,220			1,220	3,400	3,400		3,400	225	225			225	
09-Apr-05	6,881				6,881	824	1,200	1,220			1,220	3,400	3,400		3,400	225	225			225	
10-Apr-05	6,875				6,875	818	1,200	1,220			1,220	3,400	3,400		3,400	225	225			225	
11-Apr-05	6,869				6,869	812	1,200	1,220			1,220	3,400	3,400		3,400	225	225			225	
12-Apr-05	6,863				6,863	806	1,200	1,220			1,220	3,400	3,400		3,400	225	225			225	
13-Apr-05	6,857				6,857	800	1,200	1,220			1,220	3,400	3,400		3,400	225	225			225	
14-Apr-05	6,851				6,851	794	1,200	1,220			1,220	3,400	3,400		3,400	225	225			225	
15-Apr-05	6,845				6,845	789	1,200	1,220			1,220	3,400	3,400		3,400	225	225			225	
16-Apr-05	6,839				6,839	783	1,200	1,220			1,220	3,400	3,400		3,400	225	225			225	
17-Apr-05	6,834				6,834	777	1,200	1,220			1,220	3,400	3,400		3,400	225	225			225	
18-Apr-05	6,828				6,828	772	1,200	1,220			1,220	3,400	3,400		3,400	225	225			225	
19-Apr-05	6,822				6,822	766	1,200	1,220			1,220	3,400	3,400		3,400	225	225			225	
20-Apr-05	6,817				6,817	760	1,200	1,220			1,220	3,400	3,400		3,400	225	225			225	
21-Apr-05	6,811				6,811	755	1,200	1,220			1,220	3,400	3,400		3,400	225	225			225	
22-Apr-05	6,805				6,805	749	1,200	1,220			1,220	3,400	3,400		3,400	225	225			225	
23-Apr-05	6,800				6,800	743	1,200	1,220			1,220	3,400	3,400		3,400	225	225			225	
24-Apr-05	6,794				6,794	738	1,200	1,220			1,220	3,400	3,400		3,400	225	225			225	
25-Apr-05	6,788				6,788	732	1,200	1,220			1,220	3,400	3,400		3,400	225	225			225	
26-Apr-05	6,783				6,783	726	1,200	1,220			1,220	3,400	3,400		3,400	225	225			225	
27-Apr-05	6,777				6,777	721	1,200	1,220			1,220	3,400	3,400		3,400	225	225			225	
28-Apr-05	6,771				6,771	715	1,200	1,220	0	0	1,220	3,400	3,400		3,400	225	225			225	
29-Apr-05	6,766				6,766	709	1,200	1,220	0	0	1,220	2,700	2,700	0	2,700	1,500	1,500	0	0	1,500	
30-Apr-05	6,760				6,760	704	1,200	1,220	0	0	1,220	2,700	2,700	0	2,700	1,500	1,500	0	0	1,500	
01-May-05	7,329	0	0	0.00	7,329	698	1,200	1,180	0	0	1,180	2,700	2,700	0	2,700	1,500	1,500	0	0	1,500	
02-May-05	7,324	0	0	0.00	7,324	692	1,200	1,180	0	0	1,180	2,700	2,700	0	2,700	1,500	1,500	0	0	1,500	
03-May-05	7,318	0	0	0.00	7,318	687	1,200	1,180	0	0	1,180	2,700	2,700	0	2,700	1,500	1,500	0	0	1,500	
04-May-05	7,272	0	0	0.00	7,272	681	1,200	1,180	0	0	1,180	2,700	2,700	0	2,700	1,500	1,500	0	0	1,500	
05-May-05	7,267	0	0	0.00	7,267	675	1,200	1,180	0	0	1,180	2,700	2,700	0	2,700	1,500	1,500	0	0	1,500	
06-May-05	7,261	0	0	0.00	7,261	670	1,200	1,180	0	0	1,180	2,700	2,700	0	2,700	1,500	1,500	0	0	1,500	
07-May-05	7,255	0	0	0.00	7,255	664	1,200	1,180	0	0	1,180	2,700	2,700	0	2,700	1,500	1,500	0	0	1,500	
08-May-05	7,250	0	0	0.00	7,250	658	1,200	1,180	0	0	1,180	2,700	2,700	0	2,700	1,500	1,500	0	0	1,500	
09-May-05	7,244	0	0	0.00	7,244	653	1,200	1,180	0	0	1,180	2,700	2,700	0	2,700	1,500	1,500	0	0	1,500	
10-May-05	7,238	0	0	0.00	7,238	647	1,200	1,180	0	0	1,180	2,700	2,700	0	2,700	1,500	1,500	0	0	1,500	
11-May-05	7,233	0	0	0.00	7,233	641	1,200	1,180	0	0	1,180	2,700	2,700	0	2,700	1,500	1,500	0	0	1,500	
12-May-05	7,227	0	0	0.00	7,227	636	1,200	1,180	0	0	1,180	2,700	2,700	0	2,700	1,500	1,500	0	0	1,500	
13-May-05	7,221	0	0	0.00	7,221	630	1,200	1,180	0	0	1,180	2,700	2,700	0	2,700	1,500	1,500	0	0	1,500	
14-May-05	7,216	0	0	0.00	7,216	625	1,200	1,180	0	0	1,180	2,700	2,700	0	2,700	1,500	1,500	0	0	1,500	
15-May-05	7,210	0	0	0.00	7,210	620	1,200	1,180	0	0	1,180	2,700	2,700	0	2,700	1,500	1,500	0	0	1,500	
16-May-05	7,205	0	0	0.00	7,205	615	1,200	1,180	0	0	1,180	2,700	2,700	0	2,700	1,500	1,500	0	0	1,500	
17-May-05	7,200	0	0	0.00	7,200	610	1,200	1,180	0	0	1,180	2,700	2,700	0	2,700	1,500	1,500	0	0	1,500	
18-May-05	7,195	0	0	0.00	7,195	605	1,200	1,180	0	0	1,180	2,700	2,700	0	2,700	1,500	1,500	0	0	1,500	
19-May-05	7,190	0	0	0.00	7,190	600	1,200	1,180	0	0	1,180	2,700	2,700	0	2,700	1,500	1,500	0	0	1,500	
20-May-05	7,185	0	0	0.00	7,185	595	1,200	1,180	0	0	1,180	2,700	2,700	0	2,700	1,500	1,500	0	0	1,500	
21-May-05	7,180	0	0	0.00	7,180	590	1,200	1,180	0	0	1,180	2,700	2,700	0	2,700	1,500	1,500	0	0	1,500	
22-May-05	7,175	0	0	0.00	7,175	585	1,200	1,180	0	0	1,180	2,700	2,700	0	2,700	1,500	1,500	0	0	1,500	
23-May-05	7,170	0	0	0.00	7,170	580	1,200	1,180	0	0	1,180	2,700	2,700	0	2,700	1,500	1,500	0	0	1,500	
24-May-05	7,165	0	0	0.00	7,165	575	1,200	1,180	0	0	1,180	2,700	2,700	0	2,700	1,500	1,500	0	0	1,500	
25-May-05	7,160	0	0	0.00	7,160	570	1,200	1,180	0	0	1,180	2,700	2,700	0	2,700	1,500	1,500	0	0	1,500	
26-May-05	7,155	0	0	0.00	7,155	565	1,200	1,180	0	0	1,180	2,700	2,700	0	2,700	1,500	1,500	0	0	1,500	
27-May-05	7,150	0	0	0.00	7,150	560	1,200	1,180	0	0	1,180	2,700	2,700	0	2,700	1,500	1,500	0	0	1,500	
28-May-05	7,145	0	0	0.00	7,145	555	1,200	1,180	0	0	1,180	2,700	2,700	0	2,700	1,500	1,500	0	0	1,500	
29-May-05	7,140	0	0	0.00	7,140	550	1,200	1,180			1,180	2,700	2,700	0	2,700	1,500	1,500	0	0	1,500	
30-May-05	7,135	0	0	0.00	7,135	545	1,200	1,180			1,180	2,700	2,700		2,700	352	352			352	
31-May-05	7,130	0	0	0.00	7,130	540	1,200	1,180			1,180	2,700	2,700		2,700	352	352			352	
VAMP Period																					
Avg. (cfs):	7,211	0			7,211	627	1,200	1,184	0	0	1,184	2,700	2,700	0	2,700	1,500	1,500	0	0	1,500	
Suppl. Water (TAF):		0.00							0.00	0.00				0.00				0.00			

VAMP flow operation period

Appendix A-1, Table 5

2005 VAMP DAILY OPERATION PLAN
April 5, 2005 (A) • Low
Target Flow Period: May 1 - May 31 • Flow Target: greater than 7,000 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	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (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)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		(cfs)	(cfs)	(cfs)	
15-Mar-05	**6,260**				**6,260**	**1,278**	**1,183**	**285**			**285**	**3,140**	**3,140**		**3,140**	**229**	**229**			**229**	
16-Mar-05	**6,180**				**6,180**	**1,234**	**1,201**	**275**			**275**	**3,140**	**3,140**		**3,140**	**229**	**229**			**229**	
17-Mar-05	**6,040**				**6,040**	**1,181**	**1,110**	**276**			**276**	**3,120**	**3,120**		**3,120**	**229**	**229**			**229**	
18-Mar-05	**5,820**				**5,820**	**1,163**	**932**	**274**			**274**	**3,150**	**3,150**		**3,150**	**229**	**229**			**229**	
19-Mar-05	**5,800**				**5,800**	**1,163**	**995**	**292**			**292**	**3,190**	**3,190**		**3,190**	**228**	**228**			**228**	
20-Mar-05	**5,830**				**5,830**	**1,151**	**1,012**	**322**			**322**	**3,170**	**3,170**		**3,170**	**226**	**226**			**226**	
21-Mar-05	**5,850**				**5,850**	**1,246**	**995**	**335**			**335**	**3,160**	**3,160**		**3,160**	**226**	**226**			**226**	
22-Mar-05	**5,880**				**5,880**	**1,535**	**1,041**	**356**			**356**	**3,120**	**3,120**		**3,120**	**245**	**245**			**245**	
23-Mar-05	**6,540**				**6,540**	**1,502**	**1,586**	**1,774**			**1,774**	**3,170**	**3,170**		**3,170**	**232**	**232**			**232**	
24-Mar-05	**8,230**				**8,230**	**1,789**	**2,995**	**1,769**			**1,769**	**4,230**	**4,230**		**4,230**	**301**	**301**			**301**	
25-Mar-05	**9,220**				**9,220**	**2,881**	**3,960**	**1,532**			**1,532**	**5,810**	**5,810**		**5,810**	**611**	**611**			**611**	
26-Mar-05	**10,200**				**10,200**	**3,265**	**2,106**	**2,147**			**2,147**	**6,230**	**6,230**		**6,230**	**607**	**607**			**607**	
27-Mar-05	**11,700**				**11,700**	**3,095**	**629**	**4,145**			**4,145**	**6,240**	**6,240**		**6,240**	**610**	**610**			**610**	
28-Mar-05	**12,700**				**12,700**	**2,371**	**1,066**	**5,695**			**5,695**	**6,120**	**6,120**		**6,120**	**604**	**604**			**604**	
29-Mar-05	**13,500**				**13,500**	**2,364**	**1,408**	**5,451**			**5,451**	**6,440**	**6,440**		**6,440**	**603**	**603**			**603**	
30-Mar-05	**14,000**				**14,000**	**2,513**	**760**	**5,232**			**5,232**	**6,660**	**6,660**		**6,660**	**400**	**400**			**400**	
31-Mar-05	**14,300**				**14,300**	**2,378**	**-802**	**4,717**			**4,717**	**6,660**	**6,660**		**6,660**	**229**	**229**			**229**	
01-Apr-05	**14,400**				**14,400**	**2,156**	**-624**	**4,604**			**4,604**	**7,230**	**7,230**		**7,230**	**229**	**229**			**229**	
02-Apr-05	**14,300**				**14,300**	**1,906**	**-199**	**4,164**			**4,164**	**6,860**	**6,860**		**6,860**	**229**	**229**			**229**	
03-Apr-05	**14,400**				**14,400**	**1,676**	**68**	**4,076**			**4,076**	**7,070**	**7,070**		**7,070**	**229**	**229**			**229**	
04-Apr-05	**14,300**				**14,300**	**1,282**	**701**	**4,074**			**4,074**	**7,360**	**7,360**		**7,360**	**226**	**226**			**226**	
05-Apr-05	14,139				14,139	1,217	1,000	3,700			3,700	7,200	7,200		7,200	225	225			225	
06-Apr-05	13,744				13,744	1,153	800	3,200			3,200	6,500	6,500		6,500	225	225			225	
07-Apr-05	13,316				13,316	1,088	600	2,500			2,500	5,000	5,000		5,000	225	225			225	
08-Apr-05	12,178				12,178	1,023	600	2,500			2,500	4,000	4,000		4,000	225	225			225	
09-Apr-05	10,113				10,113	959	600	2,500			2,500	4,000	4,000		4,000	225	225			225	
10-Apr-05	8,348				8,348	894	600	2,500			2,500	4,000	4,000		4,000	225	225			225	
11-Apr-05	8,284				8,284	829	600	2,500			2,500	4,000	4,000		4,000	225	225			225	
12-Apr-05	8,219				8,219	765	600	2,500			2,500	4,000	4,000		4,000	225	225			225	
13-Apr-05	8,154				8,154	700	600	2,500			2,500	4,000	4,000		4,000	225	225			225	
14-Apr-05	8,090				8,090	695	600	2,500			2,500	4,000	4,000		4,000	225	225			225	
15-Apr-05	8,025				8,025	690	600	2,500			2,500	4,000	4,000		4,000	225	225			225	
16-Apr-05	8,020				8,020	684	600	2,500			2,500	4,000	4,000		4,000	225	225			225	
17-Apr-05	8,015				8,015	679	600	2,500			2,500	4,000	4,000		4,000	225	225			225	
18-Apr-05	8,009				8,009	674	600	2,500			2,500	4,000	4,000		4,000	225	225			225	
19-Apr-05	8,004				8,004	669	600	2,500			2,500	4,000	4,000		4,000	225	225			225	
20-Apr-05	7,999				7,999	663	600	2,500			2,500	4,000	4,000		4,000	225	225			225	
21-Apr-05	7,994				7,994	658	600	2,500			2,500	4,000	4,000		4,000	225	225			225	
22-Apr-05	7,988				7,988	653	600	2,500			2,500	4,000	4,000		4,000	225	225			225	
23-Apr-05	7,983				7,983	648	600	2,500			2,500	4,000	4,000		4,000	225	225			225	
24-Apr-05	7,978				7,978	642	600	2,500			2,500	4,000	4,000		4,000	225	225			225	
25-Apr-05	7,973				7,973	637	600	2,500			2,500	4,000	4,000		4,000	225	225			225	
26-Apr-05	7,967				7,967	632	600	2,500			2,500	4,000	4,000		4,000	225	225			225	
27-Apr-05	7,962				7,962	627	600	2,500			2,500	4,000	4,000		4,000	225	225			225	
28-Apr-05	7,957				7,957	622	600	2,500	0	0	2,500	4,000	4,000		4,000	225	225			225	
29-Apr-05	7,952				7,952	616	600	2,500	0	0	2,500	3,700	3,700	0	3,700	1,500	1,500	0	0	1,500	
30-Apr-05	7,947				7,947	611	600	2,500	0	0	2,500	3,700	3,700	0	3,700	1,500	1,500	0	0	1,500	
01-May-05	8,916	0	0	0.00	8,916	606	600	2,500	0	0	2,500	3,700	3,700	0	3,700	1,500	1,500	0	0	1,500	
02-May-05	8,911	0	0	0.00	8,911	601	600	2,500	0	0	2,500	3,700	3,700	0	3,700	1,500	1,500	0	0	1,500	
03-May-05	8,906	0	0	0.00	8,906	595	600	2,500	0	0	2,500	3,700	3,700	0	3,700	1,500	1,500	0	0	1,500	
04-May-05	8,901	0	0	0.00	8,901	590	600	2,500	0	0	2,500	3,700	3,700	0	3,700	1,500	1,500	0	0	1,500	
05-May-05	8,895	0	0	0.00	8,895	585	600	2,500	0	0	2,500	3,700	3,700	0	3,700	1,500	1,500	0	0	1,500	
06-May-05	8,890	0	0	0.00	8,890	580	600	2,500	0	0	2,500	3,700	3,700	0	3,700	1,500	1,500	0	0	1,500	
07-May-05	8,885	0	0	0.00	8,885	574	600	2,500	0	0	2,500	3,700	3,700	0	3,700	1,500	1,500	0	0	1,500	
08-May-05	8,880	0	0	0.00	8,880	569	600	2,500	0	0	2,500	3,700	3,700	0	3,700	1,500	1,500	0	0	1,500	
09-May-05	8,874	0	0	0.00	8,874	564	600	2,500	0	0	2,500	3,700	3,700	0	3,700	1,500	1,500	0	0	1,500	
10-May-05	8,869	0	0	0.00	8,869	559	600	2,500	0	0	2,500	3,700	3,700	0	3,700	1,500	1,500	0	0	1,500	
11-May-05	8,864	0	0	0.00	8,864	553	600	2,500	0	0	2,500	3,700	3,700	0	3,700	1,500	1,500	0	0	1,500	
12-May-05	8,859	0	0	0.00	8,859	548	600	2,500	0	0	2,500	3,700	3,700	0	3,700	1,500	1,500	0	0	1,500	
13-May-05	8,853	0	0	0.00	8,853	543	600	2,500	0	0	2,500	3,700	3,700	0	3,700	1,500	1,500	0	0	1,500	
14-May-05	8,848	0	0	0.00	8,848	538	600	2,500	0	0	2,500	3,700	3,700	0	3,700	1,500	1,500	0	0	1,500	
15-May-05	8,843	0	0	0.00	8,843	533	600	2,500	0	0	2,500	3,700	3,700	0	3,700	1,500	1,500	0	0	1,500	
16-May-05	8,838	0	0	0.00	8,838	528	600	2,500	0	0	2,500	3,700	3,700	0	3,700	1,500	1,500	0	0	1,500	
17-May-05	8,833	0	0	0.00	8,833	523	600	2,500	0	0	2,500	3,700	3,700	0	3,700	1,500	1,500	0	0	1,500	
18-May-05	8,828	0	0	0.00	8,828	518	600	2,500	0	0	2,500	3,700	3,700	0	3,700	1,500	1,500	0	0	1,500	
19-May-05	8,823	0	0	0.00	8,823	513	600	2,500	0	0	2,500	3,700	3,700	0	3,700	1,500	1,500	0	0	1,500	
20-May-05	8,818	0	0	0.00	8,818	508	600	2,500	0	0	2,500	3,700	3,700	0	3,700	1,500	1,500	0	0	1,500	
21-May-05	8,813	0	0	0.00	8,813	503	600	2,500	0	0	2,500	3,700	3,700	0	3,700	1,500	1,500	0	0	1,500	
22-May-05	8,808	0	0	0.00	8,808	498	600	2,500	0	0	2,500	3,700	3,700	0	3,700	1,500	1,500	0	0	1,500	
23-May-05	8,803	0	0	0.00	8,803	493	600	2,500	0	0	2,500	3,700	3,700	0	3,700	1,500	1,500	0	0	1,500	
24-May-05	8,798	0	0	0.00	8,798	488	600	2,500	0	0	2,500	3,700	3,700	0	3,700	1,500	1,500	0	0	1,500	
25-May-05	8,793	0	0	0.00	8,793	483	600	2,500	0	0	2,500	3,700	3,700	0	3,700	1,500	1,500	0	0	1,500	
26-May-05	8,788	0	0	0.00	8,788	478	600	2,500	0	0	2,500	3,700	3,700	0	3,700	1,500	1,500	0	0	1,500	
27-May-05	8,783	0	0	0.00	8,783	473	600	2,500	0	0	2,500	3,700	3,700	0	3,700	1,500	1,500	0	0	1,500	
28-May-05	8,778	0	0	0.00	8,778	468	600	2,500	0	0	2,500	3,700	3,700	0	3,700	1,500	1,500	0	0	1,500	
29-May-05	8,773	0	0	0.00	8,773	463	600	2,500			2,500	3,700	3,700	0	3,700	1,500	1,500	0	0	1,500	
30-May-05	8,768	0	0	0.00	8,768	458	600	2,500			2,500	3,700	3,700		3,700	352	352			352	
31-May-05	8,763	0	0	0.00	8,763	453	600	2,500			2,500	3,700	3,700		3,700	352	352			352	
VAMP Period																					
Avg. (cfs):	8,839	0			8,839	539	600	2,500	0	0	2,500	3,700	3,700	0	3,700	1,500	1,500	0	0	1,500	
Suppl. Water (TAF):		0.00							0.00	0.00				0.00				0.00			

VAMP flow operation period

Appendix A-1, Table 6

2005 VAMP DAILY OPERATION PLAN
April 5, 2005 (B) • High
Target Flow Period: May 1 - May 31 • Flow Target: greater than 7,000 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	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (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)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		(cfs)	(cfs)	(cfs)	
15-Mar-05	**6,260**				**6,260**	**1,278**	**1,183**	**285**			**285**	**3,140**	**3,140**		**3,140**	**229**	**229**			**229**	
16-Mar-05	**6,180**				**6,180**	**1,234**	**1,201**	**275**			**275**	**3,140**	**3,140**		**3,140**	**229**	**229**			**229**	
17-Mar-05	**6,040**				**6,040**	**1,181**	**1,110**	**276**			**276**	**3,120**	**3,120**		**3,120**	**229**	**229**			**229**	
18-Mar-05	**5,820**				**5,820**	**1,163**	**932**	**274**			**274**	**3,150**	**3,150**		**3,150**	**229**	**229**			**229**	
19-Mar-05	**5,800**				**5,800**	**1,163**	**995**	**292**			**292**	**3,190**	**3,190**		**3,190**	**228**	**228**			**228**	
20-Mar-05	**5,830**				**5,830**	**1,151**	**1,012**	**322**			**322**	**3,170**	**3,170**		**3,170**	**226**	**226**			**226**	
21-Mar-05	**5,850**				**5,850**	**1,246**	**995**	**335**			**335**	**3,160**	**3,160**		**3,160**	**226**	**226**			**226**	
22-Mar-05	**5,880**				**5,880**	**1,535**	**1,041**	**356**			**356**	**3,120**	**3,120**		**3,120**	**245**	**245**			**245**	
23-Mar-05	**6,540**				**6,540**	**1,502**	**1,586**	**1,774**			**1,774**	**3,170**	**3,170**		**3,170**	**232**	**232**			**232**	
24-Mar-05	**8,230**				**8,230**	**1,789**	**2,995**	**1,769**			**1,769**	**4,230**	**4,230**		**4,230**	**301**	**301**			**301**	
25-Mar-05	**9,220**				**9,220**	**2,881**	**3,960**	**1,532**			**1,532**	**5,810**	**5,810**		**5,810**	**611**	**611**			**611**	
26-Mar-05	**10,200**				**10,200**	**3,265**	**2,106**	**2,147**			**2,147**	**6,230**	**6,230**		**6,230**	**607**	**607**			**607**	
27-Mar-05	**11,700**				**11,700**	**3,095**	**629**	**4,145**			**4,145**	**6,240**	**6,240**		**6,240**	**610**	**610**			**610**	
28-Mar-05	**12,700**				**12,700**	**2,371**	**1,066**	**5,695**			**5,695**	**6,120**	**6,120**		**6,120**	**604**	**604**			**604**	
29-Mar-05	**13,500**				**13,500**	**2,364**	**1,408**	**5,451**			**5,451**	**6,440**	**6,440**		**6,440**	**603**	**603**			**603**	
30-Mar-05	**14,000**				**14,000**	**2,513**	**760**	**5,232**			**5,232**	**6,660**	**6,660**		**6,660**	**400**	**400**			**400**	
31-Mar-05	**14,300**				**14,300**	**2,378**	**-802**	**4,717**			**4,717**	**6,660**	**6,660**		**6,660**	**229**	**229**			**229**	
01-Apr-05	**14,400**				**14,400**	**2,156**	**-624**	**4,604**			**4,604**	**7,230**	**7,230**		**7,230**	**229**	**229**			**229**	
02-Apr-05	**14,300**				**14,300**	**1,906**	**-199**	**4,164**			**4,164**	**6,860**	**6,860**		**6,860**	**229**	**229**			**229**	
03-Apr-05	**14,400**				**14,400**	**1,676**	**68**	**4,076**			**4,076**	**7,070**	**7,070**		**7,070**	**229**	**229**			**229**	
04-Apr-05	**14,300**				**14,300**	**1,282**	**701**	**4,074**			**4,074**	**7,360**	**7,360**		**7,360**	**226**	**226**			**226**	
05-Apr-05	14,139				14,139	1,217	1,000	3,700			3,700	7,200	7,200		7,200	225	225			225	
06-Apr-05	14,144				14,144	1,153	1,200	3,200			3,200	6,500	6,500		6,500	225	225			225	
07-Apr-05	13,916				13,916	1,088	1,200	2,500			2,500	5,000	5,000		5,000	225	225			225	
08-Apr-05	12,778				12,778	1,023	1,200	2,500			2,500	4,000	4,000		4,000	225	225			225	
09-Apr-05	10,713				10,713	959	1,200	2,500			2,500	4,000	4,000		4,000	225	225			225	
10-Apr-05	8,948				8,948	894	1,200	2,500			2,500	4,000	4,000		4,000	225	225			225	
11-Apr-05	8,884				8,884	829	1,200	2,500			2,500	4,000	4,000		4,000	225	225			225	
12-Apr-05	8,819				8,819	765	1,200	2,500			2,500	4,000	4,000		4,000	225	225			225	
13-Apr-05	8,754				8,754	700	1,200	2,500			2,500	4,000	4,000		4,000	225	225			225	
14-Apr-05	8,690				8,690	695	1,200	2,500			2,500	4,000	4,000		4,000	225	225			225	
15-Apr-05	8,625				8,625	690	1,200	2,500			2,500	4,000	4,000		4,000	225	225			225	
16-Apr-05	8,620				8,620	684	1,200	2,500			2,500	4,000	4,000		4,000	225	225			225	
17-Apr-05	8,615				8,615	679	1,200	2,500			2,500	4,000	4,000		4,000	225	225			225	
18-Apr-05	8,609				8,609	674	1,200	2,500			2,500	4,000	4,000		4,000	225	225			225	
19-Apr-05	8,604				8,604	669	1,200	2,500			2,500	4,000	4,000		4,000	225	225			225	
20-Apr-05	8,599				8,599	663	1,200	2,500			2,500	4,000	4,000		4,000	225	225			225	
21-Apr-05	8,594				8,594	658	1,200	2,500			2,500	4,000	4,000		4,000	225	225			225	
22-Apr-05	8,588				8,588	653	1,200	2,500			2,500	4,000	4,000		4,000	225	225			225	
23-Apr-05	8,583				8,583	648	1,200	2,500			2,500	4,000	4,000		4,000	225	225			225	
24-Apr-05	8,578				8,578	642	1,200	2,500			2,500	4,000	4,000		4,000	225	225			225	
25-Apr-05	8,573				8,573	637	1,200	2,500			2,500	4,000	4,000		4,000	225	225			225	
26-Apr-05	8,567				8,567	632	1,200	2,500			2,500	4,000	4,000		4,000	225	225			225	
27-Apr-05	8,562				8,562	627	1,200	2,500			2,500	4,000	4,000		4,000	225	225			225	
28-Apr-05	8,557				8,557	622	1,200	2,500	0	0	2,500	4,000	4,000		4,000	225	225			225	
29-Apr-05	8,552				8,552	616	1,200	2,500	0	0	2,500	3,700	3,700	0	3,700	1,500	1,500	0	0	1,500	
30-Apr-05	8,547				8,547	611	1,200	2,500	0	0	2,500	3,700	3,700	0	3,700	1,500	1,500	0	0	1,500	
01-May-05	9,516	0	0	0.00	9,516	606	1,200	2,500	0	0	2,500	3,700	3,700	0	3,700	1,500	1,500	0	0	1,500	
02-May-05	9,511	0	0	0.00	9,511	601	1,200	2,500	0	0	2,500	3,700	3,700	0	3,700	1,500	1,500	0	0	1,500	
03-May-05	9,506	0	0	0.00	9,506	595	1,200	2,500	0	0	2,500	3,700	3,700	0	3,700	1,500	1,500	0	0	1,500	
04-May-05	9,501	0	0	0.00	9,501	590	1,200	2,500	0	0	2,500	3,700	3,700	0	3,700	1,500	1,500	0	0	1,500	
05-May-05	9,495	0	0	0.00	9,495	585	1,200	2,500	0	0	2,500	3,700	3,700	0	3,700	1,500	1,500	0	0	1,500	
06-May-05	9,490	0	0	0.00	9,490	580	1,200	2,500	0	0	2,500	3,700	3,700	0	3,700	1,500	1,500	0	0	1,500	
07-May-05	9,485	0	0	0.00	9,485	574	1,200	2,500	0	0	2,500	3,700	3,700	0	3,700	1,500	1,500	0	0	1,500	
08-May-05	9,480	0	0	0.00	9,480	569	1,200	2,500	0	0	2,500	3,700	3,700	0	3,700	1,500	1,500	0	0	1,500	
09-May-05	9,474	0	0	0.00	9,474	564	1,200	2,500	0	0	2,500	3,700	3,700	0	3,700	1,500	1,500	0	0	1,500	
10-May-05	9,469	0	0	0.00	9,469	559	1,200	2,500	0	0	2,500	3,700	3,700	0	3,700	1,500	1,500	0	0	1,500	
11-May-05	9,464	0	0	0.00	9,464	553	1,200	2,500	0	0	2,500	3,700	3,700	0	3,700	1,500	1,500	0	0	1,500	
12-May-05	9,459	0	0	0.00	9,459	548	1,200	2,500	0	0	2,500	3,700	3,700	0	3,700	1,500	1,500	0	0	1,500	
13-May-05	9,453	0	0	0.00	9,453	543	1,200	2,500	0	0	2,500	3,700	3,700	0	3,700	1,500	1,500	0	0	1,500	
14-May-05	9,448	0	0	0.00	9,448	538	1,200	2,500	0	0	2,500	3,700	3,700	0	3,700	1,500	1,500	0	0	1,500	
15-May-05	9,443	0	0	0.00	9,443	533	1,200	2,500	0	0	2,500	3,700	3,700	0	3,700	1,500	1,500	0	0	1,500	
16-May-05	9,438	0	0	0.00	9,438	528	1,200	2,500	0	0	2,500	3,700	3,700	0	3,700	1,500	1,500	0	0	1,500	
17-May-05	9,433	0	0	0.00	9,433	523	1,200	2,500	0	0	2,500	3,700	3,700	0	3,700	1,500	1,500	0	0	1,500	
18-May-05	9,428	0	0	0.00	9,428	518	1,200	2,500	0	0	2,500	3,700	3,700	0	3,700	1,500	1,500	0	0	1,500	
19-May-05	9,423	0	0	0.00	9,423	513	1,200	2,500	0	0	2,500	3,700	3,700	0	3,700	1,500	1,500	0	0	1,500	
20-May-05	9,418	0	0	0.00	9,418	508	1,200	2,500	0	0	2,500	3,700	3,700	0	3,700	1,500	1,500	0	0	1,500	
21-May-05	9,413	0	0	0.00	9,413	503	1,200	2,500	0	0	2,500	3,700	3,700	0	3,700	1,500	1,500	0	0	1,500	
22-May-05	9,408	0	0	0.00	9,408	498	1,200	2,500	0	0	2,500	3,700	3,700	0	3,700	1,500	1,500	0	0	1,500	
23-May-05	9,403	0	0	0.00	9,403	493	1,200	2,500	0	0	2,500	3,700	3,700	0	3,700	1,500	1,500	0	0	1,500	
24-May-05	9,398	0	0	0.00	9,398	488	1,200	2,500	0	0	2,500	3,700	3,700	0	3,700	1,500	1,500	0	0	1,500	
25-May-05	9,393	0	0	0.00	9,393	483	1,200	2,500	0	0	2,500	3,700	3,700	0	3,700	1,500	1,500	0	0	1,500	
26-May-05	9,388	0	0	0.00	9,388	478	1,200	2,500	0	0	2,500	3,700	3,700	0	3,700	1,500	1,500	0	0	1,500	
27-May-05	9,383	0	0	0.00	9,383	473	1,200	2,500	0	0	2,500	3,700	3,700	0	3,700	1,500	1,500	0	0	1,500	
28-May-05	9,378	0	0	0.00	9,378	468	1,200	2,500	0	0	2,500	3,700	3,700	0	3,700	1,500	1,500	0	0	1,500	
29-May-05	9,373	0	0	0.00	9,373	463	1,200	2,500			2,500	3,700	3,700	0	3,700	1,500	1,500	0	0	1,500	
30-May-05	9,368	0	0	0.00	9,368	458	1,200	2,500			2,500	3,700	3,700		3,700	352	352			352	
31-May-05	9,363	0	0	0.00	9,363	453	1,200	2,500			2,500	3,700	3,700		3,700	352	352			352	
VAMP Period																					
Avg. (cfs):	9,439	0			9,439	539	1,200	2,500	0	0	2,500	3,700	3,700	0	3,700	1,500	1,500	0	0	1,500	
Suppl. Water (TAF):		0.00							0.00	0.00				0.00				0.00			

VAMP flow operation period

Appendix A-1, Table 7

2005 VAMP DAILY OPERATION PLAN
April 13, 2005 (A) • Low
Target Flow Period: May 1 - May 31 • Flow Target: greater than 7,000 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	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (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)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		(cfs)	(cfs)	(cfs)	
15-Mar-05	**6,260**				**6,260**	**1,238**	**1,223**	**285**			**285**	**3,140**	**3,140**		**3,140**	**229**	**229**			**229**	
16-Mar-05	**6,180**				**6,180**	**1,194**	**1,241**	**275**			**275**	**3,140**	**3,140**		**3,140**	**229**	**229**			**229**	
17-Mar-05	**6,040**				**6,020**	**1,141**	**1,130**	**276**			**276**	**3,120**	**3,120**		**3,120**	**229**	**229**			**229**	
18-Mar-05	**5,790**				**5,790**	**1,123**	**942**	**274**			**274**	**3,150**	**3,150**		**3,150**	**229**	**229**			**229**	
19-Mar-05	**5,800**				**5,800**	**1,123**	**1,035**	**292**			**292**	**3,190**	**3,190**		**3,190**	**228**	**228**			**228**	
20-Mar-05	**5,830**				**5,830**	**1,111**	**1,052**	**322**			**322**	**3,170**	**3,170**		**3,170**	**226**	**226**			**226**	
21-Mar-05	**5,850**				**5,850**	**1,206**	**1,035**	**335**			**335**	**3,160**	**3,160**		**3,160**	**226**	**226**			**226**	
22-Mar-05	**5,850**				**5,850**	**1,495**	**1,051**	**356**			**356**	**3,120**	**3,120**		**3,120**	**245**	**245**			**245**	
23-Mar-05	**6,570**				**6,570**	**1,452**	**1,656**	**1,774**			**1,774**	**3,170**	**3,170**		**3,170**	**232**	**232**			**232**	
24-Mar-05	**8,390**				**8,390**	**1,729**	**3,195**	**1,769**			**1,769**	**4,230**	**4,230**		**4,230**	**301**	**301**			**301**	
25-Mar-05	**9,460**				**9,460**	**2,811**	**4,250**	**1,532**			**1,532**	**5,810**	**5,810**		**5,810**	**611**	**611**			**611**	
26-Mar-05	**10,500**				**10,500**	**3,185**	**2,466**	**2,147**			**2,147**	**6,230**	**6,230**		**6,230**	**607**	**607**			**607**	
27-Mar-05	**12,100**				**12,100**	**3,005**	**1,099**	**4,145**			**4,145**	**6,240**	**6,240**		**6,240**	**610**	**610**			**610**	
28-Mar-05	**13,300**				**13,300**	**2,261**	**1,746**	**5,695**			**5,695**	**6,120**	**6,120**		**6,120**	**604**	**604**			**604**	
29-Mar-05	**14,100**				**14,100**	**2,224**	**2,098**	**5,451**			**5,451**	**6,440**	**6,440**		**6,440**	**603**	**603**			**603**	
30-Mar-05	**14,600**				**14,600**	**2,393**	**1,470**	**5,232**			**5,232**	**6,660**	**6,660**		**6,660**	**400**	**400**			**400**	
31-Mar-05	**15,000**				**15,000**	**2,298**	**38**	**4,717**			**4,717**	**6,660**	**6,660**		**6,660**	**229**	**229**			**229**	
01-Apr-05	**15,100**				**15,100**	**2,086**	**196**	**4,604**			**4,604**	**7,230**	**7,230**		**7,230**	**229**	**229**			**229**	
02-Apr-05	**15,000**				**15,000**	**1,846**	**581**	**4,164**			**4,164**	**6,860**	**6,860**		**6,860**	**229**	**229**			**229**	
03-Apr-05	**15,000**				**15,000**	**1,616**	**738**	**4,076**			**4,076**	**7,070**	**7,070**		**7,070**	**229**	**229**			**229**	
04-Apr-05	**15,000**				**15,000**	**1,232**	**1,461**	**4,074**			**4,074**	**7,360**	**7,360**		**7,360**	**226**	**226**			**226**	
05-Apr-05	**14,700**				**14,700**	**1,009**	**1,621**	**3,690**			**3,690**	**7,200**	**7,200**		**7,200**	**229**	**229**			**229**	
06-Apr-05	**14,300**				**14,300**	**904**	**1,406**	**3,575**			**3,575**	**5,600**	**5,600**		**5,600**	**229**	**229**			**229**	
07-Apr-05	**13,400**				**13,400**	**719**	**888**	**3,404**			**3,404**	**5,110**	**5,110**		**5,110**	**226**	**226**			**226**	
08-Apr-05	**12,000**				**12,000**	**616**	**1,577**	**3,385**			**3,385**	**4,630**	**4,630**		**4,630**	**227**	**227**			**227**	
09-Apr-05	**11,400**				**11,400**	**582**	**1,770**	**3,349**			**3,349**	**4,090**	**4,090**		**4,090**	**225**	**225**			**225**	
10-Apr-05	**10,700**				**10,700**	**618**	**1,823**	**3,332**			**3,332**	**4,160**	**4,160**		**4,160**	**229**	**229**			**229**	
11-Apr-05	**10,300**				**10,300**	**615**	**2,018**	**3,286**			**3,286**	**4,910**	**4,910**		**4,910**	**232**	**232**			**232**	
12-Apr-05	**10,300**				**10,300**	**697**	**1,944**	**2,807**			**2,807**	**5,020**	**5,020**		**5,020**	**226**	**226**			**226**	
13-Apr-05	10,789				10,789	700	1,700	2,500			2,500	4,000	4,000		4,000	225	225			225	
14-Apr-05	10,429				10,429	695	1,200	2,500			2,500	4,000	4,000		4,000	225	225			225	
15-Apr-05	8,632				8,632	690	900	2,500			2,500	4,000	4,000		4,000	225	225			225	
16-Apr-05	8,020				8,020	684	600	2,500			2,500	3,600	3,600		3,600	225	225			225	
17-Apr-05	8,015				8,015	679	600	2,500			2,500	3,600	3,600		3,600	225	225			225	
18-Apr-05	7,609				7,609	674	600	2,500			2,500	3,600	3,600		3,600	225	225			225	
19-Apr-05	7,604				7,604	669	600	2,500			2,500	3,600	3,600		3,600	225	225			225	
20-Apr-05	7,599				7,599	663	600	2,500			2,500	3,600	3,600		3,600	225	225			225	
21-Apr-05	7,594				7,594	658	600	2,500			2,500	3,600	3,600		3,600	225	225			225	
22-Apr-05	7,588				7,588	653	600	2,500			2,500	3,600	3,600		3,600	225	225			225	
23-Apr-05	7,583				7,583	648	600	2,500			2,500	3,600	3,600		3,600	225	225			225	
24-Apr-05	7,578				7,578	642	600	2,500			2,500	3,600	3,600		3,600	225	225			225	
25-Apr-05	7,573				7,573	637	600	2,500			2,500	3,600	3,600		3,600	225	225			225	
26-Apr-05	7,567				7,567	632	600	2,500			2,500	3,600	3,600		3,600	225	225			225	
27-Apr-05	7,562				7,562	627	600	2,500			2,500	3,600	3,600		3,600	225	225			225	
28-Apr-05	7,557				7,557	622	600	1,625	220	0	1,845	3,000	3,000		3,000	225	225			225	
29-Apr-05	7,552				7,552	616	600	1,625	220	0	1,845	2,500	2,500	0	2,500	1,500	1,500	0	0	1,500	
30-Apr-05	6,947				6,947	611	600	1,625	220	0	1,845	2,500	2,500	0	2,500	1,500	1,500	0	0	1,500	
01-May-05	6,841	220	0	0.44	7,061	606	600	1,625	220	0	1,845	2,500	2,500	0	2,500	1,500	1,500	0	0	1,500	
02-May-05	6,836	220	0	0.87	7,056	601	600	1,625	220	0	1,845	2,500	2,500	0	2,500	1,500	1,500	0	0	1,500	
03-May-05	6,831	220	0	1.31	7,051	595	600	1,625	220	0	1,845	2,500	2,500	0	2,500	1,500	1,500	0	0	1,500	
04-May-05	6,826	220	0	1.75	7,046	590	600	1,625	220	0	1,845	2,500	2,500	0	2,500	1,500	1,500	0	0	1,500	
05-May-05	6,820	220	0	2.18	7,040	585	600	1,625	220	0	1,845	2,500	2,500	0	2,500	1,500	1,500	0	0	1,500	
06-May-05	6,815	220	0	2.62	7,035	580	600	1,625	220	0	1,845	2,500	2,500	0	2,500	1,500	1,500	0	0	1,500	
07-May-05	6,810	220	0	3.05	7,030	574	600	1,625	220	0	1,845	2,500	2,500	0	2,500	1,500	1,500	0	0	1,500	
08-May-05	6,805	220	0	3.49	7,025	569	600	1,625	220	0	1,845	2,500	2,500	0	2,500	1,500	1,500	0	0	1,500	
09-May-05	6,799	220	0	3.93	7,019	564	600	1,625	220	0	1,845	2,500	2,500	0	2,500	1,500	1,500	0	0	1,500	
10-May-05	6,794	220	0	4.36	7,014	559	600	1,625	220	0	1,845	2,500	2,500	0	2,500	1,500	1,500	0	0	1,500	
11-May-05	6,789	220	0	4.80	7,009	553	600	1,625	220	0	1,845	2,500	2,500	0	2,500	1,500	1,500	0	0	1,500	
12-May-05	6,784	220	0	5.24	7,004	548	600	1,625	220	0	1,845	2,500	2,500	0	2,500	1,500	1,500	0	0	1,500	
13-May-05	6,778	220	0	5.67	6,998	543	600	1,625	230	0	1,855	2,500	2,500	0	2,500	1,500	1,500	0	0	1,500	
14-May-05	6,773	220	0	6.11	6,993	538	600	1,625	230	0	1,855	2,500	2,500	0	2,500	1,500	1,500	0	0	1,500	
15-May-05	6,768	220	0	6.55	6,988	533	600	1,625	230	0	1,855	2,500	2,500	0	2,500	1,500	1,500	0	0	1,500	
16-May-05	6,763	230	0	7.00	6,993	528	600	1,625	230	0	1,855	2,500	2,500	0	2,500	1,500	1,500	0	0	1,500	
17-May-05	6,758	230	0	7.46	6,988	523	600	1,625	240	0	1,865	2,500	2,500	0	2,500	1,500	1,500	0	0	1,500	
18-May-05	6,753	230	0	7.91	6,983	518	600	1,625	260	0	1,885	2,500	2,500	0	2,500	1,500	1,500	0	0	1,500	
19-May-05	6,748	230	0	8.37	6,978	513	600	1,625	260	0	1,885	2,500	2,500	0	2,500	1,500	1,500	0	0	1,500	
20-May-05	6,743	240	0	8.85	6,983	508	600	1,625	260	0	1,885	2,500	2,500	0	2,500	1,500	1,500	0	0	1,500	
21-May-05	6,738	260	0	9.36	6,998	503	600	1,625	260	0	1,885	2,500	2,500	0	2,500	1,500	1,500	0	0	1,500	
22-May-05	6,733	260	0	9.88	6,993	498	600	1,625	260	0	1,885	2,500	2,500	0	2,500	1,500	1,500	0	0	1,500	
23-May-05	6,728	260	0	10.39	6,988	493	600	1,625	260	0	1,885	2,500	2,500	0	2,500	1,500	1,500	0	0	1,500	
24-May-05	6,723	260	0	10.91	6,983	488	600	1,625	260	0	1,885	2,500	2,500	0	2,500	1,500	1,500	0	0	1,500	
25-May-05	6,718	260	0	11.42	6,978	483	600	1,625	260	0	1,885	2,500	2,500	0	2,500	1,500	1,500	0	0	1,500	
26-May-05	6,713	260	0	11.94	6,973	478	600	1,625	260	0	1,885	2,500	2,500	0	2,500	1,500	1,500	0	0	1,500	
27-May-05	6,708	260	0	12.46	6,968	473	600	1,625	260	0	1,885	2,500	2,500	0	2,500	1,500	1,500	0	0	1,500	
28-May-05	6,703	260	0	12.97	6,963	468	600	1,625	260	0	1,885	2,500	2,500	0	2,500	1,500	1,500	0	0	1,500	
29-May-05	6,698	260	0	13.49	6,958	463	600	1,625			1,625	2,500	2,500	0	2,500	1,500	1,500	0	0	1,500	
30-May-05	6,693	260	0	14.00	6,953	458	600	1,625			1,625	2,500	2,500		2,500	352	352			352	
31-May-05	6,688	260	0	14.52	6,948	453	600	1,625			1,625	2,500	2,500		2,500	352	352			352	
									VAMP Period												
Avg. (cfs):	6,764	236			7,000	539	600	1,625	236	0	1,861	2,500	2,500	0	2,500	1,500	1,500	0	0	1,500	
Suppl. Water (TAF):		14.52							14.52	0.00				0.00				0.00			

VAMP flow operation period

Appendix A-1, Table 8

2005 VAMP DAILY OPERATION PLAN
April 13, 2005 • High
Target Flow Period: May 1 - May 31 • Flow Target: greater than 7,000 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	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (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)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		(cfs)	(cfs)	(cfs)	
15-Mar-05	6,260				**6,260**	**1,238**	**1,223**	**285**			**285**	**3,140**	**3,140**		**3,140**	**229**	**229**			**229**	
16-Mar-05	6,180				**6,180**	**1,194**	**1,241**	**275**			**275**	**3,140**	**3,140**		**3,140**	**229**	**229**			**229**	
17-Mar-05	6,040				**6,040**	**1,141**	**1,130**	**276**			**276**	**3,120**	**3,120**		**3,120**	**229**	**229**			**229**	
18-Mar-05	5,790				**5,820**	**1,123**	**942**	**274**			**274**	**3,150**	**3,150**		**3,150**	**229**	**229**			**229**	
19-Mar-05	5,800				**5,800**	**1,123**	**1,035**	**292**			**292**	**3,190**	**3,190**		**3,190**	**228**	**228**			**228**	
20-Mar-05	5,830				**5,830**	**1,111**	**1,052**	**322**			**322**	**3,170**	**3,170**		**3,170**	**226**	**226**			**226**	
21-Mar-05	5,850				**5,850**	**1,206**	**1,035**	**335**			**335**	**3,160**	**3,160**		**3,160**	**226**	**226**			**226**	
22-Mar-05	5,850				**5,880**	**1,495**	**1,051**	**356**			**356**	**3,120**	**3,120**		**3,120**	**245**	**245**			**245**	
23-Mar-05	6,570				**6,540**	**1,452**	**1,656**	**1,774**			**1,774**	**3,170**	**3,170**		**3,170**	**232**	**232**			**232**	
24-Mar-05	8,390				**8,230**	**1,729**	**3,195**	**1,769**			**1,769**	**4,230**	**4,230**		**4,230**	**301**	**301**			**301**	
25-Mar-05	9,460				**9,220**	**2,811**	**4,250**	**1,532**			**1,532**	**5,810**	**5,810**		**5,810**	**611**	**611**			**611**	
26-Mar-05	10,500				**10,200**	**3,185**	**2,466**	**2,147**			**2,147**	**6,230**	**6,230**		**6,230**	**607**	**607**			**607**	
27-Mar-05	12,100				**11,700**	**3,005**	**1,099**	**4,145**			**4,145**	**6,240**	**6,240**		**6,240**	**610**	**610**			**610**	
28-Mar-05	**13,300**				**12,700**	**2,261**	**1,746**	**5,695**			**5,695**	**6,120**	**6,120**		**6,120**	**604**	**604**			**604**	
29-Mar-05	**14,100**				**13,500**	**2,224**	**2,098**	**5,451**			**5,451**	**6,440**	**6,440**		**6,440**	**603**	**603**			**603**	
30-Mar-05	**14,600**				**14,000**	**2,393**	**1,470**	**5,232**			**5,232**	**6,660**	**6,660**		**6,660**	**400**	**400**			**400**	
31-Mar-05	**15,000**				**14,300**	**2,298**	**38**	**4,717**			**4,717**	**6,660**	**6,660**		**6,660**	**229**	**229**			**229**	
01-Apr-05	**15,100**				**14,400**	**2,086**	**196**	**4,604**			**4,604**	**7,230**	**7,230**		**7,230**	**229**	**229**			**229**	
02-Apr-05	**15,000**				**14,300**	**1,846**	**581**	**4,164**			**4,164**	**6,860**	**6,860**		**6,860**	**229**	**229**			**229**	
03-Apr-05	**15,000**				**14,400**	**1,616**	**738**	**4,076**			**4,076**	**7,070**	**7,070**		**7,070**	**229**	**229**			**229**	
04-Apr-05	**15,000**				**14,300**	**1,232**	**1,461**	**4,074**			**4,074**	**7,360**	**7,360**		**7,360**	**226**	**226**			**226**	
05-Apr-05	**14,700**				**14,100**	**1,009**	**1,621**	**3,690**			**3,690**	**7,200**	**7,200**		**7,200**	**229**	**229**			**229**	
06-Apr-05	**14,300**				**13,700**	**904**	**1,406**	**3,575**			**3,575**	**5,600**	**5,600**		**5,600**	**229**	**229**			**229**	
07-Apr-05	**13,400**				**12,800**	**719**	**888**	**3,404**			**3,404**	**5,110**	**5,110**		**5,110**	**226**	**226**			**226**	
08-Apr-05	**12,000**				**12,000**	**616**	**1,577**	**3,385**			**3,385**	**4,630**	**4,630**		**4,630**	**227**	**227**			**227**	
09-Apr-05	**11,400**				**11,400**	**582**	**1,770**	**3,349**			**3,349**	**4,090**	**4,090**		**4,090**	**225**	**225**			**225**	
10-Apr-05	**10,700**				**10,700**	**618**	**1,823**	**3,332**			**3,332**	**4,160**	**4,160**		**4,160**	**229**	**229**			**229**	
11-Apr-05	**10,300**				**10,300**	**615**	**2,018**	**3,286**			**3,286**	**4,910**	**4,910**		**4,910**	**232**	**232**			**232**	
12-Apr-05	**10,300**				**10,300**	**697**	**1,944**	**2,807**			**2,807**	**5,020**	**5,020**		**5,020**	**226**	**226**			**226**	
13-Apr-05	10,789				10,789	700	1,700	2,500			2,500	4,000	4,000		4,000	225	225			225	
14-Apr-05	10,429				10,429	695	1,200	2,500			2,500	4,000	4,000		4,000	225	225			225	
15-Apr-05	8,932				8,932	690	1,200	2,500			2,500	4,000	4,000		4,000	225	225			225	
16-Apr-05	8,620				8,620	684	1,200	2,500			2,500	3,600	3,600		3,600	225	225			225	
17-Apr-05	8,615				8,615	679	1,200	2,500			2,500	3,600	3,600		3,600	225	225			225	
18-Apr-05	8,209				8,209	674	1,200	2,500			2,500	3,600	3,600		3,600	225	225			225	
19-Apr-05	8,204				8,204	669	1,200	2,500			2,500	3,600	3,600		3,600	225	225			225	
20-Apr-05	8,199				8,199	663	1,200	2,500			2,500	3,600	3,600		3,600	225	225			225	
21-Apr-05	8,194				8,194	658	1,200	2,500			2,500	3,600	3,600		3,600	225	225			225	
22-Apr-05	8,188				8,188	653	1,200	2,500			2,500	3,600	3,600		3,600	225	225			225	
23-Apr-05	8,183				8,183	648	1,200	2,500			2,500	3,600	3,600		3,600	225	225			225	
24-Apr-05	8,178				8,178	642	1,200	2,500			2,500	3,600	3,600		3,600	225	225			225	
25-Apr-05	8,173				8,173	637	1,200	2,500			2,500	3,600	3,600		3,600	225	225			225	
26-Apr-05	8,167				8,167	632	1,200	2,500			2,500	3,600	3,600		3,600	225	225			225	
27-Apr-05	8,162				8,162	627	1,200	2,500			2,500	3,600	3,600		3,600	225	225			225	
28-Apr-05	8,157				8,157	622	1,200	1,800	0	0	1,800	3,600	3,600		3,600	225	225			225	
29-Apr-05	8,152				8,152	616	1,200	1,800	0	0	1,800	3,100	3,100	0	3,100	1,500	1,500	0	0	1,500	
30-Apr-05	8,147				8,147	611	1,200	1,800	0	0	1,800	3,100	3,100	0	3,100	1,500	1,500	0	0	1,500	
01-May-05	8,216	0	0	0.00	8,216	606	1,200	1,800	0	0	1,800	3,100	3,100	0	3,100	1,500	1,500	0	0	1,500	
02-May-05	8,211	0	0	0.00	8,211	601	1,200	1,800	0	0	1,800	3,100	3,100	0	3,100	1,500	1,500	0	0	1,500	
03-May-05	8,206	0	0	0.00	8,206	595	1,200	1,800	0	0	1,800	3,100	3,100	0	3,100	1,500	1,500	0	0	1,500	
04-May-05	8,201	0	0	0.00	8,201	590	1,200	1,800	0	0	1,800	3,100	3,100	0	3,100	1,500	1,500	0	0	1,500	
05-May-05	8,195	0	0	0.00	8,195	585	1,200	1,800	0	0	1,800	3,100	3,100	0	3,100	1,500	1,500	0	0	1,500	
06-May-05	8,190	0	0	0.00	8,190	580	1,200	1,800	0	0	1,800	3,100	3,100	0	3,100	1,500	1,500	0	0	1,500	
07-May-05	8,185	0	0	0.00	8,185	574	1,200	1,800	0	0	1,800	3,100	3,100	0	3,100	1,500	1,500	0	0	1,500	
08-May-05	8,180	0	0	0.00	8,180	569	1,200	1,800	0	0	1,800	3,100	3,100	0	3,100	1,500	1,500	0	0	1,500	
09-May-05	8,174	0	0	0.00	8,174	564	1,200	1,800	0	0	1,800	3,100	3,100	0	3,100	1,500	1,500	0	0	1,500	
10-May-05	8,169	0	0	0.00	8,169	559	1,200	1,800	0	0	1,800	3,100	3,100	0	3,100	1,500	1,500	0	0	1,500	
11-May-05	8,164	0	0	0.00	8,164	553	1,200	1,800	0	0	1,800	3,100	3,100	0	3,100	1,500	1,500	0	0	1,500	
12-May-05	8,159	0	0	0.00	8,159	548	1,200	1,800	0	0	1,800	3,100	3,100	0	3,100	1,500	1,500	0	0	1,500	
13-May-05	8,153	0	0	0.00	8,153	543	1,200	1,800	0	0	1,800	3,100	3,100	0	3,100	1,500	1,500	0	0	1,500	
14-May-05	8,148	0	0	0.00	8,148	538	1,200	1,800	0	0	1,800	3,100	3,100	0	3,100	1,500	1,500	0	0	1,500	
15-May-05	8,143	0	0	0.00	8,143	533	1,200	1,800	0	0	1,800	3,100	3,100	0	3,100	1,500	1,500	0	0	1,500	
16-May-05	8,138	0	0	0.00	8,138	528	1,200	1,800	0	0	1,800	3,100	3,100	0	3,100	1,500	1,500	0	0	1,500	
17-May-05	8,133	0	0	0.00	8,133	523	1,200	1,800	0	0	1,800	3,100	3,100	0	3,100	1,500	1,500	0	0	1,500	
18-May-05	8,128	0	0	0.00	8,128	518	1,200	1,800	0	0	1,800	3,100	3,100	0	3,100	1,500	1,500	0	0	1,500	
19-May-05	8,123	0	0	0.00	8,123	513	1,200	1,800	0	0	1,800	3,100	3,100	0	3,100	1,500	1,500	0	0	1,500	
20-May-05	8,118	0	0	0.00	8,118	508	1,200	1,800	0	0	1,800	3,100	3,100	0	3,100	1,500	1,500	0	0	1,500	
21-May-05	8,113	0	0	0.00	8,113	503	1,200	1,800	0	0	1,800	3,100	3,100	0	3,100	1,500	1,500	0	0	1,500	
22-May-05	8,108	0	0	0.00	8,108	498	1,200	1,800	0	0	1,800	3,100	3,100	0	3,100	1,500	1,500	0	0	1,500	
23-May-05	8,103	0	0	0.00	8,103	493	1,200	1,800	0	0	1,800	3,100	3,100	0	3,100	1,500	1,500	0	0	1,500	
24-May-05	8,098	0	0	0.00	8,098	488	1,200	1,800	0	0	1,800	3,100	3,100	0	3,100	1,500	1,500	0	0	1,500	
25-May-05	8,093	0	0	0.00	8,093	483	1,200	1,800	0	0	1,800	3,100	3,100	0	3,100	1,500	1,500	0	0	1,500	
26-May-05	8,088	0	0	0.00	8,088	478	1,200	1,800	0	0	1,800	3,100	3,100	0	3,100	1,500	1,500	0	0	1,500	
27-May-05	8,083	0	0	0.00	8,083	473	1,200	1,800	0	0	1,800	3,100	3,100	0	3,100	1,500	1,500	0	0	1,500	
28-May-05	8,078	0	0	0.00	8,078	468	1,200	1,800	0	0	1,800	3,100	3,100	0	3,100	1,500	1,500	0	0	1,500	
29-May-05	8,073	0	0	0.00	8,073	463	1,200	1,800			1,800	3,100	3,100	0	3,100	1,500	1,500	0	0	1,500	
30-May-05	8,068	0	0	0.00	8,068	458	1,200	1,800			1,800	3,100	3,100		3,100	352	352			352	
31-May-05	8,063	0	0	0.00	8,063	453	1,200	1,800			1,800	3,100	3,100		3,100	352	352			352	
VAMP Period																					
Avg. (cfs):	8,139	0			8,139	539	1,200	1,800	0	0	1,800	3,100	3,100	0	3,100	1,500	1,500	0	0	1,500	
Suppl. Water (TAF):		0.00							0.00	0.00				0.00				0.00			

VAMP flow operation period

Appendix A-1, Table 9

2005 VAMP DAILY OPERATION PLAN
April 21, 2005
Target Flow Period: May 1 - May 31 • Flow Target: greater than 7,000 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	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (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)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		(cfs)	(cfs)	(cfs)	
15-Mar-05	**6,260**				**6,260**	**1,238**	**1,223**	**285**			**285**	**3,140**	**3,140**		**3,140**	**229**	**229**			**229**	
16-Mar-05	**6,180**				**6,180**	**1,194**	**1,241**	**275**			**275**	**3,140**	**3,140**		**3,140**	**229**	**229**			**229**	
17-Mar-05	**6,040**				**6,040**	**1,141**	**1,130**	**276**			**276**	**3,120**	**3,120**		**3,120**	**229**	**229**			**229**	
18-Mar-05	**5,790**				**5,820**	**1,123**	**942**	**274**			**274**	**3,150**	**3,150**		**3,150**	**229**	**229**			**229**	
19-Mar-05	**5,800**				**5,800**	**1,123**	**1,035**	**292**			**292**	**3,190**	**3,190**		**3,190**	**228**	**228**			**228**	
20-Mar-05	**5,830**				**5,830**	**1,111**	**1,052**	**322**			**322**	**3,170**	**3,170**		**3,170**	**226**	**226**			**226**	
21-Mar-05	**5,850**				**5,850**	**1,206**	**1,035**	**335**			**335**	**3,160**	**3,160**		**3,160**	**226**	**226**			**226**	
22-Mar-05	**5,850**				**5,880**	**1,495**	**1,051**	**356**			**356**	**3,120**	**3,120**		**3,120**	**245**	**245**			**245**	
23-Mar-05	**6,570**				**6,540**	**1,452**	**1,656**	**1,774**			**1,774**	**3,170**	**3,170**		**3,170**	**232**	**232**			**232**	
24-Mar-05	**8,390**				**8,230**	**1,729**	**3,195**	**1,769**			**1,769**	**4,230**	**4,230**		**4,230**	**301**	**301**			**301**	
25-Mar-05	**9,460**				**9,220**	**2,811**	**4,250**	**1,532**			**1,532**	**5,810**	**5,810**		**5,810**	**611**	**611**			**611**	
26-Mar-05	**10,500**				**10,200**	**3,185**	**2,466**	**2,147**			**2,147**	**6,230**	**6,230**		**6,230**	**607**	**607**			**607**	
27-Mar-05	**12,100**				**11,700**	**3,005**	**1,099**	**4,145**			**4,145**	**6,240**	**6,240**		**6,240**	**610**	**610**			**610**	
28-Mar-05	**13,300**				**12,700**	**2,261**	**1,746**	**5,695**			**5,695**	**6,120**	**6,120**		**6,120**	**604**	**604**			**604**	
29-Mar-05	**14,100**				**13,500**	**2,224**	**2,098**	**5,451**			**5,451**	**6,440**	**6,440**		**6,440**	**603**	**603**			**603**	
30-Mar-05	**14,600**				**14,000**	**2,393**	**1,470**	**5,232**			**5,232**	**6,660**	**6,660**		**6,660**	**400**	**400**			**400**	
31-Mar-05	**15,000**				**14,300**	**2,298**	**38**	**4,717**			**4,717**	**6,660**	**6,660**		**6,660**	**229**	**229**			**229**	
01-Apr-05	**15,100**				**14,400**	**2,086**	**196**	**4,604**			**4,604**	**7,230**	**7,230**		**7,230**	**229**	**229**			**229**	
02-Apr-05	**15,000**				**14,300**	**1,846**	**581**	**4,164**			**4,164**	**6,860**	**6,860**		**6,860**	**229**	**229**			**229**	
03-Apr-05	**15,000**				**14,400**	**1,616**	**738**	**4,076**			**4,076**	**7,070**	**7,070**		**7,070**	**229**	**229**			**229**	
04-Apr-05	**15,000**				**14,300**	**1,232**	**1,461**	**4,074**			**4,074**	**7,360**	**7,360**		**7,360**	**226**	**226**			**226**	
05-Apr-05	**14,700**				**14,100**	**1,009**	**1,621**	**3,690**			**3,690**	**7,200**	**7,200**		**7,200**	**229**	**229**			**229**	
06-Apr-05	**14,300**				**13,700**	**904**	**1,406**	**3,575**			**3,575**	**5,600**	**5,600**		**5,600**	**229**	**229**			**229**	
07-Apr-05	**13,400**				**12,800**	**719**	**888**	**3,404**			**3,404**	**5,110**	**5,110**		**5,110**	**226**	**226**			**226**	
08-Apr-05	**12,000**				**12,000**	**616**	**1,577**	**3,385**			**3,385**	**4,630**	**4,630**		**4,630**	**227**	**227**			**227**	
09-Apr-05	**11,400**				**11,400**	**582**	**1,770**	**3,349**			**3,349**	**4,090**	**4,090**		**4,090**	**225**	**225**			**225**	
10-Apr-05	**10,700**				**10,700**	**618**	**1,823**	**3,332**			**3,332**	**4,160**	**4,160**		**4,160**	**229**	**229**			**229**	
11-Apr-05	**10,300**				**10,300**	**615**	**2,018**	**3,286**			**3,286**	**4,910**	**4,910**		**4,910**	**232**	**232**			**232**	
12-Apr-05	**10,300**				**10,300**	**697**	**1,944**	**2,807**			**2,807**	**5,020**	**5,020**		**5,020**	**226**	**226**			**226**	
13-Apr-05	**10,700**				**10,700**	**704**	**1,611**	**2,713**			**2,713**	**4,040**	**4,040**		**4,040**	**227**	**227**			**227**	
14-Apr-05	**9,840**				**9,840**	**595**	**611**	**2,742**			**2,742**	**4,100**	**4,100**		**4,100**	**228**	**228**			**228**	
15-Apr-05	**9,250**				**9,250**	**532**	**1,472**	**2,750**			**2,750**	**3,980**	**3,980**		**3,980**	**231**	**231**			**231**	
16-Apr-05	**9,010**				**9,010**	**458**	**1,374**	**2,702**			**2,702**	**4,070**	**4,070**		**4,070**	**229**	**229**			**229**	
17-Apr-05	**8,930**				**8,930**	**418**	**1,445**	**2,645**			**2,645**	**4,080**	**4,080**		**4,080**	**342**	**342**			**342**	
18-Apr-05	**8,740**				**8,740**	**400**	**1,233**	**2,577**			**2,577**	**4,100**	**4,100**		**4,100**	**406**	**406**			**406**	
19-Apr-05	**8,670**				**8,670**	**396**	**1,128**	**2,515**			**2,515**	**4,060**	**4,060**		**4,060**	**403**	**403**			**403**	
20-Apr-05	**8,580**				**8,580**	**375**	**1,029**	**2,460**			**2,460**	**4,030**	**4,030**		**4,030**	**400**	**400**			**400**	
21-Apr-05	8,436				8,436	390	1,000	2,500			2,500	3,600	3,600		3,600	400	400			400	
22-Apr-05	8,320				8,320	388	1,000	2,500			2,500	3,600	3,600		3,600	400	400			400	
23-Apr-05	7,850				7,850	385	1,000	2,500			2,500	3,600	3,600		3,600	400	400			400	
24-Apr-05	7,888				7,888	383	1,000	2,500			2,500	3,600	3,600		3,600	400	400			400	
25-Apr-05	7,885				7,885	381	1,000	2,500			2,500	3,600	3,600		3,600	400	400			400	
26-Apr-05	7,883				7,883	379	1,000	2,500			2,500	3,600	3,600		3,600	400	400			400	
27-Apr-05	7,881				7,881	376	1,000	2,500			2,500	3,600	3,600		3,600	400	400			400	
28-Apr-05	7,879				7,879	374	1,000	1,800	0	0	1,800	3,600	3,600		3,600	400	400			400	
29-Apr-05	7,876				7,876	372	1,000	1,800	0	0	1,800	3,300	3,300	0	3,300	1,500	1,500	0	0	1,500	
30-Apr-05	7,874				7,874	370	1,000	1,800	0	0	1,800	3,300	3,300	0	3,300	1,500	1,500	0	0	1,500	
01-May-05	7,972	0	0	0.00	7,972	367	1,000	1,800	0	0	1,800	3,300	3,300	0	3,300	1,500	1,500	0	0	1,500	
02-May-05	7,970	0	0	0.00	7,970	365	1,000	1,800	0	0	1,800	3,300	3,300	0	3,300	1,500	1,500	0	0	1,500	
03-May-05	7,967	0	0	0.00	7,967	363	1,000	1,800	0	0	1,800	3,300	3,300	0	3,300	1,500	1,500	0	0	1,500	
04-May-05	7,965	0	0	0.00	7,965	361	1,000	1,800	0	0	1,800	3,300	3,300	0	3,300	1,500	1,500	0	0	1,500	
05-May-05	7,963	0	0	0.00	7,963	358	1,000	1,800	0	0	1,800	3,300	3,300	0	3,300	1,500	1,500	0	0	1,500	
06-May-05	7,961	0	0	0.00	7,961	356	1,000	1,800	0	0	1,800	3,300	3,300	0	3,300	1,500	1,500	0	0	1,500	
07-May-05	7,958	0	0	0.00	7,958	354	1,000	1,800	0	0	1,800	3,300	3,300	0	3,300	1,500	1,500	0	0	1,500	
08-May-05	7,956	0	0	0.00	7,956	352	1,000	1,800	0	0	1,800	3,300	3,300	0	3,300	1,500	1,500	0	0	1,500	
09-May-05	7,954	0	0	0.00	7,954	349	1,000	1,800	0	0	1,800	3,300	3,300	0	3,300	1,500	1,500	0	0	1,500	
10-May-05	7,952	0	0	0.00	7,952	347	1,000	1,800	0	0	1,800	3,300	3,300	0	3,300	1,500	1,500	0	0	1,500	
11-May-05	7,949	0	0	0.00	7,949	345	1,000	1,800	0	0	1,800	3,300	3,300	0	3,300	1,500	1,500	0	0	1,500	
12-May-05	7,947	0	0	0.00	7,947	343	1,000	1,800	0	0	1,800	3,300	3,300	0	3,300	1,500	1,500	0	0	1,500	
13-May-05	7,945	0	0	0.00	7,945	340	1,000	1,800	0	0	1,800	3,300	3,300	0	3,300	1,500	1,500	0	0	1,500	
14-May-05	7,943	0	0	0.00	7,943	338	1,000	1,800	0	0	1,800	3,300	3,300	0	3,300	1,500	1,500	0	0	1,500	
15-May-05	7,940	0	0	0.00	7,940	336	1,000	1,800	0	0	1,800	3,300	3,300	0	3,300	1,500	1,500	0	0	1,500	
16-May-05	7,938	0	0	0.00	7,938	334	1,000	1,800	0	0	1,800	3,300	3,300	0	3,300	1,500	1,500	0	0	1,500	
17-May-05	7,936	0	0	0.00	7,936	331	1,000	1,800	0	0	1,800	3,300	3,300	0	3,300	1,500	1,500	0	0	1,500	
18-May-05	7,934	0	0	0.00	7,934	329	1,000	1,800	0	0	1,800	3,300	3,300	0	3,300	1,500	1,500	0	0	1,500	
19-May-05	7,931	0	0	0.00	7,931	327	1,000	1,800	0	0	1,800	3,300	3,300	0	3,300	1,500	1,500	0	0	1,500	
20-May-05	7,929	0	0	0.00	7,929	325	1,000	1,800	0	0	1,800	3,300	3,300	0	3,300	1,500	1,500	0	0	1,500	
21-May-05	7,927	0	0	0.00	7,927	322	1,000	1,800	0	0	1,800	3,300	3,300	0	3,300	1,500	1,500	0	0	1,500	
22-May-05	7,925	0	0	0.00	7,925	320	1,000	1,800	0	0	1,800	3,300	3,300	0	3,300	1,500	1,500	0	0	1,500	
23-May-05	7,922	0	0	0.00	7,922	318	1,000	1,800	0	0	1,800	3,300	3,300	0	3,300	1,500	1,500	0	0	1,500	
24-May-05	7,920	0	0	0.00	7,920	316	1,000	1,800	0	0	1,800	3,300	3,300	0	3,300	1,500	1,500	0	0	1,500	
25-May-05	7,918	0	0	0.00	7,918	313	1,000	1,800	0	0	1,800	3,300	3,300	0	3,300	1,500	1,500	0	0	1,500	
26-May-05	7,916	0	0	0.00	7,916	311	1,000	1,800	0	0	1,800	3,300	3,300	0	3,300	1,500	1,500	0	0	1,500	
27-May-05	7,913	0	0	0.00	7,913	309	1,000	1,800	0	0	1,800	3,300	3,300	0	3,300	1,500	1,500	0	0	1,500	
28-May-05	7,911	0	0	0.00	7,911	307	1,000	1,800	0	0	1,800	3,300	3,300	0	3,300	1,500	1,500	0	0	1,500	
29-May-05	7,909	0	0	0.00	7,909	304	1,000	1,800			1,800	3,300	3,300	0	3,300	1,500	1,500	0	0	1,500	
30-May-05	7,907	0	0	0.00	7,907	302	1,000	1,800			1,800	3,300	3,300		3,300	352	352			352	
31-May-05	7,904	0	0	0.00	7,904	300	1,000	1,800			1,800	3,300	3,300		3,300	352	352			352	
VAMP Period																					
Avg. (cfs):	7,938	0			7,938	338	1,000	1,800	0	0	1,800	3,300	3,300	0	3,300	1,500	1,500	0	0	1,500	
Suppl. Water (TAF):			0.00							0.00	0.00				0.00				0.00		

VAMP flow operation period

Appendix A-1, Table 10

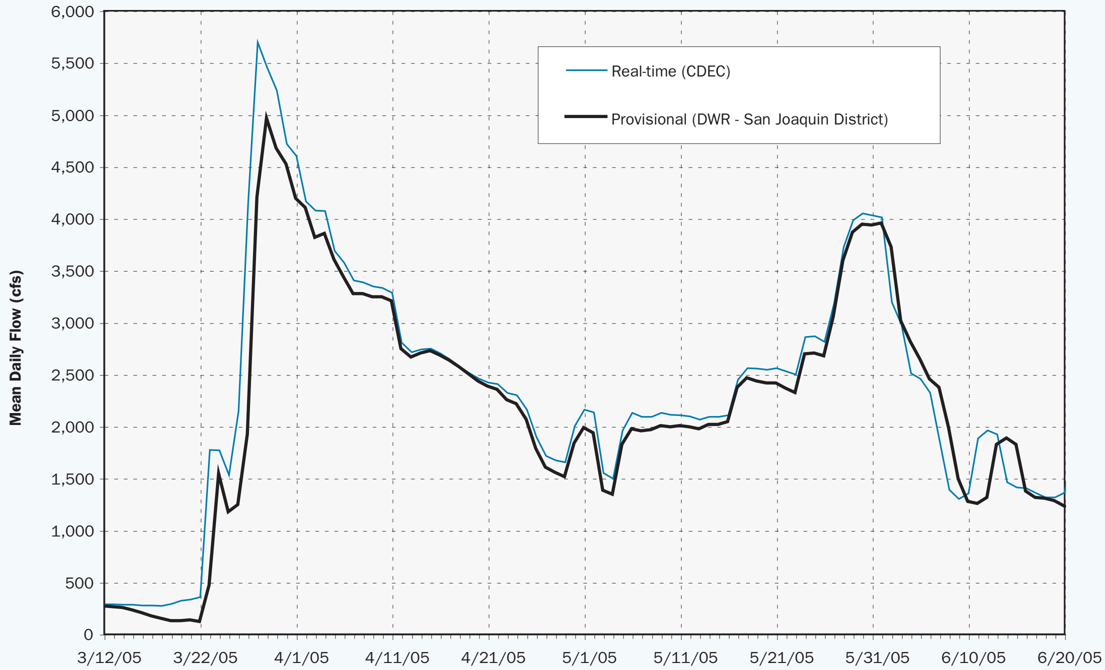
2005 VAMP DAILY OPERATION PLAN
April 28, 2005
Target Flow Period: May 1 - May 31 • Flow Target: greater than 7,000 cfs

Bold Numbers: observed real-time mean daily flows

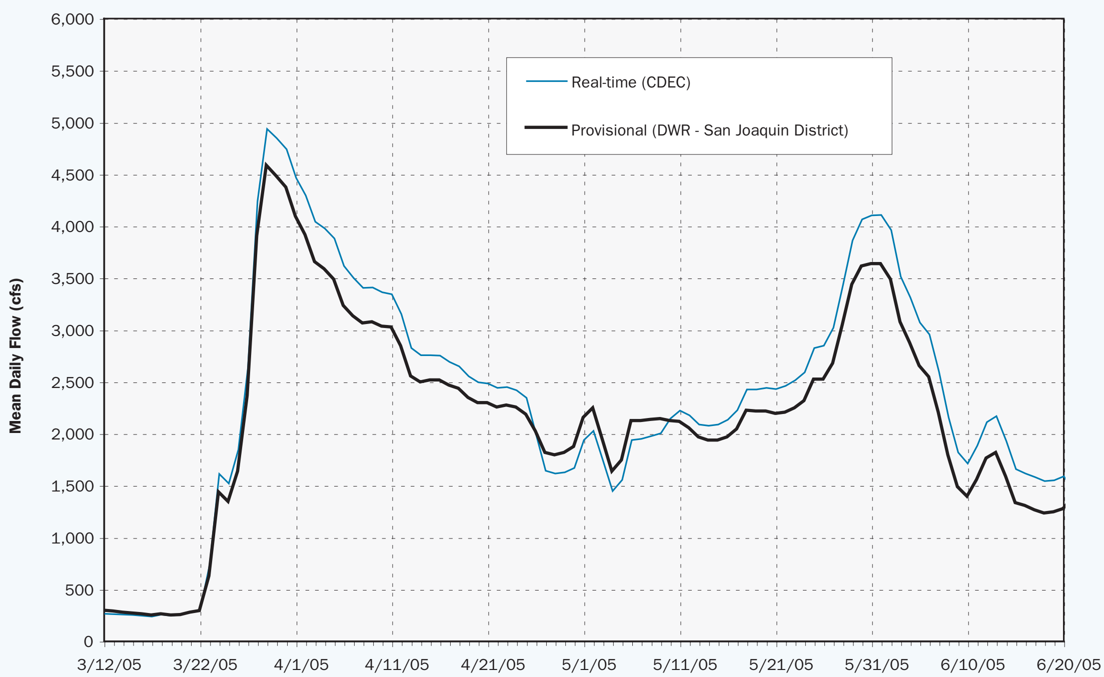
	San Joaquin River near Vernalis							Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus R blw Goodwin					
Date	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2 day lag)	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. 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)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		(cfs)	(cfs)	(cfs)	
15-Mar-05	6,260				6,260	1,238	1,223	285			285	3,140	3,140		3,140	229	229			229	
16-Mar-05	6,180				6,180	1,194	1,241	275			275	3,140	3,140		3,140	229	229			229	
17-Mar-05	6,040				6,040	1,141	1,140	276			276	3,120	3,120		3,120	229	229			229	
18-Mar-05	5,790				5,820	1,123	942	274			274	3,150	3,150		3,150	229	229			229	
19-Mar-05	5,800				5,800	1,123	1,035	292			292	3,190	3,190		3,190	228	228			228	
20-Mar-05	5,830				5,830	1,111	1,052	322			322	3,170	3,170		3,170	226	226			226	
21-Mar-05	5,850				5,850	1,206	1,035	335			335	3,160	3,160		3,160	226	226			226	
22-Mar-05	5,860				5,880	1,495	1,061	356			356	3,120	3,120		3,120	245	245			245	
23-Mar-05	6,570				6,540	1,452	1,656	1,774			1,774	3,170	3,170		3,170	232	232			232	
24-Mar-05	8,390				8,230	1,729	3,195	1,769			1,769	4,230	4,230		4,230	301	301			301	
25-Mar-05	9,470				9,220	2,811	4,260	1,532			1,532	5,810	5,810		5,810	611	611			611	
26-Mar-05	10,500				10,200	3,185	2,466	2,147			2,147	6,230	6,230		6,230	607	607			607	
27-Mar-05	12,100				11,700	3,005	1,099	4,145			4,145	6,240	6,240		6,240	610	610			610	
28-Mar-05	13,300				12,700	2,261	1,746	5,695			5,695	6,120	6,120		6,120	604	604			604	
29-Mar-05	14,100				13,500	2,224	2,098	5,451			5,451	6,440	6,440		6,440	603	603			603	
30-Mar-05	14,600				14,000	2,393	1,470	5,232			5,232	6,660	6,660		6,660	400	400			400	
31-Mar-05	15,000				14,300	2,298	38	4,717			4,717	6,660	6,660		6,660	229	229			229	
01-Apr-05	15,100				14,400	2,086	196	4,604			4,604	7,230	7,230		7,230	229	229			229	
02-Apr-05	15,000				14,300	1,846	581	4,164			4,164	6,860	6,860		6,860	229	229			229	
03-Apr-05	15,000				14,400	1,616	738	4,076			4,076	7,070	7,070		7,070	229	229			229	
04-Apr-05	15,000				14,300	1,232	1,461	4,074			4,074	7,360	7,360		7,360	226	226			226	
05-Apr-05	14,700				14,100	1,009	1,621	3,690			3,690	7,200	7,200		7,200	229	229			229	
06-Apr-05	14,400				13,700	904	1,506	3,575			3,575	5,600	5,600		5,600	229	229			229	
07-Apr-05	13,400				12,800	719	888	3,404			3,404	5,110	5,110		5,110	226	226			226	
08-Apr-05	12,000				12,000	616	1,577	3,385			3,385	4,630	4,630		4,630	227	227			227	
09-Apr-05	11,500				11,500	582	1,870	3,349			3,349	4,090	4,090		4,090	225	225			225	
10-Apr-05	10,700				10,700	618	1,823	3,332			3,332	4,160	4,160		4,160	229	229			229	
11-Apr-05	10,400				10,400	615	2,118	3,286			3,286	4,910	4,910		4,910	232	232			232	
12-Apr-05	10,300				10,300	697	1,944	2,807			2,807	5,020	5,020		5,020	226	226			226	
13-Apr-05	10,800				10,800	704	1,711	2,713			2,713	4,040	4,040		4,040	227	227			227	
14-Apr-05	9,900				9,900	595	671	2,742			2,742	4,100	4,100		4,100	228	228			228	
15-Apr-05	9,320				9,320	532	1,542	2,750			2,750	3,980	3,980		3,980	231	231			231	
16-Apr-05	9,080				9,080	458	1,444	2,702			2,702	4,070	4,070		4,070	229	229			229	
17-Apr-05	9,010				9,010	418	1,525	2,645			2,645	4,080	4,080		4,080	342	342			342	
18-Apr-05	8,810				8,810	400	1,303	2,577			2,577	4,100	4,100		4,100	406	406			406	
19-Apr-05	8,750				8,750	396	1,208	2,515			2,515	4,060	4,060		4,060	403	403			403	
20-Apr-05	8,660				8,660	375	1,109	2,460			2,460	4,030	4,030		4,030	400	400			400	
21-Apr-05	8,380				8,380	367	944	2,423			2,423	4,010	4,010		4,010	404	404			404	
22-Apr-05	8,010				8,010	340	690	2,406			2,406	3,860	3,860		3,860	401	401			401	
23-Apr-05	7,730				7,730	292	489	2,321			2,321	3,530	3,530		3,530	402	402			402	
24-Apr-05	7,490				7,490	310	466	2,301			2,301	3,280	3,280		3,280	409	409			409	
25-Apr-05	7,190				7,190	373	560	2,161			2,161	3,010	3,010		3,010	414	414			414	
26-Apr-05	6,750				6,750	626	430	1,800			1,800	3,210	3,210		3,210	401	401			401	
27-Apr-05	6,490				6,490	788	392	1,600			1,600	3,700	3,700		3,700	405	405			405	
28-Apr-05	6,798				6,798	782	400	1,600	0	0	1,600	3,750	3,750		3,750	400	400			400	
29-Apr-05	7,093				7,093	777	400	1,600	0	0	1,600	3,750	3,750	0	3,750	1,500	1,500	0	0	1,500	
30-Apr-05	6,932				6,932	771	400	1,600	0	0	1,600	3,750	3,750	0	3,750	1,500	1,500	0	0	1,500	
01-May-05	8,027	0	0	0.00	8,027	766	400	1,600	0	0	1,600	3,750	3,750	0	3,750	1,500	1,500	0	0	1,500	
02-May-05	8,021	0	0	0.00	8,021	760	400	1,600	0	0	1,600	3,750	3,750	0	3,750	1,500	1,500	0	0	1,500	
03-May-05	8,016	0	0	0.00	8,016	754	400	1,600	0	0	1,600	3,750	3,750	0	3,750	1,500	1,500	0	0	1,500	
04-May-05	8,010	0	0	0.00	8,010	749	400	1,600	0	0	1,600	3,750	3,750	0	3,750	1,500	1,500	0	0	1,500	
05-May-05	8,004	0	0	0.00	8,004	743	400	1,600	0	0	1,600	3,750	3,750	0	3,750	1,500	1,500	0	0	1,500	
06-May-05	7,999	0	0	0.00	7,999	738	400	1,600	0	0	1,600	3,750	3,750	0	3,750	1,500	1,500	0	0	1,500	
07-May-05	7,993	0	0	0.00	7,993	732	400	1,600	0	0	1,600	3,750	3,750	0	3,750	1,500	1,500	0	0	1,500	
08-May-05	7,988	0	0	0.00	7,988	726	400	1,600	0	0	1,600	3,750	3,750	0	3,750	1,500	1,500	0	0	1,500	
09-May-05	7,982	0	0	0.00	7,982	721	400	1,600	0	0	1,600	3,750	3,750	0	3,750	1,500	1,500	0	0	1,500	
10-May-05	7,976	0	0	0.00	7,976	715	400	1,600	0	0	1,600	3,750	3,750	0	3,750	1,500	1,500	0	0	1,500	
11-May-05	7,971	0	0	0.00	7,971	710	400	1,600	0	0	1,600	3,750	3,750	0	3,750	1,500	1,500	0	0	1,500	
12-May-05	7,965	0	0	0.00	7,965	704	400	1,600	0	0	1,600	3,750	3,750	0	3,750	1,500	1,500	0	0	1,500	
13-May-05	7,960	0	0	0.00	7,960	698	400	1,600	0	0	1,600	3,750	3,750	0	3,750	1,500	1,500	0	0	1,500	
14-May-05	7,954	0	0	0.00	7,954	693	400	1,600	0	0	1,600	3,750	3,750	0	3,750	1,500	1,500	0	0	1,500	
15-May-05	7,948	0	0	0.00	7,948	687	400	1,600	0	0	1,600	3,750	3,750	0	3,750	1,500	1,500	0	0	1,500	
16-May-05	7,943	0	0	0.00	7,943	682	400	1,600	0	0	1,600	3,750	3,750	0	3,750	1,500	1,500	0	0	1,500	
17-May-05	7,937	0	0	0.00	7,937	676	400	1,600	0	0	1,600	3,750	3,750	0	3,750	1,500	1,500	0	0	1,500	
18-May-05	7,932	0	0	0.00	7,932	670	400	1,600	0	0	1,600	3,750	3,750	0	3,750	1,500	1,500	0	0	1,500	
19-May-05	7,926	0	0	0.00	7,926	665	400	1,600	0	0	1,600	3,750	3,750	0	3,750	1,500	1,500	0	0	1,500	
20-May-05	7,920	0	0	0.00	7,920	659	400	1,600	0	0	1,600	3,750	3,750	0	3,750	1,500	1,500	0	0	1,500	
21-May-05	7,915	0	0	0.00	7,915	654	400	1,600	0	0	1,600	3,750	3,750	0	3,750	1,500	1,500	0	0	1,500	
22-May-05	7,909	0	0	0.00	7,909	648	400	1,600	0	0	1,600	3,750	3,750	0	3,750	1,500	1,500	0	0	1,500	
23-May-05	7,904	0	0	0.00	7,904	642	400	1,600	0	0	1,600	3,750	3,750	0	3,750	1,500	1,500	0	0	1,500	
24-May-05	7,898	0	0	0.00	7,898	637	400	1,600	0	0	1,600	3,750	3,750	0	3,750	1,500	1,500	0	0	1,500	
25-May-05	7,892	0	0	0.00	7,892	631	400	1,600	0	0	1,600	3,750	3,750	0	3,750	1,500	1,500	0	0	1,500	
26-May-05	7,887	0	0	0.00	7,887	626	400	1,600	0	0	1,600	3,750	3,750	0	3,750	1,500	1,500	0	0	1,500	
27-May-05	7,881	0	0	0.00	7,881	620	400	1,600	0	0	1,600	3,750	3,750	0	3,750	1,500	1,500	0	0	1,500	
28-May-05	7,876	0	0	0.00	7,876	614	400	1,600	0	0	1,600	3,750	3,750	0	3,750	1,500	1,500	0	0	1,500	
29-May-05	7,870	0	0	0.00	7,870	608	400	1,600			1,600	3,750	3,750	0	3,750	1,500	1,500	0	0	1,500	
30-May-05	7,864	0	0	0.00	7,864	602	400	1,600			1,600	3,750	3,750		3,750	352	352			352	
31-May-05	7,858	0	0	0.00	7,858	596	400	1,600			1,600	3,750	3,750		3,750	352	352			352	
										VAMP Period											
Avg. (cfs):	7,943	0			7,943	693	400	1,600	0	0	1,600	3,750	3,750	0	3,750	1,500	1,500	0	0	1,500	
Suppl. Water (TAF):		0.00							0.00	0.00				0.00				0.00			

VAMP flow operation period

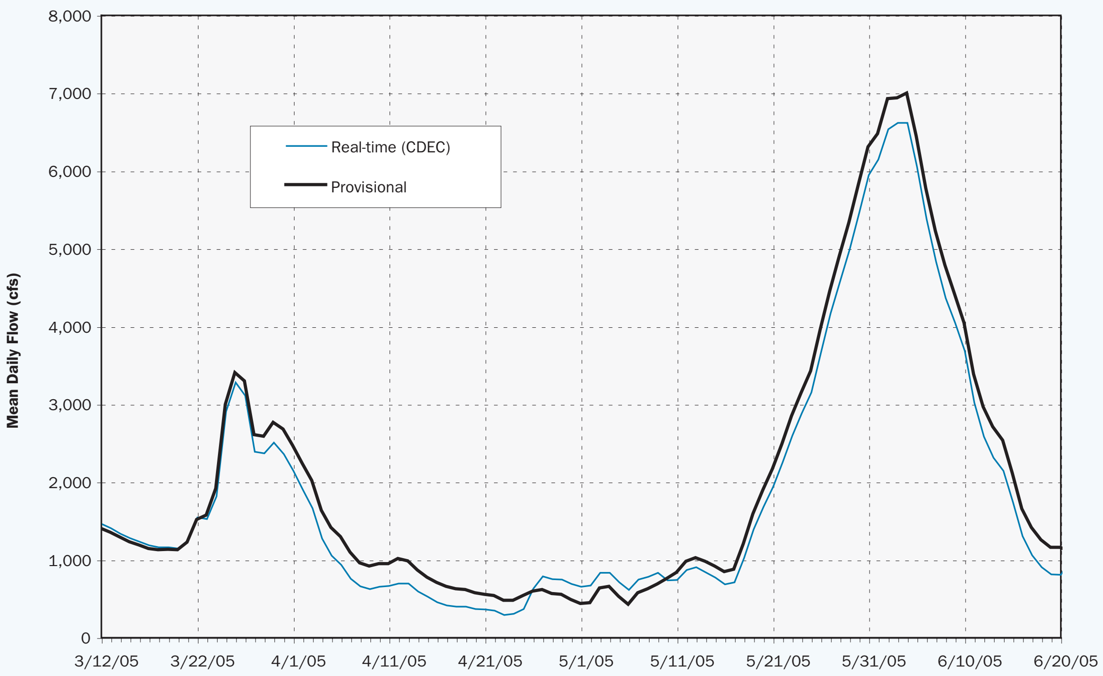
Appendix A-2, Figure 1
Merced River at Cressey



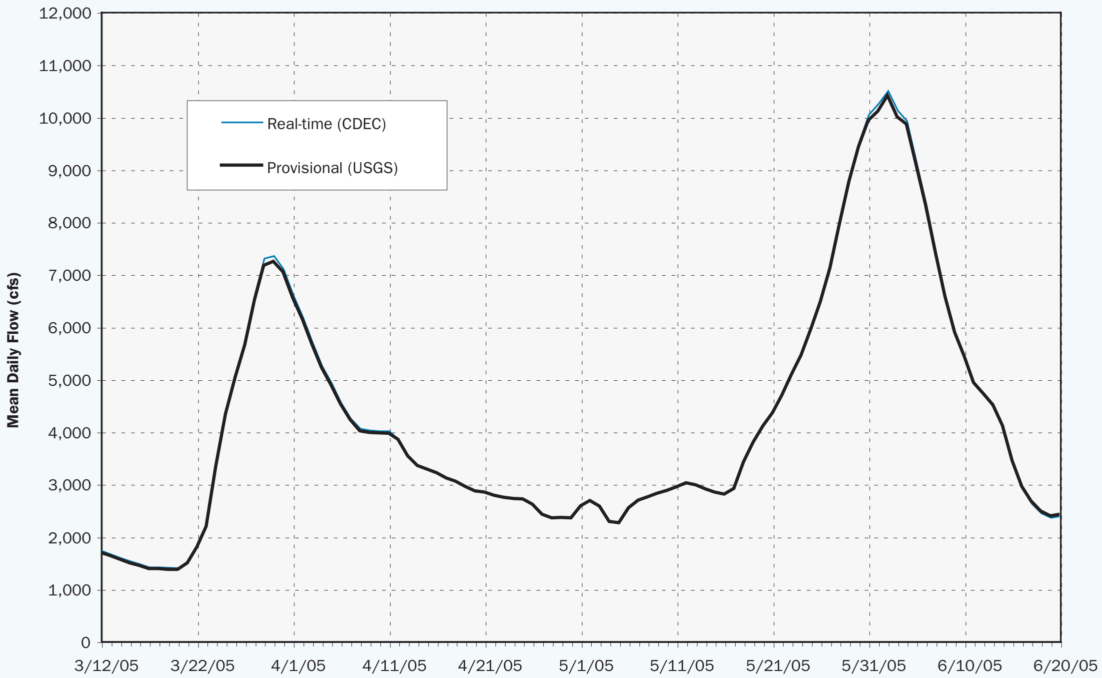
Appendix A-2, Figure 2
Merced River near Stevinson



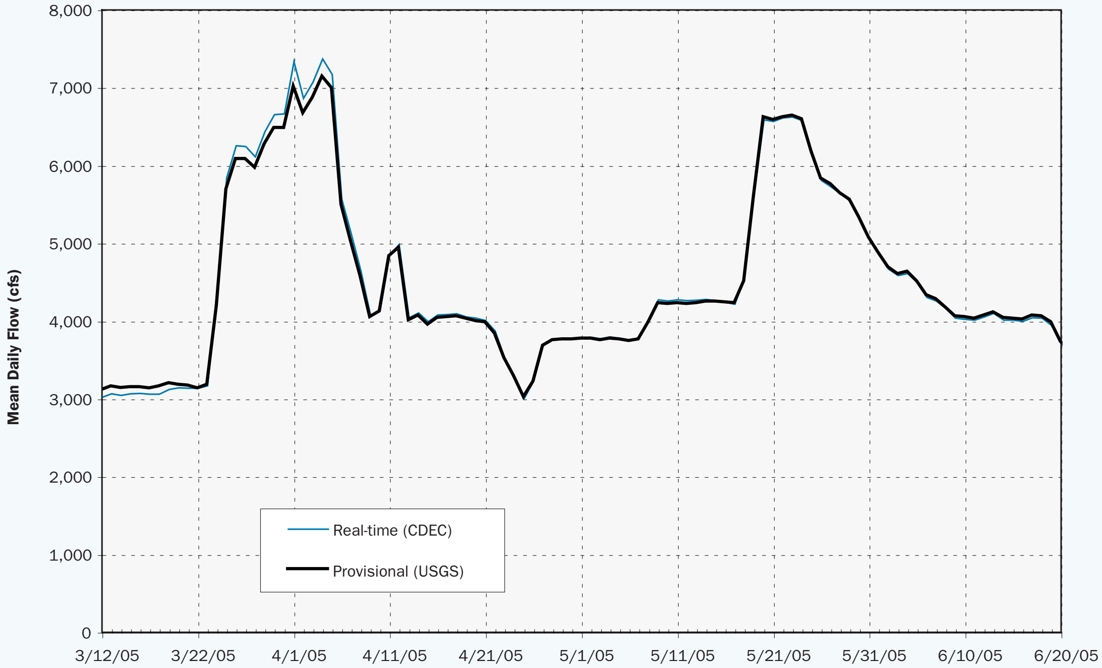
Appendix A-2, Figure 3
San Joaquin River above Merced River



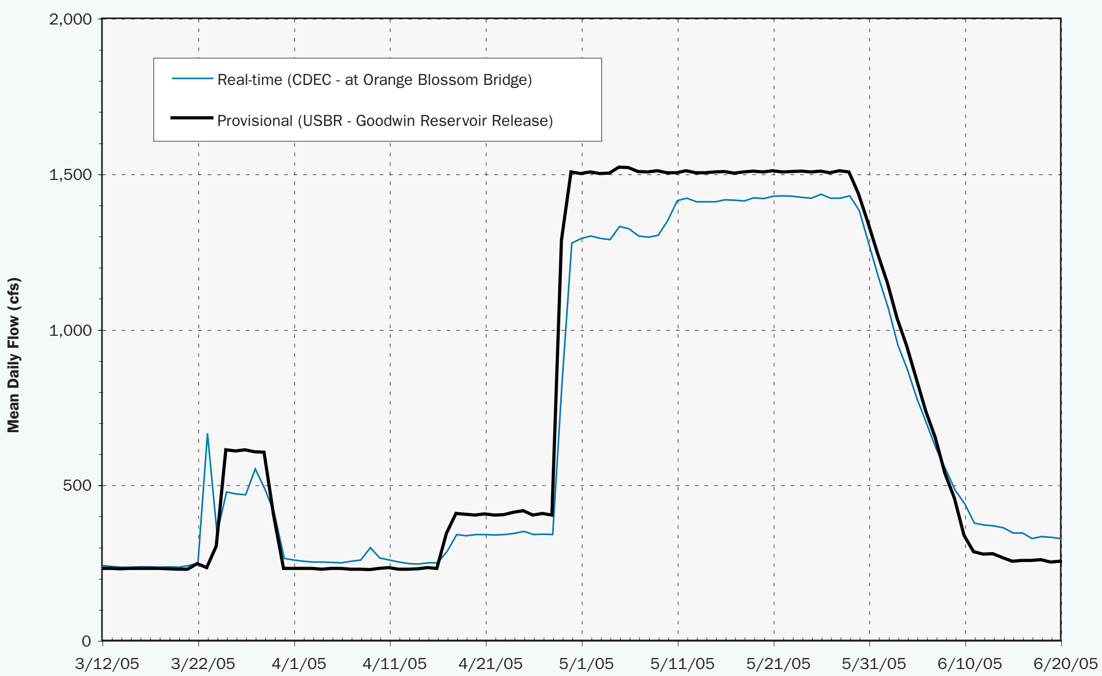
Appendix A-2, Figure 4
San Joaquin River near Newman



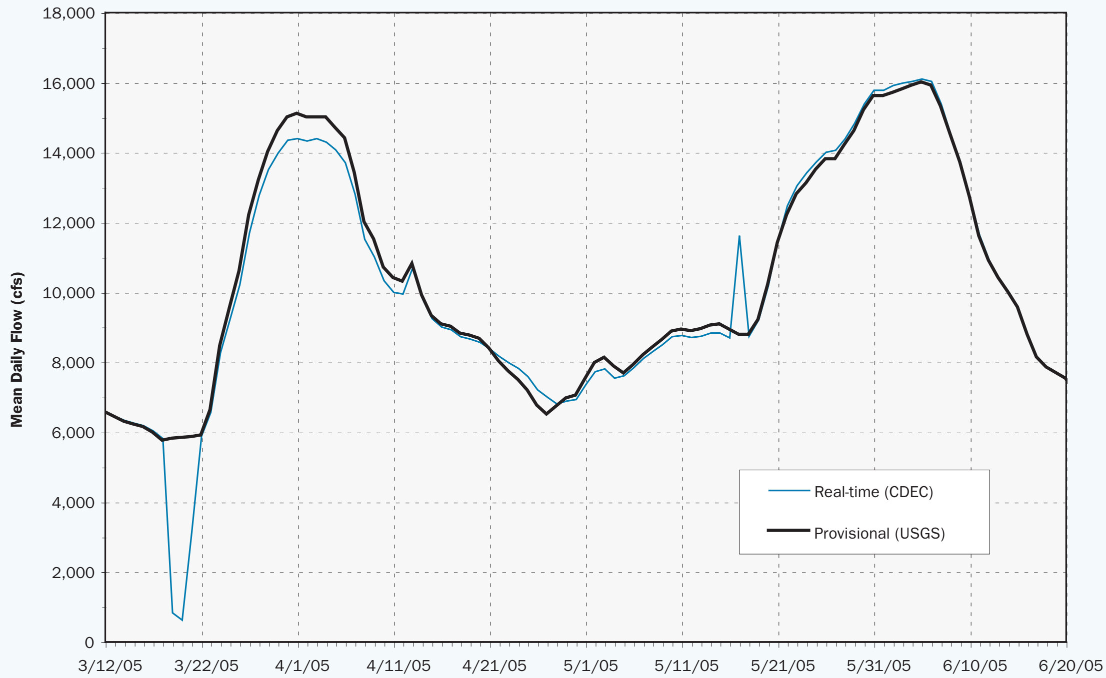
Appendix A-2, Figure 5
Tuolumne River below LaGrange Dam



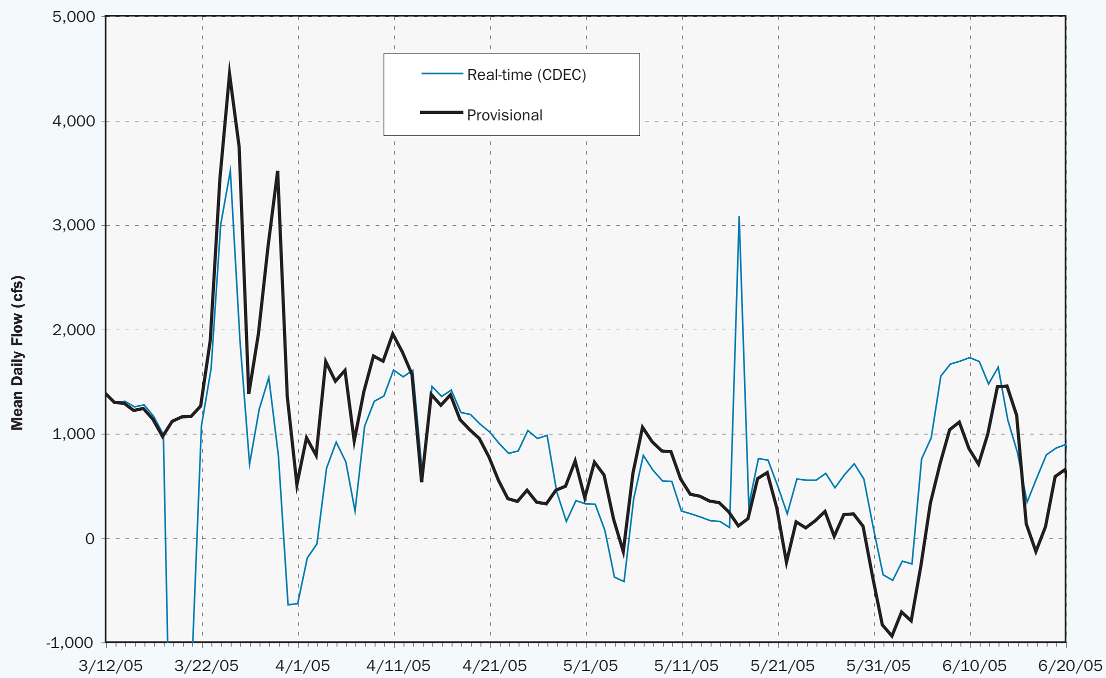
Appendix A-2, Figure 6
Stanislaus River below Goodwin Dam



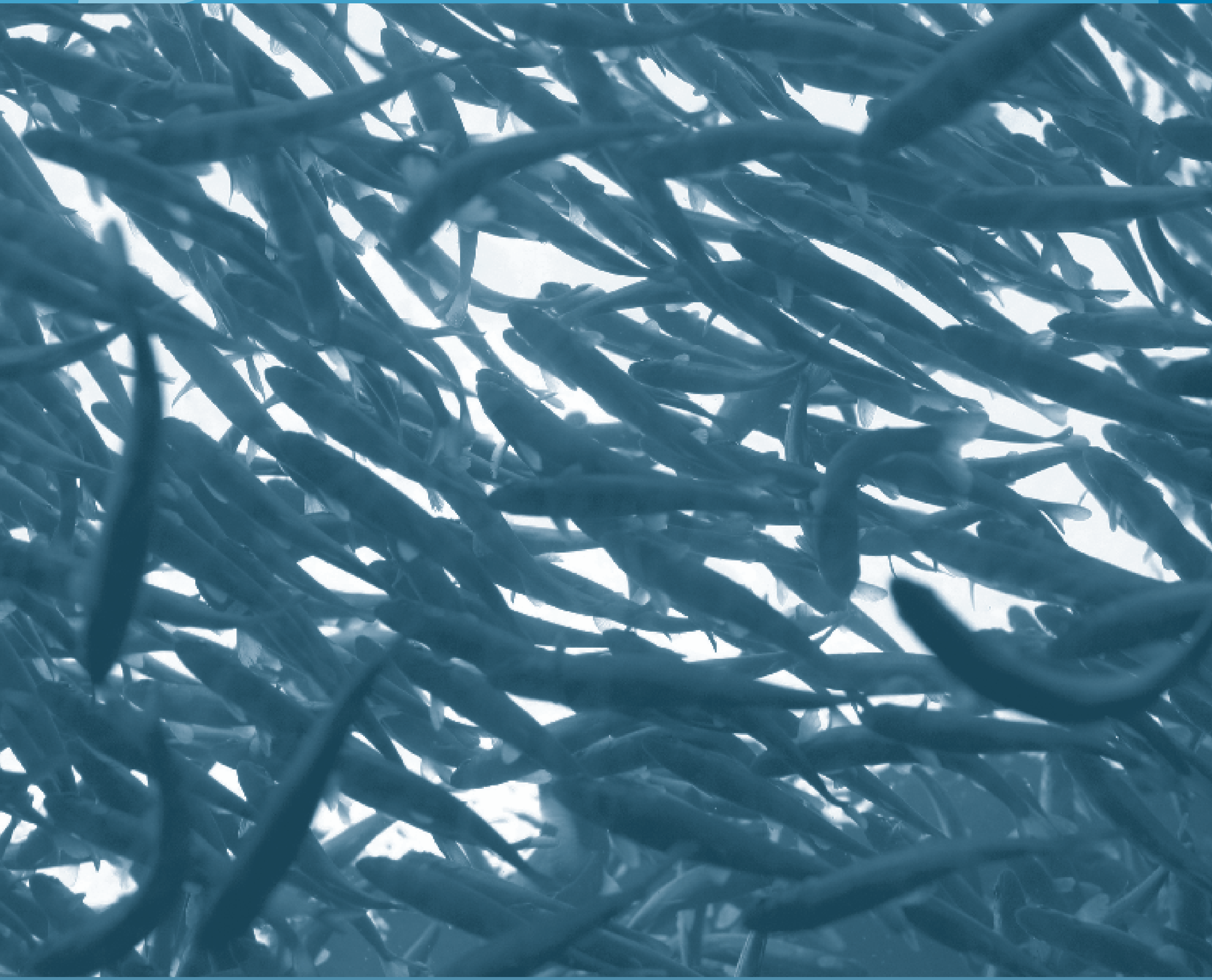
Appendix A-2, Figure 7
San Joaquin River near Vernalis



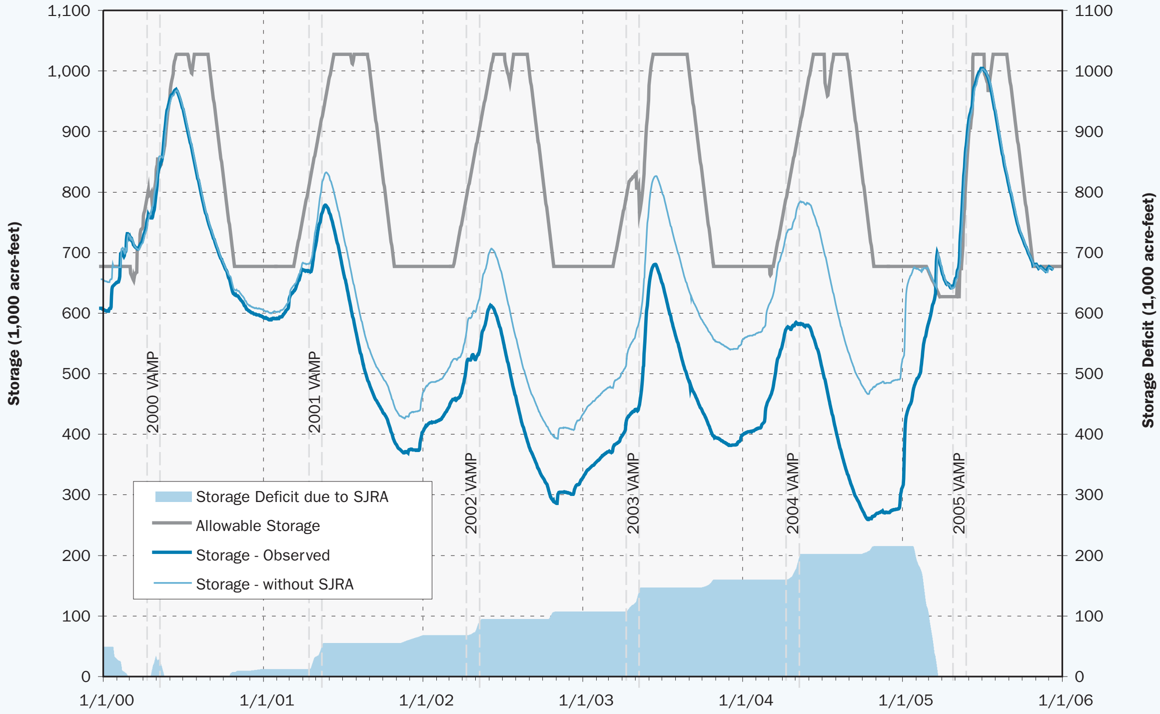
Appendix A-2, Figure 8
Ungaged Flow in San Joaquin River near Vernalis



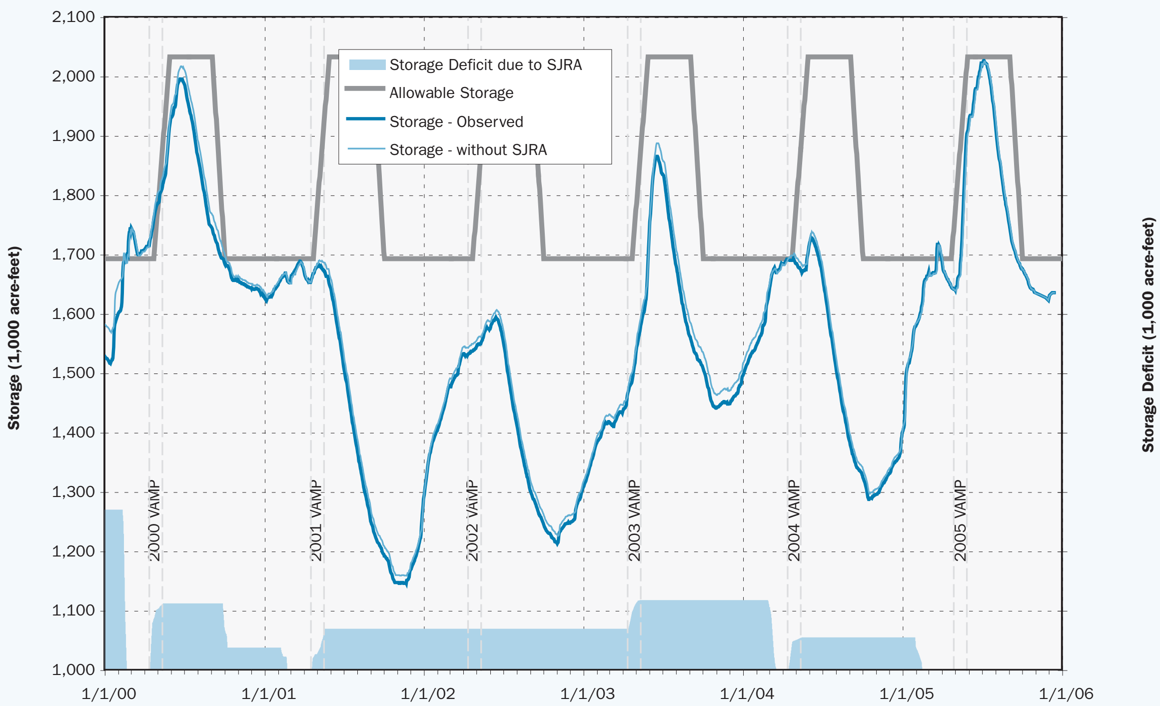
Appendix B
Historic Data



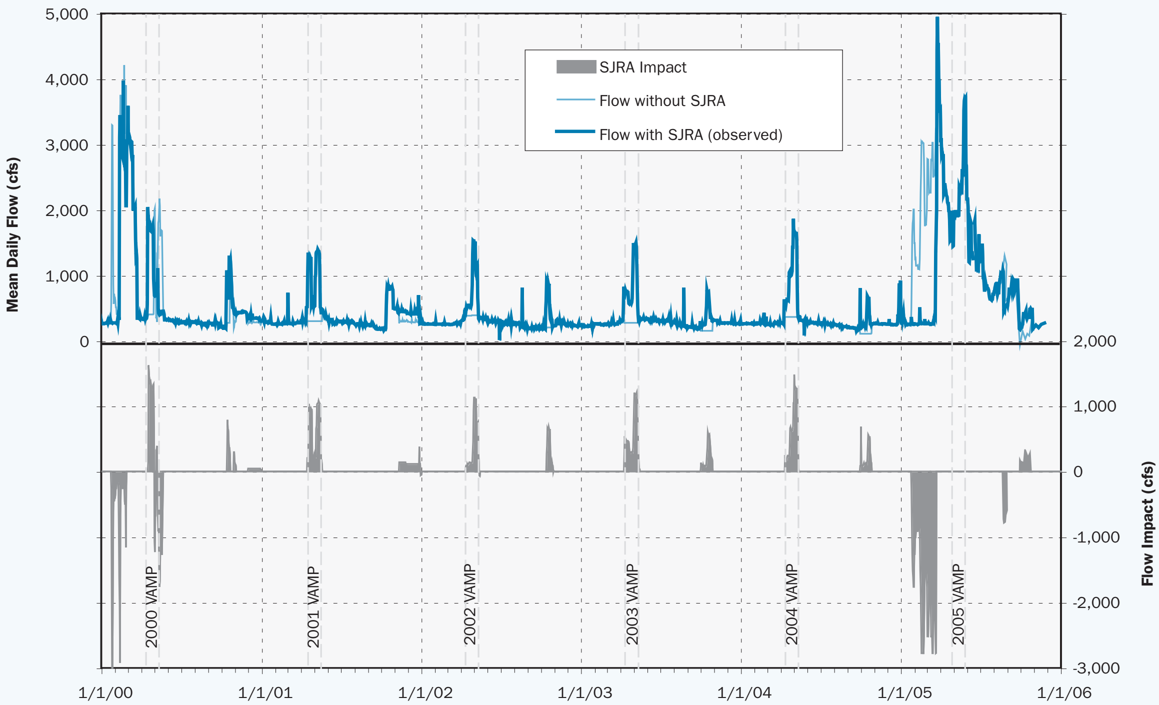
Appendix B-1, Figure 1
SJRA Storage Impacts, 2000-2005
Lake McClure (Merced River)



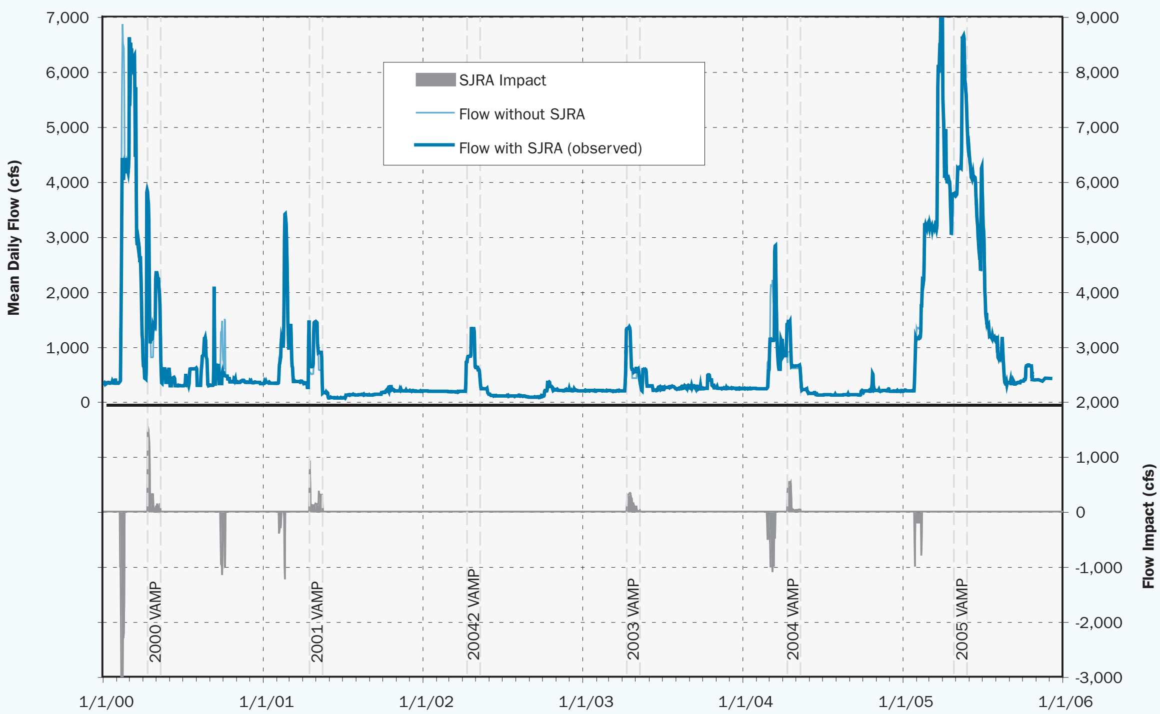
Appendix B-1, Figure 2
SJRA Storage Impacts, 2000-2005
New Don Pedro Reservoir (Tuolumne River)



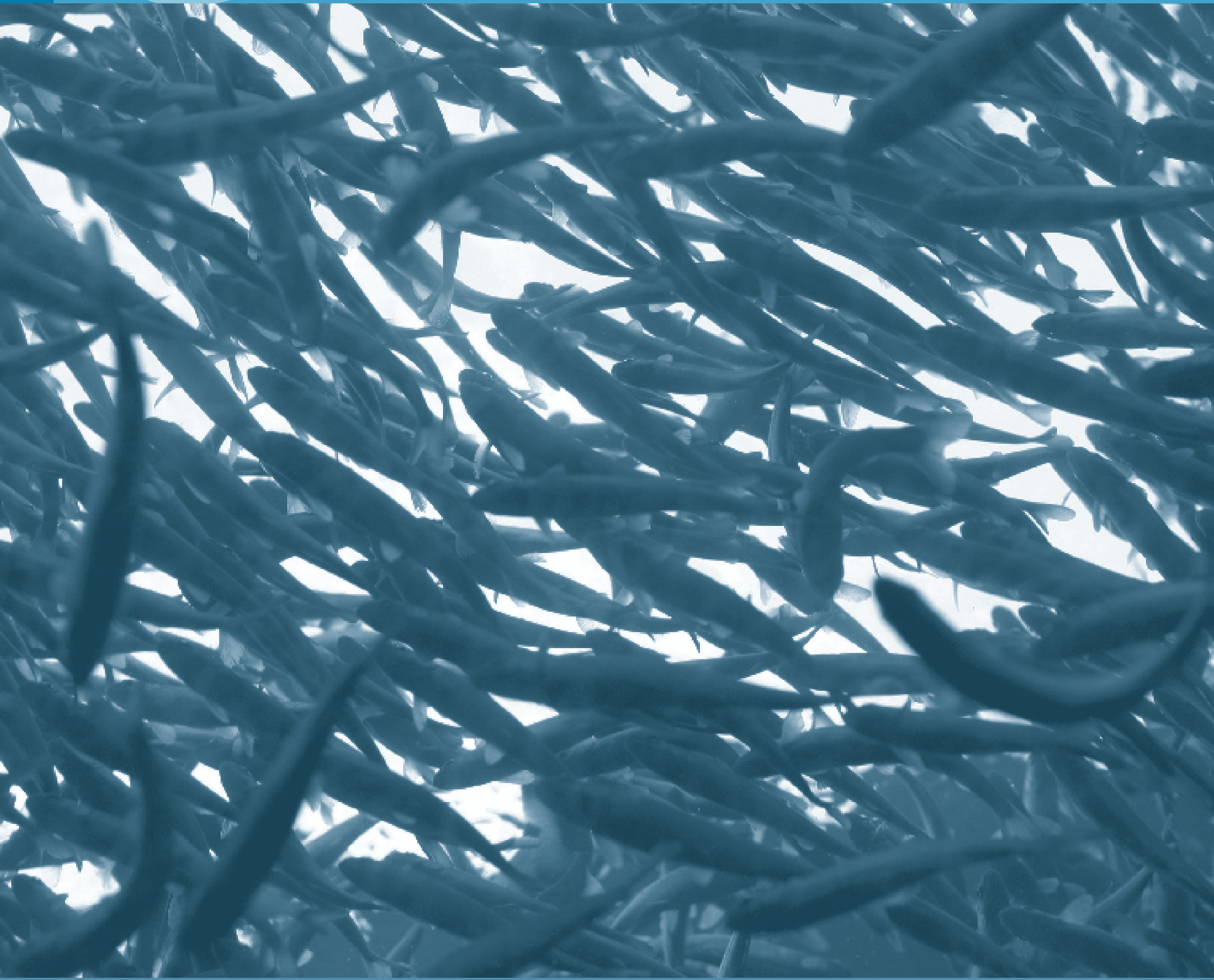
Appendix B-1, Figure 3
Merced River below Crocker-Huffman Dam
2000-2005



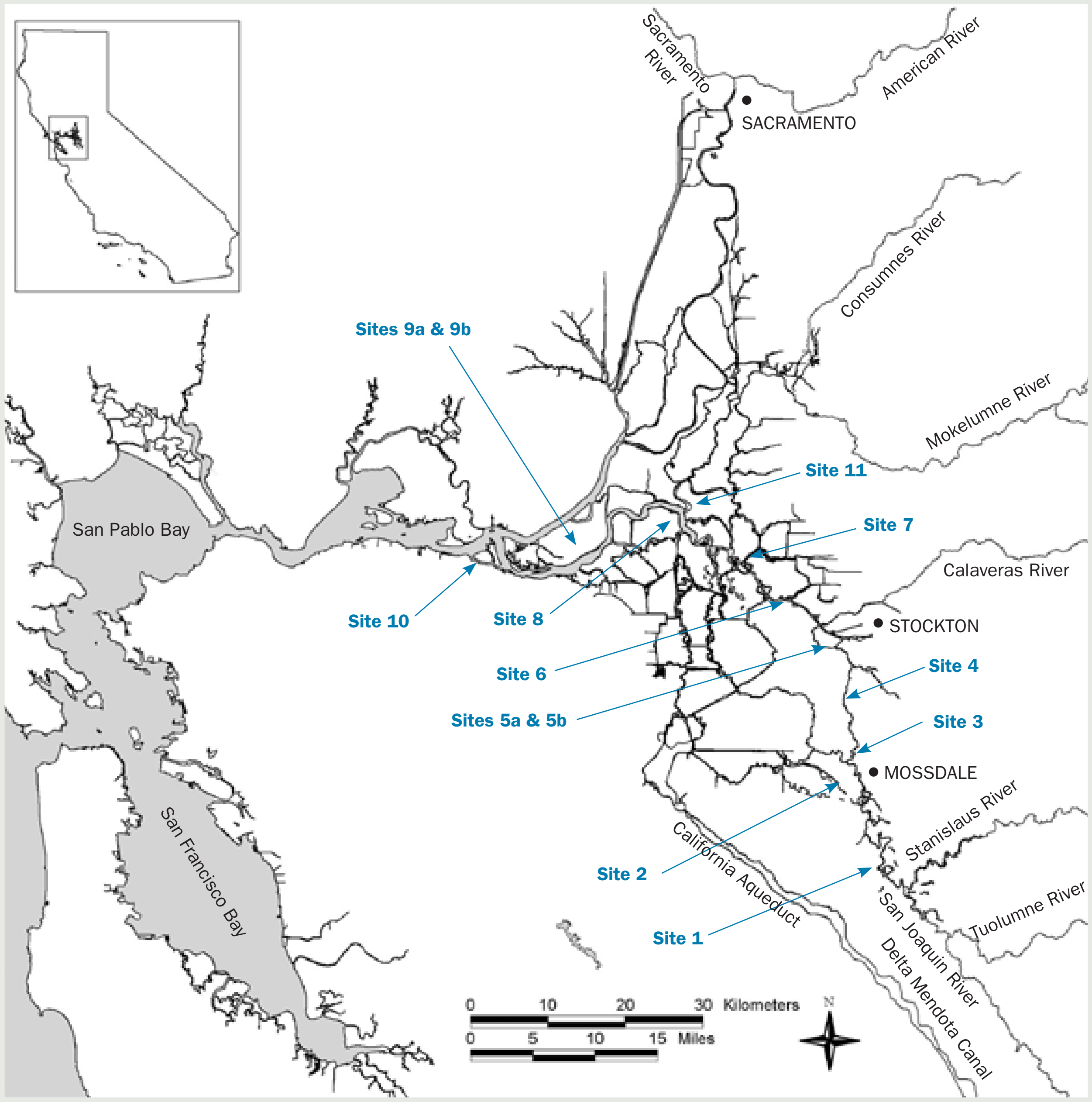
Appendix B-1, Figure 4
Tuolumne River below LaGrange Dam
2000-2005



Appendix C
Chinook Salmon Survival Investigations

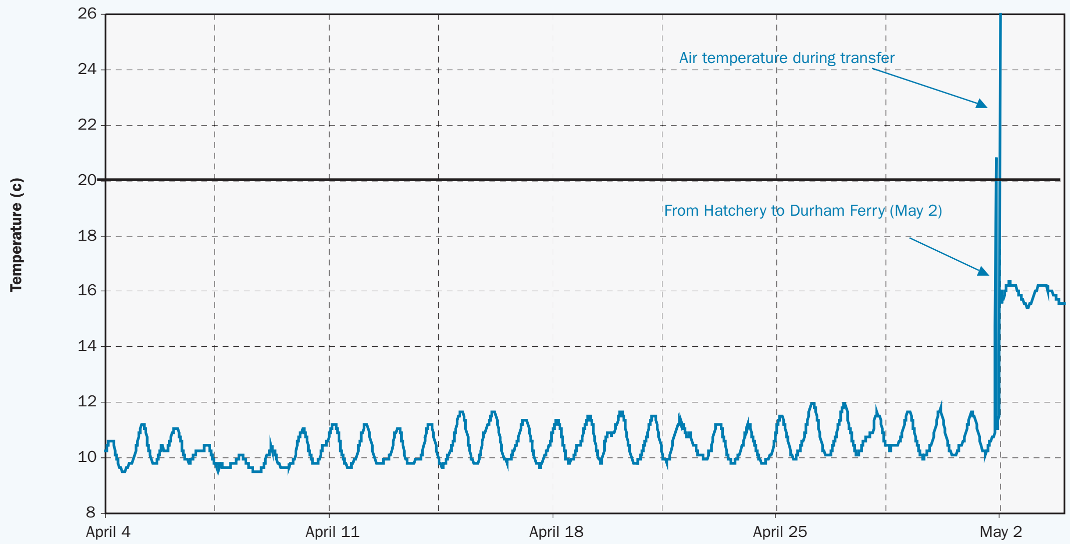


Appendix C-1
Water Temperature Monitoring Locations

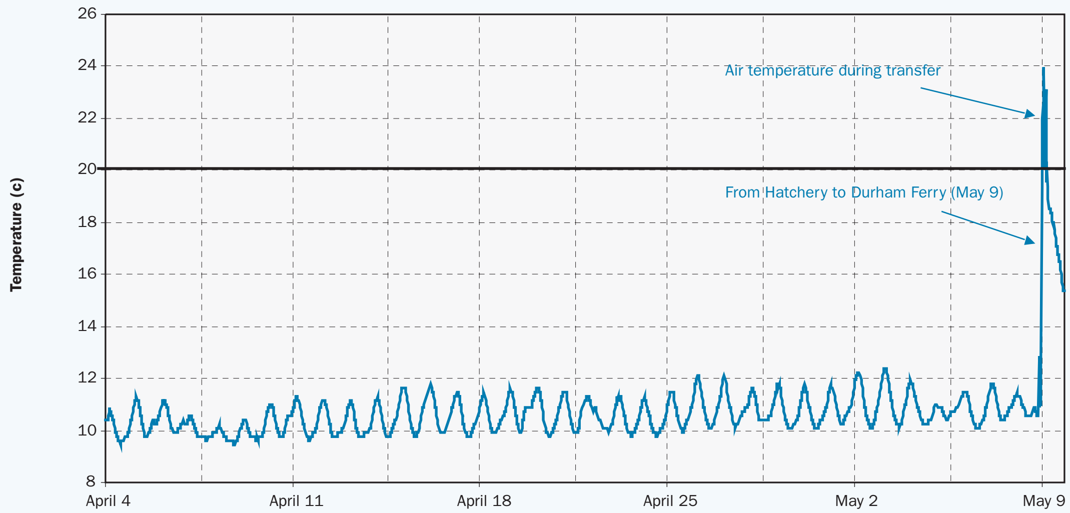


Appendix C-1 VAMP 2005 Water Temperature Monitoring							
Site #	**Temperature Monitoring Location**	**Latitude**	**Longitude**	**Distance from Durham Ferry (mi)**	**Date Deployed**	**Date Retreived**	**Notes**
	Merced River Hatchery - 1			n/a	April 4	May 4	In river May 2 at Durham Ferry
	Merced River Hatchery - 2			n/a	April 4	May 11	In river May 9 at Durham Ferry
1	Durham Ferry	N 37 41.381	W 121 15.657	n/a	April 15	June 15	3 foot depth
2	Mossdale	N 37 47.180	W 121 18.425	11.2	April 15	June 15	3 foot depth
3	Dos Reis	N 37 49.808	W 121 18.665	16.4	April 15	-	Unable to locate logger
4	DWR Monitoring Station	N 37 51.869	W 121 19.376	19.4	April 15	-	Unable to locate logger
5a	Confluence – Top	N 37 56.818	W 121 20.285	26.5	April 15	June 15	Logger was dewatered – unable to use data
5b	Confluence- Bottom	N 37 56.818	W 121 20.285	26.5	April 15	June 15	Logger located on bottom.
6	Downstream of Channel Marker 30	N 37 59.776	W 121 25.569	33.3	April 15	June 15	3 foot depth
7	1/2 mile Upstream of Channel Marker 13	N 38 01.940	W 121 28.769	37.3	April 15	June 15	3 foot depth
8	Downstream of Channel Marker 36	N 38 04.522	W 121 34.413	44.7	April 15	June 15	3 foot depth
9	Jersey Point USGS Gauging Station - Top	N 38 03.172	W121 41.637	56.0	April 15	June 15	3 foot depth
10	Chipps Island	N 38 03.084	W 121 55.463	71.5	April 15	-	Unable to locate logger
11	Mokelumne River-Lighthouse Marina	N 38 06.334	W 121 34.213	40.0	April 15	June 15	3 foot depth

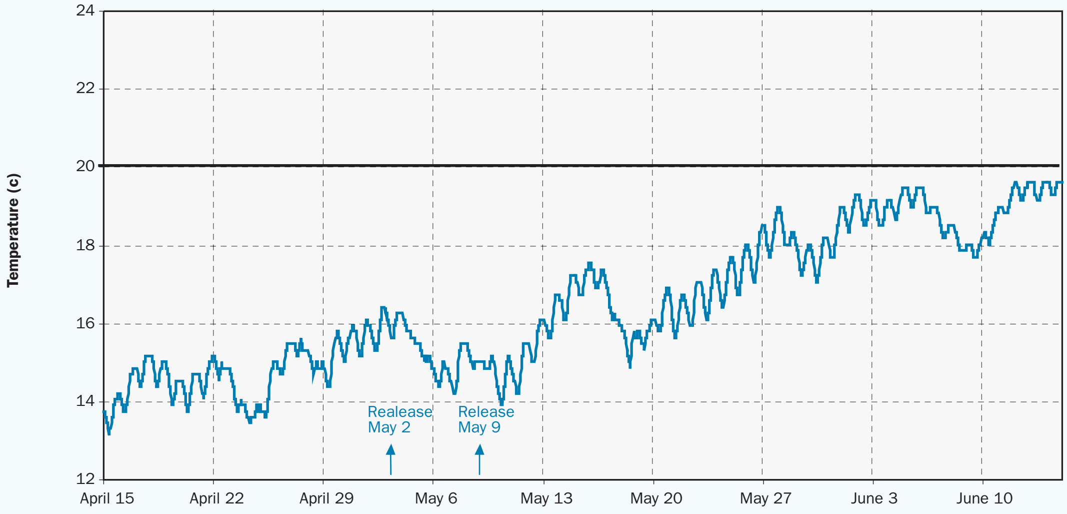
Appendix C-2
Water Temperature Monitoring
Merced River Fish Hatchery to Durham Ferry



Appendix C-2
Water Temperature Monitoring
Merced River Fish Hatchery to Durham Ferry



Appendix C-2
Water Temperature Monitoring
Site 1 Durham Ferry



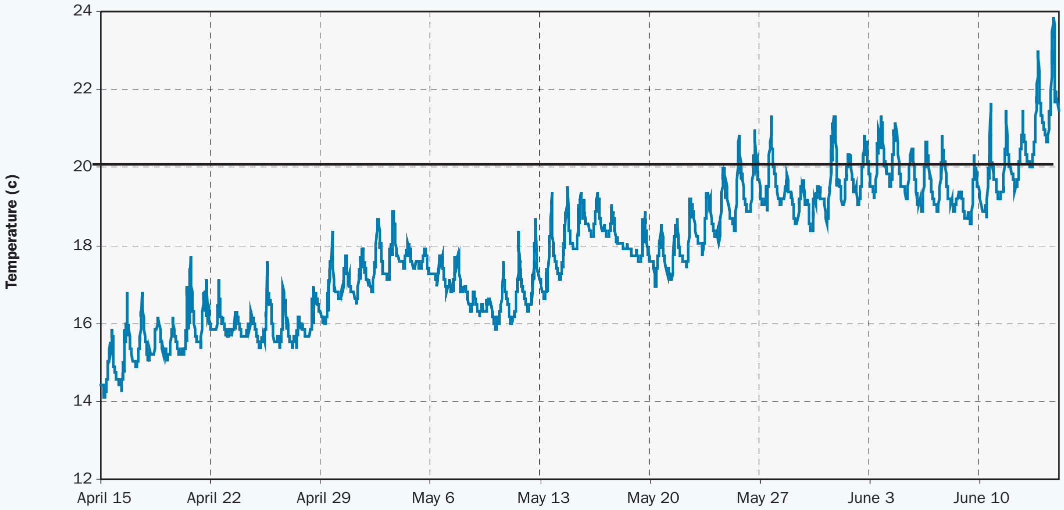
Appendix C-2
Water Temperature Monitoring
Site 2 - Mossdale

Appendix C-2

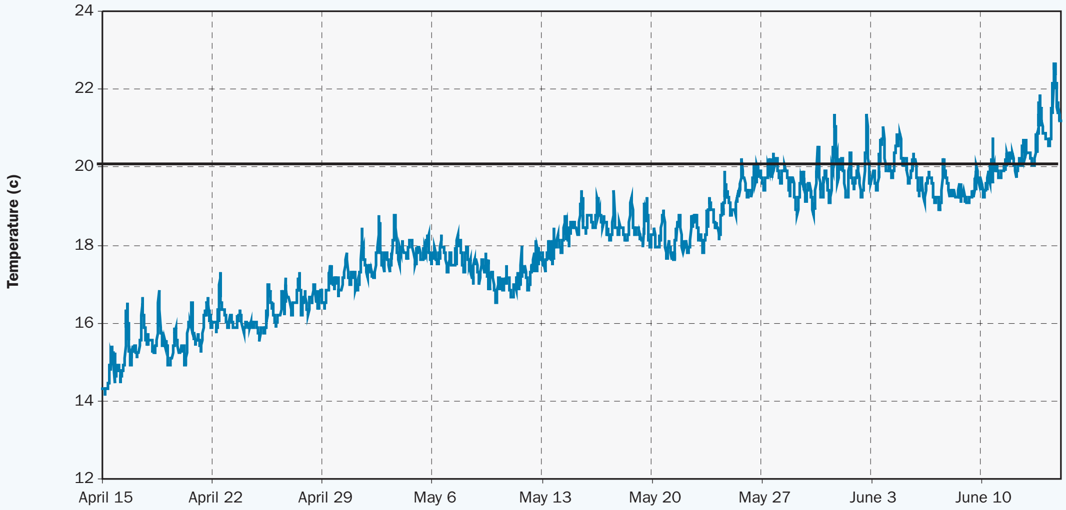
Water Temperature Monitoring
Site 5b - Confluence-Bottom

Appendix C-2

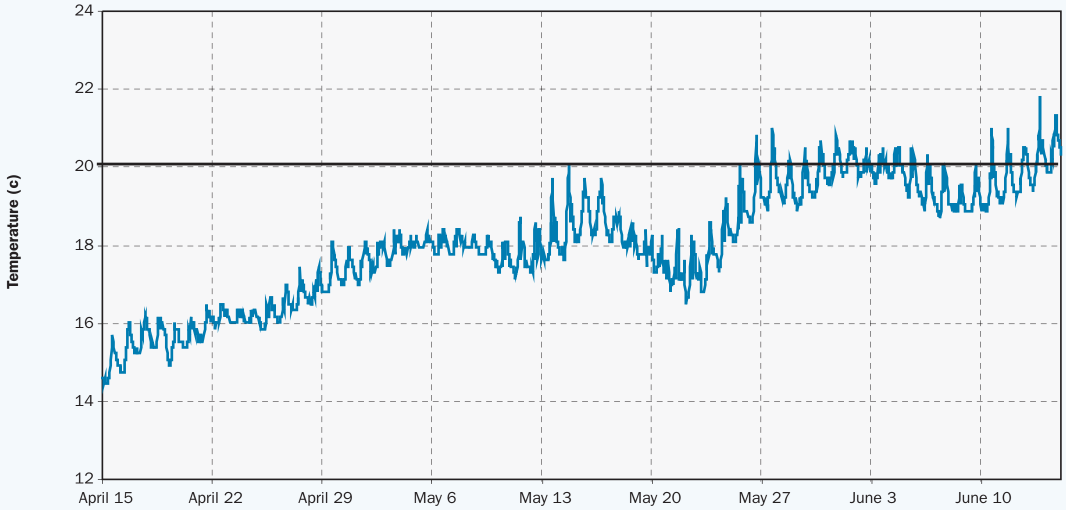
Water Temperature Monitoring
Site 6 - Downstream of Channel Marker 30



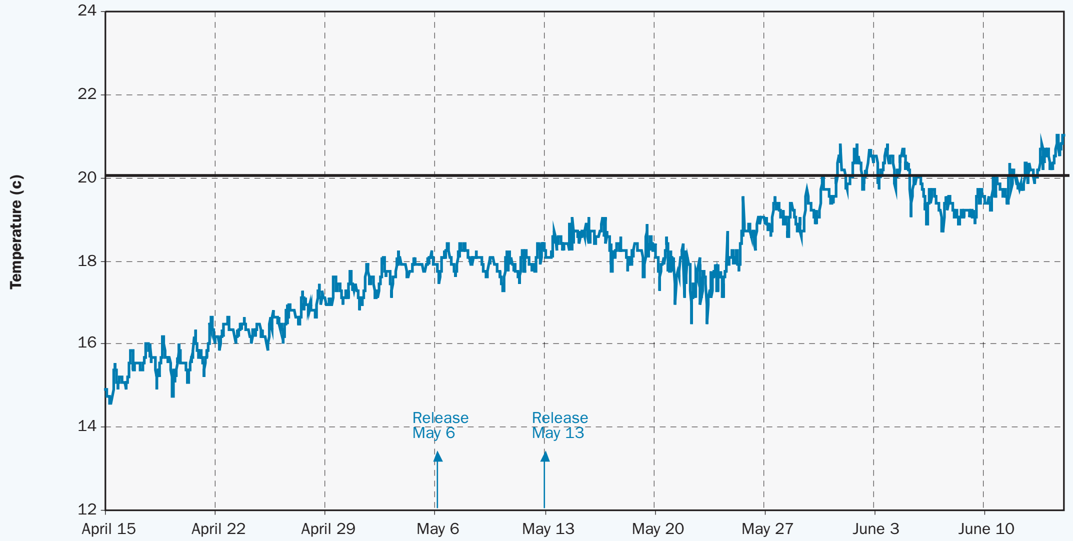
Appendix C-2
Water Temperature Monitoring
Site 7 - 1/2 Mile Upstream of Channel Marker 13



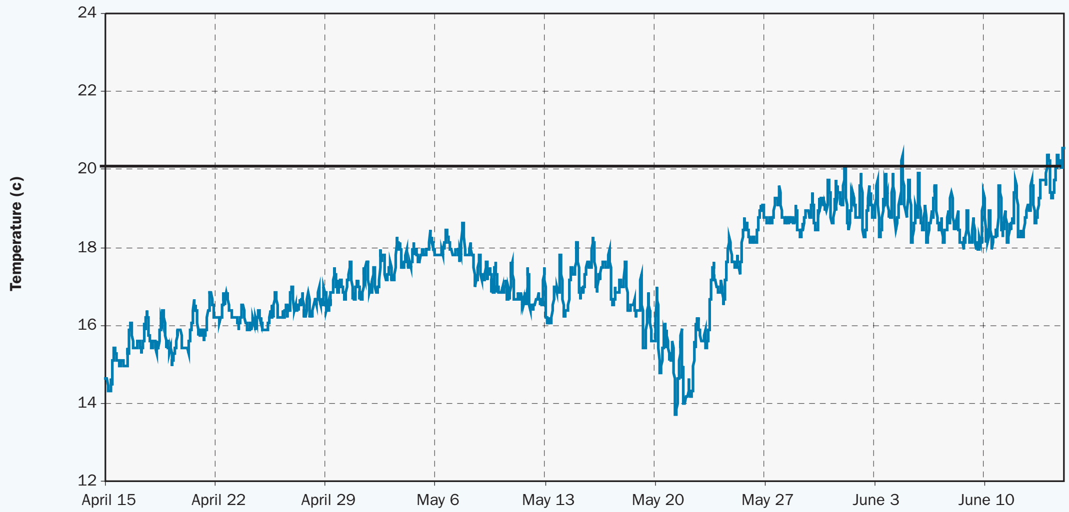
Appendix C-2
Water Temperature Monitoring
Site 8 - Downstream of Channel Marker 36



Appendix C-2
Water Temperature Monitoring
Site 9 - USGS Gauging Station at Jersey Point - Top



Appendix C-2
Water Temperature Monitoring
Site 11 - Mokelumne River - Lighthouse Marina



Appendix C-3a
Salmon Smolt Condition Post Transport, Immediately After Release

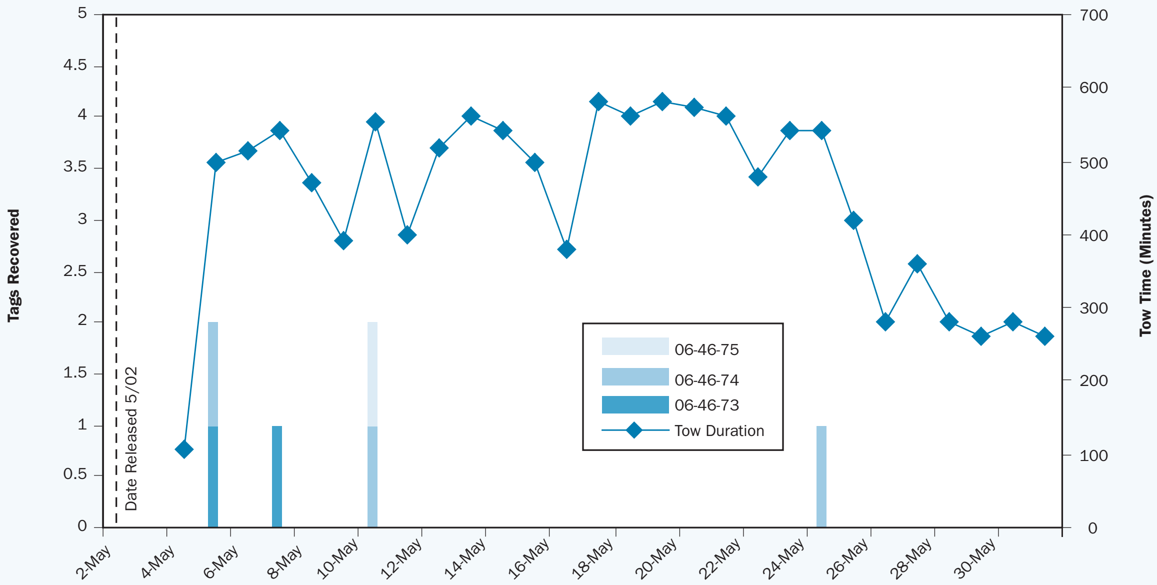
Release Site	Examination Date	Mean Fork Length (mm)	Mean Weight (g)	Vigor (%)	Mean Scale Loss (%)	Normal Body Color (%)	Fin Hemorrhaging (%)	Normal Eye Quality (%)	Normal Gill Color %	Complete Adclip (%)	% Correct Tag Code*
Durham Ferry	5/2/05	85	7	100	3	100	0	100	100	90	100
Dos Reis	5/3/05	86	7	100	3	100	0	100	100	88	100
Jersey Point	5/6/05	83	7	100	3	100	0	98	100	90	100
Durham Ferry	5/9/05	83	10	100	12	100	0	100	100	94	100
Dos Reis	5/10/05	87	7	100	6	100	0	100	100	76	100
Jersey Point	5/13/05	85	7	100	2	100	0	100	100	74	100

* % correct tag code of those that retained tags.

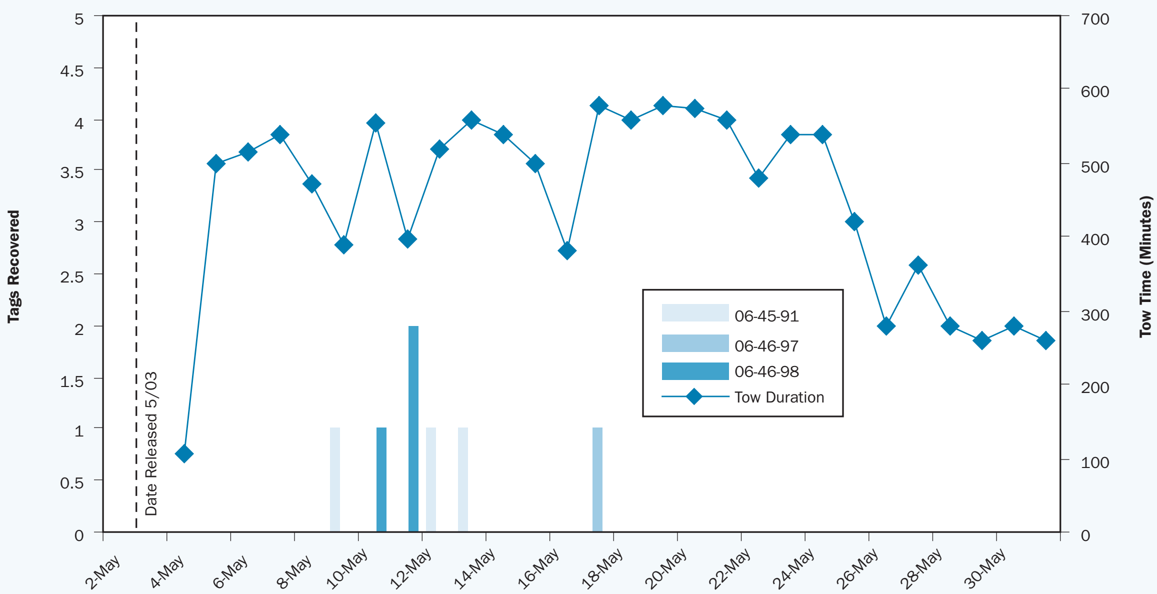
Appendix C-3b
Salmon Smolt Condition 48-hours Post Release

Release Site	Examination Date	Mean Fork Length (mm)	Mean Weight (g)	Vigor (%)	Mean Scale Loss (%)	Normal Body Color (%)	Fin Hemorrhaging (%)	Normal Eye Quality (%)	Normal Gill Color %	Complete Adclip (%)
Durham Ferry	5/4/05	84	7	100	9	96	0	100	100	74
Dos Reis	5/5/05	85	7	100	8	98	0	96	100	78
Jersey Point	5/8/05	86	7	100	7	98	2	98	100	84
Durham Ferry	5/11/05	84	6	100	7	100	0	98	100	68
Dos Reis	5/12/05	85	7	100	3	100	0	98	98	76
Jersey Point	5/15/05	87	7	100	3	100	0	100	100	70

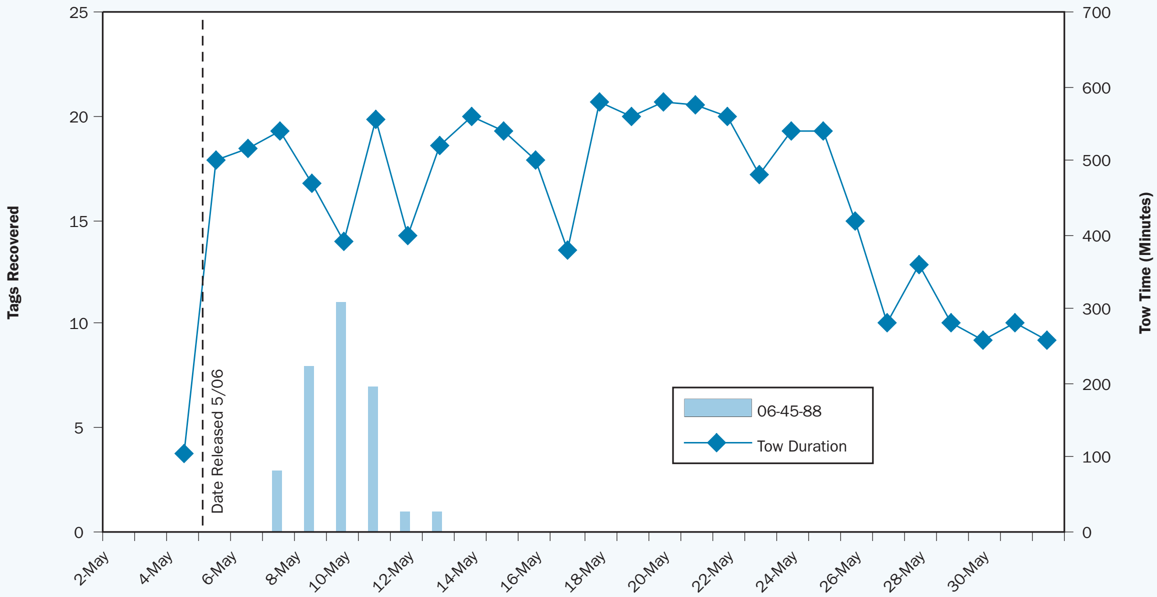
Appendix C-4, Figure 1
Antioch/Durham Ferry 1



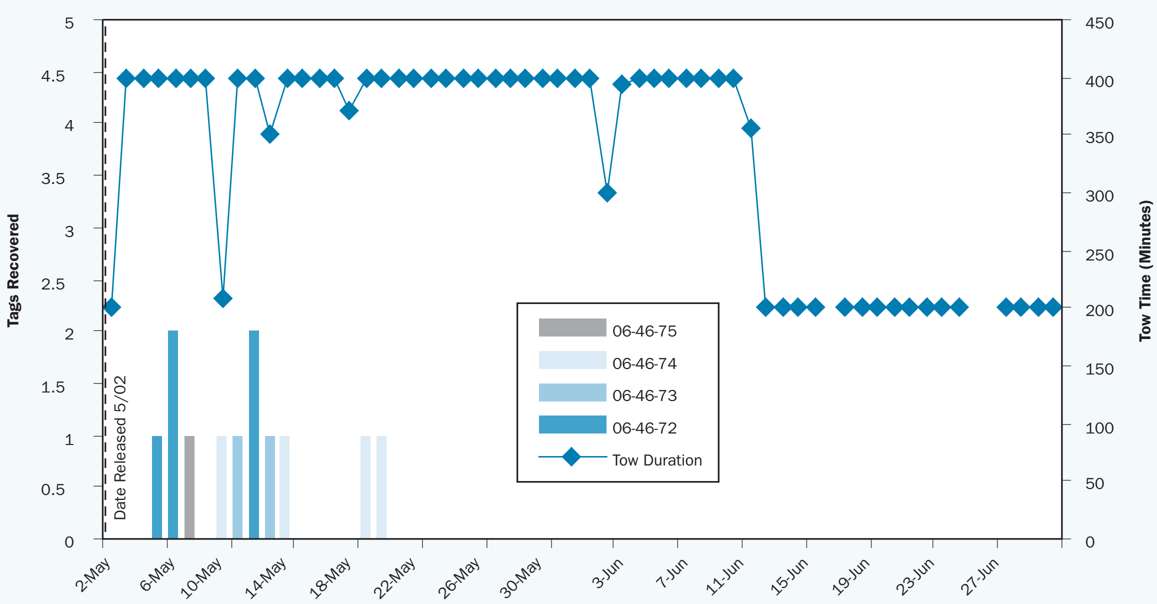
Appendix C-4, Figure 2
Antioch/Dos Reis 1



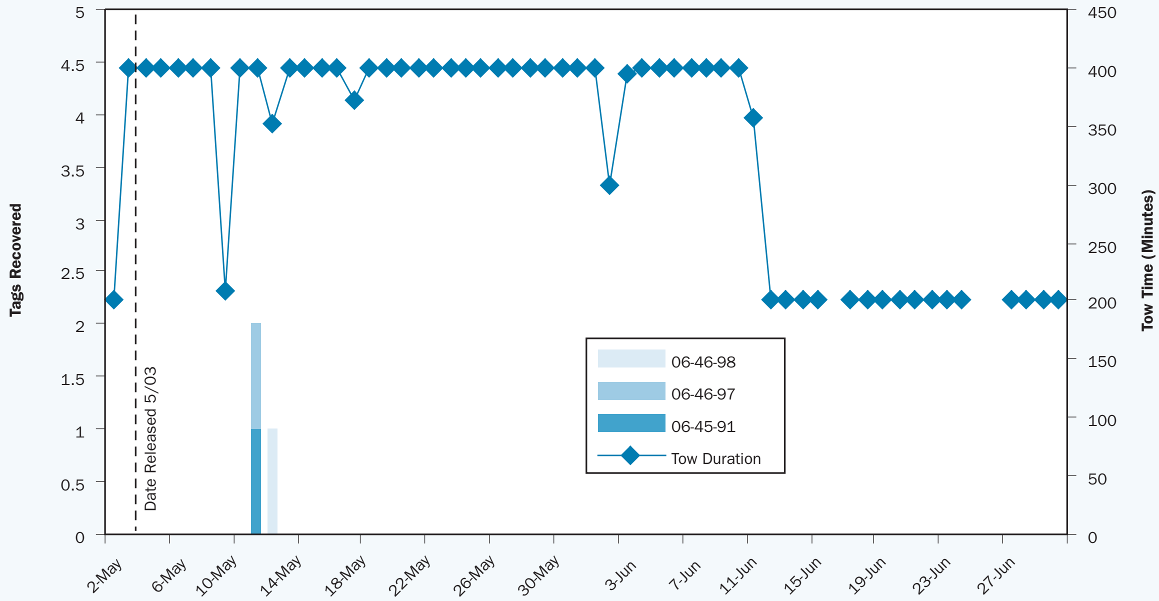
Appendix C-4, Figure 3
Antioch/Jersey Point 1



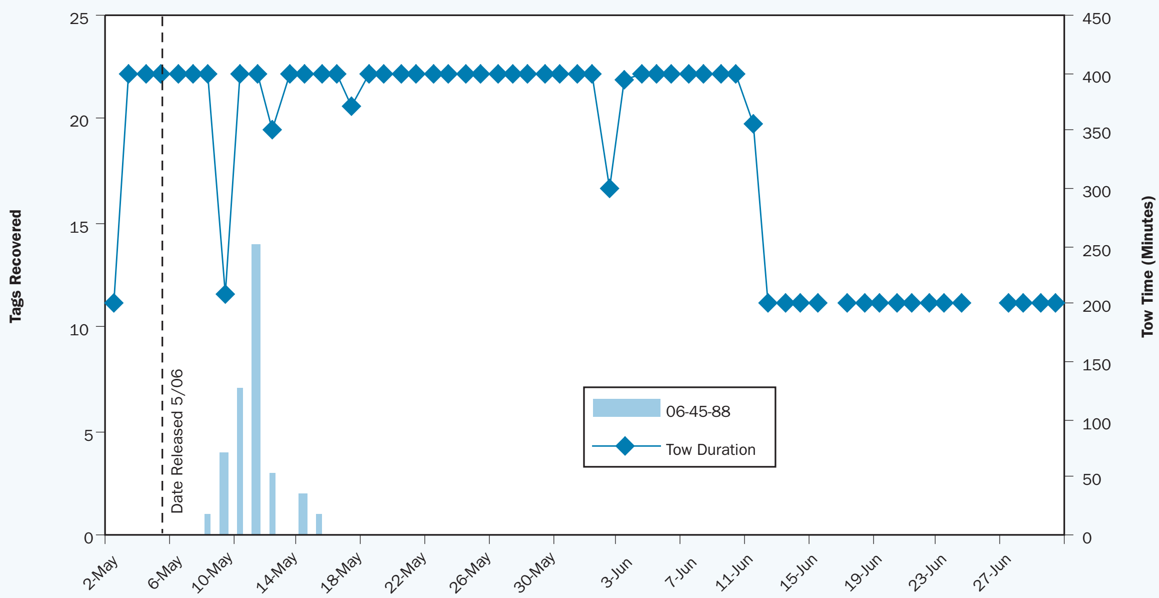
Appendix C-4, Figure 4
Chipps Island/Durham Ferry 1



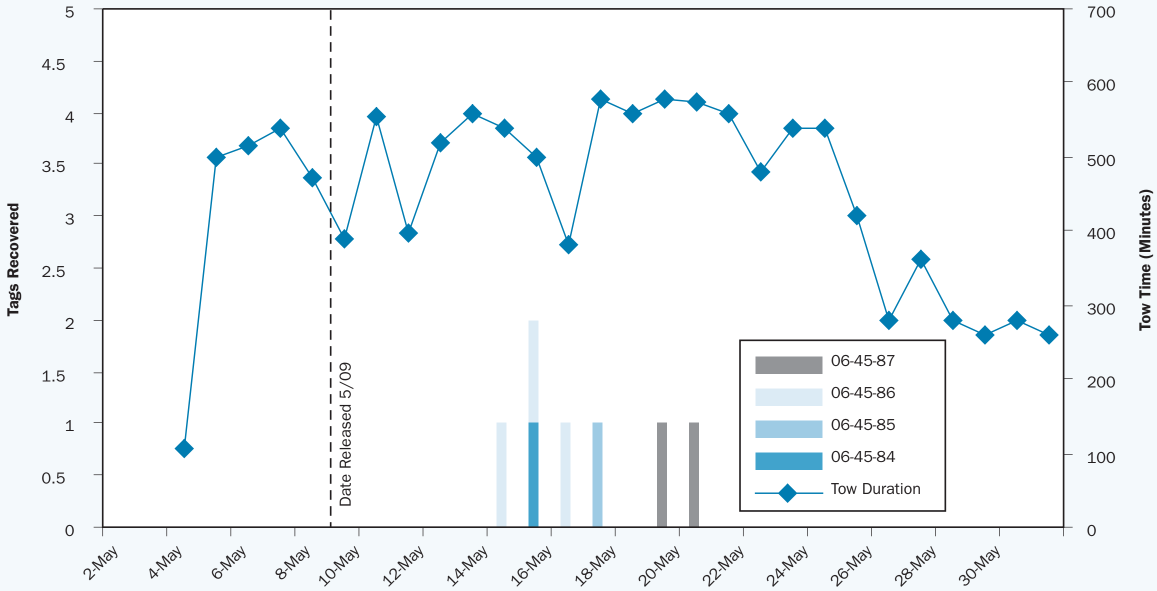
Appendix C-4, Figure 5
Chipps Island/Dos Reis 1



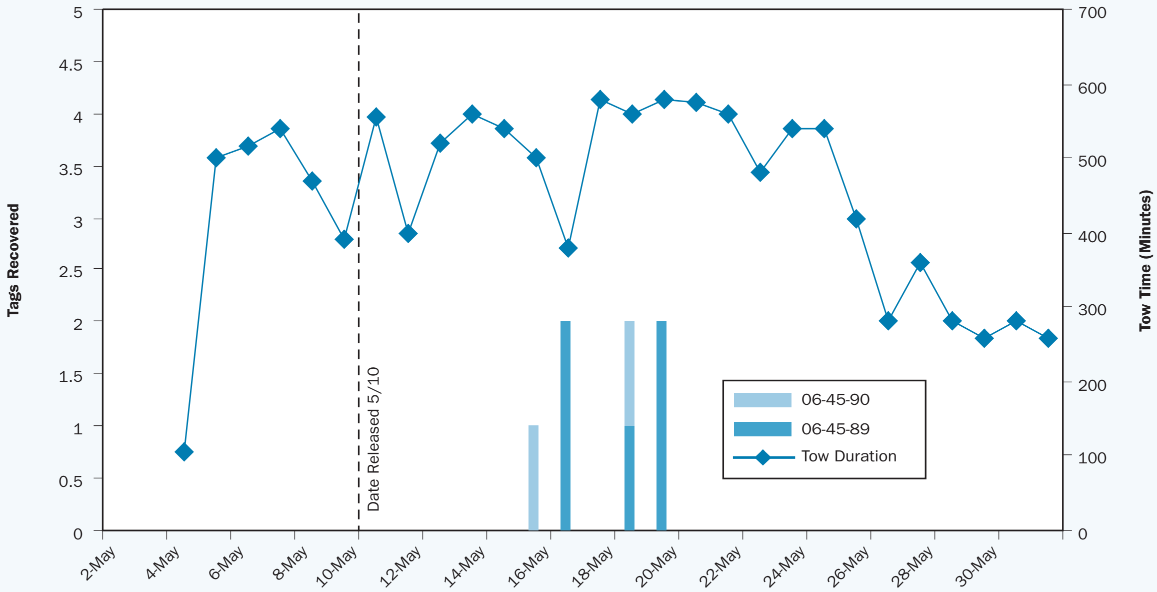
Appendix C-4, Figure 6
Chipps Island/Jersey Point 1



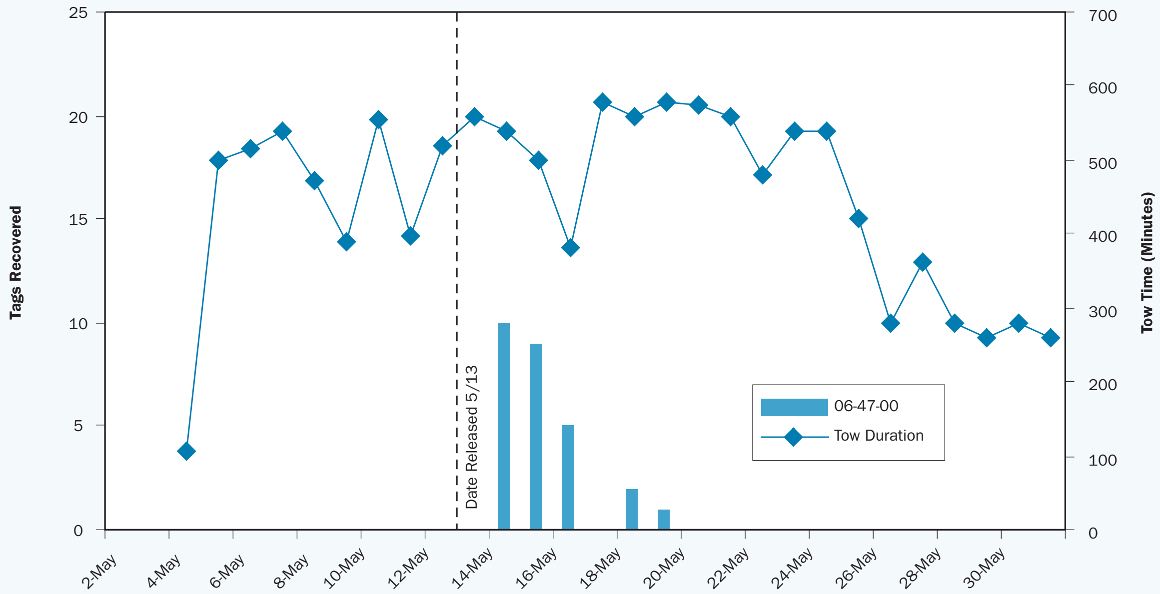
Appendix C-4, Figure 7
Antioch/Durham Ferry 2



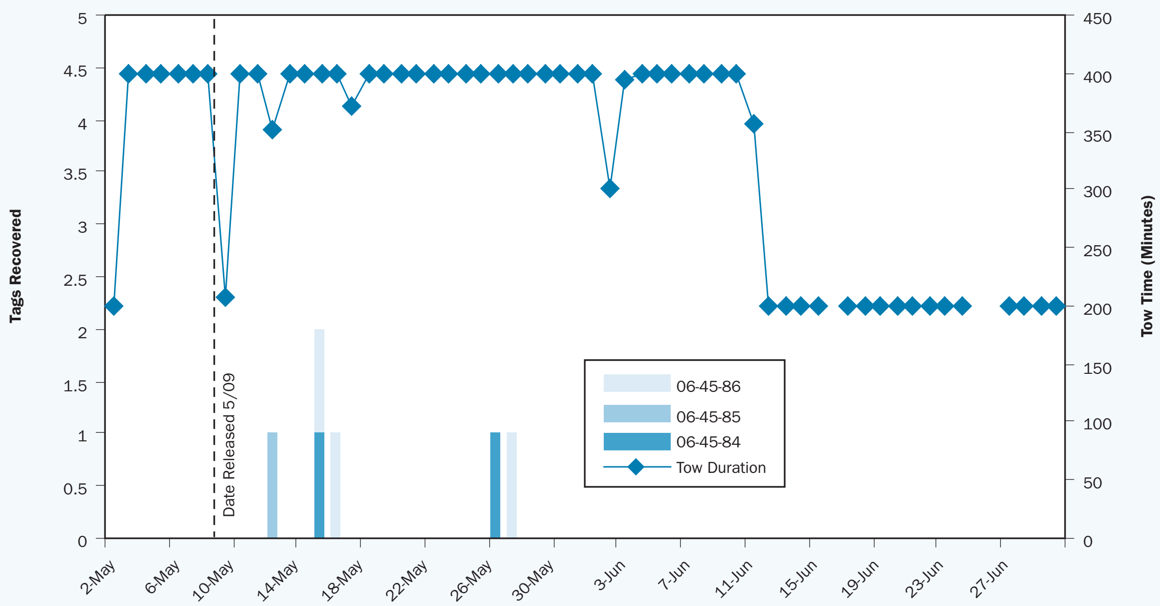
Appendix C-4, Figure 8
Antioch/Dos Reis 2



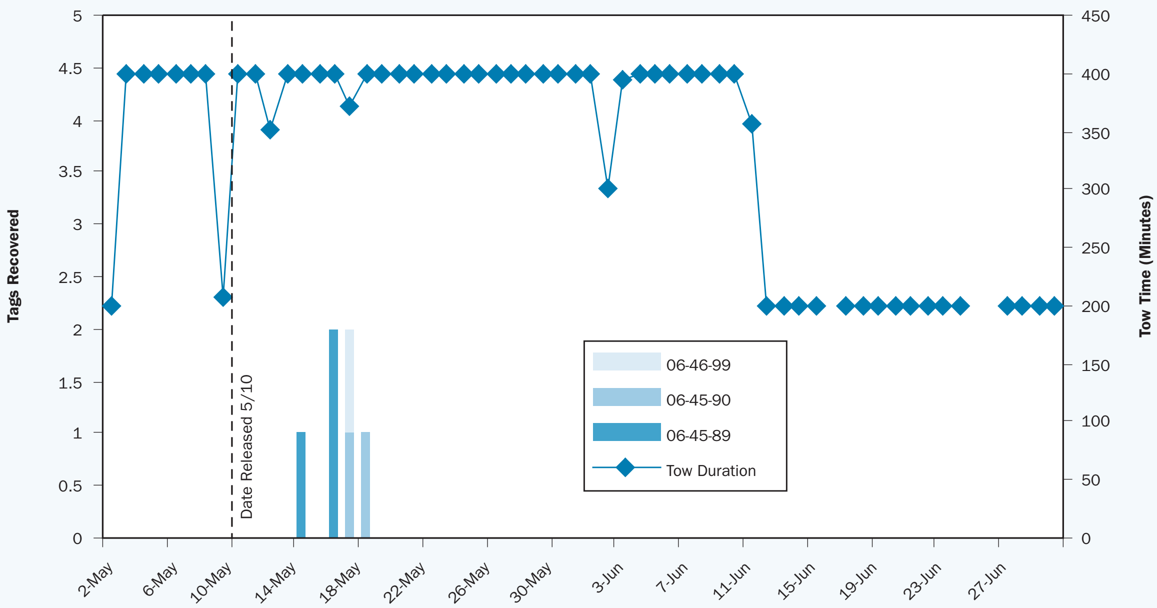
Appendix C-4, Figure 9
Antioch/Jersey Point 2



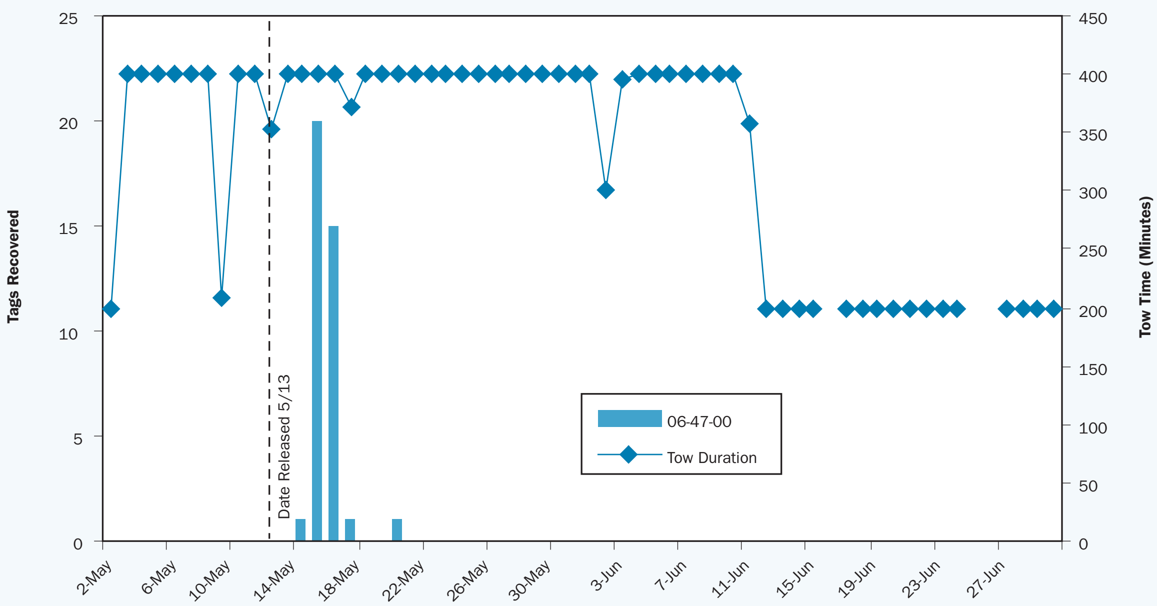
Appendix C-4, Figure 10
Chipps Island/Durham Ferry 2



Appendix C-4, Figure 11
Chipps Island/Dos Reis 2



Appendix C-4, Figure 12
Chipps Island/Jersey Point 2



Appendix D
Errata for the Year 2004 Annual Technical Report

Errata for 2004 Annual Technical Report on Implementaitn and Monitoring of the San Joaquin River Agreement and the Vernalis Adaptive Management Plan. January 2005 San Joaquin River Group Authority

Page 54 under Transit Time: The last sentence should read. “Transit times for marked salmon were estimated from the release day to the first and last day of recovery during VAMP 2004 which is included in Table 5-4.

Page 58: under Figure 5-9 Legend. “ +/- 1 and 2 Standard Errors” should be deleted from the legend text.

San Joaquin River Group Authority

P.O. Box 4060 • Modesto, CA 95352 • (209) 526-7405 • fax (209) 526-7315

Modesto Irrigation District

Turlock Irrigation District

Oakdale Irrigation District

Merced Irrigation District

Friant Water Users Authority

City and County of San Francisco

South San Joaquin Irrigation District

San Joaquin River Exchange Contractors

EXECUTIVE SUMMARY

The San Joaquin River Agreement (SJRA) and Vernalis Adaptive Management Plan (VAMP) are 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). 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. VAMP is also a scientifically recognized 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). VAMP employs an adaptive management strategy to use current knowledge of hydrology and environmental conditions to protect Chinook salmon smolts, while gathering information to allow more efficient protection in the future. Specific experimental objectives of VAMP include quantification of juvenile salmon smolt survival under a set of six San Joaquin River flow rates (3,200 to 7,000 cfs) and SWP/CVP export rates (1,500 to 3,000 cfs).

The 2004 Annual Technical Report comprises the consolidated annual SJRA Operations Report and Vernalis Adaptive Management Plan (VAMP) Monitoring Report. The VAMP 2004 program represents the fifth 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 VAMP program. Specifically, this report includes the following information on the implementation of the SJRA: the hydrologic chronicle; management of the additional SJRA water; installation, operation, and monitoring of the Head of Old River Barrier; results of the juvenile Chinook salmon smolt survival investigations; discussion of complementary investigations; and, conclusions and recommendations.

The VAMP experimental design includes two mark-recapture studies performed each year during the mid-April to mid-May juvenile salmon outmigration period that provide estimates of salmon survival under each set of conditions. Chinook salmon survival indices under each of the experimental conditions are then calculated based on the numbers of marked salmon released and the number recaptured. Absolute survival estimates are calculated and used to evaluate relationships between salmon survival and San Joaquin River flow and CVP and SWP exports. The experimental design includes both multiple release locations (Durham Ferry, Mossdale, and Jersey Point), and multiple recapture locations (Antioch, Chipps Island, SWP and CVP salvage operations, and in the ocean fisheries). The use of data from multiple release and recapture locations allows for more thorough

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evaluation of juvenile Chinook salmon survival as compared to recapture data from only one sampling location and/or one series of releases. The VAMP release and recapture locations are consistent from one year to the next, providing a greater opportunity to assess salmon survival over a range of Vernalis flows, SWP/CVP exports, with and without the presence of the Head of Old River Barrier. Releases at Jersey Point serve as controls for recaptures at Antioch and Chipps Island, thereby allowing calculation of survival estimates based on the ratio of survival indices from marked salmon recaptured from upstream (Durham Ferry and Mossdale) and downstream (control release at Jersey Point) releases. Use of ratio estimates as part of the VAMP study design factors out the potential differential gear efficiency at Antioch and Chipps Island within and among years.

VAMP employs an adaptive management strategy to use current knowledge of hydrology and environmental conditions to protect Chinook salmon smolt passage, while gathering information to allow more efficient protection in the future. In addition to providing improved protection for juvenile Chinook salmon emigrating from the San Joaquin River system, specific experimental objectives of VAMP 2004 included:

- Quantification of Chinook salmon smolt survival between Durham Ferry and Jersey Point using recapture locations at Antioch and Chipps Island, under conditions of a San Joaquin River flow at Vernalis of 3,200 cfs, with an installed HORB, and SWP/CVP export rates of 1,500 cfs; and
- Comparison of juvenile Chinook salmon survival between Durham Ferry and Mossdale for use in comparing results of VAMP 2004 with results from earlier survival studies where coded-wire tagged salmon releases occurred at Mossdale.

VAMP 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 that would occur during the pulse period absent the VAMP. As part of the development of the VAMP experimental design, 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 to refine the experimental design. This facilitates communications and coordination both as part of the VAMP experimental survival program and scheduling streamflow releases on the Tuolumne, Merced, and Stanislaus rivers to facilitate experimental investigations and provide protection for juvenile salmon within the tributaries, as well as the mainstem San Joaquin River. VAMP experimental test conditions that have occurred over the past five years are summarized below:

VAMP Period	Vernalis Flow (cfs)	SWP/CVP Exports (cfs)
April 15–May 15, 2000	5,869	2,155
April 20–May 20, 2001	4,224	1,420
April 15–May 15, 2002	3,301	1,430
April 15–May 15, 2003	3,235	1,446
April 15–May 15, 2004	3,155	1,331

A total of 476,503 acre-feet has been contributed over the five years by the SJRGA. At the end of the five years reservoir deficits in New Don Pedro and Lake McClure are 11,151 acre-feet and 215,197 acre-feet respectively as of October 14, 2004 (Appendix D). These values may be offset by SJRGA water conservation activities implemented by the irrigation districts. Water deficits of the other SJRGA members that contribute water have been replenished at the beginning of each year. A total of 1,508,809 fall-run Chinook salmon smolts were produced at the Merced River Fish Facility over the five years in support of the VAMP. The annual allotment of test fish ranged from a high of 392,186 in 2002 to a low of 188,884 in 2004, with an average of about 309,000 provided in each of the other VAMP years. As a result of the relatively low return of adult salmon to the Merced River in the fall of 2003, the availability of test fish for 2004 was limited to less than 200,000 fish. This allowed for a single release of CWT salmon at Durham Ferry, Mossdale, and Jersey Point.

Temperature data were collected through the use of a series of computerized recorders at the Merced River Fish Facility, in the transport trucks, and located throughout the lower San Joaquin River and Delta. Overall the average temperature at all sites ranged from 19 to 22 C.

Of the 21,845 juvenile Chinook salmon entrained at the HORB during the first five years of VAMP, approximately 8,300 were VAMP CWT released salmon. Most of the VAMP salmon (97%) were entrained within two days of their release. A high proportion of the entrainment at the culverts occurred at night. The yearly entrainment loss index for VAMP salmon at the HORB averaged 0.8% ± 0.4% and ranged from a high of 1.5% in 2002 to a low of 0.4% in 2004. For unknown reasons the 2003 VAMP test measured the lowest survival since the VAMP was initiated, with 2004 showing only a slight improvement. The Combined Differential Recovery Rates ranged from a high in 2001 of 0.191 to a low in 2003 of 0.019. Results of the salmon survival studies suggest a general trend in which survival improves as San Joaquin River

VAMP employs an adaptive management strategy to use current knowledge of hydrology and environmental conditions to protect Chinook salmon smolt passage, while gathering information to allow more efficient protection in the future.

flows increase and as the ratio of San Joaquin River flow to SWP/CVP exports increases. These relationships, based on data between 2000 and 2004 (including similar data obtained in 1994 and 1997), however, are not statistically significant ($p<0.05$). Hydrologic conditions occurring within the San Joaquin River watershed between 2000 and 2004 have limited the experimental flow conditions to a relatively narrow range. Further tests, over a wider range of flow and export conditions (e.g., San Joaquin River flow of 7,000 cfs and SWP/CVP export rates of 1,500 cfs), are needed to evaluate the respective roles of San Joaquin River flow and SWP/CVP exports, on juvenile Chinook salmon smolts survival. Various historical data are summarized in Appendix D.

Results of salmon migration monitoring at Mossdale between March 15 and June 30 have shown that approximately 31–76% of the juvenile Chinook salmon smolts migrate downstream from the San Joaquin River tributaries during the VAMP period and were, therefore protected by increased San Joaquin River flows, installation of the Head of Old River Barrier, and decreased export rates. The VAMP program provides improved protection for juvenile salmon when compared to "pre-VAMP" conditions.

Prior technical reports presented a series of conclusions and recommended modifications to the VAMP experimental design and/or program implementation. The 2003 recommendations were used, in part, as the basis for developing the 2004 VAMP test program. For example, the 2003 report recommended weekly measurements of San Joaquin River flow at the Vernalis gage, continued hydrology investigations to estimate ungaged flows (accretions, depletions) to improve hydrologic predictions, and continued coordination among tributary operators to facilitate implementation of the VAMP test flow conditions. The 2003 report also recommends modifications to the HORB and entrainment monitoring program including a delay in salmon releases at Durham Ferry and Mossdale for approximately five days after barrier closure to allow time for gravel and rock to flush from the culverts and improve fishery sampling, measuring flows within the culverts, continue monitoring to evaluate potential impacts of seepage, monitoring fish entrainment at the culverts, and improve the experimental design of Head of Old River Barrier investigations. These and other recommendations were addressed as part of the 2004 VAMP program.

During 2004, as since 2002, the local landowner provided a short-term curtailment of agricultural diversion pumping during the release of test fish at Durham Ferry. In addition, the 2004 VAMP program continued use of the net pen studies and a fish health assessment to determine the health and survival of test fish released as part of VAMP. Efforts also continued to improve the procedure used to statistically analyze VAMP survival and recovery information, however additional improvements remain to be made in the ability to measure flow passing through the Head of Old River Barrier culverts and the resultant flow within the San Joaquin River downstream of the confluence with Old River. Measurements in the future of San Joaquin River flow downstream of the Old River Barrier will be used in evaluating the relationship between San Joaquin River flow and juvenile Chinook salmon survival. An additional complimentary study on survival of juvenile Chinook salmon emigrating from San Joaquin River tributaries was incorporated into the 2004 VAMP investigations.

The estimated survival of CWT salmon released from Durham Ferry and Mossdale in 2004 was the second lowest measured since initiation of the VAMP. Results of health and physiological examinations indicated that the test fish were relatively healthy and should have performed adequately for outmigration assessment. Water temperatures measured within the lower San Joaquin River and Delta were within a range that may have been stressful and may have contributed to adverse effects and reduced survival of juvenile Chinook salmon released as part of the 2004 VAMP investigations.

Prior reports recommended that, to the extent possible, VAMP survival testing be conducted at high flow and low export extremes to improve the ability of the program to detect differences in juvenile Chinook salmon survival between target flow and export conditions. Hydrologic conditions within the San Joaquin River watershed did not provide conditions suitable for testing a high flow/low export relationship as part of the VAMP 2004 program. Recommendations from the 2003 VAMP program were used to improve the overall experimental design and implementation of the 2004 VAMP investigations. Recommendations made based upon analyses of the VAMP 2004 program will also be used, in a similar way, by the hydrology and fisheries technical committees in developing and implementing the experimental design for the 2005 VAMP studies.

Based on data gathered during the experimental mark-recapture studies that occurred over a 31-day period in April and May 2004, a set of conclusions and recommendations has been developed. These conclusions and recommendations provide guidance and a foundation for design and implementation of future VAMP studies. Key conclusions and recommendations derived from VAMP 2004 include:

- Differential recovery rates of the Durham Ferry and Mossdale groups relative to the Jersey Point group using recaptures at Antioch and Chipps Island indicated that there was no statistical ($p<0.05$) difference in survival between the Durham Ferry and Mossdale releases conducted in 2004.
- The proportion of CWT salmon released and recaptured from the combined Durham Ferry and Mossdale groups relative to the proportion of CWT salmon released and recaptured from the Jersey Point (control) showed that the relative proportions during 2004 were similar to 2003 but significantly lower than survival results from the 2002 VAMP, although flow and export conditions (target flow 3200 cfs and exports of 1500 cfs in all three years) were comparable. The factors contributing to the significantly lower survival in 2003 and 2004 are unknown.
- The relationships between salmon survival, Vernalis flow, and SWP/CVP exports were not statistically significant based on results of VAMP tests over the past five years and similar pre-VAMP data gathered in 1994 and 1997.
- Real-time streamflow data at Vernalis were improved by weekly flow measurements, however estimation of ungaged flow (accretions and depletions) requires further investigation for use in establishing annual VAMP target flows.
- DWR installed a stage recorder and fixed acoustic Doppler velocity meters in the San Joaquin River downstream of the confluence with Old River and in the Old River downstream of the HORB for use in measuring 2004 river flows.
- The design, construction, and operation of the HORB were successful in 2004. Salmon releases at Durham Ferry and Mossdale were delayed approximately five days after HORB closure to allow time for gravel and rock to flush from the culverts and to improve fisheries sampling at the site. Operation of the HORB with three to five culverts open was successful in maintaining South delta water levels. Mechanical malfunctions required varying culvert operations throughout the period.
- The index of salmon entrainment at the HORB from the single release in 2004 was substantially lower in comparison to the first releases made in 2002 and 2003 but similar to the 2001 loss. The comparisons may be limited due to the single release of test fish in 2004 and the varying culvert operations.
- The variability inherent in conducting salmon smolt survival studies in the lower San Joaquin River and Delta makes it difficult to detect statistically significant differences in salmon

survival between VAMP flow and export target conditions, which are relatively similar. It is strongly recommended that, when possible, high target flow and low export conditions be selected to conduct survival tests at VAMP flow and export extremes, or equivalent, to improve the ability to detect potential differences in salmon smolt survival among test conditions.

- Approximately 72 percent of the unmarked salmon smolts migrating past Mossdale in 2004 migrated during the VAMP period (April 15 through May 15) and were, therefore protected by increased San Joaquin River flow, installation of the HORB and decreased export pumping.
- Individual agency program and funding constraints limited the implementation of complementary studies in 2004. Complementary studies provide additional information on factors and mechanisms affecting salmon survival during migration from the lower San Joaquin River and through the Delta.
- The relationships between salmon survival rates and Vernalis flow and SWP/CVP export conditions tested in the first five years have not been found to be statistically significant. Survival tests at extreme target levels (e.g., 7,000 cfs flow and 1,500 cfs exports), or equivalent, are important to obtain. The VAMP program provides improved protection for juvenile salmon when compared to "pre-VAMP" conditions. Further tests, over a wider range of flow and export conditions, are needed to evaluate the respective roles of San Joaquin River flow and SWP/CVP exports on juvenile Chinook salmon smolt survival. The report recommends that the VAMP experimental test program be continued.
- It is recommended that further effort be given to identifying and evaluating opportunities to adaptively refine and modify the VAMP experimental design to improve the level of protection provided to juvenile Chinook salmon migrating downstream in the San Joaquin River, improve the ability to detect statistically significant relationships between flow and export rates and juvenile salmon survival if they exist, reduce potential adverse impacts to aquatic resources and their habitat within the upstream tributaries, and maximize the efficient use of available water resources within the San Joaquin River watershed during VAMP implementation.
- The VAMP program has demonstrated the value of large-scale, long-duration, interdisciplinary experimental investigations that provide both protection to fishery resources while also providing important information that can be used to evaluate the performance and biological benefits of various management actions. The VAMP program has also demonstrated the value of an interdisciplinary approach, integrating fisheries and hydrology adaptively in response to current environmental conditions, in the design and successful implementation of management programs.

CHAPTER 1

Introduction

Actions associated with the Vernalis Adaptive Management Plan (VAMP) were implemented between April 15 and May 15, 2004 to protect juvenile Chinook salmon and evaluate the relationship between San Joaquin River flow and State Water Project (SWP) and federal Central Valley Project (CVP) water project exports, with the HORB, on the survival of marked juvenile Chinook salmon migrating through the Sacramento–San Joaquin Delta. Studies conducted in 2004, represent the fifth year of the VAMP experiment. Results from previous VAMP experiments are available in San Joaquin River Agreement Technical Report and San Joaquin River Group Authority, Technical Reports dated 2000, 2001, 2002, and 2003. Similar 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 will describe the experimental design of VAMP, the hydrologic planning and implementation, the additional water supply arrangements and deliveries, the Head of Old River Barrier (HORB) design, installation, operation and fisheries monitoring, the salmon smolt survival investigation and complimentary studies related to VAMP. Conclusions and recommendations for future VAMP studies are also included.

EXPERIMENTAL DESIGN ELEMENTS

The VAMP experimental design measures 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 mid-April to mid-May juvenile salmon outmigration period that provide estimates of salmon survival under each set of conditions. During 2004, the reduced number of juvenile Chinook salmon produced at the Merced River Fish Facility limited the VAMP survival studies to one set of releases. Chinook salmon survival indices under the experimental conditions are calculated based on the number of marked salmon released and the number recaptured. Absolute survival estimates and combined differential recovery rates are also calculated and used in relationships between survival and San Joaquin River flow and CVP and SWP exports.

The VAMP 2004 experimental design included both multiple release locations (Durham Ferry, Mossdale, and Jersey Point), and multiple recapture locations (Antioch, Chipps Island, SWP and CVP salvage operations, and in the ocean fisheries; Figure 1-1). One release was made during the 2004 VAMP study at Durham Ferry, Mossdale, and Jersey Point as a consequence of the limited number of juvenile salmon available from the MRFF. The use of data from multiple release and recapture locations allows for a more thorough evaluation of juvenile Chinook salmon survival as compared to recapture data from only one sampling location and/or one release location. The VAMP coded-wire tag (CWT) releases (Durham Ferry, Mossdale, and Jersey Point) and recapture locations (Antioch and Chipps Island) are consistent from one year to the next, providing a greater opportunity to assess salmon smolt survival over the range of Vernalis flows, SWP/CVP exports, and with and without the presence of the Head of Old River Barrier (HORB). The recovery of marked fish at both Antioch and Chipps Island also improves the precision associated with the individual survival estimates, and improves confidence in detecting differences in salmon smolt survival as a function of Vernalis flows and SWP/CVP exports. Releases at Jersey Point serve as controls for recaptures at Antioch and Chipps Island, thereby allowing the calculation of survival estimates based on the ratio of survival indices from marked salmon recaptured from upstream (e.g., Durham Ferry and Mossdale) and downstream (control release at Jersey Point) releases. The combined differential recovery rates are calculated in a similar manner. The use of ratio estimates as part of the VAMP study design factors out the potential differential gear efficiency at Antioch and Chipps Island within and among years.

A quality assurance/quality control program has been used as a routine part of VAMP tests, and includes quantifying the number of marked fish successfully clipped and tagged. Coordination with the local landowner to curtail operation of an agricultural diversion pump located immediately downstream of Durham Ferry, coincident with the Durham Ferry release was continued in 2004. In addition, the 2004 VAMP program continued use of the net pen studies and physiological testing to assess overall condition and health of marked fish used in VAMP experiments. Improvements were also made in 2004 relative to measuring flow in the San Joaquin River downstream of the confluence with Old River. But additional improvements are needed before measurements of San Joaquin River flow downstream of the HORB are used to evaluate the relationship between San Joaquin River flow and juvenile Chinook salmon survival.

FIGURE 1–1

Sacramento–San Joaquin Estuary

Location of VAMP 2004 Release Sites

CHAPTER 1

CHAPTER 2

VAMP Hydrologic Planning & Implementation

This section documents the planning and implementation undertaken by the Hydrology Group of the San Joaquin River Technical Committee (SJRTC) for the 2004 VAMP investigations. Implementation of VAMP is guided by the framework provided in the San Joaquin River Agreement (SJRA) and anticipated hydrologic conditions within the watershed.

The Hydrology Group 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 2004, the agencies belonging to the Hydrology Group included: Merced Irrigation District (Merced), 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 installation of the HORB and the planning of Delta exports consistent with the VAMP.

VAMP FLOW AND SWP/CVP EXPORTS

The VAMP provides for a 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 SWP/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 absent the VAMP (Existing Flow) that would occur during the target flow period (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 instream 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 River, the Tuolumne River and the Stanislaus River.

TABLE 2-1

VAMP Vernalis Flow & Delta Export Targets

Forecasted Existing Flow (cfs)	VAMP Target Flow (cfs)	Delta Export Target Rates (cfs)
0 to 1,999	2,000 [a]	1,500 [a]
2,000 to 3,199	3,200	1,500
3,200 to 4,449	4,450	1,500
4,500 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 the extent possible	

[a] non-VAMP flow objectives

As part of the development of the VAMP experimental design, the VAMP Hydrology and Biology Groups jointly 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 VAMP Hydrology and Biology Groups 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 technical committees 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.

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 technical committees 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 Hydrology and Biology Groups agreed to a target range variation of plus or minus 7% of the Vernalis flow target. It was recognized by the Hydrology and Biology Groups that these guidelines are not absolute conditions, but are to be used by the VAMP hydrology and biology workgroups to evaluate experimental test conditions and the potential effect of flow and export variation on our ability to detect and assess variation in juvenile Chinook salmon survival rates among VAMP test conditions.

Under the SJRA, the following San Joaquin River Group Authority (SJRGA) agencies have agreed to provide the supplemental water needed to achieve the VAMP target flows, limited to a maximum of 110,000 acre-feet: Merced, OID, SSJID, SJRECWA, MID and TID. The Merced supplemental water would be provided on the Merced River from storage in Lake McClure and would be measured at the Merced River at Cressey 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 through system operation. The MID and TID supplemental water would be provided on the Tuolumne River from storage in New Don Pedro Reservoir and would be measured at the Tuolumne River below LaGrange Dam gage.

The target flow of 2,000 cubic feet per second (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 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 2000 cfs, the USBR, in accordance with the SJRA, shall act to purchase additional water from willing sellers to fulfill the requirements of existing biological opinions.

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 (off-ramp). These potential adjustments to the target flow are dependent on the hydrologic year type as defined by the SWRCB San Joaquin Valley Water Year Hydrologic Classification (60-20-20 classification), 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 Classifications Used in VAMP

60-20-20 Water Year Classification	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 up to 157,000 acre-feet of supplemental water may be required. If the VAMP target flow requires more than 110,000 acre-feet of supplemental water, then the USBR will attempt to acquire the needed additional water on a willing seller basis. The SJRGA will extend a "favored purchaser" offer to the USBR in accordance with the SJRA.

HYDROLOGIC PLANNING

Hydrology Group Meetings

Beginning in February 2004, and continuing until early April, the Hydrology Group held four planning and coordination meetings (February 19, March 17, March 30 and April 9). 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 estimate the Existing Flow at Vernalis. Inflows to the tributary reservoirs used in these forecasts were based on DWR Bulletin 120 runoff forecasts. The monthly operation forecasts used the 90 percent and 50 percent probability of exceedence runoff forecasts. The initial monthly operation forecast was presented at the February 19 Hydrology Group meeting. The 90 percent exceedence forecast called for a VAMP target flow of 3,200 cfs and the 50 percent exceedence forecast called for a VAMP target flow of 5,700 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 daily operation plan calculates an estimated mean daily flow at Vernalis based on estimates 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 major tributaries.

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. The 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 above 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

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 measured as follows:

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)).

Of all of the assumptions required for the development of the daily operation plan, the ungaged flow estimation is the one assumption with the greatest degree of uncertainty. An extensive review of historical ungaged flows was made to determine if there were any correlations between the ungaged flow and the hydrologic conditions that could be used to reduce the uncertainty. Unfortunately, no significant correlations were found, but the review did indicate that a reasonable estimate of the ungaged flow for entering the target flow period could be projected. The daily operation plan is developed assuming a constant ungaged flow throughout the target flow period essentially equal to the value entering the period.

By definition, the VAMP 31-day pulse flow period can occur anytime between April 1 and May 31. Factors that are considered in the determination of the timing of the VAMP target flow period include installation of HORB, availability of juvenile salmon at the MRFF, and manpower and equipment availability for salmon releases and recapture. Until a specific start date is defined, a default target flow period of April 15 to May 15 is used for the VAMP operation planning. For 2004 the conditions were such that there was no apparent advantage to a different start date, therefore the target flow period was designated to be April 15 through May 15.

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. The 60-20-20 water year classification for 2002 was “dry” (VAMP numerical indicator of two) and for 2003 was “below normal” (VAMP numerical indicator of three). Under these conditions the possibility of 2004 being an off-ramp year was eliminated since the off-ramp criterion (sum of VAMP numerical indicators for previous two plus current year equal to or less than four) was already exceeded without including the current year’s numerical indicator. Conversely, 2004 would be a “double-step” year if the 90% probability of exceedence forecast called for a 60-20-20 water year classification of “above normal” (VAMP numerical indicator of four) or “wet” (VAMP numerical indicator of five). The final determination of the current year’s VAMP numerical indicator is based on the April 1 runoff forecast, but the hydrologic conditions and forecasts prior to April are monitored so that the VAMP planning can proceed based on the most likely conditions. This year the January, February and March 90% probability of exceedence forecasts were placing 2004 in the “critical” and “dry” classifications, making the possibility of a “double-step” year remote. A drier than average March all but assured that 2004 would not be a “double-step” year. As it turned out, the April 1 90% probability of exceedence forecast classification for 2004 was “dry” (VAMP numerical indicator of two), making 2004 a normal, or single-step, VAMP year.

The initial daily operation plan was prepared on March 17, and was modified as hydrologic conditions and operational requirements changed. Table 2-3 summarizes the various iterations, and demonstrates the evolutionary nature, of the daily operation plan during the VAMP planning phase. The daily operation plans prepared during the VAMP planning phase are provided in Appendix A-1.

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

TABLE 2-3

Summary of 2004 VAMP Daily Operation Plans

Phase	VAMP Forecast Date	VAMP Target Flow Period	Assumed Ungaged Flow at Vernalis (cfs)	Existing Flow (cfs)	VAMP Target Flow (cfs)	Supplemental Water needed to meet Target Flow (1,000 AF)
	March 17	April 15–May 15	300	2,185	3,200	62,400
			800	3,779	4,450	41,280
Planning	March 30	April 15–May 15	300	2,135	3,200	65,460
			500	3,778	4,450	41,290
	April 09	April 15–May 15	500	2,353	3,200	52,070
	April 13	April 15–May 15	500	2,352	3,200	52,170
Implementation	April 20	April 15–May 15	365	2,213	3,200	59,780
	May 03	April 15–May 15	281	2,137	3,200	63,620

TABLE 2-4

Real-time Flow Data and Sources

Measurement Location	Real-time Data Source
San Joaquin River near Vernalis	USGS, station 11303500 (http://waterdata.usgs.gov/ca/nwis/dv?format=pre&period=31&site_no=11303500)
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?format=pre&period=31&site_no=11289650)
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?format=pre&period=31&site_no=11274000)

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 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. The periods of desired stable flow are highlighted with bold outlines in the daily operation plans in Appendix A.

For the 2004 VAMP operation the April 9 daily operation plan called for staggered single pulse flow periods on each of the tributaries (Figure 2-2), starting on the Tuolumne River with a nine day flow of about 1,400 cfs, followed by the Stanislaus River with a ten day flow of about 1,250 cfs, and concluding on the Merced River with a ten day flow of about 1,300 cfs. Plots of the individual tributary flows during the VAMP operation are provided in Appendix A-3.

IMPLEMENTATION

Operation Conference Calls

During implementation of the VAMP pulse flow, conference calls were conducted every Monday, Wednesday and Friday between April 16 and May 10 at 6:30 A.M. to discuss the status of the pulse flow and to make operational changes if needed. The calls were held at 6:30 A.M. 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 quality. The 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

FIGURE 2-2

April 9 Forecast of San Joaquin River Basin 2004 VAMP Operation

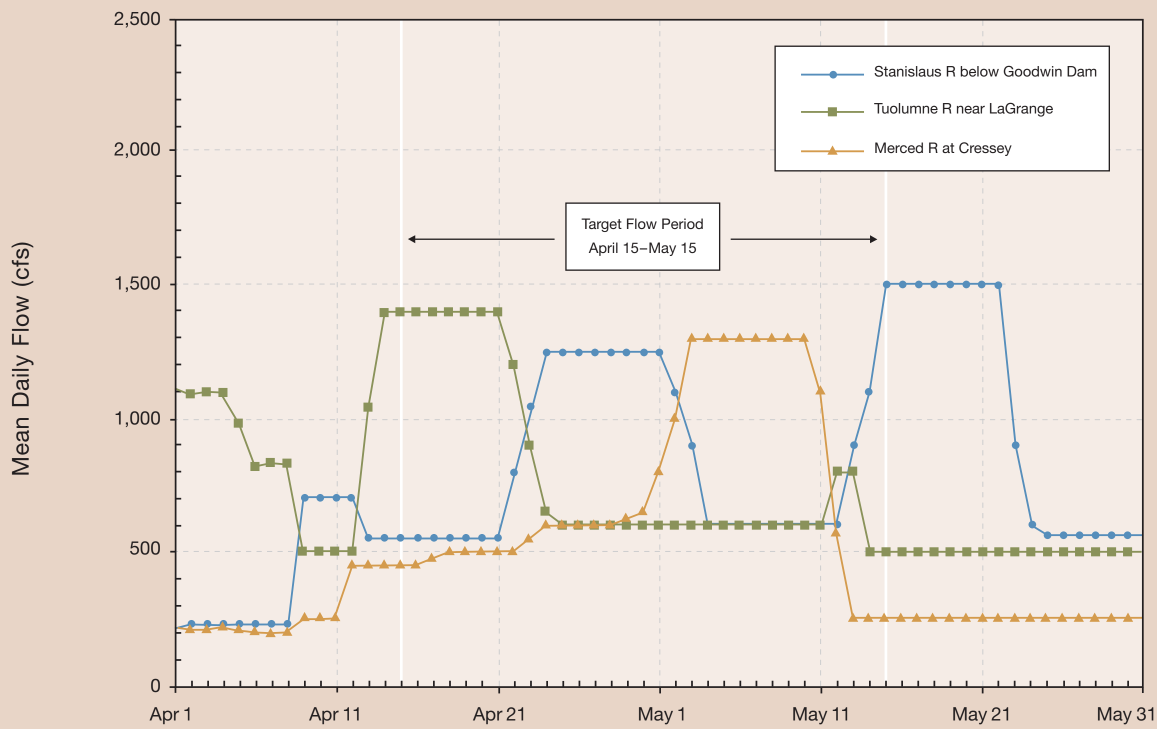


TABLE 2-5

Summary of USGS Flow Measurements at the San Joaquin River near Vernalis Gage

Date	Gage Height	Measured Flow (cfs)	Current Rating Shift Flow (cfs)	Percent Difference	Rating Shift
3/19/04 (15:10)	12.13	4,330	4,240	2.1%	No
4/06/04 (09:50)	10.46	2,640	2,720	-3.0%	No
4/14/04 (10:20)	9.64	2,050	2,030	1.0%	No
4/20/04 (09:48)	10.85	3,130	3,070	1.9%	No
4/27/04 (10:48)	11.11	3,190	3,320	-4.1%	No
5/04/04 (10:15)	11.11	3,350	3,320	0.9%	No
5/11/04 (09:50)	11.12	3,310	3,320	-0.3%	No

the supplemental water deliveries are adhering to the tributary allocations contained in the SJRGA Division Agreement to the extent possible, as well as to determine if adjustments need to be made to the operation plan.

Normally, the USGS makes monthly measurements of the flow at Vernalis to check the current rating shift. The real-time flows reported by the USGS and CDEC are dependent on the most current rating shift, therefore a new measurement and 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 6 and May 11. The results of these measurements are summarized in Table 2-5. There were no rating shifts during the 2004 VAMP operation period.

The daily operation plan was updated twice during the VAMP flow period (Table 2-3). In each update the estimation of VAMP supplemental flow was adjusted to compensate for a decline in the ungaged flow. The daily operation plans prepared during the VAMP implementation phase are provided in Appendix A-1 in the April 20 and May 3 plans. Final accounting of the supplemental VAMP water contribution is provided in Appendix A-2.

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 2, 2004. 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-3 to illustrate the differences between the real-time and the provisional data.

The mean daily flow at the Vernalis gage averaged 3,155 cfs during the April 15–May 15 VAMP target flow period, 1.4% below the target flow of 3,200 cfs. The maximum mean daily flow (Figure 2-3) during target flow period was 3,380 cfs on May 10 and the minimum was 2,370 cfs on April 15. The final Existing Flow was estimated to have averaged 2,088 cfs during the target flow period. The VAMP operation resulted in a 51% increase in flow at Vernalis during the target flow period and required 65,591 acre-feet of supplemental water. Figure 2-3 shows the flow at Vernalis with and without the VAMP supplemental water. Figure 2-4 shows the sources of the flow at Vernalis. Figures 2-5, 2-6 and 2-7 show the with and without VAMP flows at the tributary measurement points, Merced River at Cressey, Tuolumne River below LaGrange Dam and Stanislaus River below Goodwin Dam, respectively.

The initiation of the VAMP was based on the April 9 daily operation plan (see Appendix A-1) with a forecasted Existing Flow of 2,353 cfs and a supplemental water requirement of 52,070 acre-feet. During the target flow period the observed Existing Flow was substantially less than the forecasted Existing

FIGURE 2-3

2004 VAMP–San Joaquin River Near Vernalis With and Without VAMP

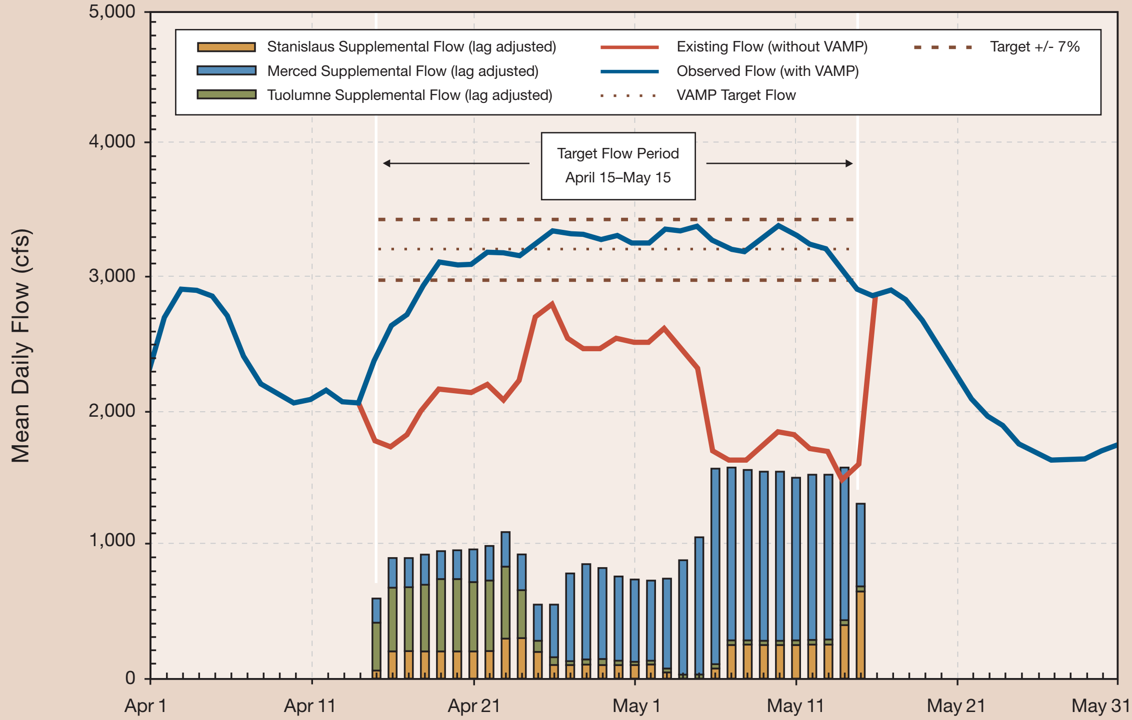
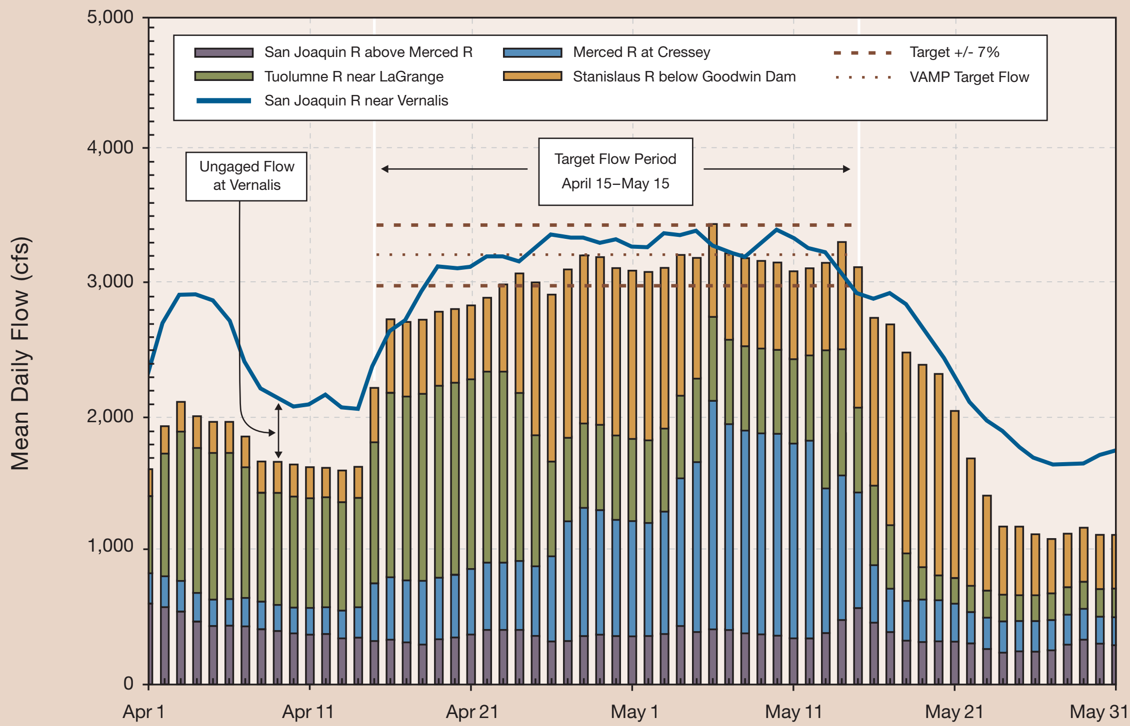


FIGURE 2-4

2004 VAMP San Joaquin River Near Vernalis With Lagged Contributions from Primary Sources



CHAPTER 2

FIGURE 2-5

2004 VAMP–Merced River at Cressey

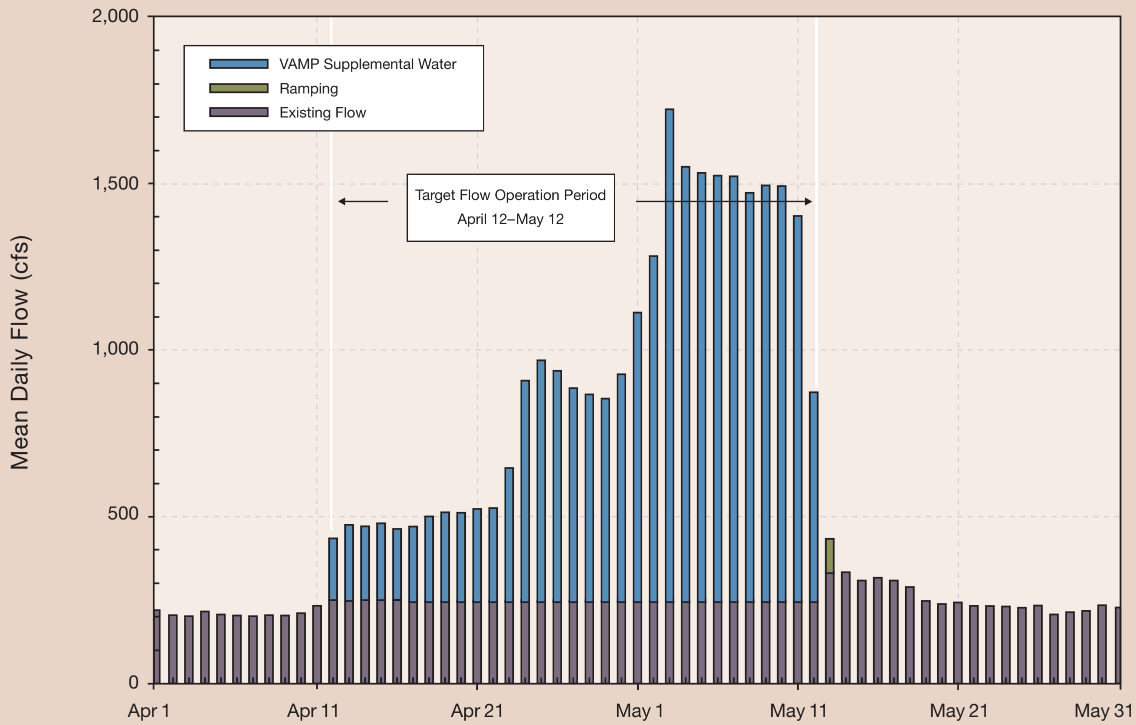


FIGURE 2-6

2004 VAMP–Tuolumne River Below LaGrange Dam

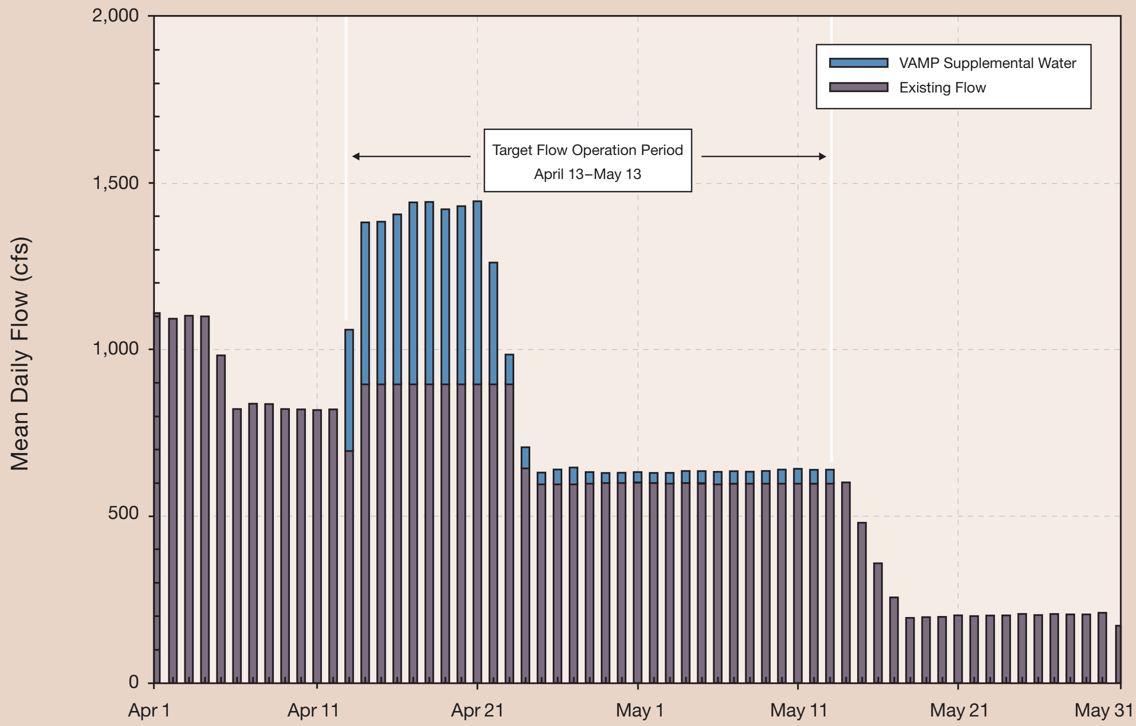


FIGURE 2-7

2004 VAMP–Stanislaus River Below Goodwin Dam

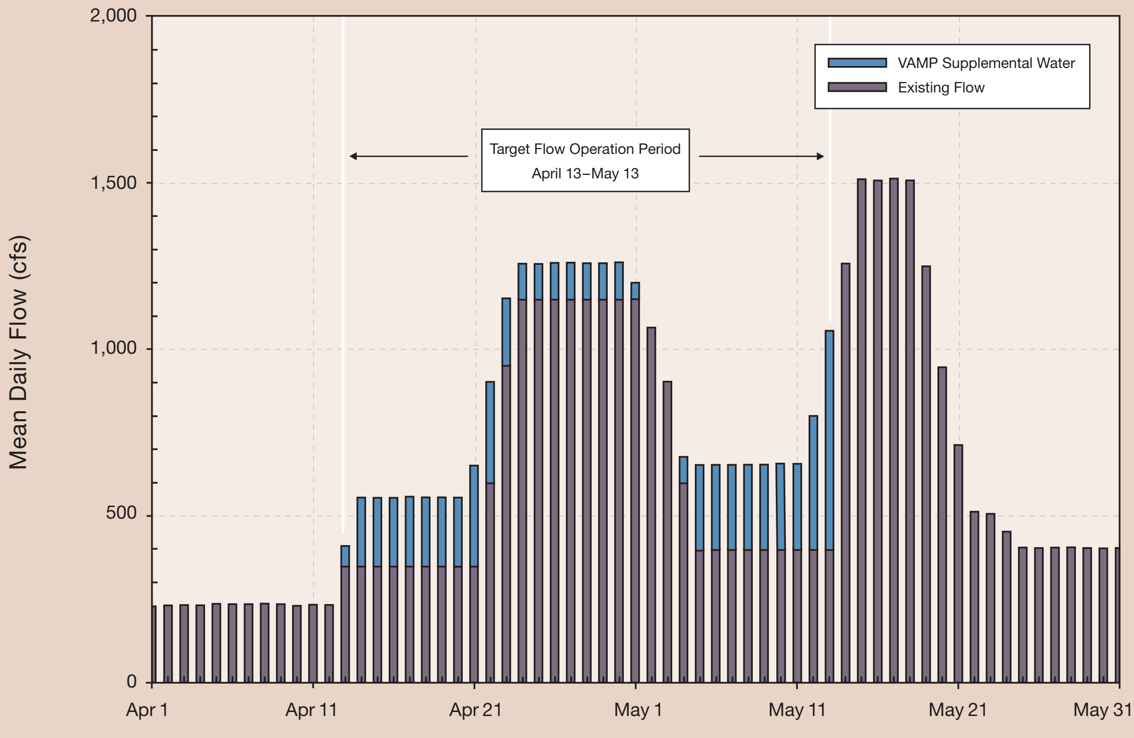
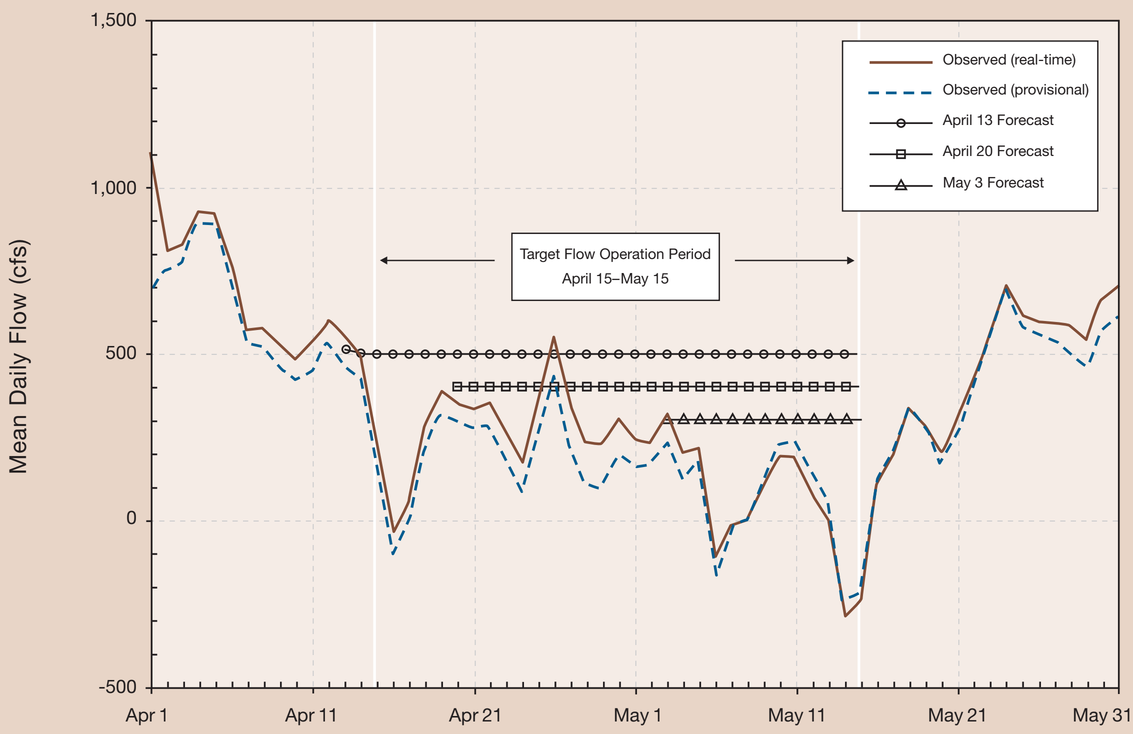


FIGURE 2-8

2004 VAMP–Ungaged Flow in San Joaquin River at Vernalis
Comparison of Forecasted and Observed



Flow, primarily due to a significant decline in the ungaged flows from that forecasted, causing the SJRGA to contribute an additional 13,521 acre-feet of supplemental water. During the target flow period, no adjustments were made to the New Melones Reservoir water quality or scheduled fishery flow releases, which are a component of the Existing Flow. Without further analysis it is unknown if any such adjustments would have been appropriate.

In planning for the VAMP operation the ungaged flow in the San Joaquin River at Vernalis is the most difficult factor to forecast for the test flow period. The daily operation plan is developed assuming a steady ungaged flow during the test flow period, but in reality there will be day to day fluctuations due to a number of unpredictable factors including weather, pre-existing conditions, irrigation operations, as well as mathematical uncertainties introduced by using mean daily flows and assumed travel times rounded to the nearest day. During the implementation phase of the VAMP operation, adjustments were made to the ungaged flow based not on day-to-day fluctuations but on evidence that the ungaged flow is trending away from the forecast. This is best illustrated in Figure 2-8, which shows in hindsight the observed ungaged flow along with that forecast prior to the test flow period on April 13 and the adjusted forecasts that were modified on an ongoing basis in an attempt to account for deviation from the existing forecast.

Another unknown in the forecast equation similar to the ungaged flow is the flow in the San Joaquin River upstream of the Merced River. This unknown tends not to be as variable as the ungaged flow, but like the ungaged flow, it may be adjusted if the observed flow warrants it. During the 2004 VAMP operation no modifications were made to the upper San Joaquin River flow forecast that was used in the April 13 daily operation plan. Figure 2-9 shows the observed and forecasted upper San Joaquin River flows.

The target combined CVP and SWP Delta export rate for the 2004 VAMP was 1,500 cfs. The observed export rate averaged 1,331 cfs during the VAMP target flow period. The daily SWP and CVP exports during the VAMP test period are shown in Figure 2-10.

The SJRGA member agencies have entered into an agreement, known as the Division Agreement, which allocates the responsibility of the member agencies for providing the VAMP supplemental water. The member agencies may also enter into additional agreements among themselves regarding delivery of the supplemental water. For the 2004 VAMP, Merced I.D. and the SJRECWA entered into an agreement whereby the SJRECWA supplemental water would be provided by Merced I.D. on the Merced River. The distribution of supplemental water for the 2004 VAMP operation, compared to the distribution called for under the Division Agreement, is summarized in Table 2-6.

Hydrologic Impacts

The Merced VAMP supplemental water is provided from storage in Lake McClure on the Merced River and the MID/TID VAMP

TABLE 2-6

Distribution of Supplemental Water

Agency	Supplemental Water Provided (acre-feet)	Division Agreement Distribution (acre-feet)	Deviation from Division Agreement (acre-feet)
Merced I.D.	37,680	36,500	+1,180
Oakdale I.D./South San Joaquin I.D.	11,760	14,091	-2,331
Exchange Contractors	5,000 [a]	5,000	0
Modesto I.D./Turlock I.D.	11,151	10,000	+1,151
Total	65,591	65,591	0

[a] The Exchange Contractors supplemental water was provided by Merced I.D.

FIGURE 2-9

2004 VAMP–San Joaquin River Above Merced River
Comparison of Forecasted and Observed

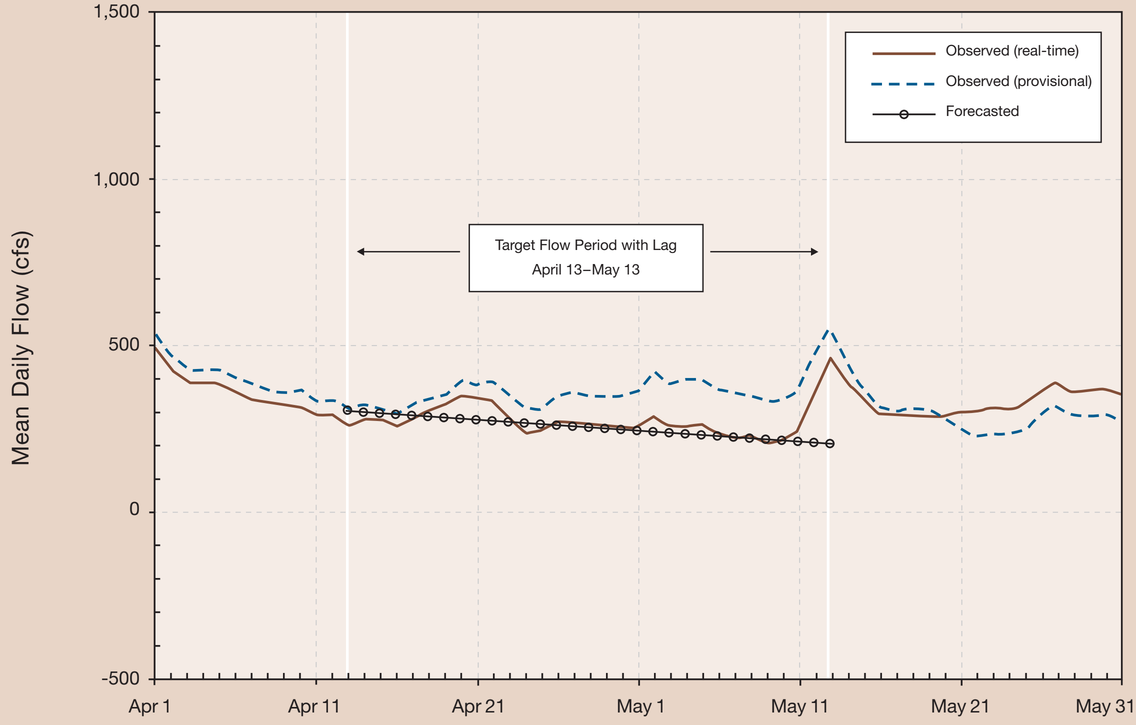
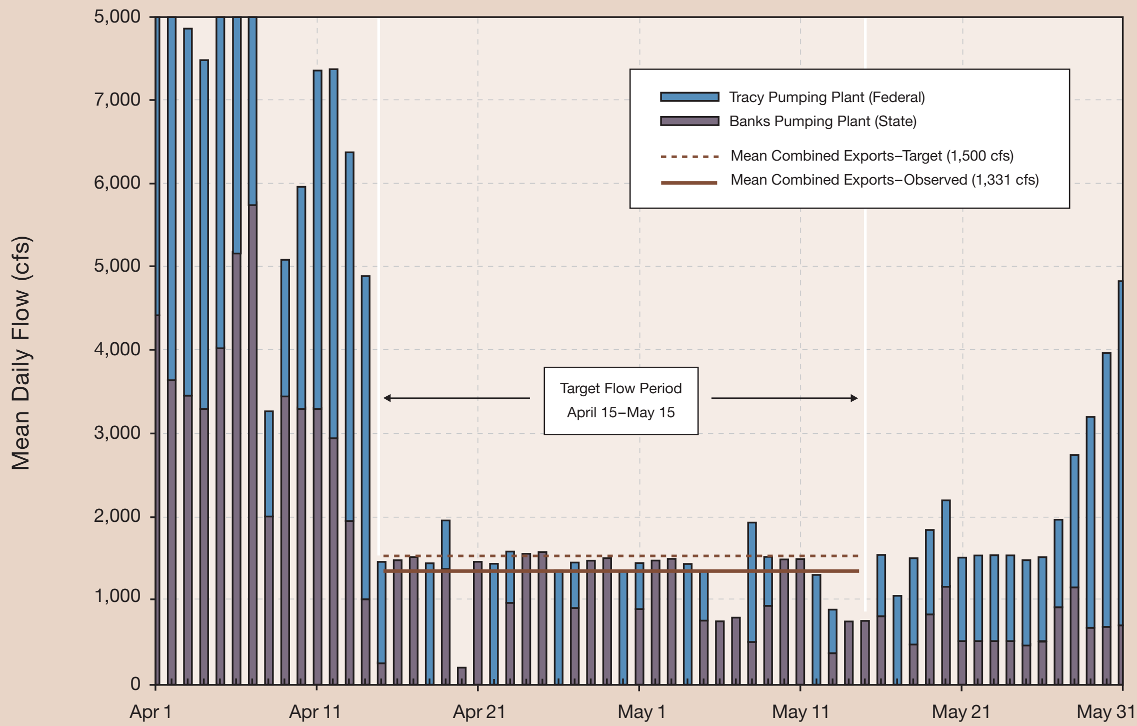


FIGURE 2-10

2004 VAMP–Federal and State Delta Exports



supplemental water is provided from storage in New Don Pedro Reservoir. 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 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.

The current cumulative impact of the SJRA on the storage in Lake McClure would be 215,197 acre-feet (Table 2-7), if Merced I.D. diversions from the Merced River are assumed to have been the same for both without and with SJRA conditions. However, as a result of the SJRA, Merced I.D. 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 D-1 (Appendix D). The impact of the conservation measures on Merced River diversions is in the process of being quantified and was not available at the time of publication of this report. The conservation impacts will be incorporated into next year's annual report. 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 period of 2000 through 2004 as shown in Figure D-3.

The cumulative impact of the SJRA on storage in New Don Pedro Reservoir following the 2003 VAMP operation was 23,790 acre-feet. This storage deficit was erased as a result of flood control operations in March 2004. Therefore, as a result of the 2004 VAMP operation the current impact of the SJRA on New Don Pedro Reservoir storage is 11,151 acre-feet (see Table 2-8).

The impacts of the SJRA on New Don Pedro Reservoir storage and on Tuolumne River flow for the period of 2000 through 2004 are shown in Appendix D, Figures D-2 and D-4.

SUMMARY OF HISTORICAL VAMP OPERATIONS

2004 marks the fifth year of VAMP operation in compliance with SWRCB Decision 1641. A summary of the VAMP target flows for these first five years is provided in Table 2-9. A summary of the SJRGA supplemental water contributions is provided in Table 2-10. The Hydrology Group monitors the cumulative impact of the SJRA on reservoir storage and stream flows. Plots of storage and flow impacts throughout the five years of VAMP operation are provided in Appendix D.

Over the first five 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. A table summarizing the differences between the forecasted and observed Existing Flows during the five years of VAMP implementation, along with the corresponding differences in the supplemental water requirements, is provided in Appendix D-5. An analysis of the variability in the upstream and ungaged flows and how these affect the computation of the Existing and supplemental flows is warranted.

TABLE 2-7

Storage Impact History, Lake McClure (Merced River)

Calendar Year	VAMP Supplemental Water (acre-feet)*	Fall Supplemental Water (acre-feet)	SJRA Storage Impact Replenishment (acre-feet)	End of Year Cumulative Storage Impact (acre-feet)**
2000	46,750	12,500	46,750 (May 2000)	-12,500
2001	43,146	12,496	0	-68,142
2002	27,120	12,470	0	-107,732
2003	39,586	12,500	0	-159,818
2004	42,879	12,500	0	-215,197

* Includes ramping flows.
** End of Year storage impacts not adjusted for conservation actions implemented by district.

CHAPTER 2

TABLE 2-8

Storage Impact History, New Don Pedro Reservoir (Tuolumne River)

Calendar Year	VAMP Supplemental Water (acre-feet)	SJRA Storage Impact Replenishment (acre-feet)	End of Year Cumulative Storage Impact (acre-feet)
2000	22,651	14,955 (Sept–Oct 2000)	-7,696
2001	14,061	7,696 (Jan–Feb 2001)	-14,061
2002	0	0	-14,061
2003	9,729	0	-23,790
2004	11,151	23,790 (March 2004)	-11,151

The SJRGA member agencies have entered into an agreement, known as the Division Agreement, which allocates the responsibility of the member agencies for providing the VAMP supplemental water.

TABLE 2-9

Summary of VAMP Flows, 2000-2004

Year	60-20-20 Water Year Hydrologic Classification	VAMP Target Flow (cfs)	Observed VAMP Flow (cfs)	Existing Flow (cfs)	VAMP Suppl. Water (acre-ft)	Delta Export Target (cfs)	Observed Delta Exports (cfs)
2000	Above Normal	5,700	5,869	4,800	77,680	2,250	2,155
2001	Dry	4,450	4,224	2,909	78,650	1,500	1,420
2002	Dry	3,200	3,301	2,757	33,430	1,500	1,430
2003	Below Normal	3,200	3,235	2,290	58,065	1,500	1,446
2004	Dry	3,200	3,155	2,088	65,591	1,500	1,331

TABLE 2-10

Summary of VAMP Supplemental Water Contributions, 2000-2004

Year	VAMP Supplemental Water (acre-ft)		Supplemental Water (acre-ft)					
			Merced ID	OID	SSJID	SJRECWA	MID	TID
2000	77,680	Observed:	46,750	[a]	[b]	8,280	15,200	7,450
		Division Agreement:	45,160	7,300	7,300	7,300	16,920	8,300
		Deviation:	+1,590	0	0	+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:	38,257	5,039	5,039	[c]	4,864.5	4,864.5
		Division Agreement:	38,065	5,000	5,000	5,000	5,000	5,000
		Deviation:	+192	+39	+39	0	-135.5	-135.5
2004	65,591	Observed:	42,680	5,880	5,880	[c]	5,575.5	5,575.5
		Division Agreement:	41,500	7,045.5	7,045.5	5,000	5,000	5,000
		Deviation:	+1,180	-1,165.5	-1,165.5	0	+575.5	+575.5

[a] Provided by Modesto ID
[b] Provided by Merced ID (54.55%), Oakdale ID (15.91%), Modesto ID (15.91%), Turlock (13.64%)
[c] Provided by Merced ID

CHAPTER 3

Additional Water Supply Arrangements & Deliveries

The SJRA includes a provision (Paragraph 8.4) stating that "Merced Irrigation District (Merced) 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." Pursuant to Paragraph 8.5 of the SJRA, "Oakdale Irrigation District (OID) shall sell 15,000 acre-feet of water to the USBR in every year of (the) Agreement…In addition to the 15,000 acre-feet, Oakdale will sell the difference between the water made available to VAMP under the SJRGA agreement and 11,000 acre-feet." This water 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

Paragraph 8.4 of the SJRA states that "Merced Irrigation District (Merced) 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." This 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 Merced ID.

The schedule for the 2004 Fall SJRA Transfer was finalized on September 28, 2004, with the transfer commencing on October 1, 2004. The transfer of the 12,500 acre-feet was completed by October 26, 2004. A daily summary of the final accounting for the 2004 Fall SJRA Transfer is provided in Appendix A, Table A-4.

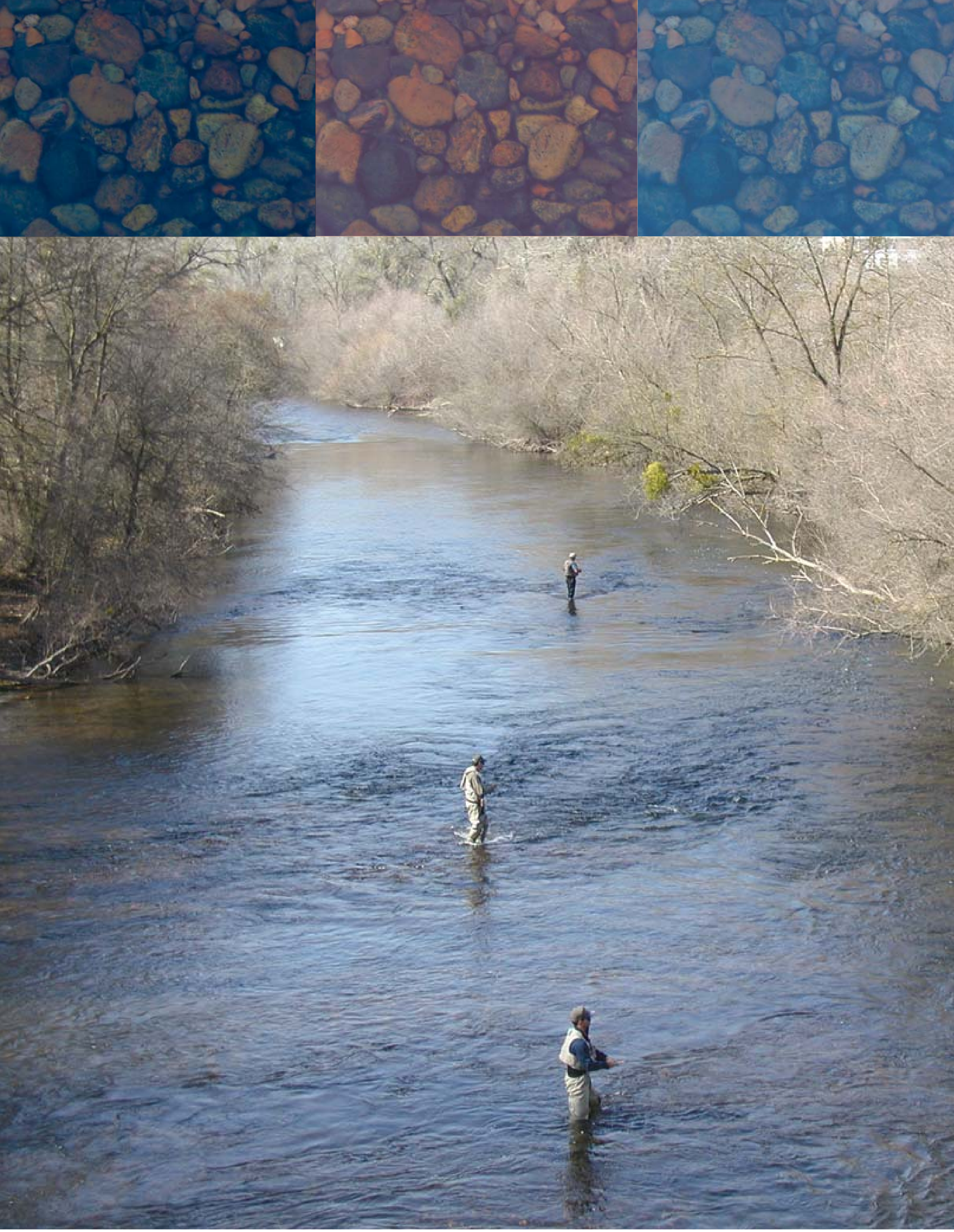
The 2003 Fall SJRA Transfer was in progress at the time of publication of the 2003 Annual Technical Report and therefore only preliminary data was provided in that report. The final data for the 2003 Fall SJRA Transfer are included in Appendix A, Table A-5 of this report.

OAKDALE IRRIGATION DISTRICT

Pursuant to Paragraph 8.5 of the SJRA, "Oakdale Irrigation District (OID) shall sell 15,000 acre-feet of water to the USBR in every year of (the) Agreement…In addition to the 15,000 acre-feet, Oakdale will sell the difference between the water made available to VAMP under the SJRGA agreement and 11,000 acre-feet." This water is referred to as the Difference Water.

OID provided 5,880 acre-feet of supplemental water for the 2004 VAMP operation, resulting in 5,120 acre-feet of Difference Water (11,000 minus 5,880). Therefore, pursuant to Paragraph 8.5 of the Agreement, OID sold a total of 20,120 acre-feet of water (15,000 plus 5,120) to the USBR in 2004. 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 USBR has used and has scheduled to be used the additional OID water as follows: 1,934 acre-feet was used to provide supplemental flow in the Stanislaus River from July 16, 2004 through July 21, 2004; 3,186 acre-feet is scheduled to be used to provide an additional 25 cfs per day of flow in the Stanislaus River from November 1, 2004 through January 3, 2005; 6,694 acre-feet was used to provide a pulse flow of 800 cfs in the Stanislaus River from October 24, 2004 through October 31, 2004; and 8,306 acre-feet is scheduled to be used to provide an additional 50 cfs in the Stanislaus River from November 1, 2004 until it runs out, around January 23, 2005.



CHAPTER 3

CHAPTER 4

Head of Old River Barrier

Installation of the spring temporary Head of Old River Barrier (HORB) was completed on April 9 with the initial operation commencing on April 15. Construction clean-up continued for a short period following the initial operation. The spring HORB is a component of the south delta Temporary Barriers Project (TBP). The TBP mitigates for low water levels in the south delta and improves water circulation and quality for agricultural purposes. The HORB, as currently configured and operated, is now fully permitted though 2005.

BARRIER DESIGN, INSTALLATION AND OPERATION

The spring HORB was first constructed in 1992. Since then, the barrier has been installed in 1994, 1996, 1997 (w/two culverts), 2000, 2001, 2002, 2003 and 2004. In 2000–2004 the barrier was installed with six culverts. The HORB was not installed in 1993, 1995 and 1998 due to high San Joaquin River flows. The HORB was not installed in 1999 due to landowner access problems. The HORB, a key component of VAMP, is intended to increase San Joaquin River Chinook salmon smolt survival by preventing them from entering Old River.

Beginning in 2001, the barrier design included two versions. A "low-flow" barrier, when San Joaquin River target flows are below 7,000 cfs, would be built to a height of 10 feet mean sea level (MSL). A "high-flow" barrier, for target flow of 7,000 cfs, would be built to a height of 11 feet MSL and additional material would be placed to raise the abutments to 13 feet MSL. Both barrier versions are equipped with six 48-inch diameter operable culverts and an overflow weir back-filled with clay. In 2004, the low-flow version was installed.

The dimensions of the 2004 HORB (Figure 4-1) were similar to the 2000, 2001, 2002 and 2003 HORB. The base width of the HORB in 2004 was 100 feet and the crest elevation was 10 feet MSL. The top of HORB was constructed with a 75-foot wide notch, protected with concrete grid mats and back-filled with clay. The HORB was designed to safely operate with flows corresponding to stages up to 8.5 feet MSL.

To help mitigate anticipated low water levels in the south delta (downstream of the HORB) caused by the operation of the HORB, two open culverts were installed in the barrier beginning in 1997, and six operable culverts were installed beginning in 2000. Operation of the culverts is controlled using slide gates located on the upstream side of HORB. DWR relied on daily modeling and field data collection to monitor water levels at three locations within the south Delta to determine when and how long to operate the culverts. Generally, the model forecasts would tend to forecast low-low water levels lower than actual levels observed in the field. Consequently, DWR takes this into consideration when making decisions regarding the culvert operations.

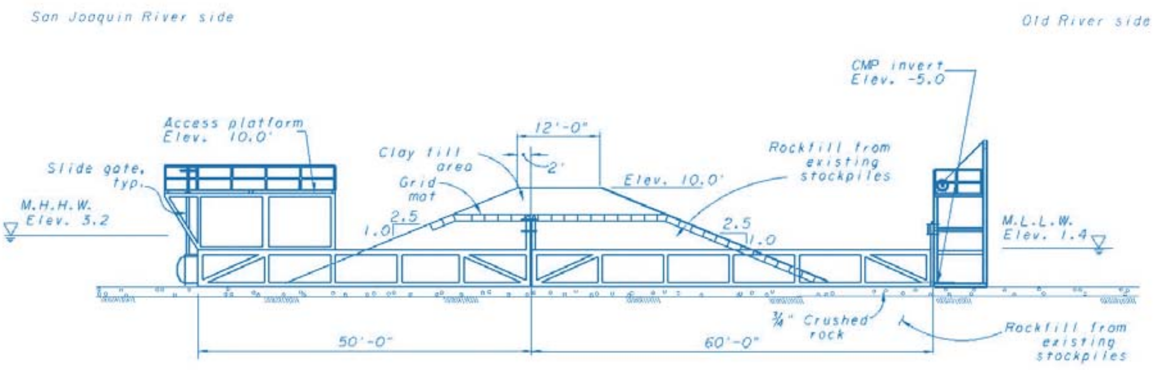
The downstream outlet of each culvert was designed so fyke nets could be attached to evaluate fish passage. DFG staff conducted a fishery-monitoring program as part of the 2004 HORB operations.

Permitting and Construction

The various permit conditions that are placed on the Temporary Barriers Program by the USFWS, National Marine Fisheries Service (NOAA), and DFG, require that the earliest in-water construction activities begin on the Head of Old River (HOR), Middle River (MR), and Old River at Tracy (ORT) barriers, during the Spring barrier installation period, no earlier than April 7. In addition, construction of the northern abutment and boat ramps of the Grant Line Canal (GLC) barrier and construction of out-of-water portions of the HOR, MR, and ORT barriers may not be started any earlier than April 1. Full closure of the GLC

FIGURE 4-1

Spring Head of Old River Barrier Cross Section



barrier is not required but construction of the north abutment and boat ramps must be completed to the extent that full barrier closure and operation can be readily achieved in a reasonable time frame, if and when directed by DWR. The permit conditions also require that all the above work be completed by April 15th, a total of 15 working days. Following is a brief summary of the various permit conditions:

USFWS Biological Opinion (1-1-01-F-81)
(item and page of referenced report)

1) The spring HORB barrier installation may begin on April 1 but in-water work shall not occur until April 7, except for construction necessary to place the scour pad and the pad for the culverts *(item No. 8, page 6);*
2) DWR may begin construction of the Middle River barrier on April 1 but in-water work shall not occur until after April 7 *(item No. 1, page 4);*
3) DWR may begin construction of the Old River at Tracy barrier on April 1 but in-water work shall not commence before April 7 *(item No. 2, page 4);*
4) DWR may begin construction of the northern abutment and the boat ramp of the GLC barrier on April 1 provided that the HOR barrier is being constructed concurrently *(item No. 3, page 5).*

NOAA Biological Opinion (SWR-00-SA-289: MEA on the proposed ACOE permit (200000696))
(item and page of referenced report)

1) The spring HORB installation shall begin on April 1 *(item 8, page 8);*
2) The MR barrier construction may begin on April 7 *(item 1, page 6);*
3) The ORT barrier construction may begin on April 1 *(item 2, page 6);*
4) The northern abutment and boat ramp of the GLC barrier may begin construction on April 1 provided that the HORB is being constructed concurrently *(item 3, page 7).*

DFG 1601 – HORB (2081-2001-009-BD)

1) HORB Spring Installation – All work in or near the stream zone will be confined to the period beginning no earlier than April.
2) DFG 1601 – Agricultural Barriers

   MR – All work in or near the stream zone will be confined to the period beginning no earlier than March 1

   ORT – All work in or near the stream zone will be confined to the period beginning no earlier than April 1

   GLC – All work in or near the stream zone will be confined to the period beginning no earlier than April 1

In addition to the above conditions, water users of the South Delta Water Agency (SDWA) and the fisheries agencies impose separate mitigation requirements on DWR for installation and operation of the HORB by itself. As a result, DWR's contractor must sequentially close and start operation of the MR and ORT barriers, and complete as much construction of north abutment and boat ramps on the GLC barrier as possible, before they can close and operate the HORB.

From the contractors point of view there are really two milestones that must be completed in sequence. First and foremost is to obtain closure and operation of the barriers in accordance

TABLE 4-1
HORB Culvert Gate Status

Date	Culvert Number					
	1	2	3	4	5	6
4/14/04	x	x	x	O	O	O
4/15/04	x	x	x	O	O	O
4/16/04	x	x	x	O	O	O
4/17/04	x	x	x	O	O	O
4/18/04	x	x	x	O	O	O
4/19/04	x	x	x	O	O	O
4/20/04	x	x	x	O	O	O
4/21/04	x	x	x	O	O	O
4/22/04	x	x	x	O	O	O
4/23/04	x	x	x	O	O	P
4/24/04	x	x	x	O	O	P
4/25/04	x	x	x	O	O	P
4/26/04	x	x	x	O	O	P
4/27/04	x	x	x	O	O	P
4/28/04	O	x	O	O	P	P
4/29/04	O	x	O	O	O	O
4/30/04	O	x	O	O	O	O
5/01/04	O	x	O	O	O	O
5/02/04	O	x	O	O	O	O
5/03/04	O	x	O	O	O	O
5/04/04	O	x	O	O	O	O
5/05/04	O	x	O	O	O	O
5/06/04	O	x	O	P	O	O
5/07/04	O	x	O	P	O	O
5/08/04	O	x	O	P	O	O
5/09/04	O	x	O	P	O	O
5/10/04	O	x	O	P	O	O
5/11/04	O	x	O	P	O	O
5/12/04	O	x	O	P	O	O
5/13/04	O	x	O	P	O	O
5/14/04	P	x	O	P	O	O
5/15/04	P	x	O	P	O	O
5/16/04	P	x	O	P	O	O
5/17/04	P	x	O	P	O	O
5/18/04	P	x	O	P	O	O

O Open   P Partially Open   x Closed

with the conditions imposed by the project permits/biological opinions and mitigation requirements. The second is to satisfy DWR's contract specifications. The first milestone can be achieved within the required 15 working days but it is unlikely that the contractor can complete the entire amount of work required to satisfy DWR's contract specifications within the same time period.

Therefore, the contractor's construction activities consist of placing enough materials to make sure they obtain closure and operation by April 15th, then following closure they continue placing barrier material above the water line until barrier construction is completed in accordance with DWR's contract specifications. The contractor continued work above the water beyond April 15 to cleanup the site and to demobilize.

Barrier Operations and Monitoring Plan

A barrier operations and monitoring plan was developed based on forecasting and monitoring of tidal conditions. DWR determined the number of culverts to be opened at the HORB so that water levels at Old River near Tracy Road Bridge and Grant Line above Doughty Cut would remain above 0.0 feet MSL and Middle River near Howard Road above 0.3 feet MSL. Based on modeling results and/or field monitoring of water levels in the south delta, three of the six culverts remained open from April 15 until May 19, 2004. Graphical results of the water level modeling are presented in Appendix B. On April 28, 2004 two additional culverts were opened and remained open until May 19, 2004. The sixth culvert slide gate (number 2 culvert) was stuck shut throughout the period the HORB was in place. A summary table of the culvert operation is provided in Table 4-1. Removal of the HORB commenced on May 19, 2004 and was completed by June 10, 2004.

Flow Measurements At and Around Barrier

DWR operates two Acoustic Doppler Current Meters (ADCM) in the vicinity of the HORB, one in the San Joaquin River 1,300 feet downstream of Old River and one in Old River 840 feet downstream of the HORB. The ADCMs record velocity measurements at a 15 minute interval from which flow values can be determined. Table 4-2 lists the daily mean, maximum and minimum flows for the April 1, 2004 through May 31, 2004 period for the two ADCMs. Both ADCMs suffered from technical difficulties that resulted in gaps in the available data for this period. The San Joaquin River below Old River ADCM had an internal battery failure that prevented data collection from April 6 at 18:15 through May 3 at 11:30. The Old River at Head ADCM

TABLE 4-2

Summary of Flows at DWR Acoustic Doppler Current Meters near HORB

Date	San Joaquin River below Old River				Old River below HORB (Old River at Head)			
	Number of Records	Mean Flow (cfs)	Maximum Flow (cfs)	Minimum Flow (cfs)	Number of Records	Mean Flow (cfs)	Maximum Flow (cfs)	Minimum Flow (cfs)
4/01/04	95	158	1,573	-1,547	(b)			
4/02/04	96	427	1,603	-1,262	(b)			
4/03/04	96	487	1,709	-1,281	(b)			
4/04/04	96	554	1,724	-1,171	(b)			
4/05/04	96	555	1,731	-1,262	(b)			
4/06/04	72		1,681	-1,221	(b)			
4/07/04	(a)				(b)			
4/08/04	(a)				(b)			
4/09/04	(a)				(b)			
4/10/04	(a)				(b)			
4/11/04	(a)				(b)			
4/12/04	(a)				(b)			
4/13/04	(a)				(b)			
4/14/04	(a)				(b)			
4/15/04	(a)				(b)			
4/16/04	(a)				(b)			
4/17/04	(a)				(b)			
4/18/04	(a)				(b)			
4/19/04	(a)				(b)			
4/20/04	(a)				(b)			
4/21/04	(a)				(b)			
4/22/04	(a)				(b)			
4/23/04	(a)				(b)			
4/24/04	(a)				(b)			
4/25/04	(a)				(b)			
4/26/04	(a)				(b)			
4/27/04	(a)				(b)			
4/28/04	(a)				(b)			
4/29/04	(a)				(b)			
4/30/04	(a)				(b)			
5/01/04	(a)				(b)			
5/02/04	(a)				(b)			
5/03/04	49		3,293	2,099	40		531	402
5/04/04	96	2,530	3,217	1,337	96	449	522	319
5/05/04	96	2,551	3,353	1,156	96	452	537	300
5/06/04	96	2,498	3,383	905	96	449	540	273
5/07/04	96	2,516	3,424	1,069	96	449	545	290
5/08/04	96	2,483	3,298	961	96	444	531	279
5/09/04	96	2,537	3,303	1,144	96	447	532	299
5/10/04	96	2,656	3,430	1,605	96	459	545	348
5/11/04	96	2,696	3,258	2,033	96	465	527	395
5/12/04	96	2,616	3,116	1,881	96	457	512	378
5/13/04	96	2,557	3,084	1,550	96	449	502	342
5/14/04	96	2,454	3,018	1,480	96	441	508	335
5/15/04	96	2,302	2,936	1,133	96	425	494	297
5/16/04	96	2,241	3,017	858	96	417	501	268
5/17/04	96	2,269	3,141	678	96	420	514	248
5/18/04	95	2,314	3,122	1,085	95	426	512	292
5/19/04	96	2,139	3,001	736	96	410	499	254
5/20/04	96	1,966	2,920	438	96	391	490	222
5/21/04	96	1,602	2,845	51	96	359	482	181
5/22/04	96	860	2,099	-970	9		334	185
5/23/04	96	826	2,107	-919	(c)			
5/24/04	96	686	1,898	-963	(c)			
5/25/04	96	508	1,760	-1,206	(c)			
5/26/04	96	421	1,632	-1,241	(c)			
5/27/04	96	438	1,489	-1,354	(c)			
5/28/04	96	400	1,530	-1,416	(c)			
5/29/04	96	368	1,501	-1,580	(c)			
5/30/04	96	301	1,467	-1,548	(c)			
5/31/04	96	274	1,589	-1,565	(c)			

[a] Internal battery failure.
[b] Meter inoperable while awaiting replacement equipment.
[c] Newly installed equipment unable to log data to data logger.

TABLE 4-3

Estimation of Total Flow Through HORB Culverts

Date	Culvert #4 Measured Flow (cfs)	Number of Fully Open Culverts [1]	Number of Partially Open Culverts [2]	Total Estimated Flow Through Culverts (cfs) [3]
4/14/04	51	3	0	204
4/15/04	65	3	0	204
4/16/04	73	3	0	204
4/17/04	73	3	0	204
4/18/04	77	3	0	204
4/19/04	81	3	0	204
4/20/04	73	3	0	204
4/21/04	72	3	0	204
4/22/04	68	3	0	204
4/23/04	75	2	1	156
4/24/04	73	2	1	156
4/25/04	76	2	1	156
4/26/04	77	2	1	156
4/27/04	72	2	1	156
4/28/04	66	3	2	244
4/29/04	67	5	0	340
4/30/04	62	5	0	340
5/01/04	64	5	0	340
5/02/04	63	5	0	340
5/03/04	62	5	0	340
5/04/04	61	5	0	340
5/05/04	59	5	0	340
5/06/04	62	5	0	340
5/07/04	30	4	1	292
5/08/04	21	4	1	292
5/09/04	21	4	1	292
5/10/04	21	4	1	292
5/11/04	22	4	1	292
5/12/04	22	4	1	292
5/13/04	22	4	1	292
5/14/04	21	3	2	244
5/15/04	20	3	2	244
5/16/04	19	3	2	244
5/17/04	19	3	2	244
5/18/04	18	3	2	244

[3] = [1] x A + [2] x B

A = Flow through fully open culvert. Assumed equal to average of measured flow through culvert #4 while fully open (4/14/04 through 5/06/04) = 68 cfs

B = Flow through partially open culvert. Assumed equal to average of measured flow through culvert #4 while partially open (5/08/04 through 5/18/04) = 20 cfs

TABLE 4-4

Estimate of Seepage Flow Through HORB

Date	Flow in Old River below HORB (Old River at Head ADCM) (cfs) [1]	Total Estimated Flow Through Culverts (cfs) [2]	Estimated Seepage Through HORB (cfs) [3] = [1] - [2]
5/04/04	449	340	109
5/05/04	452	340	112
5/06/04	449	340	109
5/07/04	449	292	157
5/08/04	444	292	152
5/09/04	447	292	155
5/10/04	459	292	167
5/11/04	465	292	173
5/12/04	457	292	165
5/13/04	449	292	157
5/14/04	441	244	197
5/15/04	425	244	181
5/16/04	417	244	173
5/17/04	420	244	176
5/18/04	426	244	182

was out of service April 1 through May 3 at 14:00 while awaiting replacement parts, and then again from May 22 at 02:15 through May 31 due to a technical problem that prevented it from logging data to the data logger.

Similar to 2003, DWR installed a Doppler “Argonaut” flow measuring device inside culvert #4. Data was recorded every 15 minutes during the period when the HORB was in operation. The flow through a completely submerged culvert is primarily dependent on the water levels at the two ends of the culvert, but is also dependent on culvert inlet geometry, slope, size and roughness. If it is assumed that all of these factors are similar for all six of the culverts, then the measured flow in culvert #4 would be a reasonable estimate of the flow in each of the other culverts. Table 4-3 summarizes the measured mean daily flows in culvert #4 and the estimation of the total flow through all of the culverts.

Since the HORB is a rock barrier there is also an unknown amount of seepage through it. The seepage through the HORB can be estimated as the difference between the measured flow at the Old River at Head ADCM and the estimated flow through the HORB culverts. For the period when both those flow records are available, May 4 through May 18, the estimated mean daily seepage averaged 152 cfs with a range of 103 cfs to 190 cfs (Table 4-4).

Barrier Emergency Response Plan

In addition to the operation and monitoring plan, DWR has also prepared an "Emergency Operations Plan for the Spring HORB". The plan provided that if the daily measured or forecasted flow at Vernalis exceeded a flow that would correspond to stage at the HORB of 10.0 feet MSL, and the stage was likely to exceed 11.0 feet MSL (the height of the barrier under the "high-flow" target), the barrier would be removed. Vernalis flows and stages at the barrier were not high enough in 2004 to warrant action under the emergency operations plan.

Seepage Monitoring

A seepage-monitoring program was initiated in April 2000 and continued this year, to evaluate the effects of HORB operations on seepage and groundwater on Upper Roberts Island.

Three seepage monitoring well sites were chosen in 2000 on Upper Roberts Island. Each site has two shallow wells, positioned 10 feet and 100 feet from the toe of the levee to monitor the seepage gradient to and from the San Joaquin River. In addition, a deeper well was drilled at Site 1 (near the Head of Old River) to determine vertical gradients.

In addition to the groundwater monitoring wells, a gage was installed in April 2000 to record water surface elevations in the San Joaquin River, about 1,500 feet downstream of the HORB. Installation of a permanent tide gage was completed in early 2002; this station is now rated and generating flow data. The water surface elevations in the San Joaquin River are compared to groundwater levels on Upper Roberts Island to determine how groundwater levels change relative to changing water level conditions in the river.

In November 2002, DWR completed a Memorandum Report "Reclamation District 544 Seepage Monitoring Study 2001–2002". This is an ongoing study to document the seepage monitoring results from Upper Robert Island (Souverville, 2004). DWR also released the latest annual (2002–2003) report. Based on the 2000, 2001 and 2002–2003 data, it is apparent that the San Joaquin River stage influences groundwater levels on Upper Roberts Island. When stage increases in the river, groundwater levels will rise toward the land surface, but not as rapidly as the river stage rises. However, over the monitoring period, river stage did not reach levels sufficient to raise groundwater levels to the point where seepage into crop root zones might occur.

Given the results of the seepage monitoring since April 2000, DWR expects that if a VAMP target flow of 7,000 was implemented, stages near the HORB would rise to about 7 1/2 to 8 feet MSL. This would translate to groundwater levels in the monitoring well closest to the levee of about 6 1/2 to 7 feet MSL. Because the ground surface elevation is 13 feet MSL near site 1, DWR concludes that seepage should not impact the root zone of crops that could be planted in this area.

The monitoring program will be continued in order to gather more data, particularly during high flow periods in the spring.

FISHERY MONITORING AT THE HEAD OF OLD RIVER BARRIER

All six culverts in the Head of Old River Barrier (HORB) were installed for the 2004 VAMP test period, although the number of culverts open varied throughout the period. The six culverts are installed to maintain water quality and water levels in the south Delta, downstream of the HORB. Since the culverts are not screened, juvenile Chinook salmon and other fish species that pass near the culverts are vulnerable to entrainment. A fish

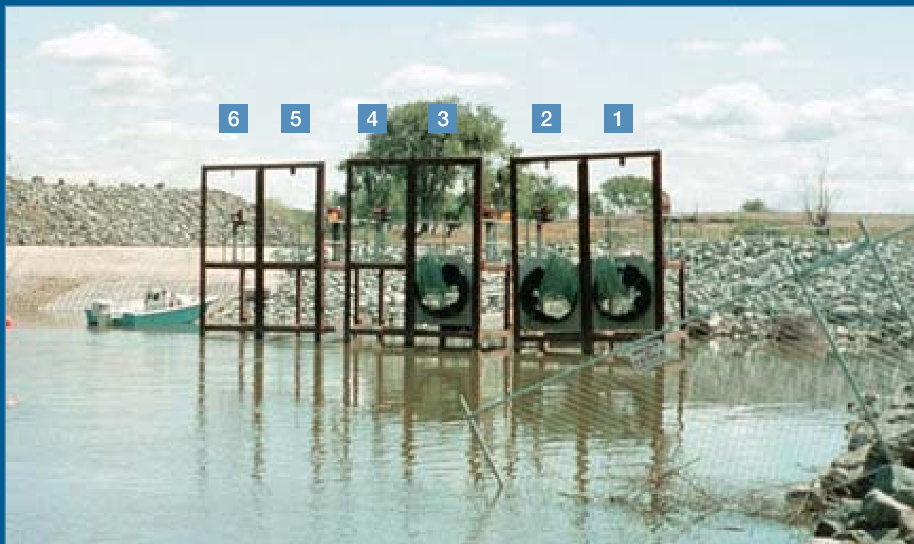
monitoring program was designed and implemented by the DFG to evaluate and quantify fish entrainment at the HORB. The specific objectives of the 2004 fishery investigations were to:

- Determine the total number of juvenile Chinook salmon and other fish species entrained through the culverts at the HORB (Entrainment Monitoring); and
- Determine the percentage of coded-wire tagged (CWT) salmon, released at Mossdale and Durham Ferry, entrained into Old River (Entrainment Monitoring).

Results from these fishery investigations are intended, in part, to provide information on the design and operation of a future permanent operable barrier at the Head of Old River.

FIGURE 4-2

Culverts in the HORB



Culverts in the HORB were numbered from 1 to 6, with number 1 closest to shore. Culvert number 1 through 3 were closed initially but were opened 8 days later.

CHAPTER 4

Material and Methods

As part of the 2004 VAMP studies, approximately 106,000 CWT salmon were released at Durham Ferry on April 22 and approximately 78,000 CWT salmon were released at Mossdale on April 23. Unlike in previous years, there was no replicate set of CWT releases the following week. Salmon from the VAMP releases were used in the Entrainment Monitoring studies. The secondary Entrainment Special Study was discontinued in 2004, therefore no color-marked salmon were released directly upstream of the HORB.

Fish entrained into the culverts were caught with fyke nets. The nets have a 48-inch cylindrical mouth tapering down to a 1-foot square cod-end, and are made of 1/4-inch braided mesh. Five of the six nets are 60 feet long and one net is 40 feet long. A live-box (15.5 x 19.5 x 36 inches), constructed of perforated aluminum sheet metal, was attached to the cod-end of each net. Each live-box has an aluminum baffle designed to reduce water velocities within the live-box and improve survival of captured fish. The culverts were numbered from 1 to 6 with number 1 located next to the shoreline (viewed from downstream) and number 6 located mid-channel (Figure 4-2). On April 20, the nets were attached to culvert numbers 4, 5 and 6 by closing the culvert slide gates on the upstream side of the barrier, raising the flanges that slide over the culvert outfalls, and then strapping the nets over the flanges. The flanges, with the attached fyke nets, were lowered down to the culvert outfalls and the live-boxes were attached to the cod-end of the nets. Sampling began on the night of April 20. On the evening of April 28, fyke nets were attached to culvert numbers 1, 2 and 3 using the same technique. However, only culvert numbers 1 and 3 were opened that night. Culvert number 2 remained closed throughout the test period due to a malfunction in the slide gate.

The fyke nets were checked on every tide change until May 14, when the nets were removed from the culverts. The nets were checked by closing the culvert slides gate for about 30 minutes, which enabled personnel to pull the live-boxes onto a boat. Fish were removed from the live-boxes and placed into buckets. Once all the nets had been checked and reset, the collected fish were processed. All the fish were identified and counted. Salmon were checked for a clipped adipose fin and for the presence of a color-mark on the dorsal, anal, or caudal fin. Salmon that had a clipped adipose fin were saved for CWT processing. The color and location of the dyed fin was noted for each color-marked salmon. A maximum of 50 CWT and unmarked salmon fork lengths (mm) were recorded per live-box. Culvert number, date, time, water temperature, tidal stage, and diel-period were recorded for each net check. Except for CWT smolts, all processed fish were released downstream of the fyke nets into Old River.

Loss indices for CWT salmon released as part of the VAMP survival studies at Durham Ferry and Mossdale were calculated using data collected from April 20 to May 14. The loss index rep-

resents the percentage of CWT salmon entrained into the HORB culverts. The loss index (I) is calculated using the equation:

$$I = (TC/TR)$$

where:

TC = Total number of CWT salmon collected in the fyke nets

TR = Total number of CWT released

Catch-Per-Unit-Effort (CPUE) for salmon was calculated as the number of fish collected per hour per culvert.

RESULTS

The HORB was closed on April 15; however, construction on the barrier continued into the following week. The DFG monitored the HORB culverts for 26 days, for approximately 2,450 hours, and collected 422 samples. Although the nets were attached

to the open culverts for the entire test period, not all of the culverts were functioning properly. Mechanical breakdowns of the slide gates resulted in the partial opening of some of the gates throughout the monitoring period (Table 4-1). On April 20, the slide gates on culverts number 4, 5, and 6 were opened to maintain water levels downstream of the HORB. On April 23, prior to the Mossdale salmon release, the gear-box on slide gate number 6 became stripped and failed. The slide gate remained near the closed position until it was repaired the following week. All six culverts were scheduled to be opened on April 28 to maintain water levels downstream of the HORB. Failure of the operating mechanism on gate number 2 caused it to remain closed throughout the remainder of the test period. The slide gate gear box on culvert number 4 failed on May 6 and the gear-box on culvert number 1 failed on May 14.

Almost 8,000 fish were collected representing at least 29 species from 14 families of fish. No delta smelt *(Hypomesus transpacificus),* one juvenile steelhead *(Oncorhynchus mykiss),* and 22 adult splittail *(Pogonichthys macrolepidotus*) were collected. The most abundant species was white catfish *(Ictalurus catus),* followed by Chinook salmon and channel catfish *(Ictalurus punctatus)* (Table 4-5). Of the 1,805 salmon caught; 1,034 had a CWT; 756 were unmarked; and 15 had a color-mark (from fishery studies being conducted in the tributaries). Overall, the number of salmon entrained per hour (0.7) was lower than it was in the past three years (3.4 in 2003; 2.5 in 2002; 1.4 in 2001). Fork lengths were similar between the CWT (85 ± 5.8 mm) and unmarked (83 ± 8.6 mm) salmon.

Salmon smolts were caught throughout the monitoring period (Figure 4-3). Most of the VAMP-released salmon were caught within two days of their release. CWT salmon entrainment was the highest on the night of April 23, especially for Mossdale released salmon (Figure 4-4). The highest CPUEs for VAMP-released fish occurred on April 23: a CPUE of 29.2 fish/hour/culvert. The average unmarked salmon CPUE for the entire monitoring period was 0.3 ± 0.8 fish/hour/culvert. The highest unmarked salmon CPUE (7.0 fish/hour/culvert) occurred on May 9. The loss indices for Durham Ferry and Mossdale releases were each 0.4%. The overall loss index for VAMP CWT salmon was also 0.4%. This year, only one set of VAMP salmon releases occurred. As a result, comparisons will only be made between the one release this year and the first set of salmon releases in previous years. This year's overall loss index was lower than the last two years' loss indices (0.9% in 2003 and 1.4% in 2002) but similar to the 2001 loss index of 0.4%.

Initial entrainment of CWT salmon was similar to the 2002 results. Entrainment was highest in culvert number 4 and lowest in culvert number 6 (Figure 4-5). This is in contrast to 2003 when CWT salmon entrainment was highest in culvert number 6 and lowest in culvert number 4. The unmarked salmon had similar entrainment among the three culverts initially (Figure 4-5). However, once the other culverts were open on April 28, culvert number 6 entrained at least twice as many salmon as the other four culverts (Figure 4-6). More VAMP salmon were entrained at night (650) than during the day (127). Likewise, more unmarked salmon were entrained at night (600) than during the day (157).

TABLE 4-5

The raw abundance and composition of fishes entrained at the HORB in 2004. Chinook salmon catch is divided into CWT salmon, unmarked salmon and color-marked salmon.

Species	Catch
American Shad	1
Prickly Sculpin	1
Red Shiner	1
Sacramento Blackfish	1
Sacramento Pikeminnow	1
Steelhead	1
Golden Shiner	2
Goldfish	2
Tule Perch	2
Petromyzontidae Spp	3
Hitch	4
Shimofury Goby	5
Green Sunfish	7
Black Crappie	8
Largemouth Bass	8
Bigscale Logperch	8
Carp	17
Striped Bass	21
Splittail	22
Ameiurus Spp	30
Redear Sunfish	30
Inland Silverside	54
Sacramento Sucker	87
Bluegill	126
Threadfin Shad	222
Channel Catfish	258
White Catfish	5,235
Total Chinook Salmon	1,805
CWT VAMP Salmon	777
CWT NonVAMP Salmon	257
Unmarked Salmon	756
Color-Marked Salmon	15
Total	7,962

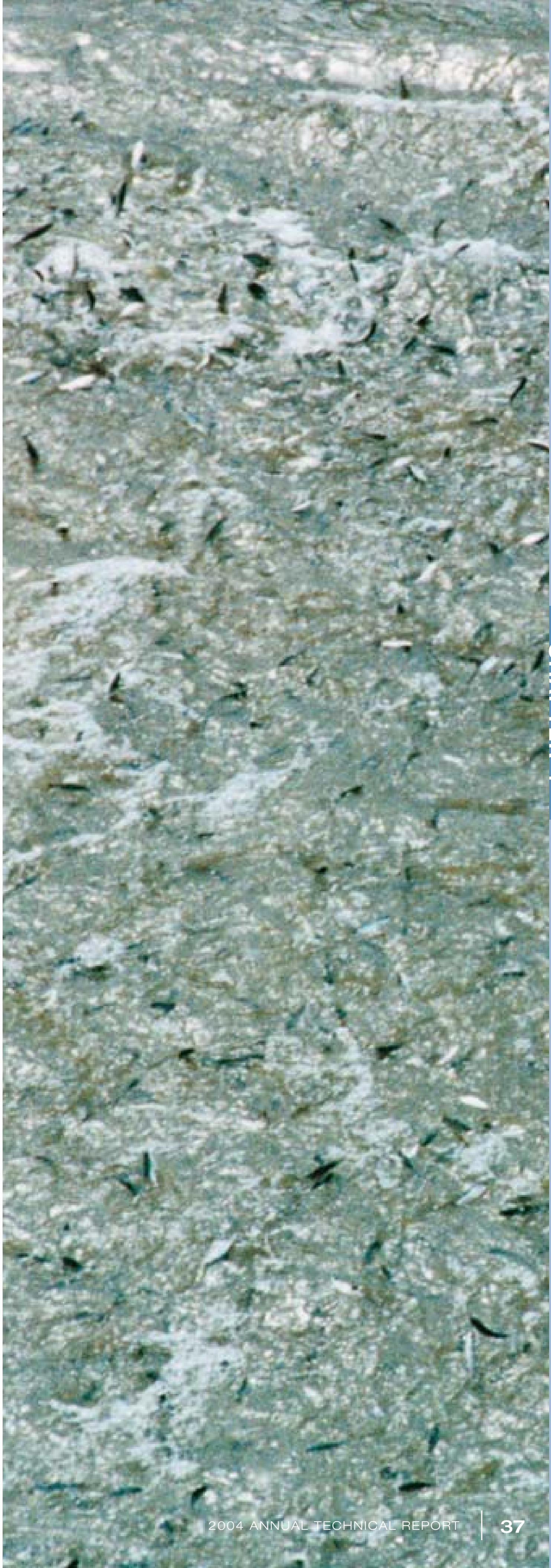


FIGURE 4-3

The daily average number of salmon entrained per culvert hour at the HORB in 2004. The catch is divided into coded wire tagged salmon (CWT) and unmarked salmon.

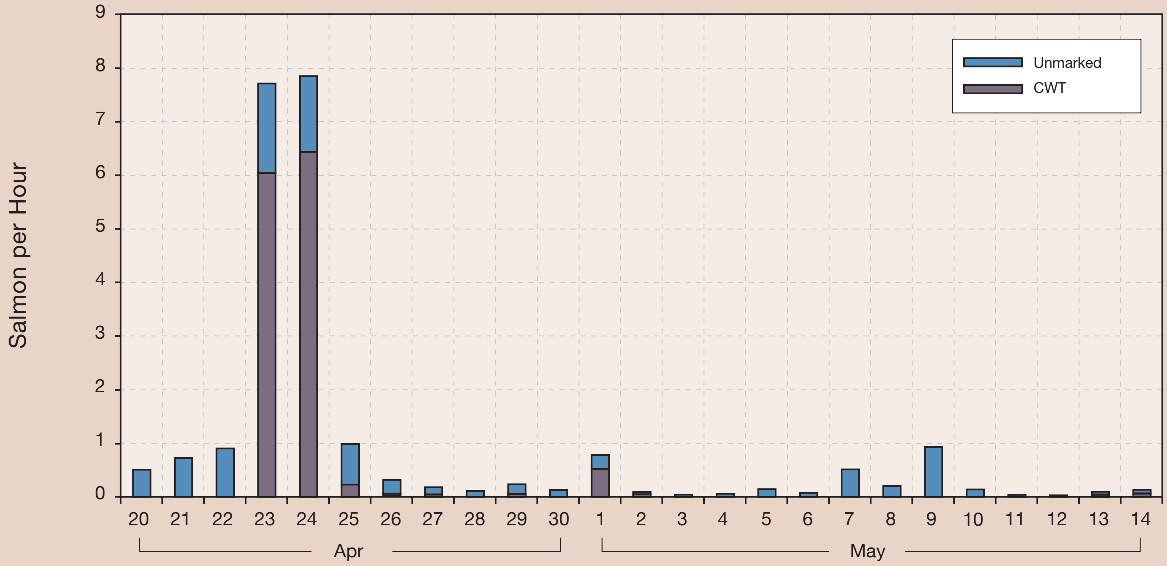


FIGURE 4-4

VAMP CWT salmon entrainment at the HORB. Salmon releases are indicated by the dashed lines. River stage at Old River is represented by the solid line.

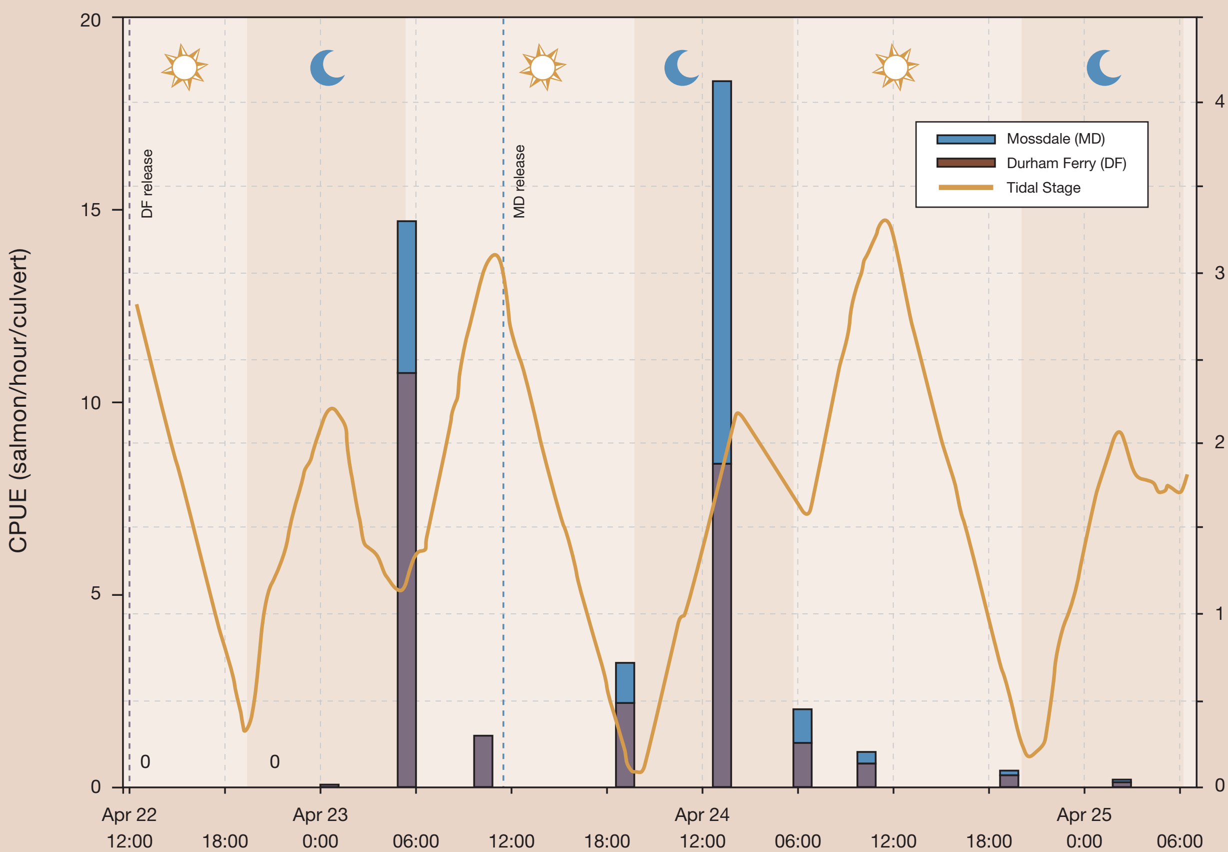


FIGURE 4-5

The total number of Unmarked, Mossdale and Durham Ferry salmon caught, by culvert, for the first eight days of monitoring: April 20 to April 28, 2004. Culverts 1–3 were closed during this time.

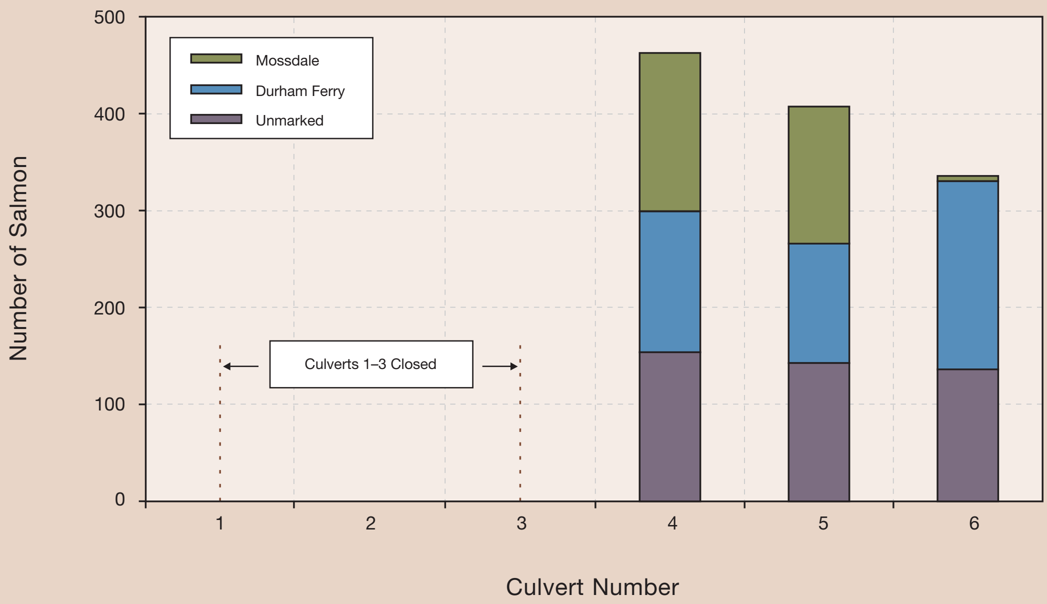


FIGURE 4-6

The total number of Unmarked, Mossdale and Durham Ferry released salmon caught, by culvert, from April 28 to May 14, 2004 when all 6 of the culverts were scheduled to be open. Culvert 2 broke and was never opened.

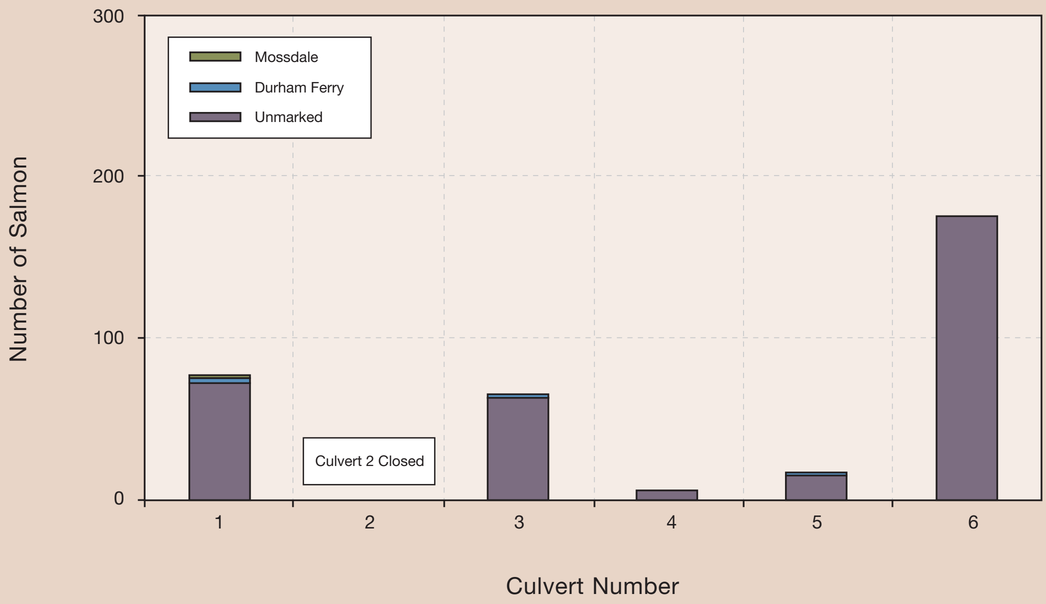
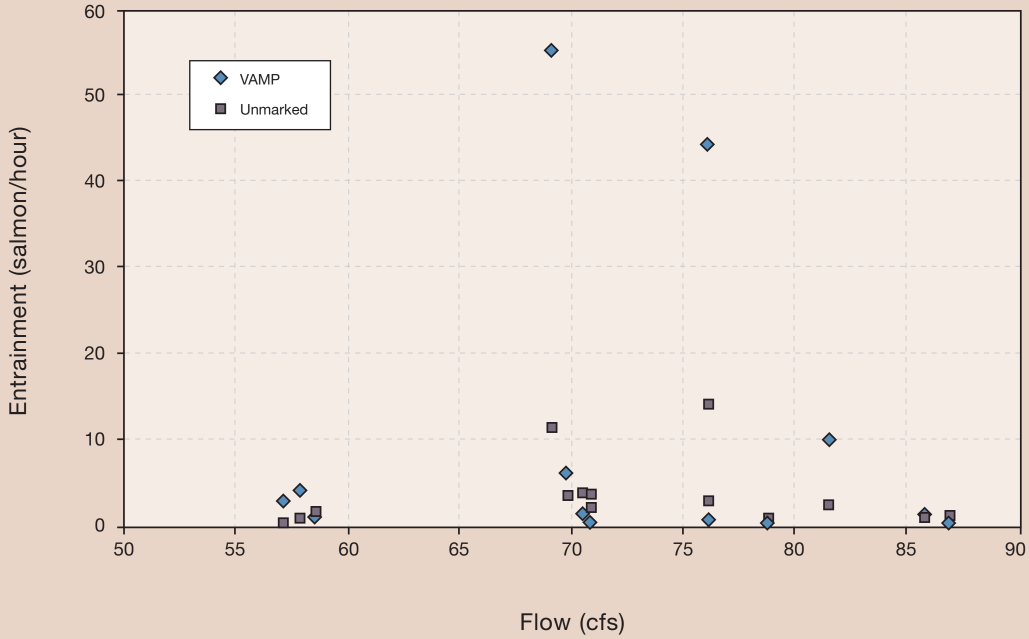


FIGURE 4-7

The relationship between flow and salmon entertained in culvert 4 from midnight April 23 to 8:45 am on April 26, 2004



CHAPTER 4

This is similar to 2002 when about 75% of both the VAMP and unmarked salmon were caught at night. Approximately 52% of the VAMP salmon and 43% of the unmarked salmon were entrained on the flood tide in 2004.

DWR installed a flow meter in culvert number 4. Flow data for culvert number 4 was recorded throughout the monitoring period (Table 4-3). Due to low salmon entrainment, entrainment-flow analyses were limited to the period when most VAMP salmon passed by the barrier: from midnight on April 23 to 8:45 am on April 26. Simple linear regression analysis indicated CWT salmon showed no significant relationship between entrainment and flow (degrees of freedom (df) = 13, Probability (P) = 0.82, Coefficient of Correlation (r^2) < 0.01). Similarly, unmarked salmon showed no significant relationship between entrainment and flow (df = 13, P = 0.86, r^2 = 0.08) (Figure 4-7).

DISCUSSION

The lower catch and broken slide gates made data comparisons among years, as well as within the 2004 VAMP period, difficult. The number of culverts fully open varied throughout the monitoring period. The culvert slide gate gear-boxes became stripped during the monitoring period, causing several of the gates to remain in the partially closed position. Because some fish were able to pass through the partially closed culverts, those culverts were still monitored for fish entrainment. Another problem arose after the CWT salmon were processed. Apparently, 65 Mossdale CWT salmon were caught before they were supposedly released upstream (Figure 4-4). We were unable to determine where the catch error occurred. The processed CWT salmon could have been misdated or labeled but all the salmon are accounted for when compared to the original field sheets. The Mossdale and Durham Ferry CWTs could have been mixed but there is no evidence of cross-contaminated tags. There is no doubt the CWT salmon were entrained in the culverts. There is only a question about when the entrainment occurred. Consequently, the questionable data was retained since the loss index calculations are not affected by when the salmon are entrained.

The color-marked salmon releases conducted in previous years were discontinued in 2004. The 2000 to 2003 color-marked study results were useful but continuing these releases

was thought to provide little additional information. It was felt that the color-marked results were similar to the larger Durham Ferry and Mossdale salmon release results and more information could be gained by using the VAMP salmon releases. However, color-marked salmon might be used in future special studies at the HORB.

More white catfish were entrained then all the other species combined. The 2004 total catfish catch was the second highest. The highest catfish catch (7,485) occurred in 2002. Over the past several years, the field crews have observed partially digested salmon smolts and catfish regurgitating smolts in the live-boxes. Most of the regurgitated salmon appear to be recently consumed which suggests catfish are preying upon salmon in the nets and in the live-boxes, or in front of the culverts. Catfish entrainment tends to increase in May after the VAMP CWT salmon have already passed the HORB. However, salmon entrained in May could be affected by catfish predation. Catfish gut content analysis is the only effective method for determining the extent of catfish predation on salmon smolts at the HORB.

Salmon entrainment appears proportional to the number of fish released upstream. In 2004, roughly half as many VAMP salmon were released upstream of the HORB than in previous years. Likewise, half as many salmon were entrained at the HORB than in previous years. Interestingly, about half as many unmarked salmon were also entrained this year compared to 2003 and about a quarter as many as in 2002. The unmarked catch is comprised of both MRFF and wild salmon. The decline in unmarked catch could be the result of fewer returning adult salmon in the fall of 2003. This resulted in lower MRFF production and lower in-stream spawning which may have caused the decline in outmigrating salmon. Also, unmarked salmon catch tends to increase around the VAMP releases. Since there was no second release, the associated unmarked salmon increase was also absent.

The HORB is fairly effective in keeping salmon on the San Joaquin side of the barrier. Less than one percent of the VAMP CWT salmon released upstream was entrained at the HORB. Salmon entrainment patterns are similar to previous years.

Approximately 85 percent of the entrained VAMP salmon were caught at night. Of the unmarked salmon entrained at the HORB, 80 percent were also caught at night. The data collected over the past four years strongly suggests salmon are more vulnerable to entrainment at night. As mentioned in previous reports, the timing of the salmon releases and the distance the fish must travel to the HORB probably affects diel entrainment patterns. A change in the VAMP salmon release times so that salmon pass the barrier midday probably would not result in the same spiked increase seen at night. This assumption could be tested with an early morning salmon release at Mossdale.

Entrainment between the flood and ebb tides were similar. Salmon entrainment is highest soon after the salmon releases at Durham Ferry and Mossdale. Peak entrainment of the fish released at Durham Ferry occurred after midnight on an ebb tide, and peak entrainment of the Mossdale-released fish

occurred before midnight, the following day, on a flood tide. The tide should affect entrainment since the head difference between upstream and downstream water levels at the HORB determines flow through the culverts. If entrainment is affected by the amount of flow through the culvert, then higher salmon entrainment should occur at higher flows at a given salmon density. In culvert number 4, there was no relationship between CWT or unmarked salmon entrainment and flow. Most of the data collected to date suggest entrainment is probably more a function of the number of salmon passing the barrier. The number of VAMP salmon passing the HORB is affected by the size, timing and location of the upstream releases.

This year, the differences in overall entrainment among culverts were affected more by culvert gate operation than in previous years. The partially closed culverts made comparisons among culverts difficult. During the Durham Ferry release, culvert numbers 4, 5, and 6 were operating and entrainment was slightly higher in culvert number 6. Culvert number 6 broke just before the Mossdale release occurred. Subsequently, few Mossdale fish were entrained in that culvert. After culvert number 6 was repaired the following week, it entrained the most salmon. Culvert number 4's entrainment declined to almost nothing after it broke on May 6. The opening of additional culverts, as well as slide gate breakdowns may have changed the hydrodynamics in front of the culverts. This change could effect salmon entrainment among the culverts.

In summary, 2004 culvert gate operation differed from the previous three years. The number of culverts fully open varied throughout the monitoring period due to scheduled gate openings and gates breaking near the closed position. Entrainment results from the past four years and this year's results suggest salmon are more vulnerable to entrainment at night. Diel changes in salmon out-migration patterns are probably a factor in entrainment vulnerability. At night, salmon might be lower in the water column and pass closer to the culverts. The tidal effects on entrainment are still unclear. Water velocities through the culverts are greatest on a low tide, near slack water. However, no significant relationship was found between CWT or unmarked salmon entrainment and flow through culvert number 4. Salmon smolt behavior and relative abundance near the barrier plays an important role in entrainment vulnerability. The highest entrainment has always occurred soon after the upstream VAMP CWT salmon releases.

It is recommended that VAMP continue delaying the first salmon release by at least 5 days after the closure of the HORB. The delay allows for completion of the barrier and minimizes the field crew's exposure to heavy equipment operation. It also allows time for any loose material near the barrier to pass through the culverts before the nets are attached. The 2003 day and evening releases at Mossdale showed markedly different entrainment rates at the HORB. Another paired day-night or early morning salmon release at Mossdale would be useful in further illuminating diel entrainment patterns at the HORB. Flow monitoring on all six culverts is desirable to fully evaluate the flow versus entrainment relationship. Additional flow meters would allow comparison of flow and salmon entrainment rate among culverts.

It is recommended that VAMP continue delaying the first salmon release by at least 5 days after the closure of the HORB. The delay allows for completion of the barrier and minimizes the field crew's exposure to heavy equipment operation.

CHAPTER 5

Salmon Smolt Survival Investigations

One of the primary objectives of the VAMP program is to identify how San Joaquin River flows and SWP and CVP export rates, with the HORB in place, affect the survival of juvenile Chinook salmon emigrating from San Joaquin River tributaries. This section describes the methods used to conduct the Chinook salmon smolt survival investigations, and presents the calculated survival indices, absolute survival estimates and combined differential recovery rates for coded-wire tagged juvenile Chinook salmon released during the VAMP 2004 test period. We also analyzed how survival varied with flow, and flow relative to exports, with and without the HORB. Ocean recovery information on past releases and catches of unmarked juvenile salmon at Mossdale and in salvage are also discussed. Additional data and information related to the salmon survival investigations are presented in Appendix C.

CODED-WIRE TAGGING

Merced River Fish Facility (MRFF) Chinook salmon smolts, released as part of VAMP 2004, were coded-wire tagged (CWT) between March and early April. After the salmon were tagged, they were held in the MRFF for at least 21 days before being released. Sub-samples of these salmon were measured (for fork length) and checked for retention of tags a day or two prior to release. Sub-samples were comprised of approximately 200 salmon collected from the top, middle, and bottom of the release group's raceway. Although tag detection is usually high, all salmon from the sub-samples without a detected tag were sacrificed to verify the accuracy of the CWT detection process. Sacrificed salmon were dissected to determine whether they contained a non-magnetized tag, an undetected tag, or no tag. Each CWT code within a release group was held separately at the MRFF with the exception of the Durham Ferry release. This release was comprised of four CWT codes that were held together at the MRFF. At release, an additional sub-sample of 25 to 75 salmon was taken to verify CWT code. Fifty salmon were taken at Durham Ferry, 75 at Mossdale and 25 at Jersey Point.

Table 5-1 summarizes the release dates, release locations, tag codes, tag retention, and effective release numbers of salmon used to calculate survival indices, estimates, and differential recovery rates. Tag retention rates appeared to be similar to last year, with an overall retention rate of 91% among 2004 VAMP groups compared to 94.5% for 2003. Tag retention rates varied from 82.5% to 96.5%. It is highly desirable that improved retention rates continue to increase for future VAMP studies.

The effective number released (ER) was calculated using the following equation:

$$ER = (T-M)*TR$$

where:

T= estimated number transported,

M = number of mortalities during release and transport (and included those sacrificed as part of the net pen evaluations), and

TR = CWT retention rate.

CODED-WIRE TAG RELEASES

Only one set of CWT salmon releases was made as part of the 2004 VAMP experiment. The releases occurred on April 22 at Durham Ferry, April 23 at Mossdale, and April 26 at Jersey Point. There was not a second set of releases during VAMP 2004, as in past years, due to a lack of fish at MRFF.

TABLE 5-1

2004 CWT Effective Release Data

Release Date	Release Site	Tag Code	Avg FL (mm)	Number Transported	Total Mort (including Net Pen Loss)	Tag Retention %	Number Released	Effective Release
4/22/04	Durham Ferry	06-27-52	83	26,475	138	89.0	26,337	23,440
		06-27-53	82	26,459	139	82.5	26,320	21,714
		06-27-54	82	26,057	138	90.0	25,919	23,327
		06-27-55	83	26,131	139	91.5	25,992	23,783
4/23/04	Mossdale	06-46-70	82	26,439	201	96.5	26,238	25,320
		06-45-82	81	25,950	201	91.6	25,749	23,586
		06-45-83	79	25,904	201	96.5	25,703	24,803
4/26/04	Jersey Point	06-45-80	85	25,708	253	90.0	25,455	22,910

A total of approximately 200,000 CWT fish, with eight distinct tag codes were used during the 2004 VAMP experiments. Each tag code lot consisted of approximately 25,000 fish. A total of approximately 100,000 (4 tag codes) fish were released at Durham Ferry, 75,000 (3 tag codes) at Mossdale and 25,000 (1 tag code) at Jersey Point (Table 5-1). During VAMP 2004, tag codes were mixed and released at each site as one group. As with VAMP 2003, the Durham Ferry release was made from the more desirable location alongside the river, instead of from the top of the levee. The nearby agricultural diversion was turned off from the time of the releases until several hours after the release to allow the tagged salmon time to disperse from the release site.

During the Durham Ferry release, the hose from the tank truck disconnected and approximately 150 salmon escaped out of the hose, spilling onto the ground. These were placed into a net pen, with some proportion later removed and placed back into the river during the counting of individuals for the net pen study.

The release at Jersey Point was made at the beginning of the flood tide to increase dispersion of the tagged fish before they passed Antioch and Chipps Island. Releases at Mossdale and Durham Ferry were not made on any specific tidal condition.

Water temperatures in the MRFF trucks and at the release sites were measured immediately prior to release. These, as well as additional release and recovery data, are provided in Table 5-2.

WATER TEMPERATURE MONITORING

Water temperature was monitored during the VAMP 2004 study using individual computerized temperature recorders (e.g., Onset Stowaway Temperature Monitoring/Data Loggers). 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). Water temperature was recorded at 24-minute intervals throughout the period of the VAMP 2004 investigations. Water temperatures were also recorded within the hatchery raceways at the MRFF coincident with the period when juvenile Chinook salmon were being tagged and held. These temperature recorders were later transported with the juvenile salmon released at Durham Ferry and Mossdale.

Results of water temperature monitoring within the Merced River Fish Facility showed that juvenile Chinook salmon were reared in, and acclimated to, water temperatures of approximately 10.5–16 C (51–61 F) prior to release into the lower San Joaquin River (Figures 5-1 and 5-2). Results of water temperature monitoring at Durham Ferry, Mossdale, and Jersey Point following the VAMP 2004 releases are shown in Figures 5-3, 5-4, and 5-5. Results of water temperature monitoring showed that water temperatures at the release locations and throughout the lower San Joaquin River and Delta (Appendix C-2) were higher than those at the MRFF, which is similar to all past years. Water temperatures at the release sites as measured from these temperature recorders indicated temperatures were initially favorable but increased

TABLE 5-2

Release Information for 2004 VAMP Releases

Release Site/Stock	Release Date	Tag Code	Truck Temp (F)	River Temp (F)	Number Released	Average Size (mm)
Durham Ferry (MRFF)	4/22/04	06-27-52	55.4	60	23,440	83
		06-27-53	55.4	60	21,714	82
		06-27-54	55.4	60	23,327	82
		06-27-55	55.4	60	23,783	83
Total					**92,264**	
Mossdale (MRFF)	4/23/04	06-46-70	55.4	63	25,320	82
		06-45-82	55.4	63	23,586	81
		06-45-83	55.4	63	24,803	79
Total					**73,709**	
Jersey Point (MRFF)	4/26/04	06-45-80	57.7	71	22,910	85

quickly over the next few days (Figures 5-3 and 5-4). Water temperatures measured within the lower San Joaquin River and Delta (Figures 5-3, 5-4 and 5-5) reached levels considered to be stressful (20–22 C; 68–72 F) and may have contributed to adverse effects and reduced survival of emigrating juvenile Chinook salmon released as part of the VAMP 2004 investigations.

Water temperatures measured during the 2004 VAMP period in the lower San Joaquin River and Delta were among the highest recorded over the five-year period of VAMP investigations (Appendix D-8). Peak temperatures recorded in 2004 exceeded 20 C (68 F) at all monitoring stations. Average temperatures in the lower San Joaquin River, such as Durham Ferry, Mossdale, Dos Reis the DWR monitoring station, confluence, Channel marker 30, and Channel marker 13 (Appendix C-2) exceeded 18 C (64 F). These temperatures were generally greater than temperatures recorded during the 2000, 2002, and 2003 VAMP tests (Appendix D-8). Water temperatures observed in 2004 were similar to temperatures observed during the 2001 test period (although survival in 2004 was much less than that measured in 2001). Exposure of juvenile Chinook salmon to elevated water temperatures during out migration has been identified as one of the factors contributing to the survival of juvenile salmon. Exposure to elevated water temperatures during out migration may affect the physiology of the smolts, reduce resistance to disease, reduce growth, and increase vulnerability to predation by largemouth bass, striped bass, and other predatory fish within the lower river and delta. The incremental contribution of water temperature exposure during 2004 and previous years to observed salmon smolt survival has not been quantified. Water temperature monitoring within the Merced River Fish Hatchery and within the river and delta is recommended to continue as part of the VAMP investigations.

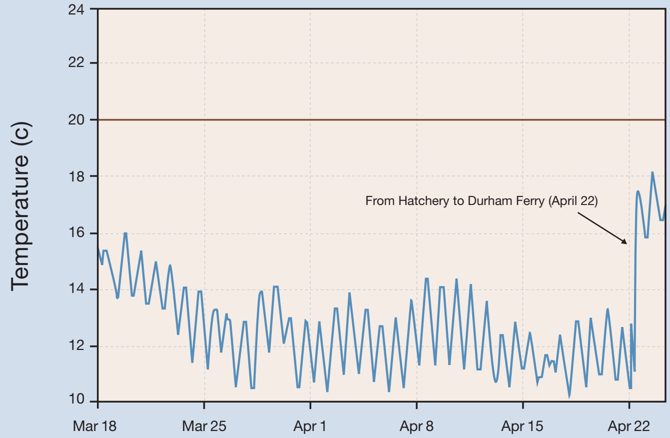
POST-RELEASE NET PEN STUDIES

Survival and Condition

The post-release survival and condition of CWT salmon were evaluated as part of the VAMP program using sub-samples of tagged salmon from each release group. Because tag codes were combined, 50 salmon from Durham Ferry, 75 from Mossdale and 25 from Jersey Point were evaluated for general condition immediately after release. To assess general condition, fork length in millimeters, weight in grams, and six other characteristics were examined (Table 5-3). Other obvious abnormalities or deformities were also noted. To assess short-term effects of handling, transport, and release, an additional sub-sample from each release group of approximately 200 fish per net pen (2 pens at Durham Ferry, 3 at Mossdale and 1 at Jersey Point) were held at the respective release sites for 48 hours. Of these, 25 were measured, weighed, and examined for the six general condition characteristics. The remaining fish were measured for length and weight and evaluated for adipose fin clips and short-term mortality. Due to the mixed tag codes for each of the releases, multiple net pens with approximately 200 fish each were held in order to maintain consistency with the other release groups and previous years. In all, 300 juvenile Chinook salmon were examined for the six general condition characteristics, and

FIGURE 5-1

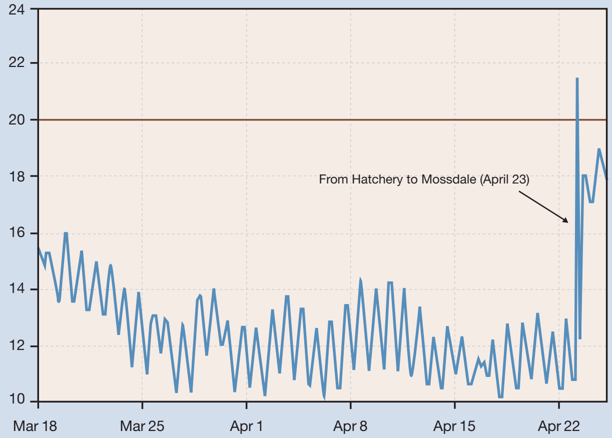
Merced River Fish Hatchery to Durham Ferry



Water temperatures measured in the Merced River Fish Facility and following release at Durham Ferry.

FIGURE 5-2

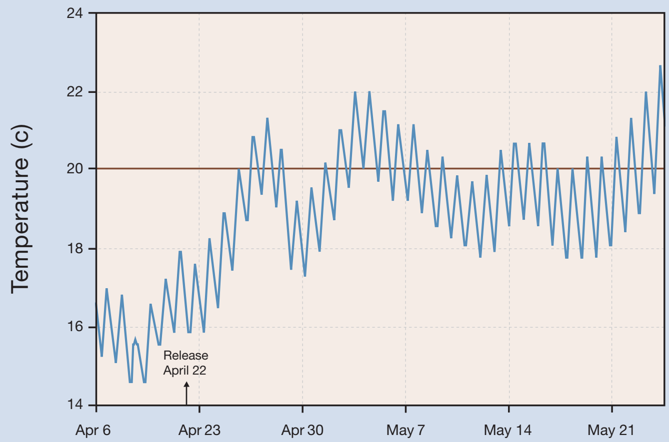
Merced River Fish Hatchery to Mossdale



Water temperatures measured in the Merced River Fish Facility and following release at Mossdale.

FIGURE 5-3

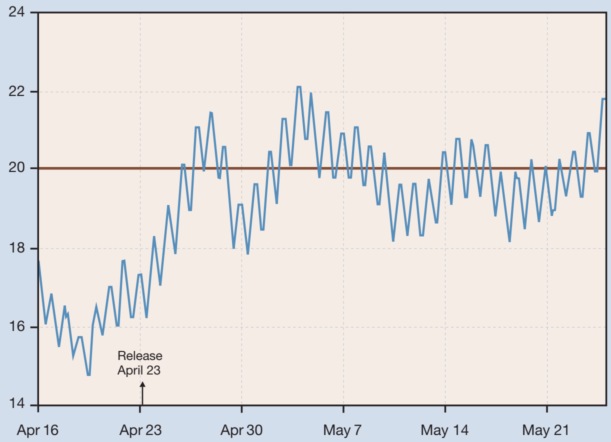
Site 1–Durham Ferry



Water temperatures measured in the San Joaquin River at Durham Ferry.

FIGURE 5-4

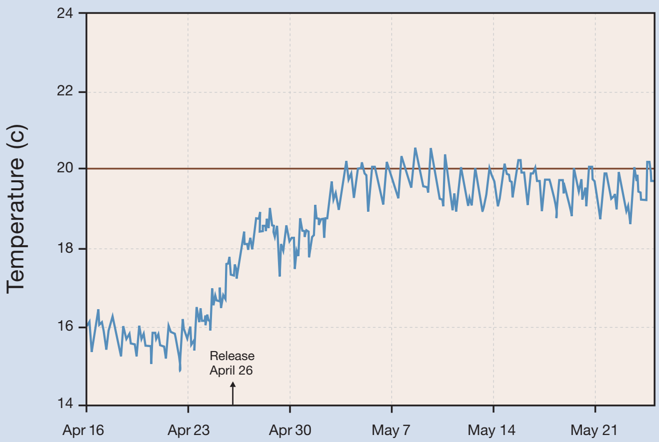
Site 2–Mossdale



Water temperatures measured in the San Joaquin River at Mossdale.

FIGURE 5-5

Site 9–USGS Gauging Station at Jersey Point–Top



Water temperatures measured in the San Joaquin River at Jersey Point.

TABLE 5-3 *Smolt Condition Characteristics Assessed for Post-release Net Pen Studies*		
	Normal	Abnormal
Eyes	Normally shaped	Bulging
Color	High contrast dark dorsal surface and light sides	Low contrast dorsal surface and sides, coppery color
Fin Hemorrhaging	No blood ore red at base of fins	Blood at base of fins
Percent Scale Loss	Lower relative numbers better based on 0–100% scale loss	Higher relative numbers worse based on 0–100% scale loss
Gill Color	Dark beet red to cherry red gill filaments	Light red to gray gill filaments
Vigor	Active swimming (prior to anesthesia)	Lethargic or motionless (prior to anesthesia)

1,200 (including the 300 examined for general condition) were measured, weighed and assessed for mortality and presence/absence of adipose fin clip.

Results of the evaluations of the 300 marked salmon examined for the six general condition characteristics, from both immediately after release and 48 hours later, showed few abnormalities (see Appendix C-3). The majority of fish examined had normal coloration (99.94%), and eye characteristics (98.44%) and no fin hemorrhaging (99.97%). Fourteen percent of fish examined showed poor gill color. Scale loss ranged from 0% to 12% and averaged 2.9%. Other abnormalities included: fin rot (0.8%), jaw deformities (< 0.5%) and ragged dorsal fins (1%). In addition, this year 22 (7%) Chinook salmon had a poor or incomplete adipose fin clip, while 2 (0.5%) had no fin clip. Of the 1,200 juvenile Chinook salmon examined, there were 10 mortalities. In comparison, we observed 11 mortalities in 2003.

As mentioned previously, during the release at Durham Ferry, approximately 150 Chinook spilled onto the ground when the hose disconnected from the tank truck. Field crew that were present stated that of the 150 fish, only 4 were directly observed to have died from the incident.

Tag Quality Control

A subset of 25 salmon from each tag group, evaluated for condition as described above, was sacrificed to verify purity of tag codes. Though rare, in the past, salmon from different tag groups have been mixed at some point prior to release. In 2004, no errant tag codes were found in these groups. The remaining fish in each net pen were archived to allow for further evaluation if necessary.

Health and Physiology

Personnel from the California-Nevada Fish Health Center (FHC) conducted physiological studies on a sub-sample of the juvenile Chinook salmon used in the VAMP study (Harmen, et.al., 2004). Results of this work are summarized below.

Ninety-six Merced River Fish Facililty salmon were examined from the three release groups (32 fish per release group) following transport to release sites at Durham Ferry, Mossdale, and Jersey Point. A general health inspection for viral, *Renibacterium salmoninarum* (Bacterial Kidney Disease agent) and systemic bacterial infection was performed on 12 fish from each release group. Additional assays were conducted on the remaining 60 fish including assessment of : 1) internal and external abnormalities; 2) smolt development (gill tissue of 36 fish, 12 from each release group were analyzed for ATPase activity); and, 3) kidney tissue from 36 fish were examined for presence of *Tetracapsula bryosalmonae* (Tb), the parasite responsible for Proliferative Kidney Disease (PKD). To assess stress recovery, blood plasma levels of chloride, sodium, lactate, glucose, total protein, and cortisol were measured from the remaining 20 fish from each group.

No viral pathogens, systemic bacteria, or *R. salmoninarum* were detected in the 96 fish tested. *Tetracapsula bryosalmonae* was detected in 37% of the salmon sampled at Durham Ferry, 50% at Mossdale and 64% at Jersey Point. Only 14% or less of the infected kidneys were rated as showing moderate inflammatory changes indicating early stages of PKD.

A large percentage of the groups from Mossdale and Durham Ferry had ATPase activities associated with pre-smolting parr (83% and 42%, respectively). Jersey Point samples were not available due to samples being lost. These data indicate that these fish were not in an advanced state of smoltification at the time of release. It is uncertain how this will effect migration behavior, because, ATPase levels can change rapidly during outmigration and therefore may not have significant effects.

Plasma cortisol tended to increase with each successive release group (i.e. Durham Ferry had the least and Jersey Point had the most). It is likely that longer transport times for each release contributed to the cortisol increase. Plasma protein and chloride levels were normal and similar among all groups.

In summary, the VAMP groups used in 2004 indicated that the incidence of *Tetracapsula bryosalmonae* infection increased with each successive release group, with six of the 66 fish examined for Tb having severe infections and 27 having moderate infection. Despite this infection, fish pathologists at the U.S. Fish and Wildlife California/Nevada Fish Health Center (FHC) concluded that fish were relatively healthy and should have performed adequately for outmigration assessments.

The FHC has provided a health and physiological assessment of VAMP release groups each year from 2000 to 2004. The purpose of these assessments was to rule out survival differences due to differential health between release groups and between years. The FHC looked at health (bacterial, viral, and parasitic infections), smolt development, and stress response to determine if there were significant differences which might affect survival of one group over another. While differences in smolt development and stress response each year were noted, the FHC feels the most significant factor affecting survival was infection with Tetracapsuloides bryosalmonae (the myxosporean which causes Proliferative Kidney Disease, PKD). Incidence of infection with *T. bryosalmonae* ranged from 4% to 100% in annual VAMP study releases between 2000 and 2004 (Table 5-4). This progressive disease can reduce a fish's performance due to associated kidney dysfunction and anemia. Not only does this infection reduce the ability for annual comparisons, but also the severity of infection may increase throughout the study period contributing to higher mortality towards the end of the study.

General Conclusions:

- Severity of PKD infection and impairment due to the disease varied annually
- Severity of PKD progressed, so a group which was healthy at release may become impaired in the weeks following release
- No other infectious diseases (viral or bacterial) have been detected
- Smolt development has been similar among release groups each year (with the exception of the year 2000 first Jersey Point release having higher gill ATPase activity)
- Blood chemistry analysis showed that all release groups were physiologically capable of handling stress in 2000, 2002, 2003 and 2004; several release groups in 2001 (both Durham Ferry and second Mossdale releases) performed poorly likely due to PKD infection or extraneous handling of live boxes.
- Confounding factors in our attempts to assess the health and survival of the VAMP release groups could include differences in transport times, fish handling and site water quality.

CHAPTER 5

TABLE 5-4

Prevalence of Tetracapsula bryosalmonae detected in Merced River Fish Facility Chinook Salmon Smolts, 1996–2004

Year	Sample Date(s)	Prevalence	
1996	May 1	5/8	(63%)
1997	May 1	0/10	(0%)
1998	April 17	0/6	(0%)
1999	April 20	0/6	(0%)
2000	April 18–May 2	2/45	(4%)
2001	May 1–May 12	34/34	(100%)
2002	April 19–May 1	92/201	(46%)
2003	April 21–May 2	30/48	(63%)
2004	April 22–April 26	33/66	(50%)

All samples were taken from VAMP (and precursor project) release groups. Fish were assayed by histopathological examination of posterior kidney by the CA-NV Fish Health Center.

CODED-WIRE TAG RECOVERY EFFORTS

Coded-wire tagged salmon were recaptured at Antioch and Chipps Island, at CVP and SWP fish salvage facilities, and during sampling Old River near the barrier (Figure 1-1). Coded-wire tagged salmon released upstream of, and at, Mossdale were also recovered in DFG Kodiak trawls at Mossdale but are not discussed in this report. Juvenile Chinook salmon with an adipose fin clip (which identifies CWT salmon) caught at any of these sampling locations were sacrificed, labeled, and frozen for CWT processing. Coded-wire tag processing was done by staff at USFWS (Stockton) for fish recovered at Chipps Island, Antioch, and SWP and CVP salvage facilities. DFG Region IV processed salmon captured in the HORB fyke net sampling.

Coded-wire tag processing consists of dissecting each tagged fish to obtain the 1 millimeter cylindrical tag from the snout. Tags are then placed under a dissecting microscope and the numbers are read and recorded in a database. All tags were read twice, with any discrepancies resolved by a third reader. All tags are archived for future reference. It should be noted that many tags are recovered at Chipps Island, Antioch, SWP/CVP salvage facilities, and other locations. VAMP releases com-

TABLE 5-5

Recovery Information at Antioch, Chipps Island and the Fish Facility for VAMP releases in 2004

				Antioch Recoveries						
Tag Code	Release Site/ Stock	Release Date	Number Released	First Day Recovered	Last Day Recovered	Number Recovered	Minutes Finished	Percent Sampled	Survival Index	Group Index
06-27-52	Durham Ferry (MRFF)		23,440	5/04/04	5/04/04	1	584	0.406	0.008	
06-27-53	Durham Ferry (MRFF)		21,714	5/0304	5/03/04	1	620	0.431	0.008	
06-27-54	Durham Ferry (MRFF)		23,327	–	–	0	–	–	–	
06-27-55	Durham Ferry (MRFF)		23,783	–	–	0	–	–	–	
	Total	4/24/04	92,264	5/03/04	5/04/04	2	1,204	0.418		0.004
06-46-70	Mossdale (MRFF)		25,320	5/02/04	5/02/04	1	590	0.410	0.007	
06-45-82	Mossdale (MRFF)		23,586	–	–	0	–	–	–	
06-45-83	Mossdale (MRFF)		24,803	–	–	0	–	–	–	
	Total	4/23/04	73,709	5/02/04	5/02/04	1	590	0.410		0.002
06-45-80	Jersey Point (MRFF)	4/26/04	22,910	4/27/04	5/06/04	22	5,812	0.404	0.171	

prise a small portion of the total tagged salmon released in the Sacramento and San Joaquin system. Consequently, many tags recovered at Chipps Island, Antioch, the SWP and CVP salvage facilities, and other locations are from coded wire tag releases not affiliated with VAMP. In order to identify tag recoveries related to VAMP, it is necessary to read all recovered tags.

SWP and CVP Salvage Recapture Sampling

Sampling at the CVP and SWP fish salvage facilities was conducted approximately every two hours. The number of marked salmon collected (raw salvage) was expanded based on the number of minutes sampled during each two hour time period. The estimated expanded total number of CWT salmon, from each release group, was obtained by adding together the expanded number of each tag group for all time periods. Only CWT salmon recovered in the raw salvage collections were sacrificed for tag processing. Expanded salvage is only a portion of the direct loss experienced by juvenile salmon at the facilities, as it does not include losses prior to, and associated with, prescreen predation, screening, handling and trucking.

Expanded CVP and SWP salvage estimates of marked salmon released as part of the VAMP 2004 studies are shown in Table 5-5. Salvage numbers were low at the CVP and SWP. These results are consistent with earlier studies showing that the HORB reduces the number of CWT salmon entrained at the fish facility.

Antioch Recapture Sampling

Fish sampling was conducted in the vicinity of Antioch on the lower San Joaquin River (Figure 1-1) using a Kodiak trawl. The Kodiak trawl has a graded stretch mesh, from 2-inch mesh at the mouth to $^{1}/_{2}$–inch mesh at the cod-end. Its overall length is 65 feet, and the mouth opening is 6 feet deep and 25 feet wide. The net was towed between two skiffs, sampling in an upstream direction. Trawls were performed parallel to the left bank, mid-channel, and right bank to sample CWT salmon emigrating from the San Joaquin River. Each sample was approximately 20 minutes in duration.

All captured fish were transferred immediately from the Kodiak trawl to buckets filled with river water, where they were held for processing. Data collected during each trawl included: species identification and fork length for each fish captured,

Chipps Island Recoveries							Expanded Fish Facility		
First Day Recovered	Last Day Recovered	Number Recovered	Minutes Finished	Percent Sampled	Survival Index	Group Index	CVP	SWP	Recovery Days
–	–	0	–	–	–		24	6	
5/03/04	5/03/04	1	400	0.278	0.022		36	0	
5/02/04	5/02/04	1	400	0.278	0.020		24	0	
5/01/04	5/01/04	1	400	0.278	0.020		0	6	
5/01/04	5/03/04	3	1,200	0.278		0.015			4/26 – 5/04
–	–	0	–	–	–				
5/06/04	5/06/04	1	390	0.271	0.020		24	0	
5/02/04	5/06/04	2	1,950	0.271	0.039		0	6	
5/02/04	5/06/04	3	1,950	0.271		0.020			4/30 – 5/10
4/28/04	5/03/04	25	2,400	0.278	0.511		12	0	5/4

tow start time and duration, and location in the channel. Any fish mortalities or injuries were documented to comply with the Endangered Species Act permit requirements.

Juvenile Chinook salmon with an adipose fin clip were retained for later CWT processing while other fish were released at a location downstream of the sampling site immediately after identification, enumeration, and measurement.

Sampling at Antioch began April 24 and continued through May 15. Each day between 5:30 a.m. and 9:00 p.m., anywhere from 11 to 31 tows were conducted. In all, 607 Kodiak trawl samples were collected, for a total of 12,080 tow minutes. During sampling, 6,157 unmarked juvenile Chinook salmon were captured; 127 salmon with an adipose fin clip (and CWT) were collected, 25 from VAMP releases (Table 5-5) and 102 from other MRFF releases. In addition, 1,543 delta smelt, 59 Sacramento splittail, 25 unmarked steelhead, and 8 adipose fin clipped steelhead were caught during sampling.

Chipps Island Recapture Sampling

As part of VAMP 2004 recovery efforts at Chipps Island, trawling shifts were conducted twice daily between April 24 and May 22. This second shift has been conducted during the spring releases since 1998. The first shift began at sunrise, while the second shift ended at or after sunset, to incorporate the crepuscular periods of the day. Based on analysis of 24-hour sampling at Jersey Point in 1997 (Hanson Environmental, unpublished data), greater numbers of juvenile Chinook salmon appear to be caught around sunrise and sunset. Therefore, targeting this crepuscular period and doubling total trawl effort at Chipps Island should increase the number of CWT salmon recaptured and reduce variability in VAMP survival indices. Sampling continued at one shift per day between May 23 and June 18, five days per week between June 21 and July 2, and three days per week after July 2.

The trawl at Chipps Island was towed at the surface using a net with a mouth opening 10 feet deep by 30 feet wide, with a total length of 82 feet. Aluminum hydrofoils were used on the top bridles and steel depressors, along with a weighted lead line, were used on the bottom bridles to keep the mouth of the net open. The net consisted of variable mesh starting with 4-inch mesh at the mouth and ending with a 1/4-inch cod end mesh.

To sample across the channel, trawling at Chipps Island was conducted in three distinct lanes; one each in the north, south, and middle of the channel. Each lane was generally sampled at least three times per shift, with one lane sampled a fourth time during each shift. The lane sampled four times was chosen at random or selected by the boat operator based on flow conditions.

Coded-wire tagged salmon released for the VAMP 2004 program, were recovered at Chipps Island between April 28 and May 6 (Table 5-5). A total of 31 VAMP CWT salmon were recovered at Chipps Island. During the April 24 through May 22 VAMP recovery period, a total of 12,214 unmarked salmon, 579 CWT salmon from non-VAMP experiments, 37 delta smelt, 82 Sacramento splittail, 7 adipose fin clipped steelhead, and 26 unmarked steelhead were sampled at Chipps Island.

VAMP CHINOOK SALMON CWT SURVIVAL

Survival Indices

Survival indices were calculated for marked salmon released at Durham Ferry, Mossdale, and Jersey Point and recovered at Antioch and Chipps Island. Survival indices (SI) were calculated using the formula:

$$SI = (R / (ER^*T^*W))$$

where:

R is the number recovered, ER is the effective number released, T is the fraction of time sampled, and W is the fraction of channel width sampled.

The fraction of the channel width sampled at Chipps Island (0.00769) was calculated by dividing the net width (30 feet) by the estimated channel width (3,900 feet). The fraction of the channel width sampled at Antioch (0.01388) was calculated in the same manner, with the net width being 25 feet and the channel width being 1,800 feet. The fraction of time sampled at both locations was calculated based on the number of minutes sampled between the first and last day of catching each particular tag code or group, divided by the total number of minutes in the time period. The fraction of time sampled for the VAMP 2004 release groups at Chipps Island was about 28%, while at Antioch it was about 41% (Table 5-5).

Survival indices were calculated for each tag code to provide a sense of the variability associated with the group survival index. To generate the group survival index, the recovery numbers and release numbers are combined for the tag codes within a release group.

Individual and group survival indices to Antioch and Chipps Island of the CWT salmon released as part of VAMP 2004 are shown in Table 5-5. Survival indices have been reported to three significant digits, but we realize indices are not likely that precise. Survival indices were not corrected for the number of CWT fish recovered at the HORB or in sampling at Mossdale conducted by DFG Region IV.

The survival indices of the Durham Ferry and Mossdale groups were very low as measured at Antioch (0.004 and 0.002 respectively) and Chipps Island (0.015 and 0.020 respectively) in 2004. The survival index of the Jersey Point group was higher at 0.171 and 0.511 at Antioch and Chipps Island respectively. While the raw recovery rate at Chipps Island and Antioch was similar, once recoveries were expanded for effort, indices indicated that recoveries were much lower at Antioch, indicating that the greater sampling at Antioch is not translating into additional recoveries. Indices in 2004 were similar to 2003 using the Chipps Island recoveries whereas they were much lower using the Antioch recovery information.

Survival indices for releases made at Durham Ferry and Mossdale were very low relative to releases made at Jersey Point using both sets of recovery numbers (Table 5-5).

Chinook Salmon Survival Estimates and Combined Differential Recovery Rates

The differences in survival indices are further evaluated using absolute survival estimates and combined differential recovery rates (CDRR). Absolute survival estimates (AS_i) are calculated by the formula:

$$AS_i = SI_u / SI_d$$

where:

SI_u is the survival index of the upstream group (Durham Ferry or Mossdale), SI_d is the survival index of the downstream group (Jersey Point) and i is either Antioch or Chipps Island.

Although referred to throughout this document as absolute survival estimates they are more aptly described as standardized or relative survival estimates. The combined recovery rate (CRR) is estimated by the formula:

$$CRR = R_{C+A} / ER$$

where:

R_{C+A} is the combined recoveries at Antioch and Chipps Island of a CWT group, and ER is the effective release number.

The combined differential recovery rate is calculated by the formula:

$$CDRR = CRR_u / CRR_d$$

where:

CRR_u is the combined recovery rate for the upstream group (Durham Ferry or Mossdale), and CRR_d is the combined recovery rate for the downstream group (Jersey Point).

The CDRR is another way to estimate survival between the upstream and downstream release locations. It is similar to calculating absolute survival estimates, but does not expand estimates based on the fraction of the time and space sampled. At times the differential recovery rate (DRR) is reported which is similar to the CDRR but only uses recovery numbers from one recovery location—either Chipps Island or the ocean fishery.

The CDRR and the absolute survival estimates should not be very different as 1) the fraction of the time sampled is similar between groups within a recovery location and 2) the fraction of space sampled at each recovery location is a constant. Neither would change the relative differences between groups. However, combining the recovery numbers from Antioch and Chipps Island could result in different survival estimates between the two methods.

Variance and standard errors were calculated for the CDRRs based on the Delta method recommended by Dr. Ken Newman. Plus or minus two standard errors are roughly equivalent to the 95% confidence intervals around the CDRR. Plus or minus one standard error equates to roughly the 68% confidence intervals for normally distributed data (Ken Newman, University of St. Andrews, Scotland, personal communication). In comparing survival between reaches the confidence intervals were used to determine if CDRRs were significantly different from each other. If the 95% confidence intervals overlapped, CDRRs were not considered statistically different from each other. Differences observed using the lower level of confidence (68%) is noted.

Absolute survival estimates and CDRRs should be more robust for comparing survival between groups, recovery locations, and years, since using ratios between upstream and downstream groups theoretically standardizes for differences in catch efficiency between recovery locations and years. Both estimates of absolute survival and CDRRs were calculated for CWT releases as part of VAMP 2004, as in past years. An additional estimate of absolute survival will be possible from recoveries made in the ocean fishery, two to four years following release.

Using the CDRR's the survival estimates from Durham Ferry to Jersey Point and Mossdale to Jersey Point were not different

CHAPTER 5

even though fish released at Durham Ferry are thought to incur additional mortality since it is 11 miles farther upstream than Mossdale (Table 5-6).

The CDRRs of the Mossdale and Durham Ferry groups were the same in 2004 (0.26). Pooling the groups also resulted in the pooled CDRR being the same as each of the individual estimates (0.026). The standard error of the pooled estimate was also calculated and reported (Table 5-7).

TRANSIT TIME

The recoveries of the few VAMP fish collected in 2004 were made at Antioch between April 27 and May 6 (Appendix C-4). Recoveries were made over a similar time period at Chipps Island: April 28 to May 6. Recoveries of upstream groups (Durham Ferry and Mossdale) at Chipps Island were recovered a few days earlier and a few days later than at Antioch. With so few CWT salmon recovered it is uncertain if the broader recovery period at Chipps Island is biologically meaningful. Transit times for marked salmon were estimated from the release day to the first and last day of recovery during VAMP 2004 which is included in Table 5-4.

Recoveries were made at the CVP and SWP fish facilities between April 26 and May 10 (Table 5-5), a longer period than at the other recovery location.

COMPARISON WITH PAST YEARS

Survival between Durham Ferry and Mossdale appeared high in 2004 as in past years. In 2000 through 2003, CDRRs indicated that survival between Durham Ferry and Jersey Point and Mossdale and Jersey Point was not statistically different ($p>0.05$) (SJRG, 2003 and 2004), thus we can infer survival between Durham Ferry and Mossdale was generally high in these years. However, low recovery numbers may hinder our ability to detect differences. Continued releases of CWT fish at both sites, will allow detection of mortality between Durham Ferry and Mossdale if it becomes great enough to detect in the future. If survival between locations is shown to be similar (not statistically different) then groups can be combined. When ocean recovery information becomes available it may also provide a means to assess mortality between Durham Ferry and Mossdale.

However, survival was much lower from Durham Ferry and Mossdale to Jersey Point in 2004 than for most of the releases in the past. The 2004 survival estimates were similar to those obtained in 2003. In 2004 the pooled CDRR from Durham Ferry and Mossdale to Jersey Point was 0.026, just slightly higher than that observed in 2003 (0.019). The estimate in 2003 was the lowest measured to date. Both the 2003 and 2004 data is much lower than that measured since VAMP started in 2000 (Table 5-7). Even prior to VAMP, with only Chipps Island recoveries, the lowest differential recovery rate with the HORB in place was 0.133 in 1994.

The health of the CWT fish in of itself did not appear to account for the low survival observed in 2004 or 2003. As we found in 2003, the infection and severe infection rates of *Tetracapsula bryosalmonea* (causative agent of Proliferative Kidney Disease) (PKD) was greater in 2001 than in 2004 (Table 5-8). Survival was greater in 2001 than in either 2003 or 2004 (Table 5-7).

However, as we hypothesized in 2003, the high level of PKD infection in combination with the lower flows could have increased the mortality of VAMP fish in both 2003 and 2004

TABLE 5-6

Survival Indices and Absolute survival estimates using recoveries at Antioch and Chipps Island for CWT fish released as part of VAMP 2004.

Release Site	Date	Antioch Group Index	Antioch Absolute Survival	Chipps Group Index	Chipps Absolute Survival	Combined Differential Recovery Rate
Durham Ferry	4/22/04	0.004	0.02	0.015	0.03	0.026
Mossdale	4/23/04	0.002	0.01	0.020	0.04	0.026
Jersey Point	4/26/04	0.171		0.511		
Durham Ferry and Mossdale						0.026

TABLE 5-7

Combined Differential Recovery Rate (CDRR) and standard errors for CWT salmon released at Mossdale and Durham Ferry in relation to those released at Jersey Point.

Year	CDRR	Standard Error
1994	0.133	0.099
1997	0.186	0.064
2000	0.187	0.019
2001	0.191	0.014
2002	0.151	0.013
2003	0.019	0.005
2004	0.026	0.010

TABLE 5-8

Severity of PKD infection in VAMP fish between 2000 and 2004. Number positive divided by the sample size is shown in parentheses.

Year	Infected	Severe Infection
2000	4% (2/45)	0%
2001	100% (34/34)	29% (10/34)
2002	46% (92/201)	1% (2/201)
2003	63% (30/48)	21% (10/48)
2004	50% (33/66)	9% (6/66)

since Jersey Point groups also had PKD but survived at a higher rate.

The number of days until first recovery of the Mossdale and Durham Ferry groups to Chipps Island appears to be related to San Joaquin River flow. In 2004 the number of days until first recovery was the longest since VAMP started in 2000, with recoveries made 9 days after release with flows at 3,261 cfs. The number of days until first recovery in 2003 and 2002 were similar (6–9) and had similar flow levels. In 2000 and 2001, flows were higher and travel times were faster (4 to 5 days with flows of 6,020 and 4,211 cfs, respectively) (Table 5-9).

In contrast, the number of days until last recovery for the Mossdale and Durham Ferry groups was sooner in 2004 (11 to 13 days) and 2003 (7 to 13 days) than in 2002 (ranged from 15 to 22 days after release) and 2000 (16 to 32 days) when PKD infection rate was lower. The number of days until last recovery in 2003 and 2004 was similar to that observed in 2001 (10 to 13 days) (Table 5-9). Both 2003 and 2001 had the highest percentage of fish with infection and severe infection of PKD (Table 5-8). Differences in the number of days until last recovery may reflect increased mortality over time on the individuals that took longer than the 7 to 13 days to reach the western Delta due to higher incidence of PKD in 2004, 2003 and 2001. It is possible that the combination of the first fish taking longer to reach Chipps Island due to the lower flows and the increased mortality due to the direct or indirect affects of PKD infection for the later migrants may in part explain why survival was so much lower in 2003 and 2004 than in past years.

Role of Flow and Exports

San Joaquin River flow and flow relative to exports between April and June is correlated to adult escapement in the San Joaquin basin 2 1/2 years later (SJRG 2003). Both relationships are statistically significant ($p<0.01$) with the ratio of flow to exports accounting for slightly more of the variability in escapement than flow alone ($r^2 = 0.58$ versus $r^2 = 0.42$; SJRG 2003). These relationships suggest that adult escapement in the San Joaquin basin is affected by flow in the San Joaquin River and exports by the CVP and SWP during the spring months when juveniles migrate through the river and Delta to the ocean. VAMP was designed to further define the mechanisms behind these relationships by testing how San Joaquin River flows (7,000 cfs or less) and exports, with the HORB, affect smolt survival through the Delta.

Survival of juvenile Chinook salmon emigrating from the San Joaquin River system has been evaluated within the framework established by the VAMP experimental design since the spring of 2000. Similar South Delta studies starting in 1994 were conducted prior to the official implementation of VAMP. Fish from the Feather River Hatchery had been used in south Delta studies conducted prior to 1999 (SJRG, 2002).

To assess the relationship between San Joaquin River flows and survival, pooled CDRRs from 2000 through 2004 were plotted. The CDRRs of all Durham Ferry and Mossdale releases within a year were pooled, as they were not significantly different from each other at the 95% confidence level. These pooled estimates and their 68% and 95% confidence intervals for 2004 and the past four years of VAMP releases (2000–2003) are shown in relation to the averaged San Joaquin River flow at Vernalis

TABLE 5-9

First and Last Day Recovered at Chipps Island of VAMP fish released in 2000–2004. N/R = No second release was made at Mossdale in 2000, and at any of the release sites in 2004.

Release Location	YEAR (San Joaquin River Flow Target)				
	2000	2001	2002	2003	2004
Durham Ferry (1)	5–32	5–11	8–22	6–11	9–11
Mossdale (1)	5–16	4–11	7–17	8–13	9–13
Durham Ferry (2)	5–23	5–13	7–15	—	N/R
Mossdale (2)	N/R	5–10	9–19	7	N/R

(Figure 5-6). Similar data obtained from releases made at Mossdale in 1994 and 1997 are included but have much wider confidence intervals because fewer recoveries were made since only one recovery location (Chipps Island) was used in these years. In 2004, flows were averaged for the 10-day period after release. In prior years the two, ten-day periods after each release were used. It is obvious that the 2003 and 2004 CDRR's are much lower than would have been predicted based on past data.

The CDRRs with confidence intervals are also shown in comparison to average Vernalis flow relative to combined CVP and SWP exports for the same periods as described above for San Joaquin River flow (Figure 5-7). Prior to 2003, the relationship of relative recovery rate to San Joaquin River flow was significant and improved by incorporating exports. The CDRR obtained in 2003 and 2004 is much lower than what would have been predicted from past data and has lessened the benefit of adding exports into the relationship.

In general, the regression lines do appear to increase as flows and flows relative to exports increase, but the addition of the 2003 and 2004 data has resulted in these relationships no longer being statistically significant. As mentioned in previous years, even when the relationships were statistically significant ($p<0.05$), confidence intervals indicated data points were not significantly different from each other (SJRG, 2003).

It does not appear that flow and exports in 2003 and 2004 accounted for the low survival observed. As mentioned earlier, the VAMP target flows and CVP/SWP exports were similar in 2002, but survival was significantly higher in 2002 as shown using the CDRRs and respective confidence intervals (Figure 5-8).

The Role of HORB on Survival

In 2004, the HORB daily culvert operation was variable during the VAMP period. Initially three culverts were open, but one became blocked on April 23—the day after our Durham Ferry release and the day of our Mossdale release. Most of the fish likely passed the barrier prior to April 28, when two additional culverts were opened and one operating culvert became partially blocked (Table 4-1).

The barrier is assumed to improve survival based on studies conducted between 1985 and 1990 (Brandes and McLain, 2001). These studies indicated that smolts released in the river downstream of the Head of Old River survived at about twice the rate of those released in the Old River. And while those data were not statistically significant, placing a temporary barrier at the Head of Old River appeared to be a management action that would improve survival through the Delta for smolts originating from the San Joaquin basin. The barrier can only be operated when San Joaquin River flows are 7000 cfs or less. The highest VAMP target flow/export ratio that can be obtained with the barrier in place is 4.7 (7000 cfs flow and 1500 exports).

In Figure 5-9 the annual pooled CDRR or the DRR's are reported for Vernalis flow/export levels of less than 4.7, with and without the barrier in place. The data with the barrier is generally higher than that without the barrier, with the exception of the 1999 and 2003 and 2004 data. In previous reports, we suggested data obtained in 1999 may have been biased high due to missed sampling for the Jersey Point group that year (Brandes, 2000). However, later reporting indicates that differential recovery rates in the ocean fishery were similar to those obtained with

FIGURE 5-6

Combined Differential Recovery Rate (CDRR) and (+/– 1 and 2 Standard Errors) from Durham Ferry and Mossdale to Jersey Point with HORB in place versus San Joaquin River flow at Vernalis in cfs, VAMP years 2000–2004 and non-VAMP years 1994, 1997. Differential Recovery Rates (DRR) from data obtained in 1994 and 1997 from Chipps Island recoveries of Mossdale release were also included.

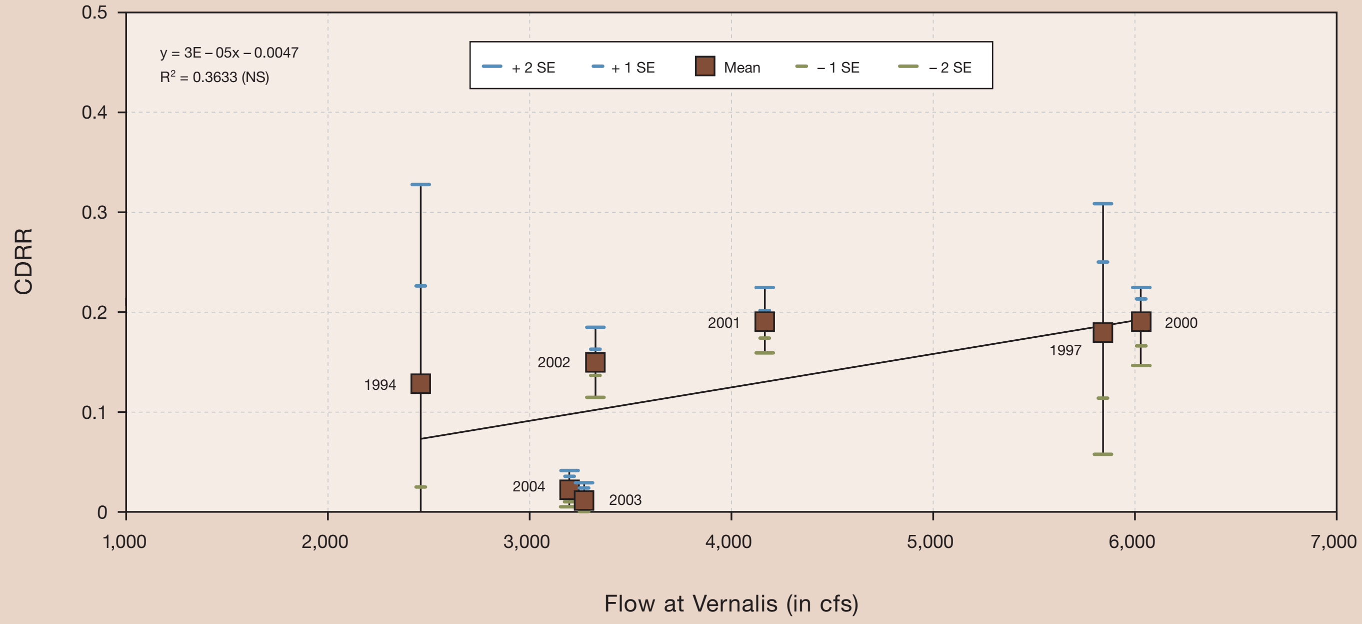


FIGURE 5-7

Combined Differential Recovery Rate (CDRR) and (+/– 1 and 2 Standard Errors) from Durham Ferry and Mossdale to Jersey Point with the HORB in place, versus inflow at Vernalis/exports, 1994, 1997, 2000–2004. Differential Recovery Rates (DRR) from data obtained in 1994 and 1997 from Chipps Island recoveries of Mossdale release were also included.

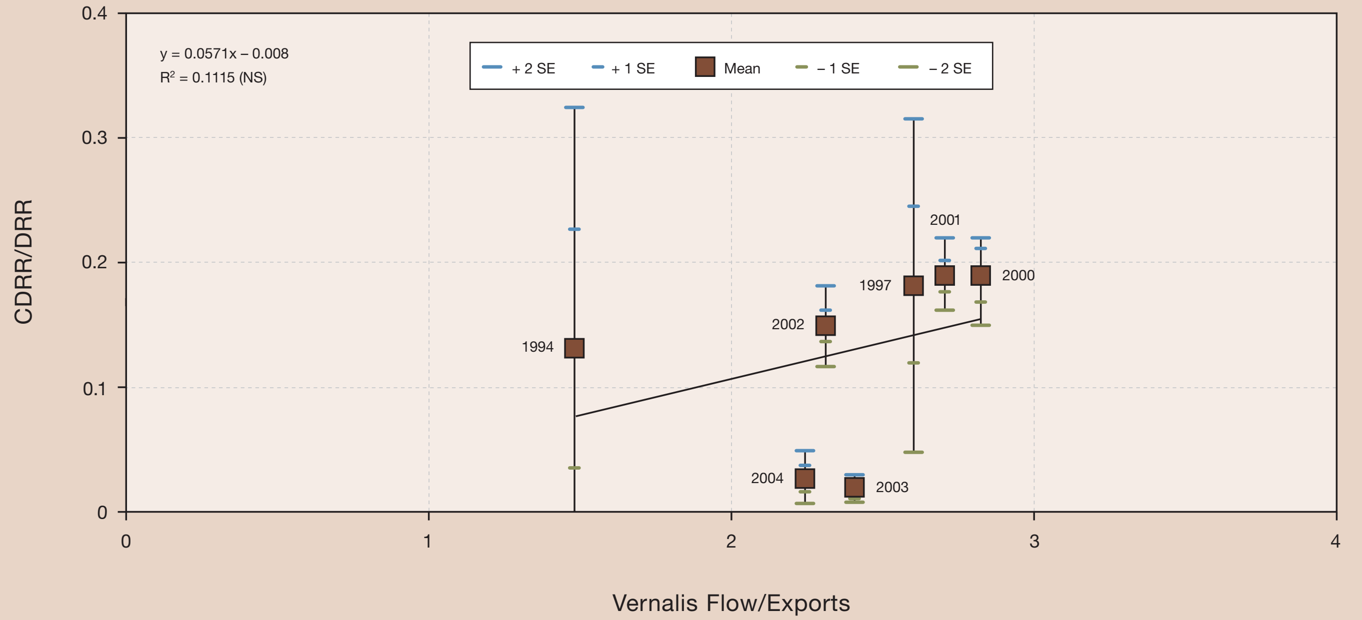


FIGURE 5-8

Combined Differential Recovery Rate (CDRR) and (+/– 1 and 2 Standard Errors) of CWT smolts released at Mossdale and Jersey Point (MD) and Durham Ferry and Jersey Point (DF) for the first release groups (1) in 2002, 2003, and 2004. CDRR were based on the sum of recoveries at Antioch and Chipps Island. Estimates for pooled CDRR's were for the two Durham Ferry and Mossdale releases in 2002 and 2003 and for the only release in 2004.

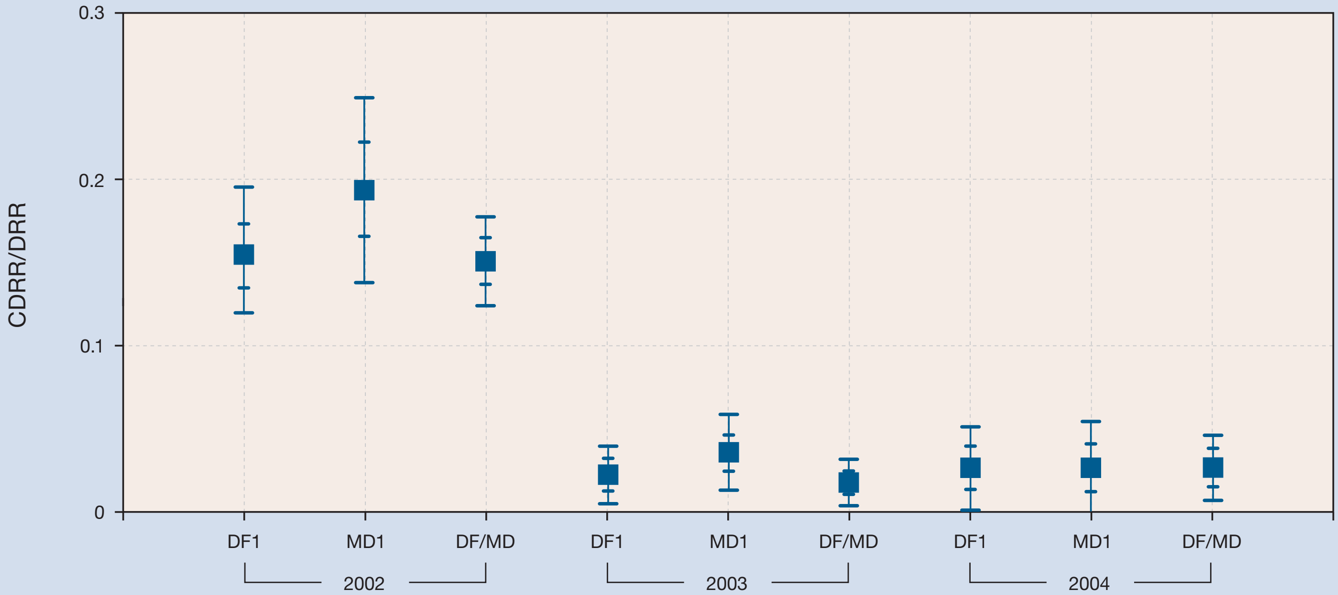


FIGURE 5-9

Combined Differential Recovery Rate (CDRR) and (+/– 1 and 2 Standard Errors) from Durham Ferry and Mossdale to Jersey Point with the HORB in place, versus inflow at Vernalis / exports, 1994, 1997, 2000–2004. Differential Recovery Rates (DRR) from data obtained in 1994 and 1997 from Chipps Island recoveries of Mossdale releases was also included.

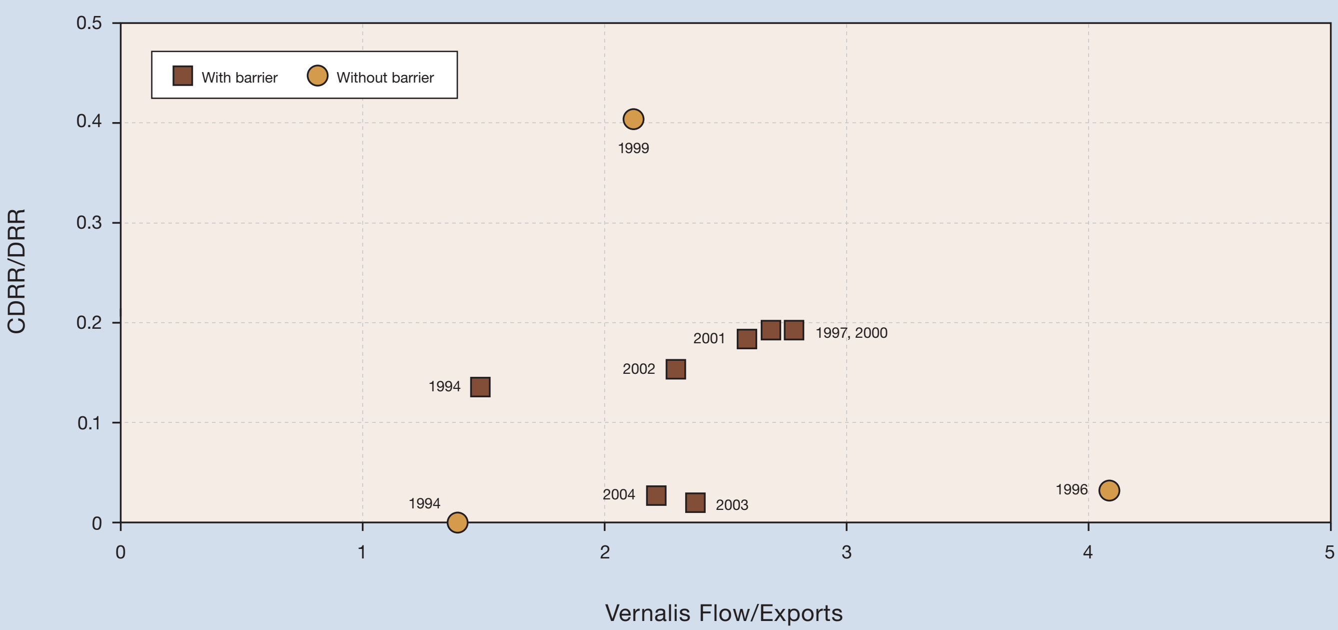
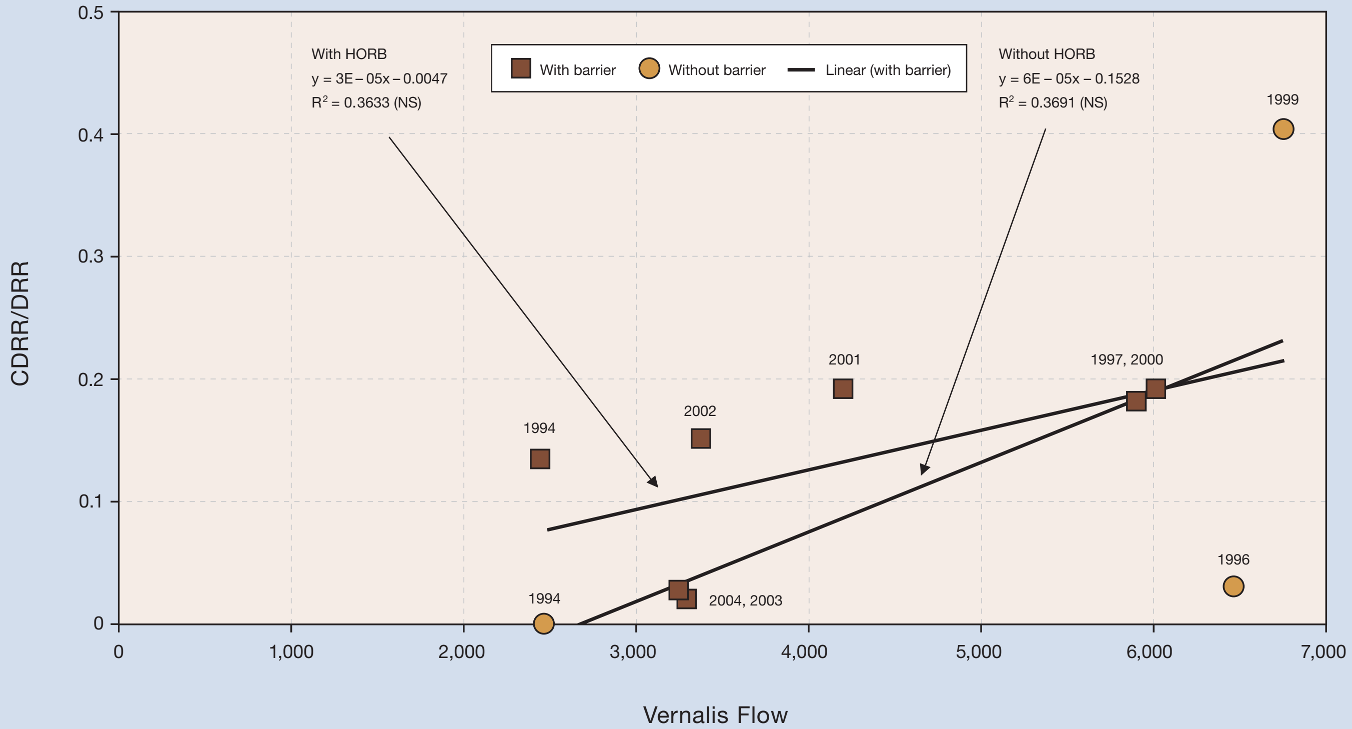


FIGURE 5-10

Combined Differential Recovery Rate (CDRR) from Durham Ferry and Mossdale to Jersey Point with the HORB in place, versus inflow at Vernalis in cfs, 2000–2004. Differential Recovery Rates (DRR) from data obtained in 1994,1996,1997 and 1999 from Chipps Island recoveries of Mossdale releases are also included. Comparable DRR's are shown for 1994, 1996, and 1999 when Vernalis flows were below 7000 cfs without the HORB.



the Chipps Island trawl, thus contradicting our suggestion that the data was biased high. The 1999 data is an instance where survival was high at a low flow/export ratio without the barrier in place. In addition, the estimated survival in 2003 and 2004, with the barrier, was low and similar to levels observed in 1994 and 1996 without a barrier in place (Figure 5-9).

The CDRR's or DRR's with and without the barrier, at San Joaquin River flows (at Vernalis) of less than 7000 cfs, are shown in Figure 5-10. These data seem to be better fitted using flow alone to show the differences in survival with and without the barrier. Survival was the highest at the highest flow even without a barrier in 1999. At the lower flows, the barrier appears to generally improve survival at any one flow. Again, the 2003 and 2004 data falls in the range of the non-barrier data at the lower flows— even though the barrier was installed and operated those two years. Measuring survival at 7000 cfs with a barrier would be informative.

The differences in the target conditions tested in VAMP so far have been small, making it difficult to measure differences in survival. In the six years of measuring survival with the HORB in place, the flow to export ratio has only varied from 1.5 (1994) to 2.9 (2000). The maximum flow to export ratio within the VAMP targets is 4.7, but as of yet it has not been tested. The ratios in the relationship between flow/export and adult escapement vary from 0.1 to 1000 (SJRG, 2003) a broader representation of how spring flows relative to exports have varied since 1951.

Varying designs and changes in the culvert operations of the HORB also make it more difficult to detect significant differences in salmon smolt survival at similar flow to export ratios. Even since the adoption of VAMP, permeability (number of culverts open during operation) of the HORB has changed. In 2000, the HORB had six gated culverts, with two open during the Mossdale and first Durham Ferry releases and four open during the second Durham Ferry release. In 2001 and 2002, six culverts were installed and operated throughout the VAMP test period. In 2003, three culverts were open during the studies. In 2004, between three and five culverts were open during the study.

The amount of water flowing through the culverts is based on the head differential between the San Joaquin River and Old River. The amount of water flow moving from the San Joaquin River into Old River would change as flow, stage and the tides change, even if the number of culverts was consistent between years. These changes in the amount of flow through the culverts and number of culverts operating between years likely affects the entrainment and resulting survival at this point in the river, adding variability in survival from factors other than flow or exports.

The flow through the culverts and seepage through the barrier affects the amount of remaining flow left in the San Joaquin River of which the salmon smolts are exposed. Using flow in the San Joaquin River at Vernalis as the estimate of flow the fish are exposed to instead of flow in the San Joaquin River downstream of the HORB adds additional variation to the relationships we are trying to identify and refine. A better estimate of flow to use in these relationships would be the net flow on the San Joaquin River downstream of upper Old River. An estimate of flow in the San Joaquin River downstream of Old River has been made in the past by subtracting the estimated mean daily flow in upper Old River 840 feet downstream of the barrier from the USGS gaged mean daily flow at Vernalis (Chapter 4). To provide more precise estimates an Acoustic Doppler Current Profiler (ADCP) was placed in the San Joaquin River downstream of the HORB in 2003 and 2004 for the purpose of estimating the flow. This method was deemed the best way to estimate flow at this location. Problems with verification and battery malfunction have prevented a full compliment of data to be gathered during these last two VAMP studies. The ADCP data gathered in 2005 will be compared to that estimated using the mean daily flow in Old River to see how they compare and determine if it is possible to estimate San Joaquin flow downstream of Old River in past years. Future analyses will attempt to use these more refined estimates in comparing smolt survival to San Joaquin River flow.

TABLE 5-10

Release and Recovery Information for CWT Smolts Released in San Joaquin Tributaries in Spring of 2004

Tag Code	Release Site/Stock	Release Date	Truck Temp (F)	River Temp (F)	Number Released	Average Size (mm)	ANTIOCH RECOVERIES First Day Recovered	Last Day Recovered	Number Recovered	Minutes Fished
06-45-92	Shaffer Bridge (MRFF)	4/19/04	N/P	N/P	23,628	85	—	—	0	—
06-45-93	Shaffer Bridge (MRFF)	4/19/04	N/P	N/P	22,440	85	05/04/04	05/04/04	1	584
	Total				**46,068**		05/04/04	05/04/04	1	584
06-45-94	Hatfield State Park (MRFF)	4/20/04	52.9	59.9	23,489	84	—	—	0	—
06-45-95	Hatfield State Park (MRFF)	4/20/04	52.9	59.9	23,037	84	—	—	0	—
	Total				**46,526**					
06-46-64	Shaffer Bridge (MRFF)	4/27/04	55.9	59	25,501	84	—	—	0	—
06-46-65	Shaffer Bridge (MRFF)	4/27/04	55.9	59	25,489	84	—	—	0	—
	Total				50,990					
06-46-66	Hatfield State Park (MRFF)	4/28/04	55.9	63.9	24,511	82	—	—	0	—
06-46-67	Hatfield State Park (MRFF)	4/28/04	55.9	63.9	25,307	82	—	—	0	—
	Total				**49,818**					
06-45-96	Upper Merced @ MRFF	5/09/04	N/P	55.9	25,028	86	—	—	0	—
06-45-97	Upper Merced @ MRFF	5/09/04	N/P	55.9	25,358	86	—	—	0	—
06-46-68	Upper Merced @ MRFF	5/09/04	N/P	55.9	25,340	86	—	—	0	—
06-46-69	Upper Merced @ MRFF	5/09/04	N/P	55.9	24,417	86	—	—	0	—
	Total				**100,143**					
06-45-81**	Hatfield State Park (MRFF)	5/12/04	47.8	65.6	24,274	89	—	—	0	—
06-45-98**	Hatfield State Park (MRFF)	5/12/04	47.8	65.6	24,897	89	—	—	0	—
06-45-99**	Hatfield State Park (MRFF)	5/12/04	47.8	65.6	24,769	89	—	—	0	—
	Total				**73,940**					

** Tag codes released on two days, 5/12 and 5/13; Drafted 9/30/04 Preliminary data

Comparison With Other Marked Fish Released From Merced River Fish Facility

Coded wire tagged salmon from the Merced River Fish Facility were released in the San Joaquin River tributaries between April 19 and May 12 as part of independent (complimentary) fishery investigations. Releases were made in the upper and lower reaches of the Merced River. These studies are reported in more detail in Chapter 6, but are discussed here as they relate to VAMP releases.

Survival indices of the downstream Merced releases (Hatfield State Park) would include mortality down the mainstem San Joaquin River as well as through the Delta. While the survival indices to Antioch and Chipps Island of these lower Merced River release groups would include some additional river mortality, if mainstem mortality was low then the indices would be comparable to survival indices of fish released at Durham Ferry and Mossdale as part of VAMP.

Survival indices of the lower Merced River groups were comparable to indices from the upstream VAMP releases. No recoveries were made at Antioch. Survival indices using Chipps Island recoveries were similar to the VAMP releases with indices ranging between 0.006–0.020 (Table 5-10). Survival indices to Chipps Island of VAMP released fish at Mossdale and Durham Ferry ranged from 0.015 to 0.020 (Table 5-5).

These data would indicate that whatever variables affected the survival of upstream released VAMP fish in 2004 also affected survival of the lower Merced groups. The mortality factor was limited to upstream groups and did not seem to affect the Jersey Point group similarly. We also found this to be true for the 2003 groups (SJRG, 2004).

ANTIOCH RECOVERIES			CHIPPS ISLAND RECOVERIES							FISH FACILITIES	
										Expanded Recoveries	
Percent Sampled	Survival Index	Group Index	First Day Recovered	Last Day Recovered	Number Recovered	Minutes Fished	Percent Sampled	Survival Index	Group Index	CVP	SWP
—	—		—	—	0	—	—	—			
0.406	0.008		—	—	0	—	—	—			
0.406		0.004	—	—	0	—	—		—		
—	—		4/30/04	4/30/04	1	400	0.278	0.020			
—	—		5/1/04	5/1/04	1	400	0.278	0.020		12	6
			4/30/04	5/1/04	2	800	0.278		0.020		
—	—		—	—	0	—	—	—			
—	—		5/16/04	5/16/04	1	400	0.278	0.018			
			5/16/04	5/16/04	1	400	0.278		0.009		
—	—		5/6/04	5/11/04	2	2388	0.276	0.038		12	
—	—		—	—	0	—	—	—		12	6
			5/6/04	5/11/04	2	2388	0.276		0.019		
—	—		—	—	0	—	—	—		24	
—	—		—	—	0	—	—	—			
—	—		—	—	0	—	—	—		12	0
—	—		—	—	0	—	—	—			
			—	—	0	—	—		—		
—	—		5/20/04	5/20/04	1	400	0.278	0.019		12	12
—	—		—	—	0	—	—	—			
—	—		—	—	0	—	—	—		36	6
			—	—	1	400	0.278		0.006		

CHAPTER 5

Comparison with Sacramento River Delta Releases

As in 2003, we reviewed survival indices for juvenile salmon released at Sacramento to see how they compared to VAMP releases in 2004. The average survival index in 2004 for the three separate groups of Feather River Hatchery smolts released on April 15, April 30 and May 14 was 0.19—much lower than that measured in 2003 (0.51). This would indicate that from a relative scale survival was lower through the Sacramento River delta in 2004 than in 2003, whereas with the VAMP fish survival was low for both years. This indicates that perhaps different variables were responsible for the low VAMP survival estimates in 2003 and 2004.

OCEAN RECOVERY INFORMATION FROM PAST YEARS

Ocean recovery data of CWT salmon groups can contribute to a more thorough understanding and evaluation of salmon smolt survival studies. These data can provide another independent estimate of the ratio of recovery rate of a test release group relative to a control release group. Differential recovery rates using ocean recovery information can be compared with absolute survival estimates based on survival indices and the differential or combined differential recovery rates of juvenile salmon recovered at Chipps Island and/or Antioch, respectively. The ocean harvest data may be particularly reliable due to the number of CWT recoveries and the extended recovery period.

Adult 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 2003. 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-classes of salmon have been either harvested or spawned by age five. Consequently, these data are essentially complete for releases made through 1999 and partially available for CWT releases made from 2000 to 2002.

Differential recovery rates based on ocean recoveries, Chipps Island recoveries or combined Antioch and Chipps Island recoveries for salmon produced at the MRFF are shown in Table 5-11. 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 (2000–2002). Releases have been made at several locations: Dos Reis (on the San Joaquin River downstream of the upper Old River junction), 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 5-11.

Results of this comparative analysis of survival estimates and differential recovery rates for Chinook salmon produced in the MRFF show: (1) to date, there is general, but variable, agreement between survival estimates and differential recovery rates based on juvenile CWT salmon recoveries in Chipps Island and adult recoveries from the ocean fishery, (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 VAMP releases for recoveries at Antioch, Chipps Island, and the ocean fishery. Information on survival of juvenile salmon and the contribution to the adult salmon population will be essential to evaluate the biological benefits of changes in flow and export rates under VAMP.

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 assumed that these actions to improve conditions for the juveniles will translate into greater adult abundance and escapement in future years, especially during low flows, when corresponding adult escapement (2 1/2 years later) has been extremely low (SJRG, 2003).

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

Unmarked Salmon Recovered at Mossdale

The time period for VAMP (April 15 to May 15) was chosen based on historical data that indicated a high percentage of the juvenile salmon emigrating from the San Joaquin tributaries passed into the Delta at Mossdale during that time. The average catch per minute per day of unmarked juvenile salmon caught in Kodiak trawling at Mossdale between March 15 and June 30, 2004 is shown in Figure 5-12. Unmarked salmon do not have an adipose clip and could be unmarked fish from the Merced River

FIGURE 5-11

Comparison of Antioch and Chipps Island survival estimates and differentials of combined differential recovery rates compared to differential ocean recovery rates for 1996-2002.

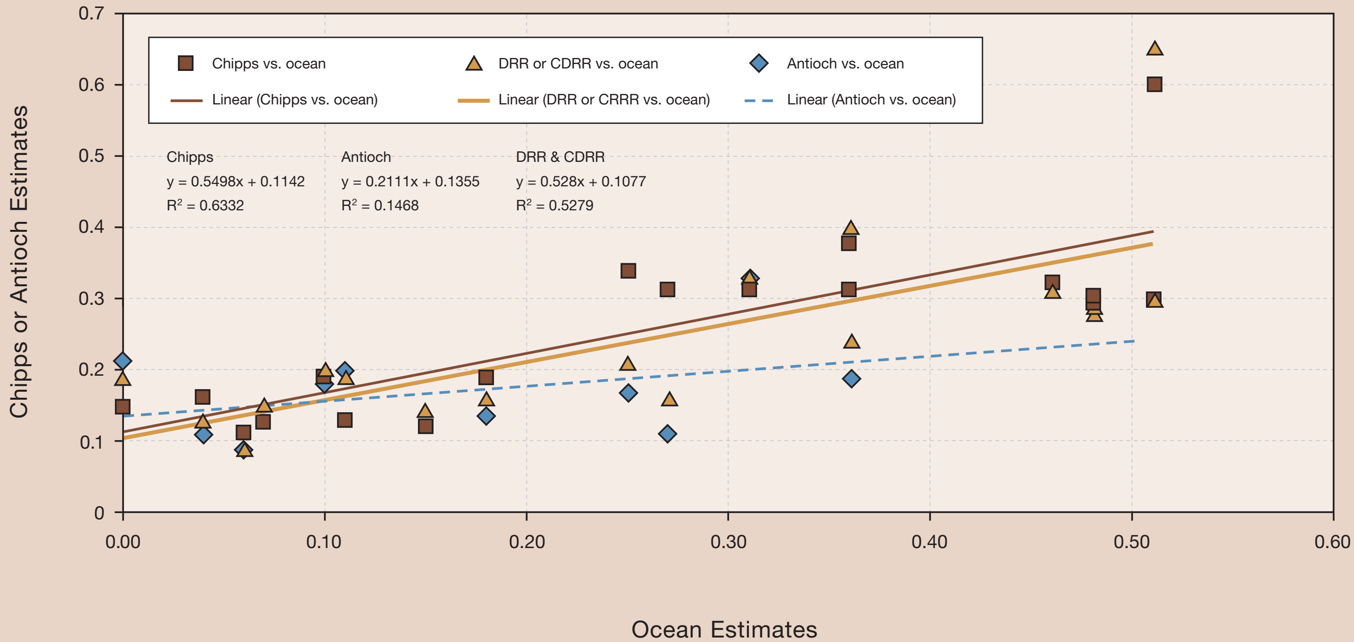


TABLE 5-11

Survival Indices Based on Chipps Island, Antioch and Ocean Recoveries of Merced River Fish Facility Salmon Released as Part of South Delta Studies Between 1996 and 2002

Release Year	San Joaquin River (Merced River origin) Tag Number	Release Number	Release Site	Release Date	Chipps Island Recovs.	Antioch Recovs.	Expanded Adult Ocean Recovs. (Age 1+ to 4+) TOTAL	Chipps Island	Antioch	DRR or CDRR	Ocean Catch
		Juvenile Salmon CWT Releases						Absolute Survival Estimates		Differential Recovery Rates	
1996	H61110412	25,633	Dos Reis	5/01/96	2		3				
	H61110413	28,192	Dos Reis	5/01/96	3		37				
	H61110414	18,533	Dos Reis	5/01/96	1		8				
	H61110415	36,037	Dos Reis	5/01/96	5		10				
	H61110501	53,337	Jersey Pt	5/03/96	39		187				
	Effective Release	107,961	Dos Reis		11		58	0.12		0.14	0.15
	Effective Release	51,737	Jersey Pt		39		187				
1997	H62545	50,695	Dos Reis	4/29/97	9		183				
	H62546	55,315	Dos Reis	4/29/97	7		167				
	H62547	51,588	Jersey Pt	5/02/97	27		355				
	Effective Release	106,010	Dos Reis		16		350	0.29		0.29	0.48
	Effective Release	51,588	Jersey Pt		27		355				
	H62548	46,728	Dos Reis	5/08/97	5		91	0.30		0.28	0.48
	H62549	47,254	Jersey Pt	5/12/97	18		192				
1998	61110809	26,465	Mossdale	4/16/98	25		61				
	61110810	25,264	Mossdale	4/16/98	31		40				
	61110811	25,926	Mossdale	4/16/98	32		58				
	61110806	26,215	Dos Reis	4/17/98	33		47				
	61110807	26,366	Dos Reis	4/17/98	23		35				
	61110808	24,792	Dos Reis	4/17/98	34		61				
	61110812	24,598	Jersey Pt	4/20/98	87		110				
	61110813	25,673	Jersey Pt	4/20/98	100		91				
	Effective Release	77,655	Mossdale		88		159	0.30		0.30	0.51
	Effective Release	77,373	Dos Reis		90		143	0.32		0.31	0.46
	Effective Release	50,271	Jersey Pt		187		201				
1999	062642	24,715	Mossdale	4/19/99	8		128				
	062643	24,725	Mossdale	4/19/99	15		134				
	062644	25,433	Mossdale	4/19/99	13		132				
	062645	25,014	Dos Reis	4/19/99	20		151				
	062646	24,841	Dos Reis	4/19/99	19		219				
	0601110815	24,927	Jersey Pt	4/21/99	34		338				
	062647	24,193	Jersey Pt	4/21/99	25		381				
	Effective Release	74,873	Mossdale		36		394	0.38		0.40	0.36
	Effective Release	49,855	Dos Reis		39		370	0.60		0.65	0.51
	Effective Release	49,120	Jersey Pt		59		719				
2000	06-45-63	24,457	Durham Ferry	4/17/00	11	11	239				
	06-04-01	23,529	Durham Ferry	4/17/00	7	6	208				
	06-04-02	24,177	Durham Ferry	4/17/00	10	10	226				
	06-44-01	23,465	Mossdale	4/18/00	9	14	206				
	06-44-02	22,784	Mossdale	4/18/00	9	16	170				
	06-44-03	25,527	Jersey Pt	4/20/00	24	50	643				
	06-44-04	25,824	Jersey Pt	4/20/00	41	47	690				
	Effective Release	72,163	Durham Ferry		28	27	673	0.31	0.19	0.24	0.36
	Effective Release	46,249	Mossdale		18	30	376	0.31	0.33	0.33	0.31
	Effective Release	51,351	Jersey Pt		65	97	1333				
	601060914	23,698	Durham Ferry	4/28/00	7	8	46				
	601060915	26,805	Durham Ferry	4/28/00	5	15	42				
	0601110814	23,889	Durham Ferry	4/28/00	10	8	70				
	0601061001	25,572	Jersey Pt	5/01/00	48	76	356				
	0601061002	24,661	Jersey Pt	5/01/00	30	76	228				
	Effective Release	74,392	Durham Ferry		22	31	158	0.19	0.14	0.16	0.18
	Effective Release	50,233	Jersey Pt		78	152	584				

TABLE 5-11 (continued)

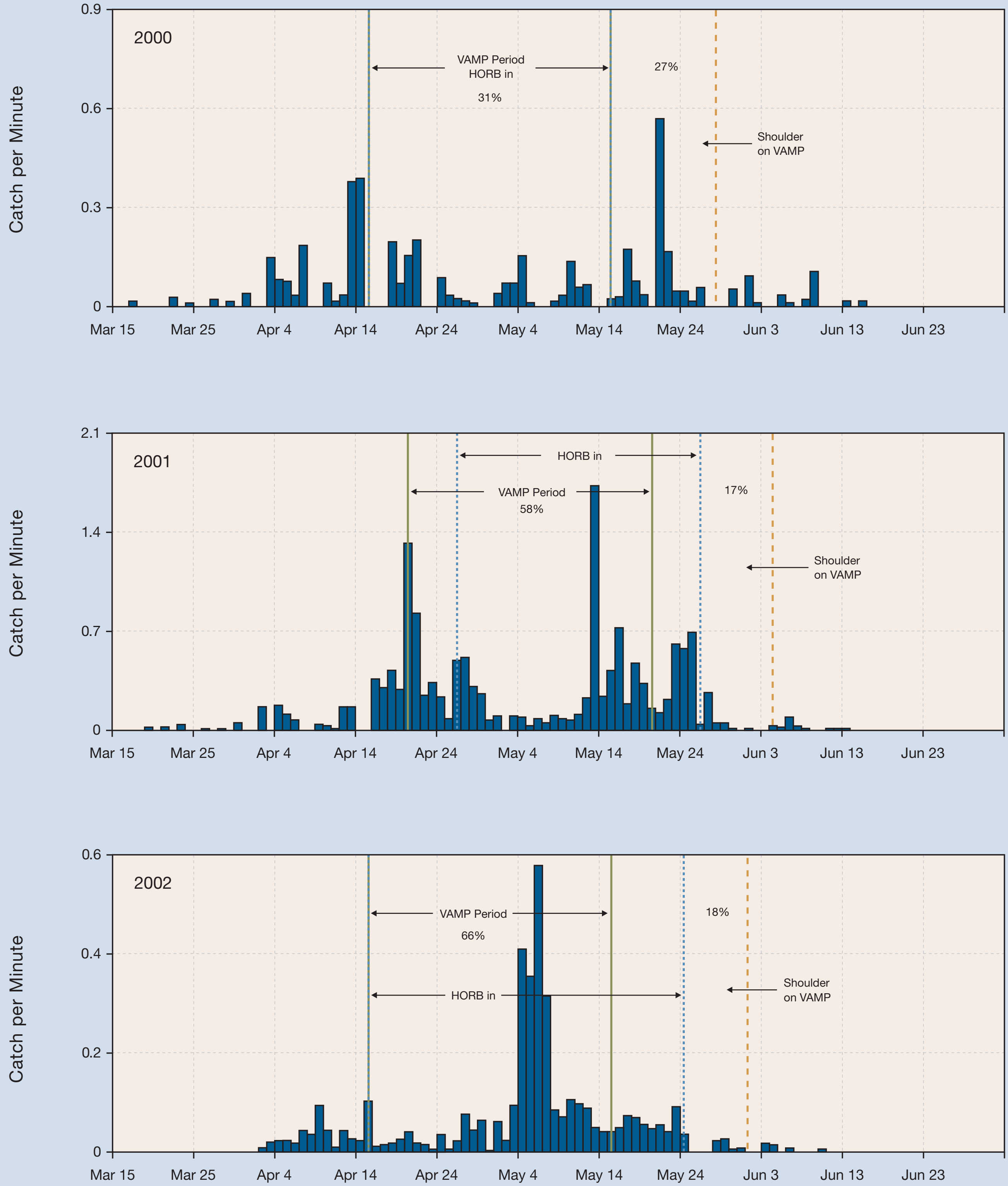
Survival Indices Based on Chipps Island, Antioch and Ocean Recoveries of Merced River Fish Facility Salmon Released as Part of South Delta Studies Between 1996 and 2002

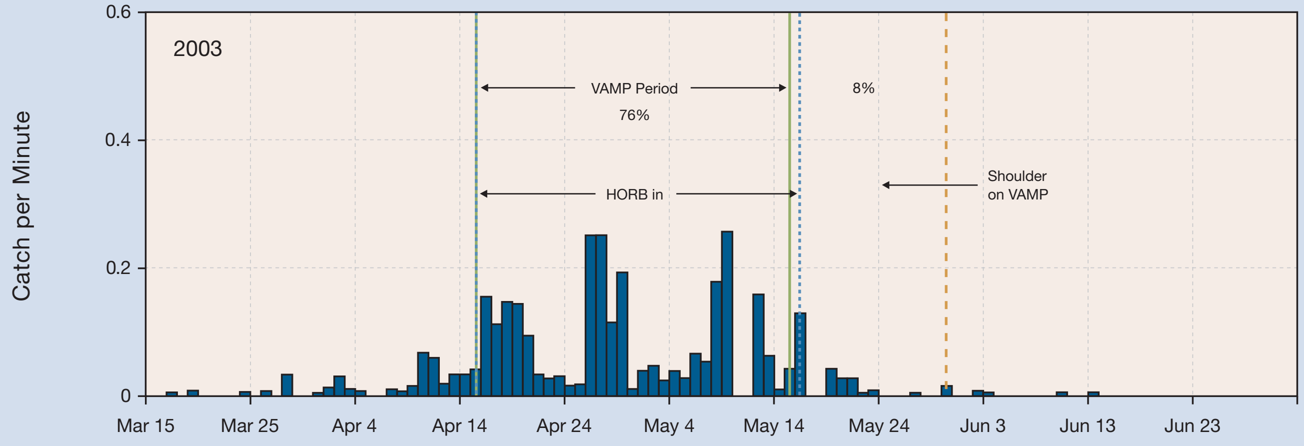
Release Year	San Joaquin River (Merced River origin) Tag Number	Release Number	Release Site	Release Date	Chipps Island Recovs.	Antioch Recovs.	Expanded Adult Ocean Recovs. (Age 1+ to 4+) TOTAL	Chipps Island	Antioch	DRR or CDRR	Ocean Catch
		Juvenile Salmon CWT Releases						Absolute Survival Estimates		Differential Recovery Rates	
2001	06-44-29	23,354	Durham Ferry	4/30/01	14	28	70				
	06-44-30	22,837	Durham Ferry	4/30/01	22	30	141				
	06-44-31	22,491	Durham Ferry	4/30/01	17	18	94				
	06-44-32	23,000	Mossdale	5/01/01	17	18	116				
	06-44-33	22,177	Mossdale	5/01/01	14	15	101				
	06-44-34	24,443	Jersey Pt	5/04/01	50	156	416				
	06-44-35	24,992	Jersey Pt	5/04/01	61	173	467				
	Effective Release	68,682	Durham Ferry		53	76	305	0.34	0.17	0.21	0.25
	Effective Release	45,177	Mossdale		31	33	217	0.31	0.11	0.16	0.27
	Effective Release	49,435	Jersey Pt		111	329	883				
	06-44-36	24,025	Durham Ferry	5/07/01	2	8	14				
	06-44-37	24,029	Durham Ferry	5/07/01	5	11	35				
	06-44-38	24,177	Durham Ferry	5/07/01	2	10	25				
	06-44-39	23,878	Mossdale	5/08/01	4	8	19				
	06-44-40	25,308	Mossdale	5/08/01	4	11	27				
	06-44-41	25,909	Jersey Pt	5/11/01	17	43	191				
	06-44-42	25,465	Jersey Pt	5/11/01	27	53	270				
	Effective Release	72,231	Durham Ferry		9	29	74	0.13	0.20	0.19	0.11
	Effective Release	49,186	Mossdale		8	19	46	0.19	0.18	0.20	0.10
	Effective Release	51,374	Jersey Pt		44	96	461				
2002	06-44-71	23,920	Durham Ferry	4/18/02	4	11	0				
	06-44-72	25,176	Durham Ferry	4/18/02	9	20	12				
	06-44-73	23,872	Durham Ferry	4/18/02	4	12	0				
	06-44-74	24,747	Durham Ferry	4/18/02	4	20	0				
	06-44-57	25,515	Mossdale	4/19/02	6	13	0				
	06-44-58	25,272	Mossdale	4/19/02	7	29	0				
	06-44-59	24,802	Jersey Pt	4/22/02	46	101	41				
	06-44-60	24,128	Jersey Pt	4/22/02	37	89	40				
	Effective Release	97,715	Durham Ferry		21	63	12	0.13	0.13	0.15	0.07
	Effective Release	50,787	Mossdale		13	42	0	0.15	0.21	0.19	0.00
	Effective Release	48,930	Jersey Pt		83	190	81				
	06-44-70	24,680	Durham Ferry	4/25/02	3	6	0				
	06-44-75	24,659	Durham Ferry	4/25/02	5	2	3				
	06-44-76	24,783	Durham Ferry	4/25/02	3	4	0				
	06-44-77	24,381	Durham Ferry	4/25/02	4	6	0				
	06-44-78	24,519	Mossdale	4/26/02	2	3	2				
	06-44-79	24,820	Mossdale	4/26/02	3	4	0				
	06-44-80	24,032	Jersey Pt	4/30/02	18	43	14				
	06-44-81	22,880	Jersey Pt	4/30/02	28	32	19				
	Effective Release	98,503	Durham Ferry		15	18	3	0.16	0.11	0.13	0.04
	Effective Release	49,339	Mossdale		5	7	2	0.11	0.09	0.09	0.06
	Effective Release	46,912	Jersey Pt		46	75	33				

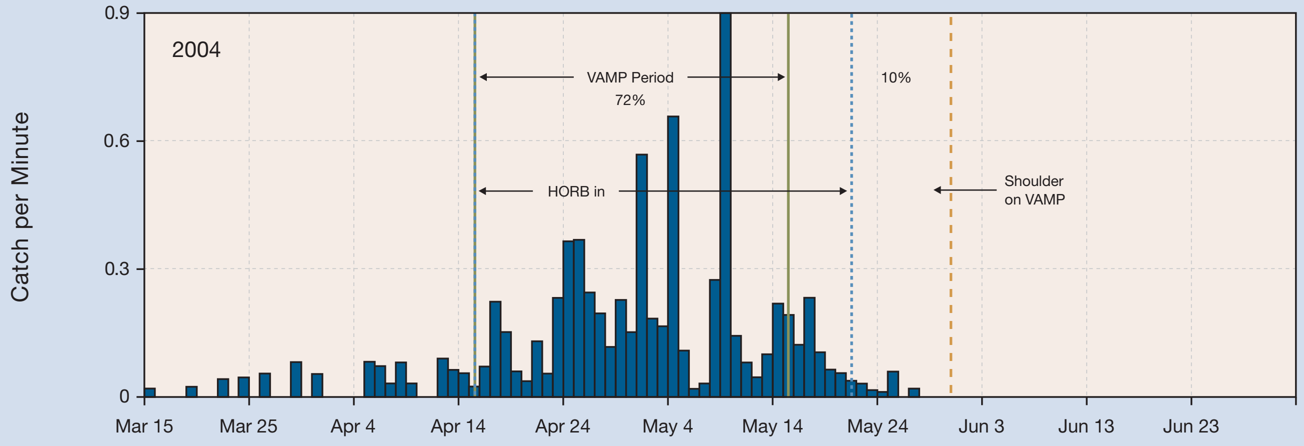
Note: Ocean recoveries are based on data through 2003.

FIGURE 5-12

Catch per minute of unmarked juvenile Chinook caught in the Mossdale Kodiak trawl between March 15 and June 30 of 2000 through 2004. Percentages equate to share of Chinook caught during the VAMP period or Shoulder period of the total catch between March 15 and June 30.




2003
VAMP Period
76%
8%
HORB in
Shoulder
on VAMP
Catch per Minute
0.6
0.4
0.2
0
Mar 15
Mar 25
Apr 4
Apr 14
Apr 24
May 4
May 14
May 24
Jun 3
Jun 13
Jun 23


2004
VAMP Period
72%
10%
HORB in
Shoulder
on VAMP
Catch per Minute
0.9
0.6
0.3
0
Mar 15
Mar 25
Apr 4
Apr 14
Apr 24
May 4
May 14
May 24
Jun 3
Jun 13
Jun 23

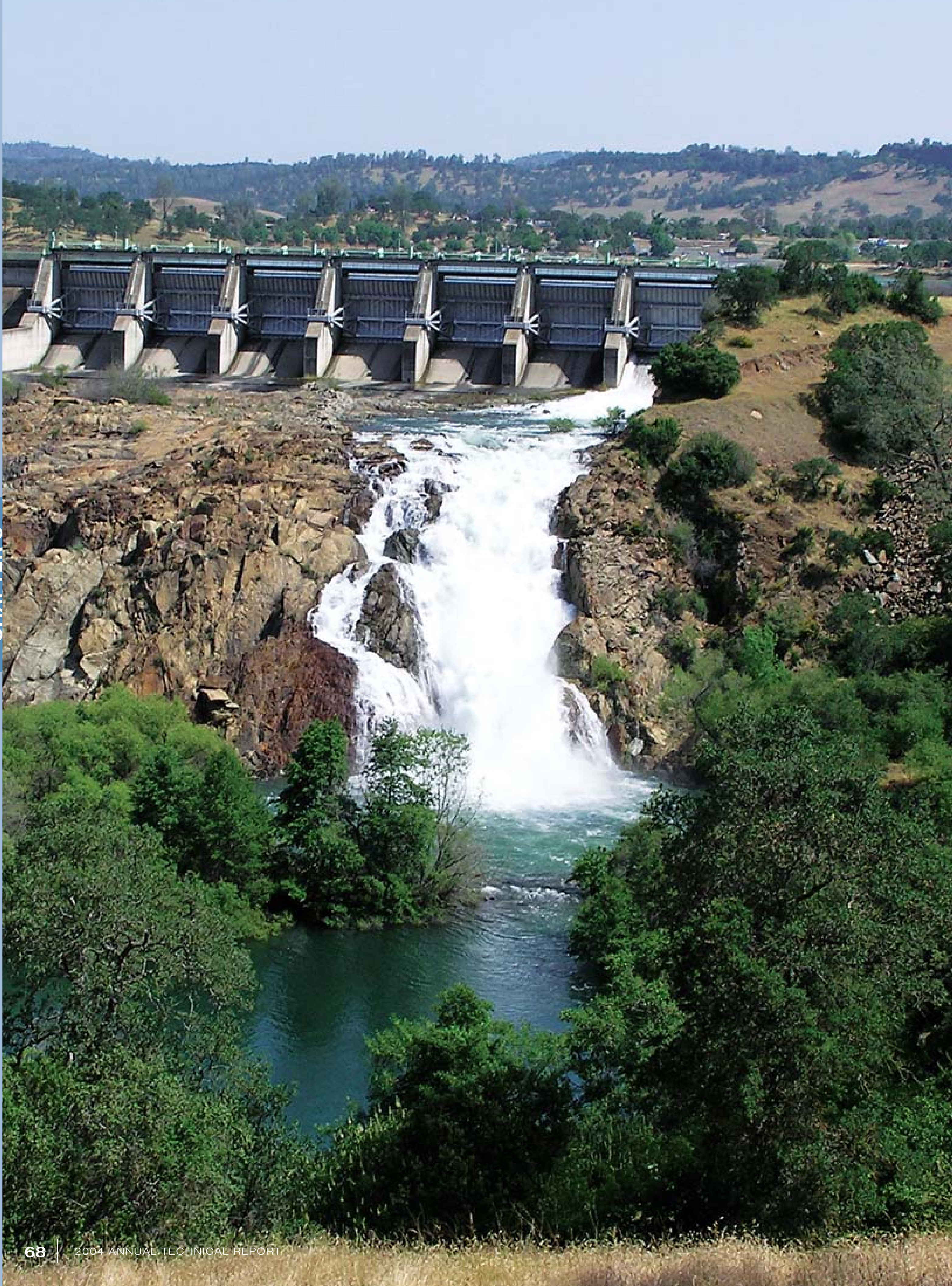
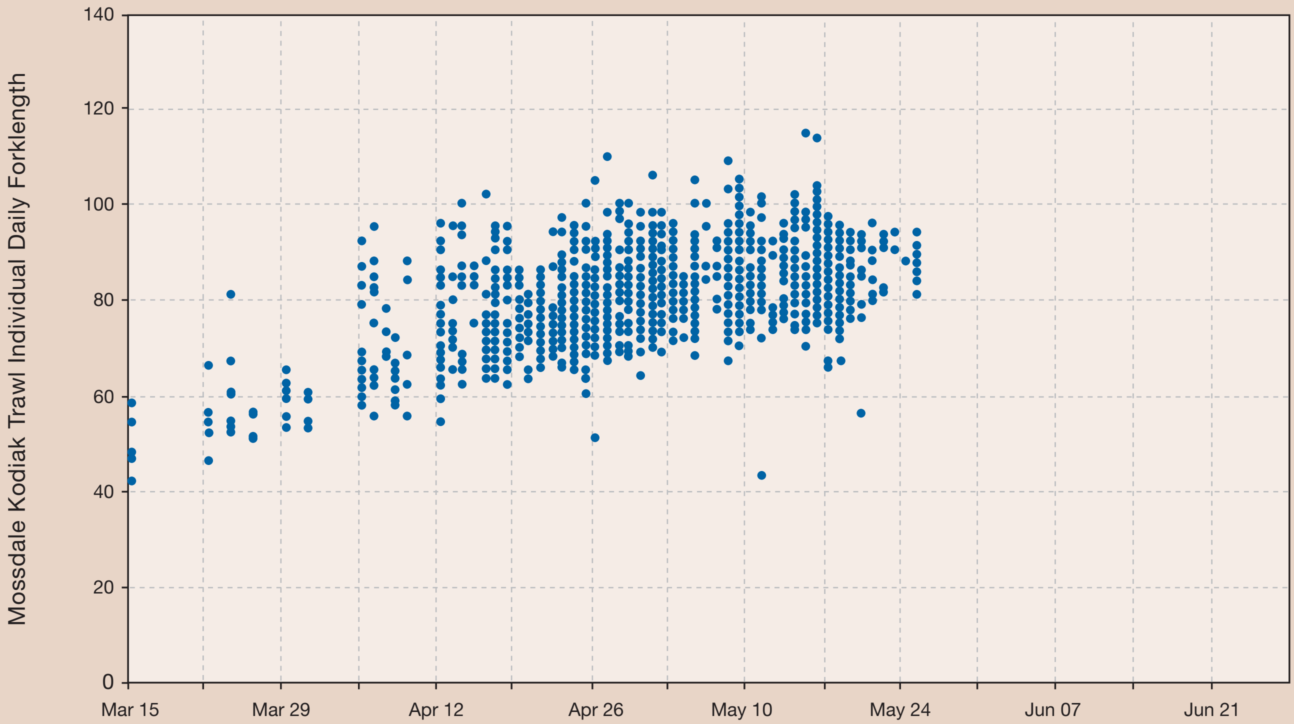


FIGURE 5-13

Mossdale Kodiak trawl individual daily forklengths of all unmarked juvenile Chinook salmon, March 15, 2004 through June 30, 2004.



Fish Facility or juveniles from natural spawning. Approximately 72% of the unmarked catch that passed Mossdale between March 15 and June 30 passed during the VAMP period: April 15 to May 15—which is similar or higher than in past years since the VAMP has been implemented. The shoulder on VAMP that restricts exports until later in May or early June also provided protection to an additional 8 to 27% of the population over the years (Figure 5-12). The percentage of juvenile salmon migrating during the shoulder on the VAMP period in 2004 was 10%. The size of the juvenile salmon migrating past Mossdale between March 15 and June 30, 2004 is shown in Figure 5-13.

Salmon Salvage and Losses at Delta Export Pumps

Fish salvage operations at the CVP and SWP export facilities capture unmarked salmon for transport by tanker truck and release them downstream in the western Sacramento-San Joaquin Delta. The untagged salmon are either naturally produced or untagged MRFF salmon, 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 CWT recovery data for Merced River Fish Facility smolts at the facilities to provide some general indications.

The salvage at the facilities is based on expansions from sub-samples taken throughout the day. Four to five salmon are estimated to be lost per salvaged salmon in the SWP Clifton Court Forebay based on high predation rates. The CVP pumps divert directly from the Old River channel and the loss estimates range from about 50 to 80% of the number salvaged, or about six to eight times less per salvaged salmon than for the SWP. The loss estimates do not include any indirect mortality in the Delta due to water export operations, additional mortality associated with trucking and handling, or post-release predation. Salvage density of salmon is the number of salvaged salmon 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

Releases have been made at several locations: Dos Reis (on the San Joaquin River downstream of the upper Old River junction), Mossdale, Durham Ferry, and Jersey Point.

is an indicator of when concentrations of juvenile salmon may be more susceptible to the export facilities and salvage system.

The weekly data covering the period of April 18 to May 15 approximated the 2004 VAMP period. A review of weekly data for late February through May indicates that the highest salvage and losses occurred during early to mid-March (Figures 5-14 and 5-15). Combined CVP and SWP weekly export rates at that time averaged 11,500–12,000 cfs and Vernalis flow averaged 3,400–3,600 cfs (Figure 5-16). Salmon density at the CVP facilities were very elevated in March as well, but their density was highest in the first week of May (Figure 5-17). Densities at the SWP facilities were generally lower than at the CVP, but were at their highest levels the week prior to and during most of the VAMP period (Figure 5-17). The size distribution of unmarked salmon during mid-March through May in the Mossdale trawl (Figure 5-13) was a subset of the size distribution of those salvaged at the fish facilities (Figure 5-18: Source E. Chappell, DWR). Based on comparisons with Mossdale data, it appears that some salmon salvaged prior to VAMP could have been of San Joaquin basin origin. The high salvage and density observed in early to mid March was also preceded by peak capture of fry and juvenile (pre-smolt) outmigrants in screw traps at Caswell State Park on the Stanislaus River upstream of Vernalis and at Mossdale (Figure 6-1) (Cramer 2004).

Results of these analyses showed that the 2004 VAMP test period coincided with much of the peak period of San Joaquin River salmon smolt emigration. Reductions in SWP and CVP exports and increased San Joaquin River flow likely provided improved conditions for salmon survival, although starting the VAMP period two to three weeks earlier may have had benefits for San Joaquin salmon smolts and smolts of other salmon races and stocks.

SUMMARY AND RECOMMENDATIONS

The survival estimates and CDRRs measured in 2003 and 2004 were low compared to past years. It is unclear why survival in 2003 and 2004 were so low but it does not seem to be directly related to San Joaquin River flow or CVP and SWP exports. It is also possible the low survival observed in the past two years is due to different factors. The MRFF fish were infected with the

FIGURE 5-14

2004 SWP Salmon Salvage & Loss

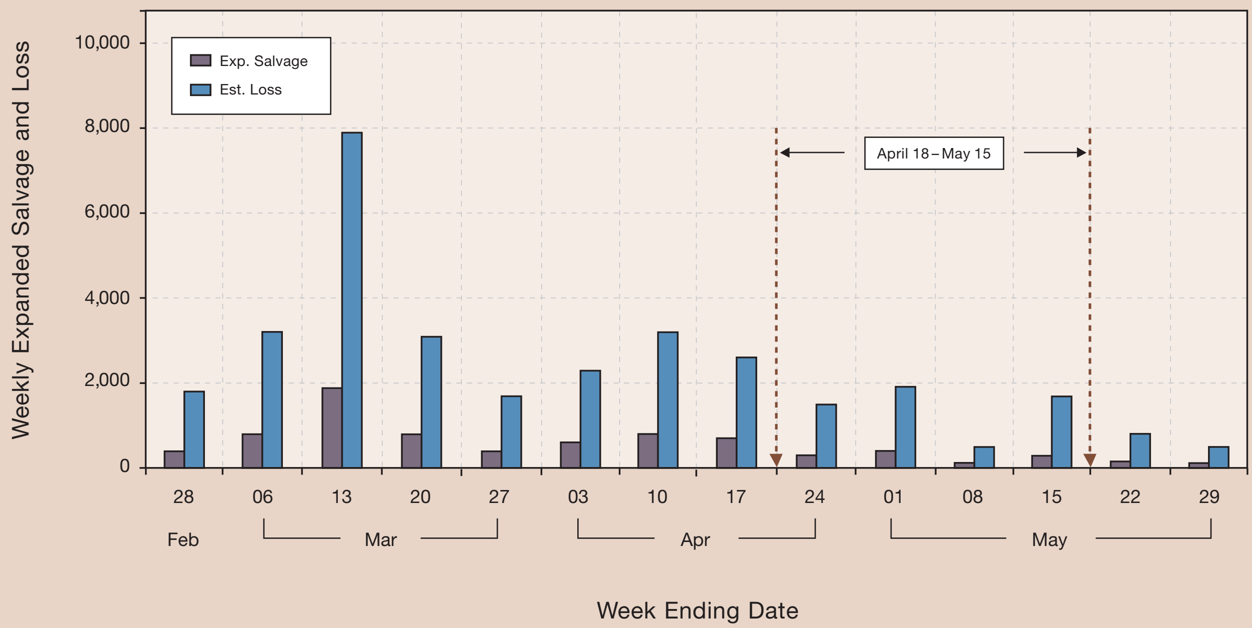
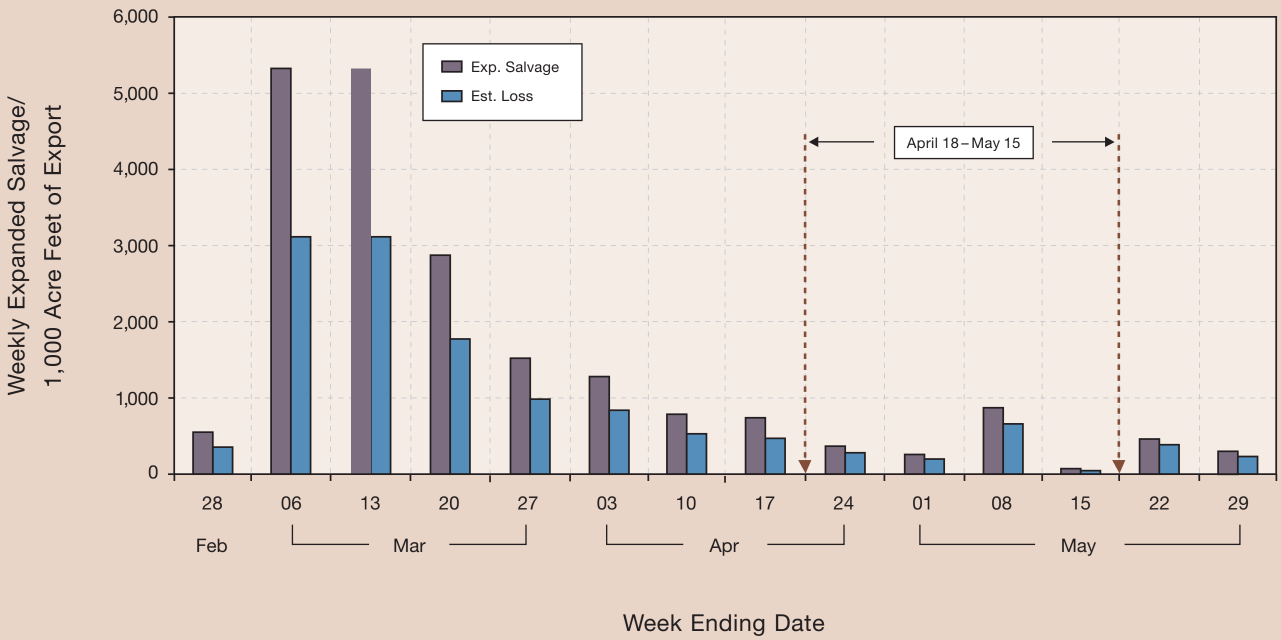


FIGURE 5-15

2004 CVP Salmon Salvage & Loss



CHAPTER 5

FIGURE 5-16

2004 Weekly Export Rates and Vernalis Flow

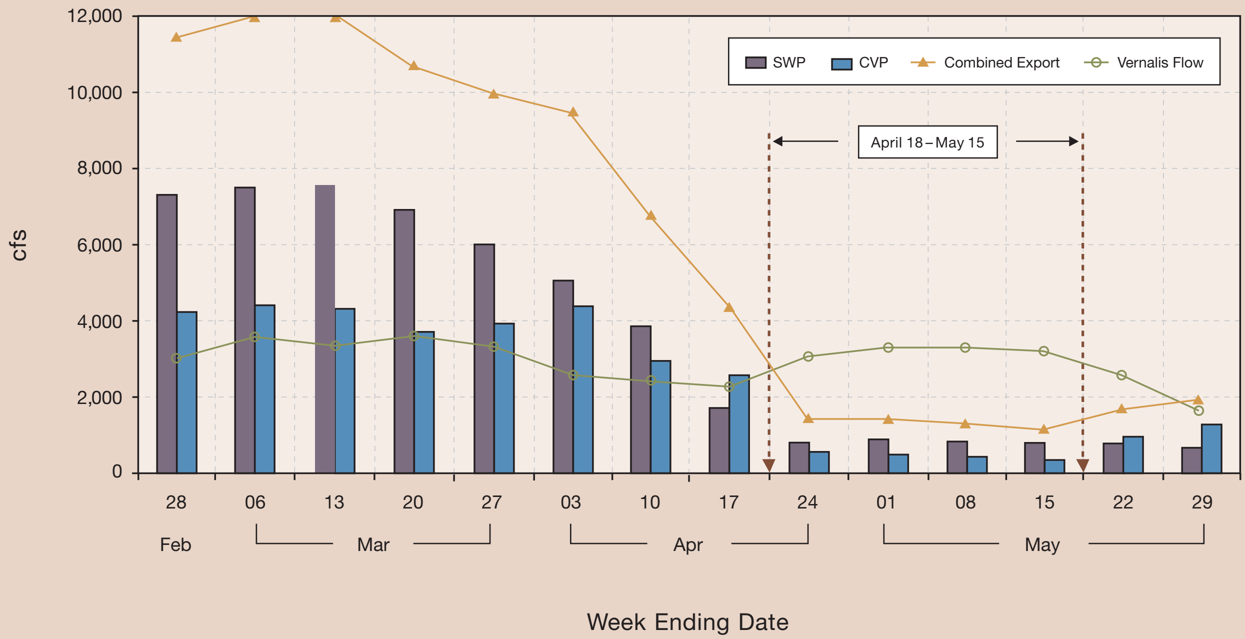
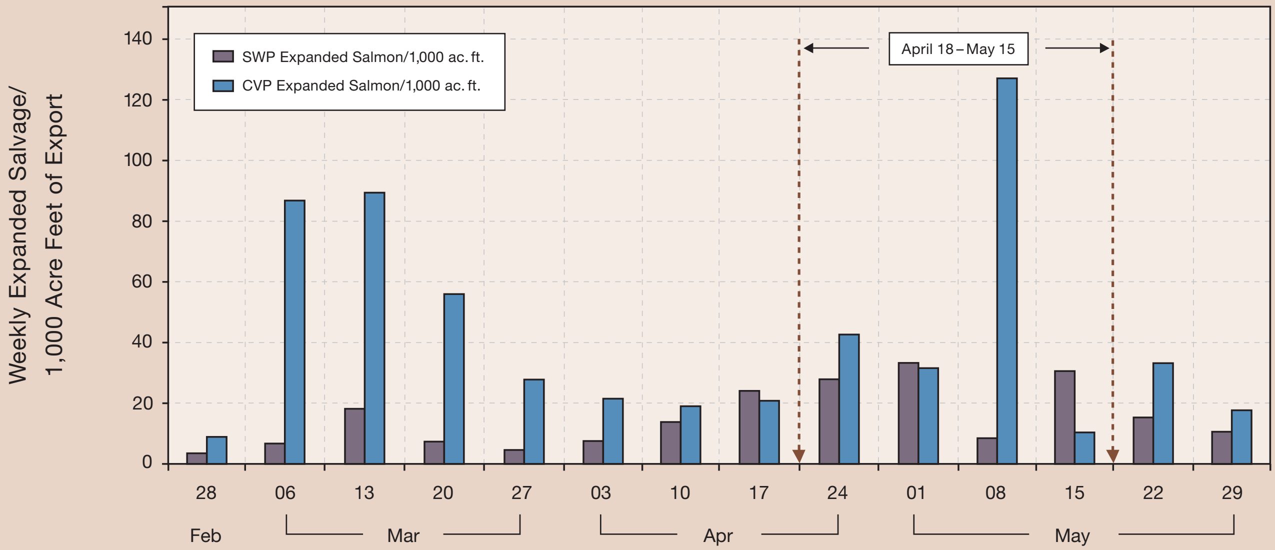


FIGURE 5-17

2004 SWP / CVP Expanded Salmon Salvage Density



parasite that causes PKD. Fish have been infected in past VAMP study years and it does not appear that the incidence of PKD was actually higher in 2003 or 2004. However, the combination of the lower flows and PKD infection may have affected the mortality of the VAMP fish in 2003 and 2004 resulting in shorter transit duration and higher mortality relative to past VAMP releases.

The high and similar mortality of the CWT groups released on the Merced River indicates that whatever increased the mortality of the VAMP fish was some condition that was common to the other marked fish released into the Merced River and lasted for several weeks. This condition also appeared to be restricted to the lower San Joaquin River and Delta or differences in the survival indices for the upstream and downstream Merced River releases would have been greater. While the causes are unclear, it would appear the condition continued into or reappeared in 2004. Repeating the study in future years will determine if this is to be continuous change in the survival rates or limited to lower flow years or just 2003 and 2004.

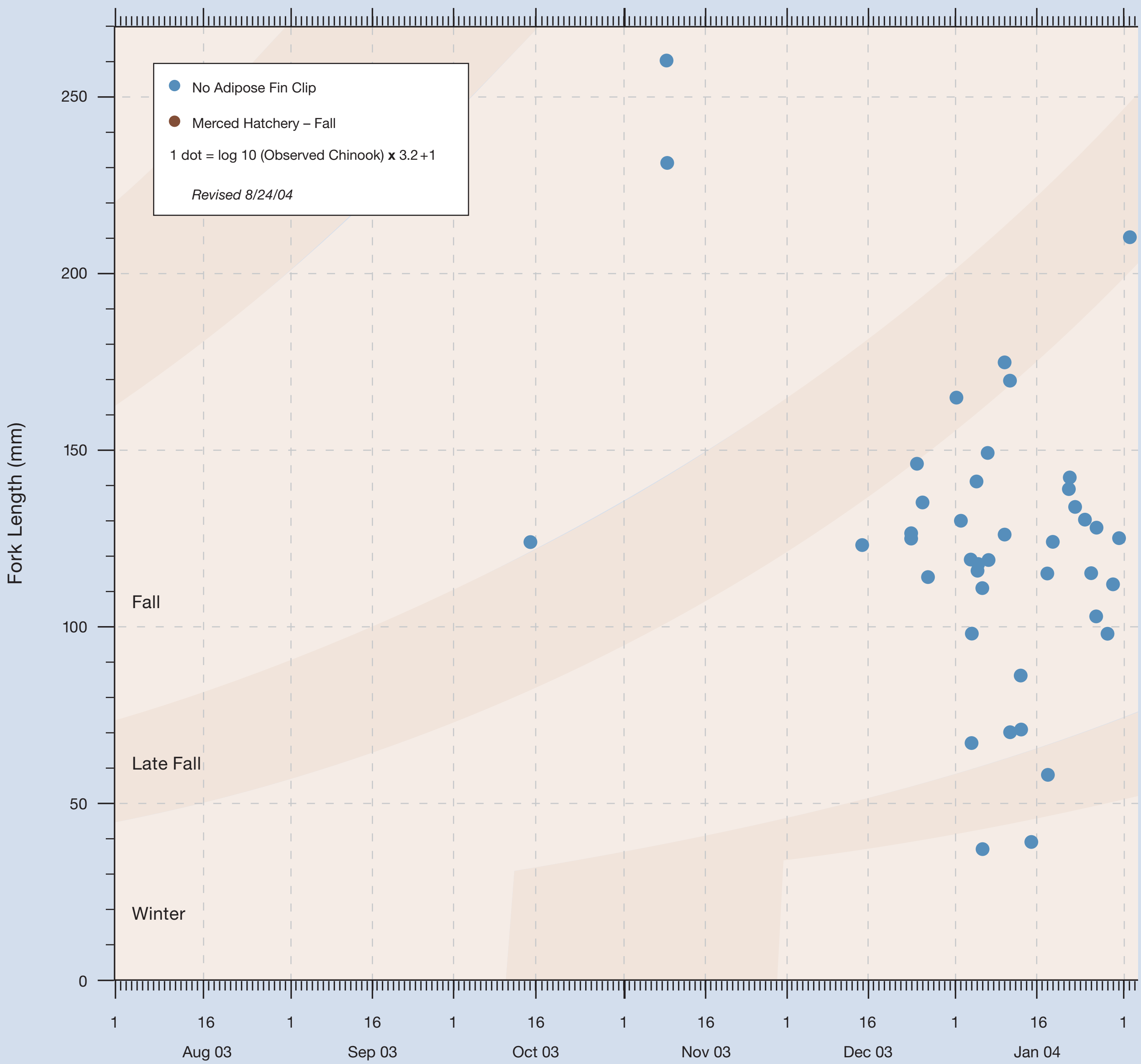
Even without the change since 2003, there have been several impediments to defining and refining the relationships between smolt survival and San Joaquin River flow and CVP and SWP exports. These impediments have been discussed in this and previous VAMP reports. The different permeability of the HORB and not having estimates of flow in the San Joaquin River downstream of the barrier add noise to our estimates of flow. In addition, using diseased MRFF fish in VAMP experiments adds a potential bias to our estimates of survival, even-though PKD is also present in wild stocks (Ken Nichols, USFWS internal memo, 12/6/02). Measuring survival within the narrowly defined flow and export VAMP targets further exacerbates the problem of noise in the variables of interest. The level of precision of our survival estimates and the noise in flow measurements limits our ability to precisely define the relationship of survival to flow and exports. Yearly, pooled estimates are now based on releases of 300,000 to 400,000 fish with two recovery locations, sampling roughly seven to ten hours per day, yet recoveries have not been great enough to statistically differentiate between survival estimates measured at VAMP target flow and exports levels obtained to date. Differences in survival may be occurring but our ability to detect them is limited.

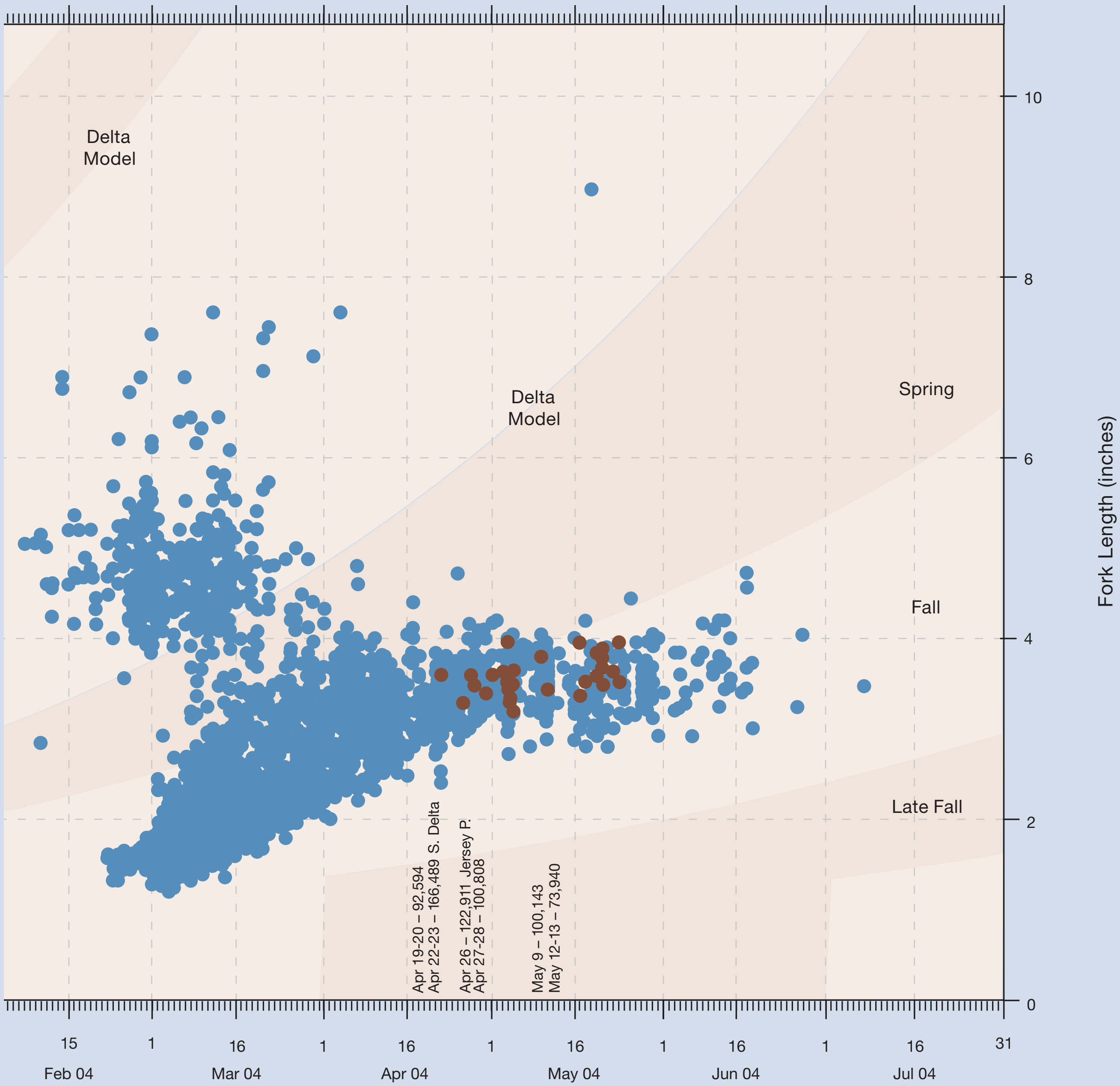
To address this dilemma, future studies should prioritize measuring survival at the highest VAMP target flow and lowest export levels. Flows of 7,000 cfs and exports of 1,500 cfs would achieve the highest inflow to export ratio (4.7) within the VAMP design and provide a new target to test. Based on information to date, the higher flow would probably increase survival and may lessen any effects or infection rate of PKD. This should increase recovery numbers such that confidence intervals may be statistically different from previously obtained CDRRs. It is uncertain how such a condition can be prescribed, independent of the hydrology, within the existing San Joaquin River Agreement, but the idea should be explored by the VAMP Management Team.

Further confidence in defining and refining the relationship of smolt survival to flow and exports could be obtained by increasing the length of the study. The fifth year of VAMP was completed in 2004 with seven years remaining in the study. Additional replication can resolve uncertainty when variation is high. Continued assessment of past data is also recommended such that other methodologies or criteria for determining statistical differences between groups may be developed.

FIGURE 5-18

Observed Chinook Salvage at the SWP & CVP Delta Fish facilities August 1, 2003 through July 31, 2004.




Delta
Model
Delta
Model
Spring
Fall
Late Fall
Fork Length (inches)
0
2
4
6
8
10
Apr 19-20 – 92,594
Apr 22-23 – 166,489 S. Delta
Apr 26 – 122,911 Jersey P.
Apr 27-28 – 100,808
May 9 – 100,143
May 12-13 – 73,940
15
1
16
1
16
1
16
1
16
1
16
31
Feb 04
Mar 04
Apr 04
May 04
Jun 04
Jul 04

6

CHAPTER 6

Complementary Studies Related to the VAMP

Throughout 2004 several fishery studies were conducted that were considered to be important to the overall understanding of the abundance and survival in the San Joaquin River basin. These are presented below to provide the reader with summary information on each study. More information can be obtained from each study manager or report author.

SURVIVAL ESTIMATED FOR CWT RELEASES MADE IN THE SAN JOAQUIN TRIBUTARIES

Contributed by Pat Brandes, U.S. Fish and Wildlife Service

CWT salmon releases were made in the Merced River between April 19 and May 12 as part of independent (complementary) fishery investigations. Three sets of releases were made in the upper Merced River (MRFF/Schaffer Bridge) and lower Merced River (Hatfield State Park).

Group survival indices for salmon released in the Merced River and recovered at Antioch ranged between 0.0 and 0.004 (Table 5-10). Group survival indices ranged between 0.0 and 0.02 to Chipps Island (Table 5-10). These indices were similar to those in 2002 and 2003, but much lower than in 2001, where indices ranged from 0.03 to 0.20 (SJRG 2004, 2003, 2002). These indices include both the survival upstream as well as through the Delta. Vernalis flows were lower in 2002, 2003 and 2004 than in 2001(3200 cfs vs 4450 cfs target flows).

Comparison of survival indices of the upstream tributary groups relative to the downstream tributary groups provides an index of survival through the tributary. Only the survival through the Merced River could be estimated from the second groups release on April 27 and 28th, because it was the only group that had recoveries from both groups at a similar recovery location (Chipps Island). Survival through the Merced River was estimated at 0.47 for this group. Survival through the Merced River ranged between 0.26 and 0.96 in 2003, although there were instances where no recoveries were made at Chipps Island. It appeared survival through the tributaries was generally high using this method of comparison and higher than for those migrating through the Delta.

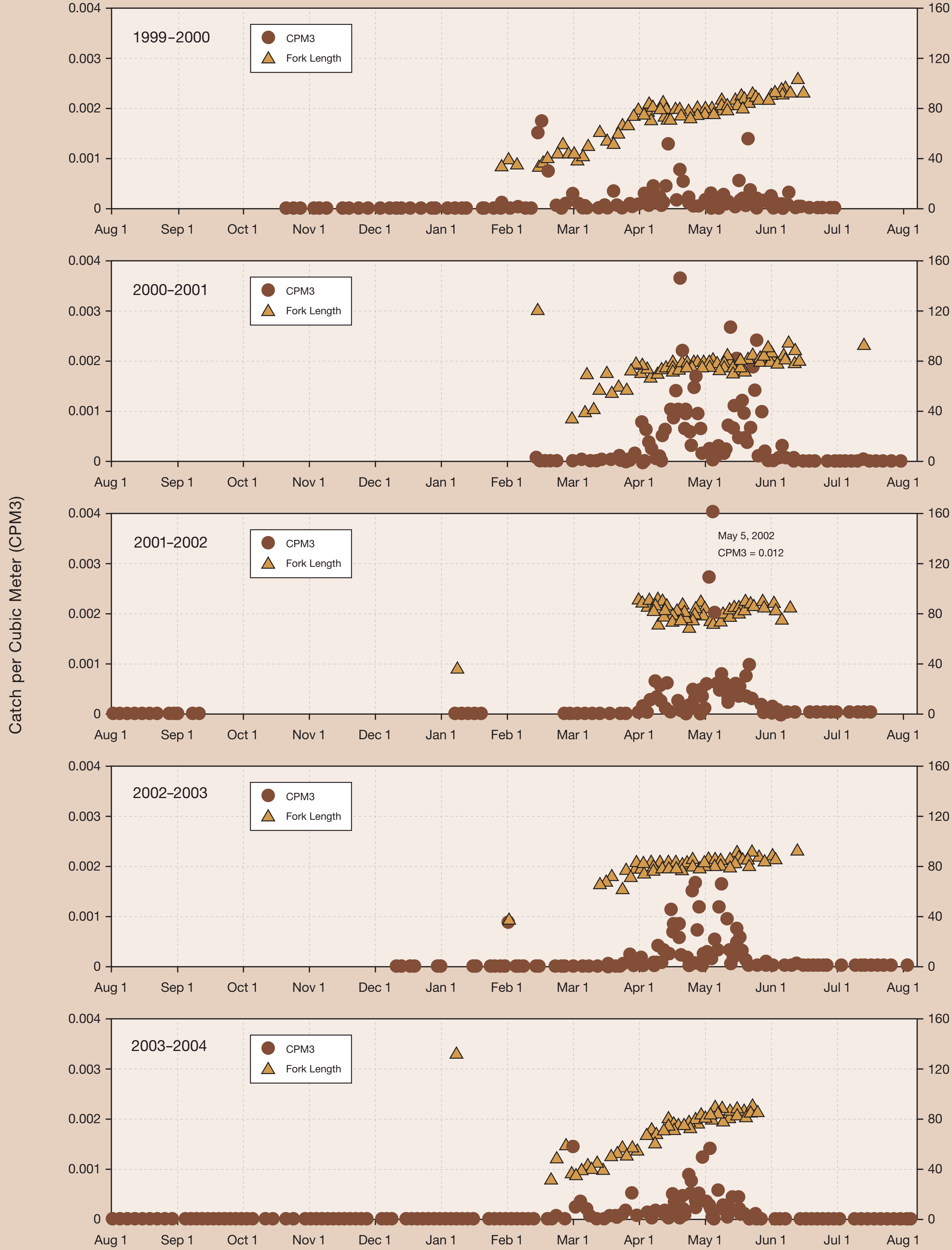
KODIAK TRAWL SAMPLING OF SALMON AT MOSSDALE

Contributed by Pat Brandes, U.S. Fish and Wildlife Service

As part of the Interagency Ecological Program (IEP), kodiak trawl sampling is conducted at Mossdale, two to three times a week throughout the year, when water and staffing levels permit. VAMP has been designed for implementation during the time juvenile salmon from the San Joaquin tributaries migrate through the Delta. Most of the salmon that migrate through the Delta during the VAMP period are smolts that are migrating directly through the Delta to the ocean. In some years, smaller sized juvenile salmon (fry) enter the Delta from the tributaries prior to mid-April. There was no evidence that many fry entered the Delta prior to March in 2004 (Figure 6-1). In most of the past years, there has been evidence of some smaller fish (and sometimes larger salmon) caught at Mossdale as they enter the Delta, as early as mid-January and February (Figure 6-2). In most years numbers were low—the year with the largest number entering the Delta was in 1999–2000. As mentioned in earlier chapters, the spring of 2000 was wetter than the springs since then. Higher flows likely bring more fry into the Delta. However, even in the years when fry from the San Joaquin tributaries enter the Delta it is likely they do not migrate all the way to the ocean until they are of smolt size. Survival for fry in the Delta compared to that upstream has not been measured for the San Joaquin tributaries, although in wet years it was found that fry survive at a higher rate when released in the Sacramento River near Red Bluff than in the north Delta (Brandes and McLain, 2001). In drier years survival was similar between the two groups (Brandes and McLain, 2001).

FIGURE 6-1

Daily catch per cubic meter and mean fork lengths of juvenile Chinook salmon in the Mossdale Kodiak trawl between for August through July periods, 1999 through 2004. Blanks indicate no sampling.



CHAPTER 7

Conclusions & Recommendations

The VAMP experimental investigation of juvenile Chinook salmon survival was implemented during spring 2004. The Vernalis target flow was 3,200 cfs, with a combined SWP and CVP export rate of 1500 cfs. The HORB was successfully installed and maintained throughout the VAMP test period. Estimates of juvenile Chinook salmon smolt survival were calculated based upon releases of CWT juvenile salmon produced in the MRFF and released at Durham Ferry, Mossdale, and Jersey Point. Marked salmon were subsequently recaptured in sampling at the HORB, SWP and CVP export facility salvage, and through intensive fisheries sampling at Antioch and Chipps Island. Based upon the data and experience gained during the VAMP 2004 investigations, conclusions and recommendations have been developed, as summarized in Table 7-1. The conclusions and recommendations include both technical and policy/management issues that will affect the design and implementation of VAMP 2005 operations and investigations.

Based on testing the relationship of salmon survival rates against flow and export conditions over the first five years it has been shown that survival generally improves as flows increase and flows relative to exports increase. With the addition of the 2003 and 2004 data, the relationships between salmon survival rates and Vernalis flows to SWP/CVP exports ratios are no longer statistically significant. Opportunities will be explored for variability in test conditions that are statistically robust and biologically valid in order to obtain fish survival data over a broader range of flow and export reductions. Survival testing at high flows and low exports (a high flow/export ratio) are important to obtain. The VAMP program provides improved protection for juvenile salmon when compared to "pre-VAMP" or without "VAMP" conditions.

TABLE 7–1

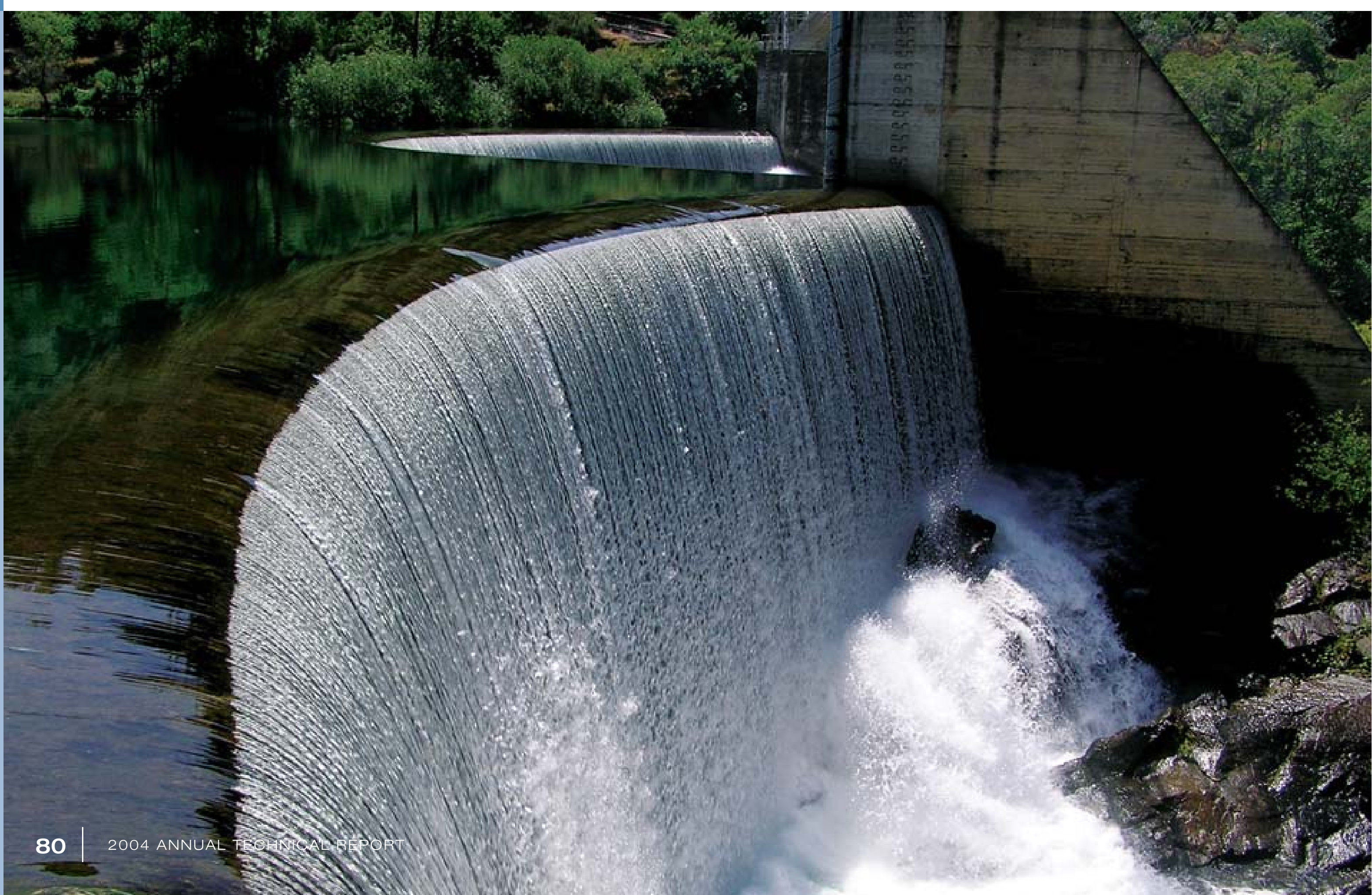
Summary of VAMP 2004 Conclusions and Recommendations

CONCLUSIONS	RECOMMENDATIONS FOR 2005
Survival from Durham Ferry and Mossdale in 2003 and 2004 was significantly less then prior years. Further evaluation of survival rate versus flow and export rate is needed to detect differences in survival.	Survival tests at extreme target levels (e.g. 7,000 cfs flow and 1,500 cfs exports), or equivalent high flow/export ratios are necessary. The VAMP tests should be continued.
Flow measurements in the Old River and in the San Joaquin River downstream of the HORB were hampered by equipment malfunctions and calibration.	Maintenance and calibration of flow measurement equipment should be performed before the initiation of the 2005 VAMP and periodically checked throughout the VAMP period.
An accurate measurement of flow diverted through the HORB is essential to better understand the flow and entrainment relationship at the barrier.	Continue measurement of flow in at least one culvert as done in 2004 with desire to measure flow in all culverts.

CONCLUSIONS CONT.	RECOMMENDATIONS CONT.
Mossdale Kodiak trawl is an important component in determining distribution of out migration from the San Joaquin Basin.	Maintain the Mossdale Kodiak trawl at existing or higher level of effort throughout year.
Observed ungaged flows (accretions, depletions) between upstream measurement points and Vernalis varied significantly from those forecasted resulting in differences between forecasted and required supplemental flows.	Hydrology committee to refine estimates of ungaged flow and develop a management scheme to accommodate variability.
Real-time streamflow data at San Joaquin River near Vernalis were improved by weekly verification of rating curves.	Continue weekly flow and calibration measurements. Investigate alternative flow measurement methods and/or locations.
Flow in the lower San Joaquin River downstream of Old River is important to evaluate the flow split at Old River and survival of salmon.	Calibrate the stage and flow monitoring system prior to and during the 2005 VAMP test period.
Coordination with upstream tributary operations was successful, though some imbalance against the Division Agreement resulted.	Continue coordination among tributary operators.
Operation of the HORB was successful in maintaining south delta water levels.	Continue to refine operational criteria for culverts, water level modeling, and groundwater level monitoring.
The use of fyke nets was successful in collecting entrained fish at the culverts.	Continue monitoring culverts using fyke nets to document fish entrainment.
The index of salmon entrainment at the HORB was significantly lower in 2004 (0.7 salmon per hour) compared to the past three years (3.4 in 2003; 2.5 in 2002; 1.4 in 2001).	Continue barrier monitoring and analysis of factors affecting entrainment.
Most salmon were entrained at night in 2004, similar to prior years. The relationship between tidal condition and salmon entrainment at HORB was variable.	Split releases at Mossdale should be re-instituted in 2005 to evaluate tidal-diel interactions affecting salmon entrainment.
2004 studies were successful in determining salmon entrainment at HORB culverts, but did not estimate mortality associated with HORB.	Evaluate methods to estimate mortality associated with HORB.
The release at Durham Ferry was improved by having the diversion pump at the site curtail operation.	Continue to curtail diversion pump operations during releases—coordinate release schedule with landowner.
Results of net pen studies showed a 0.8 percent mortality rate in 2004 compared to 0.5 percent in 2003.	Continue net pen studies and fish health inspections.
Physiological studies provided useful information on fish health and condition. Fish pathologists concluded that fish were relatively healthy and should have performed adequately for outmigration assessments.	Recommend continued health monitoring to compare within and between year trends of health and condition.
Blood chemistry analysis showed that all release groups were physiologically capable of handling stress associated with outmigration.	Baseline data for blood chemistry analyses should be taken from unstressed fish (not subjected to stress for 24 or more hours).

CONTINUED ON NEXT PAGE

CONCLUSIONS CONT.	RECOMMENDATIONS CONT.
2003 and 2004 survival rates were the lowest since the initiation of the VAMP and were significantly lower than those in 2002 under similar flow and export conditions.	Continue to evaluate differences in survival rates between release locations, flows, and export conditions.
Complimentary studies to evaluate mechanisms affecting survival of fish from tributaries and across the Delta were conducted.	Encourage an expansion of complementary studies to provide additional information on factors and mechanisms affecting salmon survival.
Few CWT salmon from VAMP releases were recovered at the SWP and CVP salvage facilities.	Continue salvage monitoring to document direct losses at SWP/CVP export facilities.
VAMP has been designed to adaptively manage experimental test conditions each year.	Continue to identify and evaluate opportunities to adaptively manage and refine the VAMP test conditions to improve protection for juvenile Chinook salmon out-migrating from the San Joaquin River, improve survival test conditions to detect differences in survival, if they exist, as a function of river flow and SWP/CVP export operations, and optimize the allocation of available water supplies each year.



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DFG, Department of Fish and Game to DWR on Proposed ACOE permit number 200000696, Temporary Barriers Project. April 4, 2001.

Souverville, M. Department of Water Resources, (msouv@water.ca.gov). Geology and Groundwater Section, Temporary Barriers Project.

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Signatories to the San Joaquin River Agreement

SIGNATORIES

U.S. Bureau of Reclamation

U.S. Fish and Wildlife Service

California Department of Water Resources

California Department of Fish and Game

Oakdale Irrigation District*

South San Joaquin Irrigation District*

Modesto Irrigation District*

Turlock Irrigation District*

Merced Irrigation District*

San Joaquin River Exchange Contractors
Water Authority*

- Central California Irrigation District
- Firebaugh Canal Water District
- Columbia Canal Company
- Sal Luis Canal Company

Friant Water Users Authority*

Public Utilities Commission of the City
and County of San Francisco*

Natural Heritage Institute

Metropolitan Water District of
Southern California

San Luis And Delta-Mendota
Canal Water Authority

San Joaquin River Group Authority

**San Joaquin River Group Authority Members*

Useful Web Pages

PAGE 3

San Joaquin River Agreement

www.sjrg.org/agreement.htm

SWRCB Decision 1641

www.waterrights.ca.gov/hearings/Decisions.htm

PAGE 8

VAMP Annual Technical Reports

www.sjrg.org/technicalreport/2003_tech_report.htm

VAMP Experimental Design

www.sjrg.org/agreement.htm

PAGE 11

Operation Monitoring, CDEC Hourly

http://cdec.water.ca.gov/cgi-progs/queryGroup?s=fw1

Operation Monitoring, CDEC Daily

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

Vernalis USGS Real-Time

http://waterdata.usgs.gov/nwis/uv?format=pre&period=1&site_no=11303500

Vernalis, USGS Daily

http://waterdata.usgs.gov/ca/nwis/dv?format=pre&period=31&site_no=11303500

Newman, USGS Daily

http://waterdata.usgs.gov/ca/nwis/dv?format=pre&period=31&site_no=11274000

LaGrange, USGS Daily

http://waterdata.usgs.gov/ca/nwis/dv?format=pre&period=31&site_no=11289650

Goodwin, USBR Daily

http://www.usbr.gov/mp/cvo/vungvari/gdwdop.pdf

Cressey, CDEC Daily

http://cdec.water.ca.gov/cgi-progs/queryF?s=crs

Stevinson, CDEC Daily

http://cdec.water.ca.gov/cgi-progs/queryF?s=mst

PAGE 28

Temporary Barrier Program

http://sdelta.water.ca.gov/web_pg/tempmesr.html

PAGE 33

Reclamation District 544
Seepage Monitoring Study

http://wwwdpla.water.ca.gov/cd/groundwater/Delta_Seepage.html

PAGE 42

HORB on Old River Tidal Stage

http://cdec.water.ca.gov/cgi-progs/queryF?s=MSD

PAGE 69

CVP and SWP Salvage Data

http://baydelta.water.ca.gov

USFWS Stockton

http://www.delta.dfg.ca.gov/usfws/monitoring_main/monitoring_main.html

Pacifica States Marine Fisheries Commission
Regional Mark Information System

http://www.rmis.org

Common Acronyms & Abbreviations

ADCP Acoustic Doppler Current Profiler

Bay-Delta Sacramento and San Joaquin Rivers San Francisco Bay Delta

CDEC California Data Exchange Center

CDRR Combined Differential Recovery Rate

CFS Cubic Feet Per Second

CPUE Catch Per Unit Effort

CRR Combined Recovery Rate

CVP Central Valley Project

CWT Coded-Wire Tagged

D-1641 Water Rights Decision 1641 of the SWRCB

DFG California Department of Fish and Game

DWR California Department of Water Resources

FHC California-Nevada Fish Health Center

GLC Grant Line Canal

HOR Head of Old River

HORB Head of Old River Barrier

Merced Merced Irrigation District

MID Modesto Irrigation District

MR Middle River

MRFF Merced River Fish Facility

MSL Mean Sea Level

NOAA National Oceanic and Atmospheric Administration

OID Oakdale Irrigation District

ORT Old River at Tracy

PKD Proliferative Kidney Disease

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

TBP Temporary Barriers Project

TID Turlock Irrigation District

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

APPENDIX A

Hydrology & Operation Plans

APPENDIX A–1, TABLE 1

VAMP Daily Operation Plan, March 17, 2004 (A) • Low

Target Flow Period: April 15–May 15 • Flow Target: 3,200 cfs

	San Joaquin River near Vernalis							Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus River below Goodwin				
	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. Flow	Exch Contr VAMP Supp. Flow	VAMP Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol. S=Stan.
	(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	
Apr 01						349	300	250			250	500	500		500	765			765	
Apr 02						346	300	250			250	500	500		500	765			765	
Apr 03						342	300	250			250	500	500		500	765			765	
Apr 04	2,161				2,161	339	300	250			250	500	500		500	765			765	
Apr 05	2,157				2,157	335	300	250			250	500	500		500	765			765	
Apr 06	2,154				2,154	332	300	250			250	500	500		500	765			765	
Apr 07	2,150				2,150	328	300	250			250	500	500		500	765			765	
Apr 08	2,147				2,147	325	300	250			250	500	500		500	765			765	
Apr 09	2,143				2,143	321	300	250			250	500	500		500	765			765	
Apr 10	2,140				2,140	318	300	250			250	500	500		500	765			765	
Apr 11	2,136				2,136	314	300	250	150		400	500	500		500	765			765	
Apr 12	2,133				2,133	311	300	250	400	90	740	500	500		500	765			765	
Apr 13	2,129	0			2,129	307	300	250	560	90	900	700	1,030	170	1,200	400	200	0	600	
Apr 14	2,126	150			2,276	304	300	250	560	90	900	700	1,030	170	1,200	400	100	0	500	
Apr 15	2,287	860	0	1.71	3,147	300	300	250	590	90	930	700	1,030	170	1,200	400	100	0	500	
Apr 16	2,284	920	0	3.53	3,204	297	300	250	600	80	930	700	1,030	170	1,200	400	100	0	500	
Apr 17	2,280	920	0	5.36	3,200	293	300	250	600	80	930	700	1,030	170	1,200	400	100	0	500	
Apr 18	2,277	950	0	7.24	3,227	290	300	250	600	80	930	700	1,030	170	1,200	400	100	0	500	
Apr 19	2,273	950	0	9.12	3,223	286	300	250	600	80	930	700	1,030	170	1,200	400	100	0	500	
Apr 20	2,270	950	0	11.01	3,220	283	300	250	600	80	930	700	1,030	170	1,200	400	100	0	500	
Apr 21	2,266	950	0	12.89	3,216	279	300	250	600	80	930	700	1,040	160	1,200	400	100	0	500	
Apr 22	2,263	950	0	14.78	3,213	276	300	250	600	80	930	700	980	160	1,140	400	100	0	500	
Apr 23	2,269	940	0	16.64	3,209	272	300	250	600	80	930	700	640	160	800	600	150	0	750	
Apr 24	2,206	940	0	18.51	3,146	269	300	250	270	80	600	700	440	160	600	1,000	150	0	1,150	
Apr 25	2,062	990	0	20.47	3,052	265	300	250	270	80	600	700	440	160	600	1,200	300	0	1,500	
Apr 26	2,259	990	0	22.43	3,249	262	300	250	270	80	600	700	440	160	600	1,200	300	0	1,500	
Apr 27	2,455	810	0	24.04	3,265	258	300	250	270	80	600	700	440	160	600	1,200	300	0	1,500	
Apr 28	2,452	810	0	25.65	3,262	255	300	250	270	80	600	700	440	160	600	1,200	300	0	1,500	
Apr 29	2,448	810	0	27.25	3,258	251	300	250	270	80	600	700	440	160	600	1,200	300	0	1,500	
Apr 30	2,445	810	0	28.86	3,255	248	300	250	270	80	600	700	440	160	600	1,200	300	0	1,500	
May 01	2,441	810	0	30.47	3,251	244	300	250	270	80	600	700	440	160	600	1,200	300	0	1,500	
May 02	2,438	810	0	32.07	3,248	241	300	250	530	80	860	700	440	160	600	1,200	300	0	1,500	
May 03	2,434	810	0	33.68	3,244	237	300	250	570	80	900	700	440	160	600	1,200	0	0	1,200	
May 04	2,431	810	0	35.29	3,241	234	300	250	920	80	1,250	700	640	160	800	900	0	0	900	
May 05	2,427	770	0	36.81	3,197	230	300	250	970	80	1,300	700	640	160	800	600	0	0	600	
May 06	2,324	810	0	38.42	3,134	227	300	250	970	80	1,300	700	640	160	800	400	100	0	500	
May 07	2,020	1,160	0	40.72	3,180	223	300	250	970	80	1,300	700	640	160	800	400	100	0	500	
May 08	1,817	1,310	0	43.32	3,127	220	300	250	970	80	1,300	700	640	160	800	400	200	0	600	
May 09	1,813	1,310	0	45.92	3,123	216	300	250	970	80	1,300	700	640	160	800	400	200	0	600	
May 10	1,810	1,410	0	48.71	3,220	213	300	250	920	80	1,250	700	640	160	800	400	200	0	600	
May 11	1,806	1,410	0	51.51	3,216	209	300	250	870	80	1,200	700	640	160	800	400	300	0	700	
May 12	1,803	1,410	0	54.31	3,213	206	300	250	670	80	1,000	700	640	160	800	400	300	0	700	
May 13	1,799	1,460	0	57.20	3,259	202	300	250	250		500	700	640	160	800	400	300	0	700	
May 14	1,796	1,410	0	60.00	3,206	199	300	250			250	500	500		500	565			565	
May 15	1,792	1,210	0	62.40	3,002	195	300	250			250	500	500		500	565			565	
May 16	1,814	250			2,064	192	300	250			250	500	500		500	565			565	
May 17	1,810	0			1,810	188	300	250			250	500	500		500	565			565	
May 18	1,807	0			1,807	185	300	250			250	500	500		500	565			565	
May 19	1,803	0			1,803	181	300	250			250	500	500		500	565			565	
May 20	1,800	0			1,800	178	300	250			250	500	500		500	565			565	
May 21	1,796	0			1,796	174	300	250			250	500	500		500	565			565	
May 22	1,793	0			1,793	171	300	250			250	500	500		500	565			565	
May 23	1,789	0			1,789	167	300	250			250	500	500		500	565			565	
May 24	1,786	0			1,786	164	300	250			250	500	500		500	565			565	
May 25	1,782	0			1,782	160	300	250			250	500	500		500	565			565	
May 26	1,779	0			1,779	157	300	250			250	500	500		500	565			565	
May 27	1,775	0			1,775	153	300	250			250	500	500		500	565			565	
May 28	1,772	0			1,772	150	300	250			250	500	500		500	565			565	
May 29	1,768	0			1,768	146	300	250			250	500	500		500	565			565	
May 30	1,765	0			1,765	143	300	250			250	500	500		500	565			565	
May 31	1,761	0			1,761	139	300	250			250	500	500		500	565			565	
	VAMP Period																			
Avg. (cfs):	2,185	1,015			3,200	255	300	250	594	81	925	700	700	163	863	681	177	0	858	
Suppl. Water (TAF)		62.40							36.50	5.00				10.00			10.91			

Target flow period

APPENDIX A–1, TABLE 2

VAMP Daily Operation Plan, March 17, 2004 (B) • High

Target Flow Period: April 15–May 15 • Flow Target: 4,450 cfs

	San Joaquin River near Vernalis							Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus River below Goodwin				
	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. Flow	Exch Contr VAMP Supp. Flow	VAMP Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol. S=Stan.
	(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	
Apr 01						667	800	250			250	500	500		500	1,191			1,191	
Apr 02						662	800	250			250	500	500		500	1,191			1,191	
Apr 03						658	800	250			250	500	500		500	1,191			1,191	
Apr 04	3,403				3,403	653	800	250			250	500	500		500	1,191			1,191	
Apr 05	3,399				3,399	648	800	250			250	500	500		500	1,191			1,191	
Apr 06	3,394				3,394	643	800	250			250	500	500		500	1,191			1,191	
Apr 07	3,389				3,389	638	800	250			250	500	500		500	1,191			1,191	
Apr 08	3,384				3,384	634	800	250			250	500	500		500	1,191			1,191	
Apr 09	3,379				3,379	629	800	250			250	500	500		500	1,191			1,191	
Apr 10	3,375				3,375	624	800	250			250	500	500		500	1,191			1,191	
Apr 11	3,370				3,370	619	800	250			250	500	500		500	1,191			1,191	
Apr 12	3,365				3,365	614	800	250	400	90	740	500	500		500	1,191			1,191	
Apr 13	3,360	0			3,360	610	800	250	600	90	940	1,000	1,070	25	1,095	500	700	0	1,200	
Apr 14	3,355	0			3,355	605	800	250	600	90	940	1,000	1,070	30	1,100	500	500	0	1,000	
Apr 15	3,230	1,215	0	2.41	4,445	600	800	250	600	90	940	1,000	1,070	30	1,100	500	500	0	1,000	
Apr 16	3,225	1,220	0	4.83	4,445	595	800	250	515	80	845	1,000	1,080	20	1,100	500	500	0	1,000	
Apr 17	3,220	1,220	0	7.25	4,440	590	800	250	260	80	590	1,000	980	20	1,000	900	300	0	1,200	
Apr 18	3,225	1,210	0	9.65	4,435	586	800	250	260	80	590	1,000	980	20	1,000	1,500	0	0	1,500	
Apr 19	3,520	915	0	11.46	4,435	581	800	250	260	80	590	1,000	980	20	1,000	1,500	0	0	1,500	
Apr 20	4,116	360	0	12.18	4,476	576	800	250	260	80	590	1,000	980	20	1,000	1,500	0	0	1,500	
Apr 21	4,111	360	0	12.89	4,471	571	800	250	260	80	590	1,000	980	20	1,000	1,500	0	0	1,500	
Apr 22	4,106	360	0	13.61	4,466	566	800	250	260	80	590	1,000	980	20	1,000	1,500	0	0	1,500	
Apr 23	4,101	360	0	14.32	4,461	562	800	250	270	80	600	1,000	980	20	1,000	1,500	0	0	1,500	
Apr 24	4,096	360	0	15.03	4,456	557	800	250	270	80	600	1,000	980	20	1,000	1,500	0	0	1,500	
Apr 25	4,092	360	0	15.75	4,452	552	800	250	270	80	600	1,000	980	20	1,000	1,500	0	0	1,500	
Apr 26	4,087	370	0	16.48	4,457	547	800	250	270	80	600	1,000	980	20	1,000	1,500	0	0	1,500	
Apr 27	4,082	370	0	17.22	4,452	542	800	250	280	80	610	1,000	980	20	1,000	1,500	0	0	1,500	
Apr 28	4,077	370	0	17.95	4,447	538	800	250	300	80	630	1,000	980	20	1,000	1,500	0	0	1,500	
Apr 29	4,072	370	0	18.68	4,442	533	800	250	300	80	630	1,000	980	20	1,000	1,500	0	0	1,500	
Apr 30	4,068	380	0	19.44	4,448	528	800	250	300	80	630	1,000	980	20	1,000	1,500	0	0	1,500	
May 01	4,063	400	0	20.23	4,463	523	800	250	320	80	650	1,000	980	20	1,000	1,500	0	0	1,500	
May 02	4,058	400	0	21.02	4,458	518	800	250	320	80	650	1,000	980	20	1,000	1,500	0	0	1,500	
May 03	4,053	400	0	21.82	4,453	514	800	250	320	80	650	1,000	980	20	1,000	1,500	0	0	1,500	
May 04	4,048	420	0	22.65	4,468	509	800	250	320	80	650	1,000	980	20	1,000	1,500	0	0	1,500	
May 05	4,044	420	0	23.48	4,464	504	800	250	320	80	650	1,000	980	20	1,000	1,500	0	0	1,500	
May 06	4,039	420	0	24.32	4,459	499	800	250	320	80	650	1,000	980	20	1,000	1,500	0	0	1,500	
May 07	4,034	420	0	25.15	4,454	494	800	250	630	80	960	1,000	980	20	1,000	1,500	0	0	1,500	
May 08	4,029	420	0	25.98	4,449	490	800	250	770	80	1,100	1,000	980	20	1,000	1,160	40	0	1,200	
May 09	4,024	420	0	26.82	4,444	485	800	250	770	80	1,100	1,000	980	20	1,000	860	160	0	1,020	
May 10	3,680	770	0	28.34	4,450	480	800	250	770	80	1,100	1,000	980	20	1,000	500	520	0	1,020	
May 11	3,375	1,030	0	30.39	4,405	475	800	250	670	80	1,000	1,000	1,030	20	1,050	500	520	0	1,020	
May 12	3,010	1,390	0	33.14	4,400	470	800	250	540	80	870	1,000	1,080	20	1,100	500	600	0	1,100	
May 13	3,055	1,390	0	35.90	4,445	466	800	250			250	1,000	1,080	20	1,100	500	700	0	1,200	
May 14	3,100	1,370	0	38.62	4,470	461	800	250			250	500	500		500	1,191			1,191	
May 15	3,096	1,340	0	41.28	4,436	456	800	250			250	500	500		500	1,191			1,191	
May 16	3,202	0			3,202	451	800	250			250	500	500		500	1,191			1,191	
May 17	3,197	0			3,197	446	800	250			250	500	500		500	1,191			1,191	
May 18	3,192	0			3,192	442	800	250			250	500	500		500	1,191			1,191	
May 19	3,187	0			3,187	437	800	250			250	500	500		500	1,191			1,191	
May 20	3,183	0			3,183	432	800	250			250	500	500		500	1,191			1,191	
May 21	3,178	0			3,178	427	800	250			250	500	500		500	1,191			1,191	
May 22	3,173	0			3,173	422	800	250			250	500	500		500	1,191			1,191	
May 23	3,168	0			3,168	418	800	250			250	500	500		500	1,191			1,191	
May 24	3,163	0			3,163	413	800	250			250	500	500		500	1,191			1,191	
May 25	3,159	0			3,159	408	800	250			250	500	500		500	1,191			1,191	
May 26	3,154	0			3,154	403	800	250			250	500	500		500	1,191			1,191	
May 27	3,149	0			3,149	398	800	250			250	500	500		500	1,191			1,191	
May 28	3,144	0			3,144	394	800	250			250	500	500		500	1,191			1,191	
May 29	3,139	0			3,139	389	800	250			250	500	500		500	1,191			1,191	
May 30	3,135	0			3,135	384	800	250			250	500	500		500	1,191			1,191	
May 31	3,130	0			3,130	379	800	250			250	500	500		500	1,191			1,191	
	VAMP Period																			
Avg. (cfs):	3,779	671			4,450	538	300	250	407	81	738	1,000	1,000	21	1,021	1,191	163	0	1,354	
Suppl. Water (TAF)		41.28							25.00	5.00				1.28			10.00			

Target flow period

APPENDIX A-1, TABLE 3

VAMP Daily Operation Plan, March 30, 2004 (A) • Low

Target Flow Period: April 15–May 15 • Flow Target: 3,200 cfs

	San Joaquin River near Vernalis							Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus River below Goodwin				
	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. Flow	Exch Contr VAMP Supp. Flow	VAMP Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol. S=Stan.
	(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	
Apr 01						349	300	250			250	500	500		500	765			765	
Apr 02						346	300	250			250	500	500		500	765			765	
Apr 03						342	300	250			250	500	500		500	765			765	
Apr 04	2,161				2,161	339	300	250			250	500	500		500	765			765	
Apr 05	2,157				2,157	335	300	250			250	500	500		500	765			765	
Apr 06	2,154				2,154	332	300	250			250	500	500		500	765			765	
Apr 07	2,150				2,150	328	300	250			250	500	500		500	765			765	
Apr 08	2,147				2,147	325	300	250			250	500	500		500	765			765	
Apr 09	2,143				2,143	321	300	250			250	500	500		500	765			765	
Apr 10	2,140				2,140	318	300	250			250	500	500		500	765			765	
Apr 11	2,136				2,136	314	300	250			250	500	500		500	765			765	
Apr 12	2,133				2,133	311	300	250	60	90	400	500	500		500	765			765	
Apr 13	2,129	0			2,129	307	300	250	60	90	400	650	1,030	170	1,200	400	600	0	1,000	
Apr 14	2,126	0			2,126	304	300	250	60	90	400	650	1,030	170	1,200	400	600	0	1,000	
Apr 15	2,287	920	0	1.82	3,207	300	300	250	60	90	400	650	1,030	170	1,200	400	600	0	1,000	
Apr 16	2,284	920	0	3.65	3,204	297	300	250	320	80	650	650	1,030	170	1,200	400	600	0	1,000	
Apr 17	2,280	920	0	5.47	3,200	293	300	250	620	80	950	650	1,030	170	1,200	400	350	0	750	
Apr 18	2,277	920	0	7.30	3,197	290	300	250	620	80	950	650	1,030	170	1,200	400	100	0	500	
Apr 19	2,273	920	0	9.12	3,193	286	300	250	620	80	950	650	1,030	170	1,200	400	100	0	500	
Apr 20	2,270	970	0	11.05	3,240	283	300	250	620	80	950	650	1,030	170	1,200	400	100	0	500	
Apr 21	2,266	970	0	12.97	3,236	279	300	250	620	80	950	650	1,040	160	1,200	400	100	0	500	
Apr 22	2,263	970	0	14.90	3,233	276	300	250	620	80	950	650	1,040	160	1,200	400	100	0	500	
Apr 23	2,269	960	0	16.80	3,229	272	300	250	620	80	950	650	790	160	950	600	90	0	690	
Apr 24	2,266	960	0	18.70	3,226	269	300	250	570	80	900	650	540	160	700	1,000	0	0	1,000	
Apr 25	2,212	950	0	20.59	3,162	265	300	250	320	80	650	650	390	160	550	1,200	0	0	1,200	
Apr 26	2,359	860	0	22.29	3,219	262	300	250	320	80	650	650	340	160	500	1,200	300	0	1,500	
Apr 27	2,405	810	0	23.90	3,215	258	300	250	320	80	650	650	340	160	500	1,200	300	0	1,500	
Apr 28	2,352	860	0	25.61	3,212	255	300	250	320	80	650	650	340	160	500	1,200	300	0	1,500	
Apr 29	2,348	860	0	27.31	3,208	251	300	250	320	80	650	650	340	160	500	1,200	300	0	1,500	
Apr 30	2,345	860	0	29.02	3,205	248	300	250	320	80	650	650	340	160	500	1,200	300	0	1,500	
May 01	2,341	860	0	30.72	3,201	244	300	250	320	80	650	650	340	160	500	1,200	300	0	1,500	
May 02	2,338	860	0	32.43	3,198	241	300	250	620	80	950	650	340	160	500	1,200	300	0	1,500	
May 03	2,334	860	0	34.14	3,194	237	300	250	690	80	1,020	650	340	160	500	1,200	0	0	1,200	
May 04	2,331	860	0	35.84	3,191	234	300	250	1,020	80	1,350	650	540	160	700	900	0	0	900	
May 05	2,327	860	0	37.55	3,187	230	300	250	1,070	80	1,400	650	540	160	700	600	0	0	600	
May 06	2,224	930	0	39.39	3,154	227	300	250	1,070	80	1,400	650	540	160	700	400	200	0	600	
May 07	1,920	1,260	0	41.89	3,180	223	300	250	1,070	80	1,400	650	540	160	700	400	200	0	600	
May 08	1,717	1,510	0	44.89	3,227	220	300	250	1,070	80	1,400	650	540	160	700	400	200	0	600	
May 09	1,713	1,510	0	47.88	3,223	216	300	250	1,070	80	1,400	650	540	160	700	400	200	0	600	
May 10	1,710	1,510	0	50.88	3,220	213	300	250	1,070	80	1,400	650	540	160	700	400	200	0	600	
May 11	1,706	1,510	0	53.87	3,216	209	300	250	1,070	80	1,400	650	540	160	700	400	200	0	600	
May 12	1,703	1,510	0	56.87	3,213	206	300	250	870	80	1,200	650	540	160	700	400	200	0	600	
May 13	1,699	1,510	0	59.86	3,209	202	300	250	350		600	650	540	160	700	400	200	0	600	
May 14	1,696	1,510	0	62.86	3,206	199	300	250	50		300	500	500		500	565			565	
May 15	1,692	1,310	0	65.45	3,002	195	300	250			250	500	500		500	565			565	
May 16	1,814	350			2,164	192	300	250			250	500	500		500	565			565	
May 17	1,810	50			1,860	188	300	250			250	500	500		500	565			565	
May 18	1,807	0			1,807	185	300	250			250	500	500		500	565			565	
May 19	1,803	0			1,803	181	300	250			250	500	500		500	565			565	
May 20	1,800	0			1,800	178	300	250			250	500	500		500	565			565	
May 21	1,796	0			1,796	174	300	250			250	500	500		500	565			565	
May 22	1,793	0			1,793	171	300	250			250	500	500		500	565			565	
May 23	1,789	0			1,789	167	300	250			250	500	500		500	565			565	
May 24	1,786	0			1,786	164	300	250			250	500	500		500	565			565	
May 25	1,782	0			1,782	160	300	250			250	500	500		500	565			565	
May 26	1,779	0			1,779	157	300	250			250	500	500		500	565			565	
May 27	1,775	0			1,775	153	300	250			250	500	500		500	565			565	
May 28	1,772	0			1,772	150	300	250			250	500	500		500	565			565	
May 29	1,768	0			1,768	146	300	250			250	500	500		500	565			565	
May 30	1,765	0			1,765	143	300	250			250	500	500		500	565			565	
May 31	1,761	0			1,761	139	300	250			250	500	500		500	565			565	
	VAMP Period																			
Avg. (cfs):	2,135	1,065			3,200	255	300	250	594	81	925	650	650	163	813	681	227	0	908	
Suppl. Water (TAF)		65.45							36.50	5.00				10.00			13.96			

Target flow period

APPENDIX A

APPENDIX A–1, TABLE 4

VAMP Daily Operation Plan, March 30, 2004 (B) • High

Target Flow Period: April 15–May 15 • Flow Target: 4,450 cfs

	San Joaquin River near Vernalis							Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus River below Goodwin				
	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. Flow	Exch Contr VAMP Supp. Flow	VAMP Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol. S=Stan.
	(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	
Apr 01						667	800	250			250	500	500		500	1,191			1,191	
Apr 02						662	800	250			250	500	500		500	1,191			1,191	
Apr 03						658	800	250			250	500	500		500	1,191			1,191	
Apr 04	3,403				3,403	653	800	250			250	500	500		500	1,191			1,191	
Apr 05	3,399				3,399	648	800	250			250	500	500		500	1,191			1,191	
Apr 06	3,394				3,394	643	800	250			250	500	500		500	1,191			1,191	
Apr 07	3,389				3,389	638	800	250			250	500	500		500	1,191			1,191	
Apr 08	3,384				3,384	634	800	250			250	500	500		500	1,191			1,191	
Apr 09	3,379				3,379	629	800	250			250	500	500		500	1,191			1,191	
Apr 10	3,375				3,375	624	800	250			250	500	500		500	1,191			1,191	
Apr 11	3,370				3,370	619	800	250			250	500	500		500	1,191			1,191	
Apr 12	3,365				3,365	614	800	250	50	90	390	500	500		500	1,191			1,191	
Apr 13	3,360	0			3,360	610	800	250	50	90	390	1,000	1,325	25	1,350	500	800	0	1,300	
Apr 14	3,355	0			3,355	605	800	250	50	90	390	1,000	1,325	25	1,350	500	800	0	1,300	
Apr 15	3,485	965	0	1.91	4,450	600	800	250	50	90	390	1,000	1,325	25	1,350	500	800	0	1,300	
Apr 16	3,480	965	0	3.83	4,445	595	800	250	320	80	650	1,000	1,325	25	1,350	500	800	0	1,300	
Apr 17	3,475	965	0	5.74	4,440	590	800	250	320	80	650	1,000	945	30	975	900	400	0	1,300	
Apr 18	3,470	965	0	7.66	4,435	586	800	250	320	80	650	1,000	950	20	970	1,500	0	0	1,500	
Apr 19	3,485	830	0	9.30	4,315	581	800	250	320	80	650	1,000	950	20	970	1,500	0	0	1,500	
Apr 20	4,086	420	0	10.14	4,506	576	800	250	320	80	650	1,000	950	20	970	1,500	0	0	1,500	
Apr 21	4,081	420	0	10.97	4,501	571	800	250	320	80	650	1,000	950	20	970	1,500	0	0	1,500	
Apr 22	4,076	420	0	11.80	4,496	566	800	250	320	80	650	1,000	950	20	970	1,500	0	0	1,500	
Apr 23	4,071	420	0	12.63	4,491	562	800	250	320	80	650	1,000	950	20	970	1,500	0	0	1,500	
Apr 24	4,066	420	0	13.47	4,486	557	800	250	320	80	650	1,000	950	20	970	1,500	0	0	1,500	
Apr 25	4,062	420	0	14.30	4,482	552	800	250	320	80	650	1,000	950	20	970	1,500	0	0	1,500	
Apr 26	4,057	420	0	15.13	4,477	547	800	250	320	80	650	1,000	950	20	970	1,500	0	0	1,500	
Apr 27	4,052	420	0	15.97	4,472	542	800	250	320	80	650	1,000	950	20	970	1,500	0	0	1,500	
Apr 28	4,047	420	0	16.80	4,467	538	800	250	320	80	650	1,000	950	20	970	1,500	0	0	1,500	
Apr 29	4,042	420	0	17.63	4,462	533	800	250	320	80	650	1,000	950	20	970	1,500	0	0	1,500	
Apr 30	4,038	420	0	18.47	4,458	528	800	250	320	80	650	1,000	950	20	970	1,500	0	0	1,500	
May 01	4,033	420	0	19.30	4,453	523	800	250	320	80	650	1,000	950	20	970	1,500	0	0	1,500	
May 02	4,028	420	0	20.13	4,448	518	800	250	320	80	650	1,000	950	20	970	1,500	0	0	1,500	
May 03	4,023	420	0	20.97	4,443	514	800	250	420	80	750	1,000	950	20	970	1,500	0	0	1,500	
May 04	4,018	420	0	21.80	4,438	509	800	250	420	80	750	1,000	880	20	900	1,500	0	0	1,500	
May 05	4,014	420	0	22.63	4,434	504	800	250	420	80	750	1,000	880	20	900	1,500	0	0	1,500	
May 06	3,939	520	0	23.66	4,459	499	800	250	420	80	750	1,000	880	20	900	1,500	0	0	1,500	
May 07	3,934	520	0	24.69	4,454	494	800	250	755	80	1,085	1,000	880	20	900	1,500	0	0	1,500	
May 08	3,929	520	0	25.73	4,449	490	800	250	920	80	1,250	1,000	880	20	900	1,160	0	0	1,160	
May 09	3,924	520	0	26.76	4,444	485	800	250	920	80	1,250	1,000	1,030	20	1,050	860	0	0	860	
May 10	3,580	855	0	28.45	4,435	480	800	250	920	80	1,250	1,000	1,030	20	1,050	500	360	0	860	
May 11	3,425	1,020	0	30.48	4,445	475	800	250	920	80	1,250	1,000	1,030	20	1,050	500	360	0	860	
May 12	3,060	1,380	0	33.21	4,440	470	800	250	850	80	1,180	1,000	1,030	20	1,050	500	360	0	860	
May 13	3,055	1,380	0	35.95	4,435	466	800	250	400		650	1,000	1,030	20	1,050	500	360	0	860	
May 14	3,050	1,380	0	38.69	4,430	461	800	250	50		300	500	500		500	1,191			1,191	
May 15	3,046	1,310	0	41.29	4,356	456	800	250			250	500	500		500	1,191			1,191	
May 16	3,202	400			3,602	451	800	250			250	500	500		500	1,191			1,191	
May 17	3,197	50			3,247	446	800	250			250	500	500		500	1,191			1,191	
May 18	3,192	0			3,192	442	800	250			250	500	500		500	1,191			1,191	
May 19	3,187	0			3,187	437	800	250			250	500	500		500	1,191			1,191	
May 20	3,183	0			3,183	432	800	250			250	500	500		500	1,191			1,191	
May 21	3,178	0			3,178	427	800	250			250	500	500		500	1,191			1,191	
May 22	3,173	0			3,173	422	800	250			250	500	500		500	1,191			1,191	
May 23	3,168	0			3,168	418	800	250			250	500	500		500	1,191			1,191	
May 24	3,163	0			3,163	413	800	250			250	500	500		500	1,191			1,191	
May 25	3,159	0			3,159	408	800	250			250	500	500		500	1,191			1,191	
May 26	3,154	0			3,154	403	800	250			250	500	500		500	1,191			1,191	
May 27	3,149	0			3,149	398	800	250			250	500	500		500	1,191			1,191	
May 28	3,144	0			3,144	394	800	250			250	500	500		500	1,191			1,191	
May 29	3,139	0			3,139	389	800	250			250	500	500		500	1,191			1,191	
May 30	3,135	0			3,135	384	800	250			250	500	500		500	1,191			1,191	
May 31	3,130	0			3,130	379	800	250			250	500	500		500	1,191			1,191	
	VAMP Period																			
Avg. (cfs):	3,778	671			4,450	538	300	250	407	81	738	1,000	1,000	21	1,021	1,191	163	0	1,354	
Suppl. Water (TAF)		41.29							25.00	5.00				1.29			10.00			

Target flow period

APPENDIX A-1, TABLE 5

VAMP Daily Operation Plan, April 9, 2004

Target Flow Period: April 15–May 15 • Flow Target: 3,200 cfs

bold numbers: observed real-time

	San Joaquin River near Vernalis							Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus River below Goodwin					
	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. Flow	Exch Contr VAMP Supp. Flow	VAMP Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	Existing Flow (re-shaped)	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol. S=Stan.
	(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		(cfs)	(cfs)	(cfs)	
Apr 01	**2,290**				**2,310**	**495**	**1,131**	**224**			**224**	500	**1,110**		**1,110**	707	**215**			**215**	
Apr 02	**2,680**				**2,710**	**424**	**802**	**209**			**209**	500	**1,090**		**1,090**	707	**226**			**226**	
Apr 03	**2,890**				**2,910**	**390**	**826**	**205**			**205**	500	**1,100**		**1,100**	707	**225**			**225**	
Apr 04	**2,890**				**2,890**	**392**	**926**	**218**			**218**	500	**1,100**		**1,100**	707	**222**			**222**	
Apr 05	**2,849**				**2,849**	**385**	**925**	**206**			**206**	500	**980**		**980**	707	**228**			**228**	
Apr 06	**2,700**				**2,700**	**362**	**781**	**199**			**199**	500	**819**		**819**	707	**226**			**226**	
Apr 07	**2,380**				**2,380**	**335**	**569**	**194**			**194**	500	**837**		**837**	707	**226**			**226**	
Apr 08	**2,190**				**2,189**	**326**	**576**	**196**			**196**	500	**833**		**833**	707	225			225	
Apr 09	2,146				2,146	318	549	250			250	500	500		500	707	707			707	
Apr 10	2,117				2,117	315	539	250			250	500	500		500	707	707			707	
Apr 11	2,251				2,251	312	530	250			250	500	500		500	707	707			707	
Apr 12	2,292				2,292	309	520	250	200	0	450	500	500		500	707	707			707	
Apr 13	2,279	0			2,279	306	510	250	200	0	450	725	700	340	1,040	707	350	200	0	550	T
Apr 14	2,266	0			2,266	303	500	250	200	0	450	725	900	500	1,400	707	350	200	0	550	T
Apr 15	2,106	740	0	1.47	2,846	300	500	250	200	0	450	700	900	500	1,400	707	350	200	0	550	T
Apr 16	2,303	900	0	3.25	3,203	297	500	250	200	0	450	700	900	500	1,400	707	350	200	0	550	T
Apr 17	2,300	900	0	5.04	3,200	293	500	250	225	0	475	700	900	500	1,400	707	350	200	0	550	T
Apr 18	2,297	900	0	6.82	3,197	290	500	250	250	0	500	700	900	500	1,400	707	350	200	0	550	T
Apr 19	2,293	900	0	8.61	3,193	286	500	250	250	0	500	700	900	500	1,400	707	350	200	0	550	T
Apr 20	2,290	925	0	10.44	3,215	283	500	250	250	0	500	700	900	500	1,400	707	350	200	0	550	T
Apr 21	2,286	950	0	12.33	3,236	279	500	250	250	0	500	700	900	500	1,400	707	350	200	0	550	T
Apr 22	2,283	950	0	14.21	3,233	276	500	250	250	0	500	700	900	300	1,200	707	600	200	0	800	T
Apr 23	2,279	950	0	16.10	3,229	272	500	250	300	0	550	700	900	0	900	707	950	100	0	1,050	T,S
Apr 24	2,526	750	0	17.58	3,276	269	500	250	350	0	600	700	650	0	650	707	1,150	100	0	1,250	S
Apr 25	2,872	350	0	18.28	3,222	265	500	250	350	0	600	700	600	0	600	707	1,150	100	0	1,250	S
Apr 26	2,819	400	0	19.07	3,219	262	500	250	350	0	600	700	600	0	600	707	1,150	100	0	1,250	S
Apr 27	2,765	450	0	19.96	3,215	258	500	250	350	0	600	700	600	0	600	707	1,150	100	0	1,250	S
Apr 28	2,762	450	0	20.86	3,212	255	500	250	350	0	600	700	600	0	600	707	1,150	100	0	1,250	S
Apr 29	2,758	450	0	21.75	3,208	251	500	250	375	0	625	700	600	0	600	707	1,150	100	0	1,250	S
Apr 30	2,755	450	0	22.64	3,205	248	500	250	400	0	650	700	600	0	600	707	1,150	100	0	1,250	S
May 01	2,751	450	0	23.53	3,201	244	500	250	550	0	800	700	600	0	600	565	1,150	100	0	1,250	S
May 02	2,748	475	0	24.48	3,223	241	500	250	500	250	1,000	700	600	0	600	565	1,060	40	0	1,100	S,M
May 03	2,744	500	0	25.47	3,244	237	500	250	850	200	1,300	700	600	0	600	565	900	0	0	900	M
May 04	2,651	590	0	26.64	3,241	234	500	250	850	200	1,300	700	600	0	600	565	600	0	0	600	M
May 05	2,487	750	0	28.13	3,237	230	500	250	850	200	1,300	700	600	0	600	565	400	200	0	600	M
May 06	2,184	1,050	0	30.21	3,234	227	500	250	850	200	1,300	700	600	0	600	565	400	200	0	600	M
May 07	1,980	1,250	0	32.69	3,230	223	500	250	850	200	1,300	700	600	0	600	565	400	200	0	600	M
May 08	1,977	1,250	0	35.17	3,227	220	500	250	850	200	1,300	700	600	0	600	565	400	200	0	600	M
May 09	1,973	1,250	0	37.65	3,223	216	500	250	850	200	1,300	700	600	0	600	565	400	200	0	600	M
May 10	1,970	1,250	0	40.13	3,220	213	500	250	850	200	1,300	700	600	0	600	565	400	200	0	600	M
May 11	1,966	1,250	0	42.60	3,216	209	500	250	350	500	1,100	700	600	0	600	565	400	200	0	600	M
May 12	1,963	1,250	0	45.08	3,213	206	500	250	150	170	570	700	600	200	800	565	400	200	0	600	M
May 13	1,959	1,250	0	47.56	3,209	202	500	250			250	700	600	200	800	565	400	500	0	900	
May 14	1,956	1,250	0	50.04	3,206	199	500	250			250	575	500		500	565	565		535	1,100	
May 15	1,952	1,020	0	52.07	2,972	195	500	250			250	450	500		500	565	565		935	1,500	
May 16	2,014	0			2,549	192	500	250			250	325	500		500	565	565		935	1,500	
May 17	2,010	0			2,945	189	500	250			250	225	500		500	565	565		935	1,500	
May 18	2,007	0			2,942	186	500	250			250	150	500		500	565	565		935	1,500	
May 19	2,004	0			2,939	183	500	250			250	150	500		500	565	565		935	1,500	
May 20	2,001	0			2,936	180	500	250			250	500	500		500	565	565		935	1,500	
May 21	1,998	0			2,933	177	500	250			250	500	500		500	565	565		935	1,500	
May 22	1,995	0			2,930	174	500	250			250	500	500		500	565	565		935	1,500	
May 23	1,992	0			2,927	171	500	250			250	500	500		500	565	565		335	900	
May 24	1,989	0			2,924	168	500	250			250	500	500		500	565	565		35	600	
May 25	1,986	0			2,321	165	500	250			250	500	500		500	565	565			565	
May 26	1,983	0			2,018	162	500	250			250	500	500		500	565	565			565	
May 27	1,980	0			1,980	159	500	250			250	500	500		500	565	565			565	
May 28	1,977	0			1,977	156	500	250			250	500	500		500	565	565			565	
May 29	1,974	0			1,974	153	500	250			250	500	500		500	565	565			565	
May 30	1,971	0			1,971	150	500	250			250	500	500		500	565	565			565	
May 31	1,968	0			1,968	147	500	250			250	500	500		500	565	565			565	
	VAMP Period																				
Avg. (cfs):	2,353	847			3,200	254	300	250	440	81	772	702	702	163	864	647	647	163	0	913	
Suppl. Water (TAF)		52.07							27.07	5.00				10.00			39.79				

Target flow period

Period of desired flow stability

APPENDIX A

APPENDIX A–1, TABLE 6

VAMP Daily Operation Plan, April 13, 2004

Target Flow Period: April 15–May 15 • Flow Target: 3,200 cfs

bold numbers: observed real-time

	San Joaquin River near Vernalis							Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus River below Goodwin					
	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. Flow	Exch Contr VAMP Supp. Flow	VAMP Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	Existing Flow (re-shaped)	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol. S=Stan.
	(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		(cfs)	(cfs)	(cfs)	
Apr 01	**2,290**				**2,310**	**495**	**1,131**	**224**			**224**	500	**1,110**		**1,110**	707	**215**			**215**	
Apr 02	**2,680**				**2,710**	**424**	**802**	**209**			**209**	500	**1,090**		**1,090**	707	**226**			**226**	
Apr 03	**2,890**				**2,910**	**390**	**826**	**205**			**205**	500	**1,100**		**1,100**	707	**225**			**225**	
Apr 04	**2,890**				**2,890**	**392**	**926**	**218**			**218**	500	**1,100**		**1,100**	707	**222**			**222**	
Apr 05	**2,849**				**2,849**	**385**	**925**	**206**			**206**	500	**980**		**980**	707	**228**			**228**	
Apr 06	**2,700**				**2,700**	**362**	**781**	**199**			**199**	500	**819**		**819**	707	**226**			**226**	
Apr 07	**2,380**				**2,380**	**335**	**569**	**194**			**194**	500	**837**		**837**	707	**226**			**226**	
Apr 08	**2,190**				**2,189**	**326**	**576**	**196**			**196**	500	**833**		**833**	707	**228**			**228**	
Apr 09	**2,120**				**2,118**	**319**	**521**	**192**			**192**	500	**823**		**823**	707	**227**			**227**	
Apr 10	**2,060**				**2,060**	**315**	**479**	**194**			**194**	500	**820**		**820**	707	**227**			**227**	
Apr 11	**2,090**				**2,090**	**289**	**525**	**212**			**212**	500	**817**		**817**	707	**232**			**232**	
Apr 12	**2,150**				**2,150**	**292**	**596**	250	166	0	**416**	500	**819**		**819**	707	**231**			**231**	
Apr 13	2,042	0			2,042	306	510	250	200	0	450	700	700	340	1,040	707	350	200	0	550	T
Apr 14	2,054	0			2,054	303	500	250	200	0	450	700	900	500	1,400	707	350	200	0	550	T
Apr 15	2,106	706	0	1.40	2,812	300	500	250	200	0	450	700	900	500	1,400	707	350	200	0	550	T
Apr 16	2,303	900	0	3.19	3,203	297	500	250	200	0	450	700	900	500	1,400	707	350	200	0	550	T
Apr 17	2,300	900	0	4.97	3,200	293	500	250	225	0	475	700	900	500	1,400	707	350	200	0	550	T
Apr 18	2,297	900	0	6.76	3,197	290	500	250	250	0	500	700	900	500	1,400	707	350	200	0	550	T
Apr 19	2,293	900	0	8.54	3,193	286	500	250	250	0	500	700	900	500	1,400	707	350	200	0	550	T
Apr 20	2,290	925	0	10.38	3,215	283	500	250	250	0	500	700	900	500	1,400	707	350	200	0	550	T
Apr 21	2,286	950	0	12.26	3,236	279	500	250	250	0	500	700	900	500	1,400	707	350	200	0	550	T
Apr 22	2,283	950	0	14.14	3,233	276	500	250	250	0	500	700	850	300	1,150	707	600	200	0	800	T
Apr 23	2,279	950	0	16.03	3,229	272	500	250	300	0	550	700	900	0	900	707	950	100	0	1,050	T,S
Apr 24	2,476	750	0	17.52	3,226	269	500	250	350	0	600	700	650	0	650	707	1,150	100	0	1,250	S
Apr 25	2,872	350	0	18.21	3,222	265	500	250	350	0	600	700	600	0	600	707	1,150	100	0	1,250	S
Apr 26	2,819	400	0	19.00	3,219	262	500	250	350	0	600	700	600	0	600	707	1,150	100	0	1,250	S
Apr 27	2,765	450	0	19.90	3,215	258	500	250	375	0	625	700	600	0	600	707	1,150	100	0	1,250	S
Apr 28	2,762	450	0	20.79	3,212	255	500	250	375	0	625	700	600	0	600	707	1,150	100	0	1,250	S
Apr 29	2,758	450	0	21.68	3,208	251	500	250	375	0	625	700	600	0	600	707	1,150	100	0	1,250	S
Apr 30	2,755	475	0	22.62	3,230	248	500	250	400	0	650	700	600	0	600	707	1,150	100	0	1,250	S
May 01	2,751	475	0	23.57	3,226	244	500	250	550	0	800	700	600	0	600	565	1,150	100	0	1,250	S
May 02	2,748	475	0	24.51	3,223	241	500	250	500	250	1,000	700	600	0	600	565	1,060	40	0	1,100	S,M
May 03	2,744	500	0	25.50	3,244	237	500	250	850	200	1,300	700	600	0	600	565	900	0	0	900	M
May 04	2,651	590	0	26.67	3,241	234	500	250	850	200	1,300	700	600	0	600	565	600	0	0	600	M
May 05	2,487	750	0	28.16	3,237	230	500	250	850	200	1,300	700	600	0	600	565	400	200	0	600	M
May 06	2,184	1,050	0	30.24	3,234	227	500	250	850	200	1,300	700	600	0	600	565	400	200	0	600	M
May 07	1,980	1,250	0	32.72	3,230	223	500	250	850	200	1,300	700	600	0	600	565	400	200	0	600	M
May 08	1,977	1,250	0	35.20	3,227	220	500	250	850	200	1,300	700	600	0	600	565	400	200	0	600	M
May 09	1,973	1,250	0	37.68	3,223	216	500	250	850	200	1,300	700	600	0	600	565	400	200	0	600	M
May 10	1,970	1,250	0	40.16	3,220	213	500	250	850	200	1,300	700	600	0	600	565	400	200	0	600	M
May 11	1,966	1,250	0	42.64	3,216	209	500	250	350	500	1,100	700	600	0	600	565	400	200	0	600	M
May 12	1,963	1,250	0	45.12	3,213	206	500	250	150	170	570	700	600	200	800	565	400	200	0	600	M
May 13	1,959	1,250	0	47.60	3,209	202	500	250			250	700	600	200	800	565	400	500	0	900	
May 14	1,956	1,250	0	50.07	3,206	199	500	250			250	575	500		500	565	565		535	1,100	
May 15	1,952	1,020	0	52.10	2,972	195	500	250			250	450	500		500	565	565		935	1,500	
May 16	2,014	0			2,549	192	500	250			250	325	500		500	565	565		935	1,500	
May 17	2,010	0			2,945	189	500	250			250	225	500		500	565	565		935	1,500	
May 18	2,007	0			2,942	186	500	250			250	150	500		500	565	565		935	1,500	
May 19	2,004	0			2,939	183	500	250			250	150	500		500	565	565		935	1,500	
May 20	2,001	0			2,936	180	500	250			250	500	500		500	565	565		935	1,500	
May 21	1,998	0			2,933	177	500	250			250	500	500		500	565	565		935	1,500	
May 22	1,995	0			2,930	174	500	250			250	500	500		500	565	565		935	1,500	
May 23	1,992	0			2,927	171	500	250			250	500	500		500	565	565		335	900	
May 24	1,989	0			2,924	168	500	250			250	500	500		500	565	565		35	600	
May 25	1,986	0			2,321	165	500	250			250	500	500		500	565	565			565	
May 26	1,983	0			2,018	162	500	250			250	500	500		500	565	565			565	
May 27	1,980	0			1,980	159	500	250			250	500	500		500	565	565			565	
May 28	1,977	0			1,977	156	500	250			250	500	500		500	565	565			565	
May 29	1,974	0			1,974	153	500	250			250	500	500		500	565	565			565	
May 30	1,971	0			1,971	150	500	250			250	500	500		500	565	565			565	
May 31	1,968	0			1,968	147	500	250			250	500	500		500	565	565			565	
	VAMP period																				
Avg. (cfs):	2,353	847			3,199	254	300	250	441	81	772	700	700	163	863	647	647	163	0	913	
Suppl. Water (TAF)		52.10							27.11	5.00				10.00			39.79				

Target flow period

Period of desired flow stability

APPENDIX A–1, TABLE 7

VAMP Daily Operation Plan, April 20, 2004

Target Flow Period: April 15–May 15 • Flow Target: 3,200 cfs

bold numbers: observed real-time

	San Joaquin River near Vernalis							Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus River below Goodwin					
	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. Flow	Exch Contr VAMP Supp. Flow	VAMP Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	Existing Flow (re-shaped)	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol. S=Stan.
	(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		(cfs)	(cfs)	(cfs)	
Apr 01	2,290				2,310	495	1,131	224			224	500	1,110		1,110	707	215			215	
Apr 02	2,680				2,710	424	802	209			209	500	1,090		1,090	707	226			226	
Apr 03	2,890				2,910	390	826	205			205	500	1,100		1,100	707	225			225	
Apr 04	2,890				2,890	392	926	218			218	500	1,100		1,100	707	222			222	
Apr 05	2,849				2,849	385	925	206			206	500	980		980	707	228			228	
Apr 06	2,700				2,700	362	781	199			199	500	819		819	707	226			226	
Apr 07	2,380				2,380	335	569	194			194	500	837		837	707	226			226	
Apr 08	2,190				2,189	326	576	196			196	500	833		833	707	228			228	
Apr 09	2,120				2,118	319	521	192			192	500	823		823	707	227			227	
Apr 10	2,060				2,060	315	479	194			194	500	820		820	707	227			227	
Apr 11	2,090				2,090	289	525	212			212	500	817		817	707	232			232	
Apr 12	2,150				2,150	292	596	250	166	0	416	500	819		819	707	231			231	
Apr 13	2,080	0			2,080	259	548	250	202	0	452	700	700	360	1,060	707	350	57	0	407	T
Apr 14	2,039	0			2,039	278	485	250	191	0	441	700	900	480	1,380	707	350	202	0	552	T
Apr 15	1,787	583	0	1.16	2,370	274	228	250	197	0	447	700	900	480	1,380	707	350	205	0	555	T
Apr 16	1,736	884	0	2.91	2,620	255	-42	250	184	0	434	700	900	500	1,400	707	350	204	0	554	T
Apr 17	1,834	876	0	4.65	2,710	286	60	250	190	0	440	700	900	540	1,440	707	350	205	0	555	T
Apr 18	2,029	901	0	6.43	2,930	308	274	250	221	0	471	700	900	540	1,440	707	350	204	0	554	T
Apr 19	2,171	929	0	8.28	3,100	325	385	250	236	0	486	700	900	519	1,419	707	350	204	0	554	T
Apr 20	2,208	934	0	10.13	3,142	283	400	250	250	0	500	700	900	500	1,400	707	350	200	0	550	T
Apr 21	2,225	944	0	12.00	3,169	279	400	250	250	0	500	700	900	500	1,400	707	350	300	0	650	T
Apr 22	2,183	936	0	13.86	3,119	276	400	250	250	0	500	700	850	300	1,150	707	600	300	0	900	T
Apr 23	2,179	1,050	0	15.94	3,229	272	400	250	350	0	600	700	900	0	900	707	950	200	0	1,150	T,S
Apr 24	2,376	850	0	17.63	3,226	269	400	250	500	0	750	700	650	0	650	707	1,150	100	0	1,250	S
Apr 25	2,772	450	0	18.52	3,222	265	400	250	600	0	850	700	600	0	600	707	1,150	100	0	1,250	S
Apr 26	2,719	450	0	19.41	3,169	262	400	250	600	0	850	700	600	0	600	707	1,150	100	0	1,250	S
Apr 27	2,665	600	0	20.60	3,265	258	400	250	600	0	850	700	600	0	600	707	1,150	100	0	1,250	S
Apr 28	2,662	700	0	21.99	3,362	255	400	250	600	0	850	700	600	0	600	707	1,150	100	0	1,250	S
Apr 29	2,658	700	0	23.38	3,358	251	400	250	600	0	850	700	600	0	600	707	1,150	100	0	1,250	S
Apr 30	2,655	700	0	24.77	3,355	248	400	250	650	0	900	700	600	0	600	707	1,150	100	0	1,250	S
May 01	2,651	700	0	26.16	3,351	244	400	250	800	0	1,050	700	600	0	600	565	1,150	50	0	1,200	S
May 02	2,648	700	0	27.54	3,348	241	400	250	700	250	1,200	700	600	0	600	565	1,060	0	0	1,060	S,M
May 03	2,644	700	0	28.93	3,344	237	400	250	1,050	200	1,500	700	600	0	600	565	900	0	0	900	M
May 04	2,551	800	0	30.52	3,351	234	400	250	1,050	200	1,500	700	600	0	600	565	600	0	0	600	M
May 05	2,387	950	0	32.40	3,337	230	400	250	1,050	200	1,500	700	600	0	600	565	400	200	0	600	M
May 06	2,084	1,250	0	34.88	3,334	227	400	250	1,050	200	1,500	700	600	0	600	565	400	200	0	600	M
May 07	1,880	1,450	0	37.76	3,330	223	400	250	1,050	200	1,500	700	600	0	600	565	400	200	0	600	M
May 08	1,877	1,450	0	40.64	3,327	220	400	250	1,050	200	1,500	700	600	0	600	565	400	200	0	600	M
May 09	1,873	1,450	0	43.51	3,323	216	400	250	1,050	200	1,500	700	600	0	600	565	400	200	0	600	M
May 10	1,870	1,450	0	46.39	3,320	213	400	250	1,050	200	1,500	700	600	0	600	565	400	200	0	600	M
May 11	1,866	1,450	0	49.26	3,316	209	400	250	500	500	1,250	700	600	0	600	565	400	200	0	600	M
May 12	1,863	1,450	0	52.14	3,313	206	400	250	300	170	720	700	600	160	760	565	400	200	0	600	M
May 13	1,859	1,450	0	55.02	3,309	202	400	250	150		400	700	600	160	760	565	400	410	0	810	
May 14	1,856	1,360	0	57.71	3,216	199	400	250			250	575	500		500	565	565		535	1,100	
May 15	1,852	1,040	0	59.78	2,892	195	400	250			250	450	500		500	565	565		935	1,500	
May 16	1,914	150	535		2,599	192	400	250			250	325	500		500	565	565		935	1,500	
May 17	1,910	0	935		2,845	189	400	250			250	225	500		500	565	565		935	1,500	
May 18	1,907	0	935		2,842	186	400	250			250	150	500		500	565	565		935	1,500	
May 19	1,904	0	935		2,839	183	400	250			250	150	500		500	565	565		935	1,500	
May 20	1,901	0	935		2,836	180	400	250			250	500	500		500	565	565		935	1,500	
May 21	1,898	0	935		2,833	177	400	250			250	500	500		500	565	565		935	1,500	
May 22	1,895	0	935		2,830	174	400	250			250	500	500		500	565	565		935	1,500	
May 23	1,892	0	935		2,827	171	400	250			250	500	500		500	565	565		335	900	
May 24	1,889	0	935		2,824	168	400	250			250	500	500		500	565	565		35	600	
May 25	1,886	0	335		2,221	165	400	250			250	500	500		500	565	565			565	
May 26	1,883	0	35		1,918	162	400	250			250	500	500		500	565	565			565	
May 27	1,880	0	0		1,880	159	400	250			250	500	500		500	565	565			565	
May 28	1,877	0	0		1,877	156	400	250			250	500	500		500	565	565			565	
May 29	1,874	0	0		1,874	153	400	250			250	500	500		500	565	565			565	
May 30	1,871	0	0		1,871	150	400	250			250	500	500		500	565	565			565	
May 31	1,868	0	0		1,868	147	400	250			250	500	500		500	565	565			565	
	VAMP period																				
Avg. (cfs):	2,213	972			3,186	252	300	250	566	81	897	700	700	163	863	647	647	163	0	916	
Suppl. Water (TAF)		59.78							34.78	5.00				9.99			39.79				

Target flow period

Period of desired flow stability

APPENDIX A–1, TABLE 8

VAMP Daily Operation Plan, May 3, 2004

Target Flow Period: April 15–May 15 • Flow Target: 3,200 cfs

bold numbers: observed real-time

	San Joaquin River near Vernalis							Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus River below Goodwin					
	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. Flow	Exch Contr VAMP Supp. Flow	VAMP Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	Existing Flow (re-shaped)	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol. S=Stan.
	(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		(cfs)	(cfs)	(cfs)	
Apr 01	2,290				2,310	495	1,131	224			224	500	1,110		1,110	707	215			215	
Apr 02	2,680				2,710	424	802	209			209	500	1,090		1,090	707	226			226	
Apr 03	2,890				2,910	390	826	205			205	500	1,100		1,100	707	225			225	
Apr 04	2,890				2,890	392	926	218			218	500	1,100		1,100	707	222			222	
Apr 05	2,849				2,849	385	925	206			206	500	980		980	707	228			228	
Apr 06	2,700				2,700	362	781	199			199	500	819		819	707	226			226	
Apr 07	2,380				2,380	335	569	194			194	500	837		837	707	226			226	
Apr 08	2,190				2,189	326	576	196			196	500	833		833	707	228			228	
Apr 09	2,120				2,118	319	521	192			192	500	823		823	707	227			227	
Apr 10	2,060				2,060	315	479	194			194	500	820		820	707	227			227	
Apr 11	2,090				2,090	289	525	212			212	500	817		817	707	232			232	
Apr 12	2,150				2,150	292	596	250	166	0	416	500	819		819	707	231			231	
Apr 13	2,080	0			2,080	259	548	250	202	0	452	700	700	360	1,060	707	350	57	0	407	T
Apr 14	2,039	0			2,039	278	485	250	191	0	441	700	900	480	1,380	707	350	202	0	552	T
Apr 15	1,787	583	0	1.16	2,370	274	228	250	197	0	447	700	900	480	1,380	707	350	205	0	555	T
Apr 16	1,736	884	0	2.91	2,620	255	-42	250	184	0	434	700	900	500	1,400	707	350	204	0	554	T
Apr 17	1,834	876	0	4.65	2,710	286	60	250	190	0	440	700	900	540	1,440	707	350	205	0	555	T
Apr 18	2,029	901	0	6.43	2,930	308	274	250	221	0	471	700	900	540	1,440	707	350	204	0	554	T
Apr 19	2,171	929	0	8.28	3,100	325	385	250	236	0	486	700	900	519	1,419	707	350	204	0	554	T
Apr 20	2,156	934	0	10.13	3,090	350	348	250	232	0	482	700	900	529	1,429	707	350	205	0	555	T
Apr 21	2,156	944	0	12.00	3,100	341	331	250	241	0	491	700	900	540	1,440	707	350	299	0	649	T
Apr 22	2,200	970	0	13.93	3,170	336	350	250	242	0	492	700	850	410	1,260	707	600	300	0	900	T
Apr 23	2,099	1,071	0	16.05	3,170	288	258	250	346	0	596	700	900	83	983	707	950	198	0	1,148	T,S
Apr 24	2,199	951	0	17.94	3,150	238	163	250	610	0	860	700	650	58	708	707	1,150	102	0	1,252	S
Apr 25	2,717	523	0	18.97	3,240	244	329	250	669	0	919	700	600	29	629	707	1,150	100	0	1,250	S
Apr 26	2,834	506	0	19.98	3,340	274	546	250	639	0	889	700	600	38	638	707	1,150	104	0	1,254	S
Apr 27	2,581	739	0	21.44	3,320	266	337	250	596	0	846	700	600	44	644	707	1,150	102	0	1,252	S
Apr 28	2,499	811	0	23.05	3,310	259	225	250	624	0	874	700	600	31	631	707	1,150	102	0	1,252	S
Apr 29	2,495	785	0	24.61	3,280	260	229	250	637	0	887	700	600	27	627	707	1,150	101	0	1,251	S
Apr 30	2,571	729	0	26.05	3,300	252	312	250	720	0	970	700	600	27	627	707	1,150	105	0	1,255	S
May 01	2,498	752	0	27.55	3,250	256	238	250	918	0	1,168	700	600	28	628	565	1,150	46	0	1,196	S
May 02	2,481	769	0	29.07	3,250	288	229	250	875	250	1,375	700	600	27	627	565	1,160	2	0	1,062	S,M
May 03	2,556	794	0	30.65	3,350	237	300	250	1,050	200	1,500	700	600	0	600	565	900	0	0	900	M
May 04	2,498	947	0	32.52	3,445	234	300	250	1,050	200	1,500	700	600	0	600	565	600	50	0	650	M
May 05	2,287	1,125	0	34.76	3,412	230	300	250	1,050	200	1,500	700	600	0	600	565	400	250	0	650	M
May 06	1,984	1,300	0	37.33	3,284	227	300	250	1,050	200	1,500	700	600	0	600	565	400	250	0	650	M
May 07	1,780	1,500	0	40.31	3,280	223	300	250	1,050	200	1,500	700	600	0	600	565	400	250	0	650	M
May 08	1,777	1,500	0	43.29	3,277	220	300	250	1,050	200	1,500	700	600	0	600	565	400	250	0	650	M
May 09	1,773	1,500	0	46.26	3,273	216	300	250	1,050	200	1,500	700	600	0	600	565	400	250	0	650	M
May 10	1,770	1,500	0	49.24	3,270	213	300	250	1,050	200	1,500	700	600	0	600	565	400	250	0	650	M
May 11	1,766	1,500	0	52.21	3,266	209	300	250	650	500	1,400	700	600	0	600	565	400	250	0	650	M
May 12	1,763	1,500	0	55.19	3,263	206	300	250	380	170	800	700	600	0	600	565	400	400	0	800	M
May 13	1,759	1,500	0	58.16	3,259	202	300	250	150		400	700	600	0	600	565	400	650	0	1,050	
May 14	1,756	1,550	0	61.24	3,306	199	300	250			250	575	500		500	565	565		535	1,100	
May 15	1,752	1,200	0	63.62	2,952	195	300	250			250	450	500		500	565	565		935	1,500	
May 16	1,814	150	535		2,499	192	300	250			250	325	500		500	565	565		935	1,500	
May 17	1,810	0	935		2,745	189	300	250			250	225	500		500	565	565		935	1,500	
May 18	1,807	0	935		2,742	186	300	250			250	150	500		500	565	565		935	1,500	
May 19	1,804	0	935		2,739	183	300	250			250	150	500		500	565	565		935	1,500	
May 20	1,801	0	935		2,736	180	300	250			250	500	500		500	565	565		935	1,500	
May 21	1,798	0	935		2,733	177	300	250			250	500	500		500	565	565		935	1,500	
May 22	1,795	0	935		2,730	174	300	250			250	500	500		500	565	565		935	1,500	
May 23	1,792	0	935		2,727	171	300	250			250	500	500		500	565	565		335	900	
May 24	1,789	0	935		2,724	168	300	250			250	500	500		500	565	565		35	600	
May 25	1,786	0	335		2,121	165	300	250			250	500	500		500	565	565			565	
May 26	1,783	0	35		1,818	162	300	250			250	500	500		500	565	565			565	
May 27	1,780	0	0		1,780	159	300	250			250	500	500		500	565	565			565	
May 28	1,777	0	0		1,777	156	300	250			250	500	500		500	565	565			565	
May 29	1,774	0	0		1,774	153	300	250			250	500	500		500	565	565			565	
May 30	1,771	0	0		1,771	150	300	250			250	500	500		500	565	565			565	
May 31	1,768	0	0		1,768	147	300	250			250	500	500		500	565	565			565	
	VAMP period																				
Avg. (cfs):	2,137	1,035			3,172	260	300	250	592	81	924	700	700	171	871	647	647	190	0	913	
Suppl. Water (TAF)		63.62							36.43	5.00				10.49			39.79				

Target flow period

Period of desired flow stability

APPENDIX A–2, TABLE 1

2004 Vernalis Adaptive Management Plan (VAMP)

Final Accounting of Supplemental Water Contributions

Target Flow Period: April 15–May 15 • Flow Target: 3,200 cfs

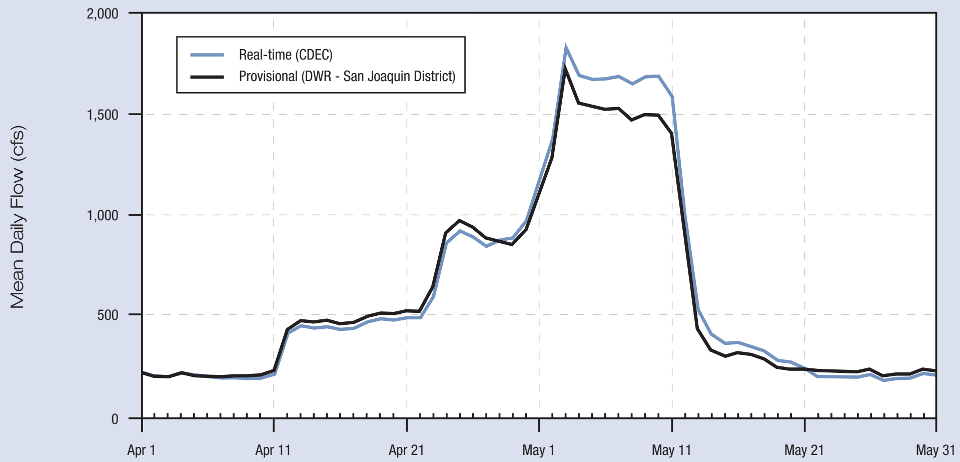
	Merced R. at Cressey (3 Day Travel Time to Vernalis)			Tuolumne R. below LaGrange Dam (2 Day Travel Time to Vernalis)			Stanislaus R. below Goodwin Dam (2 Day Travel Time to Vernalis)			Upper SJR	Vernalis Ungaged	San Joaquin River at Vernalis		
	Existing Flow	Observed Flow	VAMP Suppl. Water	Existing Flow	Observed Flow	VAMP Suppl. Water	Existing Flow	Observed Flow	VAMP Suppl. Water	Observed Flow	Observed Flow	Existing Flow	Observed Flow	VAMP Suppl. Water
	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
Apr 01	217	217		1,110	1,110		226	226		531	690	2,290	2,290	
Apr 02	201	201		1,090	1,090		231	231		457	755	2,680	2,680	
Apr 03	200	200		1,100	1,100		230	230		424	785	2,890	2,890	
Apr 04	215	215		1,100	1,100		230	230		426	895	2,890	2,890	
Apr 05	205	205		980	980		233	233		423	894	2,849	2,849	
Apr 06	202	202		820	820		233	233		400	744	2,700	2,700	
Apr 07	199	199		837	837		233	233		385	529	2,380	2,380	
Apr 08	203	203		833	833		235	235		368	522	2,180	2,180	
Apr 09	202	202		823	823		233	233		358	453	2,110	2,110	
Apr 10	208	208		820	820		227	227		364	415	2,050	2,050	
Apr 11	229	229		817	817		232	232		332	453	2,070	2,070	
Apr 12	250	432	182	819	819		231	231		336	527	2,140	2,140	
Apr 13	250	473	223	700	1,060	360	350	407	57	311	461	2,050	2,050	
Apr 14	250	468	218	900	1,380	480	350	552	202	321	424	2,039	2,039	
Apr 15	250	477	227	900	1,380	480	350	555	205	304	160	1,771	2,370	599
Apr 16	250	460	210	900	1,400	500	350	554	204	289	(106)	1,715	2,620	905
Apr 17	250	467	217	900	1,440	540	350	555	205	326	3	1,807	2,710	903
Apr 18	250	497	247	900	1,440	540	350	554	204	340	210	1,999	2,930	931
Apr 19	250	510	260	900	1,419	519	350	554	204	358	319	2,145	3,100	955
Apr 20	250	509	259	900	1,429	529	350	555	205	393	289	2,129	3,090	961
Apr 21	250	520	270	900	1,440	540	350	649	299	382	272	2,130	3,100	970
Apr 22	250	523	273	900	1,260	360	600	900	300	392	283	2,176	3,170	994
Apr 23	250	643	393	900	983	83	950	1,148	198	350	190	2,072	3,170	1,098
Apr 24	250	907	657	650	708	58	1,150	1,252	102	307	78	2,220	3,150	930
Apr 25	250	967	717	600	629	29	1,150	1,250	100	310	236	2,686	3,240	554
Apr 26	250	935	685	600	638	38	1,150	1,254	104	348	430	2,787	3,340	553
Apr 27	250	883	633	600	644	44	1,150	1,252	102	359	224	2,534	3,320	786
Apr 28	250	865	615	600	631	31	1,150	1,252	102	345	103	2,451	3,310	859
Apr 29	250	853	603	600	627	27	1,150	1,251	101	348	90	2,449	3,280	831
Apr 30	250	925	675	600	627	27	1,150	1,255	105	350	189	2,534	3,300	766
May 01	250	1,110	860	600	628	28	1,150	1,196	46	365	159	2,507	3,250	743
May 02	250	1,280	1,030	600	627	27	1,060	1,062	2	424	165	2,515	3,250	735
May 03	250	1,720	1,470	600	629	29	900	900	0	380	236	2,601	3,350	749
May 04	250	1,550	1,300	600	633	33	600	673	73	400	117	2,451	3,340	889
May 05	250	1,530	1,280	600	635	35	400	651	251	400	181	2,311	3,370	1,059
May 06	250	1,520	1,270	600	632	32	400	654	254	369	(166)	1,684	3,260	1,576
May 07	250	1,520	1,270	600	632	32	400	651	251	359	(26)	1,624	3,210	1,586
May 08	250	1,470	1,220	600	633	33	400	650	250	350	(5)	1,614	3,180	1,566
May 09	250	1,490	1,240	600	636	36	400	650	250	330	118	1,727	3,280	1,553
May 10	250	1,490	1,240	600	637	37	400	652	252	330	227	1,827	3,380	1,553
May 11	250	1,400	1,150	600	639	39	400	652	252	370	234	1,814	3,320	1,506
May 12	250	874	624	600	637	37	400	799	399	470	131	1,711	3,240	1,529
May 13	250	433		600	639	39	400	1,050	650	556	59	1,679	3,210	1,531
May 14	250	332		602	602		565	1,256		447	(246)	1,474	3,060	1,586
May 15	250	304		481	481		565	1,504		375	(219)	1,587	2,900	1,313
May 16	250	318		358	358		565	1,501		313	121	2,859	2,859	
May 17	250	308		257	257		565	1,508		304	208	2,900	2,900	
May 18	250	288		196	196		565	1,505		310	343	2,819	2,819	
May 19	245	245		200	200		565	1,247		307	273	2,660	2,660	
May 20	237	237		200	200		565	943		290	161	2,480	2,480	
May 21	237	237		201	201		565	708		253	248	2,290	2,290	
May 22	230	230		202	202		508	508		222	392	2,070	2,070	
May 23	230	230		204	204		502	502		232	551	1,950	1,950	
May 24	227	227		203	203		450	450		229	701	1,870	1,870	
May 25	225	225		207	207		403	403		243	582	1,750	1,750	
May 26	233	233		206	206		403	403		285	558	1,670	1,670	
May 27	204	204		207	207		403	403		321	540	1,620	1,620	
May 28	212	212		208	208		403	403		292	501	1,620	1,620	
May 29	215	215		207	207		402	402		286	456	1,620	1,620	
May 30	233	233		209	209		400	400		293	573	1,680	1,680	
May 31	225	225		173	173		404	404		276	612	1,719	1,719	
Avg. (cfs):	250	944		702	883		647	838		362	127	2,088	3,155	
Suppl. Water (acre-feet)			42,680[a]			11,151			11,760					65,591

[a] includes San Joaquin River Exchange Contractors Water Authority supplemental water contribution of 5,000 acre-feet.

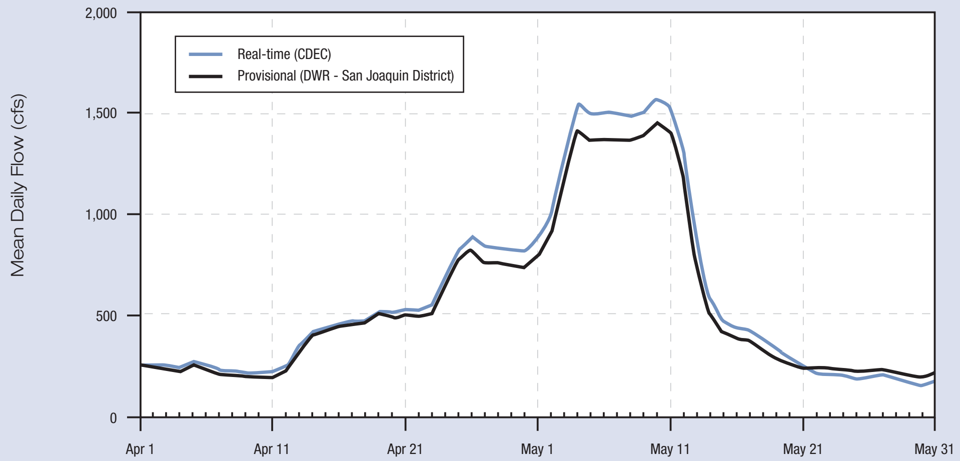
Observed Flow Sources: Merced River at Cressey (CA DWR B05155): California DWR, San Joaquin District (6/22/04) • Tuolumne River below LaGrange Dam near LaGrange (USGS 11289650): USGS (7/2/04) • Stanislaus River below Goodwin Dam: USBR, Goodwin Reservoir Daily Operations Report –OID/SSJID/Tri-Dams (5/20/04 and 6/18/04) • San Joaquin River near Vernalis (USGS 11303500): USGS (7/2/04)

A–3. Comparison of "Real-time" and Provisional Flows

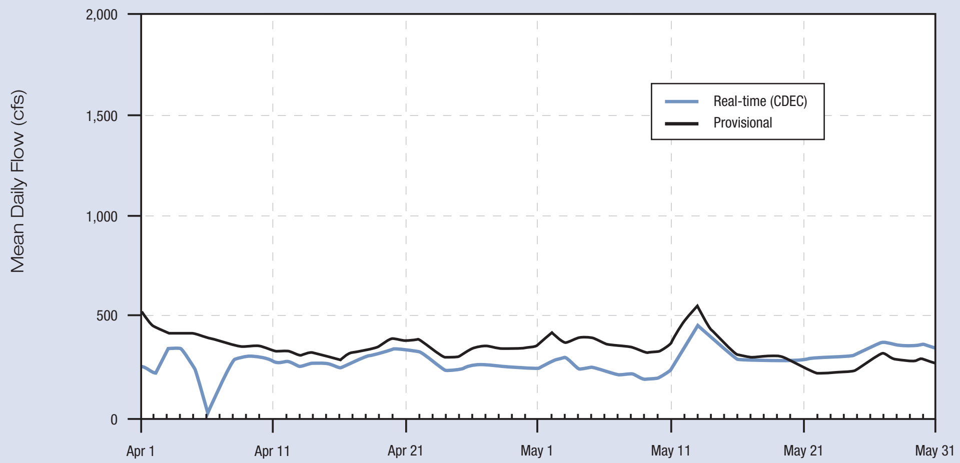
Merced River at Cressey



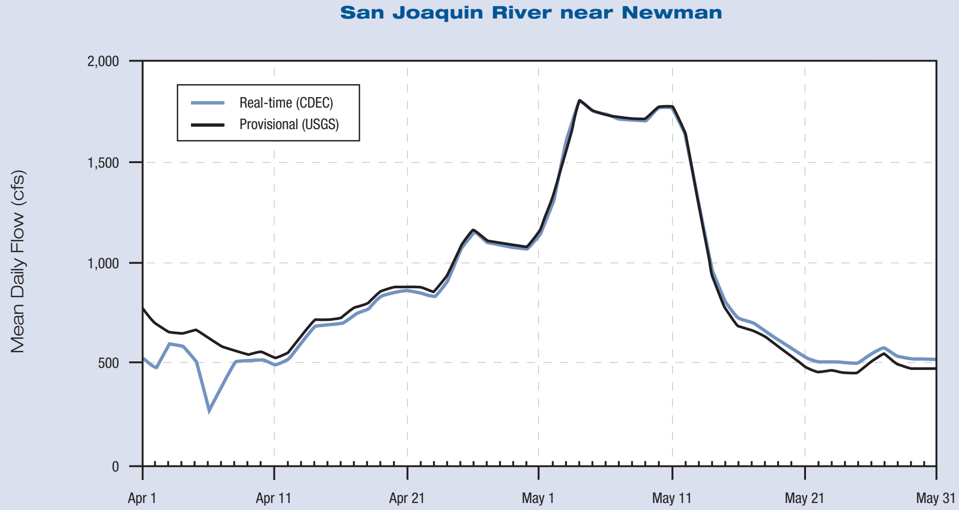
Merced River near Stevinson

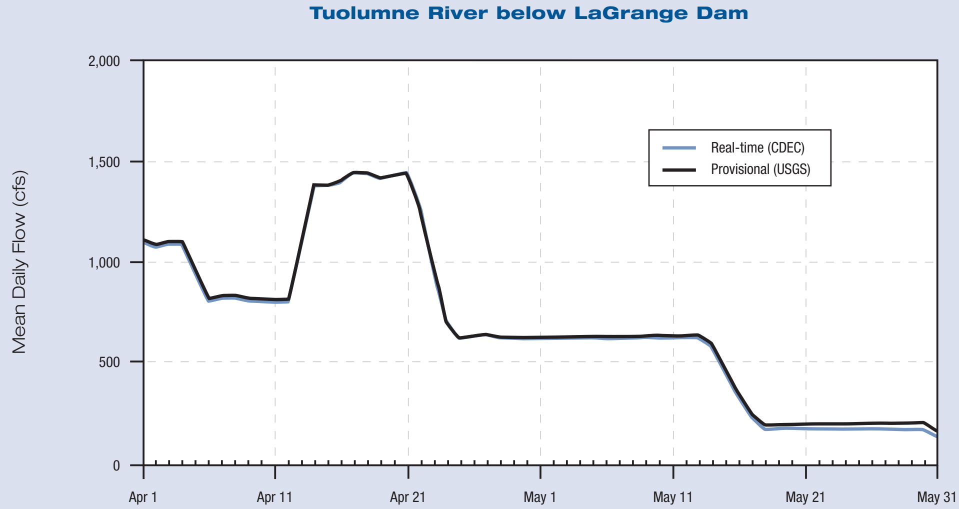


San Joaquin River above Merced River

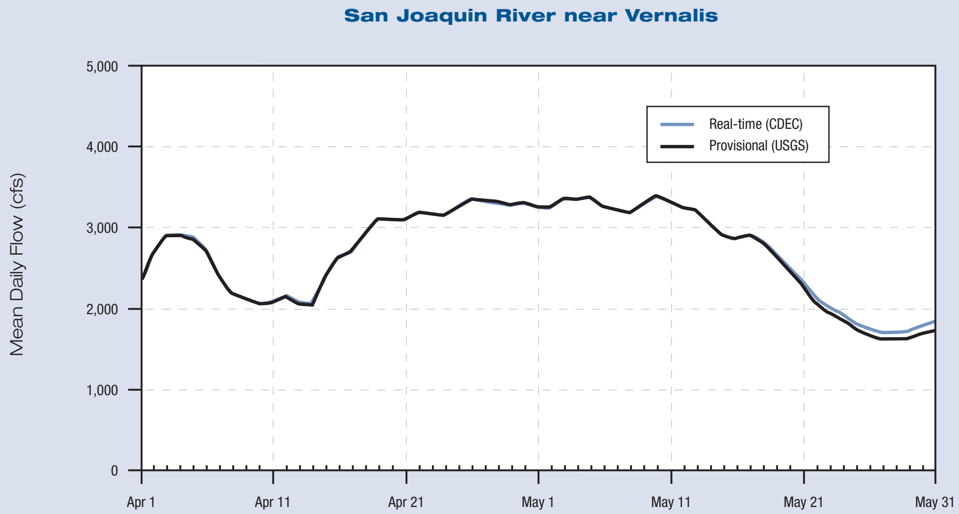


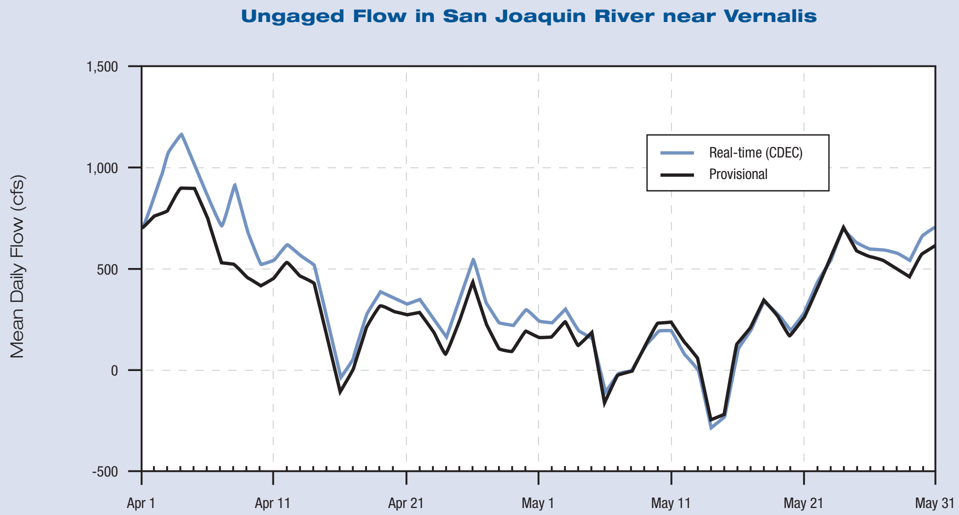
A–3. Comparison of "Real-time" and Provisional Flows





A–3. Comparison of "Real-time" and Provisional Flows





APPENDIX A

A-4 MERCED IRRIGATION DISTRICT

SJRA Fall 2004 Water Transfer • Daily Summary (FINAL)

	SCHEDULED				OBSERVED				
	Base Flow	Transfer Water: Daily Flow Rate	Transfer Water: Cumulative Volume	Target Flow (see Note 1)	Observed Flow Merced River at Shaffer Bridge (PG&E)	Observed Flow Merced R at Cressey (DWR)	Observed Flow for Transfer (see Note 1)	Transfer Water: Daily Flow Rate	Transfer Water: Cumulative Volume
	(cfs)	(cfs)	(acre-feet)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(acre-feet)
	(1)	(2)	(3)	(4) = (1) + (2)	(5)	(6)	(7)	(8) = (7) − (1)	(9)
Oct 01	30	125	248	155	158	117	158	128	254
Oct 02	30	125	496	155	171	139	171	141	534
Oct 03	30	125	744	155	174	141	174	144	819
Oct 04	30	125	992	155	173	142	173	143	1,103
Oct 05	30	125	1,240	155	177	151	177	147	1,394
Oct 06	30	125	1,488	155	172	147	172	142	1,676
Oct 07	30	125	1,736	155	170	140	170	140	1,954
Oct 08	30	125	1,983	155	161	128	161	131	2,214
Oct 09	30	125	2,231	155	176	138	176	146	2,503
Oct 10	30	125	2,479	155	210	171	210	180	2,860
Oct 11	30	125	2,727	155	208	171	208	178	3,213
Oct 12	30	125	2,975	155	247	208	247	217	3,644
Oct 13	30	125	3,223	155	252	215	252	222	4,084
Oct 14	30	125	3,471	155	232	198	232	202	4,485
Oct 15	30	125	3,719	155	226	196	226	196	4,873
Oct 16	85	125	3,967	210	220	193	220	135	5,141
Oct 17	85	175	4,314	260	290	252	290	205	5,548
Oct 18	85	300	4,909	385	534	403	403	318	6,179
Oct 19	85	505	5,911	590	810	577	577	492	7,154
Oct 20	85	505	6,912	590	884	639	639	554	8,253
Oct 21	85	505	7,914	590	793	588	588	503	9,251
Oct 22	85	503	8,912	588	775	572	572	487	10,217
Oct 23	85	500	9,903	585	780	574	574	489	11,187
Oct 24	85	300	10,499	385	548	452	452	367	11,915
Oct 25	85	200	10,895	285	385	348	348	263	12,436
Oct 26	85	135	11,163	220	322	308	308	32	12,500
Oct 27	85	135	11,431	220	338	308	308		
Oct 28	85	135	11,699	220	274	264	274		
Oct 29	85	135	11,966	220	255	246	255		
Oct 30	85	135	12,234	220	255	244	255		
Oct 31	85	135	12,502	220	255	240	255		

[a] The Technical Appendix to the San Joaquin River Group Division Agreement states that "[T]he Merced River at Shaffer Bridge…will be used for flows between 0 and 300 cfs. …[F]or the flows above 300 cfs, measurements will be provided at the gage on the Merced River located near Cressey.

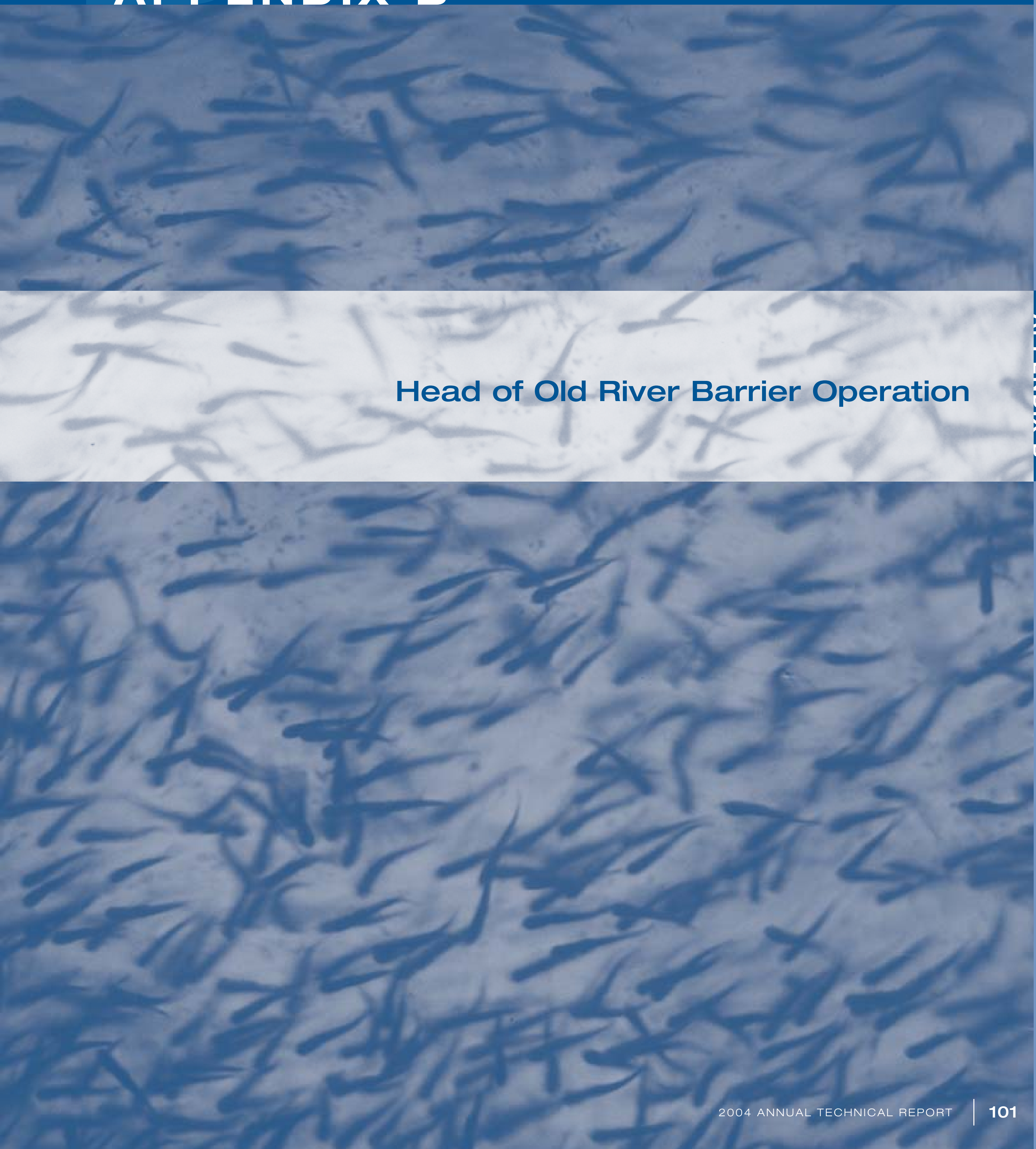
A-5 MERCED IRRIGATION DISTRICT

SJRA Fall 2003 Water Transfer • Daily Summary (FINAL)

	SCHEDULED				OBSERVED				
	Base Flow	Transfer Water		Target Flow (see Note 1)	Observed Flow Merced River at Shaffer Bridge (PG&E)	Observed Flow Merced R at Cressey (DWR)	Observed Flow for Transfer (see Note 1)	Transfer Water	
		Daily Flow Rate	Cumulative Volume					Daily Flow Rate	Cumulative Volume
	(cfs)	(cfs)	(acre-feet)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(acre-feet)
	(1)	(2)	(3)	(4) = (1) + (2)	(5)	(6)	(7)	(8) = (7) − (1)	(9)
Oct 01	30	70	139	100	109	90	109	79	157
Oct 02	30	70	278	100	118	94	118	88	331
Oct 03	30	125	526	155	144	119	144	114	557
Oct 04	30	125	774	155	157	136	157	127	809
Oct 05	30	125	1,021	155	161	141	161	131	1,069
Oct 06	30	125	1,269	155	162	137	162	132	1,331
Oct 07	30	125	1,517	155	156	131	156	126	1,581
Oct 08	30	125	1,765	155	157	134	157	127	1,833
Oct 09	30	125	2,013	155	172	149	172	142	2,114
Oct 10	30	125	2,261	155	194	174	194	164	2,440
Oct 11	30	125	2,509	155	205	188	205	175	2,787
Oct 12	30	125	2,757	155	202	190	202	172	3,128
Oct 13	30	125	3,005	155	203	179	203	173	3,471
Oct 14	30	125	3,253	155	204	182	204	174	3,816
Oct 15	30	125	3,501	155	204	188	204	174	4,161
Oct 16	85	125	3,749	210	247	236	247	162	4,483
Oct 17	85	185	4,116	270	322	301	301	216	4,911
Oct 18	85	315	4,740	400	471	389	389	304	5,514
Oct 19	85	515	5,762	600	739	554	554	469	6,444
Oct 20	85	515	6,783	600	755	586	586	501	7,438
Oct 21	85	515	7,805	600	734	579	579	494	8,418
Oct 22	85	515	8,826	600	791	615	615	530	9,469
Oct 23	85	515	9,848	600	768	610	610	525	10,510
Oct 24	85	315	10,473	400	566	495	495	410	11,324
Oct 25	85	215	10,899	300	442	412	412	327	11,972
Oct 26	85	135	11,167	220	323	332	332	247	12,462
Oct 27	85	135	11,435	220	294	304	294	19	12,500
Oct 28	85	135	11,702	220	292	297	292		
Oct 29	85	135	11,970	220	287	292	287		
Oct 30	85	135	12,238	220	252	269	252		
Oct 31	85	135	12,506	220	232	248	232		

[a] The Technical Appendix to the San Joaquin River Group Division Agreement states that "[T]he Merced River at Shaffer Bridge… will be used for flows between 0 and 300 cfs. …[F]or the flows above 300 cfs, measurements will be provided at the gage on the Merced River located near Cressey.

APPENDIX B



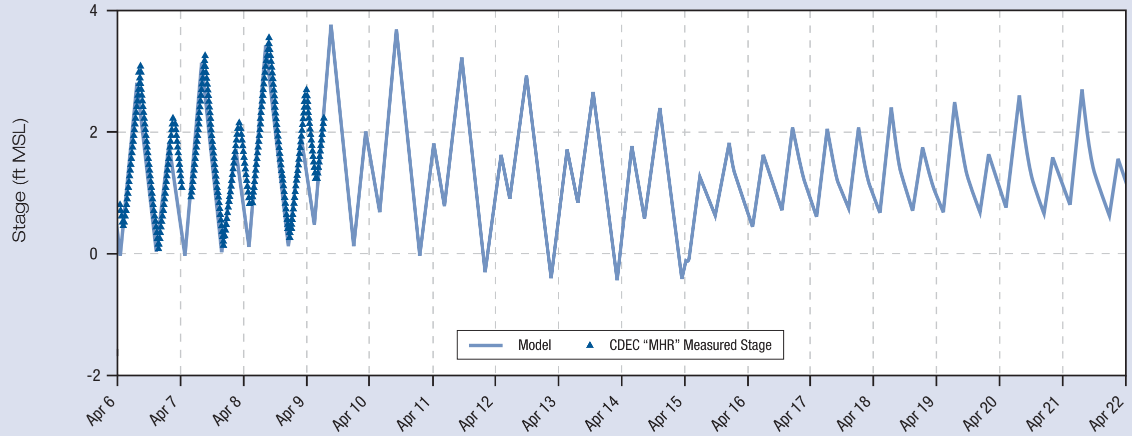
Head of Old River Barrier Operation

APPENDIX B

B–1. Forecasted Low-Low Tide Stage
Middle River at Howard Road

As of April 6, 2004

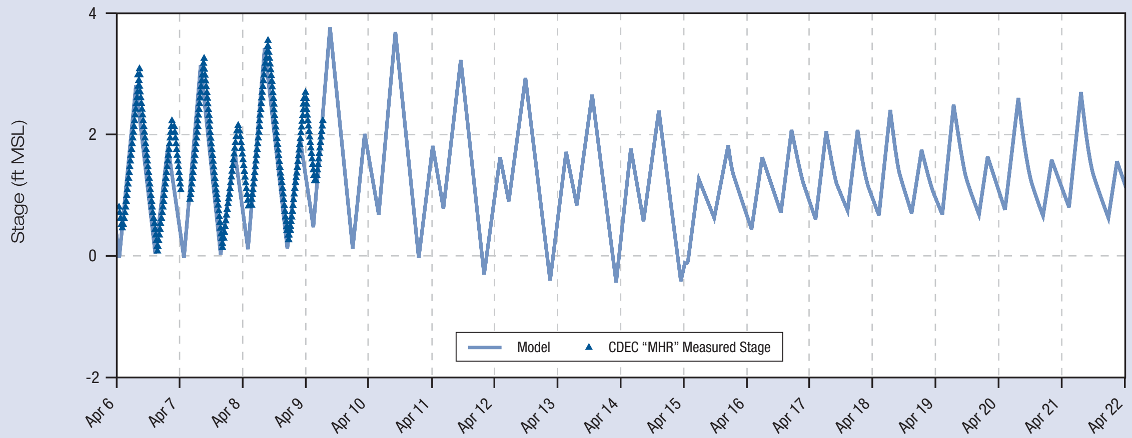
Note: 2 AG barriers tidally operated, GLC partial, ***All HORB culverts closed***



Notes:
All barriers closed on 4/15/04 except GLC.
The DMC and Middle River barriers modeled with culverts tidally operated
The GLC modeled partial barrier.

As of April 6, 2004

Note: 2 AG barriers tidally operated, GLC partial, ***3 HORB culverts open***



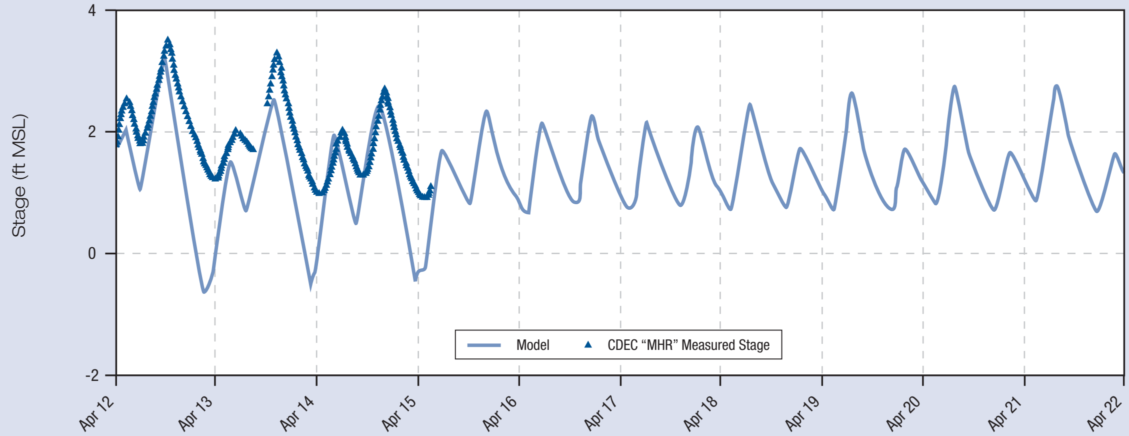
Notes:
GLC barrier partially closed 4/9/04, MR barrier closed 4/12/04, DMC and HORB barriers closed 4/15/04.
The DMC and Middle River barriers modeled with culverts tidally operated
The GLC modeled partial barrier.

APPENDIX B

B–1. Forecasted Low-Low Tide Stage
Middle River at Howard Road

As of April 12, 2004

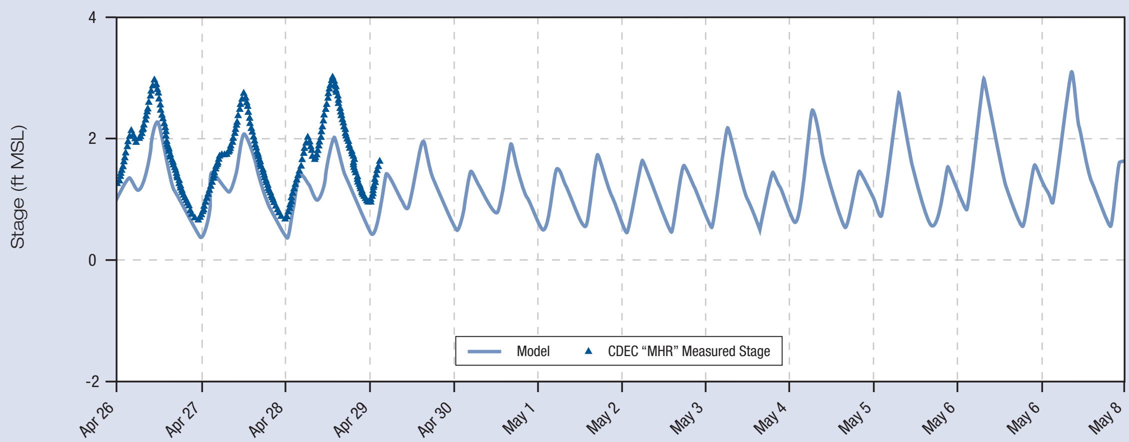
Note: 2 AG barriers tidally operated, GLC partial, ***HORB 3 culverts open***



Notes:
GLC barrier partially closed 4/9/04, MR barrier closed 4/12/04, DMC and HORB barriers closed 4/15/04.
The DMC and Middle River barriers modeled with culverts tidally operated
The GLC modeled partial barrier.

As of April 26, 2004

Note: 2 AG barriers tidally operated, GLC partial, ***HORB 6 culverts open***



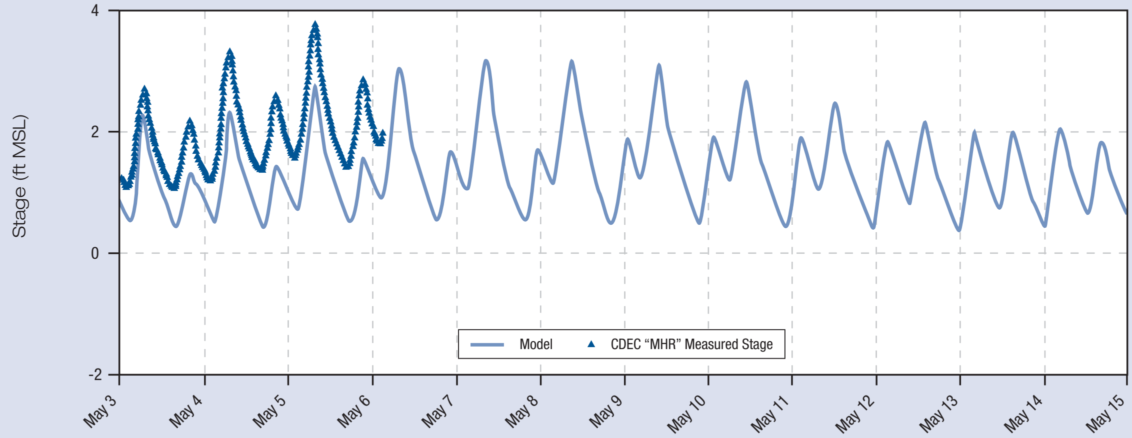
Notes:
GLC barrier partially closed 4/9/04, MR barrier closed 4/12/04, DMC and HORB barriers closed 4/15/04.
The DMC and Middle River barriers modeled with culverts tidally operated
The GLC modeled partial barrier.

APPENDIX B

B–1. Forecasted Low-Low Tide Stage
Middle River at Howard Road

As of May 3, 2004

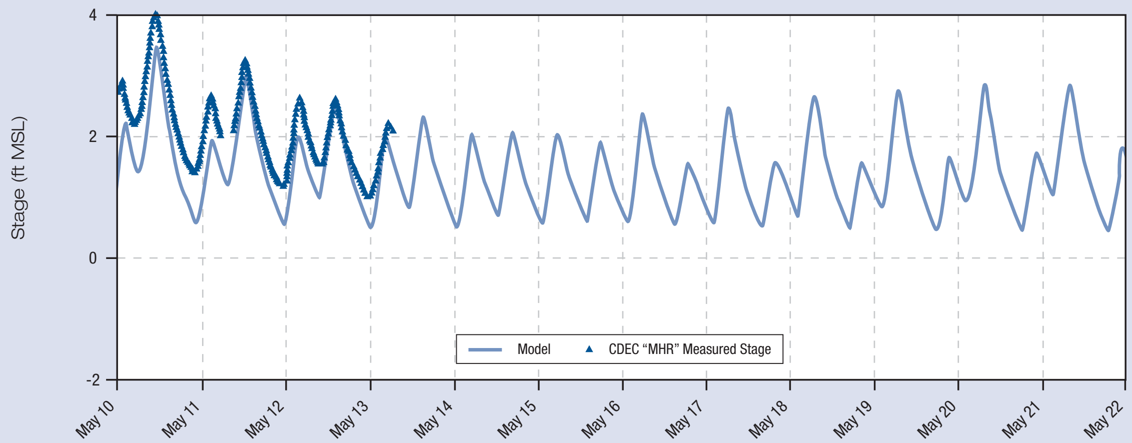
Note: 2 AG barriers tidally operated, GLC partial, ***HORB 6 culverts open***



Notes:
GLC barrier partially closed 4/9/04, MR barrier closed 4/12/04, DMC and HORB barriers closed 4/15/04.
The DMC and Middle River barriers modeled with culverts tidally operated
The GLC modeled partial barrier.

As of May 10, 2004

Note: 2 AG barriers tidally operated, GLC partial, ***HORB 6 culverts open***

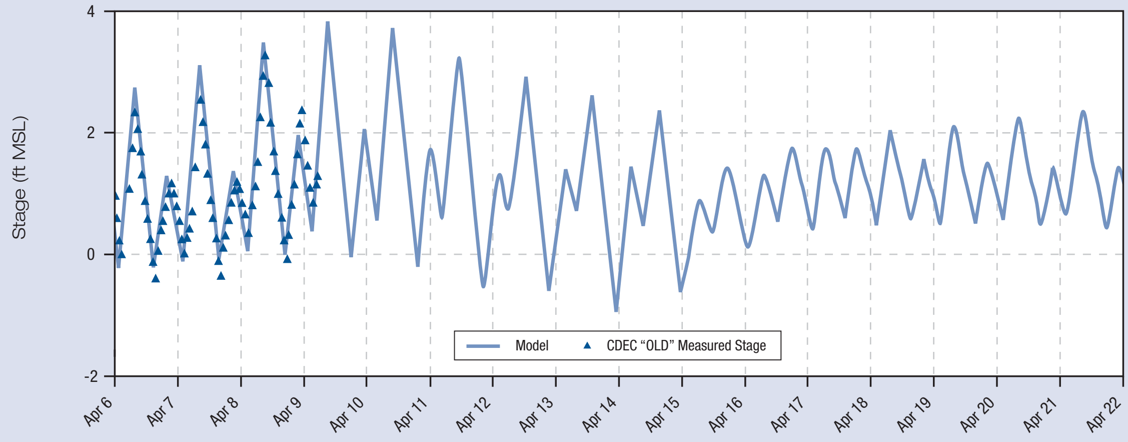


Notes:
GLC barrier partially closed 4/9/04, MR barrier closed 4/12/04, DMC and HORB barriers closed 4/15/04.
The DMC and Middle River barriers modeled with culverts tidally operated
The GLC modeled partial barrier.

B–2. Forecasted Low-Low Tide Stage
Old River near Tracy Road Bridge

As of April 6, 2004

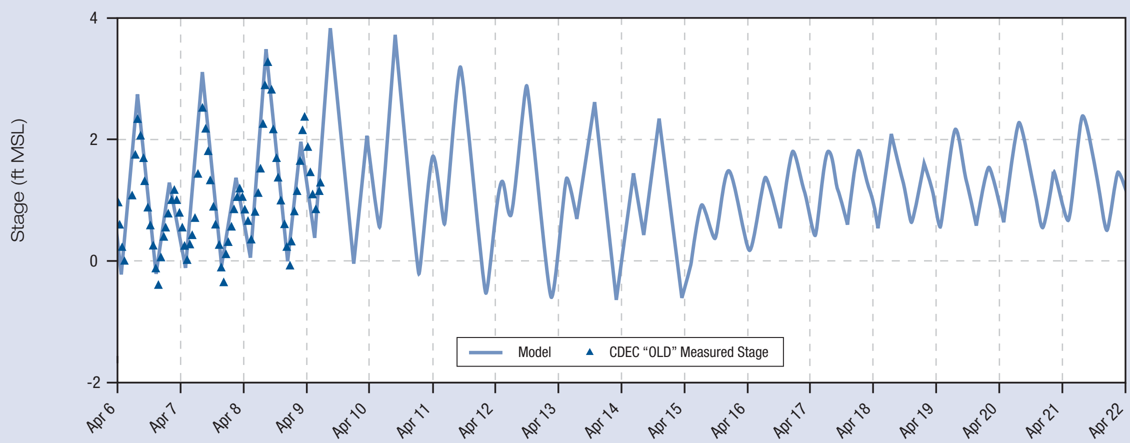
Note: 2 AG barriers tidally operated, GLC partial, ***All HORB culverts closed***



Notes:
All barriers closed on 4/15/04 except GLC.
The DMC and Middle River barriers modeled with culverts tidally operated
The GLC modeled partial barrier.

As of April 6, 2004

Note: 2 AG barriers tidally operated, GLC partial, ***3 HORB culverts open***



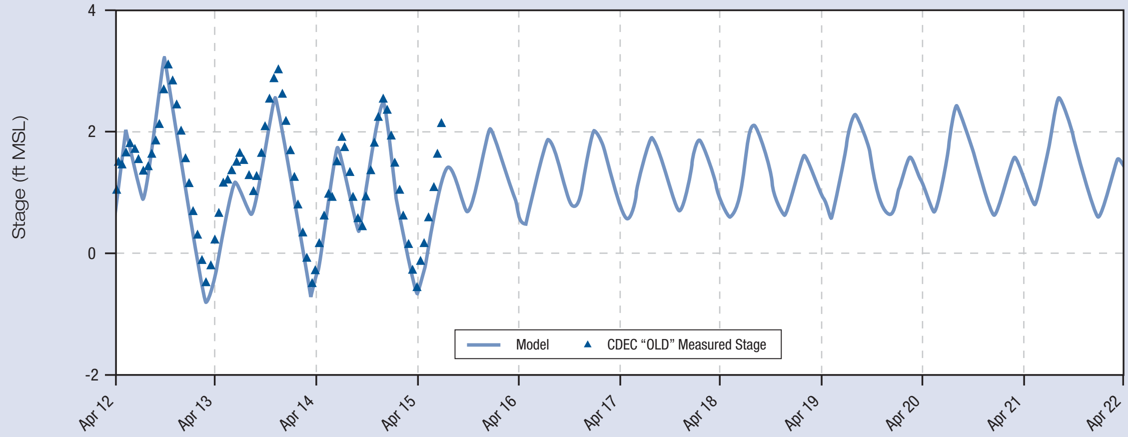
Notes:
GLC barrier partially closed 4/9/04, MR barrier closed 4/12/04, DMC and HORB barriers closed 4/15/04.
The DMC and Middle River barriers modeled with culverts tidally operated
The GLC modeled partial barrier.

APPENDIX B

B-2. Forecasted Low-Low Tide Stage
Old River near Tracy Road Bridge

As of April 12, 2004

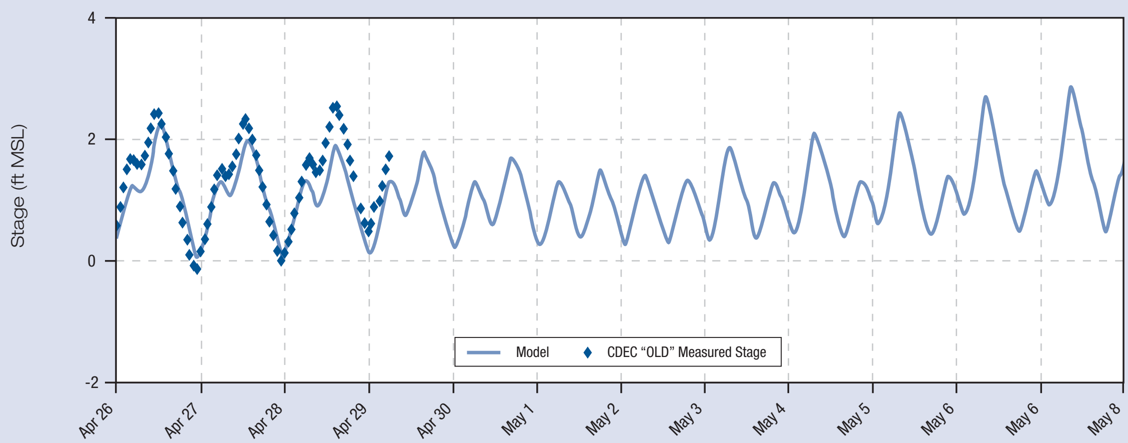
Note: 2 AG barriers tidally operated, GLC partial, ***HORB 3 culverts open***



Notes:
GLC barrier partially closed 4/9/04, MR barrier closed 4/12/04, DMC and HORB barriers closed 4/15/04.
The DMC and Middle River barriers modeled with culverts tidally operated
The GLC modeled partial barrier.

As of April 26, 2004

Note: 2 AG barriers tidally operated, GLC partial, ***HORB 6 culverts open***



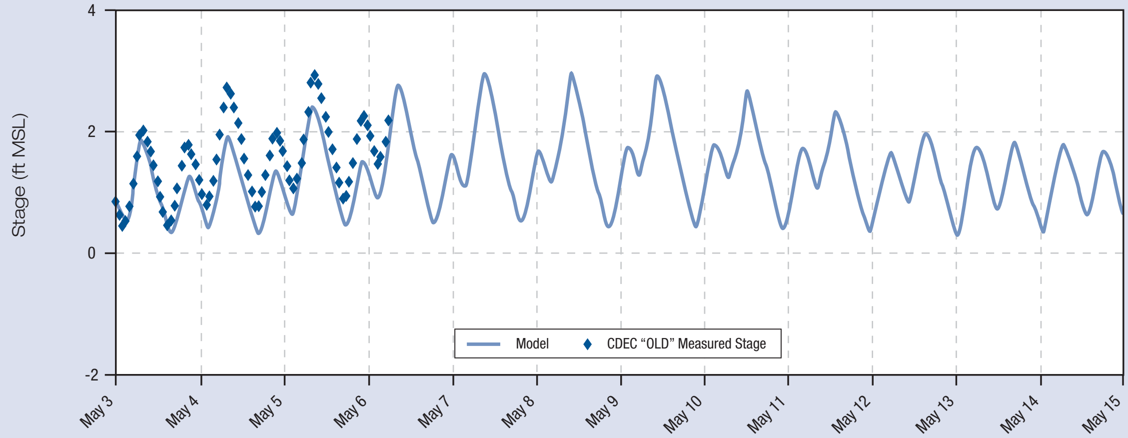
Notes:
GLC barrier partially closed 4/9/04, MR barrier closed 4/12/04, DMC and HORB barriers closed 4/15/04.
The DMC and Middle River barriers modeled with culverts tidally operated
The GLC modeled partial barrier.

APPENDIX B

B-2. Forecasted Low-Low Tide Stage
Old River near Tracy Road Bridge

As of May 3, 2004

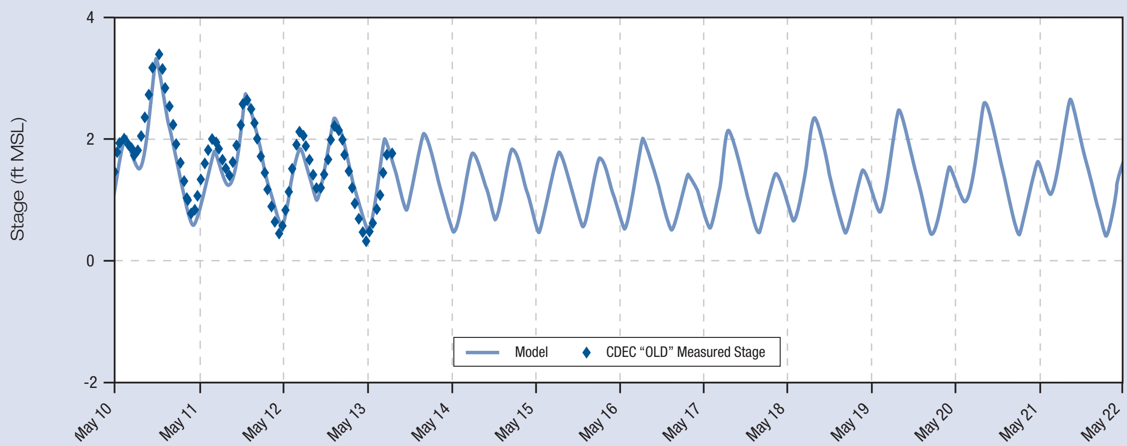
Note: 2 AG barriers tidally operated, GLC partial, ***HORB 6 culverts open***



Notes:
GLC barrier partially closed 4/9/04, MR barrier closed 4/12/04, DMC and HORB barriers closed 4/15/04.
The DMC and Middle River barriers modeled with culverts tidally operated
The GLC modeled partial barrier.

As of May 10, 2004

Note: 2 AG barriers tidally operated, GLC partial, ***HORB 6 culverts open***



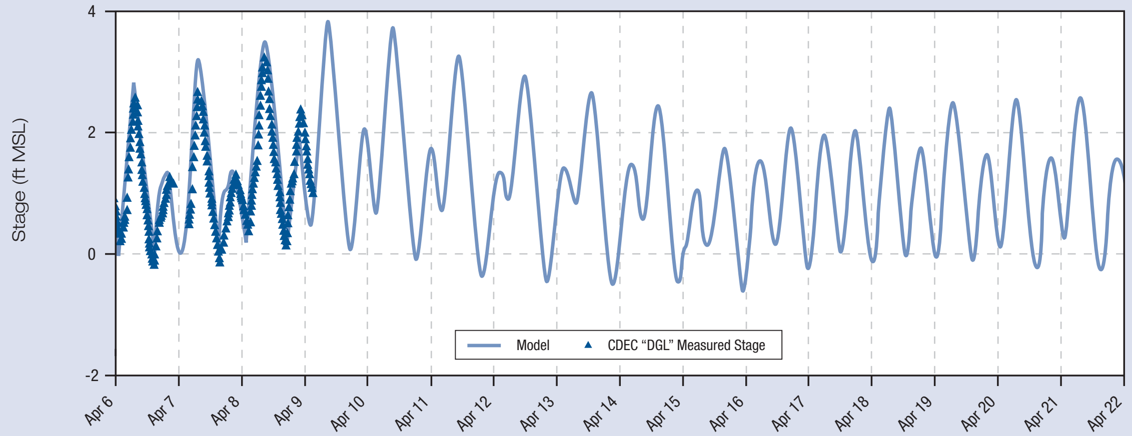
Notes:
GLC barrier partially closed 4/9/04, MR barrier closed 4/12/04, DMC and HORB barriers closed 4/15/04.
The DMC and Middle River barriers modeled with culverts tidally operated
The GLC modeled partial barrier.

APPENDIX B

B–3. Forecasted Low-Low Tide Stage Doughty Cut above GLC Barrier

As of April 6, 2004

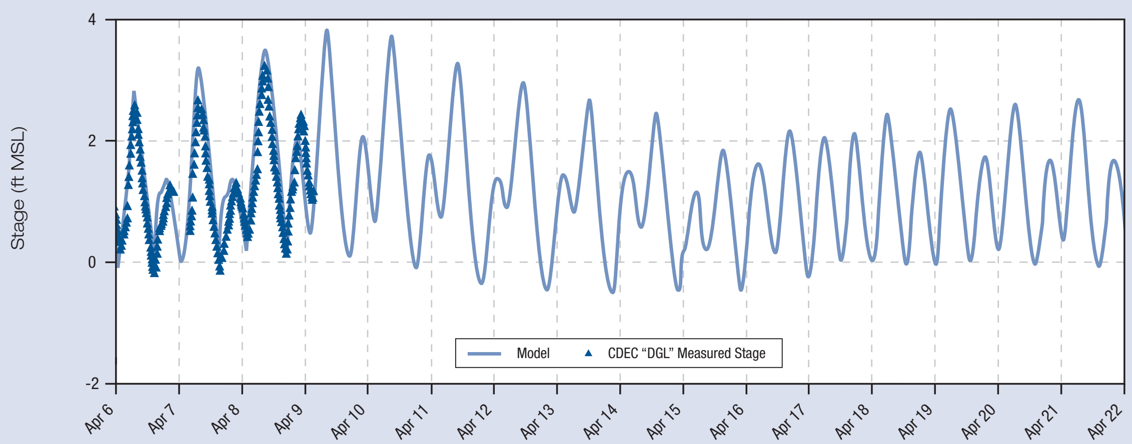
Note: 2 AG barriers tidally operated, GLC partial, ***All HORB culverts closed***



Notes:
All barriers closed on 4/15/04 except GLC.
The DMC and Middle River barriers modeled with culverts tidally operated
The GLC modeled partial barrier.

As of April 6, 2004

Note: 2 AG barriers tidally operated, GLC partial, ***3 HORB culverts open***



Notes:
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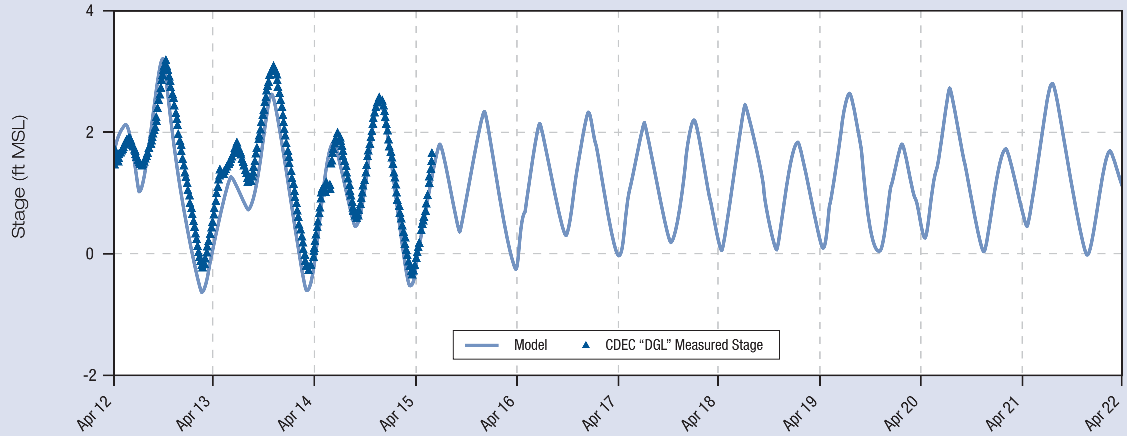
The DMC and Middle River barriers modeled with culverts tidally operated
The GLC modeled partial barrier.

APPENDIX B

B–3. Forecasted Low-Low Tide Stage
Doughty Cut above GLC Barrier

As of April 12, 2004

Note: 2 AG barriers tidally operated, GLC partial, ***HORB 3 culverts open***



Notes:
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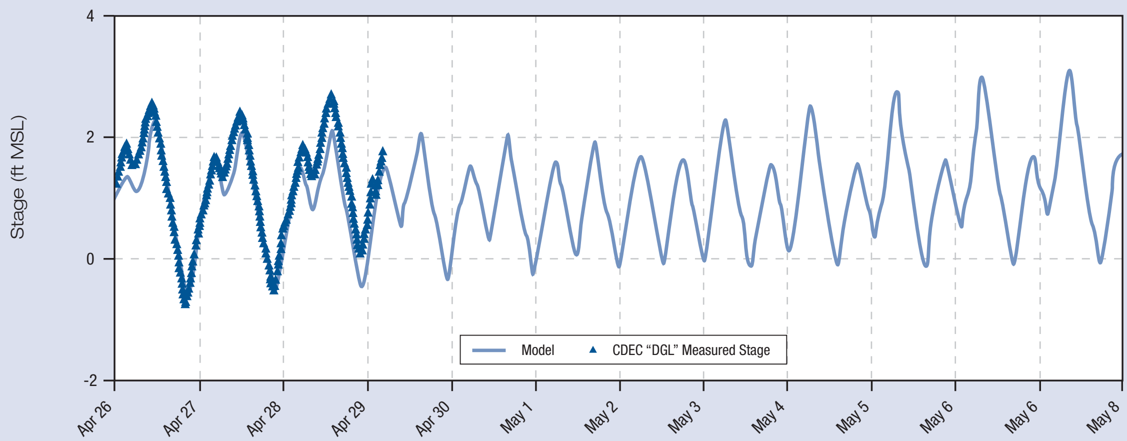
The DMC and Middle River barriers modeled with culverts tidally operated
The GLC modeled partial barrier.

As of April 26, 2004

Note: 2 AG barriers tidally operated, GLC partial, ***HORB 6 culverts open***



Notes:
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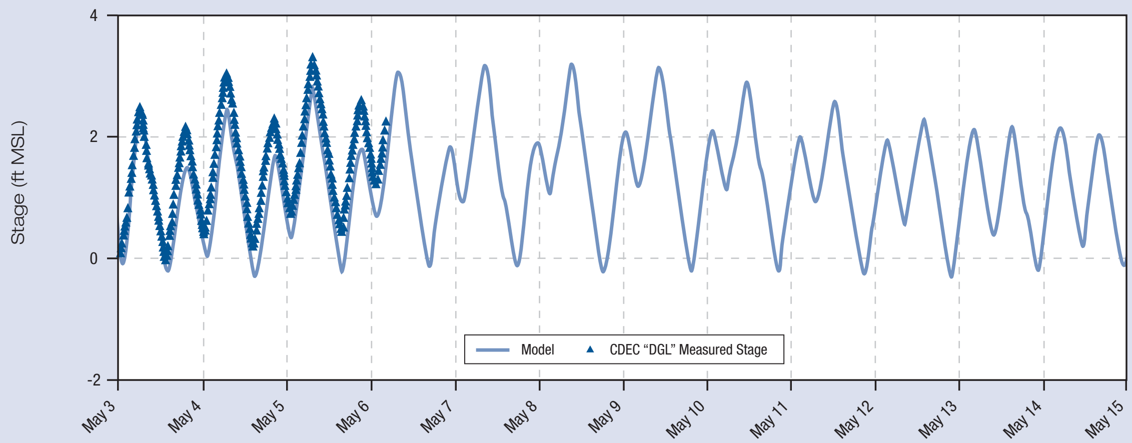
The DMC and Middle River barriers modeled with culverts tidally operated
The GLC modeled partial barrier.

APPENDIX B

B–3. Forecasted Low-Low Tide Stage Doughty Cut above GLC Barrier

As of May 3, 2004

Note: 2 AG barriers tidally operated, GLC partial, ***HORB 6 culverts open***



Notes:
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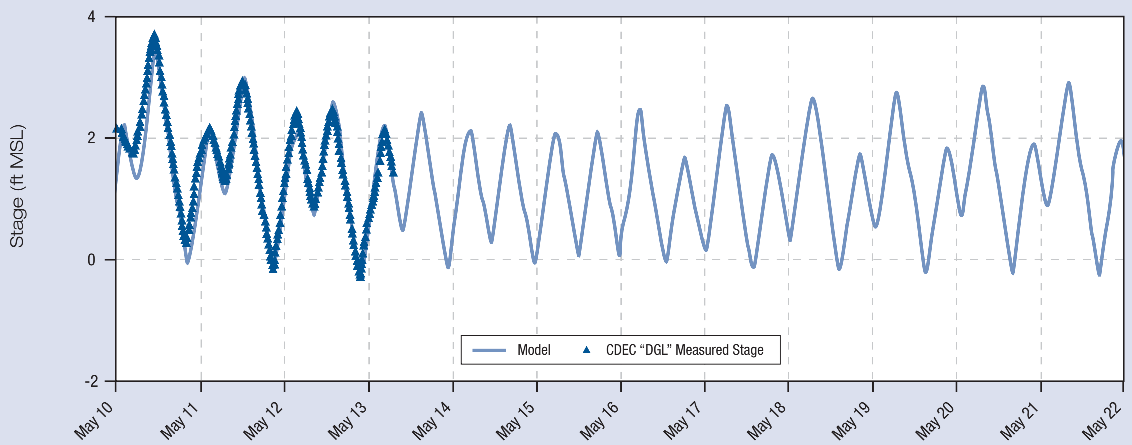
The GLC modeled partial barrier.

As of May 10, 2004

Note: 2 AG barriers tidally operated, GLC partial, ***HORB 6 culverts open***



Notes:
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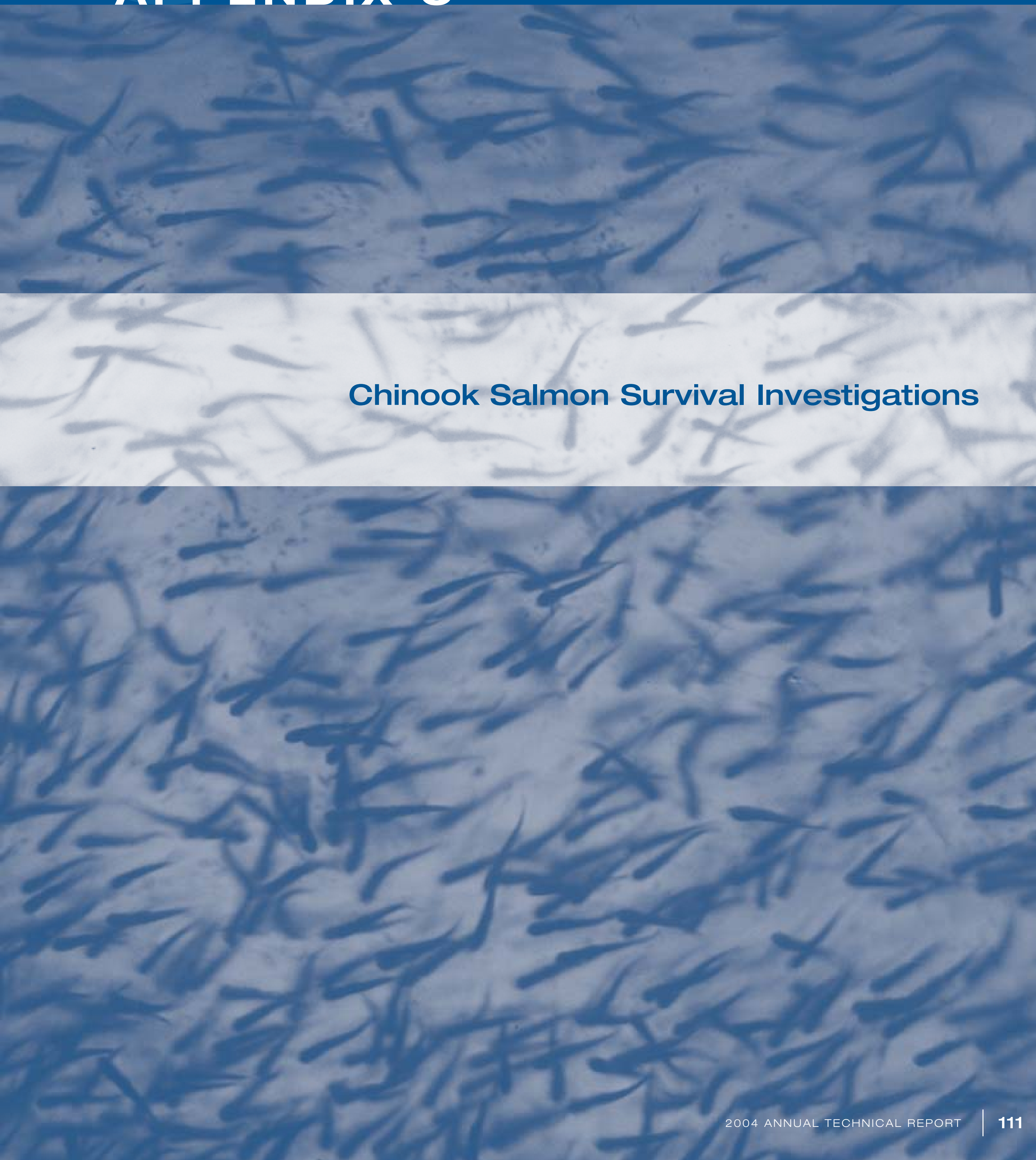
The GLC modeled partial barrier.

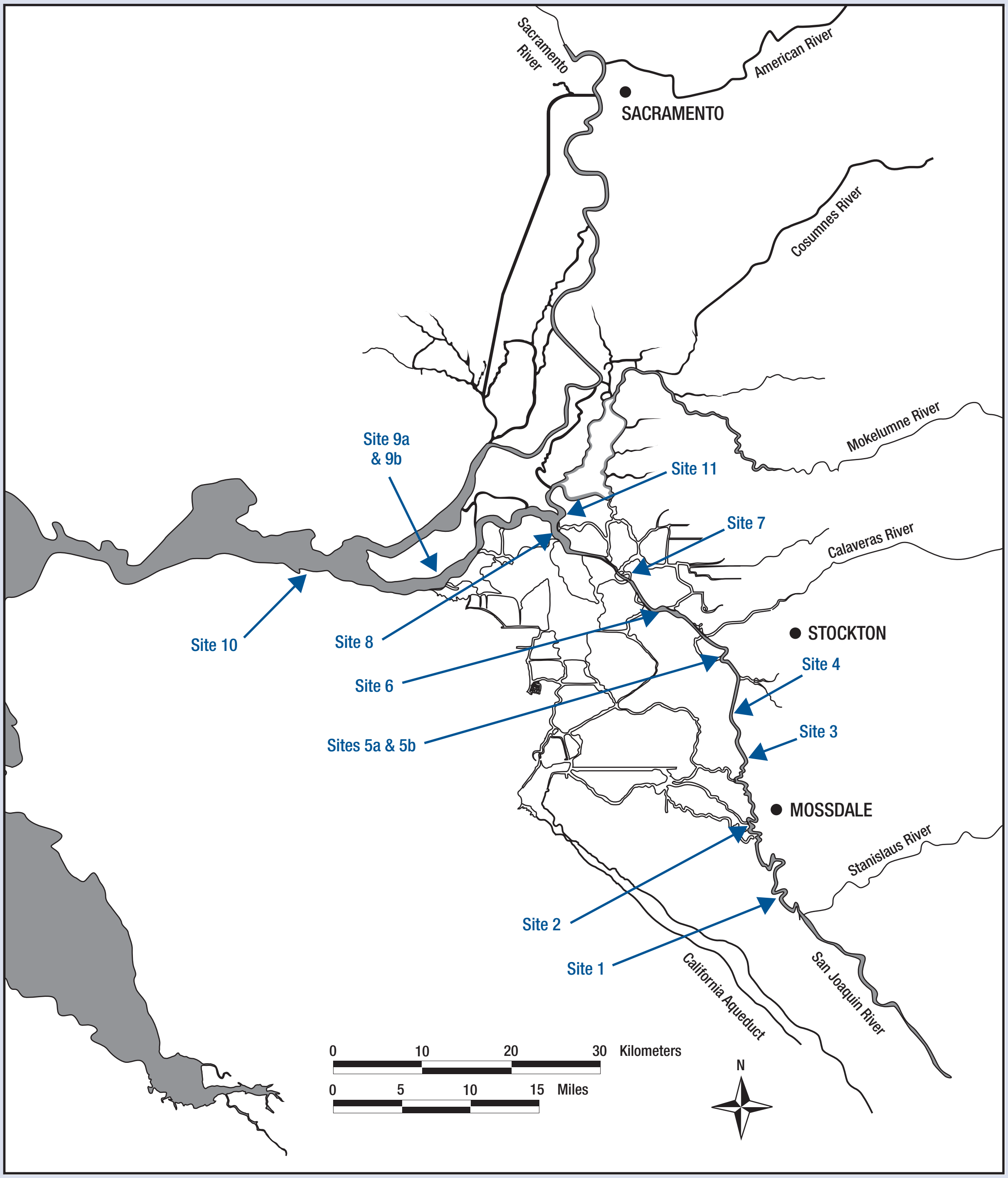
APPENDIX B

APPENDIX C



Chinook Salmon Survival Investigations

C–1. Water Temperature Monitoring Locations

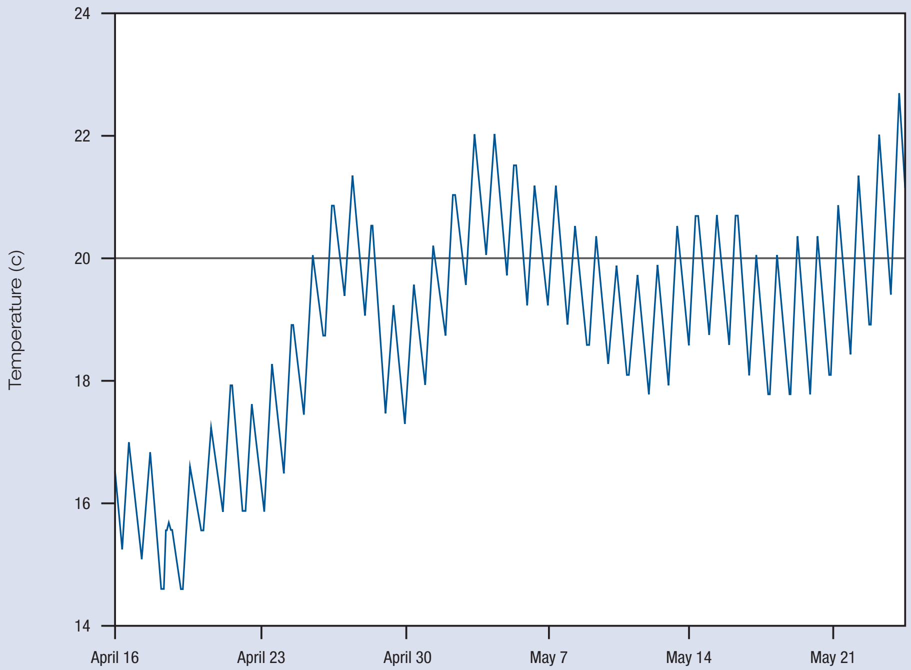


C–1. VAMP 2004 Water Temperature Monitoring

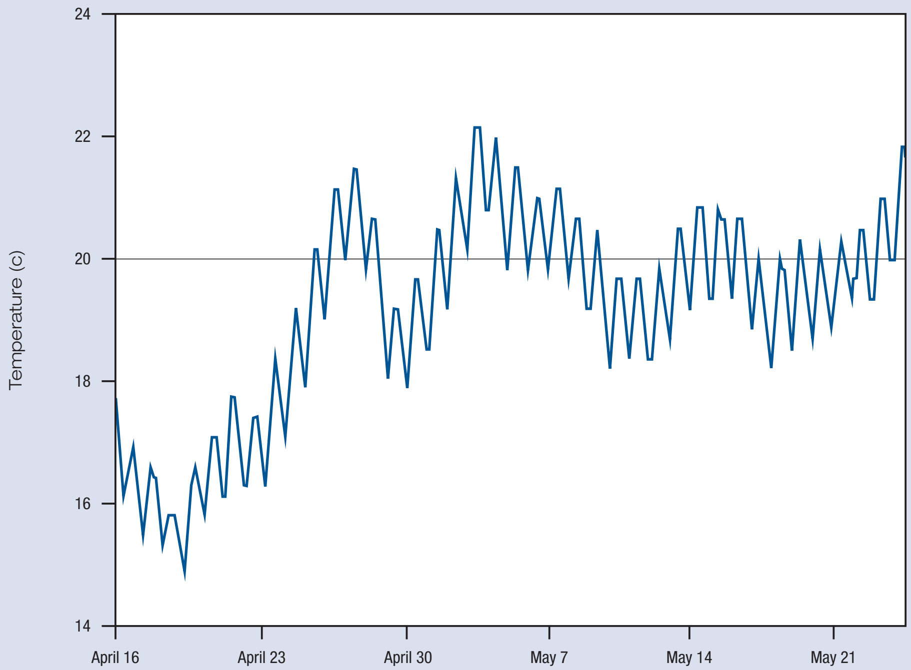
	Temperature Monitoring Location	Latitude	Longitude	Distance from Durham Ferry (mi)	Date Deployed	Date Retrieved	Notes
	Merced River Hatchery–1			n/a	March 18	April 24	In river April 22, 2004 at Durham Ferry
	Merced River Hatchery–2			n/a	March 18	April 25	In river April 23, 2004 at Mossdale
1	Durham Ferry	N 37 41.381	W 121 15.657	n/a	April 15	May 25	3 foot depth
2	Mossdale	N 37 47.180	W 121 18.425	11.2	April 15	May 25	3 feet below surface
3	Dos Reis	N 37 49.808	W 121 18.665	16.4	April 15	May 25	3 feet below surface
4	DWR Monitoring Station	N 37 51.869	W 121 19.376	19.4	April 15	May 25	3 feet below surface
5a	Confluence–Top	N 37 56.818	W 121 20.285	26.5	April 15	May 25	Logger Malfunction
5b	Confluence–Bottom	N 37 56.818	W 121 20.285	26.5	April 15	May 25	Located on bottom
6	Downstream of Channel Marker 30	N 37 59.776	W 121 25.569	33.3	April 15	May 25	3 feet below surface
7	½ mile Upstream of Channel Marker 13	N 38 01.940	W 121 28.769	37.3	April 15	May 25	3 feet below surface
8	Downstream of Channel Marker 36	N 38 04.522	W 121 34.413	44.7	April 15	May 25	3 feet below surface
9a	Jersey Point USGS Gauging Station–Top	N 38 03.172	W121 41.637	56.0	April 15	May 25	3 feet below surface
10	Chipps Island	N 38 03.084	W 121 55.463	71.5	April 15	May 25	4½ feet below surface
11	Mokelumne River-Lighthouse Marina	N 38 06.334	W 121 34.213	40.0	April 15	May 25	Logger malfunction

C–2. Water Temperature Monitoring

Site 1 · Durham Ferry

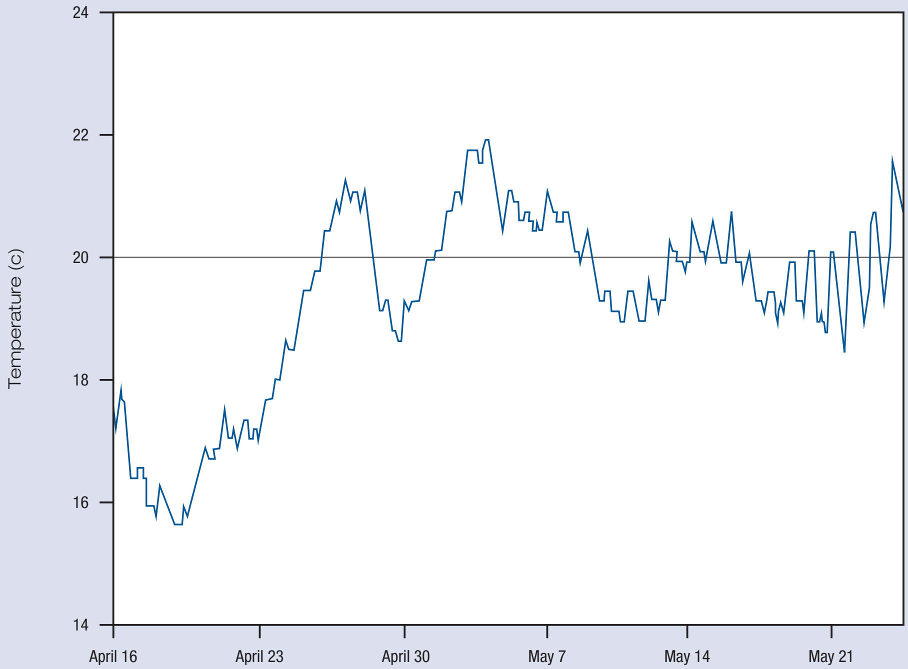


Site 2 · Mossdale

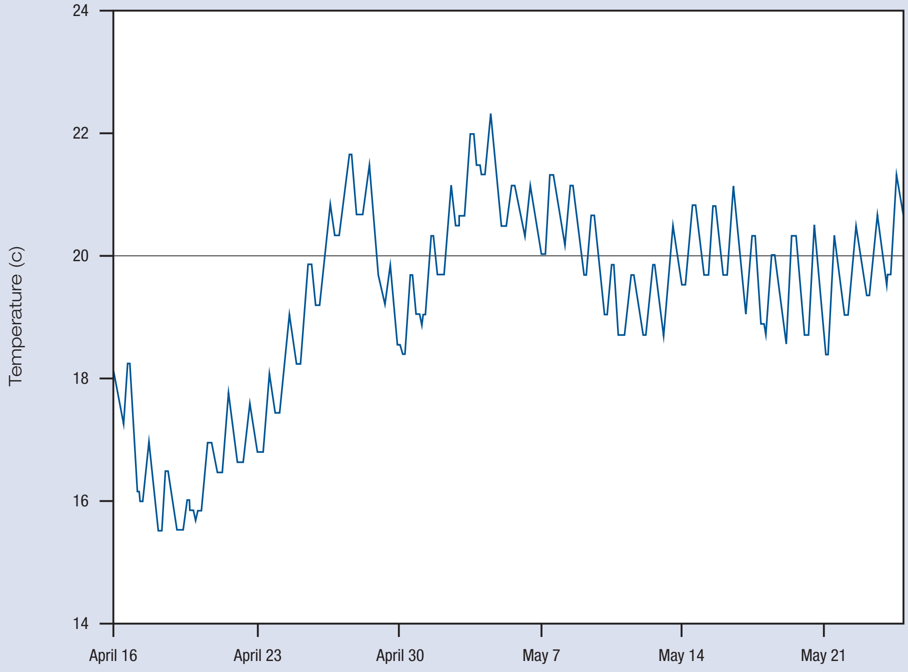


C–2. Water Temperature Monitoring

Site 3 · Dos Reis



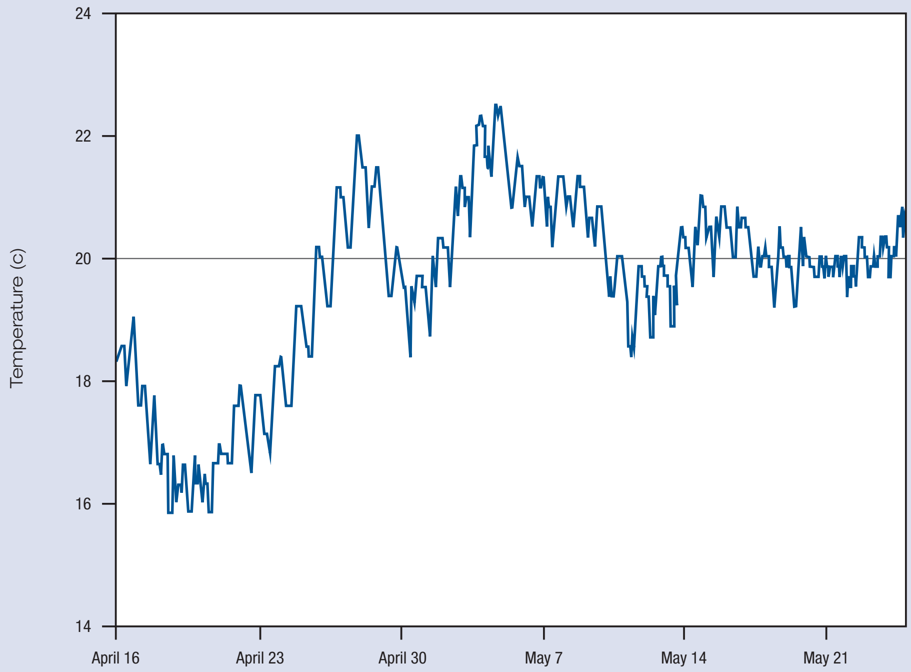
Site 4 · DWR Monitoring Station



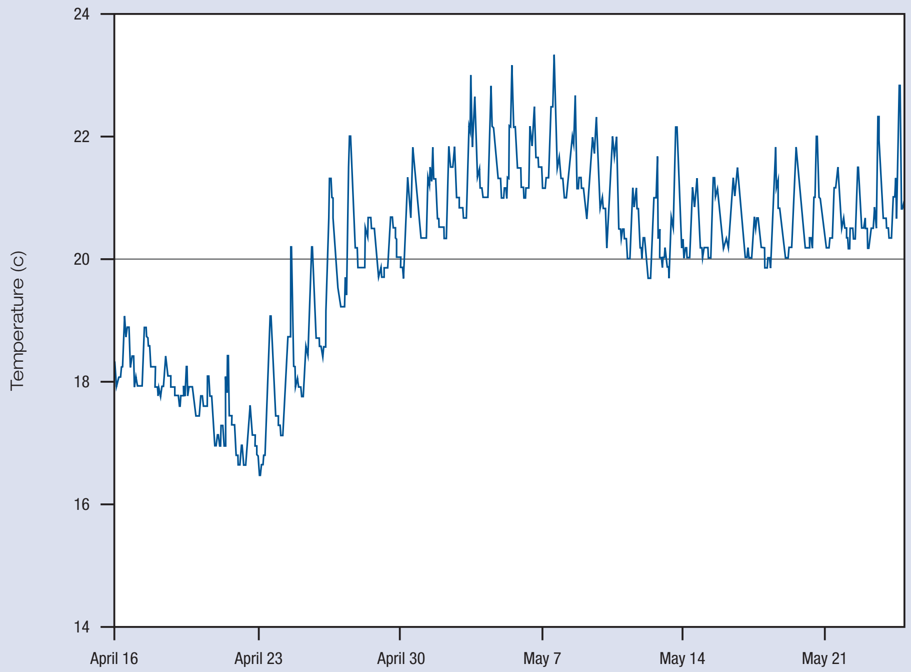
APPENDIX C

C–2. Water Temperature Monitoring

Site 5b · Confluence-Bottom

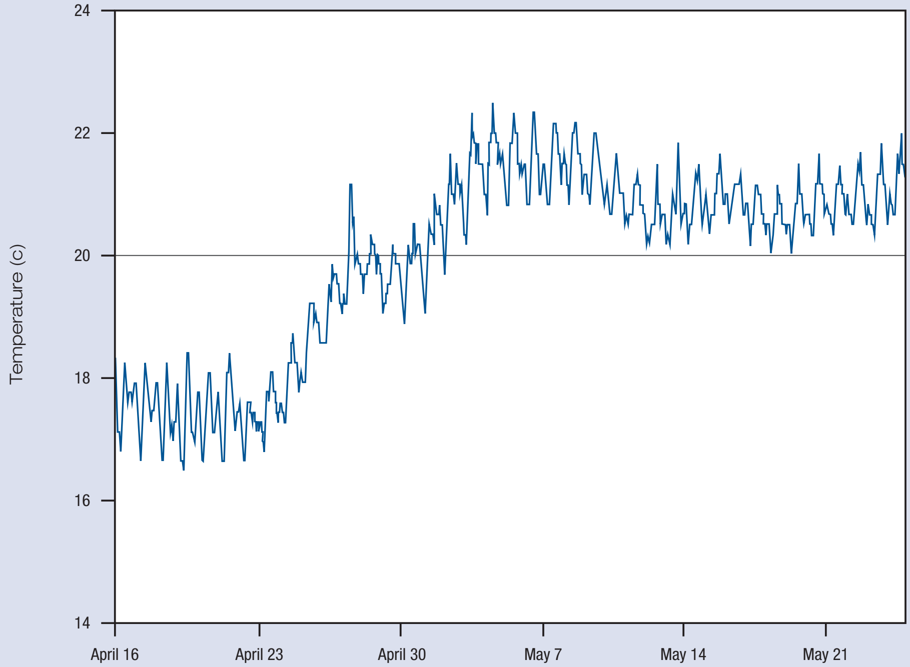


Site 6 · Downstream of Channel Marker 30

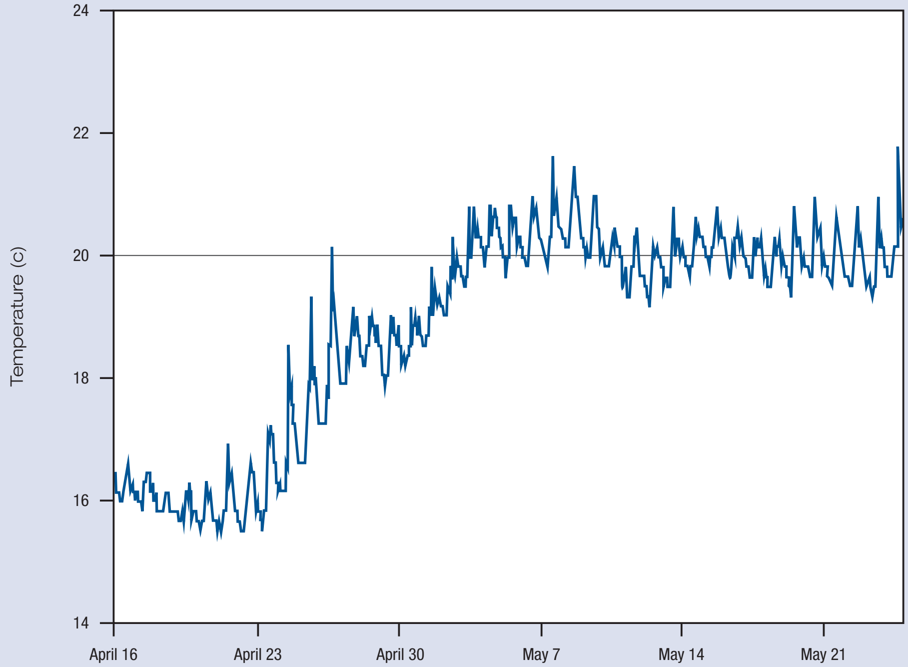


C-2. Water Temperature Monitoring

Site 7 · 1/2 Mile Upstream of Channel Marker 13



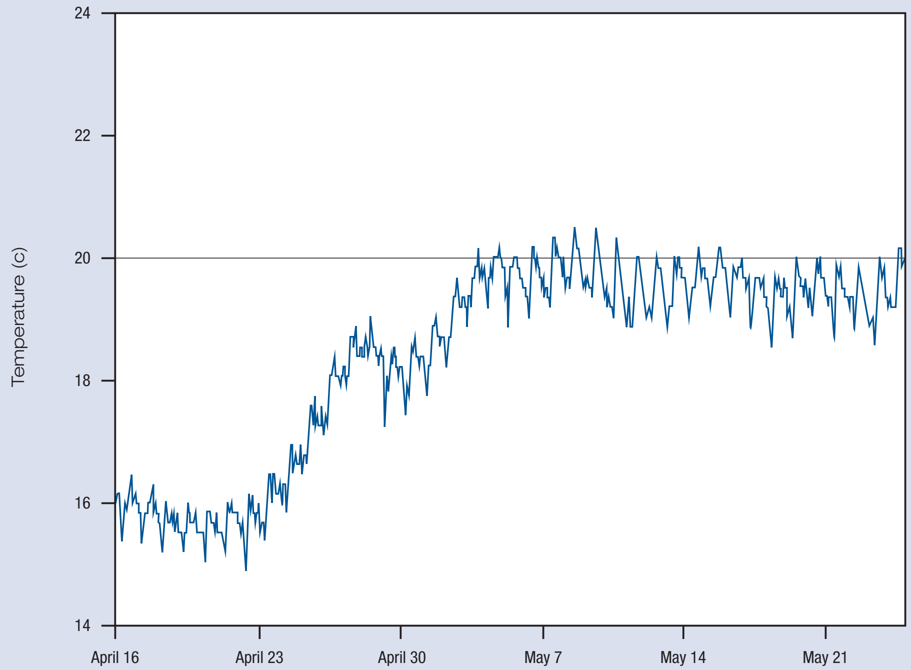
Site 8 · Downstream of Channel Marker 36



APPENDIX C

C–2. Water Temperature Monitoring

Site 9 · USGS Gauging Station at Jersey Point—Top



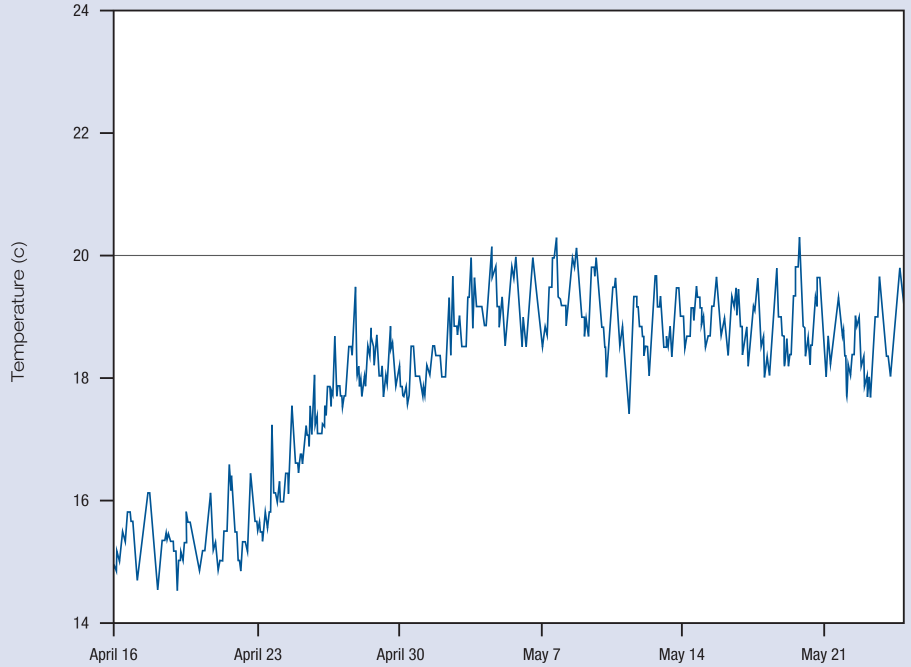
C–3. RESULTS OF NET PEN SAMPLING

a. Condition assessments immediately after release

Release Location	Coded-wire Tag Codes(s)	Number in Sample	Min FL	Max FL	Mean FL	Min Weight	Max Weight	Mean Weight	Min Scale Loss	Max scale loss	Mean scale loss
Durham Ferry I	06-27-52, 06-27-53, 06-27-54, 06-27-55	50	67	94	83.8	3.1	8.7	6.4	0.0	10.0	0.4
Mossdale I	06-46-70, 06-45-82, 06-45-83	75	71	91	83.8	3.4	7.8	6.1	2.0	12.0	5.1
Jersey Point I	06-45-80	25	76	96	89.5	4.5	9.4	7.6	1.0	8.0	3.2

C-2. Water Temperature Monitoring

Site 10 · Chipps Island



Color (% normal)	Fin Hemorrhaging (% none)	Eyes (% normal)	Gill Color (% normal)	Partial Adipose Fin Clips (%)	Missing Adipose Fin Clips (%)	Number of Mortalities	Other Abnormalities and Comments
98	100.0	92	56	0	0	4	44% of fish had pale gills; possible ick. Appx. 150 fish (tag code 06-2-52) spilled onto boat ramp when hose disconnected from truck.
100	98.7	100	100	7	0	3	
100	100.0	100	100	4	0	1	

APPENDIX A

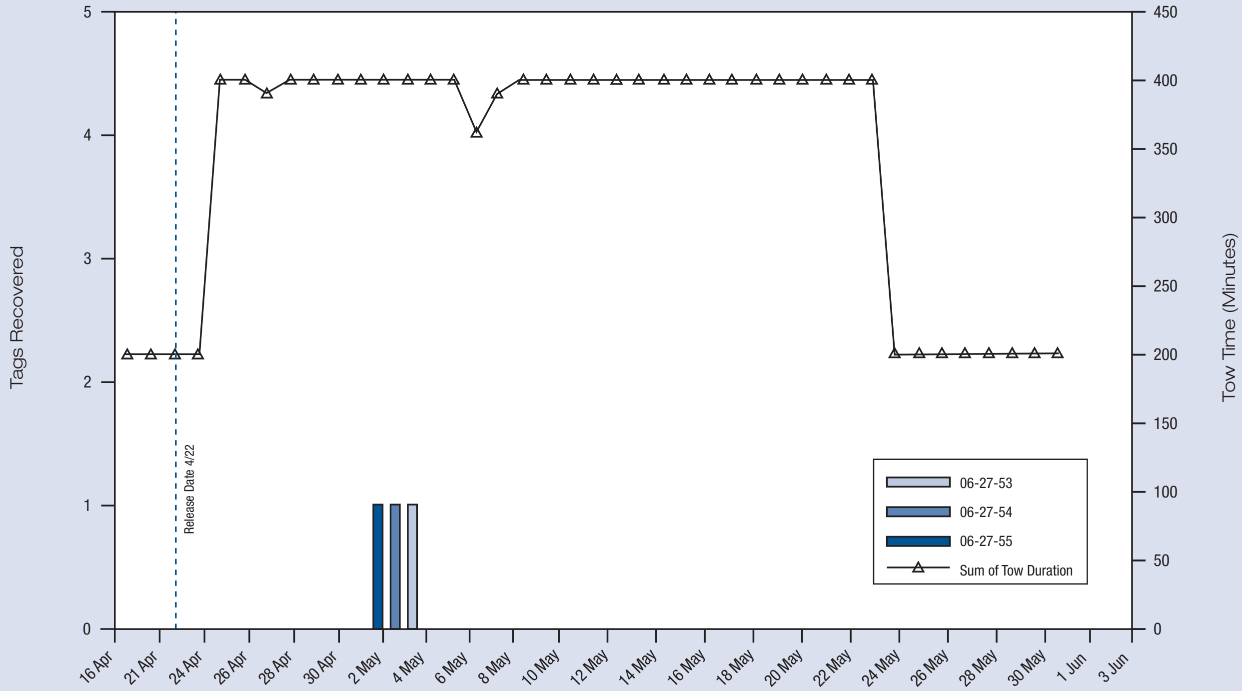
C–3. RESULTS OF NET PEN SAMPLING

b. Condition assessments 48 hours after release (fish held in net pens)

Release Location	Coded-wire Tag Codes(s)	Number in Sample	Min FL	Max FL	Mean FL	Min Weight	Max Weight	Mean Weight	Min Scale Loss	Max scale loss	Mean scale loss
Durham Ferry I	06-27-52, 06-27-53, 06-27-54, 06-27-55	400	60	102	84.9	1.9	11.1	6.2	3.0	15.0	8.0
Mossdale I	06-46-70, 06-45-82, 06-45-83	400	62	100	83.9	2.0	10.4	5.9	0.5	15.0	4.3
Jersey Point I	06-45-80	200	74	100	86.8	4.4	11.1	6.9	4.4	11.1	6.9

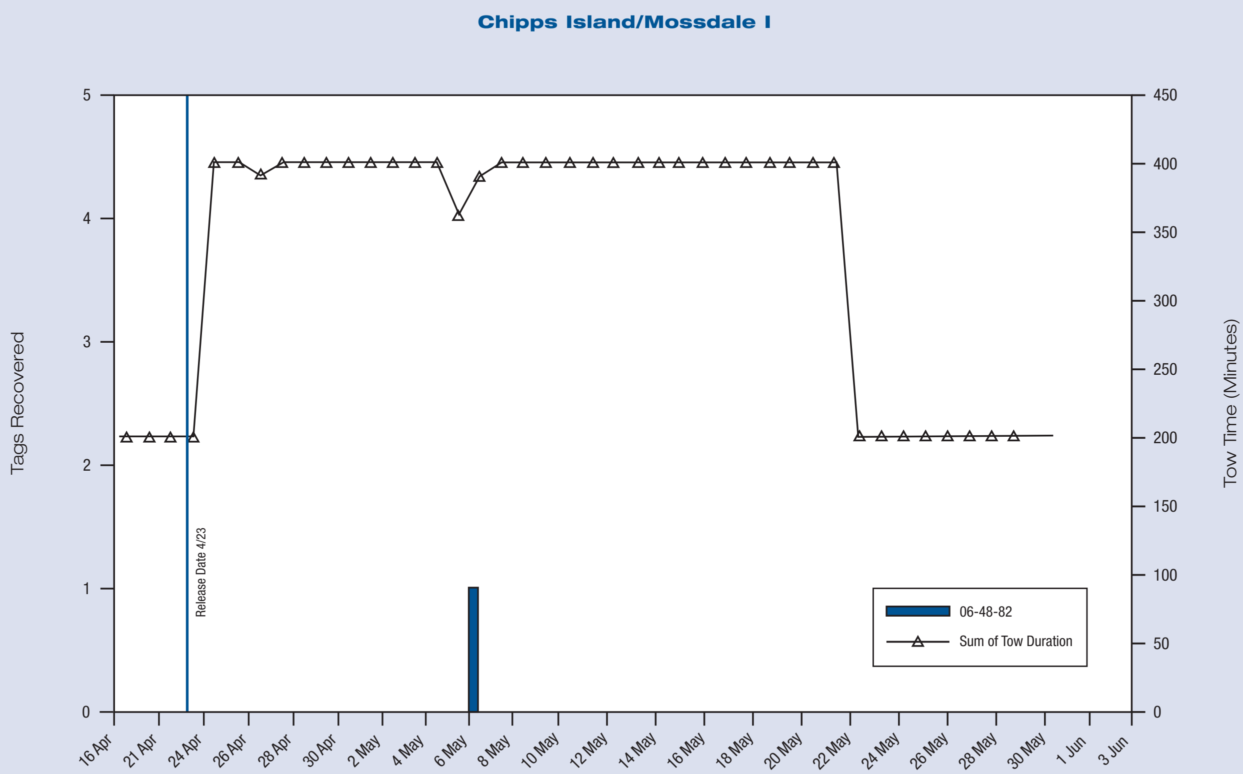
C–4. Coded Wire Tag Recovery Data (Recovery location/Release location)

Chipps Island/Durham Ferry I



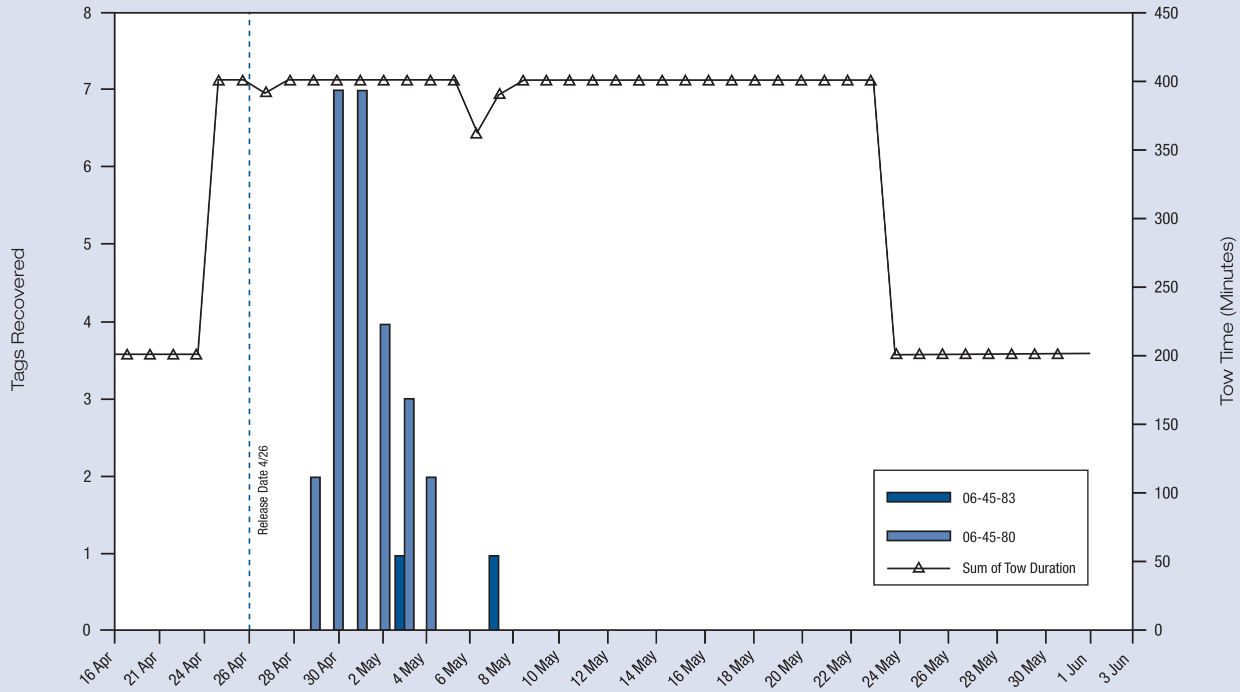
Color (% normal)	Fin Hemorrhaging (% none)	Eyes (% normal)	Gill Color (% normal)	Partial Adipose Fin Clips (%)	Missing Adipose Fin Clips (%)	Number of Mortalities	Other Abnormalities and Comments
100	196	100.0	100.0	6	1	4	1 fish with eroded caudal fin, 1 fish with deformed dorsal fin
100	100	97.3	98.7	3	1	0	1 fish had bulging eyes
100	100	100.0	100.0	2	0	2	2 fish had possible ick spots

APPENDIX C

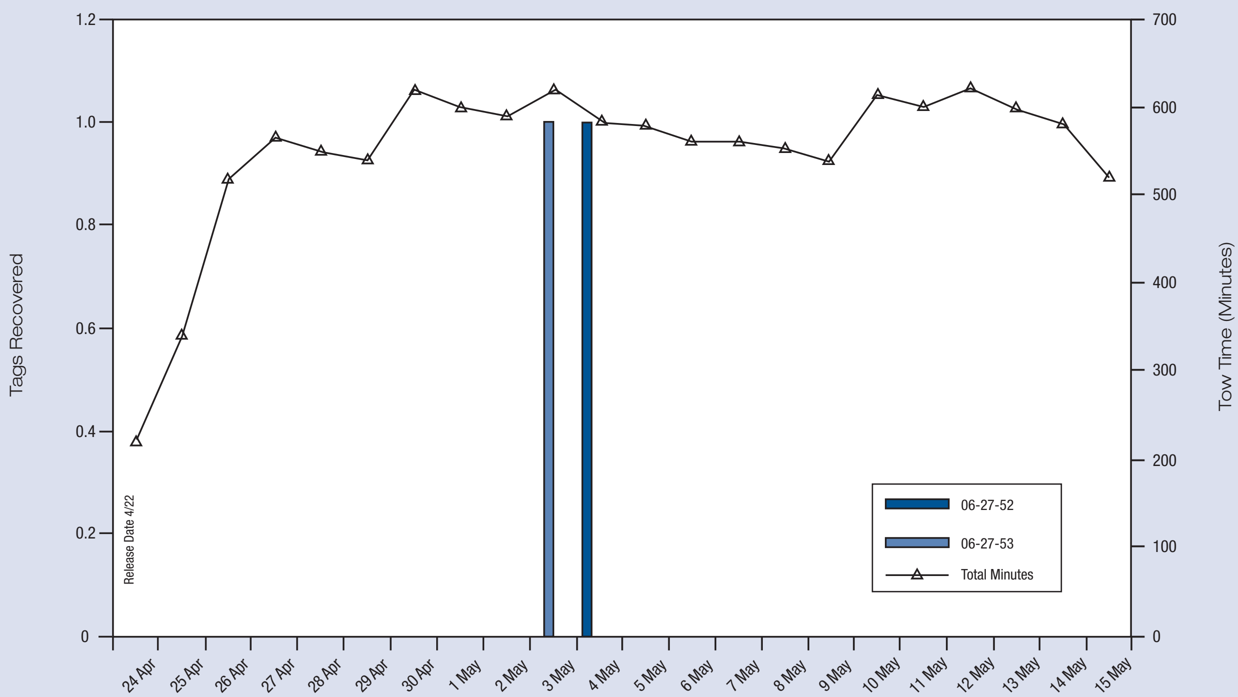


C-4. Coded Wire Tag Recovery Data

Chipps Island/Jersey Point I



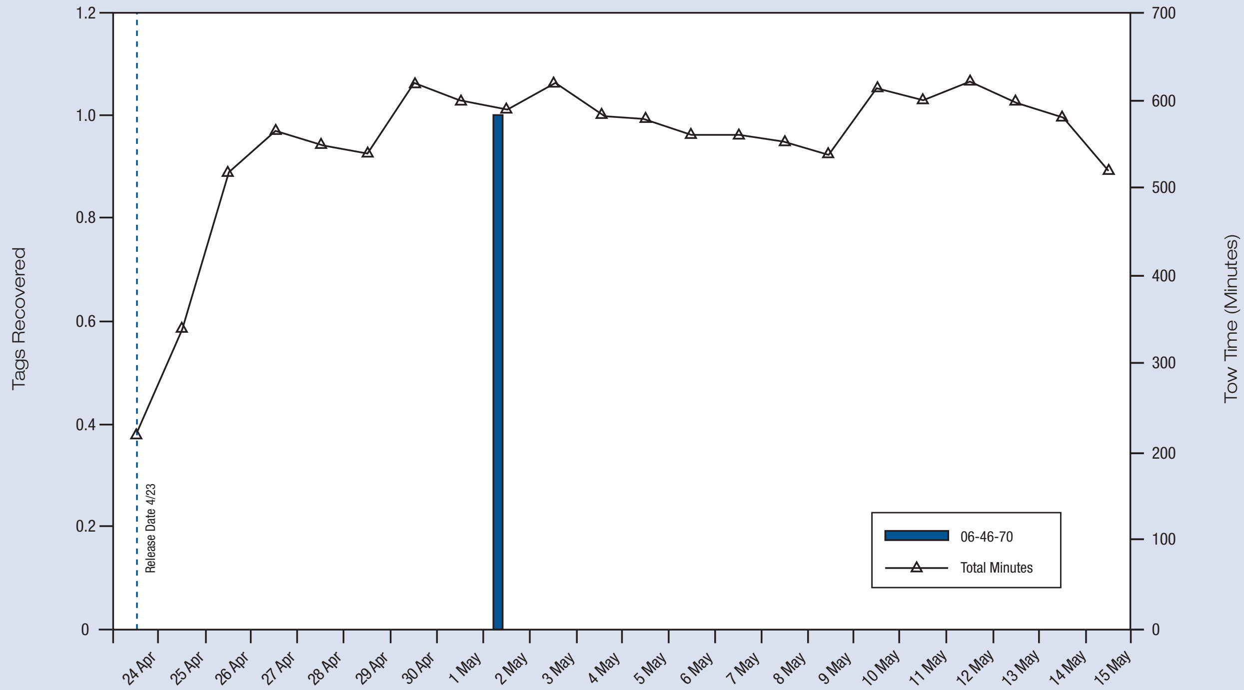
Antioch/Durham Ferry I



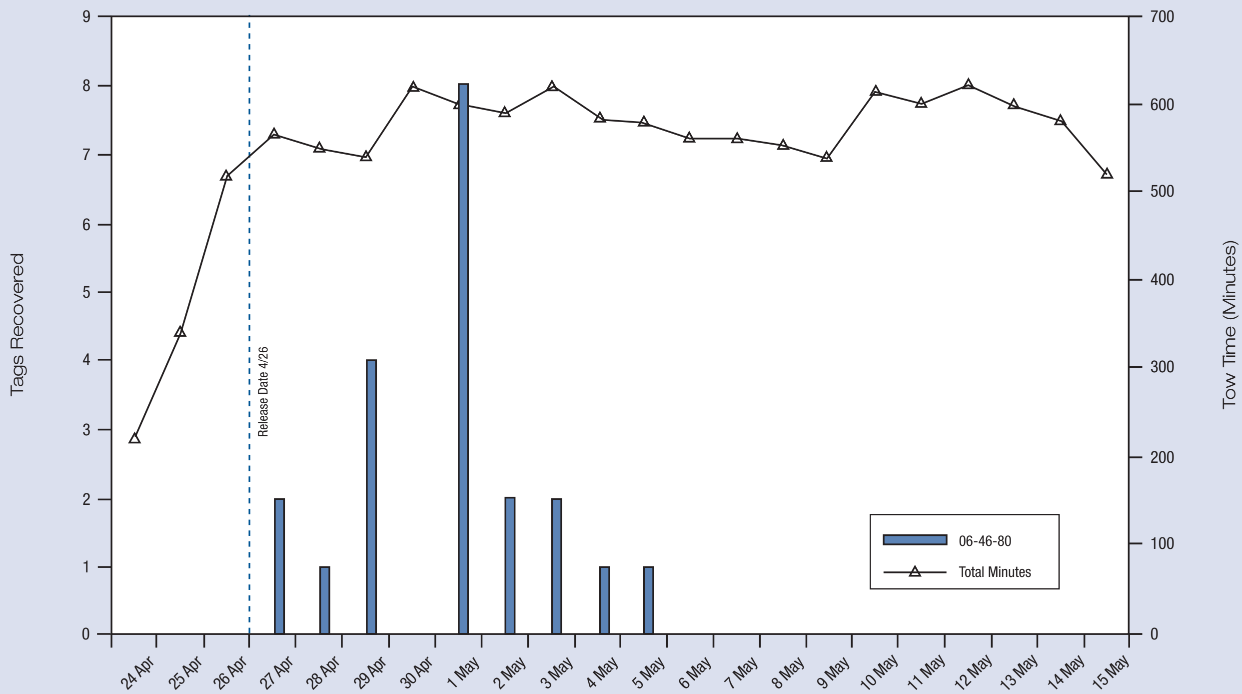
APPENDIX C

C–4. Coded Wire Tag Recovery Data

Antioch/Mossdale I



Antioch/Jersey Point I



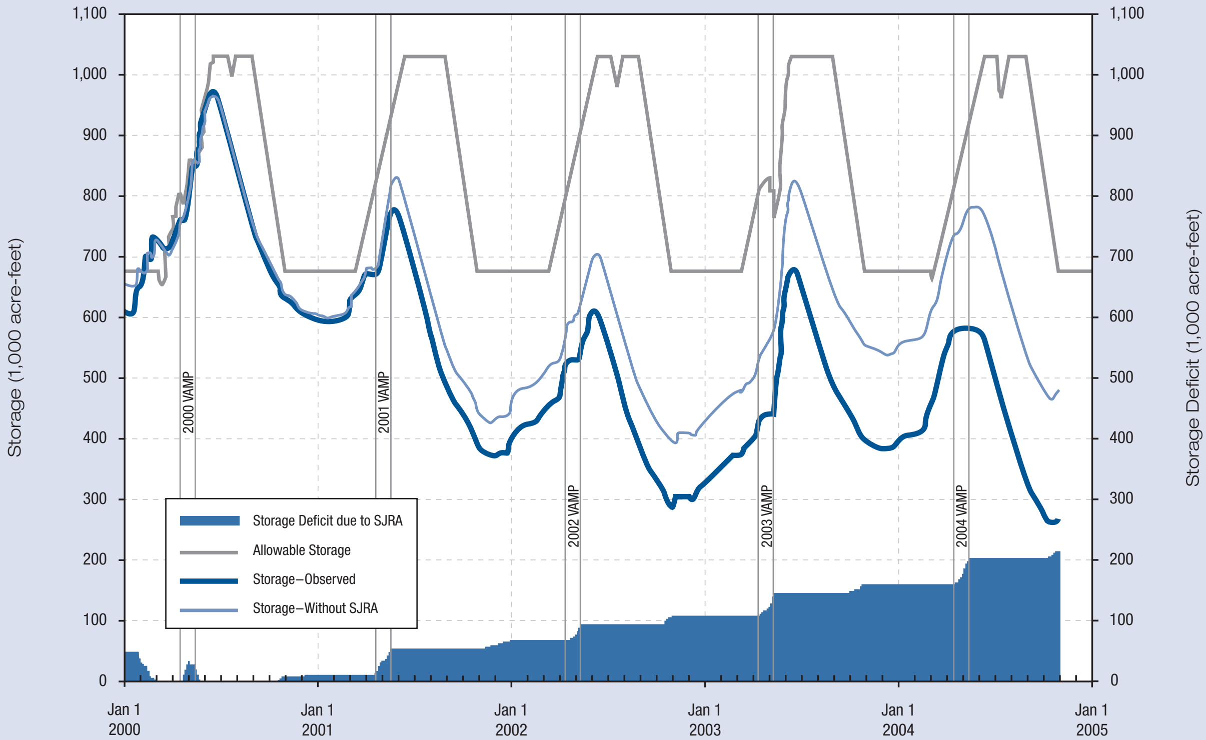
APPENDIX C

APPENDIX D

Historic Data

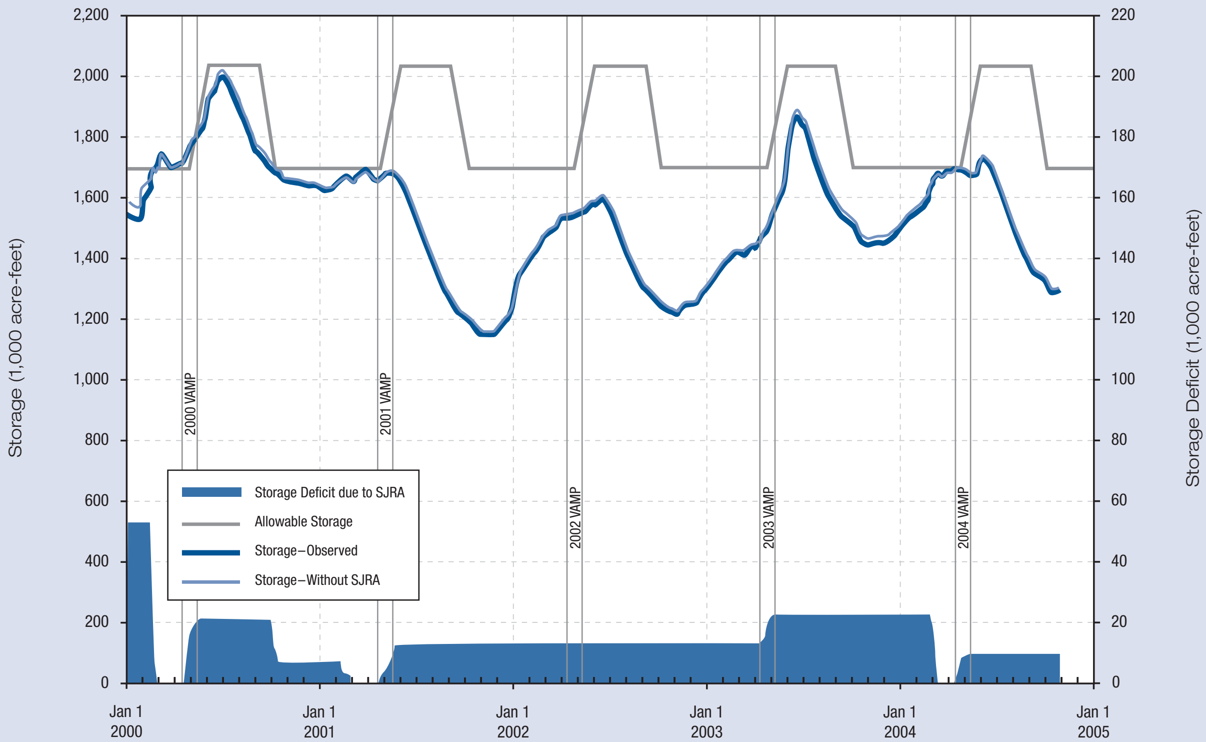
D-1. SJRA Storage Impacts, 2000–2004

Lake McClure (Merced River)



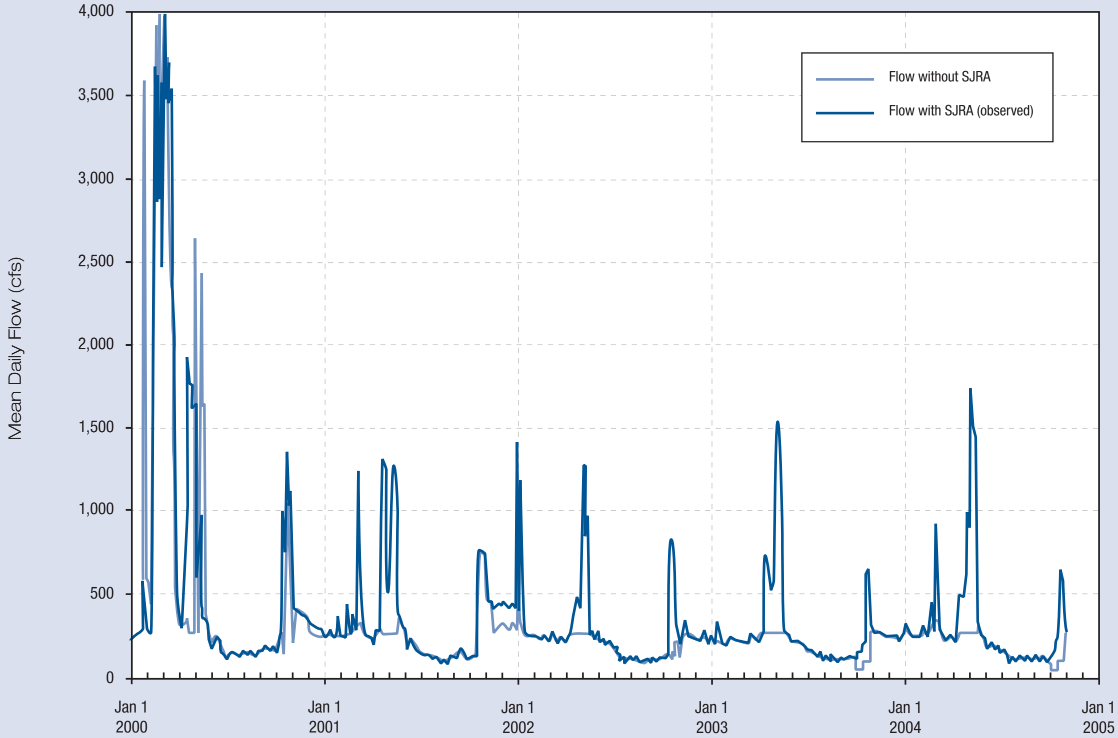
D-2. SJRA Storage Impacts, 2000–2004

New Don Pedro Reservoir (Tuolumne River)

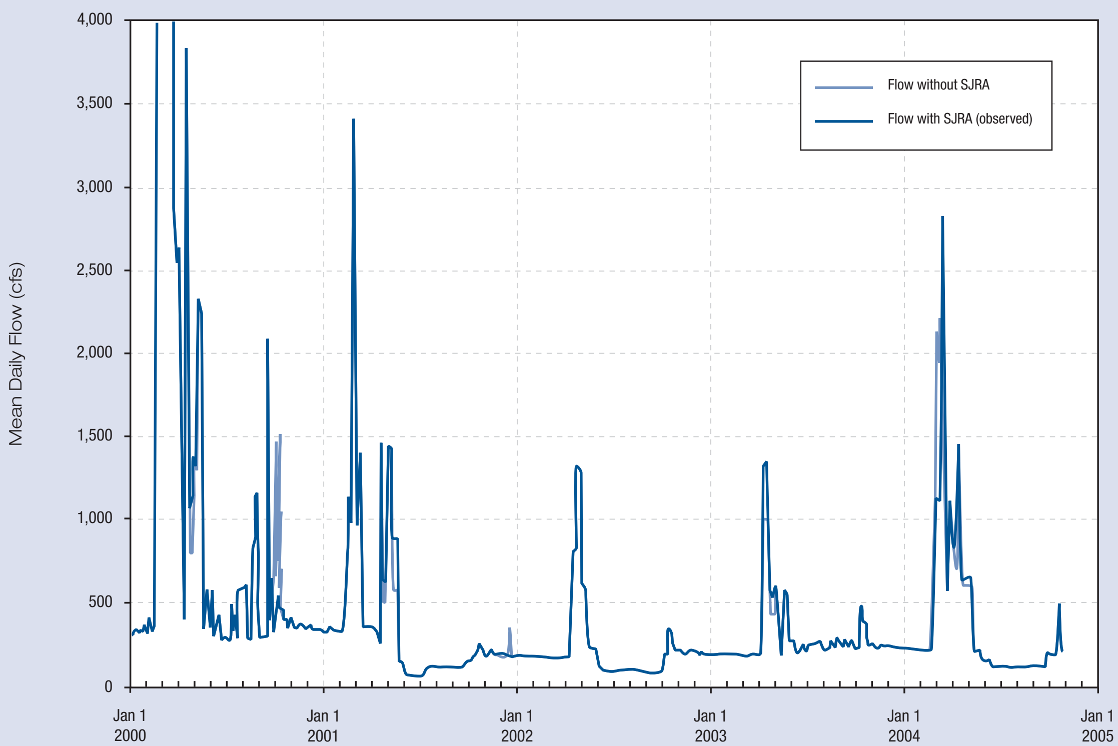


APPENDIX D

D-3. Merced River at Cressey, 2000–2004



D-4. Tuolumne River below LaGrange Dam, 2000–2004



APPENDIX D-5

2004 Vernalis Adaptive Management Plan (VAMP)

Comparison of Supplemental Water Contributions • Forecasted vs. Actual

A = Low Target B = High Target

			EXISTING FLOW					VERNALIS					DIFFERENCE
Year	Operation Plan Date	Merced River	Tuolumne River	Stanislaus River	SJR up-stream of Merced R	Ungaged Flow at Vernalis	SJR at Vernalis	VAMP Target Flow	VAMP Forecast Flow	Observed Flow	VAMP Suppl. Flow	VAMP Suppl. Water Vol.	Suppl. Water Deviation: Decision Forecast to Actual
		(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	TAF	TAF
2004	Mar 17 A	250	694	681	255	300	2,185	3,200	3,200		1,015	62,400	
	B	250	1,000	1,191	538	800	3,779	4,450	4,450		671	41,280	
	Mar 30 A	250	650	681	255	300	2,135	3,200	3,200		1,065	65,460	
	B	250	1,000	1,191	538	800	3,778	4,450	4,450		671	41,280	
	Apr 9	250	702	647	254	500	2,352	3,200	3,200		847	52,070	
1/	Apr 13	250	700	647	254	500	2,352	3,200	3,199		847	52,170	
	Apr 20	250	700	647	252	365	2,213	3,200	3,186		972	59,780	
	May 3	250	700	647	260	281	2,137	3,200	3,172		1,035	63,620	
Final Acct.	Real-time	250	702	647	283	174	2,048	3,200		3,155	1,108	68,120	
	Provisional 2/	250	702	647	362	127	2,088	3,200		3,155	1,067	65,591	13,421
2003	Mar 12 A	250	467	750	304	300	2,071	3,200	3,201		1,130	69,480	
	B	250	732	924	472	600	2,978	3,200	3,200		222	13,670	
	Mar 26 A	250	730	750	248	300	2,278	3,200	3,200		922	56,710	
	B	250	730	924	435	500	2,839	3,200	3,200		361	22,210	
	Apr 4	250	730	750	435	400	2,565	3,200	3,200		635	39,060	
1/	Apr 9	250	652	750	388	300	2,340	3,200	3,200		860	52,900	
	Apr 22	250	652	750	360	319	2,331	3,200	3,199		868	53,340	
	Apr 30	250	652	750	339	331	2,322	3,200	3,189		884	54,350	
Final Acct.	Real-time	250	652	750	283	370	2,304	3,200		3,235	930	57,200	
	Provisional 2/	250	652	750	276	362	2,290	3,200		3,235	945	58,065	5,165
2002	Mar 13 A	250	650	654	201	400	2,154	3,200	3,200		1,046	64,300	
	B	250	851	798	435	800	3,133	3,200	3,200		67	4,120	
	Mar 22 A	250	945	654	201	400	2,449	3,200	3,200		751	46,160	
	B	250	945	654	435	600	2,883	3,200	3,200		317	19,470	
	Mar 28 A	250	945	735	201	400	2,531	3,200	3,200		669	41,160	
	B	250	945	1,295	435	600	3,525	4,450	4,450		925	56,910	
	Apr 8	250	945	999	248	400	2,842	3,200	3,200		358	22,040	
1/	Apr 9	250	845	999	248	400	2,742	3,200	3,200		459	28,190	
	Apr 16	250	845	999	247	294	2,645	3,200	3,199		554	34,060	
	Apr 19	250	845	1,000	245	283	2,623	3,200	3,200		577	35,470	
	Apr 25	250	845	1,000	246	292	2,636	3,200	3,199		563	34,640	
	May 9	250	845	1,002	201	446	2,747	3,200	3,295		548	33,700	
Final Acct.	Real-time	250	848	1,002	210	434	2,744	3,200		3,298	555	34,100	
	Provisional 2/	250	852	1,002	230	424	2,757	3,200		3,301	544	33,430	5,240
2001	Mar 14 A	250	1,145	1,500	348	700	3,943	4,450	4,450		507	31,170	
	B	250	1,148	1,500	348	1,000	4,246	4,450	4,450		204	12,520	
	Mar 20 A	250	769	766	348	700	2,833	3,200	3,200		367	22,570	
	B	250	769	766	348	1,000	3,133	3,200	3,200		67	4,130	
	Mar 23	250	769	766	348	500	2,633	3,200	3,200		567	34,870	
	Apr 3 A	250	769	769	348	500	2,636	3,200	3,200		564	34,660	
	Apr 3 B	250	769	769	348	1,000	3,136	3,200	3,200		64	3,910	
	Apr 10 A	250	735	1,103	332	500	2,920	3,200	3,200		280	17,190	
	Apr 10 B	250	736	1,103	332	800	3,221	4,450	4,450		1,229	75,550	
	Apr 12	250	736	1,205	375	650	3,216	4,450	4,450		939	57,720	
1/	Apr 16	250	736	1,205	375	650	3,216	4,450	4,450		1,189	73,090	
	Apr 23	250	736	1,205	353	686	3,230	4,450	4,441		1,173	72,150	
	May 2	250	736	1,205	357	664	3,211	4,450	4,450		1,203	73,980	
	May 4	250	736	1,205	353	483	3,026	4,450	4,317		1,276	78,440	
	May 7	250	736	1,205	345	469	3,004	4,450	4,291		1,249	76,800	
	May 14	250	736	1,205	309	450	2,950	4,450	4,247		1,261	77,510	
Final Acct.	Real-time	250	736	1,205	311	417	2,918	4,450		4,224	1,276	78,470	
	Provisional 2/	250	736	1,205	350	368	2,909	4,450		4,224	1,308	78,650	5,560
2000	Mar 15	250	1,760	1,500	1,937	1,000	6,447	7,000	7,015		567	34,890	
	Mar 23	250	1,719	1,500	465	1,000	4,934	7,000	7,000		2,066	127,030	
	Mar 29	250	1,719	1,500	465	1,000	4,934	7,000	7,002		2,068	127,140	
	Apr 5	250	1,694	1,500	506	1,000	4,949	7,000	7,044		2,095	128,830	
	Apr 11	250	1,763	1,500	506	1,000	5,018	7,000	7,048		2,029	124,770	
1/	Apr 13	250	1,763	1,439	395	565	4,412	5,700	5,813		1,400	86,100	
	Apr 14	250	1,761	1,441	363	500	4,320	5,700	5,776		1,456	89,530	
	Apr 17	250	1,761	1,439	364	437	4,265	5,700	5,721		1,456	89,500	
Final Acct.	Real-time	264	1,706	1,506	375	902	4,754	5,700		5,940	1,279	78,660	
	Provisional 2/	299	1,706	1,515	496	784	4,800	5,700		5,869	1,263	77,680	-8,420

1/ Operation plan forecast prepared prior to start of VAMP approved by SJRA Management Committee.
2/ Final accounting of supplemental water contributions.

APPENDIX D-6

Summary of VAMP Flows 2000–2004

Year	VAMP Pulse Period	Target Vernalis/Export Flows	Observed Vernalis/Export Flows	VAMP Supplemental Water	Test Fish Released	Combined Differential Recovery Rate
		(cfs)	(cfs)	(acre-feet)	(effective number)	
2000	April 15–May 15	5,700/2,250	5,869/2,155	77,680	294,388	0.187
2001	April 20–May 20	4,450/1,500	4,224/1,420	78,650	336,085	0.191
2002	April 15–May 15	3,200/1,500	3,301/1,430	33,430	392,186	0.151
2003	April 15–May 15	3,200/1,500	3,235/1,446	58,065	297,266	0.019
2004	April 15–May 15	3,200/1,500	3,155/1,331	65,591	188,884	0.026

APPENDIX D-7

Head of Old River Barrier

	INSTALLATION			REMOVAL		
Year	Started	Closed	Completed	Started	Breached	Completed
1992	April 15–boat port on		April 23@4 ft April 26@6 ft May 1	Jun 2		Jun 8
1993						
1994	April 21–boat port on		April 23@10 ft May 1	May 18		May 20
1995			(a)			
1996	May 6		May 11	May 16		Sept 3 (b)
1997	April 9		April 16	May 15		May 19
1998	(a)					
1999	(a)					
2000	April 5		April 16	May 19		Jun 2
2001	April 17		April 26	May 23		May 30
2002	April 2		April 18	May 22	May 24	Jun 7
2003	April 1	April 15	April 21	May 16	May 18	Jun 3
2004	April 1	April 15	April 21			

(a) Not installed due to high San Joaquin River flows.

(b) Barrier was breached on 5/16 on an emergency basis, but complete removal wasn't done until 9/3, after Corps demanded permit compliance of complete removal.

APPENDIX D-8

2004 Vernalis Adaptive Management Plan (VAMP)

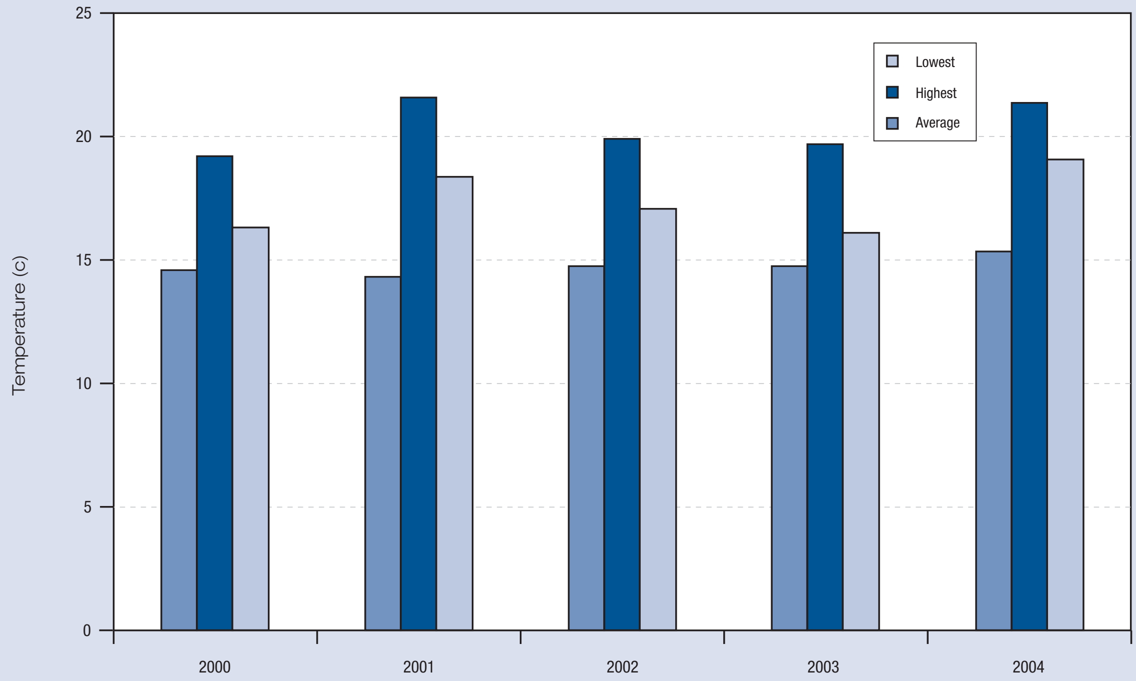
Comparison of Water Temperatures (°C) Measured During the VAMP Sampling Period • April 16–May 16*

Year	Durham Ferry	Mossdale	Dos Reyes	DWR Monitoring Station	Confluence Top	Confluence bottom	Dwnstrm of Channel Mkr. 30	Dwnstrm of Channel Mkr. 13	Dwnstrm of Channel Mkr. 36	Jersey Point	Chipps Island	Mokelumne River	Average All Sites
2000*													
Lowest	13.07	13.32	logger	13.48	logger	13.97	14.65	15.22	15.97	logger	15.19	14.83	14.41
Highest	18.92	19.03	lost	19.04	dewatered	19.06	20.43	19.37	18.69	dewatered	18.54	18.82	19.10
Average	16.29	16.55		16.63		16.73	17.27	17.36	17.25		16.66	16.57	16.81
2001**													
Lowest	13.07	13.66	14.44	14.32	14.62	14.71	15.07	12.45	14.83	14.45	logger	no logger	14.16
Highest	21.87	22.32	21.85	22.04	22.52	21.63	23.33	22.91	21.93	21.34	lost	placed	22.17
Average	18.11	18.55	18.66	18.75	18.91	18.77	18.95	18.97	18.28	18.17			18.61
2002													
Lowest	13.08	13.33	14.21	14.21	14.39	14.79	15.22	16.18	15.70	15.35	14.41	15.35	14.69
Highest	20.05	20.15	19.79	20.27	20.33	19.91	20.99	20.52	19.38	18.70	19.03	19.84	19.91
Average	16.69	16.98	17.17	17.25	17.41	17.42	17.52	17.77	17.06	16.80	16.39	17.06	17.13
2003													
Lowest	14.31	14.67	15.43	15.07	logger	15.07	15.38	15.38	14.67	logger	13.81	13.20	14.70
Highest	21.03	20.93	20.73	21.02	dewatered	20.03	20.18	20.04	17.85	lost	17.43	17.93	19.72
Average	16.64	16.83	16.98	16.88		16.86	17.06	16.83	15.71		15.22	14.98	16.40
2004													
Lowest	14.60	14.83	15.59	15.52	logger	15.85	16.48	16.48	15.49	14.90	14.55	logger	15.43
Highest	22.01	22.09	21.89	22.32	dewatered	22.49	23.34	22.49	21.61	20.50	20.31	malfunction	21.91
Average	18.65	18.93	19.15	19.13		19.41	19.83	19.67	18.47	18.12	17.74		18.91

* 2000 Chipps Island temperature data begins April 17
** 2001 all temperature data begins April 20

APPENDIX D

D-8a. Comparison of Average Temperatures at All Sites during VAMP April 16–May 16, 2000–2004



APPENDIX D

APPENDIX E

Errata

ERRATA FOR THE YEAR 2003 ANNUAL TECHNICAL REPORT

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

Page 44:

Survival indices using Antioch recoveries for the 06-27-44 Jersey Point group should be changed to 0.525 and the 06-27-51 group should be changed to 0.256.

Page 56:

The group survival index using Antioch recoveries should be changed for the Hatfield State Park group released on 4/16/03 to 0.031.

2003 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

January 2004

TABLE OF CONTENTS

EXECUTIVE SUMMARY . . . 3

CHAPTER 1:

Introduction . . . 7

Experimental Design Elements . . . 7

CHAPTER 2:

VAMP Hydrologic Planning & Implementation . . . 9

VAMP flow and SWP/CVP Exports . . . 9

Hydrologic Planning . . . 10

Implementation . . . 12

Results of Operations . . . 15

CHAPTER 3:

Additional Water Supply Arrangements & Deliveries . . . 20

Merced Irrigation District . . . 20

Oakdale Irrigation District . . . 20

CHAPTER 4:

Head of Old River Barrier . . . 22

Barrier Design, Installation and Operation . . . 22

Materials and Methods . . . 29

Results . . . 31

Discussion . . . 34

CHAPTER 5:

Salmon Smolt Survival Investigations . . . 37

Coded-Wire Tagging . . . 37

Coded-Wire Tag Releases . . . 37

Water Temperature Monitoring . . . 39

Post-Release Net Pen Studies . . . 41

Coded-Wire Tag Recovery Efforts . . . 44

VAMP Chinook Salmon CWT Survival . . . 46

Transit Time . . . 50

Comparison with Past Years . . . 51

Ocean Recovery Information from Past Years . . . 57

San Joaquin River Salmon Protection . . . 60

Summary & Recommendations . . . 66

CHAPTER 6:

Complimentary Studies Related to the VAMP . . . 72

Survival Estimates for the Tributaries . . . 72

Evaluation of Chinook Salmon Fry Survival . . . 72

Radio Tagging Studies in the Lower River . . . 77

CHAPTER 7:

Conclusions & Recommendations . . . 82

References Cited . . . 84

Contributing Authors . . . 85

Signatories to the San Joaquin River Agreement . . . 86

Useful Web Pages . . . 87

Acronyms & Abbreviations . . . 88

APPENDICES . . . 89

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). Using a consensus-based approach, the SJRA united a large and diverse group of agricultural, urban, environmental and governmental interests.

The 2003 Annual Technical Report comprises the consolidated annual SJRA Operations Report and Vernalis Adaptive Management Plan (VAMP) Monitoring Report. The VAMP 2003 program represents the fourth 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 VAMP program. Specifically, this report includes the following information on the implementation of the SJRA: the hydrologic chronicle; management of the additional SJRA water; installation, operation, and monitoring of the Head of Old River Barrier (HORB); results of the juvenile Chinook salmon smolt survival investigations; discussion of complementary investigations; and, conclusions and recommendations. Condition 4.b of D-1641 directs the Department of Water Resources (DWR) and the U.S. Bureau of Reclamation (USBR) to send the Executive Director of the State Board the results of the fishery monitoring studies on an annual basis and Condition 7 of D-1641 directs Merced, Modesto, Turlock, South San Joaquin and Oakdale irrigation districts to submit a report detailing district operations as a result of the SJRA. By letter dated September 8, 2000, the SWRCB approved combining these two reports into a single comprehensive report due the SWRCB on January 31 of each year.

The 2003 Annual Technical Report comprises the consolidated annual SJRA Operations Report and Vernalis Adaptive Management Plan (VAMP) Monitoring Report.

A key part of this landmark agreement is the VAMP. VAMP is designed to protect juvenile Chinook salmon migrating from the San Joaquin River through the Sacramento—San Joaquin Delta. VAMP is also a scientifically recognized 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 HORB.

VAMP employs an adaptive management strategy to use current knowledge of hydrology and environmental conditions to protect Chinook salmon smolt passage, while gathering information to allow more efficient protection in the future. In addition to providing improved protection for juvenile Chinook salmon emigrating from the San Joaquin River system, specific experimental objectives of VAMP 2003 included:

- Quantification of Chinook salmon smolt survival from Durham Ferry and Mossdale to Jersey Point using recapture locations at Antioch and Chipps Island, under conditions of a San Joaquin River flow at Vernalis of 3,200 cfs, with an installed HORB, and SWP/CVP export rates of 1,500 cfs; and
- Comparison of juvenile Chinook salmon survival between Durham Ferry and Mossdale for use in comparing results of VAMP 2003 with results from earlier survival studies where coded-wire tagged salmon releases occurred at Mossdale.

See Useful Web Pages

The VAMP 2002 Annual Technical Report presented a series of conclusions and recommended modifications to the VAMP experimental design and/or program implementation. The 2002 recommendations were used, in part, as the basis for developing the 2003 VAMP test program. For example, the 2002 report recommended weekly measurements of San Joaquin River flow at the Vernalis gage, continued hydrology investigations to estimate ungaged flows (accretions, depletions) to improve hydrologic predictions, and continued coordination among tributary operators to facilitate implementation of the VAMP test flow conditions. As part of the 2003 program, the hydrology technical committee, working in cooperation with tributary operators and USGS, was able to improve our understanding of San Joaquin River hydrology, provide measurements of Vernalis flow, and provide effective coordination of releases from upstream tributaries. The 2002 report also recommended modifications to the Head of Old River Barrier (HORB) and entrainment monitoring program including a delay in salmon releases at Durham Ferry and Mossdale for approximately five days after barrier closure to allow time for gravel and rock to flush from the culverts and improve fishery sampling, measure flows within the culverts, continue monitoring to evaluate potential impacts of seepage, monitor fish entrainment at the culverts, and improve the experimental design of Head of Old River Barrier investigations. These recommendations were addressed as part of the 2003 VAMP program through delayed salmon releases at Durham Ferry and Mossdale after barrier closure, continued water level monitoring to refine the operational criteria for the culverts and evaluate potential seepage through groundwater well monitoring, and improved fisheries monitoring at the culverts to provide information on the percentage of VAMP CWT salmon released at Mossdale and Durham Ferry, in addition to unmarked salmon, subsequently entrained into the barrier culverts. The Department of Water Resources (DWR) was successful in securing all of the necessary permits and approvals for the installation of the Head of Old River Barrier over the next five years. However, landowner access remains to be negotiated annually.

A quality assurance/quality control program has been used as a routine part of VAMP tests. The 2003 CWT tagging at the Merced River Fish Facility included information useful in quantifying CWT retention and tag efficiency. During the 2003 program, coordination with the local landowner was continued to curtail operation of an agricultural diversion pump located immediately downstream of Durham Ferry, coincident with each of the two releases. In addition, the 2003 VAMP program continued use of the net pen studies and a fish health assessment to determine the health and survival of test fish released as part of VAMP. Additional measurements are needed of flow passing through the Head of Old River Barrier culverts and in the San Joaquin River downstream of the confluence with Old River. In the future measurements of San Joaquin River flow downstream of the Old River Barrier will be used in the relationship between San Joaquin River flow and juvenile Chinook salmon survival. Additional complimentary studies, including survival studies for juvenile Chinook salmon emigrating from San Joaquin River tributaries, were incorporated into the 2003 VAMP investigations.

Recommendations from the 2002 VAMP program were used to improve the overall experimental design and implementation of the 2003 VAMP investigations.

The estimated survival of CWT salmon released from Durham Ferry and Mossdale was the lowest measured to date and the lowest since initiation of the VAMP. An elevated percentage of Proliferative Kidney Disease when combined with low flow conditions may have contributed to an increase in mortality but it is uncertain based on only the 2003 data. The 2002 report recommended that, to the extent possible, VAMP survival testing be conducted at flow and export extremes to improve the ability of the program to detect differences in juvenile Chinook salmon survival among target flow and export conditions. Hydrologic conditions within the San Joaquin River watershed did not provide conditions suitable for testing extreme target conditions as part of the VAMP 2003 program. These and other recommendations from the 2002 VAMP program were used to improve the overall experimental design and implementation of the 2003 VAMP investigations. Recommendations made based upon analyses of the VAMP 2003 program will also be used, in a similar way, by the hydrology and fisheries technical committees in developing and implementing the experimental design for the 2004 VAMP studies.

Based on data gathered during the experimental mark-recapture studies that occurred over a 31-day period in April and May 2003, a set of conclusions and recommendations has been developed. These conclusions and recommendations provide guidance and a foundation for design and implementation of future VAMP operations. Key conclusions and recommendations derived from VAMP 2003 include:

- VAMP 2003 is the fourth year of full implementation of the program. Average Vernalis flow during the VAMP period was 3,235 cfs. SWP and CVP export rates averaged 1,446 cfs. The VAMP period was between April 15 and May 15, 2003.
- Recovery rates of the Durham Ferry and Mossdale groups relative to the Jersey Point groups using recaptures at Antioch and Chipps Island indicated that there was no statistical ($p > 0.05$) difference between the two replicates or release locations in 2003. The number of CWT salmon recovered from the second set of release groups, however, was lower than recoveries from the first release groups with no recoveries made for the second Durham Ferry release group at either Antioch or Chipps Island. The second set of release groups was found to have a significantly higher incidence of PKD infection, than the first set of releases.
- The combined differential recovery rate of CWT salmon recovered from Durham Ferry and Mossdale groups relative to the Jersey Point groups showed that the relative survival in 2003 was significantly lower than survival results from the 2002 VAMP although flow and export conditions (target flow 3200 cfs and exports of 1500 cfs in both years) were comparable for the two years. The factors contributing to the significantly lower survival in 2003 are unknown, although may be related to the combined effects of PKD infection and the lower flows.
- The relationships between salmon survival, Vernalis flow, and SWP/CVP exports are no longer statistically significant.
- Streamflow data at Vernalis were improved by weekly flow measurements and rating curve verification, however estimation of ungaged flow (accretions and depletions) requires further investigation for use in establishing annual VAMP target flows. Alternative methods of measuring flow at Vernalis and/or alternative measurement locations should also be investigated. DWR installed a stage recorder and fixed acoustic Doppler velocity meter in the San Joaquin River downstream of the confluence with Old River for use in measuring river flow. The monitoring station is being calibrated and is anticipated to be available for flow measurements associated with the VAMP 2004 studies.
- The design, construction, and operation of the HORB were successful in 2003. Salmon releases at Durham Ferry and Mossdale were delayed approximately five days after HORB closure to allow time for gravel and rock to flush from the culverts and to assure the safety of personnel conducting fisheries sampling at the site. Operation of the HORB with three culverts open was successful in maintaining south Delta water levels.
- The index of salmon entrainment at the HORB in 2003 with three culverts open was substantially greater then in 2001 and 2002 with all six culverts open.
- Construction of multiple barriers within the south Delta during the spring has the potential to delay completion of the construction of HORB, which may contribute to exposure of juvenile Chinook salmon to elevated water temperatures. Due to the high risk of losing major salmon protection benefits and biasing experimental conditions, it is strongly recommended that construction of the HORB be completed on schedule to avoid delays in implementing survival investigations. The report also recommends that flow measurements be made to document flow through HORB culverts and the resultant flow within the San Joaquin River downstream of the confluence with Old River.
- The variability inherent in measuring salmon smolt survival in the lower San Joaquin River and Delta makes it difficult to detect statistically significant differences in salmon survival between VAMP flow and export target conditions, which are relatively similar. It is strongly recommended that, conditions be tested at 7000 cfs flow and 1500 cfs export to improve ability to detect potential differences in salmon smolt survival among test conditions.

- Approximately 80 percent of the unmarked salmon migrating past Mossdale in 2003 migrated during the VAMP period (April 15 through May 15) and were, therefore protected by increased San Joaquin River flow, installation of the HORB and decreased export pumping.
- The selection and management of VAMP flow conditions should, if possible, minimize or avoid requiring upstream tributary flows that adversely affect potential habitat quality or survival of natural salmon produced within the tributaries. It is therefore recommended that upstream tributary and VAMP studies be coordinated as much as possible. Coordination during 2003 with upstream tributary operations was successful and coordination among tributary operators should continue in the future.
- The report encourages expansion of complementary studies to provide additional information on factors and mechanisms affecting salmon survival during migration from the lower San Joaquin River through the delta.
- Past data indicates that survival improves as flows increase and flows relative to exports increase. With the addition of the 2003 data the relationships between salmon survival rates and Vernalis flow and flow relative to SWP/CVP export conditions are no longer statistically significant. The VAMP program provides improved protection for juvenile salmon when compared to "pre-VAMP" conditions. Further tests, over a wider range of flow and export conditions, are needed to evaluate the respective roles of San Joaquin River flow and SWP/CVP exports on juvenile Chinook salmon smolt survival. The report recommends that the VAMP experimental test program be continued.

The relationships between salmon survival rates and Vernalis flow and flow relative to SWP/CVP export conditions are no longer statistically significant. The VAMP program provides improved protection for juvenile salmon when compared to "pre-VAMP" conditions. The report recommends that the VAMP experimental test program be continued.

CHAPTER 1

Introduction

Actions associated with the Vernalis Adaptive Management Plan (VAMP) were implemented between April 15 and May 15, 2003 to protect juvenile Chinook salmon and evaluate the relationship between San Joaquin River flow and State Water Project (SWP) and federal Central Valley Project (CVP) water project exports on the survival of marked juvenile Chinook salmon migrating through the Sacramento-San Joaquin Delta. Studies conducted in 2003, represent the fourth year of the VAMP experiment. Results from previous VAMP experiments are available in San Joaquin River Agreement 2000 Technical Report and San Joaquin River Group Authority, Technical Reports 2001 and 2002. Similar experiments were conducted prior to the official implementation of VAMP with results available in South Delta Temporary Barriers Annual Reports (DWR, 2001, 1999, 1998). This report will describe the experimental design of VAMP, the hydrologic planning and implementation, the additional water supply arrangements and deliveries, the Head of Old River Barrier (HORB) design, installation, operation and fisheries monitoring, the smolt survival investigation and complimentary studies related to VAMP. Conclusions and Recommendations for future VAMP studies are also included.

EXPERIMENTAL DESIGN ELEMENTS

The VAMP experimental design measures 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 mid-April to mid-May juvenile salmon outmigration period that provide estimates of salmon survival under each set of conditions. Chinook salmon survival indices under each of the experimental conditions are then calculated based on the numbers of marked salmon released and the number recaptured. Absolute survival estimates and combined differential recovery rates were also calculated and used in relationships between survival and San Joaquin River flow and CVP and SWP exports.

The VAMP 2003 experimental design included both multiple release locations (Durham Ferry, Mossdale, and Jersey Point), and multiple recapture locations (Antioch, Chipps Island, SWP and CVP salvage operations, and in the ocean fisheries; Figure 1-1). Two sets of releases were made at Durham Ferry, Mossdale, and Jersey Point. The use of data from multiple release and recapture locations allows for a more thorough evaluation of juvenile Chinook salmon survival as compared to recapture data from only one sampling location and/or one series of releases. The VAMP coded-wire tag (CWT) releases (Durham Ferry, Mossdale, and Jersey Point) and recapture locations (Antioch and Chipps Island) are consistent from one year to the next, providing a greater opportunity to assess salmon smolt survival over the range of Vernalis flows, SWP/CVP exports, and with and without the presence of the Head of Old River Barrier (HORB). Releases at Jersey Point serve as controls for recaptures at Antioch and Chipps Island, thereby allowing the calculation of survival estimates based on the ratio of survival indices from marked salmon recaptured from upstream (e.g., Durham Ferry and Mossdale) and downstream (control release at Jersey Point) releases. The combined differential recovery rates are calculated in a similar manner. The use of ratio estimates as part of the VAMP study design factors out the potential differential gear efficiency at Antioch and Chipps Island within and among years.

The added recovery numbers from recapturing marked fish at both Antioch and Chipps Island improves the precision associated with the individual survival estimates, and improves confidence in detecting differences in salmon smolt survival as a function of Vernalis flows and SWP/CVP exports.

A quality assurance/quality control program has been used as a routine part of VAMP tests, and includes quantifying the number of marked fish successfully clipped and tagged. Coordination with the local landowner to curtail operation of an agricultural diversion pump located immediately downstream of Durham Ferry, coincident with each of the two Durham Ferry releases was continued in 2003. In addition, the 2003 VAMP program continued use of the net pen studies and physiological testing to assess overall condition and health of marked fish used in VAMP experiments. Additional improvements are needed relative to measuring and reporting flow in San Joaquin River downstream of the confluence with Old River. Measurements of San Joaquin River flow downstream of the HORB will be used to evaluate the relationship between San Joaquin River flow and juvenile Chinook salmon survival in the future.

FIGURE 1–1

Sacramento—San Joaquin Estuary

Location of VAMP 2003 Release Sites (Durham Ferry, Mossdale and Jersey Point), Recovery Locations (Antioch and Chipps Island), and Head of Old River Barrier Location Within the Sacramento-San Joaquin River Delta/Estuary.

CHAPTER 2

VAMP Hydrologic Planning & Implementation

This section documents the planning and implementation undertaken by the Hydrology Group of the San Joaquin River Technical Committee (SJRTC) for the 2003 VAMP investigations. Implementation of VAMP is guided by the framework provided in the San Joaquin River Agreement (SJRA) and anticipated hydrologic conditions within the watershed.

The Hydrology Group 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 2003, the agencies belonging to the Hydrology Group included: Merced Irrigation District (Merced), Turlock Irrigation District (TID), Modesto Irrigation District (MID), Oakdale Irrigation District (OID), South San Joaquin Irrigation District (SSJID), San Joaquin River Exchange Contractors Water Authority (SJREC), 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 installation of the HORB and the planning of Delta exports consistent with the VAMP.

VAMP FLOW AND SWP/CVP EXPORTS

The VAMP provides for a 31-day pulse flow (target flow) in the San Joaquin River at the Vernalis gage during the months of April and May, along with a corresponding reduction in SWP/CVP exports, as shown in Table 2-1. The magnitude of the pulse flow is based on flow that would occur during the pulse period absent the VAMP, referred to as the existing flow.

As part of the development of the VAMP experimental design, the VAMP Hydrology and Biology Groups jointly 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 VAMP Hydrology and Biology Groups 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 technical committees 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

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	

The ability to manage and regulate San Joaquin River flows is difficult due to variation in unregulated flows, uncertainty 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 technical committees 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 joint Hydrology and Biology Groups agreed to a target range variation of plus or minus 7% of the Vernalis flow target. It was recognized by the Hydrology and Biology Groups that these guidelines were not absolute conditions, but was to be used by the VAMP hydrology and biology workgroups to evaluate experimental test conditions and the potential effect of flow and export variation on our ability to detect and assess variation in juvenile Chinook salmon survival rates among VAMP test conditions.

Under the SJRA, the following SJRGA agencies have agreed to provide the supplemental water, limited to a maximum of 110,000 acre-feet, needed to achieve the VAMP target flows shown in Table 2-1: Merced, OID, SSJID, SJREC, MID and TID.

The 2,000 cubic feet per second (cfs) VAMP target flow shown in Table 2-1 does not represent a VAMP experiment data point but is used to define the supplemental water volume to be provided by the SJRGA agencies in critically dry years 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 2000 cfs, the USBR, in accordance with the SJRA, shall act to purchase additional water from willing sellers to fulfill the requirements of existing biological opinions.

Based upon hydrologic conditions, the target flow in a given year could either be increased to the next highest value ("double-step") or the supplemental water requirement could be eliminated entirely. A numerical procedure has been established in the SJRA to determine the target flow. The SWRCB San Joaquin Valley Water Year Hydrologic Classification ("60-20-20" classification) is given a numerical indicator as shown in Table 2-2.

TABLE 2–2
San Joaquin Valley Water Year Hydrologic Classifications Used in VAMP

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

"Double-step" flow years occur when the sum of last year's numerical indicator and the 90 percent exceedence forecast of the current year's numerical indicator is seven (7) or greater.

If the sum of the two previous years' numerical indicators and the 90 percent exceedence forecast of the current year's numerical indicator is four (4) or less, indicative of an extended dry period, no VAMP supplemental water will be provided. The USBR, however, has a continuing obligation to meet San Joaquin River flows pursuant to the March 6, 1995 Delta smelt Biological Opinion.

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. Based on the targets outlined in Table 2-1, in a double-step year up to 157,000 acre-feet of supplemental water may be required. If the VAMP target flow requires more than 110,000 acre-feet of supplemental water, then additional water may be acquired on a willing seller basis.

HYDROLOGIC PLANNING

Hydrology Group Meetings

Beginning in February 2003, and continuing until early April, the Hydrology Group held four planning and coordination meetings (February 19, March 12, March 26 and April 9). At these meetings, forecasts of hydrologic and operational conditions on the San Joaquin River and its tributaries were discussed and refined.

Monthly Operation Forecasts

As part of the early planning efforts, monthly operation forecasts were developed by the Hydrology Group to estimate the existing flow at Vernalis. Inflows to the tributary reservoirs used in these forecasts were based on DWR Bulletin 120 runoff forecasts. The monthly operation forecasts used the 90 percent and 50 percent probability of exceedence runoff forecasts. The initial monthly operation forecast was presented at the February 19 Hydrology Group meeting. The 90 percent exceedence forecast called for a VAMP target flow of 3,200 cfs and the 50 percent exceedence forecast called for a VAMP target flow of 5,700 cfs. Hydrologic projections and planning were subsequently refined as additional information became available in March and April.

Daily Operation Plan

Starting in mid-March, the Hydrology Group began development of a daily operation plan, updating it as hydrologic conditions and operational requirements changed. The daily operation plan calculated an estimated mean daily flow at Vernalis based on estimates 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 major tributaries. The following key assumptions were used in the development of the daily operation plan:

(1) The travel times for flows from the tributary control points and upper San Joaquin River to the Vernalis gauge are assumed as follows:

a. Merced River at Cressey to Vernalis	3 days
b. San Joaquin River above Merced River to Vernalis	2 days
c. Tuolumne River at LaGrange to Vernalis	2 days
d. Stanislaus River below Goodwin Dam to Vernalis	2 days

(2) Based upon a review of the historical flow record, the ungaged flow at Vernalis was assumed to be constant throughout the VAMP period and based upon the value entering the period. By definition, the ungaged flow is the unmeasured flow entering the system between Vernalis and the upstream measuring points and is calculated as follows:

Vernalis Ungauged =

VNS – GDWlag – LGNlag – CRSlag – USJRlag

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 gauged flow but is the calculated difference between the gauged flows at the San Joaquin River at Newman (NEW) and the Merced River near Stevinson (MST)).

By definition, the VAMP 31-day pulse flow period can occur anytime between April 1 and May 31. Factors needed to be considered in determining the timing of the VAMP period include installation of the HORB, availability of juvenile salmon at the hatchery, and manpower and equipment availability for salmon releases and recapture. Until a specific start date is defined, a default target flow period of April 15 to May 15 is used for the VAMP operation planning. The current installation and operational constraints for the HORB are described in Chapter 4.

The previous two years, 2001 and 2002, were both classified as "dry" years using the 60-20-20 water year classification, giving each a VAMP numerical indicator of two. Therefore, there was no possibility of 2003 being a dry period offramp year (numerical indicator of previous two plus current year total of 4 or less). Conversely, in order for 2003 to be a "double-step" year, 2003 would need to be classified as a "wet" year based on the 90 percent exceedence forecast as of April 1, with a VAMP numerical indicator of 5. The early 90% exceedence forecasts (Jan., Feb. and Mar.) were indicating a "dry" or "critical" year, making it very unlikely that 2003 would be a "double-step" year; therefore, planning efforts concentrated on the "single step" criteria. In fact, the 90% exceedence forecast on April 1 for the San Joaquin Valley was for a "critical" year, resulting in the 2003 VAMP following the "single step" criteria.

The initial Daily Operation Plan was prepared on March 12, and was modified as hydrologic conditions and operational requirements changed. Table 2-3 summarizes the various iterations of, and demonstrates the evolutionary nature of the daily operation plan. Copies of the daily operation plans are provided in Appendix A-1.

The SJRTC Biology Group was interested in setting a VAMP target flow start date earlier than April 15. DWR noted that due to regulatory and construction limitations it was highly unlikely that the HORB could be closed prior to April 15, but that it was on schedule for closure by April 15. Therefore the period of April 15 through May 15 was designated as the target flow period.

Normally, the USGS measures the flow at Vernalis to check the current rating shift on a monthly basis. The real-time flows reported by the USGS and CDEC are dependent on the most current rating shift, therefore a new measurement and 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 2 and May 7. The results of these measurements

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 operation is that the flows scheduled on the Merced, Tuolumne and Stanislaus Rivers to achieve this goal do not conflict with studies or flow requirements on the individual tributaries, and to the degree possible, provide benefits on the tributaries.

are summarized in Table 2-4. A shift was applied to the Vernalis rating curve as a result of the April 16 measurement, which indicated that the actual flow was approximately 150 cfs higher than what was being reported real-time (3,040 cfs actual flow verses 2,890 cfs reported flow). This shift did not result in any changes to the planned VAMP operation.

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 operation is that the flows scheduled on the Merced, Tuolumne and Stanislaus Rivers to achieve this goal do not conflict with studies or flow requirements on the individual tributaries, and to the degree possible, provide benefits on the tributaries. During the development of the daily operation plan, the Hydrology group consults with DFG and the tributary biological teams to determine periods of time when stable flows are desirable on the tributaries, what flow rates are desired, and what flow limitation exist, specifically in regards to ramping, minimum and maximum flows. The periods of desired stable flow are highlighted with bold outlines in the daily operation plans in Appendix A-1.

For the 2003 VAMP operation there were two periods of desired stable flow on the Merced River, one on the Stanislaus River, but none on the Tuolumne River. On the Merced River the desire was to have a period with a stable flow of about 500 cfs and a stable pulse flow in excess of 1000 cfs for a period of 8 to 9 days. On the Stanislaus River the desire was to have a pulse flow of 1500 cfs for as long a period as possible. The coordination of these desired flows resulted in an initial pulse in the Tuolumne River, followed by an eight day 1500 cfs pulse flow on the Stanislaus, which was followed by an eight day 1500 cfs pulse flow on the Merced River. Plots of the individual tributary flows are provided in Appendix A-3.

IMPLEMENTATION

Operation Conference Calls

During implementation of the VAMP pulse flow, conference calls were conducted on a regular basis among members of the Hydrology Group and SJRGA member staff to discuss the status of the pulse flow and to make changes to the operation plan if needed. The calls were held at 6:30 a.m. so that potential operational changes could be implemented on that day. The conference calls were held every Monday, Wednesday and Friday, starting on April 16 and ending on May 9.

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 2-5. The CDEC real-time data has not been reviewed for accuracy or adjusted for rating shifts; 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 were continuously monitored. Similarly, the computed ungaged flow at Vernalis and the flow in the San Joaquin River upstream of the Merced River were continuously updated. The monitoring was necessary to verify that supplemental water deliveries were adhering to tributary allocations contained in the SJRA Division Agreement to the extent possible, as well as to determine if changes in hydrologic conditions would require changes to the operation plan.

The daily operation plan was updated throughout the VAMP flow period. A summary of the updated daily operation plans is provided in Table 2-6. Copies of the updated daily operation plans are provided in Appendix A-2.

TABLE 2–3
Summary of Daily Operation Plans Prepared During Planning Phase

VAMP Forecast Date	VAMP Target Flow Period	Assumed Ungaged Flow at Vernalis (cfs)*	Existing Flow (cfs)*	VAMP Target Flow (cfs)*	Supplemental Water needed to meet Target Flow (1,000 AF)*
March 12	April 15 - May 15	300 - 600	2,070 - 2,980	3,200	69.42 - 13.67
March 26	April 15 - May 15	300 - 500	2,280 - 2,840	3,200	56.70 - 22.22
April 4	April 15 - May 15	400	2,565	3,200	39.06
April 9	April 15 - May 15	300	2,340	3,200	52.91

*Figures represent the most probable range of low and high hydrologic conditions.

TABLE 2–4
Summary of USGS Flow Measurements at the San Joaquin River near Vernalis Gage

Date	River Stage (ft)	Measured Flow (cfs)	CDEC Reported Real-time Flow (cfs)	Percent Difference	Rating Shift
March 4 (9:22)	9.87	2,140	2,150	-0.5%	No
April 2 (10:09)	9.68	2,070	2,000	3.5%	No
April 9 (9:46)	9.6	2,000	1,950	2.6%	No
April 16 (10:00)	10.74	3,040	2,890	5.2%	Yes
April 23 (9:17)	11.07	3,320	3,350	-0.9%	No
April 30 (10:01)	11.04	3,390	3,320	2.1%	No
May 7 (9:50)	10.92	3,100	3,210	-3.4%	No

TABLE 2–5
Real-time Flow Data and Sources

Measurement Location	Real-time Data Source
San Joaquin River near Vernalis	USGS, station 11303500 (http://waterdata.usgs.gov/ca/nwis/dv?format=pre&period=31&site_no=11303500)
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?format=pre&period=31&site_no=11289650)
Merced River at Cressey	CDEC, station CRS (http://cdec.water.ca.gov/cgi-progs/queryF?s=crs)
Merced River near Stevinson	CDEC, station MST (http://cdec.water.ca.gov/cgi-progs/queryF?s=mst)
San Joaquin River at Newman	USGS, station 11274000 (http://waterdata.usgs.gov/ca/nwis/dv?format=pre&period=31&site_no=11274000)

TABLE 2–6
Summary of Daily Operation Plans Prepared During Implementation Phase

VAMP Forecast Date	VAMP Target Flow Period	Assumed Ungaged Flow at Vernalis (cfs)	Existing Flow (cfs)	VAMP Target Flow (cfs)	Supplemental Water needed to meet Target Flow (1,000 AF)
April 22	April 15 - May 15	300	2,331	3,200	53.43
April 30	April 15 - May 15	300	2,322	3,200	53.98

FIGURE 2–1

2003 VAMP—San Joaquin River near Vernalis with and without VAMP.

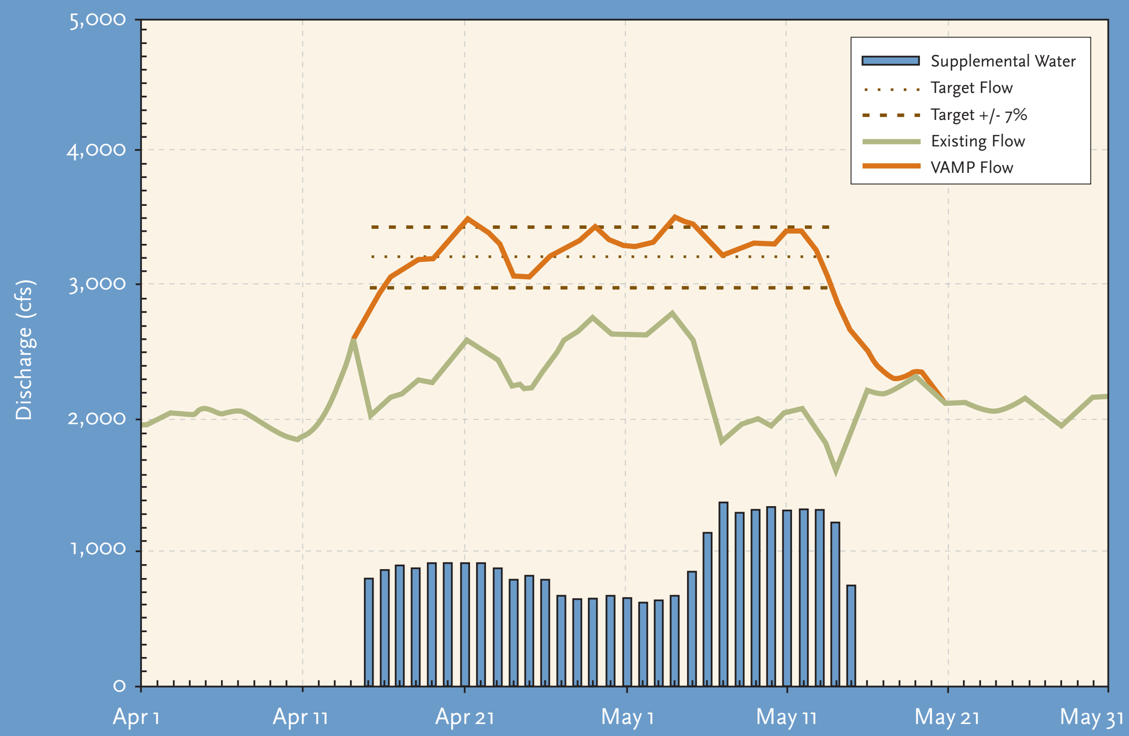
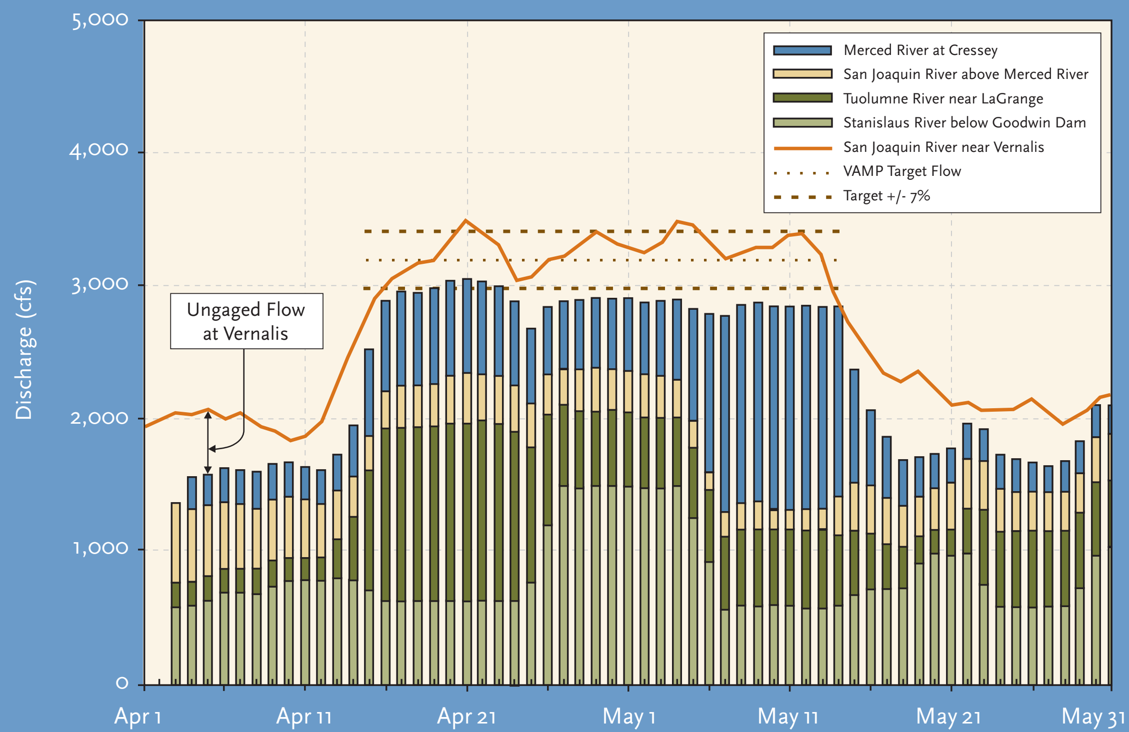


FIGURE 2–2

2003 VAMP—San Joaquin River near Vernalis with lagged contributions from primary sources.



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 the end of July.[1] Provisional data 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 to illustrate the differences between the real-time and the provisional data.

The mean daily flow at the Vernalis gage averaged 3,235 cfs during the April 15 – May 15 VAMP test flow period, with a maximum of 3,500 cfs and a minimum of 2,650 cfs. The average flow for the test flow period absent the VAMP supplemental water (existing flow) was estimated to be 2,290 cfs. The VAMP operation resulted in a 41 percent increase in flow at Vernalis during the target flow period. Figure 2-1 shows the flow at Vernalis with and without the VAMP pulse flow. Figure 2-2 shows the sources of the flow at Vernalis. A total of 58,065 acre-feet of supplemental water was provided during the VAMP test flow period.

In planning for the VAMP operation the ungaged flow in the San Joaquin River at Vernalis is the most difficult factor to forecast for the test flow period. The Daily Operation Plan is developed assuming a steady ungaged flow during the test flow period, but in reality there will be day to day fluctuations due to a number of unpredictable factors including weather, pre-existing conditions, irrigation operations, as well as mathematical uncertainties introduced by using mean daily flows and assumed travel times rounded to the nearest day. During the implementation phase of the VAMP operation, the forecasted ungaged flow were not necessarily adjusted as a result of the day to day fluctuations, but were adjusted if the general trend appeared to be deviating from the existing forecast. This is best illustrated in Figure 2-3, which shows in hindsight the observed ungaged flow along with that forecast prior to the test flow period on April 4 and the adjusted forecast that was modified on an ongoing basis in an attempt to account for deviation from the existing forecast.

Another unknown in the forecast equation similar to the ungaged flow is the flow in the San Joaquin River upstream of the Merced River. This unknown tends not to be as variable as the ungaged flow, but, like the ungaged flow, may be adjusted if the observed flow warrants it. Figure 2-4 shows the observed upper San Joaquin River flow along with the forecasts made just prior to the test flow period and during the VAMP implementation.

[1] The SJRA Division Agreement Technical Appendix specifies that "By July 31st of each year, each SJTA participant shall provide the records necessary to calculate the flow contribution by each entity to the San Joaquin River Group co-coordinator."

In planning for the VAMP operation the ungaged flow in the San Joaquin River at Vernalis is the most difficult factor to forecast for the test flow period. The Daily Operation Plan is developed assuming a steady ungaged flow during the test flow period, but in reality there will be day to day fluctuations due to a number of unpredictable factors including weather, pre-existing conditions, irrigation operations, as well as mathematical uncertainties introduced by using mean daily flows and assumed travel times rounded to the nearest day.

The target combined CVP and SWP export rate for the 2003 VAMP was 1,500 cfs. The observed export rate averaged 1,446 cfs during the 31-day period, about 4 percent below the 1,500 cfs target. The daily SWP and CVP exports during the VAMP test period are shown in Figure 2-5.

SJRG member agencies have entered into the Division Agreement, which allocates responsibility of the member agencies for providing VAMP supplemental water. The member agencies may also enter into additional agreements among themselves regarding delivery of the supplemental water. For the 2003 VAMP Merced I.D and the Exchange Contractors entered into an agreement whereby the Exchange Contractors supplemental water would be provided by Merced I.D. The distribution of supplemental water for the 2003 VAMP operation, compared to the distribution called for under the Division Agreement, is summarized in Table 2-7.

FIGURE 2–3

2003 VAMP—Ungaged flow in San Joaquin River near Vernalis.
Comparison of forecast and observed.

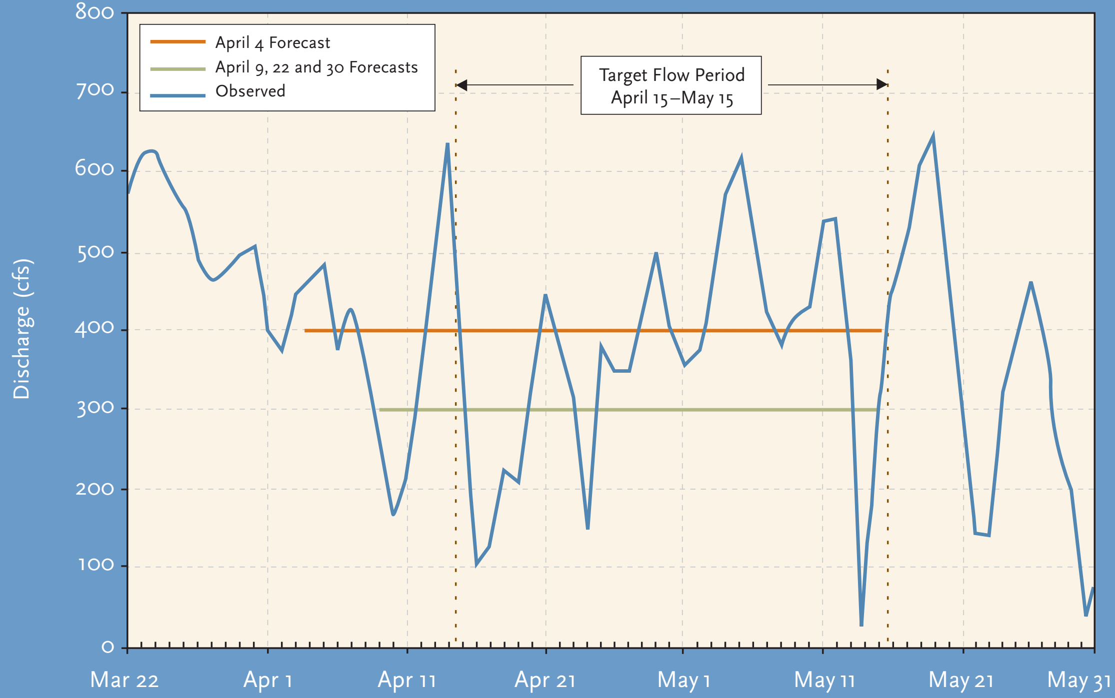
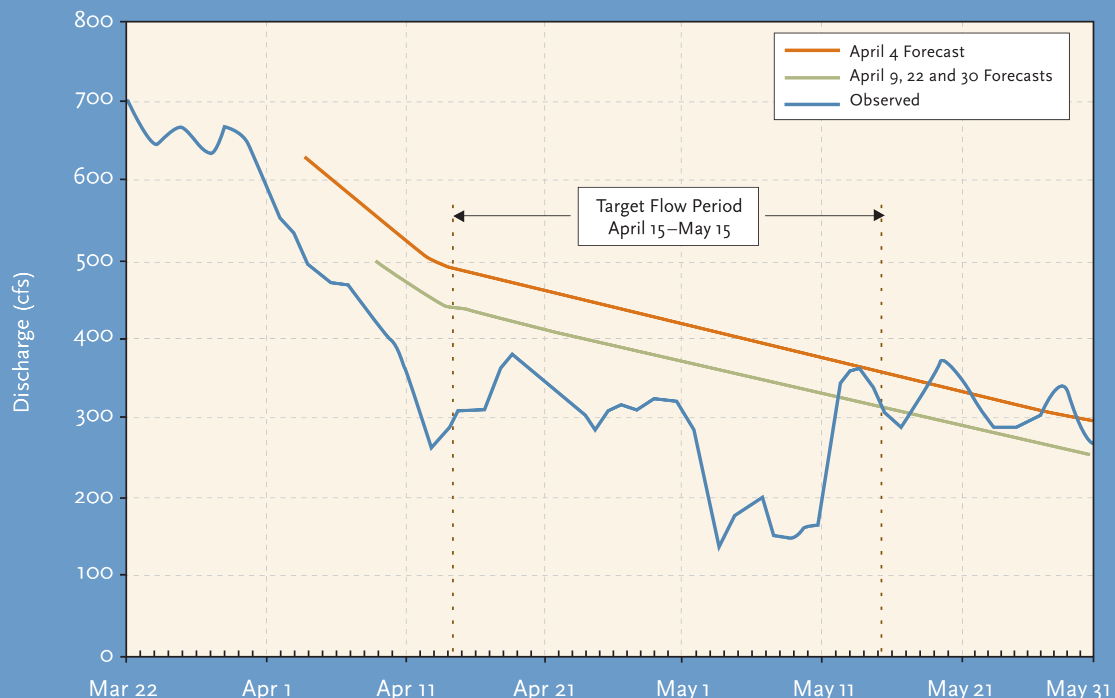


FIGURE 2–4

2003 VAMP—San Joaquin River above Merced River.
Comparison of forecast and observed.



Hydrologic Impacts

The VAMP supplemental water contributions, with the exception of that provided by the Exchange Contractors and OID/SSJID, are supplied from reservoir storage: Lake McClure on the Merced River and New Don Pedro Reservoir on the Tuolumne River. 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.

As noted in the 2002 Annual Technical Report, the storage impact in Lake McClure on the Merced River following the April 15 to May 15, 2002 VAMP operation was 95,262 acre-feet. As per the SJRA, Merced provided 12,470 acre-feet of supplemental water in the Fall of 2002 (see Chapter 3), resulting in a total SJRA storage impact on Lake McClure as of October 31, 2002 of 107,732 acre-feet. There were no opportunities to make up for any of this impact during the winter, therefore the entire impact of 107,732 acre-feet carried over into the 2003 VAMP

TABLE 2–7
Distribution of Supplemental Water

Agency	Division Agreement Distribution (acre-feet)	Supplemental Water Provided (acre-feet)	Deviation from Division Agreement (acre-feet)
Merced I.D.	33,065	33,257	+ 192
Oakdale I.D./South San Joaquin I.D.	10,000	10,078	+ 78
Exchange Contractors	5,000	5,000[a]	0
Modesto I.D./Turlock I.D.	10,000	9,729	- 271

[a]The Exchange Contractors supplemental water was provided by Merced I.D.

FIGURE 2–5

2003 VAMP—Federal and State Exports. (Source: USBR Delta Operations Report)

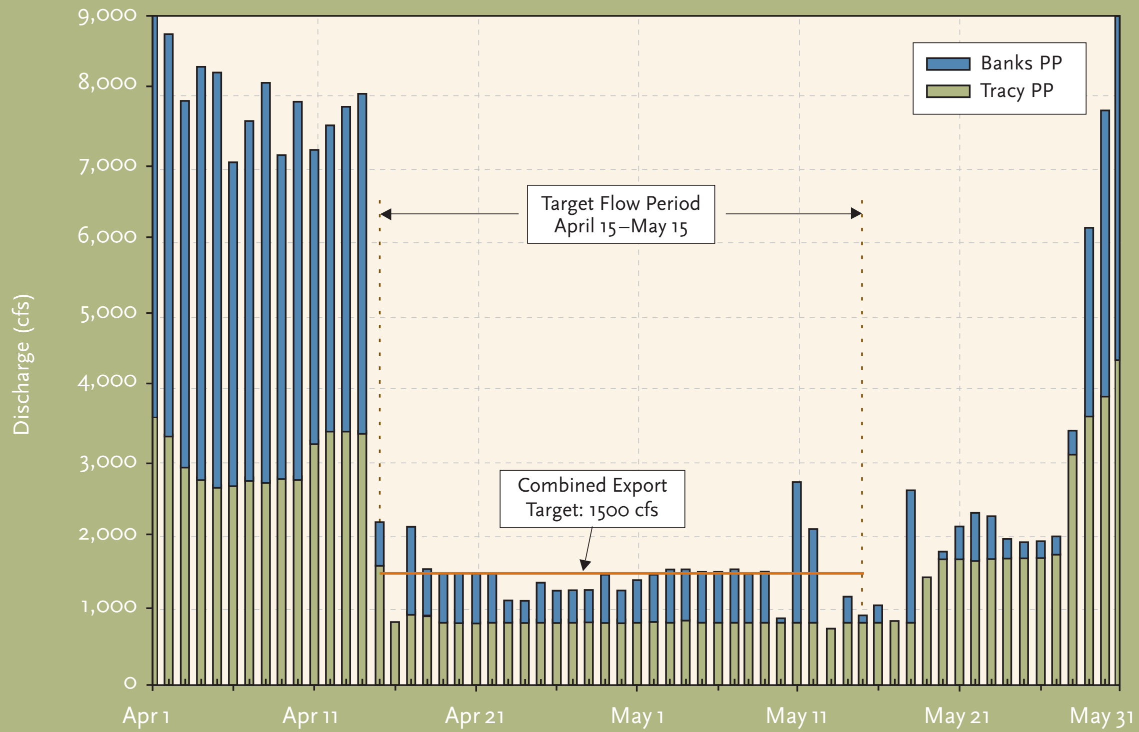


FIGURE 2–6

SJRA storage impacts—Lake McClure (Merced River). October 2002 through November 2003.

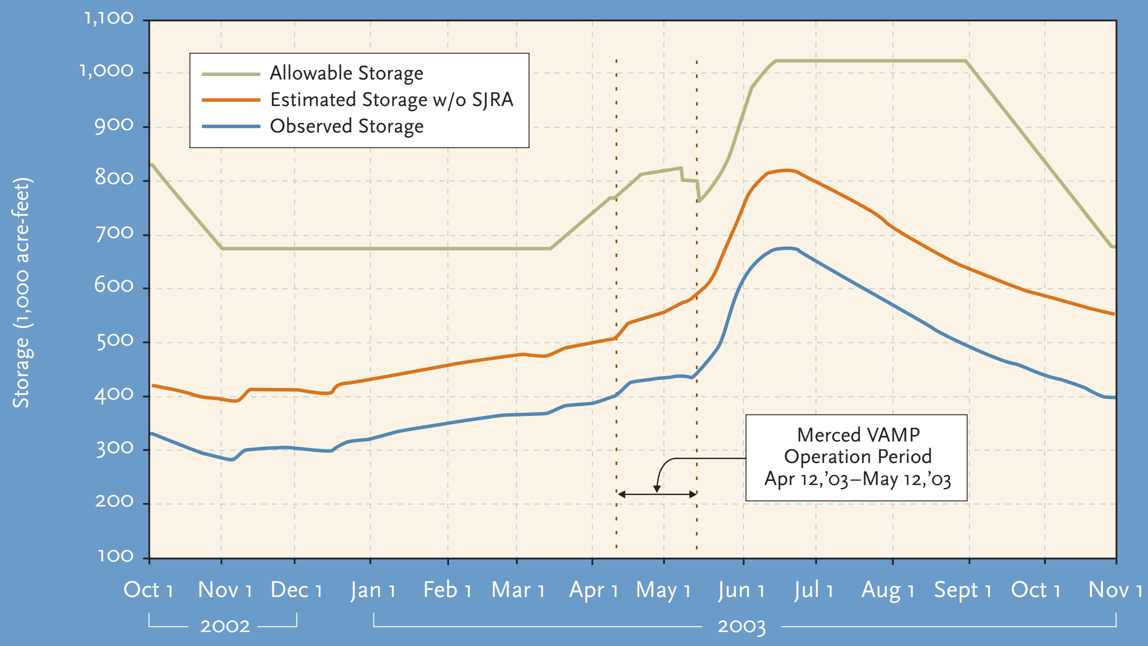


FIGURE 2–7

SJRA storage impacts—New Don Pedro Reservoir (Tuolumne River). October 2002 through November 2003.

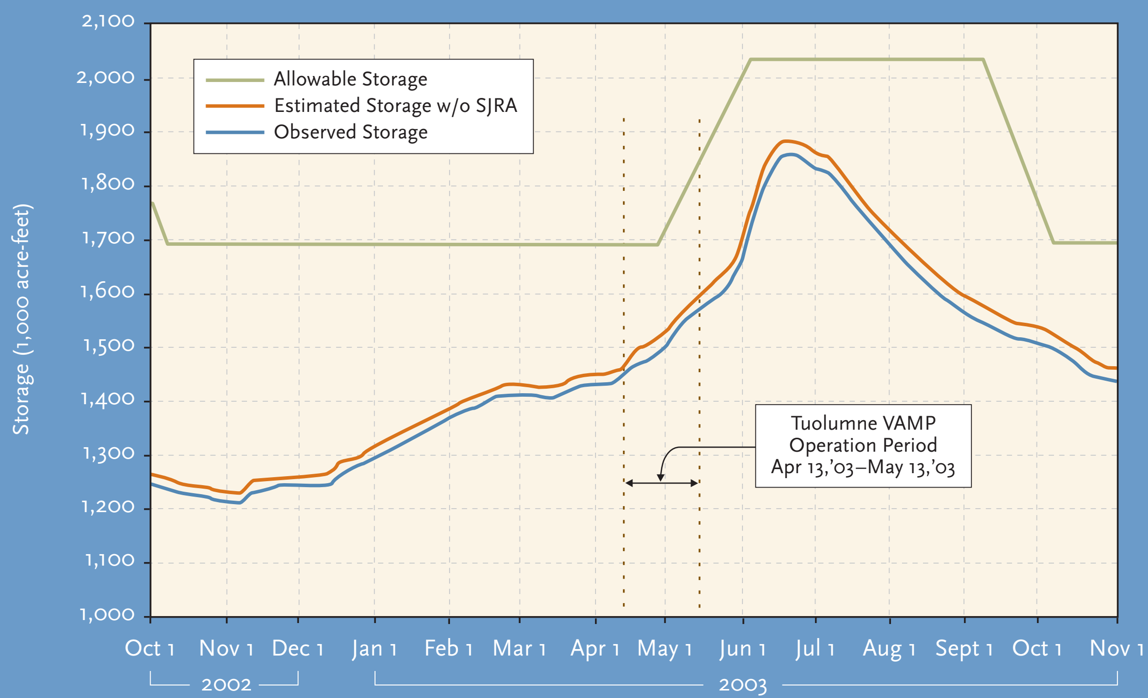


TABLE 2–8
Storage Impact History, Lake McClure (Merced River)

Year	VAMP Supplemental Water (acre-feet)[a]	Fall Supplemental Water (acre-feet)	SJRA Storage Impact Replenishment (acre-feet)	Cumulative Storage Impact (acre-feet)
1998	0	0	0	0
1999	85,339	11,998	48,025 (Jun.–Sep. 1999) 49,312 (Jan.–Feb. 2000)	0
2000	46,750	12,500	46,750 (May 2000)	-12,500
2001	43,146	12,496	0	-68,142
2002	27,120	12,470	0	-107,732
2003	39,586	12,500[b]		-147,318[c]

[a] Includes ramping flows [b] Scheduled as of Sep.30, 2003 [c] As of Sep. 30, 2003

TABLE 2–9
Storage Impact History, New Don Pedro Reservoir (Tuolumne River)

Year	VAMP Supplemental Water (acre-feet)	SJRA Storage Impact Replenishment (acre-feet)	Cumulative Storage Impact (acre-feet)
1998	0	0	0
1999	54,268	54,268 (Feb. 2000)	0
2000	22,651	14,955 (Sep.–Oct. 2000) 7,696 (Jan.–Feb. 2001)	0
2001	14,061	0	-14,061
2002	0	0	-14,061
2003	9,729		-23,790[a]

[a] As of Sep. 30, 2003

operation period. With the 38,257 acre-feet of supplemental water provided by Merced for the 2003 VAMP operation along with 1,329 acre-feet of operational ramp-up and ramp-down water, the current impact of the SJRA on Lake McClure storage as of May 15, 2003 was 147,318 acre-feet (Table 2-8). Figure 2-6 shows Lake McClure storage for water year 2003 with and without the SJRA.

As noted in the 2002 Annual Technical Report, the storage impact in New Don Pedro Reservoir on the Tuolumne River following the 2002 VAMP operation was 14,061 acre-feet. There were no opportunities to make up for any of this impact during the winter, therefore the entire impact of 14,061 acre-feet carried over into the 2003 VAMP operation period. With the 9,729 acre-feet of supplemental water provided by Modesto I.D. and Turlock I.D. for the 2003 VAMP operation, the current impact of the SJRA on the New Don Pedro Reservoir storage is 23,790 acre-feet (Table 2-9). Figure 2-7 shows New Don Pedro Reservoir storage for water year 2003 with and without the SJRA.

The supplemental water provided by OID/SSJID is made available from their diversion entitlements; therefore there are no storage impacts in New Melones Reservoir on the Stanislaus River due to the SJRA.

CHAPTER 3

Additional Water Supply Arrangements & Deliveries

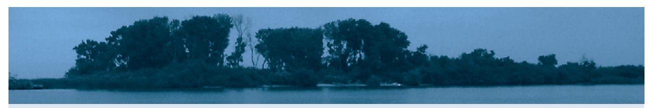
The SJRA includes a provision (Paragraph 8.4) stating that "Merced Irrigation District (Merced) shall provide, and the USBR shall purchase 12,500 acre-feet of water…during October of all years." The SJRA also states in Paragraph 8.4.4 that "Water purchased pursuant to Paragraph 8.4 may be scheduled for months other than October provided Merced, DFG and USFWS all agree." Pursuant to Paragraph 8.5 of the SJRA, "Oakdale Irrigation District (OID) shall sell 15,000 acre-feet of water to the USBR in every year of (the) Agreement…In addition to the 15,000 acre-feet, Oakdale will sell the difference between the water made available to VAMP under the SJRGA agreement and 11,000 acre-feet." This water 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 SJRA includes a provision (Paragraph 8.4) stating that "Merced Irrigation District (Merced) 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." This water is referred to as the Fall SJRA Transfer Water. The daily schedule for the Fall SJRA Transfer Water is to be developed by Department of Fish and Game (DFG), United States Fish and Wildlife Services (USFWS) and Merced ID.

The schedule for the 2003 Fall SJRA Transfer was finalized on October 1, 2003, with the transfer commencing on October 1, 2003. The schedule is provided in Appendix B, Table B-1. As with the VAMP operation, the final accounting for the Fall Transfer will be done using provisional flow data.

The 2002 Fall SJRA Transfer was in progress at the time of publication of the 2002 Annual Technical Report and therefore only preliminary data was provided in that report. The final data for the 2002 Fall SJRA Transfer are included in Appendix B, Table B-2, of this report.



The schedule for the 2003 Fall SJRA Transfer was finalized on October 1, 2003, with the transfer commencing on October 1, 2003.

OAKDALE IRRIGATION DISTRICT

Pursuant to Paragraph 8.5 of the SJRA, "Oakdale Irrigation District (OID) shall sell 15,000 acre-feet of water to the USBR in every year of (the) Agreement…In addition to the 15,000 acre-feet, Oakdale will sell the difference between the water made available to VAMP under the SJRGA agreement and 11,000 acre-feet." This water is referred to as the Difference water.

OID provided 5,039 acre-feet of supplemental water for the 2003 VAMP operation, resulting in 5,961 acre-feet of Difference water (11,000 minus 5,039). Therefore, pursuant to Paragraph 8.5 of the Agreement, OID sold a total of 20,961 acre-feet of water (15,000 plus 5,961) to the USBR in 2003.

The USBR released 6,613 acre-feet of the OID additional water in early June 2003 to support Vernalis flow objectives. The remainder of the OID additional water, 14,348 acre-feet, was released between October 19, 2003 and October 29, 2003, as shown in Table 3-1.

TABLE 3–1

USBR Release of Oakdale Irrigation District SJRA Additional Water (not including 6,613 acre-feet released in June 2003).

Date	Base Flow (cfs)	Total River Flow (cfs)	Supplemental Water (cfs)	Cumulative Supplemental Water (acre-ft)
19 Oct 03	200	227	27	54
20 Oct 03	200	917	717	1,476
21 Oct 03	200	977	777	3,017
22 Oct 03	200	979	779	4,562
23 Oct 03	200	977	777	6,103
24 Oct 03	200	976	776	7,642
25 Oct 03	200	976	776	9,181
26 Oct 03	200	979	779	10,727
27 Oct 03	200	976	776	12,266
28 Oct 03	200	976	776	13,805
29 Oct 03	200	876	676	15,146[a]

[a]14,348 acre-feet of Oakdale I.D. SJRA Additional Water was released in this period. Supplemental water in excess of this is non-SJRA water.

CHAPTER 4

Head of Old River Barrier

A key component to the VAMP design is the operation of a fish barrier at the Head of Old River. The purpose of the barrier is to prevent migrating salmon smolts from entering Old River. The Old River leads to the SWP/CVP export pumps. A study conducted by the California Department of Fish and Game investigates the entrainment of salmon smolt as part of the Old River barrier evaluation. Monitoring is performed to document juvenile Chinook salmon entrainment through the operable culverts of the HORB.

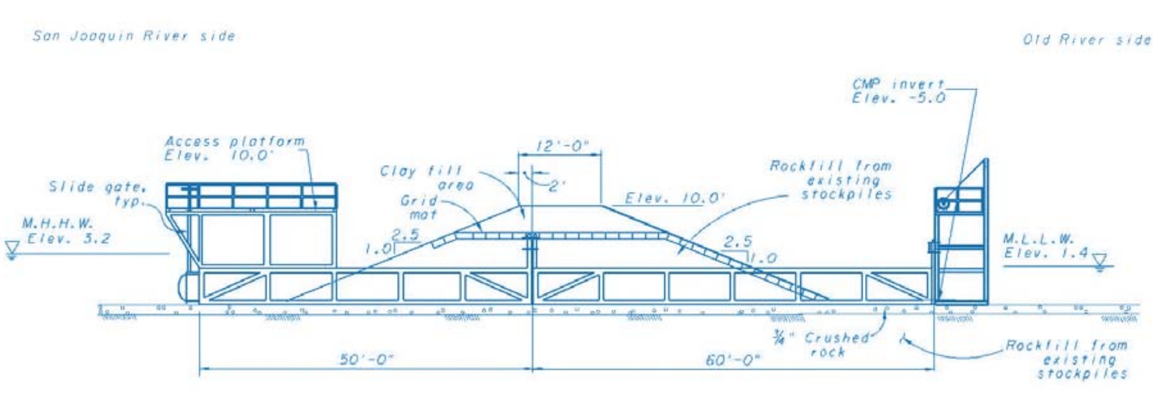
BARRIER DESIGN, INSTALLATION AND OPERATION

In early April 2003, DWR installed and operated the temporary Head of Old River Barrier (HORB). The spring HORB is a component of the south Delta Temporary Barriers Project (TBP). The TBP mitigates for low water levels in the south Delta and improves water circulation and quality for agricultural purposes. The HORB, as currently configured, is fully permitted though 2005, but must get annual landowner access approval.

The spring HORB was first constructed in 1992. Since then, the barrier has been installed in 1994, 1996, 1997 (w/two culverts), and 2000—2003 (six culverts). The HORB was not installed in 1993, 1995 and 1998 due to high San Joaquin River flows. The HORB was not installed in 1999 due to landowner access problems. The HORB, a key component of VAMP, is intended to increase San Joaquin River Chinook salmon smolt survival by preventing them from entering Old River.

The HORB was originally designed to withstand a San Joaquin River flow of about 3,000 cfs. Through the years, the design and installation of the HORB has been revised on several occasions to accommodate different needs. Beginning in 2001, the barrier design included two versions. A "low-flow" barrier, when San Joaquin River target flows are below 7,000 cfs would be built to a height of 10 feet mean sea level (MSL). A "high-flow" barrier, for target flow of 7,000 cfs, would be built to a height of 11 feet MSL and additional material would be placed to raise the abutments to 13 feet MSL. Both barrier versions are equipped with six 48-inch diameter operable culverts and an overflow weir back-filled with clay. In 2003, the low-flow version of the HORB was installed.

FIGURE 4–1
Head of Old River Barrier (HORB)



The dimensions of the 2003 HORB (Figure 4-1) were similar to the 2000, 2001 and 2002 HORB. The base width of the HORB in 2003 was 100 feet and the crest elevation was 10 feet MSL. The top of HORB was constructed with a 75-foot wide notch, protected with concrete grid mats and back-filled with clay. The HORB was designed to safely operate with flows corresponding to stages up to 8.5 feet MSL.

To help mitigate anticipated low water levels in the south Delta (downstream of the HORB) caused by the operation of the HORB, two open culverts were installed in the barrier in 1997, and six operable culverts were installed beginning in 2000. Operation of the culverts is controlled by a slide gate control structure located on the upstream side of HORB. DWR relied on daily modeling and field data collection to monitor water levels at three locations within the south Delta to determine when and how long to operate the culverts. Generally, the model would forecast lower low-low water levels lower than actual levels observed in the field. Consequently, DWR would make decisions regarding the culvert operations that would take this into consideration.

The downstream outlet of each culvert was designed so fyke nets could be attached to evaluate fish entrainment. DFG staff conducted a fishery-monitoring program as part of the 2003 HORB operations.

Permitting and Construction

The various permit conditions that are placed on the Temporary Barriers Program, by the USFWS, National Marine Fisheries Service (NOAA Fisheries), and DFG, require that the spring in-water construction activities begin no earlier than April 7 on the Head of Old River (HOR), Middle River (MR), and Old River at Tracy (ORT) barriers. In addition, construction of the northern abutment and boat ramps of the Grant Line Canal (GLC) barrier and construction of out-of-water portions of the HORB, MR, and ORT barriers may not be started any earlier than April 1. Full closure of the GLC barrier is not required but construction of the north abutment and boat ramps must be completed to the extent that full barrier closure and operation can be readily achieved in a reasonable time frame, if and when directed by DWR. The permit conditions also require that all the above work be completed by April 15th, a total of 15 working days. The various permit conditions are as follows:

A key component to the VAMP design is the operation of a fish barrier at the Head of Old River. The purpose of the barrier is to prevent migrating salmon smolts from entering Old River.

USFWS Biological Opinion

1) The spring HORB barrier installation may begin on April 1 but in-water work shall not occur until April 7, except for construction necessary to place the scour pad and the pad for the culverts;
2) DWR may begin construction of the Middle River barrier on April 1 but in-water work shall not occur until after April 7;
3) DWR may begin construction of the Old River at Tracy barrier on April 1 but in-water work shall not commence before April 7;
4) DWR may begin construction of the northern abutment and the boat ramp of the GLC barrier on April 1 provided that the HORB barrier is being constructed concurrently.

NOAA Fisheries Biological Opinion

1) The spring HORB installation shall begin on April 1;
2) The Middle River barrier construction may begin on April 7;
3) The Old River at Tracy barrier construction may begin on April 1;
4) The northern abutment and boat ramp of the GLC barrier may begin construction on April 1 provided that the HORB is being constructed concurrently.

DFG 1601—HORB

1) HORB Spring Installation—All work in or near the stream zone will be confined to the period beginning no earlier than April.
2) DFG 1601—Agricultural Barriers

   MR—All work in or near the stream zone will be confined to the period beginning no earlier than March 1.

   ORT—All work in or near the stream zone will be confined to the period beginning no earlier than April 1.

   GLC—All work in or near the stream zone will be confined to the period beginning no earlier than April 1.

In addition to the above conditions, water users of the South Delta Water Agency (SDWA) and the fisheries agencies impose separate mitigation requirements on DWR for installation and operation of the HORB by itself. As a result, DWR's contractor must sequentially close and start operation of the MR and ORT barriers, and complete as much construction of north abutment and boat ramps on the GLC barrier as possible, before they can close and operate the HORB.

From the contractors point of view there are really two milestones that must be completed in sequence. First and foremost is to obtain closure and operation of the barriers in accordance with the conditions imposed by the project permits/ biological opinions and mitigation requirements. The second is to satisfy DWR's contract specifications. The first milestone can be achieved within the required 15 working days but it is unlikely that the contractor can complete the entire amount of work required to satisfy DWR's contract specifications within the same time period. Therefore, the contractor's construction activities consist of placing enough materials to make sure they obtain closure and operation by April 15th, then following closure they continue placing barrier material above the water line until barrier construction is completed in accordance with DWR's contract specifications. The contractor then conducts site cleanup and demobilizes from the site. This is why work usually continues beyond the April 15 deadline.

The current permits allow for in-water work to begin April 1 with barrier closure no earlier than April 15th. Once the HORB is closed, typically on April 15, construction crews remain on site to install a clay plug, lay down concrete mats, put up fencing and lighting and perform general site clean-up. Post barrier closure work can take up to a week to complete.

The Department of Fish and Game (DFG), who monitors fish entrainment through the barrier culverts, does not begin sampling efforts (for safety reasons) until the crews have finished their work and moved heavy equipment out of the area. A delay in beginning sampling at the barrier, in turn, delays VAMP releases of salmon smolts. Knowing how many smolts are entrained at the barrier is important in interpreting the survival data from VAMP tagged salmon. VAMP usually conducts two sets of releases. Optimally, salmon releases would occur a week apart to measure survival under replicate conditions. Delaying releases can result in increased river temperatures for the latter replicate, making it difficult to have similar water temperature conditions for the two sets of releases.

Numerous discussions with DWR, NOAA Fisheries, USFWS, and DFG biologists explored every aspect of HORB installation, timing, and fishery concerns. Construction and complete closure of HORB takes two weeks, not including site clean-up. Concurrent installation of Old River at Tracy, Middle River and Grant Line Canal barriers requires substantial effort because the Middle River and Old River at Tracy barriers must be available along with the HORB to protect water levels downstream.

In February of 2003, the VAMP technical committee wanted to explore the possibility of changing the Head of Old river Barrier operating permits to allow flexibility on a year-to-year basis to install and operate the barrier prior to April 15th. At this time, changing the permits to allow for early construction of the HORB is not feasible. The following are constraints to closure and operating the HORB prior to April 15th:

(1) The DFG and USFWS will not allow in-water work to begin any earlier than April 1 due to Delta smelt concerns. When the HORB is closed and the State Water Project and Central Valley Project are pumping at rates higher than the San Joaquin River flows, reverse flows occur in the central Delta. During reverse flows, Delta smelt that have migrated upriver may have increased vulnerability to entrainment in the south Delta. Conditions may be better for Delta smelt that spawn in early spring when barrier closure is delayed.

(2) With an experienced construction crew, the HORB takes two weeks to close. If the culverts were to be semi-permanently installed, the barrier could be constructed in approximately a week. The current HORB permits allow for the culverts to be semi-permanently installed, however, there are difficulties in accomplishing this. Entry permits for the south side of the river are difficult to obtain and are granted for a limited period of time each year, and the culverts would partially protrude into the river. DWR would have to cut into the bank and dredge the river and mitigation would be costly.

(3) If the HORB were to be installed early, the three agricultural barriers would also have to be installed early. The South Delta Water Agency would have to be involved to renegotiate the terms of barrier operations on a yearly basis.

Optimally, salmon releases would occur a week apart to measure survival under replicate conditions. Delaying releases can result in increased river temperatures for the latter replicate, making it difficult to have similar water temperature conditions for the two sets of releases.

Barrier Operations and Monitoring Plan

A barrier operations and monitoring plan was developed based on forecasting and monitoring of tidal conditions. DWR determined the number of culverts to be opened at the HORB so that water levels at Old River near Tracy Road Bridge and Grant Line above Doughty Cut would remain above 0.0 feet MSL and Middle River near Howard Road above 0.3 feet MSL. Based on modeling results and field monitoring of water levels in the south delta, three of the six culvert slide gates remained open during the VAMP target flow period.

Flow Measurement At and Around Barrier

This year DWR installed a Doppler "Argonaut" flow measuring device inside culvert #4. Data was recorded every 15 minutes during the period when the HORB was in operation. Table 4-1 displays the daily average, maximum and minimum flows measured in culvert #4. The mean daily flow through the culverts varied in response to tidal and San Joaquin River flow conditions. The characteristics of the flow through the culverts are complicated in that the flow rate is influenced by many variables, including the culvert inlet geometry, slope, size, culvert roughness, and approach and tail water conditions. Since the culverts are similar in configuration and size, the total flow through the three culverts can be estimated by using three times the measured flow through culvert #4. Under this assumption the mean daily flow through the culverts during the target flow period ranged from 139 cfs to 198 cfs, with an average of 171 cfs.

In addition to the Doppler "Argonaut" in culvert #4, a fixed Acoustic Doppler Current Meter was operated approximately 840 feet downstream of the HORB. The Acoustic Doppler Current Meter records velocity measurements every 15 minutes, from

TABLE 4–1
Measured flows Through Culvert #4 of HORB

Date	Flow (cfs)		
	Average	Minimum	Maximum
4/14/03	46	32	63
4/15/03	51	33	69
4/16/03	62	13	81
4/17/03	66	47	85
4/18/03	65	44	81
4/19/03	64	45	83
4/20/03	62	42	81
4/21/03	58	11	79
4/22/03	60	13	83
4/23/03	60	13	79
4/24/03	56	12	78
4/25/03	59	20	75
4/26/03	59	12	76
4/27/03	59	10	77
4/28/03	55	12	72
4/29/03	57	12	73
4/30/03	58	11	74
5/1/03	56	11	75
5/2/03	56	8	76
5/3/03	54	14	72
5/4/03	56	9	77
5/5/03	59	13	77
5/6/03	56	12	78
5/7/03	53	8	73
5/8/03	52	12	72
5/9/03	57	15	78
5/10/03	57	10	75
5/11/03	57	12	77
5/12/03	57	7	77
5/13/03	57	7	73
5/14/03	54	37	71
5/15/03	53	37	68
5/16/03	51	32	68

TABLE 4–2

Flow in San Joaquin River and Old River Downstream of the HORB – 2003 (values in CFS)

Date	San Joaquin River near Vernalis (1)	Old River at Head (2)	San Joaquin River below Old River (3)	Through HORB Culverts (4)	Estimated HORB Seepage (5)	Date	San Joaquin River near Vernalis (1)	Old River at Head (2)	San Joaquin River below Old River (3)	Through HORB Culverts (4)	Estimated HORB Seepage (5)
4/01/03	1,950	1,017	933			5/01/03	3,280	258	3,022	168	90
4/02/03	2,010	820	1,190			5/02/03	3,260	189	3,071	168	21
4/03/03	2,050	846	1,204			5/03/03	3,330	192	3,138	162	30
4/04/03	2,030	838	1,192			5/04/03	3,489	326	3,163	168	158
4/05/03	2,080	862	1,218			5/05/03	3,459	341	3,118	177	164
4/06/03	2,010	832	1,178			5/06/03	3,320	354	2,966	168	186
4/07/03	2,050	709	1,341			5/07/03	3,210	325	2,885	159	166
4/08/03	1,970	649	1,321			5/08/03	3,240	388	2,852	156	232
4/09/03	1,920	507	1,413			5/09/03	3,290	360	2,930	171	189
4/10/03	1,850	617	1,233			5/10/03	3,270	334	2,936	171	163
4/11/03	1,880	368	1,512			5/11/03	3,370	305	3,065	171	134
4/12/03	1,970	262	1,708			5/12/03	3,360	316	3,044	171	145
4/13/03	2,260	379	1,881			5/13/03	3,190	359	2,831	171	188
4/14/03	2,600	415	2,185	138	277	5/14/03	2,829	434	2,395	162	272
4/15/03	2,839	354	2,485	153	201	5/15/03	2,600	389	2,211	159	230
4/16/03	3,000	388	2,612	186	202	5/16/03	2,430	372	2,058	153	219
4/17/03	3,090	467	2,623	198	269	5/17/03	2,270	385	1,885		
4/18/03	3,160	427	2,733	195	232	5/18/03	2,210	373	1,837		
4/19/03	3,180	469	2,711	192	277	5/19/03	2,290	661	1,629		
4/20/03	3,350	459	2,891	186	273	5/20/03	2,160	462	1,698		
4/21/03	3,469	409	3,060	174	235	5/21/03	2,020	432	1,588		
4/22/03	3,390	280	3,110	180	100	5/22/03	2,010	500	1,510		
4/23/03	3,300	291	3,009	180	111	5/23/03	1,960	603	1,357		
4/24/03	3,050	207	2,843	168	39	5/24/03	1,940	721	1,219		
4/25/03	3,070	179	2,891	177	2	5/25/03	1,950	756	1,194		
4/26/03	3,200	270	2,930	177	93	5/26/03	2,020	675	1,345		
4/27/03	3,240	284	2,956	177	107	5/27/03	1,900	613	1,287		
4/28/03	3,320	218	3,102	165	53	5/28/03	1,810	663	1,147		
4/29/03	3,420	285	3,135	171	114	5/29/03	1,890	822	1,068		
4/30/03	3,320	322	2,998	174	148	5/30/03	2,000	945	1,055		
						5/31/03	2,020	906	1,114		

VAMP target flow period highlighted

(1) USGS provisional data as of 11/6/2003
(2) DWR Acoustic Doppler Current Meter located 840 ft. downstream of HORB
(3) (1) – (2)
(4) Three times the measured flow in HORB Culvert #4.
(5) (2) – (4)

which the flow is calculated using the known cross-sectional area of the channel as a function of the stage elevation at that location. The mean daily flow measured in Old River during the target flow period ranged from 179 to 469 cubic feet per second as shown in Table 4-2 and Appendix A-4.

Hydraulic modeling of the San Joaquin River between Vernalis and Old River[1] shows that the tidal effects on flow at the Head of Old River are insignificant when mean daily flows are used, and that the mean daily flow in the San Joaquin River near Vernalis is essentially the same as the mean daily flow in the San Joaquin River at Old River. Therefore the mean daily flow in the San Joaquin River downstream of Old River can be estimated as the difference between the mean daily flow near Vernalis and the mean daily flow measured by the Acoustic Doppler in Old River downstream of the HORB. The difference between the Old River flow and the flow through the culverts is representative of the seepage through the HORB. The flows at and around the HORB are summarized in Table 4-2.

The Department also installed a stage monitoring station on the San Joaquin River approximately 1000 feet downstream of the confluence with Old River. At this station, they installed an acoustical fixed Doppler as well as a satellite transmission devices required to post the data on the website. At this time, the Department is in the process of calibrating this station by establishing a stage-flow relationship. The station is expected to be fully operational and transmitting flow data by February 2004. Currently the mean daily flow in the San Joaquin River can be estimated as the mean daily flow at Vernalis minus the mean daily flow measured by the Acoustic Doppler in Old River.

Barrier Emergency Response Plan

In addition to the operations and monitoring plan, DWR has also prepared an "Emergency Operations Plan for the Spring HORB". The plan provided that if the daily measured or forecasted flow at Vernalis exceeded a flow that would correspond to stage at the HORB of 10.0 feet MSL, and the stage was likely to exceed 11.0 feet MSL (the height of the barrier under the "high-flow" target), the barrier would be removed. Vernalis flows and stages at the barrier were not high enough in 2003 to warrant action under the emergency operations plan.

Levee Seepage Monitoring

A seepage-monitoring program on adjacent lands was initiated in April 2000 and continued this year, to evaluate the effects of HORB operations on seepage and groundwater on Upper Roberts Island.

Three seepage monitoring well sites were chosen in 2000 on Upper Roberts Island. Each site has two shallow wells, positioned 10 feet and 100 feet from the toe of the levee to monitor the seepage gradient to and from the San Joaquin River. In addition, a deeper well was drilled at Site 1 (near the Head of Old River) to determine vertical gradients.

In addition to the groundwater monitoring wells, a temporary gage was installed in April 2000 to record water surface elevations in the San Joaquin River, about 1,500 feet downstream of the HORB. Installation of a permanent tide gage was completed in early 2002. Flow data will be generated as staff resources permit. The water surface elevations in the San Joaquin River are compared to groundwater levels on Upper Roberts Island to determine how groundwater levels change relative to changing water level conditions in the river.

As reported in the 2002 VAMP Technical Report DWR produced a seepage report for the 2001—2002 period. DWR will be releasing the latest annual (2002—2003) report in late 2003 once the current data analysis is completed. Based on the 2000 and 2001 data it is apparent that the San Joaquin River stage influences groundwater levels on Upper Roberts Island. When stage increases in the river, groundwater levels will rise toward the land surface, but not as rapidly as the river stage rises. However, over the monitoring period, river stage did not reach levels sufficient to raise groundwater levels to the point where seepage into crop root zones might occur.

Given the results of the seepage monitoring since April 2000, DWR staff expects that if a VAMP target flow of 7,000 was implemented, stages near the HORB would rise to about $7\frac{1}{2}$ to 8 feet MSL. This would translate to groundwater levels in the monitoring well closest to the levee of about $6\frac{1}{2}$ to 7 feet MSL. Because the ground surface elevation is 13 feet MSL near site 1, DWR concludes that seepage should not impact the root zone of crops that could be planted in this area.

The monitoring program will be continued in order to gather more data, particularly during high flow periods in the spring.

Fishery Monitoring At The Head Of Old River Barrier

During the VAMP 2003 test period, all six culverts in the Head of Old River Barrier (HORB) were installed; however, only three of the culverts were open. The six culverts are installed to maintain water quality and water levels in the south Delta downstream of the HORB. Since the culverts are not screened, juvenile

[1] UNET (one-dimensional unsteady flow computer model) analysis of lower San Joaquin River by MBK Engineers.

Chinook salmon and other fish species that pass near the culverts are vulnerable to entrainment. An entrainment monitoring study was designed and implemented by the DFG to evaluate and quantify fish entrainment at the HORB. The specific objectives of the 2003 fishery investigations were:

- Determine the total number of juvenile Chinook salmon and other fish species entrained through the culverts at the HORB (Entrainment Monitoring);
- Determine the percentage of coded-wire tagged (CWT) salmon released at Mossdale and Durham Ferry entrained into Old River (Entrainment Monitoring); and
- Determine tidal and diel effects on juvenile Chinook salmon entrainment (Entrainment Special Study).

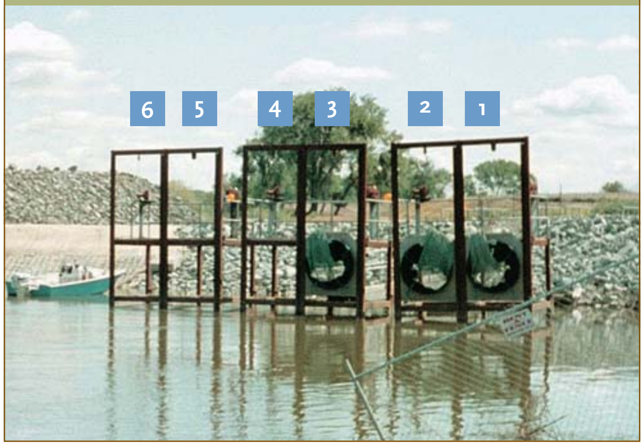
Results of these fishery investigations are intended, in part, to provide information on the design and operation of a future permanent operable barrier at the head of Old River.

MATERIALS AND METHODS

As part of the VAMP 2003 studies, approximately 75,000 VAMP CWT salmon were released at Durham Ferry on April 21 and approximately 50,000 CWT salmon were released at Mossdale on April 22. The Mossdale release was split in half with 25,000 CWT salmon released around noon and a second group of 25,000 CWT salmon released at 6 pm. The same size releases were repeated on April 28 and 29 at Durham Ferry and Mossdale, respectively. Salmon from the VAMP releases were used in the Entrainment Monitoring studies. For the Entrainment Special Study, 8 uniquely color-marked groups of juvenile Chinook salmon (approximately 3,000 fish per group) were marked with photonic fluorescent microspheres at the Merced River Hatchery. The salmon were transported to the HORB and placed in live cages where they were held at least 10 hours before release. Each color-marked group was released approximately one mile upstream of the HORB, in the middle of the San Joaquin River. The color-marked releases coincided with the two VAMP salmon releases. On the night of April 22, one group was released on the ebb tide and one group on the flood tide. The following day, a group was released on the subsequent ebb and flood tides. The process was repeated on April 29.

Fish entrained into the culverts were caught with fyke nets. The nets have a 48 inch cylindrical mouth tapering down to a 1-foot square cod-end, are made of 1/4 inch braided mesh, and are 60 feet long. A live-box (15.5 x 19.5 x 36 inches), constructed of perforated aluminum sheet metal, was attached to the cod-end of each net. Each live-box has an aluminum baffle designed to reduce water velocities within the live-box and improve survival of captured fish. The fyke nets were attached to the culvert flanges on April 17. The culverts were numbered 1 through 6 with number 1 located next to the shoreline and number 6 located mid-channel (Figure 4-2). The nets were attached to culvert number 4, 5 and 6. They were attached to the culverts by closing the culvert slide gates on the upstream side of the barrier, raising the flanges that slide over the culvert outfalls, and then strapping the nets over the flanges. On April 21, the flanges, with the attached fyke nets, were lowered down to the culvert outfalls and the live-boxes were attached to the cod-end of the nets to commence sampling.

FIGURE 4–2
Culverts in the HORB. Culverts 1-3 were closed in 2003.



The fyke nets were checked on every tide change until May 10. From May 10 through May 12, the nets were checked at 04:00, 08:00, 18:00 and 22:00 hours. On May 13, the nets were removed. The nets were checked by closing the culvert slide gate for about 30 minutes which enabled the live-boxes to be pulled onto a boat so that the fish could be removed and placed into buckets. Once all the nets had been checked and reset, the collected fish were processed. The fish were speciated and counted. Fork lengths (mm) were recorded for up to 50 salmon per live-box. Salmon were checked for a clipped adipose fin and for the presence of a color mark on the dorsal, anal, or caudal fin. Salmon that had a clipped adipose fin were saved for CWT processing. The color and location of the dyed fin was noted for each color-marked salmon. Culvert number, date, time, water temperature, tidal stage, and diel-period were

FIGURE 4–3

Daily average number of salmon entrained per hour at the HORB in 2003.
The total catch is divided into CWT and unmarked salmon.

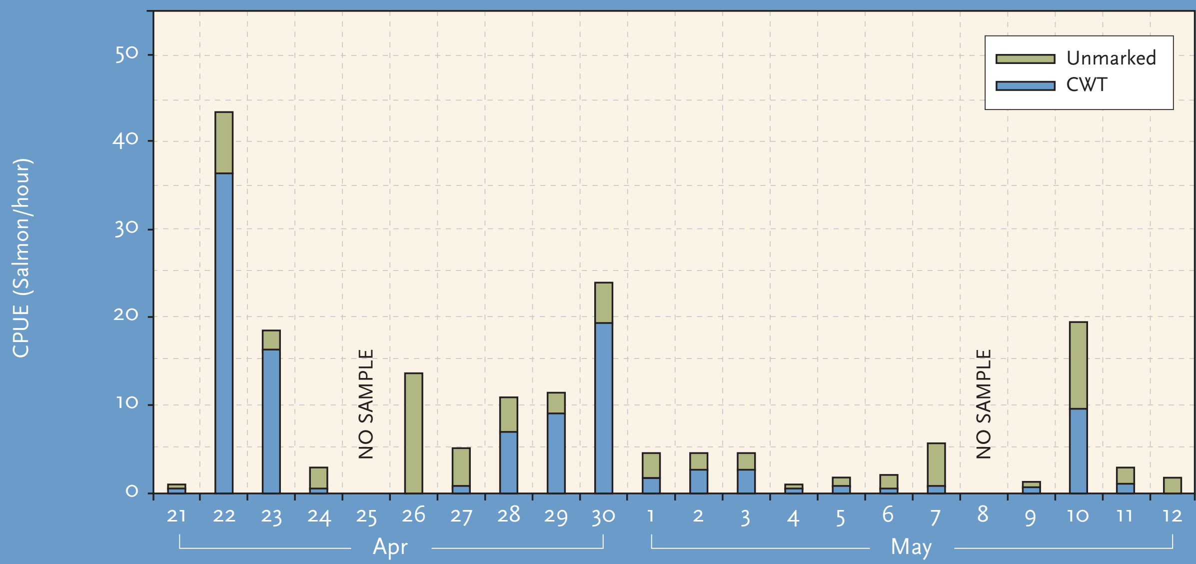
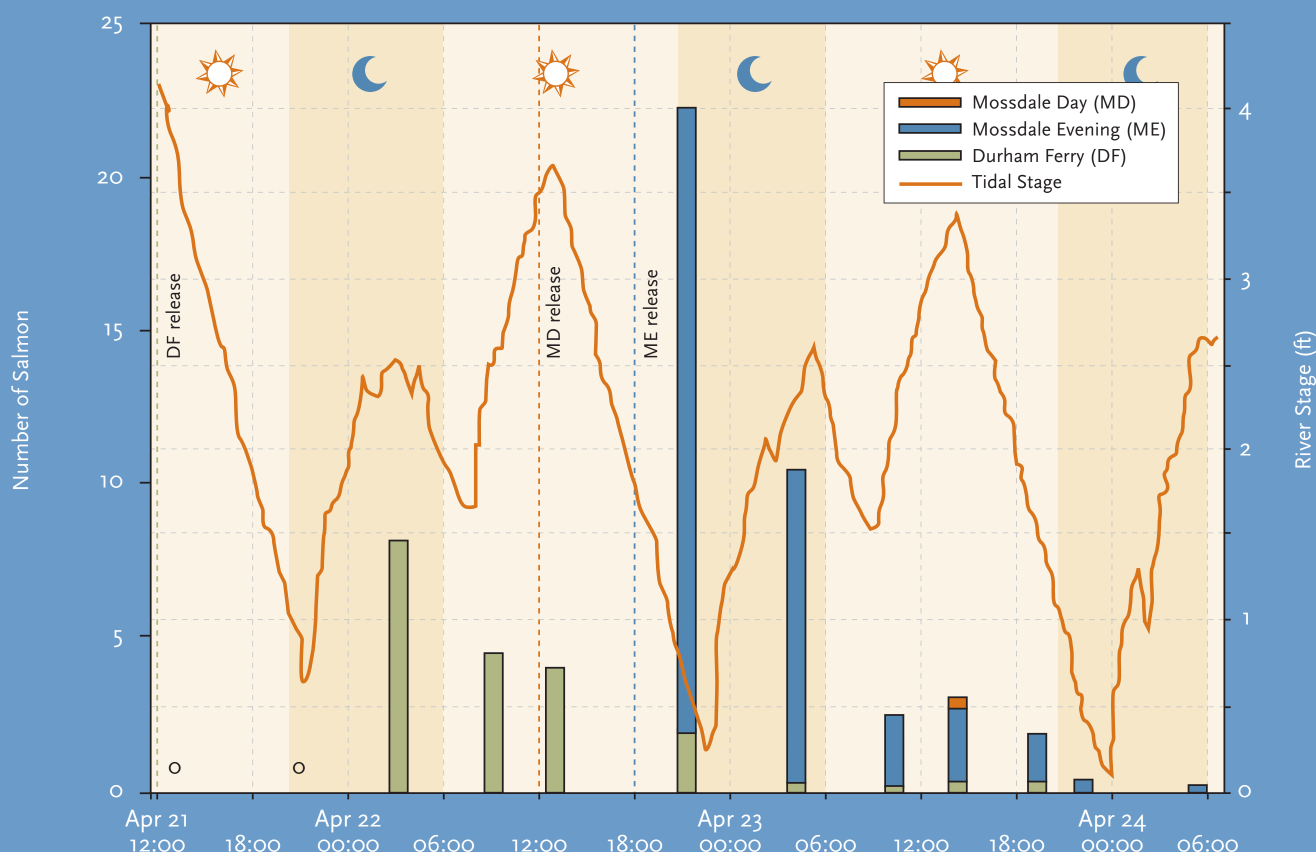


FIGURE 4–4

The average number of salmon per hour entrained at the HORB, by tidal stage, for the first VAMP salmon release.
Salmon release times are marked by dashed lines. River stage for Old River is indicated by solid line.



recorded for each net check. Except for the CWT smolts, all processed fish were released downstream of the fyke nets into Old River.

Loss indices for the CWT salmon released as part of the VAMP survival studies at Durham Ferry and Mossdale were calculated based on data collected from April 21 to May 12. The loss index represents the percentage of CWT salmon entrained into the HORB culverts. The loss index (I) is calculated using the equation:

$$I = (TC / TR)$$

Where:
TC = Total number of CWT salmon collected in fyke nets, and
TR = Total number of CWT released

For the two occasions when all three nets were pulled and the culverts were still open, the number of salmon entrained was estimated by averaging the salmon entrainment the day before and after the time period the nets were pulled. Catch-Per-Unit-Effort (CPUE) for salmon was calculated as the number of fish collected per hour. The percentage of color-marked salmon recovered in the fyke nets compared to the total number released was used as an index of entrainment vulnerability at the HORB.

RESULTS

The HORB was closed on April 15; however, construction on the barrier continued for another week. The DFG monitored the HORB culverts for 22 days and collected 246 samples. The nets sampled 1,421 hours out of a possible 1,581 hours. Approximately 7,000 fish were collected representing at least 25 species from 12 families of fish. No delta smelt (Hypomesus transpacificus), 2 juvenile steelhead (Oncorhynchus mykiss), and 45 adult splittail (Pogonichthys macrolepidotus) were collected. The most abundant species was Chinook salmon, followed by white catfish (Ictalurus catus) and common carp (Cyprinus carpio) (Table 4-3). These 3 fish comprised 90% of the total entrainment. Of the 4,872 salmon caught; 2,511 had a CWT; 1,937 were unmarked; and 424 had a color-mark. Overall, the amount of salmon entrained per hour (3.4) with the 3 culverts was higher than the 6 culverts in 2003 (2.5 salmon/hour) and in 2002 (1.4 salmon/hour).

Salmon smolts were caught throughout the monitoring period (Figure 4-3). Most of the VAMP released salmon were caught within two days of their release. During the first set of VAMP salmon release, CWT salmon entrainment was the highest on the evening of April 22, especially for the Mossdale

TABLE 4–3
The raw abundance and composition of fishes entrained at the HORB in 2003. Chinook salmon catch is divided into CWT salmon, unmarked salmon, and color-marked salmon.

Species	Catch
American Shad	1
Western Mosquitofish	1
Spotted Bass	1
Warmouth Bass	1
Yellowfin Goby	1
Petromyzontidae	2
Golden Shiner	2
Prickly Sculpin	2
Steelhead	**2**
Black Crappie	4
Tule Perch	4
Largemouth Bass	5
Bigscale Logperch	6
Striped Bass	7
Green Sunfish	9
Ameiurus Spp.	12
Inland Silverside	13
Redear Sunfish	13
Bluegill	37
Splittail	**45**
Goldfish	58
Sacramento Sucker	65
Channel Catfish	161
Threadfin Shad	273
Common Carp	383
White Catfish	1,170
Total Chinook Salmon	**4,872**
CWT VAMP Salmon	1,819
CWT NonVAMP Salmon	692
Unmarked Salmon	1,937
Color-Marked Chinook Salmon	308
TOTAL	**7,150**

evening released fish (Figure 4-4). For the set of second VAMP release, the highest salmon entrainment occurred during the night of April 29 (Figure 4-5). The loss indices for the first Durham Ferry and Mossdale releases were 0.5% and 1.6%, respectively. The loss indices for the second Durham Ferry and Mossdale releases were 0.3% and 0.8%, respectively. Within the Mossdale releases, the highest loss indices were for the releases that occurred in the evening: 3.1% for the first release and 1.5% for the second release. Both of the day releases at Mossdale had a loss index of 0.1%. The overall loss index for VAMP CWT salmon was 0.7%. This year's overall loss index was lower than in 2002 (1.5%) but similar to 2001 (0.5%) and 2000 (0.8%) loss indices.

For the entire monitoring duration, the mean ±SD CPUE for VAMP salmon per culvert was 1.1 ± 3.3 fish/hour. The highest CPUEs occurred soon after the VAMP releases, with a maximum CPUE of 25.1 fish/hour on April 22. The mean unmarked smolt CPUE (1.2 ± 2.2) was similar to the VAMP CPUE. The highest unmarked CPUE (12.2) occurred April 27. VAMP mean salmon CPUE was similar between the flood (1.3 ± 4.0) and ebb (1.2 ± 3.0) tides, and slightly higher at night (1.2 ± 3.0) than during the day (0.8 ± 3.2). Unmarked mean CPUE was similar between the flood (1.1 ± 2.2) and ebb (1.3 ± 2.2) tides, and higher at night (2.6 ± 2.8) than during the day (0.5 ± 0.4).

To address tidal and diel effects, color-marked smolts were released on various tidal and diel period combinations. The first releases went well; however, like last year, some problems were encountered during the second release when an unknown number of smolts escaped from the holding pens before their intended release. Although some salmon escaped, entrainment rates were higher for the second releases (1.7%) than the first releases (0.8%) (Table 4-4). The overall color-marked salmon entrainment rate was 1.3%. More smolts were caught at night than during the day, and more smolts were entrained during the flood than the ebb tide.

Culvert number 4 entrained about half as many salmon as culvert numbers 5 and 6. (Figure 4-6). This is in contrast to 2002 results in which culvert number 4 entrained the most salmon and culvert number 6 the least. While the mean CPUE for unmarked fish caught at night was about 5 times greater than during the day, the total number of unmarked fish entrained was almost 11 times more during the night than during the day.In contrast to the unmarked salmon, only twice as many CWT salmon and 3.5 times as many color-marked salmon were entrained at night (Table 4-5).

TABLE 4–4
The percentage of color-marked salmon entrained for various diel and tidal stages. Due to some salmon escaping from their live-cages the number of salmon released was estimated for the second releases.

	No. Release	Diel	Tide	Entrained	Percent Recovered
First Releases (22 & 23 April)	3,005	Night	Flood	91	3.0%
	3,008	Night	Ebb	3	0.1%
	2,997	Day	Flood	1	0.0%
	3,014	Day	Ebb	6	0.2%
Total	12,024			101	0.8%
Second Releases (29 & 30 April)	3,000	Night	Flood	80	2.7%
	2,990	Night	Ebb	104	3.5%
	3,000	Day	Flood	18	0.6%
	2,980	Day	Ebb	6	0.2%
Total	11,992			208	1.7%

TABLE 4–5
The total number of CWT and Unmarked salmon caught per culvert by diel period.

		Culvert Number			Total
		4	5	6	
CWT	Day	141	407	313	861
	Night	356	569	801	1,726
Unmarked	Day	22	59	54	135
	Night	261	603	701	1,565
Color-marked	Day	16	32	20	68
	Night	27	101	112	240

No current velocity meter was used this year; however, DWR installed a flowmeter in culvert number 4. Flow data for culvert number 4 was recorded throughout the monitoring period. Simple linear regression analysis indicated CWT salmon showed no significant relationship between CPUE and flow (df=65, P=0.11, r2=0.04) and unmarked salmon showed a weak positive relationship (df=65, P<.01, r2=0.10) (Figure 4-7).

FIGURE 4–5

The average number of salmon per hour entrained at the HORB, by tidal stage, for the second VAMP salmon release. Salmon release times are marked by dashed lines. River stage for Old River is indicated by solid line.

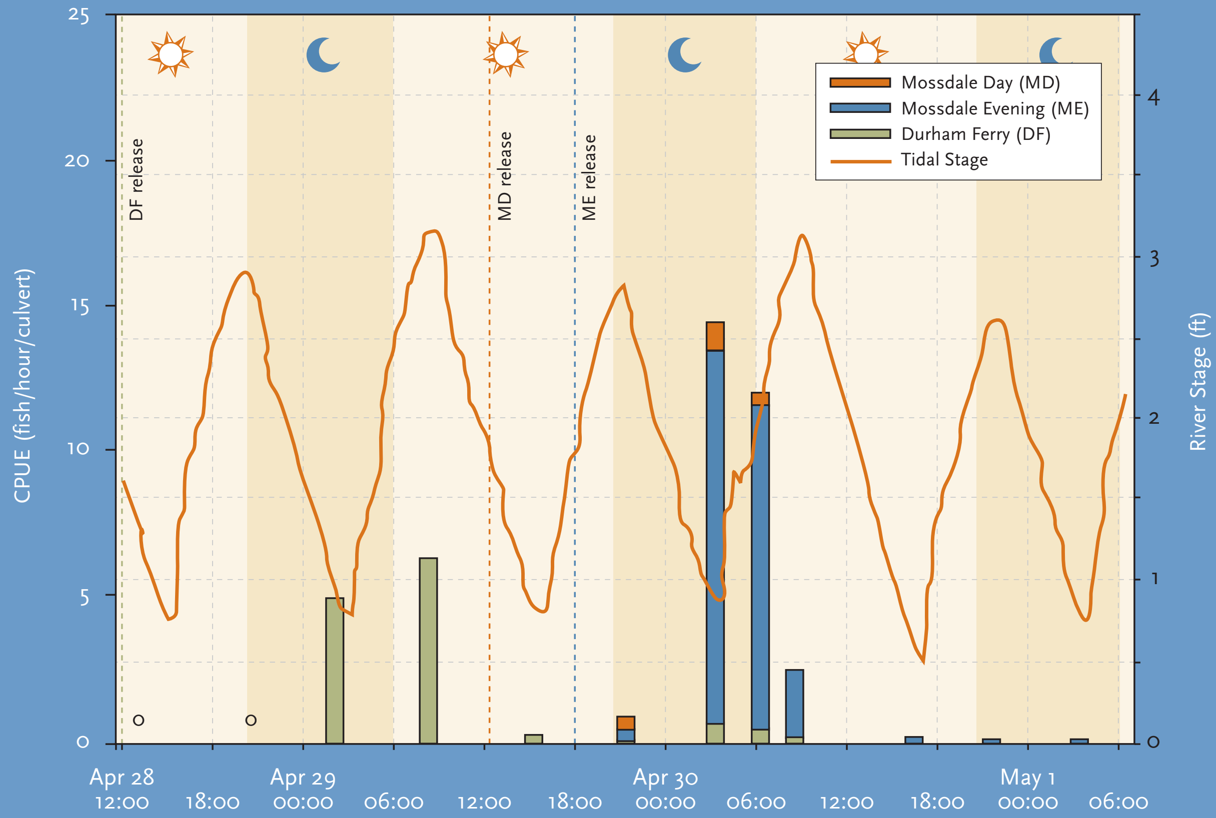


FIGURE 4–6

The total number of unmarked, color marked, and VAMP salmon caught by culvert. Culvert numbers 1–3 were closed in 2003.

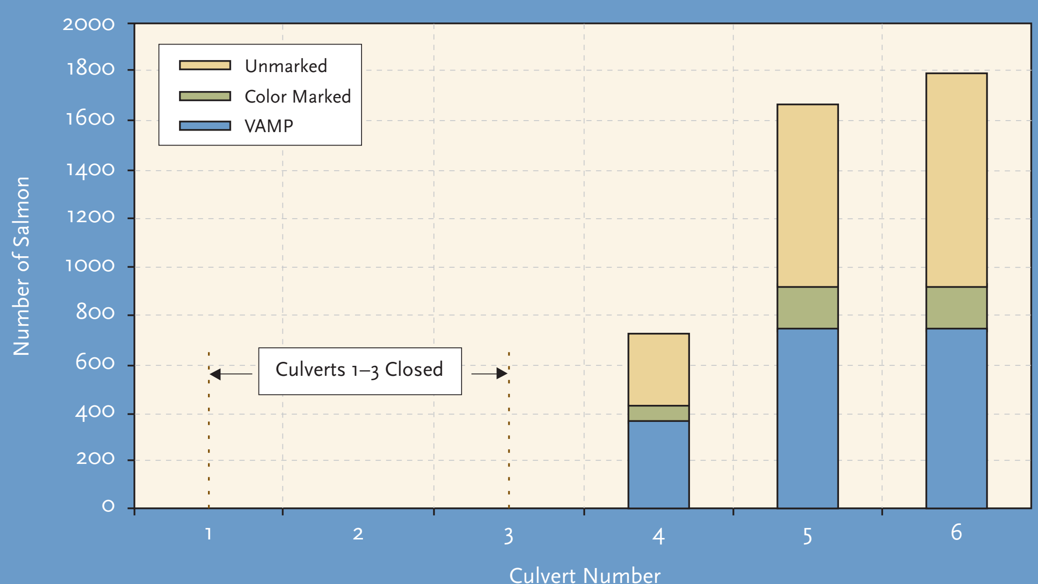
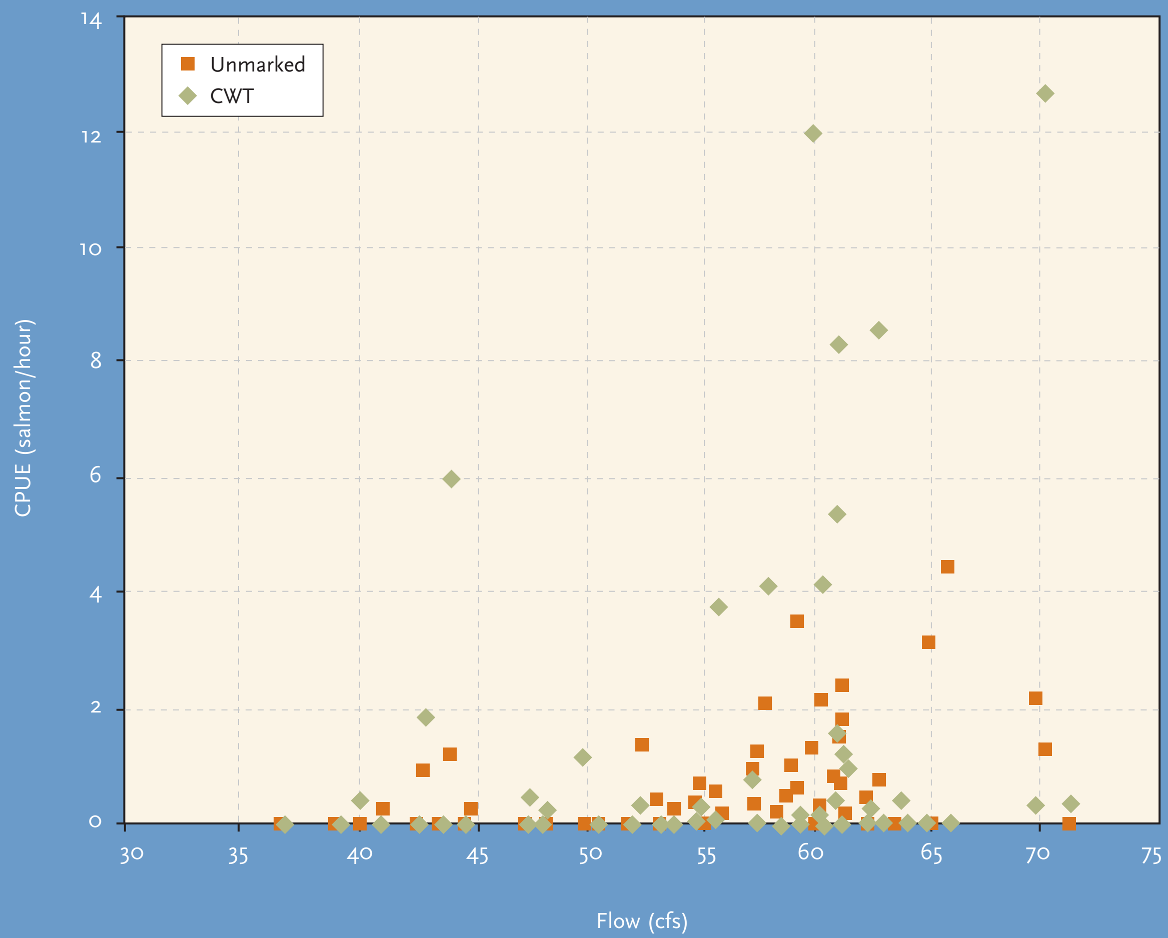


FIGURE 4–7

Relationship between salmon entrainment and flow in culvert number 4.



DISCUSSION

Although only half of the culverts were open during the VAMP experiment, some patterns in salmon entrainment were similar to previous years, e.g. higher entrainment at night, and more salmon were entrained from the first releases than the second releases. Interestingly, with fewer open culverts, the overall mean salmon entrainment rate was higher this year than in previous years. The higher entrainment rate was mostly due to the non VAMP salmon. It is possible that the salmon that would normally be entrained in the first three culverts, which were closed, were lingering around the culvert structure and some were subsequently entrained in the three open culverts. Even though the VAMP released salmon loss index was lower than in 2002, the rate at which the salmon were entrained was similar. If all six culverts were open in 2003, the estimated VAMP salmon loss index of 1.4% (estimated by multiplying the 3 culvert loss index by 2) would be similar to last year's loss index.

Tidal stage may affect salmon entrainment. Although the mean entrainment rate between the flood and ebb tides was similar, a closer look at when the salmon were released and when they first arrived at the HORB reveals that there are some tidal entrainment differences. As in previous years, more salmon were entrained from the first set of VAMP releases than the second set of releases. This difference could be due to the tides, assuming the survival rate to the HORB was the same for each of the releases. The first evening release at Mossdale resulted in the highest entrainment near dusk: 469 of the Mossdale salmon were entrained within 3.5 hours of their release.

However, seven days later, only 5 of the evening released Mossdale salmon were entrained within 3 hours of their release. The highest entrainment occurred closer to dawn: 240 salmon. After the first VAMP Mossdale release, a relatively strong ebb tide occurred during the afternoon and evening. Low slack water occurred soon after dark. The low tide caused a relatively large head difference between upstream and downstream water levels as salmon arrived at the HORB. The resulting increase in flow through the culverts, due to the head difference, probably played a role in the high entrainment of Mossdale salmon. In contrast, a week later, high slack water occurred at dusk. Consequently, there was less head difference between upstream and downstream water levels which may have contributed to the lower salmon entrainment. The following morning, when the low tide occurred, salmon entrainment increased considerably. The Mossdale evening results are similar to last year's VAMP results which suggested entrainment is affected by tidal stage near the HORB.

The results for the Mossdale evening releases were different than the day releases. More salmon were entrained from the two evening releases than for all the other VAMP releases combined. Very few of the Mossdale day released fish were caught. This is also in contrast to the previous years when the daytime released fish at Mossdale were typically entrained at a slightly higher rate (1.2%) than they were in 2003 (0.1%). The Mossdale day released salmon that were entrained followed the same pattern as the evening released fish. More salmon were entrained during the evening for the first release and more during the early morning for the second release. It is also possible the day and evening released fish are behaving differently as they move downstream. The day released fish could be migrating down the main channel as they pass the barrier. The evening released fish could be migrating closer to shore, and lower in the water column, where they are more vulnerable to entrainment. The overall higher salmon entrainment at night, than during the day, is similar to previous years' results. The higher nighttime entrainment results of VAMP salmon could be confounded by the daytime release of the salmon. Due to the timing of the VAMP release and the distance of the release sites from the HORB, a majority of the fish may pass by the barrier at night.

Diel entrainment of unmarked salmon differed from the VAMP salmon. Overall, 59% of the entrained VAMP salmon were caught at night compared to 92% of the unmarked salmon. In 2002, about 75% of both the entrained VAMP and unmarked salmon were caught at night. The proportionately higher entrainment of unmarked salmon at night, when compared to the VAMP salmon, suggests the VAMP released fish are not behaving the same as the unmarked fish at the HORB. However, without knowing how many unmarked salmon passed the barrier and what percent was entrained, we can only speculate whether this difference is meaningful. In contrast to the diel results, the tidal results were similar to the overall VAMP salmon tidal results. Entrainment on the flood and ebb tides was similar.

The results for the Mossdale evening releases were different than the day releases. More salmon were entrained from the two evening releases than for all the other VAMP releases combined. Very few of the Mossdale day released fish were caught.

Results from the Entrainment Special Study are similar to last year's Entrainment Special Study results. More color-marked salmon were entrained on a flood tide than on an ebb tide, and more were entrained at night than during the day. Marked salmon were entrained at the highest rate during a night-flood for the first release. Very few color-marked salmon were entrained on the night-ebb, day-flood and day-ebb. During the second release, slightly more salmon were caught on the night-ebb. The reason for the low entrainment during the first release is unknown. Although only three culverts were open, the overall color-marked salmon entrainment was similar to last year (1.3% compared to 1.7%). It is possible attraction to the culvert structure, or localized current patterns caused the salmon to linger near the culverts and be entrained.

The low fish entrainment in culvert number 4 was surprising. Salmon entrainment was roughly half of the entrainment in culvert numbers 5 and 6. Debris or something could have been partially obstructing culvert number 4. The measured flows through the culvert were lower than the calculated flows. However, the lower flows in the culvert could be due to net resistance or other factors that affected all three culverts equally. We were unable to measure flows in all three culverts to see if there was a difference among culverts. If entrainment is

It is recommended that VAMP continue delaying the first salmon release by at least 5 days after the closure of the HORB. The delay allows for the completion of the barrier and minimizes the field crew's exposure to heavy equipment operation. The split releases at Mossdale should also be continued to help us better understand how tidal-diel interactions affect salmon entrainment at the HORB.

affected by the amount of flow through the culvert, then higher salmon entrainment should occur at higher flows. In culvert number 4, there was no relationship between CWT salmon entrainment and flow, and only a slight positive relationship between increasing flow and entrainment of unmarked salmon. The reduced catch of salmon in culvert number 4 relative to the other culverts suggest something might have been affecting the flow through the culvert and thus affecting the flow-entrainment relationship.

In summary, the results from the 2003 Entrainment Monitoring Study and the Entrainment Special Study suggest salmon are more vulnerable to entrainment at night. The tidal effects on entrainment are still unclear. Water velocities through the culverts are greatest on a low tide, near slack water. Salmon entrainment should be highest at this time which was somewhat evident for the Mossdale released fish. However, no significant relationship was found between CWT salmon entrainment and flow through culvert number 4. Only a weak positive relationship was found for unmarked salmon entrainment and flow in culvert number 4. The changing hydraulics surrounding the barrier as the tide changes effects flows near the culverts which may affect entrainment. Salmon smolt behavior and relative abundance near the barrier may play an important role in entrainment vulnerability.

It is recommended that VAMP continue delaying the first salmon release by at least 5 days after the closure of the HORB. The delay allows for the completion of the barrier and minimizes the field crew's exposure to heavy equipment operation. The delayed VAMP salmon releases also allows time for any loose material near the culverts to pass through the culverts before the nets are attached. In 2003, no samples were lost to gravel accumulation in the nets. The split releases at Mossdale should also be continued to help us better understand how tidal-diel interactions affect salmon entrainment at the HORB. If feasible, a release should be made at noon and midnight.

CHAPTER 5

Salmon Smolt Survival Investigations

One of the primary objectives of the VAMP program is to identify how San Joaquin River flows and SWP and CVP export rates, with the HORB in place, affect the survival of juvenile Chinook salmon emigrating from San Joaquin River system. This section describes the methods used to conduct the VAMP 2003 Chinook salmon smolt survival investigations, and presents the calculated survival indices, absolute survival estimates and combined differential recovery rates for coded-wire tagged juvenile Chinook salmon released during the VAMP 2003 test period. We also analyzed how the survival varied with flow, and flow relative to exports, with and without the HORB. Ocean recovery information on past releases and catches of unmarked juvenile salmon at Mossdale and in CVP/SWP salvage are also discussed. Additional data and information related to the salmon survival investigations are presented in Appendix C.

CODED-WIRE TAGGING

Merced River Fish Facility Chinook salmon smolts, released as part of VAMP 2003, were coded-wire tagged (CWT) between March and early April. After the salmon were tagged, they were held in the hatchery for at least 21 days before being released. Sub-samples of these salmon were measured (for fork length) and checked for retention of tags a day or two prior to release. Sub-samples were comprised of approximately 200 salmon collected from the top, middle, and bottom of the release group's raceway. Although tag detection is usually high, all salmon from the sub-samples without a detected tag were sacrificed to verify the accuracy of the CWT detection process. Sacrificed salmon were dissected to determine whether they contained a non-magnetized tag, an undetected tag, or no tag. Each CWT code within a release group was held separately at the hatchery with the exception of the two Durham Ferry releases. Each of these releases was comprised of three CWT codes that were held together at the hatchery.

At release, an additional sub-sample of 25 salmon was sacrificed from each tag group to verify CWT code, except at Durham Ferry. Fifty fish were sampled from each of the Durham Ferry releases because tag codes were combined prior to release.

Coded-wire tag retention rates were typical in 2003, ranging between 93 and 97.5% (Table 5-1). Coded-wire tag retention rates appeared higher than last year, with an overall retention rate of 94.5% for 2003 VAMP groups compared to 90.5% for 2002. Coded-wire tag retention rates were used to estimate the effective release size used in calculating survival indices (Table 5-1). The effective number released (ER) was calculated using the following equation:

$$ER = (T - M) \times TR$$

Where:

T = *estimated number transported,*

M = *number of mortalities during release and transport (includes those sacrificed as part of the net pen evaluations), and*

TR = *CWT retention rate*

CODED-WIRE TAG RELEASES

Two sets of CWT salmon releases were made as part of the 2003 VAMP experiment. The first set occurred on April 21 at Durham Ferry, April 22 at Mossdale, and April 25 at Jersey Point. The second set of releases occurred on April 28 at Durham Ferry, April 29 at Mossdale, and May 2 at Jersey Point.

For each set of releases approximately 75,000 salmon, divided among three CWT codes with approximately 25,000 fish, were released at Durham Ferry. Approximately 50,000 fish, divided between two CWT codes, were released at Mossdale. Approximately 25,000 fish with one CWT code were released at Jersey Point (Table 5-1). Prior to VAMP 2000, all CWT groups were trucked from the hatchery and released as a single group. However, since VAMP 2000, a new transport trailer with three tanks has allowed each CWT group to be transported to its

TABLE 5–1
Coded-wire tag (CWT) retention rates and estimated release numbers for juvenile chinook salmon released for VAMP 2003

Release Site	Release Date	CWT Code	CWT Retention Sample Size	CWT Retention %	Estimated Number Transported	Mortalities After Transport[1]	Estimated Number Released	Effective Number Released
Durham Ferry[2]	4/21/03	06-02-82	199	94.97	25,862	114	25,748	24,453
		06-02-83		94.97	27,414	114	27,300	25,927
		06-27-42		94.97	25,458	114	25,344	24,069
Mossdale	4/22/03	06-27-43	201	94.53	26,955	284	26,671	25,212
		06-27-48	200	93.50	26,464	292	26,172	24,471
Jersey Point	4/25/03	06-27-44	200	93.00	26,504	252	26,252	24,414
Durham Ferry[2]	4/28/03	06-27-45	200	95.00	26,121	137	25,984	24,685
		06-27-46		95.00	26,651	137	26,514	25,189
		06-27-47		95.00	26,061	137	25,924	24,628
Mossdale	4/29/03	06-27-49	189	93.12	26,028	61	25,967	24,180
		06-27-50	201	94.03	26,061	169	25,892	24,346
Jersey Point	5/2/03	06-27-51	200	97.50	26,615	264	26,351	25,692

[1] Mortalities include juvenile Chinook salmon held and later sacrificed for the net pen studies.
[2] Coded-wire tag codes were combined at the hatchery. Therefore, CWT retentions are for all three tag codes combined and mortalities were divided equally among the three tag codes.

TABLE 5–2
Release time, temperatures, fork length (FL), and effective number released for juvenile Chinook salmon released for VAMP 2003, by coded-wire tag (CWT) code.

Release Site	Date	CWT Code	Release Time	Truck Temp (°F)	Release Temp (°F)	Average FL (mm)	Effective Number Released
Durham Ferry	4/21/03	06-02-82	1245	51.8	59.0	86	24,453
		06-02-83		51.8	59.0		25,927
		06-27-42		51.8	59.0		24,069
Total							74,449
Mossdale	4/22/03	06-27-43	1200	51.8	58.6	86	25,212
		06-27-48	1800	55.4	59.9	86	24,471
Total							49,683
Jersey Point	4/25/03	06-27-44	1800	56.0	62.0	88	24,414
Durham Ferry	4/28/03	06-27-45	1215	53.0	62.0	86	24,685
		06-27-46		53.0	62.0		25,189
		06-27-47		53.0	62.0		24,628
Total							74,502
Mossdale	4/29/03	06-27-49	1245	55.0	60.0	87	24,180
		06-27-50	1800	55.0	61.0	88	24,346
Total							48,527
Jersey Point	5/02/03	06-27-51	1145	55.0	59.0	89	25,692

release site in a separate tank and released. As mentioned earlier, each Durham Ferry group consisted of three tag codes which were already mixed at the hatchery and were therefore transported in a large, single tank, release truck.

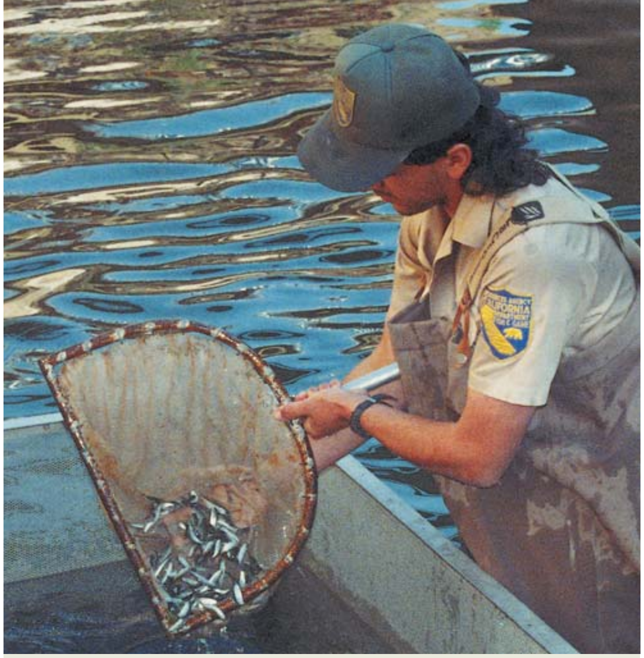
Release strategies were similar to VAMP 2002, except at Mossdale. Both Durham Ferry releases were made from the more desirable location alongside the river, instead of from the top of the levee. The nearby agricultural diversion was turned off from the time of the releases until several hours after each release to allow the tagged salmon time to disperse from the release site. Releases at Jersey Point were made one hour prior to the beginning of the flood tide to increase dispersion of the tagged fish before they passed Antioch and Chipps Island. Water temperatures in the hatchery trucks and at the release sites were measured immediately prior to release (Table 5-2). In all cases, differences between water temperatures in the transport trucks and the release site were less than 5°C (9°F). Releases at Mossdale and Durham Ferry were not made on any specific tidal condition.

Both of the Mossdale releases were divided by CWT code, into afternoon (around 1200) and evening (around 1800) releases (Table 5-2). The two tag groups were released at different times to test day and night differences in entrainment at the HORB (see Chapter 4). We also planned to test if survival differed between the two release strategies; however, low recoveries prevented evaluation of survival by release time this year. If this release strategy is continued, we may be able to test for differences in survival in the future.

WATER TEMPERATURE MONITORING

Water temperature was monitored during the VAMP 2003 study using individual computerized temperature recorders (e.g., Onset Stowaway Temperature Monitoring/Data Loggers). 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). Water temperature was recorded at 24-minute intervals throughout the period of the VAMP 2003 investigations. Water temperatures were also recorded within the hatchery raceways at the Merced River Hatchery coincident with the period when juvenile Chinook salmon were being tagged. These temperature recorders were later transported with the juvenile salmon released at Durham Ferry.

Results of water temperature monitoring within the Merced River Fish Facility showed that juvenile Chinook salmon were



Results of water temperature monitoring showed that water temperatures at the release locations and throughout the lower San Joaquin River and Delta (Appendix C-2) were higher than those at the hatchery.

reared in, and acclimated to, water temperatures of approximately 10.5°–14°C (51°–57°F) prior to release into the lower San Joaquin River (Figures 5-1 and 5-2). Results of water temperature monitoring at Durham Ferry and Mossdale following the first and second sets of VAMP 2003 releases are compared in Figures 5-3 and 5-4. No temperature data were available for Jersey Point (the recorder was lost). Results of water temperature monitoring showed that water temperatures at the release locations and throughout the lower San Joaquin River and Delta (Appendix C-2) were higher than those at the hatchery. Water temperatures measured within the lower San Joaquin River and Delta were not expected to result in mortality or adverse effects to emigrating juvenile Chinook salmon released as part of the VAMP 2003 investigations. A comparison of water temperatures measured at Durham Ferry during VAMP 2002 and VAMP 2003 (Figure 5-5a) showed that temperatures were similar during the two years. A comparison of temperatures at downstream locations showed that temperatures were generally higher during VAMP 2002 when compared to the VAMP 2003 test period (Figures 5-5b–5-5d).

WATER TEMPERATURE MONITORING RESULTS:

Water temperatures measured within the lower San Joaquin River and Delta were not expected to result in mortality or adverse effects to emigrating juvenile Chinook salmon released as part of the VAMP 2003 investigations.

FIGURE 5–3

Site 1—Durham Ferry.

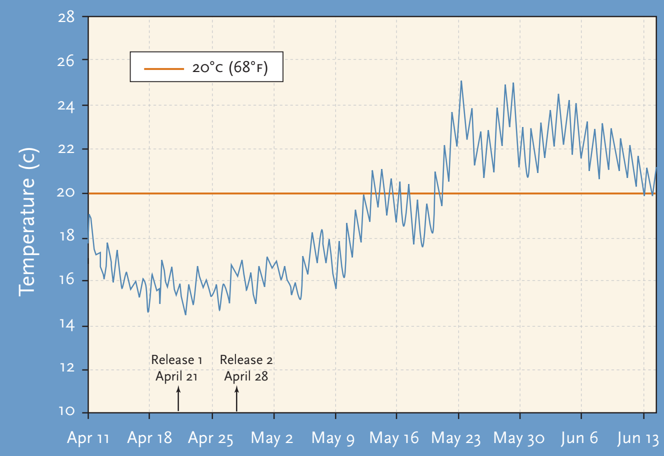


FIGURE 5–1

Merced River Fish Hatchery—1.

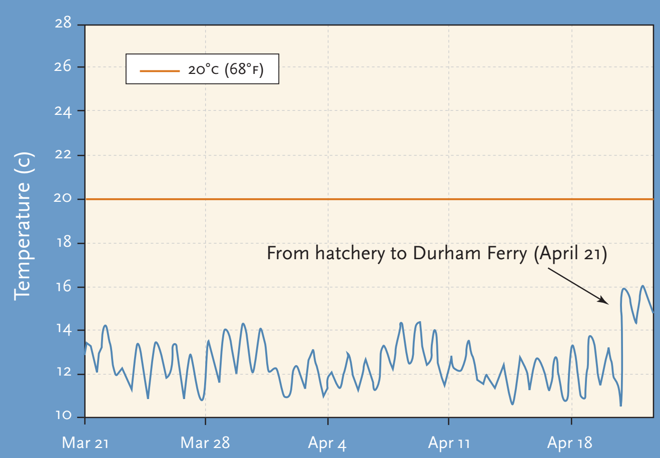


FIGURE 5–4

Site 2—Mossdale.

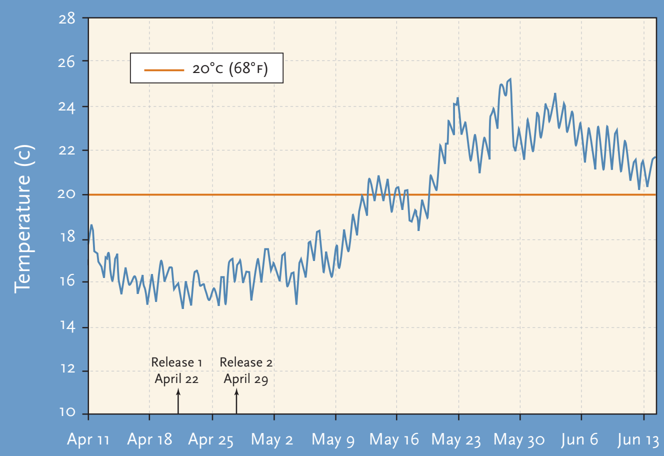


FIGURE 5–2

Merced River Fish Hatchery—2.

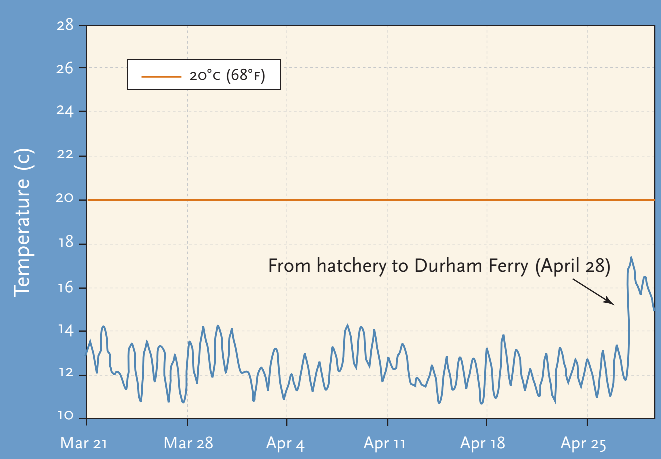


FIGURE 5–5A

Site 1—Durham Ferry.

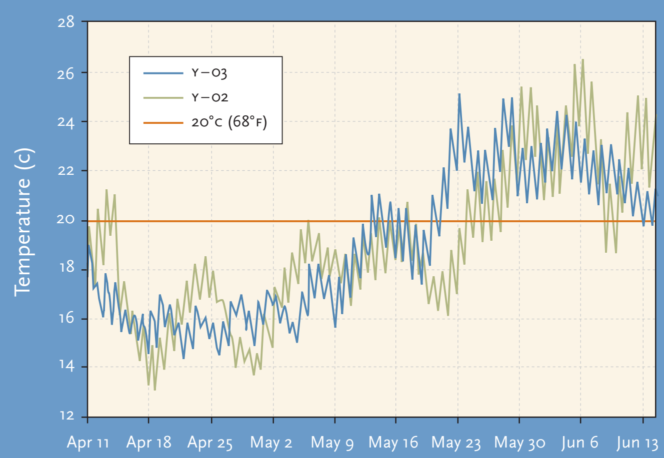


FIGURE 5–5B

Site 4—DWR Monitoring Station.

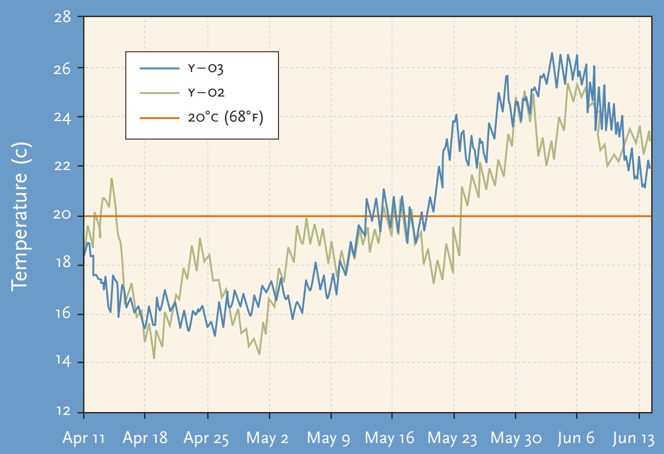


FIGURE 5–5C

Site 7—1/2 mile upstream of Channel Marker 13.

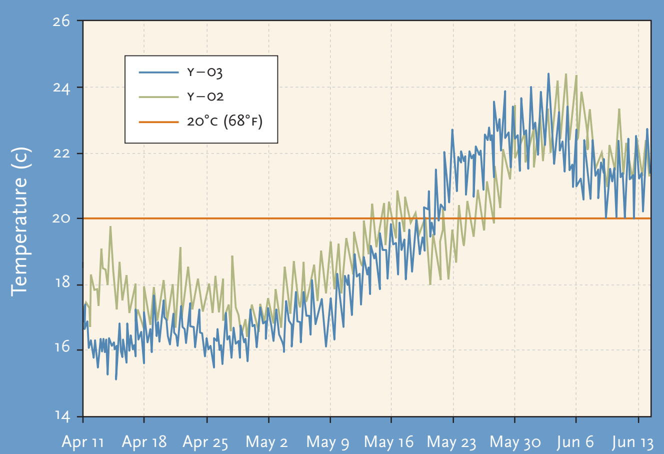
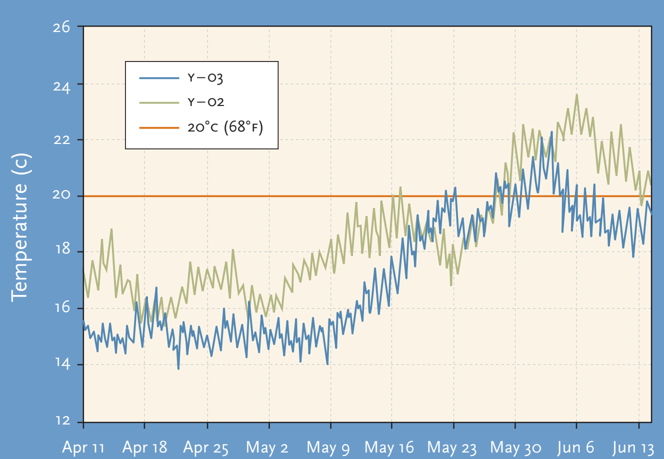


FIGURE 5–5D

Site 10—Chipps Island.



POST-RELEASE NET PEN STUDIES

Survival and Condition

Post-release survival and condition of marked salmon were evaluated as part of the VAMP program using sub-samples of marked salmon from each release group. Twenty-five salmon from each CWT group were evaluated for general condition immediately after release. To assess general condition, fork length in millimeters, weight in grams, and six other characteristics were examined (Table 5-3). Other obvious abnormalities or deformities were also noted. To assess short-term effects of handling, transport, and release, an additional sub-sample of approximately 200 salmon from each tag code were held at the respective release sites for 48 hours. Of these, 25 were measured, weighed, and examined for the six general condition characteristics. The remaining fish were measured, weighed, and evaluated for adipose fin clips and short-term mortality. Because CWT codes were held together for the Durham Ferry releases, 50 fish from these release groups (all three CWT codes combined) were evaluated for general condition immediately and 48 hours after release, and two net pens with approximately 200 fish each were held in order to maintain consistency with the other release groups. In all, 499 juvenile Chinook salmon were examined for the six general condition characteristics, and 2,038 (including the 499 examined for general condition) were measured, weighed, and assessed for mortality and presence/absence of an adipose fin clip.

Results of the evaluations of the 499 marked salmon examined for the six general condition characteristics showed few abnormalities (see Appendix C-3). The majority of fish examined had normal coloration (99.2%), no fin hemorrhaging (100%), normal eye characteristics (99.2%), and normal gill color (92.4%). Scale loss ranged from 1% to 35% and averaged 8.6%. Other abnormalities included: fin rot (1%), dorsal fin splitting (0.8%), partial operculum (1%) and ragged dorsal fins (1%). In addition, this year 65 (3%) Chinook salmon had a poor or incomplete adipose fin clip, while 11 (0.5%) had no fin clip. Of the 2,038 juvenile Chinook salmon examined, there were 11 mortalities. In contrast, we observed no mortalities in 2002.

Tag Quality Control

Though rare, in the past, salmon from different release groups have been unintentionally mixed at some point prior to release. The subset of 25 salmon from each tag group (a total of 25 from each of the Durham Ferry net pens) evaluated for condition as described above were sacrificed to verify purity of tag codes.

TABLE 5–3
Smolt condition characteristics assessed for post-release net pen studies.

	Normal	Abnormal
Eyes	Normally shaped	Bulging
Color	High contrast dark dorsal surface and light sides	Low contrast dorsal surface and sides, coppery color
Fin Hemorrhaging	No blood or red at base of fins	Blood at base of fins
Percent Scale Loss	Lower relative numbers better based on 0–100% scale loss	Higher relative numbers worse based on 0–100% scale loss
Gill Color	Dark beet red to cherry red gill filaments	Light red to gray gill filaments
Vigor	Active swimming (prior to anesthesia)	Lethargic or motionless (prior to anesthesia)

In 2003, there were no errant tags codes associated with the VAMP 2003 net pen study. The remaining fish from each release group that were held in the net pens were archived in a freezer for further evaluation of tag code mixing if deemed necessary.

Health and Physiology

Personnel from the USFWS's California-Nevada Fish Health Center conducted physiological studies on a sub-sample of the juvenile Chinook salmon used in the VAMP study (Nichols and Foott 2003). Results of this work are summarized below.

A total of 284 Merced River Fish Facility fish were examined from the six release groups following transport to release sites at Durham Ferry, Mossdale, and Jersey Point. A general health inspection for viral, *Renibacterium salmoninarum* (Bacterial Kidney Disease agent) and systemic bacterial infection was performed on 60 fish from the first Mossdale release. Additional assays were conducted on the remaining 224 fish including: (1) internal and external abnormalities were recorded for each smolt; (2) smolt development was assessed (gill tissue was analyzed for ATPase activity from 64 fish, spread out over all release groups); and, (3) kidney tissue from 48 fish was examined for presence of *Tetracapsula bryosalmonae*, the parasite responsible for Proliferative Kidney Disease (PKD). To assess stress recovery, blood plasma levels of chloride, sodium, lactate, glucose, total protein, and cortisol were measured. At each release site, blood samples were taken from 7 to 16 fish directly out of the transport truck, and after being held in net pens for two and four hours after release. Because of time and personnel constraints, samples were not taken for fish held two and four hours after release for the second Mossdale release. Additional blood samples were taken and analyzed at 24 hours post-release for both Durham Ferry releases and for the second Jersey Point release.

No viral pathogens or *R. salmoninarum* were detected in the 60 fish sample. Low levels of bacteria common in the skin and gastrointestinal tract of fish were isolated from 30% of these fish. These isolations were not considered to be significant health risks. *Tetracapsula bryosalmonae* was detected in 63% of the 48 kidneys examined by histology and 21% showed severe inflammation caused by the parasite. Gross clinical signs (swollen kidney or spleen) of PKD were observed in 11% of the 222 smolts examined. Proliferative Kidney Disease infection was more prevalent in the second set of releases (21% for second releases combined) than the first set (3% for first releases combined; $p<0.001$, z-test). Because PKD can reduce performance due to associated kidney dysfunction and anemia, smolts in the first release groups may have had higher survival than cohorts in the second release groups.

All sample groups demonstrated similar levels of smolt development as demonstrated by gill ATPase activity. Observed ATPase levels were consistent with fish undergoing smoltification.

There were few consistent patterns in blood chemistry values among the release groups. It appears that net pen confinement failed to reduce stress on the transported fish as indicators of stress (cortisol, glucose, and lactate) tended to remain altered throughout sampling (up to 24 hours). Plasma chloride was below normal in four of five groups at four hours post-release, but did return to normal in the 24 hour samples. No biologically significant shifts in plasma protein levels were detected in any group. Comparisons of the release groups are complicated by differences in transport time and handling prior to placement in net pens. The variations created by these differences may hide some trends in blood chemistry values that signal survival differences in the release groups. There may also be problems with extrapolating blood chemistry values of smolts held in net pens to those released into the river.

TABLE 5–4

Survival Indices at Antioch and Chipps Island and expanded salvage at the Central Valley Project (CVP) and State Water Project (SWP) Fish Facilities for the 2003 VAMP Study (drafted: 10/22/03)

Tag Code	Release Site	Date	Effective Number Released[1]	ANTIOCH Number Recovered	Minutes Fished[2]	Fraction of Time Sampled[3]	Survival Index[4]	Group Index
San Joaquin								
06-02-82	Durham Ferry		24,453	1	560	0.389	0.008	
06-02-83	Durham Ferry		25,927	4	1140	0.396	0.028	
06-27-42	Durham Ferry		24,069	1	560	0.389	0.008	
Total		4/21/03	74,449	6	2790	0.388		0.015
06-27-43	Mossdale		25,212	2	1140	0.396	0.014	
06-27-48	Mossdale		24,471	2	1690	0.391	0.015	
Total		4/22/03	49,683	4	3370	0.390		0.015
06-27-44	Jersey Point	4/25/03	24,414	71	6828	0.395	0.530	
06-27-45	Durham Ferry		24,685	0	–	–		
06-27-46	Durham Ferry		25,189	0	–	–		
06-27-47	Durham Ferry		24,628	0	–	–		
Total		4/28/03	74,502	0			–	–
06-27-49	Mossdale		24,180	0	–	–		
06-27-50	Mossdale		24,346	0	–	–		
Total		4/29/03	48,526	0			–	–
06-27-51	Jersey Point	5/02/03	25,692	36	5622	0.390	0.258	

In summary, the incidence of clinical PKD was notably higher in smolts used for the second set of releases compared to smolts from the first set of releases. Consequently, survival of smolts from the second set of releases may be reduced in comparison to cohorts from the first releases. No biologically significant differences in smolt development or stress response were detected among fish from the different release times or sites. Plasma ion balance was disturbed in fish held in net pens for up to four hours post-release but returned to normal by 24 hours.

CODED-WIRE TAG RECOVERY EFFORTS

Coded-wire tagged salmon were recaptured at Antioch and Chipps Island, at CVP and SWP fish salvage facilities, and during sampling at HORB (for locations see Figure 1-1). Coded-wire tagged salmon released upstream of, and at, Mossdale were also recovered in DFG Kodiak trawls at Mossdale but are not discussed in this report. Juvenile Chinook salmon with an adipose fin clip (which identifies CWT salmon) caught at any of these sampling locations were sacrificed, labeled, and frozen for CWT processing. Coded-wire tag processing was done by USFWS (Stockton) for fish recovered at Chipps Island, Antioch, and SWP and CVP salvage facilities. DFG Region IV processed salmon captured in the HORB fyke net sampling.

Coded-wire tags are processed by dissecting each tagged fish to obtain the half (0.5 millimeters) or full (1 millimeter) cylindrical CWT from the snout. Tags are then placed under a dissecting microscope and the numbers are read and recorded in a database. All tags were read twice, and any discrepancies

CHIPPS ISLAND					Expanded Salvage Numbers[5]	
Number Recovered	Minutes Fished[2]	Fraction of Time Sampled[3]	Survival Index[4]	Group Index	CVP	SWP
0	–	–	–		24	0
2	2394	0.277	0.036		12	0
1	400	0.278	0.019		12	3
3	2394	0.277		0.019		
3	2379	0.275	0.056		0	0
2	1185	0.274	0.039		0	0
5	2379	0.275		0.048		
57	4779	0.277	1.097		0	0
0	–	–	–		12	0
0	–	–	–		12	0
0	–	–	–		0	0
0						
0	–	–	–		12	0
1	400	0.278	0.019		0	0
1	400	0.278		0.010		
39	3460	0.267	0.739		0	0

[1] The Effective Number Released is an estimate of the number of fish released with an adipose fin clip and CWT.

[2] The Minutes Fished is the number of minutes sampled between the first and last day of recovery.

[3] The fraction of time sampled is between the first and last day of recovery.

[4] The survival index is calculated using the formula: # recovered /(# released x fraction of time sampled x fraction of channel sampled)

[5] Expanded salvage numbers are: the number recovered in salvage/(minutes sampled/total minutes between samples)

were resolved by a third reader. Tags were archived for future reference. VAMP releases comprise a small portion of the total tagged salmon released in the Sacramento and San Joaquin system. Consequently, many tags recovered at Chipps Island, Antioch, the SWP and CVP salvage facilities, and other locations are from CWT releases not affiliated with VAMP. It is necessary to read all recovered tags to identify CWT recoveries related to VAMP.

SWP and CVP Salvage Recapture Sampling

Sampling at the CVP and SWP fish salvage facilities was conducted approximately every two hours. The number of marked salmon collected (raw salvage) was expanded based on the number of minutes sampled during each two hour time period.

The estimated expanded total number of CWT salmon, from each release group, was obtained by adding together the expanded number of each tag group for all time periods. Only CWT salmon recovered in the raw salvage collections were sacrificed for tag processing. Expanded salvage is only a portion of the direct loss experienced by juvenile salmon at the facilities as it does not include losses prior to, and associated with, pre-screen predation, screening, handling and trucking.

Expanded salvage numbers were low at the CVP (n = 84), and only three Chinook salmon were salvaged at the SWP (Table 5-4). These results are consistent with earlier studies showing that the HORB reduces the number of CWT salmon entrained at the fish facilities (Brandes and McLain, 2001). Additional VAMP fish were recovered during special studies at the SWP (n = 13).

Antioch Recapture Sampling

Fish sampling was conducted in the vicinity of Antioch on the lower San Joaquin River (Figure 1-1) using a Kodiak trawl. The Kodiak trawl has a graded stretch mesh, from 2-inch mesh at the mouth to 1/2-inch mesh at the cod-end. Its overall length is 65 feet, and the mouth opening is 6 feet deep and 25 feet wide. The net was towed between two boats, sampling in an upstream direction. Trawls were performed parallel to the left bank, mid-channel, and right bank to sample CWT salmon emigrating from the San Joaquin River. Each tow was approximately 20 minutes in duration.

All captured fish were transferred immediately from the Kodiak trawl to buckets filled with river water, where they were held for processing. Data collected during each trawl included: species identification and fork length for each fish captured, tow start time and duration, and location in the channel. Any fish mortalities or injuries were documented to comply with the Endangered Species Act permit requirements.

Juvenile Chinook salmon with an adipose fin clip were retained for later CWT processing while other fish were released at a location downstream of the sampling site immediately after identification, enumeration, and measurement.

Sampling at Antioch began April 21 and continued through May 20. Each day between 5:00 a.m. and 9:00 p.m., anywhere from 3 to 32 tows were conducted. In all, 800 Kodiak trawl samples were collected, for a total of 15,877 tow minutes. During sampling, 6,971 unmarked juvenile Chinook salmon were captured; 341 salmon with an adipose fin clip (and CWT) were collected, 117 from VAMP releases (Table 5-4) and 214 from other hatchery releases. In addition, 1,328 delta smelt, 16 Sacramento splittail, 29 unmarked steelhead, and 43 adipose fin clipped steelhead were caught during sampling.

Chipps Island Recapture Sampling

As part of VAMP 2003 recovery efforts at Chipps Island, trawling shifts were conducted twice daily between April 21 and May 31. This second shift has been conducted during the spring releases since 1998. The first shift began at sunrise, while the second shift ended at or after sunset, to incorporate the crepuscular periods of the day. Based on analysis of 24-hour sampling at Jersey Point in 1997 (Hanson, Hanson Environmental, unpublished data), greater numbers of juvenile Chinook salmon appear to be caught around sunrise and sunset. Therefore, targeting this crepuscular period and doubling total trawl effort at Chipps Island should increase the number of CWT salmon recaptured and reduce variability in VAMP survival indices. Sampling for other studies occurs once daily between June 1 and June 14, and three days per week after June 16 and prior to April 21.

Midwater trawls were conducted at Chipps Island by towing the trawl net at the surface. The mouth of the net was 10 feet deep by 30 feet wide, and the total length was 82 feet. Aluminum hydrofoils were used on the top bridles and steel depressors, along with a weighted lead line, were used on the bottom bridles to keep the mouth of the net open. The net consisted of graded mesh starting with 4-inch mesh at the mouth and ending with a 1/4-inch cod end mesh.

To sample across the channel, trawling at Chipps Island was conducted in three distinct lanes: the north, south, and middle of the channel. Each lane was generally sampled at least three times per shift, with one lane sampled a fourth time during each shift. The lane sampled four times was chosen at random or selected by the boat operator based on flow conditions.

During the VAMP recovery period, 105 VAMP CWT Chinook salmon were recovered at Chipps Island (Table 5-4). In addition, 11,226 unmarked salmon, 711 CWT salmon from non VAMP experiments, 15 delta smelt, 11 Sacramento splittail, 12 unmarked steelhead, and 17 adipose fin clipped steelhead were collected.

VAMP CHINOOK SALMON CWT SURVIVAL

Survival Indices

Survival indices were calculated for marked salmon released at Durham Ferry, Mossdale, and Jersey Point and recovered at Antioch and Chipps Island. Survival indices (SI) were calculated using the formula:

$$SI = (R / (E*T*W))$$

Where:
R = the number recovered,
E = the effective number released,
T = the fraction of time sampled, and
W = the fraction of channel width sampled

The fraction of the channel width sampled at Chipps Island (0.00769) was calculated by dividing the net width (30 feet) by the estimated channel width (3,900 feet). The fraction of the channel width sampled at Antioch (0.01388) was calculated in the same manner, with the net width being 25 feet and the channel width being 1,800 feet. The fraction of time sampled at both locations was calculated based on the number of minutes sampled between the first and last day of catching each particular tag code or group, divided by the total number of minutes

Survival indices were calculated for each tag code to provide a sense of the variability associated with the group survival index.

in the time period. The fraction of time sampled for the VAMP 2003 release groups at Chipps Island was about 0.28, while at Antioch it was about 0.39 (Table 5-4).

Survival indices were calculated for each tag code to provide a sense of the variability associated with the group survival index. To generate the group survival index, the recovery numbers and release numbers were combined for the tag codes within a release group.

Individual and group survival indices to Antioch and Chipps Island of the CWT salmon released as part of VAMP 2003 are shown in Table 5-4. Survival indices have been reported to three significant digits, but we realize indices were not likely that precise. Survival indices were not corrected for the number of CWT fish recovered at the HORB or in sampling at Mossdale conducted by DFG Region IV.

The first set of VAMP releases appeared to survive at a higher rate than the second set of releases. The first Durham Ferry releases had survival indices to Antioch and Chipps Island of 0.015 and 0.019, respectively. The second Durham Ferry group had an unknown but likely lower survival rate since none were recovered at either location. The first releases at Mossdale had survival indices to Antioch of 0.015 and 0.048 to Chipps Island. No fish were recovered at Antioch from the second Mossdale release and the survival index to Chipps Island was 0.010. Survival indices for the two Jersey Point groups were 0.530 and 0.258 at Antioch and 1.097 and 0.739 at Chipps Island for the first and second releases respectively. Why survival was lower for the second groups relative to the first groups is unknown but may be related to the higher incidence of PKD.

Survival indices for both sets of releases made at Durham Ferry and Mossdale were very low relative to releases made at Jersey Point (Table 5-4).

Chinook Salmon Survival Estimates and Combined Differential Recovery Rates

More important than the differences in survival indices between sets of releases is the comparison of absolute survival estimates and combined differential recovery rates (CDRR). Absolute survival estimates (AS_i) are calculated by the formula:

$$AS_i = SI_u / SI_d$$

Where:

SI_u = *the survival index of the upstream group (Durham Ferry or Mossdale), to the recovery location*

SI_d = *the survival index of the downstream group (Jersey Point) to the recovery location and*

i = *recovery location (Antioch or Chipps Island).*

Although referred to throughout this document as absolute survival estimates they are more aptly described as standardized or relative survival estimates. The combined recovery rate (CRR) is estimated by the formula:

$$CRR = R_{C+A} / ER$$

Where:

R_{C+A} = *the combined recoveries at Antioch and Chipps Island of a CWT group, and*

ER = *the effective number released.*

The combined differential recovery rate (CDRR) is calculated by the formula:

$$CDRR = CRR_u / CRR_d$$

Where:

CRR_u = *the combined recovery rate for the upstream group (Durham Ferry or Mossdale), and*

CRR_d = *the combined recovery rate for the downstream group (Jersey Point).*

The CDRR is another way to estimate survival between the upstream and downstream release locations. It is similar to calculating absolute survival estimates, but does not expand estimates

FIGURE 5–6

Combined Differential Recovery Rates (CDRR) and (+/- 1 and 2 standard errors) of coded wire tagged (CWT) smolts released in 2003 at Mossdale and Jersey Point (Mossdale) and Durham Ferry and Jersey Point (Durham Ferry) for the first (1) and second (2) release groups. CWT smolts were recovered at Antioch and Chipps Island.

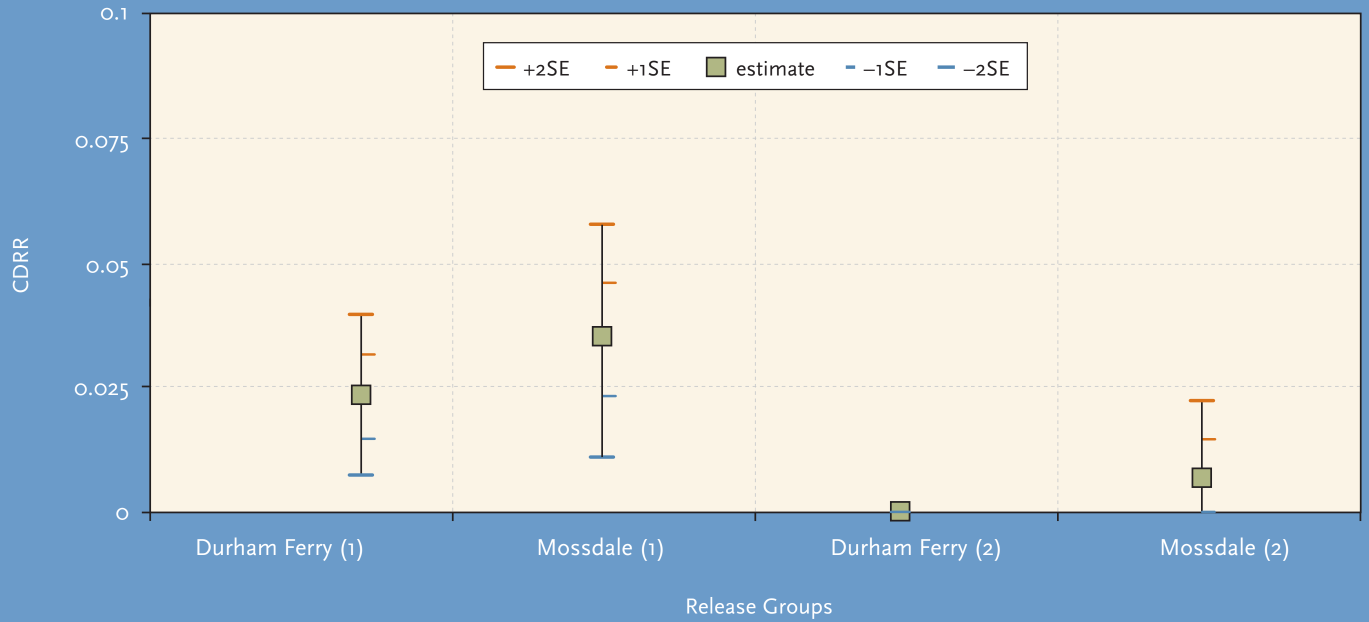
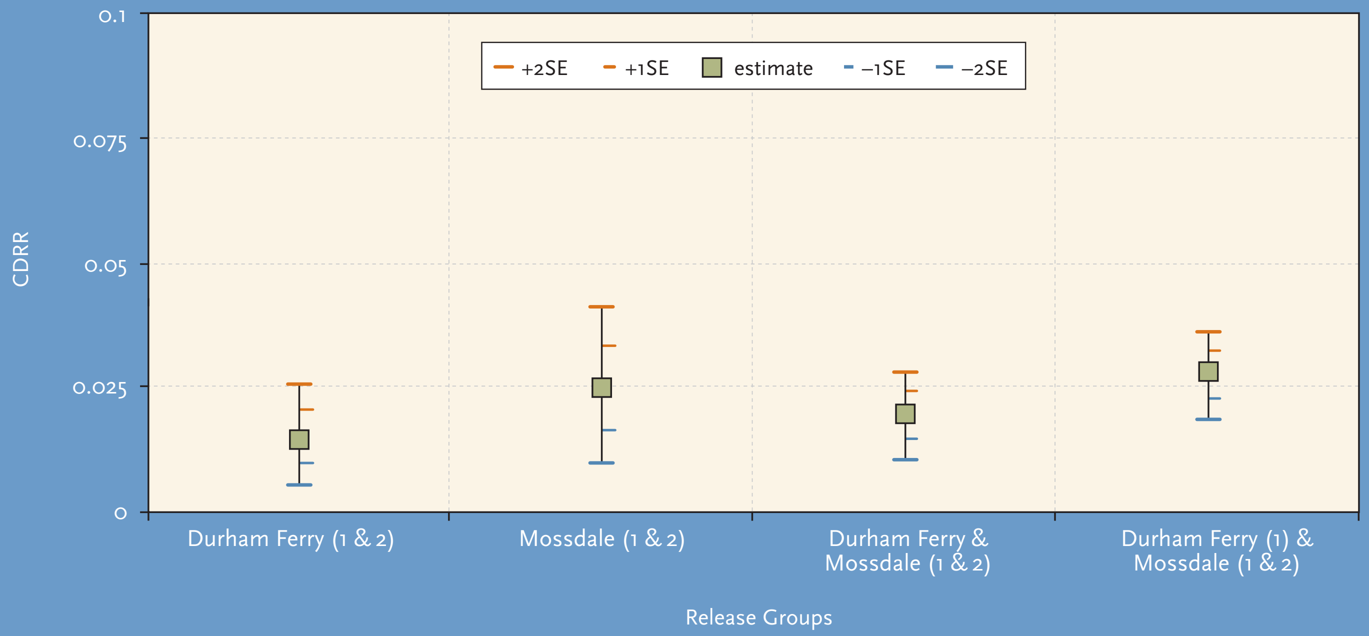


FIGURE 5–7

Pooled, Combined Differential Recovery Rates (CDRR) and (+/- 1 and 2 standard errors) of CWT smolts released in 2003 at Durham Ferry and Jersey Point (Durham Ferry) and Mossdale and Jersey Point (Mossdale) for the first (1) and second (2) release groups and for the combined Durham Ferry and Mossdale release groups (with and without the second Durham Ferry release group).Recoveries were made at Antioch and Chipps Island.



based on the fraction of the time and space sampled. At times the differential recovery rate (DRR) is reported which is similar to the CDRR but only uses recovery numbers from one recovery location—either Chipps Island or the ocean fishery.

The CDRR and the absolute survival estimates should not be very different as (1) the fraction of the time sampled is similar between groups for a recovery location and (2) the fraction of the channel width sampled at each recovery location is a constant. Neither would change the relative differences between groups. However, combining the recovery numbers from Antioch and Chipps Island could result in different survival estimates between the two methods.

Variance and standard errors were calculated for the CDRRs based on the Delta method recommended by Dr. Ken Newman. Plus or minus two standard errors are roughly equivalent to the 95% confidence intervals around the CDRR. Plus or minus one standard error equates to roughly the 68% confidence intervals for normally distributed data (Ken Newman, University of St. Andrews, Scotland, personal communication). In comparing survival between reaches and replicates, the confidence intervals were used to determine if CDRRs were significantly different from each other. If the 95% confidence intervals overlapped CDRRs were not considered statistically different from each other. Differences observed using the lower level of confidence (68%) are noted. It is not clear how variances, standard errors, or confidence intervals could be generated for absolute survival estimates.

Absolute survival estimates and CDRRs should be more robust for comparing survival between groups, recovery locations, and years, since using ratios between upstream and downstream groups theoretically standardizes for differences in catch efficiency between recovery locations and years. Both estimates of absolute survival and CDRRs were calculated for CWT releases as part of VAMP 2003, as in past years. An additional estimate of absolute survival will be possible from recoveries made in the ocean fishery, two to four years following release.

Although the first groups released at Durham Ferry and Mossdale appeared to survive slightly better than the second groups when evaluated using the absolute survival estimates and CDRRs (Table 5-5), the CDRRs of the two Mossdale groups were not statistically different at the 95% confidence level ($p<0.05$ level). They were significantly different using the 68% confidence level (Figure 5-6). No recoveries were made for the second Durham Ferry group at either recovery location, thus the second groups appeared to survive at a lower rate than the first groups. In addition, no recoveries were made at Antioch for the second Mossdale group.

The first Mossdale group appeared to survive slightly better than the first Durham Ferry group using the absolute survival estimates generated using Chipps Island recoveries and CDRR (Table 5-5). The first Mossdale group appeared to survive about the same as the first Durham Ferry group using the Antioch recoveries (Table 5-5). The CDRR indicated that differences were not significant (Figure 5-6). Fish released at Durham Ferry are thought to incur additional mortality since it is 11 miles farther upstream than Mossdale.

Because there were no significant differences between the CDRRs of the two Mossdale release groups, the groups were pooled and a new CDRR (0.025) and standard error were calculated (Figure 5-7). The first Durham Ferry group was also

TABLE 5–5
Group survival indices (SI) and absolute survival estimates (AS) combined differential recovery rates (CDRR) using recoveries at Antioch, Chipps Island or both for coded wire tagged Chinook salmon released as part of VAMP 2003.

Release Site	Date	Antioch Group SI	Antioch Group AS	Chipps Group SI	Chipps Group AS	Combined Differential Recovery Rate
Durham Ferry	4/21/03	0.015	0.028	0.019	0.017	0.023
Mossdale	4/22/03	0.015	0.028	0.048	0.043	0.035
Jersey Point	4/25/03	0.530		1.097		
Durham Ferry	4/28/03	–	–	–	–	–
Mossdale	4/29/03	–	–	0.010	0.014	0.007
Jersey Point	5/02/03	0.258		0.739		

TABLE 5–6
Recovery timing of juvenile CWT salmon released as part of VAMP 2003

Tag Code	Release Site	Release Date	ANTIOCH Number Recovered	First Day Recovered	Last Day Recovered	Days to First Rec.	Days at Large
06-02-82	Durham Ferry		1	5/4	5/4		13
06-02-83	Durham Ferry		4	4/30	5/1		10
06-27-42	Durham Ferry		1	4/30	4/30		9
Total		4/21/03	6	4/30	5/4	9	13
06-27-43	Mossdale		2	4/30	5/1		9
06-27-48	Mossdale		2	5/3	5/5		13
Total		4/22/03	4	4/30	5/5	8	13
06-27-44	Jersey Point	4/25/03	71	4/26	5/7	1	12
06-27-45	Durham Ferry		0	–	–		
06-27-46	Durham Ferry		0	–	–		
06-27-47	Durham Ferry		0	–	–		
Total		4/28/03	0				
06-27-49	Mossdale		0	–	–		
06-27-50	Mossdale		0	–	–		
Total		4/29/03	0				
06-27-51	Jersey Point	5/02/03	36	5/3	5/12	1	10

combined with the two Mossdale groups (Figure 5-7) since there were no statistical differences in the CDRRs at the 95% level between groups (Figure 5-6). Since no recoveries were made for the second Durham Ferry group, we were uncertain whether it was appropriate to combine Durham Ferry groups and include the second Durham Ferry group in the pooling with the Mossdale groups. To address this, CDRRs were calculated using the two sets of pooled data to determine if they were statistically different. The CDRR for the pooled two Durham Ferry and Mossdale releases was 0.019. Without the second Durham Ferry release included the CDRR was 0.027. CDRRs of the two sets of pooled data were not significantly different. The pooled CDRR for the two Durham Ferry releases was 0.015 (Figure 5-7).

TRANSIT TIME

Data on transit times for marked salmon from release to recapture sites during VAMP 2003 is summarized in Table 5-6. The transit time (from release location to Antioch and Chipps Island) for both sets of releases was similar. Recoveries of all groups were made within 13 days after release. It is interesting that the Jersey Point groups were still recovered 10 to 12 days after release, similar to groups released upstream. Daily recovery of each release group by tag code and sampling effort is shown in Appendix C-4.

Transit time for the CWT groups to the CVP and SWP fish facilities varied more than transit times to Antioch and Chipps Island. Coded wire tagged fish released as part of the first Durham Ferry group arrived at the facilities earlier (tag group: 06-02-82), at roughly the same time (tag group: 06-02-83) or

CHIPPS ISLAND					CVP	SWP
Number Recovered	First Day Recovered	Last Day Recovered	Days to First Rec.	Days at Large	First and Last Day Recovered	First and Last Day Recovered
0	–	–			4/29-5/1	
2	4/27	5/2		11	5/1	
1	4/29	4/29		8	5/7	5/12
3	4/27	5/2	6	11		
3	4/30	5/5		13		
2	5/2	5/4		12		
5	4/30	5/5	8	13		
57	4/26	5/7	1	12		
0	–	–			5/1	
0	–	–			5/7	
0	–	–				
0						
0	–	–			5/7	
1	5/6	5/6		7		
1	5/6	5/6	7	7		
39	5/4	5/12	2	10		

much later (tag group: 06-27-42) than they reached Antioch or Chipps Island (Table 5-6). Fish from the second Durham Ferry group and one tag group from the second Mossdale release were observed during salvage operations but were never recovered at Chipps Island or Antioch. Variability in recovery timing could an artifact of low recoveries at all recovery locations.

COMPARISON WITH PAST YEARS

Survival between Durham Ferry and Mossdale appeared high in 2003 as in past years. In 2000 through 2003, CDRRs indicated that survival between Durham Ferry and Jersey Point and Mossdale and Jersey Point was not statistically different ($p<0.05$) (SJRG, 2002 and Figure 5-6), thus we can infer survival between Durham Ferry and Mossdale was generally high in these years. However, low recovery numbers may hinder our ability to detect differences. Continued releases of CWT fish at both sites may allow estimates of mortality between Durham Ferry and Mossdale if it becomes great enough to detect in the future. If survival between locations is shown to be similar (not statistically different) then groups can be combined. When ocean recovery information becomes available it may also provide a means to assess mortality between Durham Ferry and Mossdale.

Survival from Durham Ferry and Mossdale to Jersey Point was much lower in 2003 than in the past. In 2003 the pooled CDRR from Durham Ferry and Mossdale to Jersey Point was 0.019 (or 0.027 including only the first Durham Ferry release). The pooled CDRR in 2003 was the lowest measured to date, and significantly lower than any pooled CDRR estimated since 2000 (Table 5-7). Even prior to VAMP, with only Chipps Island recoveries, the lowest differential recovery rate with the HORB in place was 0.133 in 1994.

TABLE 5–7

Combined Differential Recovery Rate (CDRR) and standard errors for CWT salmon released at Mossdale and Durham Ferry in relation to those released at Jersey Point

Year	CDRR	Standard Error
1994	0.133	0.099
1997	0.186	0.064
2000	0.187	0.019
2001	0.191	0.014
2002	0.151	0.013
2003	0.019*	0.005

*significantly lower than values in other years

TABLE 5–8

Severity of PKD infection in VAMP fish between 2000 and 2003. Number positive divided by the sample size is shown in parentheses.

Year	Percent Infected	Percent with Severe Infection
2000	4 (2/45)	0 (0/45)
2001	100 (34/34)	29 (10/34)
2002	46 (92/201)	1 (2/201)
2003	63 (30/48)	21 (10/48)

TABLE 5–9

Number of days after release of first and last recovery at Chipps Island and the duration of recovery (in days) for VAMP released fish in 2000-2003. Mean duration of recovery period and mean flow in cubic feet per second (cfs) at Vernalis during the two upstream Durham Ferry releases is included.

Release Location	Year (San Joaquin Flow Target)			
	2000	2001	2002	2003
Durham Ferry (1)	5-32 (27)	5-11(6)	8-22(14)	6-11(5)
Mossdale (1)	5-16(11)	4-11(7)	7-17(10)	8-13(5)
Jersey Point (1)	2-12(10)	1-7(6)	2-21(19)	1-12(11)
Durham Ferry (2)	5-23(18)	5-13(8)	7-15(8)	–
Mossdale (2)	N/R	5-10(5)	9-19(10)	7(0)
Jersey Point (2)	1-16(15)	1-11(16)	1-19(18)	2-10(8)
Mean Duration (in days)	16.2	7	13.1	6
Mean Flow (in cfs)	6020	4211	3341	3298

N/R = No second release was made
– = no fish were recovered

The health of the CWT fish in of itself did not appear to account for the low survival observed in 2003. Indices of fish health for VAMP fish used in 2003 were compared with VAMP fish used in earlier years to determine if the incidence and severity of PKD was greater in 2003 than in past years. The severity of PKD infection was determined by examining the kidney tissue. If the parasite was observed the fish was classified as infected. If the parasite had reached a stage where a reaction to the parasite (inflammation) was observed the fish was classified as severely infected.

In 2003, both infection and severe infection were observed in a high percentage of fish used in the VAMP experiments (Table 5-8). However, both the infection and severe infection rates were greater for the VAMP fish released in 2001, when survival through the Delta was estimated to be an order of magnitude higher (0.191 in 2001 versus 0.019 in 2003) (Table 5-8). These data indicate that the PKD infection in and of itself probably did not cause the high mortality of the VAMP fish observed in 2003.

The high level of PKD infection in combination with the lower flows could have increased the mortality of VAMP fish in 2003. PKD in the field likely compromises the fish's performance in many areas (swimming, salt water entry and disease resistance) and could decrease their survival through the Delta (Nichols and Foott, 2002). Nichols and Foott (2002) speculate that differences in the rate of PKD infection could be due to environmental conditions—namely flow and water temperature and that the small number of infected fish in 2000 may have been caused by the lower concentration of the infectious stage of the parasite because of the dilution effect of higher flows. Thus in contrast the lower flows in 2003 may have concentrated the infectious stage of the parasite.

The transit time (the span of time fish were recovered) at Chipps Island for VAMP groups in 2003 was shorter than in past years and may be a reflection of the lower flows and higher incidence of PKD infection. The mean number of days between the first and last day of recovery at Chipps Island for all VAMP groups was less in 2003 (6) compared to past years (Table 5-9).

The number of days until first recovery to Chipps Island appears to be related to San Joaquin River flow. In 2003 the number of days until first recovery was longer (1 to 8 days) when flows were lower (3298 cfs) than in 2000 and 2001 (1 to 5 days and 6020 and 4211 cfs flow respectively). The number of days until first recovery (1 to 9 days) and flow (3341 cfs) (in 2002) was similar to that observed in 2003 (Table 5-9).

In contrast, the number of days until last recovery was sooner in 2003 (7 to 13 days) than in 2002 (ranged from 15 to 22 days after release) and 2000 (12 to 32 days) when PKD infection rate was lower. The number of days until last recovery in 2003 was similar to that observed in 2001 (Table 5-9). Both 2003 and 2001 had the highest percentage of fish infected with PKD (Table 5-8). Differences in the number of days until last recovery may reflect increased mortality over time. Individuals that took longer than the 7 to 13 days to reach the western Delta had higher mortality due to the higher incidence of PKD in 2003 and 2001. It is possible that the combination of the first fish taking longer to reach Chipps Island due to the lower flows and the increased mortality due to the direct or indirect effects of PKD infection for the later migrants may in part explain why survival was so much lower in 2003 than in past years.

Role of Flow and Exports

San Joaquin River flow and flow relative to exports between April and June is correlated to adult escapement in the San Joaquin basin 2 1/2 years later (SJRG 2003). Both relationships are statistically significant ($p<0.01$) with the ratio of flow to exports accounting for slightly more of the variability in escapement than flow alone ($r^2 = 0.58$ versus $r^2 = 0.42$) (SJRG, 2003). These relationships suggest that adult escapement in the San Joaquin basin is affected by flow in the San Joaquin River and exports from the CVP and SWP during the spring months when juveniles migrate through the river and Delta to the ocean. VAMP was designed to further define the mechanisms behind these relationships by testing how San Joaquin River flows and exports with the HORB affect smolt survival through the Delta.

Survival of juvenile Chinook salmon emigrating from the San Joaquin River system has been evaluated within the framework established by the VAMP experimental design since the spring of 2000. Similar South Delta studies were conducted in 1994 and 1997, prior to the official implementation of VAMP. Fish from the Feather River Hatchery have been used in south Delta studies conducted prior to 1999 (SJRG, 2002).

To assess the relationship between San Joaquin River flows and survival, pooled CDRRs from 2000 through 2003 were plotted. The CDRRs of all Durham Ferry and Mossdale releases within a year were pooled as they were not significantly different from each other at the 95% confidence level. These pooled estimates and their 68% and 95% confidence intervals for 2003 (including the second Durham Ferry release) and the past three years of VAMP releases (2000–2002) are shown in relation to the average San Joaquin River flow at Vernalis for the two, ten-day periods after each release in Figure 5-8. Similar data obtained from releases made at Mossdale in 1994 and 1997 are included but have much wider confidence intervals because fewer recoveries were made since tagged fish were recovered at only one location (Chipps Island) in these years. It is obvious that the 2003 CDRR is much lower than would have been predicted based on past data.

The CDRRs with confidence intervals are also shown in comparison to average Vernalis flow relative to combined CVP and SWP exports for the averaged two, ten-day periods after release for each year (Figure 5-9). Prior to 2003, the relationship of CDRRs to San Joaquin River flow was improved by incorporating exports. The CDRR obtained in 2003 is much lower than what would have been predicted from past data and has weakened the benefit of adding exports into the relationship.

In general, the CDRRs do appear to increase as flows and flows relative to exports increase, but the addition of the 2003 data has resulted in these relationships no longer being statistically significant. As mentioned last year, even when the relationships were statistically significant ($p<0.10$), confidence intervals indicated data points were not significantly different from each other (SJRG, 2003).

The high level of PKD infection in combination with the lower flows could have increased the mortality of VAMP fish in 2003. PKD in the field likely compromises the fish's performance in many areas and could decrease their survival through the Delta.

FIGURE 5–8

Combined Differential Recovery Rates (CDRR) and (+/- 1 and 2 standard errors) of CWT smolts released at Durham Ferry and Mossdale relative to Jersey Point releases (with HORB in place) versus San Joaquin River flow at Vernalis in cfs, 2000–2003. 1994 and 1997 releases were made at Mossdale and Jersey Point.

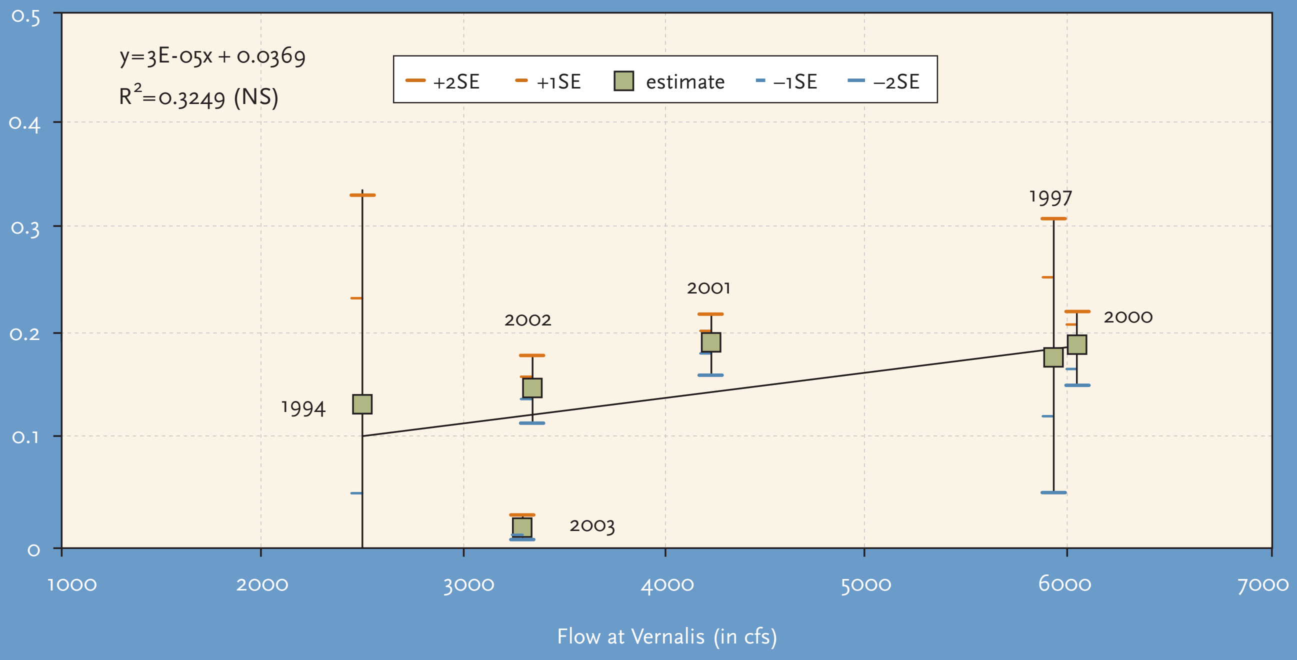
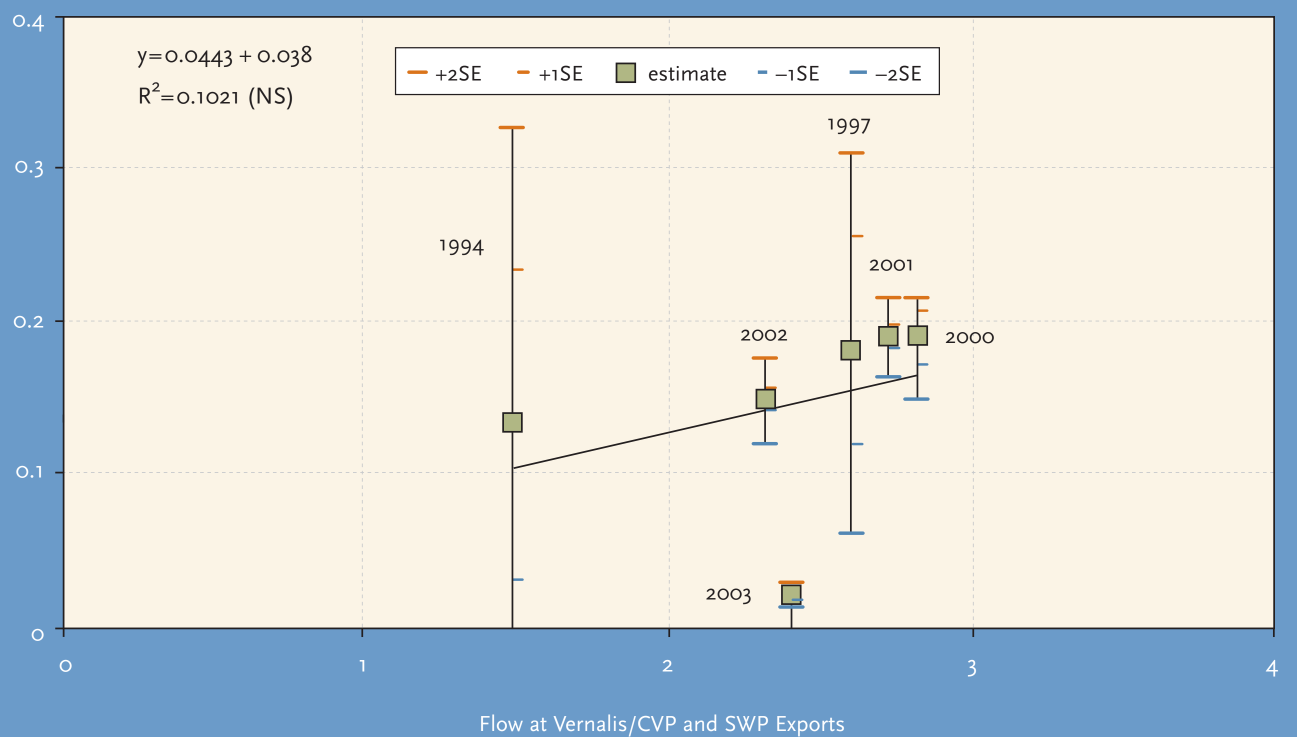


FIGURE 5–9

Combined Differential Recovery Rates (CDRR) and (+/- 1 and 2 standard errors) of CWT smolts released at Durham Ferry and Mossdale relative to Jersey Point releases (with HORB in place) versus the ratio of inflow at Vernalis and CVP and SWP exports, 2000–2003. 1994 and 1997 releases were made at Mossdale and Jersey Point.



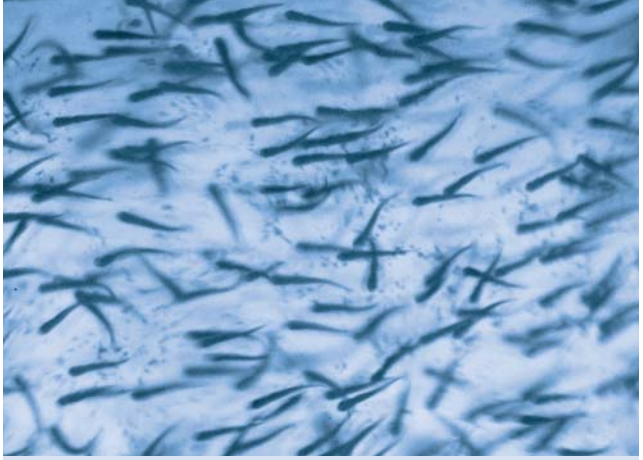
It does not appear that flow and exports in 2003 accounted for the low survival observed. As mentioned earlier, San Joaquin River flows and CVP and SWP exports were similar in 2002, but survival was significantly higher in 2002 as shown using the CDRRs and respective confidence intervals (Figure 5-10).

The Role of HORB on Survival

In 2003, the HORB was in place with three culverts operating during the VAMP study period. The barrier is assumed to improve survival based on studies conducted in the 1980s and 1990s (Brandes and McLain, 2001). These studies indicated that smolts released downstream of the Head of Old River survived at about twice the rate of those released upstream. And while those data were not statistically significant, placing a temporary barrier at the Head of Old River appeared to be a management action that would improve survival through the Delta for smolts originating from the San Joaquin basin.

The relationships of absolute survival estimates between Mossdale and Jersey Point and the ratio of San Joaquin River flow at Vernalis to exports with and without the HORB are shown in Figure 5-11. Differential recovery rates (using Chipps Island recoveries only) were not reported since they have not been calculated for past releases without the barrier in place. We assume absolute survival estimates would be comparable to the differential recovery rates. Thus, while comparisons can be made between regression lines, variance around each data point has not been estimated. The two regression lines have been developed based on survival data with and without the HORB. The barrier appears to generally increase survival at any one flow to export ratio, although estimated survival in 2003 was lower than would have been predicted from the model and is similar to levels observed without a barrier in place at the lower inflow to export ratios. In addition there hasn't been much variability in the Vernalis flow to export ratios to test with the barrier in place.

The differences in the target conditions tested in VAMP so far have been small, making it difficult to measure differences in survival due to changes in target conditions. In the six years of measuring survival with the HORB in place, the flow to export ratio has only varied from 1.5 (1994) to 2.9 (2000) (Figures 5-9 and 5-11). The maximum flow to export ratio within the VAMP targets is 4.7, but as of yet has not been tested. The ratios in the relationship between flow to export and adult escapement vary from 0.1 to 1000 (SJRG, 2003); a broader representation of how flows relative to exports, during the spring, have varied since 1951.



Placing a temporary barrier at the Head of Old River appeared to be a management action that would improve survival through the Delta for smolts originating from the San Joaquin basin.

Varying designs and changes in the culvert operations of the HORB also make it more difficult to detect significant differences in salmon smolt survival at similar flow to export ratios. During the six years the HORB has been installed (and comparable survival studies conducted) the design and permeability of the HORB have changed. In 1994, the HORB was installed without culverts, while in 1997 the barrier had two open culverts that diverted approximately 300 cfs into upper Old River. In 2000, the HORB had six gated culverts, with two open during the Mossdale and first Durham Ferry releases and four open during the second Durham Ferry release. In 2001 and 2002, six culverts were installed and operated throughout the VAMP test period. It was estimated that approximately 400 cfs from the San Joaquin River moved through the culverts in 2001 and 2002 (Simon Kwan, DWR, personal communication). In 2003, three culverts were open during the studies.

The amount of water flowing through the culverts is based on the head differential between the San Joaquin River and Old River. The amount of water flow moving from the San Joaquin River into Old River would change as flow, stage and the tides change, even if all six culverts remained open for the remaining nine years of the study. These changes in the amount of flow through the culverts and number of culverts operating between years likely affects the entrainment and resulting survival at this point in the river, adding variability in survival from factors other than flow or exports.

FIGURE 5–10

Combined Differential Recovery Rates (CDRR) and (+/- 1 and 2 standard errors) of CWT smolts released at Mossdale and Jersey Point (Mossdale) and Durham Ferry And Jersey Point (Durham Ferry) for the first (1) and second (2) release groups in 2003 (black) and 2002 (red). CDRR were based on the sum of recoveries at Antioch and Chipps Island. Estimates for pooled CDRR's for the two Durham Ferry and Mossdale releases are also provided.

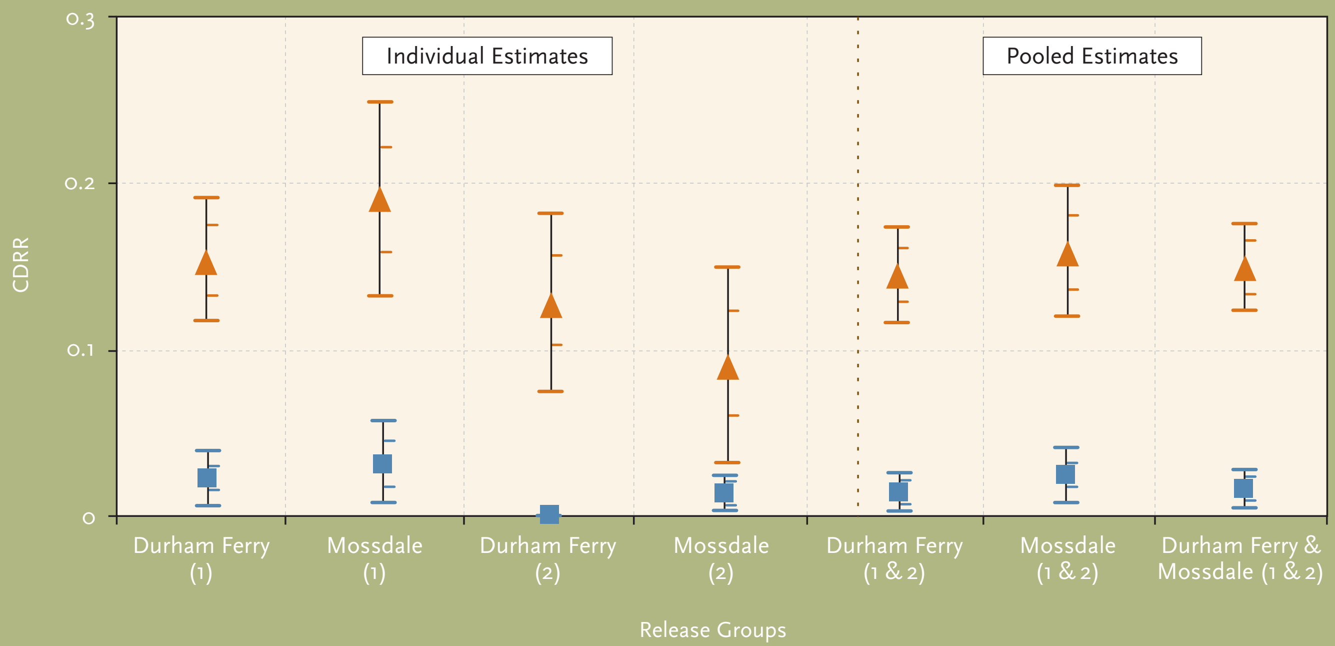
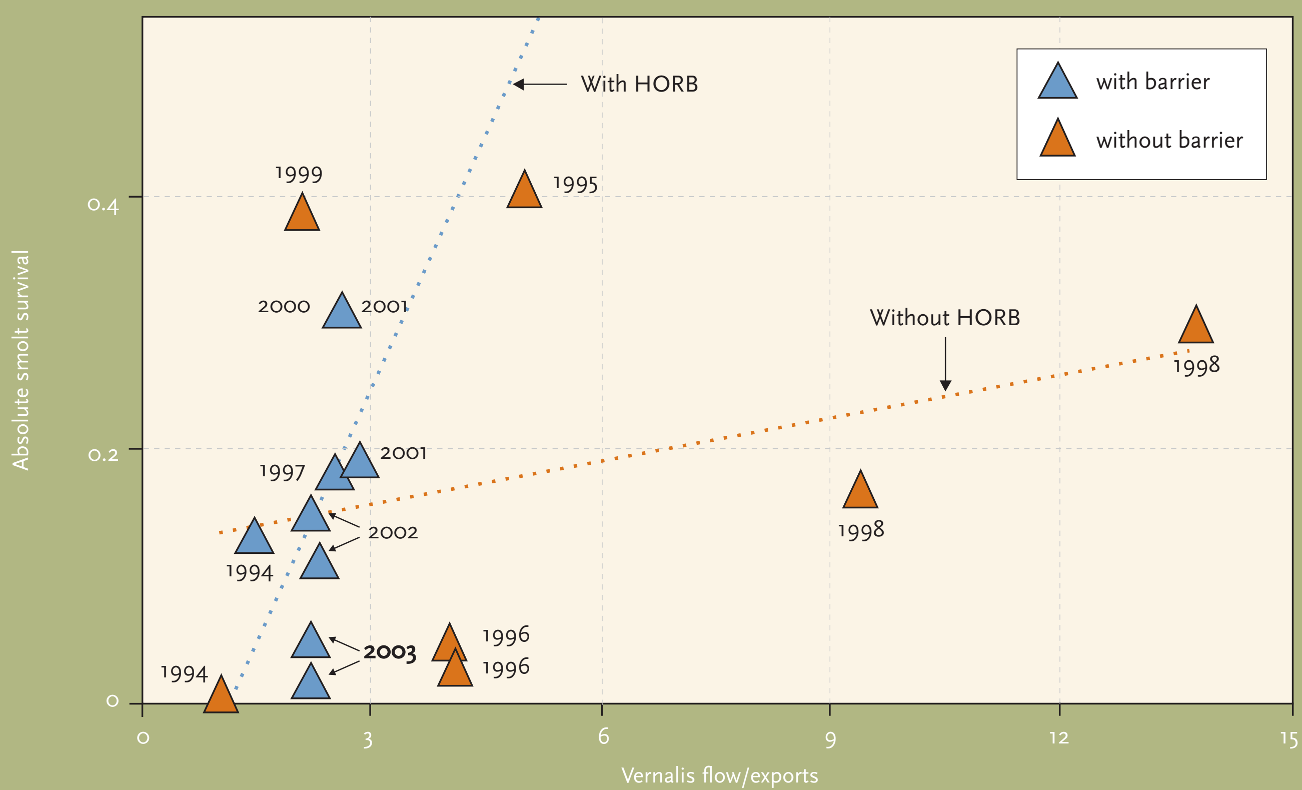


FIGURE 5–11

Estimates of survival of CWT fish released at Mossdale relative to those released at Jersey Point and recovered at Chipps Island with and without a HORB between 1994 and 2003. Similar values were obtained for one 2000 and one 2001 release. HORB can not be installed at Vernalis flow/export levels >4.6



Survival indices of the downstream tributary groups were comparable to indices from the upstream VAMP releases.

The flow through the culverts and the seepage through the rock barrier and would affect the amount of remaining flow left in the San Joaquin River of which the salmon smolts are exposed. Using flow in the San Joaquin River at Vernalis as the estimate of flow the fish are exposed to instead of flow in the San Joaquin River downstream of the HORB adds additional variation to the relationships we are trying to identify and refine. A better estimate of flow to use in these relationships would be the net flow on the San Joaquin River downstream of upper Old River. An estimate of flow in the San Joaquin River downstream of Old River has been made by subtracting the estimated mean daily flow in upper Old River 840 feet downstream of the barrier from the USGS gauged mean daily flow at Vernalis (Chapter 4). In addition in 2003, an Acoustic Doppler Current Profiler (ACDP) was placed in the San Joaquin River downstream of the HORB for the purpose of estimating the flow. This method was deemed the best way to estimate flow at this location. Data from the ACDP are not yet available to use in our analyses. The ACDP data will be compared to that estimated using the mean daily flow in Old River to see how they compare and determine if it is possible to estimate San Joaquin flow downstream of Old River in past years. Future analyses will attempt to use these estimates in comparing smolt survival to San Joaquin River flow.

Comparison with other marked fish released from Merced River Fish Facility

Coded wire tagged salmon from Merced River Fish Facility were released in the San Joaquin River tributaries between April 13 and May 7 as part of independent (complimentary) fishery investigations. Releases were made in the Merced and Stanislaus Rivers at the upper and lower reaches of the rivers below the dams. These studies are reported in more detail in Chapter 6, but are discussed here as they relate to VAMP releases.

Survival indices of the downstream tributary groups to Antioch or Chipps Island would include mortality down the mainstem San Joaquin River as well as through the Delta. While the survival indices of these lower tributary released groups would include some additional river mortality, if mainstem mortality was low then the indices would be comparable to survival indices of fish released at Durham Ferry and Mossdale as part of VAMP.

Survival indices of the downstream tributary groups were comparable to indices from the upstream VAMP releases. Group survival indices for salmon released in the lower tributaries and recovered at Antioch ranged between 0.002 and 0.032 (Table 5-10). Group survival indices ranged between 0.014 and 0.060 for recoveries made at Chipps Island (Table 5-10). No recoveries were made from the downstream group on the Stanislaus River (Two Rivers) at Chipps Island. Survival indices to Antioch and Chipps Island of VAMP released fish at Mossdale and Durham Ferry ranged from 0.010 to 0.048 (Table 5-4).

These data would indicate that whatever variable affected the survival of upstream released VAMP fish may have affected survival of the lower tributary released fish. It is also likely, that the tributary released fish from Merced River Fish Facility also were infected with PKD.

The survival indices using Antioch and Chipps Island recoveries of releases made in the upper tributaries were also low (Table 5-11) ranging between 0.002 and 0.020. No recoveries were made at Chipps Island for one of the upstream groups released in the Merced River. Again these indices are similar to those obtained for VAMP fish released at Durham Ferry and Mossdale indicating that low survival was not specific to upstream VAMP releases.

Comparison with Sacramento River Delta releases

Average survival indices for three groups of Feather River Hatchery smolts released at Sacramento on April 15, April 30 and May 15, 2003 averaged 0.51. This is within the range and near the average observed in past years (Brandes and McLain, 2001). It appears that whatever factor contributed to the low survival observed for all Durham Ferry and Mossdale CWT fish released from Merced River Fish Facility in 2003 was limited to the San Joaquin basin or Merced River Fish Facility and did not have a similar affect on marked fish released at Sacramento that originated from Feather River Hatchery.

OCEAN RECOVERY INFORMATION FROM PAST YEARS

Ocean recovery data of CWT salmon groups can contribute to a more thorough understanding and evaluation of salmon smolt survival studies. These data can provide another independent estimate of the ratio of recovery rate of a test release group relative to a control release group. Differential recovery rates using ocean recovery information can be compared with

TABLE 5–10

Survival indices at Antioch and Chipps Island of CWT fish released in the lower Merced and Stanislaus Rivers in 2003. Expanded salvage at the CVP and SWP are also included.

Tag Code	Release Site	Date	Number Released	ANTIOCH Number Recovered	Minutes Fished	Percent Sampled	Survival Index	Group Index
Merced River								
06-44-93	Hatfield State Park (lower Merced)		23274	6	2185	0.379	0.049	
06-44-94	Hatfield State Park (lower Merced)		23872	2	5083	0.392	0.015	
06-44-95	Hatfield State Park (lower Merced)		23833	4	2145	0.372	0.032	
Total		4/16/03	70979	12	6103	0.385		0.032
06-45-64	Hatfield State Park (lower Merced)		24545	0	–	–	–	
06-45-65	Hatfield State Park (lower Merced)		24483	0	–	–	–	
06-45-66	Hatfield State Park (lower Merced)		24358	1	590	0.410	0.007	
Total		4/29/03	73386	1	590	0.410		0.002
06-45-46	Hatfield State Park (lower Merced)		22603	0	–	–	–	
06-45-47	Hatfield State Park (lower Merced)		22714	2	1780	0.412	0.015	
06-45-72	Hatfield State Park (lower Merced)		22649	0	–	–	–	
Total		5/7/03	67966	2	1780	0.412		0.005
Stanislaus River								
06-45-70	Two Rivers		26101	1	580	0.403	0.007	
06-45-71	Two Rivers		26632	3	3392	0.393	0.021	
Total		4/27–4/28/03	52733	4	4512	0.392		0.014

TABLE 5–11

Survival indices at Antioch and Chipps Island for coded wire tag releases made in the upper Merced and Stanislaus Rivers in 2003. Expanded salvage at the CVP and SWP are also included.

Tag Code	Release Site	Date	Number Released	ANTIOCH Number Recovered	Minutes Fished	Percent Sampled	Survival Index	Group Index
Merced River								
06-44-89	Merced River Fish Facility		22677	3	2185	0.379	0.025	
06-44-90	Merced River Fish Facility		22816	1	590	0.410	0.008	
06-44-91	Merced River Fish Facility		22946	2	5108	0.394	0.016	
06-44-92	Merced River Fish Facility		21725	0	–	–	–	
Total		4/13/03	90164	6	6123	0.387		0.012
06-44-96	Merced River Fish Facility		24232	0	–	–	–	
06-44-97	Merced River Fish Facility		23869	0	–	–	–	
06-44-98	Merced River Fish Facility		23757	1	572	0.397	0.008	
06-44-99	Merced River Fish Facility		23950	0	–	–	–	
		4/25/03	95808	1	572	0.397		0.002
06-27-77	Merced River Fish Facility		23590	0	–	–	–	
06-27-78	Merced River Fish Facility		23862	0	–	–	–	
06-44-49	Merced River Fish Facility		23512	1	487	0.338	0.009	
06-44-50	Merced River Fish Facility		24330	0	–	–	–	
Total		5/4/03	95294	1	487	0.338		0.002
Stanislaus River								
06-45-67	Knight's Ferry		25599	1	600	0.417	0.007	
06-45-68	Knight's Ferry		26226	0	–	–	–	
06-45-69	Knight's Ferry		26136	1	560	0.389	0.007	
Total		4/25/03	77961	2	7967	0.395		0.005

CHIPPS ISLAND					Expanded Salvage Numbers	
Number Recovered	Minutes Fished	Percent Sampled	Survival Index	Group Index	CVP	SWP
4	1200	0.278	0.080		12	18
1	400	0.278	0.020		12	9
4	4379	0.276	0.079		12	0
9	4779	0.277		0.060		
0	–	–	–		0	0
2	1460	0.253	0.042		0	0
0	–	–	–		0	6
2	1460	0.253		0.014		
1	400	0.278	0.021		0	0
0	–	–	–		0	0
2	400	0.278	0.041		0	0
3	1200	0.278		0.021		
0	–	–	–		0	0
0	–	–	–		0	0
0				–		

CHIPPS ISLAND					Expanded Salvage Numbers	
Number Recovered	Minutes Fished	Percent Sampled	Survival Index	Group Index	CVP	SWP
1	400	0.278	0.021		24	6
1	400	0.278	0.021		0	0
0	–	–	–		0	6
1	400	0.278	0.022		0	6
3	2800	0.278		0.016		
0	–	–	–		0	0
0	–	–	–		0	0
0	–	–	–		0	0
0	–	–	–		12	0
0				–		
1	400	0.278	0.020		0	0
0	–	–	–		12	0
1	400	0.278	0.020		12	0
2	1600	0.278	0.038		0	6
4	2387	0.276		0.020		
0	–	–	–		0	0
1	400	0.278	0.018		0	0
0	–	–	–		0	0
1	400	0.278		0.006		

These data would indicate that whatever variable affected the survival of upstream released VAMP fish may have affected survival of the lower tributary released fish. It is also likely, that fish released from Merced River Fish Facility into tributaries also were infected with PKD.

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.

absolute survival estimates and the differential or combined differential recovery rates of juvenile salmon recovered at Chipps Island or Chipps Island and Antioch, respectively. The ocean harvest data may be particularly reliable due to the number of CWT recoveries and the extended recovery period.

Adult 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 2002. The ocean CWT recovery data accumulate over a one to four year period after the year a study release is made as nearly all given year-classes of salmon have been either harvested or spawned by age five. Consequently, these data are essentially complete for releases made through 1998 and partially available for CWT releases made from 1999 to 2001.

Differential recovery rates based on ocean recoveries, Chipps Island recoveries or combined differential recovery rates using Antioch and Chipps Island recoveries for salmon produced at the Merced River Hatchery are shown in Table 5-12. 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 (2000–2001). Releases have been made at several locations: Dos Reis (on the San Joaquin River downstream of the upper Old River junction), 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 5-12.

Results of this comparative analysis of survival estimates and differential recovery rates for Chinook salmon produced in the Merced River Hatchery show: (1) to date, there is general, but variable, agreement between survival estimates and differential recovery rates based on juvenile CWT salmon recoveries in Chipps Island and Antioch trawling and adult recoveries from the ocean fishery, (2) absolute survival estimates using Chipps Island or Antioch recoveries were either lower or similar to estimates based on ocean recoveries, with the exception of first releases in 2001, and (3) additional comparisons need to be made, as more data becomes available from VAMP releases for recoveries at Antioch, Chipps Island, and the ocean fishery. Information on survival of juvenile salmon and the contribution to the adult salmon population will be essential to evaluate the biological benefits of changes in flow and export rates under VAMP.

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 assumed that these actions to improve conditions for the juveniles will translate into greater adult abundance and escapement in future years, especially during low flows, when corresponding adult escapement ($2\frac{1}{2}$ years later) has been extremely low (SJRG, 2003).

To determine if VAMP in 2003 was successful in targeting the migration period of naturally produced juvenile salmon, catches of unmarked salmon at Mossdale and in salvage at the CVP and SWP facilities were compared prior to and during the VAMP period.

Unmarked Salmon Recovered at Mossdale

The time period for VAMP (April 15 to May 15) was chosen based on historical data that indicated a high percentage of the juvenile salmon emigrating from the San Joaquin tributaries passed into the Delta at Mossdale during that time. The average catch per minute per day of unmarked juvenile salmon caught in kodiak trawling at Mossdale between March 15 and June 30, 2003 is shown in Figure 5-13. Unmarked salmon do not have an adipose clip and could be unmarked fish from the Merced River

FIGURE 5–12

Comparison of Antioch and Chipps Island survival estimates and differential or combined differential recovery rates compared to differential ocean recovery rates. The one to one line is also included.

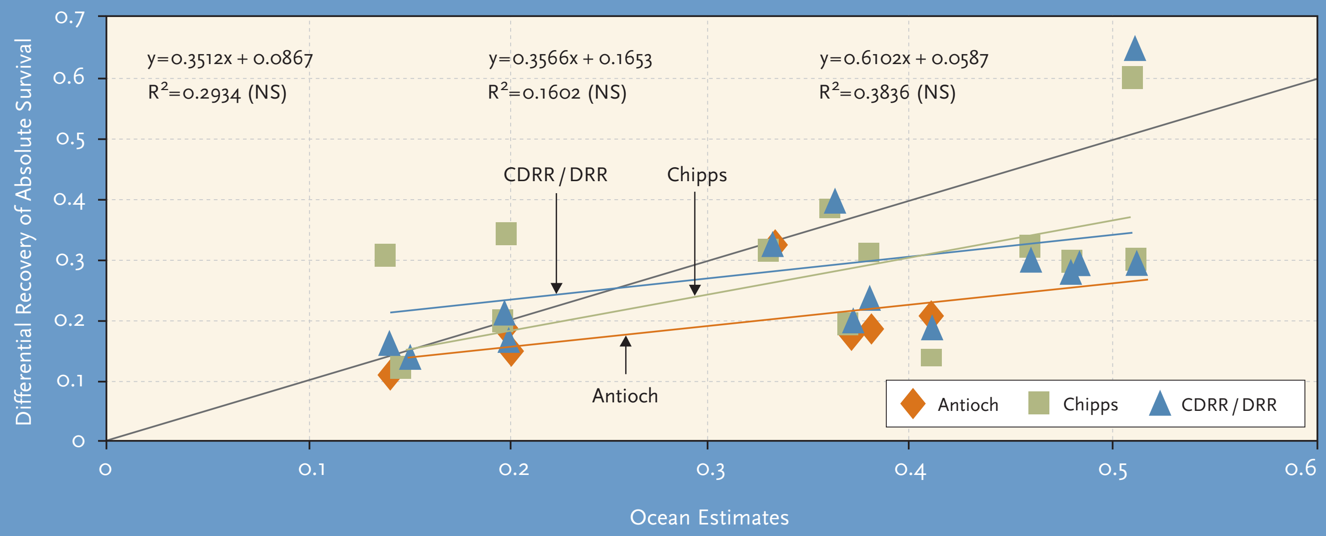


FIGURE 5–13

Standardized catch per cubic meter of all unmarked juvenile Chinook salmon in the Mossdale Kodiak trawl, March 15, 2003 through June 30, 2003.

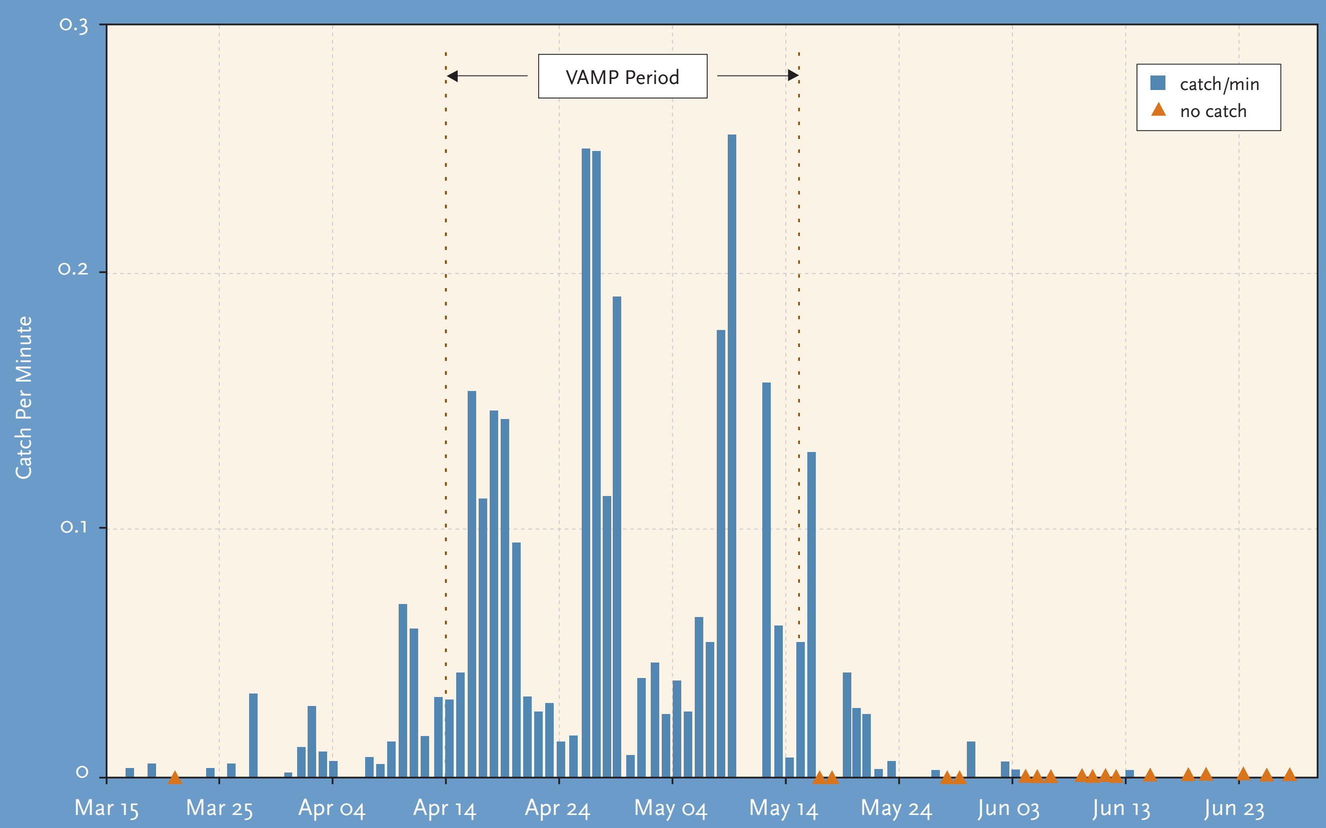


TABLE 5–12

Survival indices based on Chipps Island, Antioch, and ocean recoveries of Merced River Fish Facility salmon released as part of South Delta studies between 1996 and 2001.

Release Year	San Joaquin River (Merced River origin) Tag No.	Release Number	Release Site	Release Date	Chipps Island Recovs.	Antioch Recovs.	Expanded Adult Ocean Recovs. (age 1+ to 4+) Total	Chipps Island	Antioch	DRR or CDRR	Ocean Catch
		Juvenile Salmon CWT Releases						Absolute Survival Estimates		Differential Recovery Rates	
1996	H61110412	25,633	Dos Reis	1 May 96	2		3				
	H61110413	28,192	Dos Reis	1 May 96	3		37				
	H61110414	18,533	Dos Reis	1 May 96	1		8				
	H61110415	36,037	Dos Reis	1 May 96	5		10				
	H61110501	53,337	Jersey Pt	3 May 96	39		187				
	Effective Release	107,961	Dos Reis		11		58	0.12		0.14	0.15
	Effective Release	51,737	Jersey Pt		39		187				
1997	H62545	50,695	Dos Reis	29 Apr 97	9		183				
	H62546	55,315	Dos Reis	29 Apr 97	7		167				
	H62547	51,588	Jersey Pt	2 May 97	27		355				
	Effective Release	106,010	Dos Reis		16		350	0.29		0.29	0.48
	Effective Release	51,588	Jersey Pt		27		355				
	H62548	46,728	Dos Reis	8 May 97	5		91	0.30		0.28	0.48
	H62549	47,254	Jersey Pt	12 May 97	18		192				
1998	61110809	26,465	Mossdale	16 Apr 98	25		61				
	61110810	25,264	Mossdale	16 Apr 98	31		40				
	61110811	25,926	Mossdale	16 Apr 98	32		58				
	61110806	26,215	Dos Reis	17 Apr 98	33		47				
	61110807	26,366	Dos Reis	17 Apr 98	23		35				
	61110808	24,792	Dos Reis	17 Apr 98	34		61				
	61110812	24,598	Jersey Pt	20 Apr 98	87		110				
	61110813	25,673	Jersey Pt	20 Apr 98	100		91				
	Effective Release	77,655	Mossdale		88		159	0.30		0.30	0.51
	Effective Release	77,373	Dos Reis		90		143	0.32		0.31	0.46
	Effective Release	50,271	Jersey Pt		187		201				
1999	062642	24,715	Mossdale	19 Apr 99	8		128				
	062643	24,725	Mossdale	19 Apr 99	15		134				
	062644	25,433	Mossdale	19 Apr 99	13		130				
	062645	25,014	Dos Reis	19 Apr 99	20		151				
	062646	24,841	Dos Reis	19 Apr 99	19		218				
	0601110815	24,927	Jersey Pt	21 Apr 99	34		333				
	062647	24,193	Jersey Pt	21 Apr 99	25		379				
	Effective Release	74,873	Mossdale		36		392	0.38		0.40	0.36
	Effective Release	49,855	Dos Reis		39		369	0.60		0.65	0.51
	Effective Release	49,120	Jersey Pt		59		712				

TABLE 5–12 (continued)

Survival indices based on Chipps Island, Antioch, and ocean recoveries of Merced River Fish Facility salmon released as part of South Delta studies between 1996 and 2001.

Release Year	San Joaquin River (Merced River origin) Tag No.	Release Number	Release Site	Release Date	Chipps Island Recovs.	Antioch Recovs.	Expanded Adult Ocean Recovs. (age 1+ to 4+) Total	Chipps Island	Antioch	DRR or CDRR	Ocean Catch
		Juvenile Salmon CWT Releases						Absolute Survival Estimates		Differential Recovery Rates	
2000	06-45-63	24,457	Durham Ferry	17 Apr 00	11	11	235				
	06-04-01	23,529	Durham Ferry	17 Apr 00	7	6	190				
	06-04-02	24,177	Durham Ferry	17 Apr 00	10	10	225				
	06-44-01	23,465	Mossdale	18 Apr 00	9	14	198				
	06-44-02	22,784	Mossdale	18 Apr 00	9	16	159				
	06-44-03	25,527	Jersey Pt	20 Apr 00	24	50	592				
	06-44-04	25,824	Jersey Pt	20 Apr 00	41	47	617				
	Effective Release	72,163	Durham Ferry		28	27	650	0.31	0.19	0.24	0.38
	Effective Release	46,249	Mossdale		18	30	357	0.31	0.33	0.33	0.33
	Effective Release	51,351	Jersey Pt		65	97	1209				
	601060914	23,698	Durham Ferry	28 Apr 00	7	8	43				
	601060915	26,805	Durham Ferry	28 Apr 00	5	15	36				
	0601110814	23,889	Durham Ferry	28 Apr 00	10	8	70				
	0601061001	25,572	Jersey Pt	1 May 00	48	76	300				
	0601061002	24,661	Jersey Pt	1 May 00	30	76	215				
	Effective Release	74,392	Durham Ferry		22	31	149	0.19	0.14	0.16	0.20
	Effective Release	50,233	Jersey Pt		78	152	515				
2001	06-44-29	23,354	Durham Ferry	30 Apr 01	14	28	4				
	06-44-30	22,837	Durham Ferry	30 Apr 01	22	30	26				
	06-44-31	22,491	Durham Ferry	30 Apr 01	17	18	4				
	06-44-32	23,000	Mossdale	1 May 01	17	18	16				
	06-44-33	22,177	Mossdale	1 May 01	14	15	0				
	06-44-34	24,443	Jersey Pt	4 May 01	50	156	50				
	06-44-35	24,992	Jersey Pt	4 May 01	61	173	72				
	Effective Release	68,682	Durham Ferry		53	76	34	0.34	0.17	0.21	0.20
	Effective Release	45,177	Mossdale		31	33	16	0.31	0.11	0.16	0.14
	Effective Release	49,435	Jersey Pt		111	329	122				
	06-44-36	24,025	Durham Ferry	7 May 01	2	8	5				
	06-44-37	24,029	Durham Ferry	7 May 01	5	11	9				
	06-44-38	24,177	Durham Ferry	7 May 01	2	10	4				
	06-44-39	23,878	Mossdale	8 May 01	4	8	11				
	06-44-40	25,308	Mossdale	8 May 01	4	11	0				
	06-44-41	25,909	Jersey Pt	11 May 01	17	43	18				
	06-44-42	25,465	Jersey Pt	11 May 01	27	53	13				
	Effective Release	72,231	Durham Ferry		9	29	18	0.13	0.20	0.19	0.41
	Effective Release	49,186	Mossdale		8	19	11	0.19	0.18	0.20	0.37
	Effective Release	51,374	Jersey Pt		44	96	31				

Note: Ocean recoveries are based on data through 2002

FIGURE 5–14

Individual fork lengths (mm) of all unmarked juvenile Chinook salmon in the Mossdale Kodiak trawl, March 15, 2003 through June 30, 2003.

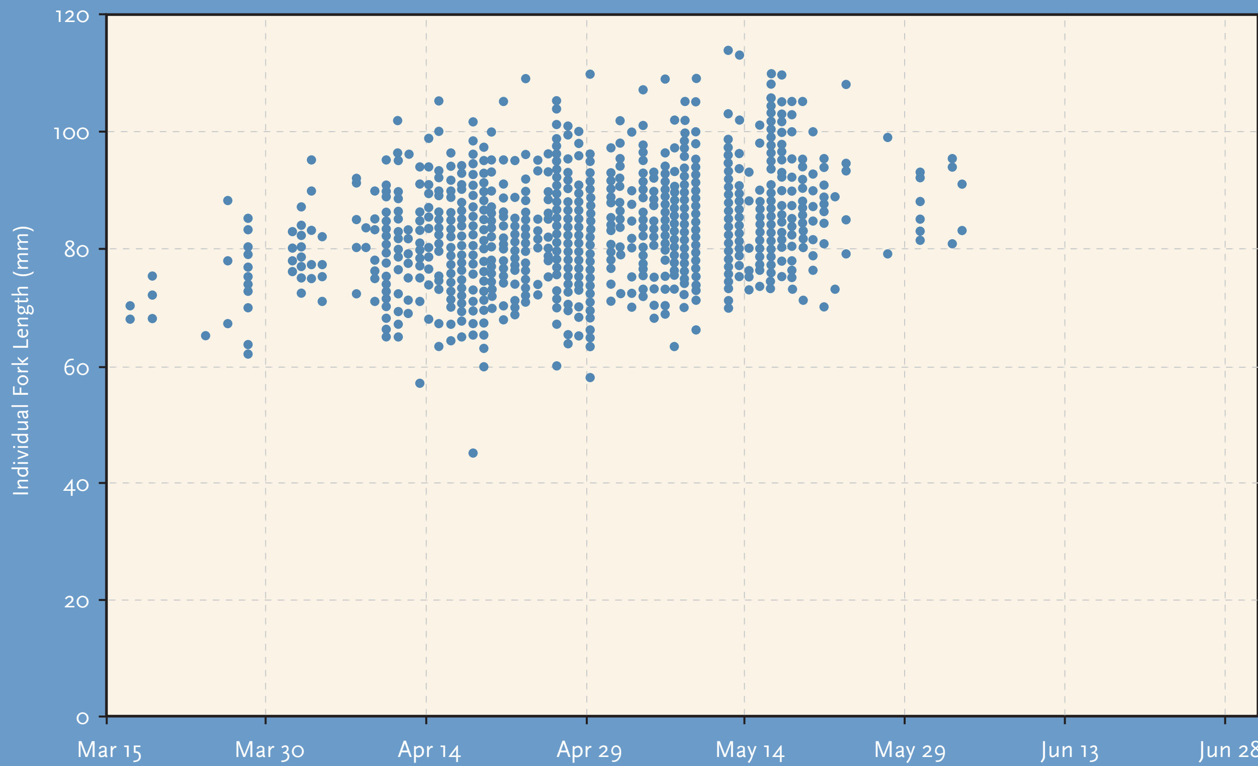
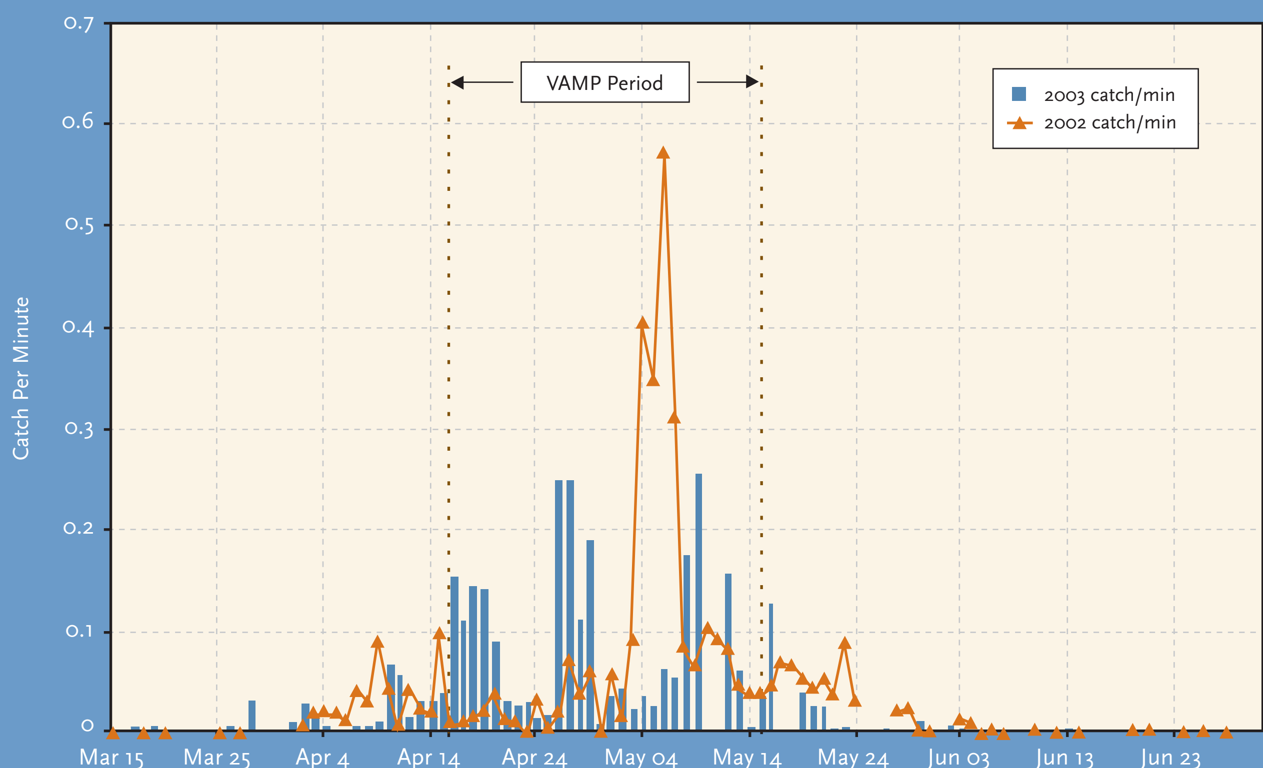


FIGURE 5–15

Standardized catch per minute of all unmarked juvenile Chinook salmon in the Mossdale Kodiak trawl, March 15 through June 30, 2002 and 2003.



Fish Facility or juveniles from natural spawning. Approximately 80% of the unmarked catch that passed Mossdale between March 15 and June 30 passed during the VAMP period: April 15 to May 15. The size of the juvenile salmon migrating past Mossdale between March 15 and June 30, 2003 is shown in Figure 5-14.

The pattern of unmarked juvenile salmon caught at Mossdale in 2003 was different than that observed in 2002, and did not obviously show that the number of fish passing Mossdale was less in 2003 than it was in 2002 (Figure 5-15). The peak in early May of 2002 was greater than any peak observed in 2003, but catches in 2003 were greater than 2002 during other times.

Salmon Salvage and Losses at Delta Export Pumps

Fish salvage operations at the CVP and SWP export facilities capture unmarked salmon for transport by tanker truck and release them downstream in the western Sacramento – San Joaquin Delta. The untagged salmon are either naturally produced or untagged hatchery salmon, 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 CWT recovery data for Merced River Fish Facility smolts at the facilities to provide some general indications.

The salvage at the facilities is based on expansions from sub-samples taken throughout the day. Four to five salmon are estimated to be lost per salvaged salmon in the SWP Clifton Court Forebay based on high predation rates. The CVP pumps divert directly from the Old River channel and the loss estimates range from about 50 to 80% of the number salvaged, or about six to eight times less per salvaged salmon than for the SWP. The loss estimates do not include any indirect mortality in the Delta due to water export operations, additional mortality associated with trucking and handling, or post-release predation. Salvage density of salmon is the number of salvaged salmon per acre-foot of water pumped. The California Department of Water Resources maintains 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 the best indicator of when concentrations of juvenile salmon are most susceptible to the export facilities and salvage system.

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.

The weekly data covering the period of April 13 to May 17 encompassed the 2003 VAMP period. A review of weekly data for March through May indicates that the highest salvage and losses occurred during the three weeks prior to VAMP (period of March 23 to April 12), with the exception of the highest CVP losses being recorded in the second VAMP week, April 20 to 26 (Figures 5-16 and 5-17). Combined CVP and SWP weekly export rates during those three weeks proceeding VAMP averaged 7,500 – 10,900 cfs (Figure 5-18). Salmon density was highest in the second week of the VAMP period at both the CVP and SWP facilities, and continued to be relatively high during the VAMP period (Figure 5-19), indicating the VAMP export reductions were in place when the density of salmon was the highest. Based on comparisons with Mossdale data in Figure 5-13, it appears that most of the salmon salvaged in early April may not have been of San Joaquin basin origin. Reducing exports earlier in April may provide better conditions for juvenile spring-, winter-, and fall- run Chinook salmon migrating through the Delta from the Sacramento River basin.

The size distribution of unmarked salmon during April and May in the Mossdale trawl (Figure 5-14) is a subset of the size distribution of those salvaged at the fish facilities (Figure 5-20: Source E. Chappell, DWR). In 2003, the fish facilities salvaged some juvenile salmon between March 15 and early May that were larger (winter run sized) than any observed at Mossdale.

Results of these analyses showed that the 2003 VAMP test period coincided with much of the peak period of San Joaquin River salmon smolt emigration. Reductions in SWP and CVP exports and increased San Joaquin River flow likely provided improved conditions for salmon survival, although starting the VAMP period two to three weeks earlier may have had substantial benefits for other salmon races and stocks.

FIGURE 5–16

2003 SWP salmon salvage and loss.

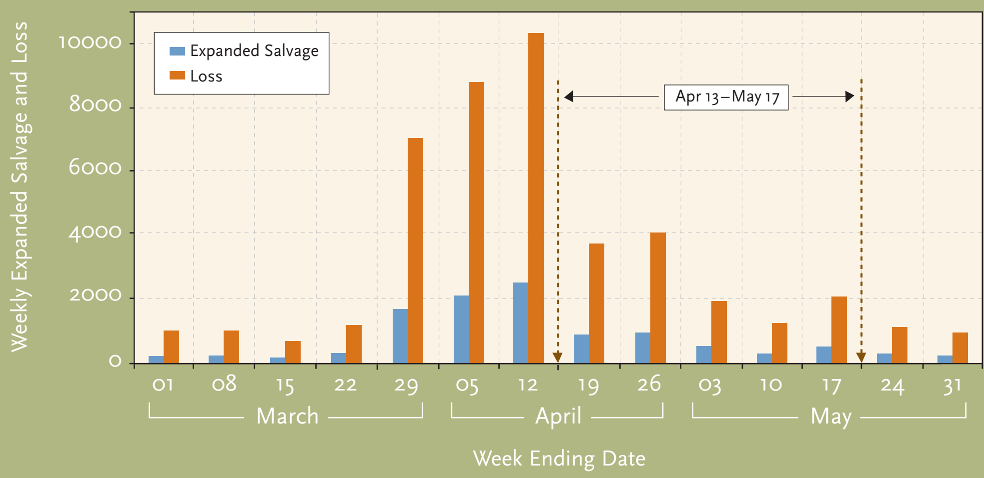
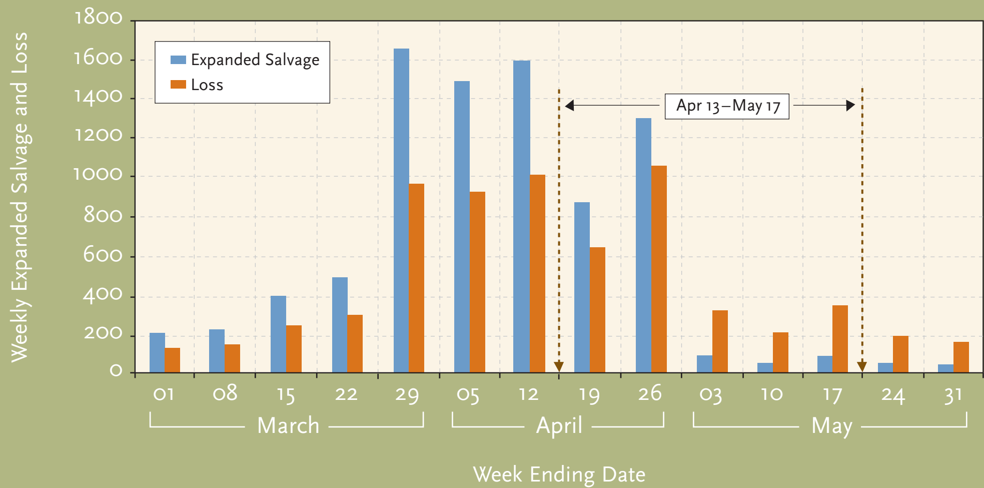


FIGURE 5–17

2003 CVP salmon salvage and loss.



SUMMARY AND RECOMMENDATIONS

The survival estimates and CDRRs measured in 2003 were low compared to past years. It is unclear why survival in 2003 was so low but it does not seem to be directly related to San Joaquin River flow, CVP and SWP exports or water temperature. The hatchery fish were infected with the parasite that causes PKD. Fish have been infected in past VAMP study years and it does not appear that the incidence of PKD was actually higher in 2003. However, the combination of the lower flows and PKD infection may have affected the mortality of the VAMP fish in 2003 resulting in shorter transit duration and higher mortality relative to past VAMP releases.

Some rain occurred during the studies, which was somewhat unusual, and possibly agricultural and/or urban run-off from the storm caused mortality, but a toxic event due to storm-water run-off should be episodic and not be a long-term event affecting all the releases made at Merced River Fish Facility over a three week period. The high and similar mortality of the tributary CWT groups released from Merced River Fish Facility indicates that whatever increased the mortality of the VAMP fish was some condition that was common to the Merced River Fish Facility (with the exception of the Jersey Point releases) and lasted for several weeks. This condition also appeared to be restricted to the Delta or differences in the survival indices for the upstream

FIGURE 5–18

2003 weekly SWP/CVP export rates and Vernalis flow.

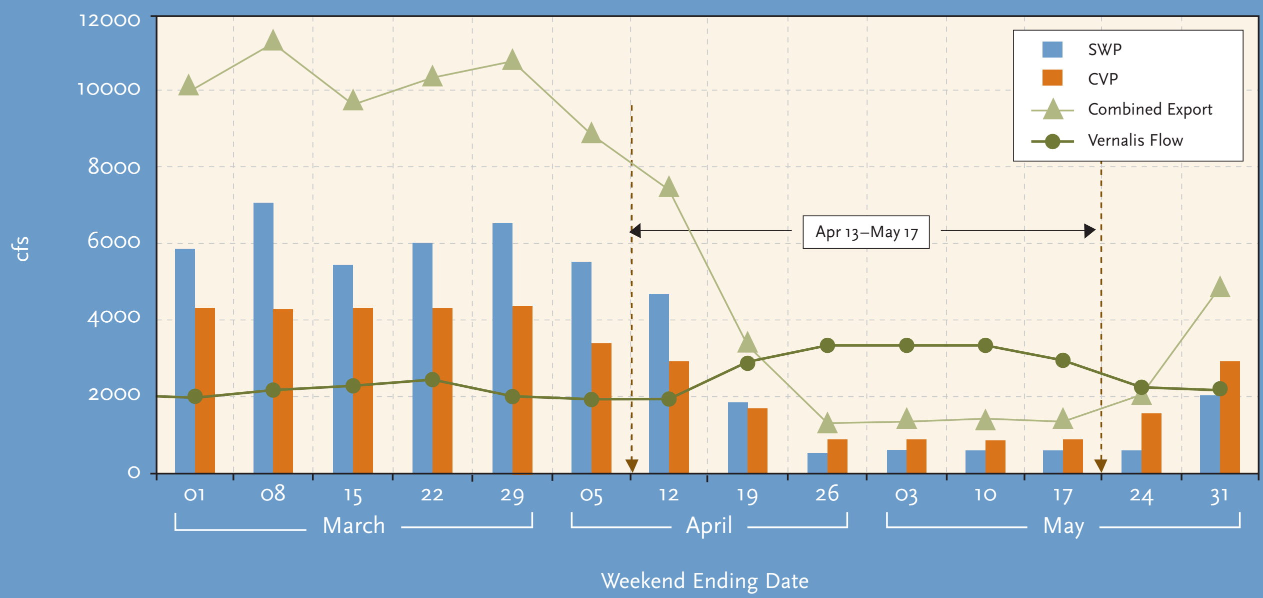


FIGURE 5–19

2003 SWP/CVP expanded salmon salvage density.

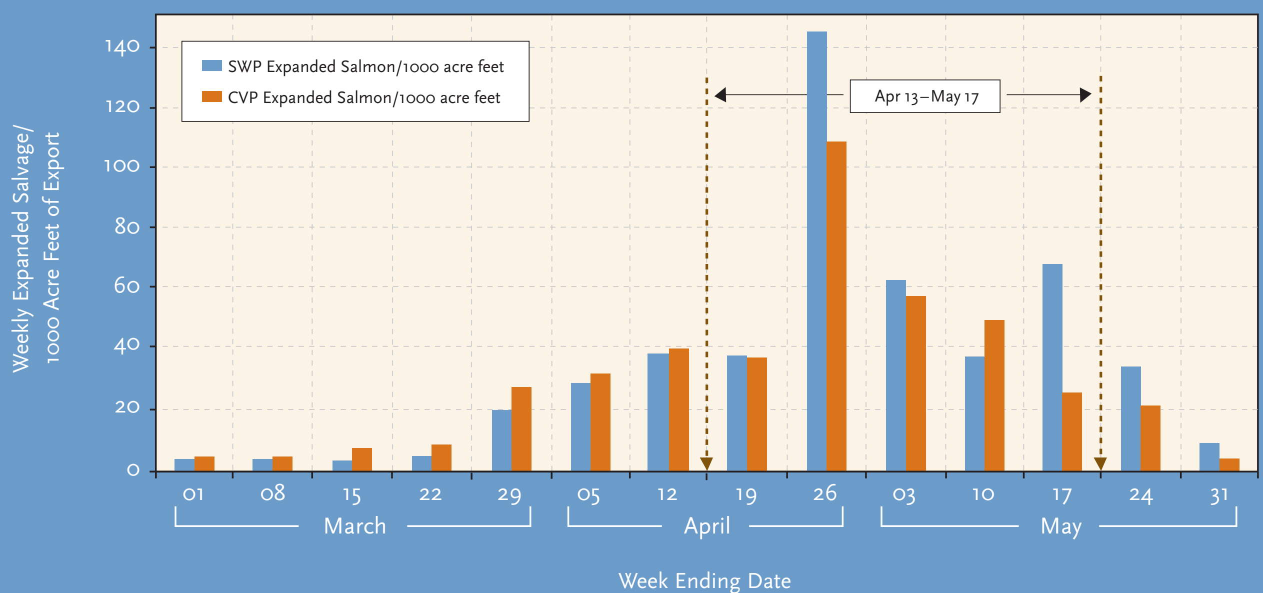
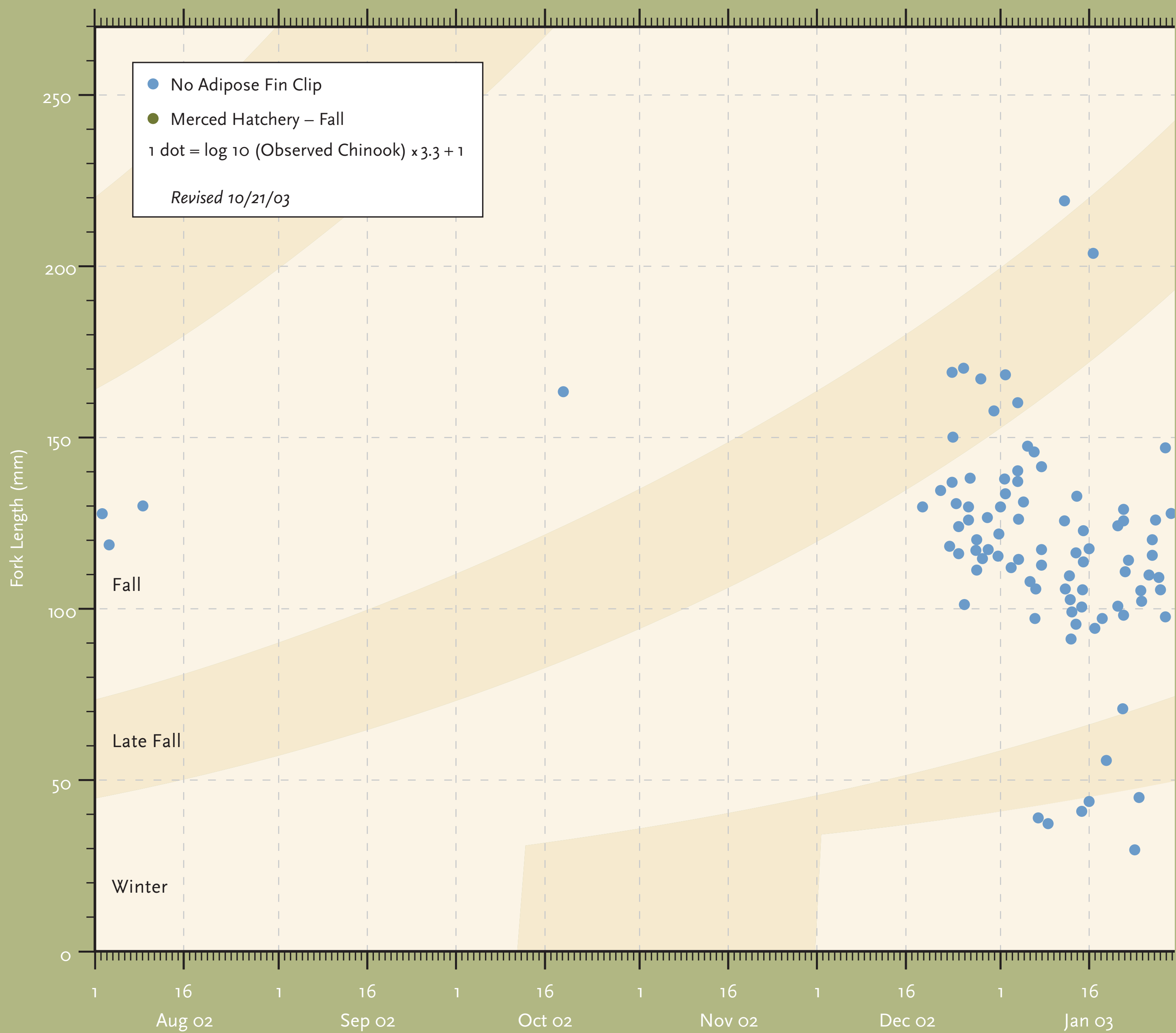
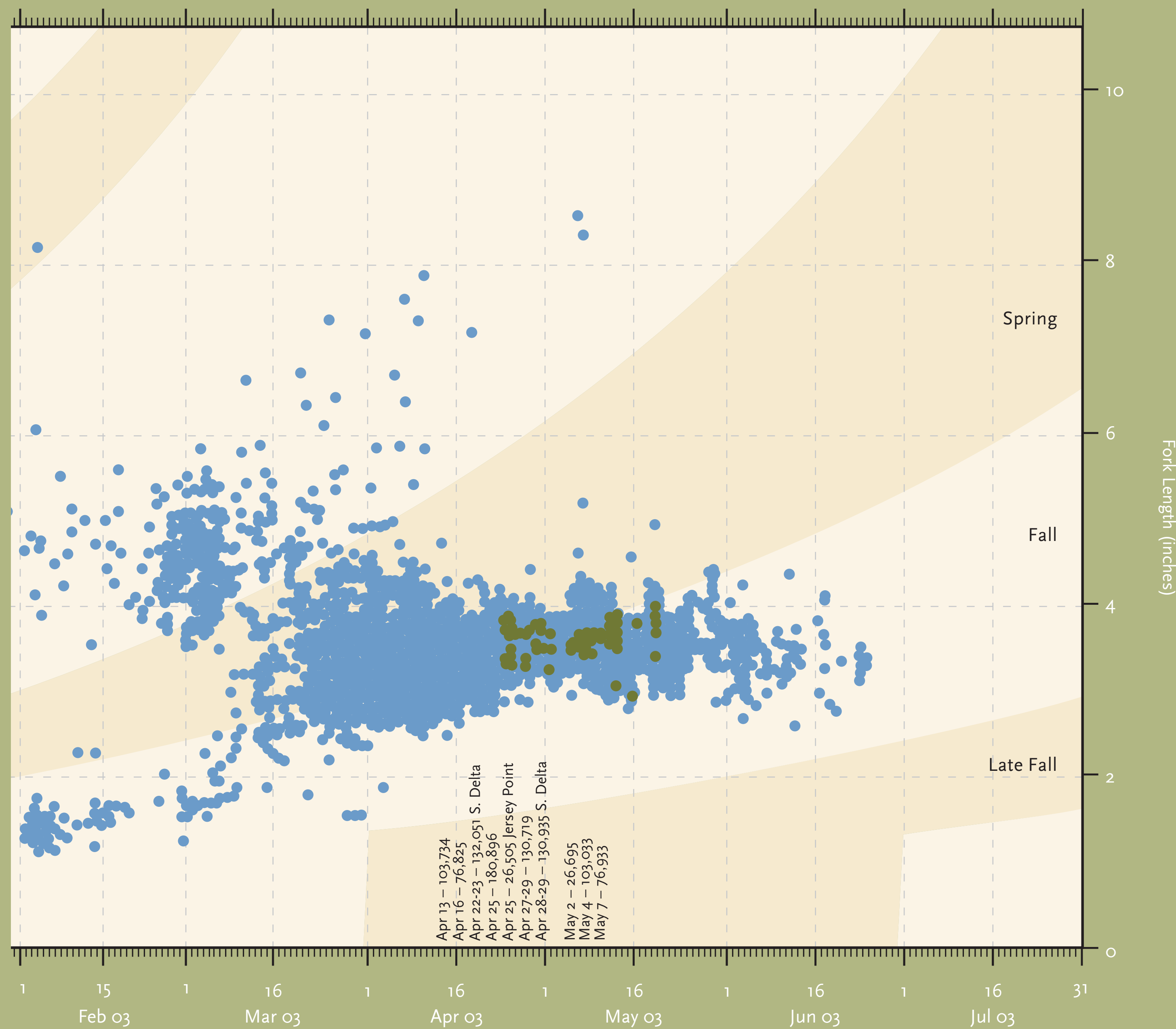


FIGURE 5–20

Observed Chinook Salvage at the SWP & CVP Delta Fish Facilities 8/1/02 through 7/31/03





Spring
Fall
Late Fall
Fork Length (inches)
0
2
4
6
8
10
Apr 13 – 103,734
Apr 16 – 76,825
Apr 22-23 – 132,051 S. Delta
Apr 25 – 180,896
Apr 25 – 26,505 Jersey Point
Apr 27-29 – 130,719
Apr 28-29 – 130,935 S. Delta
May 2 – 26,695
May 4 – 103,033
May 7 – 76,933
1
15
Feb 03
1
16
Mar 03
1
16
Apr 03
1
16
May 03
1
16
Jun 03
1
16
Jul 03
31

and downstream tributary releases would have been greater. While the causes are unclear, it would appear the VAMP data in 2003 are outliers and repeating the study in future years will determine if this anomaly is limited to 2003 or is a change in overall conditions.

Even without the 2003 data, there have been several impediments to defining and refining the relationships between smolt survival and San Joaquin River flow and CVP and SWP exports. These impediments have been discussed in this and previous VAMP reports. The different permeability of the HORB and not having estimates of flow in the San Joaquin River downstream of the barrier add noise to our estimates of flow. In addition, using diseased hatchery fish in VAMP experiments adds a potential bias to our estimates of survival, even though PKD is also present in wild stocks (Ken Nichols, USFWS internal memo, 12/6/02). Measuring survival within the narrowly defined flow and export VAMP targets further exacerbates the problem of noise in the variables of interest. The level of precision of our survival estimates and the noise in flow measurements limits our ability to precisely define the relationship of survival to flow and exports. Yearly, pooled estimates are now based on releases of 300,000 to 400,000 fish with two recovery locations, sampling roughly seven to ten hours per day, yet recoveries have not been great enough to statistically differentiate between survival estimates measured at VAMP target flow and exports levels obtained to date. Differences in survival may be occurring but our ability to detect them is limited.

To address this dilemma, future studies should prioritize measuring survival at the highest VAMP target flow and lowest export levels. Flows of 7000 cfs and exports of 1500 cfs would achieve the highest inflow to export ratio (4.7) within the VAMP design and provide a new target to test. Based on information to date, the higher flow would be probably increase survival and may lessen any effects or infection rate of PKD. The higher survival should increase recovery numbers such that CDRRs

Even without the 2003 data, there have been several impediments to defining and refining the relationships between smolt survival and San Joaquin River flow and CVP and SWP exports.

and confidence intervals may show statistical differences when compared to previously obtained CDRRs. It is uncertain how such a condition can be prescribed, independent of the hydrology, within the existing San Joaquin River Agreement, but the idea should be explored by the VAMP Management Team.

Further confidence in defining and refining the relationship of smolt survival to flow and exports could be obtained by increasing the length of the study. The fourth year of VAMP was completed in 2003 with eight years remaining in the study. Additional replication can resolve uncertainty when variation is high.

Continued assessment of past data is also recommended such that other methodologies or criteria for determining statistical differences between groups may be developed.

CHAPTER 6

Complimentary Studies Related to the VAMP

Throughout 2003 several fishery studies were conducted that were considered to be important to the overall understanding of the salmon life cycle and survival in the San Joaquin River. These are presented below to provide the reader with summary information on each study. More information can be obtained from each study manager or report author.

SURVIVAL ESTIMATES FOR CWT RELEASES MADE IN THE SAN JOAQUIN TRIBUTARIES

contributed by Pat Brandes, U.S. Fish and Wildlife Service

As discussed previously, CWT salmon releases were made in the San Joaquin River tributaries between April 13 and May 7 as part of independent (complimentary) fishery investigations. Three sets of releases were made in the upper Merced River (Merced River Fish Facility) and lower Merced River (Hatfield State Park). One additional set of CWT salmon were also released in the upper (Knights Ferry) and lower (Two Rivers) Stanislaus River.

Group survival indices for salmon released in the tributaries and recovered at Antioch ranged between 0.002 and 0.032 (Tables 5-10 and Table 5-11). Group survival indices ranged between 0.014 and 0.060 to Chipps Island (Tables 5-10 and 5-11). These indices were similar to those in 2002, but much lower than in 2001, where indices ranged from 0.03 to 0.20. Vernalis flow targets were lower in 2002 and 2003 than in 2001 (3300 cfs vs. 4200 cfs). The tributary flows were also likely lower. No recoveries at Chipps Island were made for the second upper Merced and lower Stanislaus releases.

Comparison of survival indices of the upstream tributary groups relative to the downstream groups provides an estimate of survival through the tributaries. The survival estimates through the tributaries are provided in Table 6-1. Survival through the Merced River ranged between 0.26 and 0.96, although there were instances where no recoveries were made at Chipps Island. Survival through the Stanislaus was estimated at 0.34 using Antioch recoveries. No recoveries were made of the lower Stanislaus group at Chipps Island. It appeared survival through the tributaries was generally high using this method of comparison. Confidently estimating survival through the tributaries, is not likely using this method because the number of recoveries is so low.

CWT smolts released on the tributaries took between 7 to 22 days to arrive at Antioch and 8 and 16 days to arrive at Chipps Island. The groups released on the Stanislaus appeared to take the longest to arrive at Antioch and Chipps Island. Information on the transit time between release and recovery of the CWT groups released in the San Joaquin River mainstem and tributaries at both Antioch and Chipps Island is summarized in Appendix C-5. As observed for VAMP releases, recovery times were generally similar between Antioch and Chipps Island for the various groups released upstream in the mainstem San Joaquin and tributaries.

EVALUATION OF CHINOOK SALMON FRY SURVIVAL IN THE STANISLAUS RIVER: BIOLOGICAL RESPONSE TO SUPPLEMENTAL WINTER FLOW PULSE

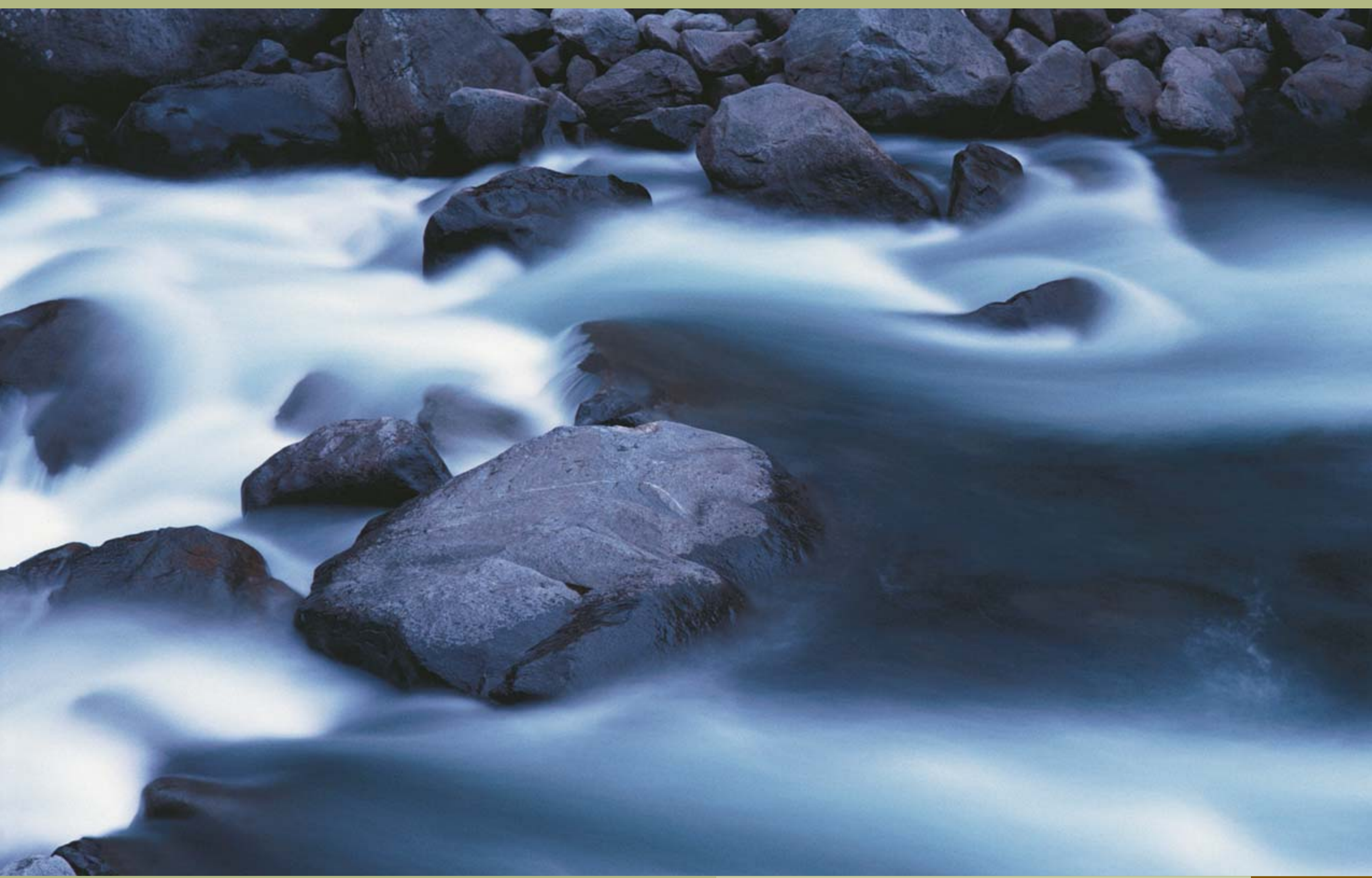
contributed by Doug Demko, S.P. Cramer Consultant

Previous monitoring of juvenile salmon migration (1998–2002) from the Stanislaus River at Oakdale (RM 40.1) and Caswell (RM 8.6) indicates that survival of fall-run Chinook salmon fry (<45mm fork length) is greater under moderate winter flow conditions than under low winter flows. During intermediate to wet years (1998 through 2000), 75% or more of fry migrants passing Oakdale also passed Caswell during pulse flow events above 750 cfs. Flow pulses included natural freshets (i.e., short pulses in flow due to a rainfall event) and flood control releases. During dry years (i.e., 2001 and 2002), relatively small changes

TABLE 6-1

Survival indices and absolute survival estimates through the tributaries using recoveries at Antioch and Chipps Island for coded wire tagged smolts released as part of San Joaquin tributary studies in the spring of 2003.

Release Site	Date	Antioch Survival Indices	Antioch Absolute Survival	Chipps Survival Indices	Chipps Absolute Survival
Merced River Fish Facility (upper Merced)	4/13/03	0.012	0.38	0.016	0.26
Hatfield State Park (lower Merced)	4/16/03	0.032		0.060	
Merced River Fish Facility	4/25/03	0.00189	0.79	–	–
Hatfield State Park	4/29/03	0.00239		0.014	
Merced River Fish Facility	5/04/03	0.002	0.43	0.01977	0.96
Hatfield State Park	5/07/03	0.005		0.02064	
Knight's Ferry (upper Stanislaus)	4/25/03	0.005	0.34	0.006	–
Two Rivers (lower Stanislaus)	4/27 – 4/28/03	0.014		–	



The objective of the flow experiment in the Stanislaus River during 2003 was to determine whether fry survival during dry or low flow years could be increased by managed flow pulses in winter.

in flow (e.g., 50 cfs) and turbidity had the ability to stimulate fish migration past Oakdale, however, less than 10% migrated as far downstream as Caswell. In years when low proportions of fry were observed passing between Oakdale and Caswell, there was no corresponding increase in the proportion of parr (45–70mm) and smolts (>70mm) passing between the two sites which indicates that fry did not rear in the river below Oakdale and subsequently migrate as older fish. Rather, in-river fry survival during these dry years was reduced. Although high winter flows during intermediate to wet years were found to increase fry migration and survival past Caswell, the subsequent fate of fry downstream in the San Joaquin River and Delta is unknown. In addition, it is uncertain whether high supplemental flows provided during dry years would result in increased in-river and/or downstream survival.

The objective of the flow experiment in the Stanislaus River during 2003 was to determine whether fry survival during dry, or low, (i.e., no natural freshets in excess of 1,000 cfs) flow years could be increased by managed flow pulses in winter. The purpose of the study was to evaluate whether a supplemental winter flow of approximately 1,000 cfs during a dry year could both stimulate and sustain fry migration out of the Stanislaus River. The effectiveness of artificial freshets at increasing in-river fry survival was determined by estimating the proportion of fry that passed Caswell after passing Oakdale. Potential mortality through the San Joaquin River and Delta was assessed from fry salvage and loss rates at the CVP and SWP Delta export facilities during 1998–2003.

Studies of juvenile outmigration in 1998–2002 indicated that flow increases to less than 750 cfs for 1 to 2 days during January and February, stimulated fry passage at Oakdale, but few fish subsequently reached Caswell 31.5 miles downstream. In contrast, short duration flow increases above 750 cfs resulted in increased fry passage past both Oakdale and Caswell indicating that more than 750 cfs is needed to sustain fry migration from the upper river through the lower river and past Caswell (Table 6-2). In addition, fry migration past Caswell begins within 1 to 2 days of initial flow increases during a pulse event and peak passage typically occurs within 3 days.

In addition to flow fluctuations, turbidity was considered to be an important factor in stimulating migration and protecting outmigrants from predators (Gregory and Levings 1998, Ginetz and Larkin 1976). In dry years on the Stanislaus River, some turbidity is created by run-off, but is typically 25% or less of that created by run-off in wet years. Therefore, the 2003 flow experiment was intended to occur simultaneously with a rain event to take advantage of turbidity created by natural run-off.

During 2003, circumstances (i.e., hydropower facility maintenance) did not allow the experiment to coincide with a rain event as originally designed. Instead, the 2-day experiment began in late January when daily average flow, as measured at Goodwin Dam (RM 58.5), was increased from 280 cfs on the 26th to 1,003 cfs on the 28th and ramped down to 350 cfs by

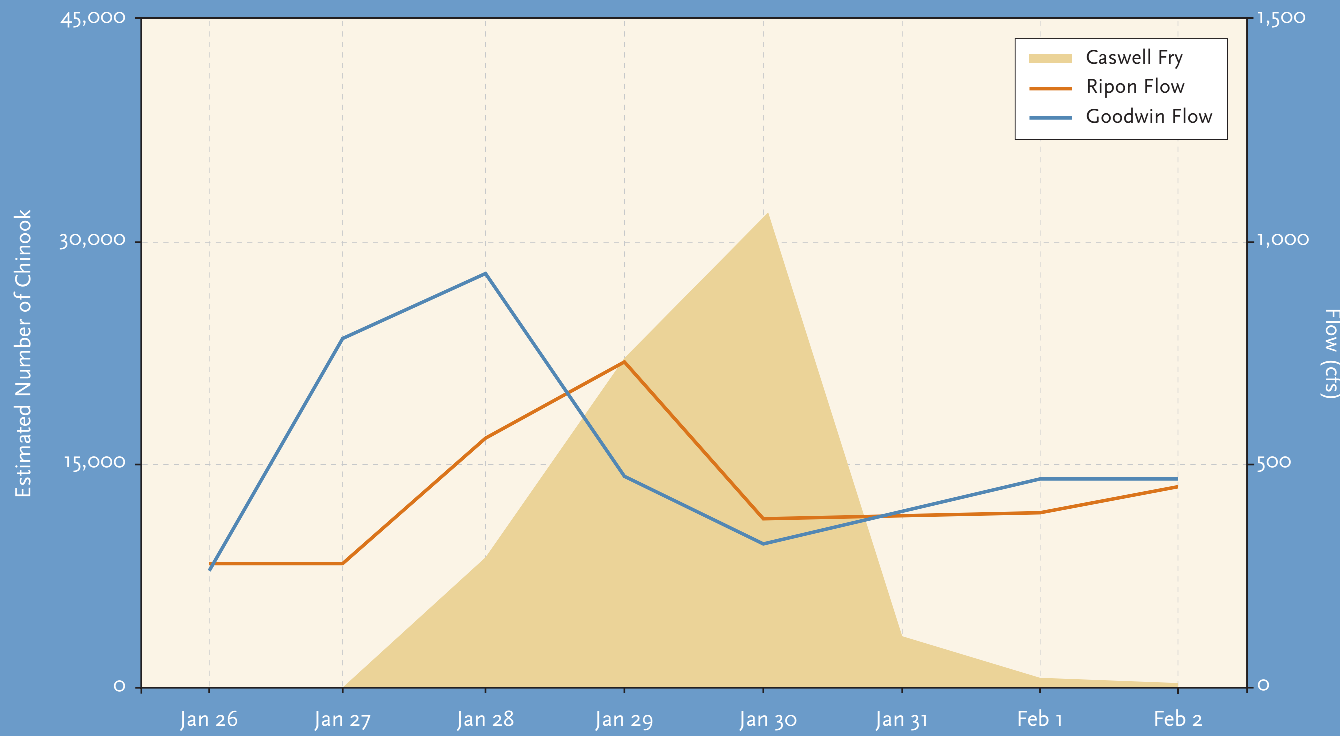
TABLE 6–2

Observed Fry Response to Freshet Flows at Oakdale and Caswell during 1998 to 2002.

Daily Average Pulse Flow	Pulse Flow Duration	Fry Response
< 750	1 Day	Substantial passage at Oakdale No passage at Caswell
750	1 Day	Substantial pass at Oakdale Increased passage at Caswell
750 to 1,500	2 Days	Substantial passage at Oakdale Substantial passage at Caswell

FIGURE 6–1

2003 Supplemental pulse flow event of 1,000 cfs released from Goodwin Dam (RM58.4) including corresponding flows at Ripon (RM15.8) and fry passage at Caswell (RM8.6).



the 30th (Figure 6-1). Flow at Ripon followed a similar pattern, with a one day lag. Turbidity was measured at Ripon on the 29th and 30th and was 8.2 and 4.1 NTUs, respectively. Water temperature at Ripon decreased from 54.6°F on the 28th to 52.1°F on the 30th.

Throughout the 2003 supplemental flow period, rotary screw traps at Oakdale and Caswell were monitored frequently to ensure proper trap function and limit overcrowding of captured fish. Catch at Caswell increased within 1 day and peaked in 3 days of the beginning of the 2 day pulse event (Figure 6-1). When flows began to decrease, passage dropped sharply, but did not drop as low as levels observed in 2001 and 2002. During 2003, an estimated total of 79,137 fry moved past Caswell compared with fry passage in other low flow winters such as 6,376 in 2001 and 4,470 in 2002. However, in high flow winters, estimated totals of 809,614 fry and 1,018,946 fry moved past Caswell in 2000 and 1999, respectively. During January 2003, the artificial pulse flow and corresponding migratory response were similar in magnitude and duration to a natural (i.e., freshet) pulse flow event that occurred during January 2000, which indicates that managed flow releases from reservoir storage can stimulate fry migration comparable to natural flows with similar characteristics.

Passage estimates for 2003 suggest that 5.1% of fry passing Oakdale also passed Caswell as fry. This represents approximately a five to 12-fold increase in the proportion of fry that reached Caswell during the same period in previous dry years including 2001 (0.9%) and 2002 (0.4%). Passage estimates indicate that providing supplemental winter flow releases of at least 750 cfs for 2 days stimulates and sustains migration of some fry past Caswell.

While the flow test indicates that additional fry can be moved out of the Stanislaus River, it still remains to be determined whether those fry survive to smolt through the Delta in a low flow year. Based on fish salvage and loss data at the CVP and SWP Delta export facilities from 1998–2002, large numbers of

FIGURE 6–2

Passage of fall-run Chinook salmon fry in 1998 at Caswell and salvage/loss at the CVP and SWP Delta facilities.

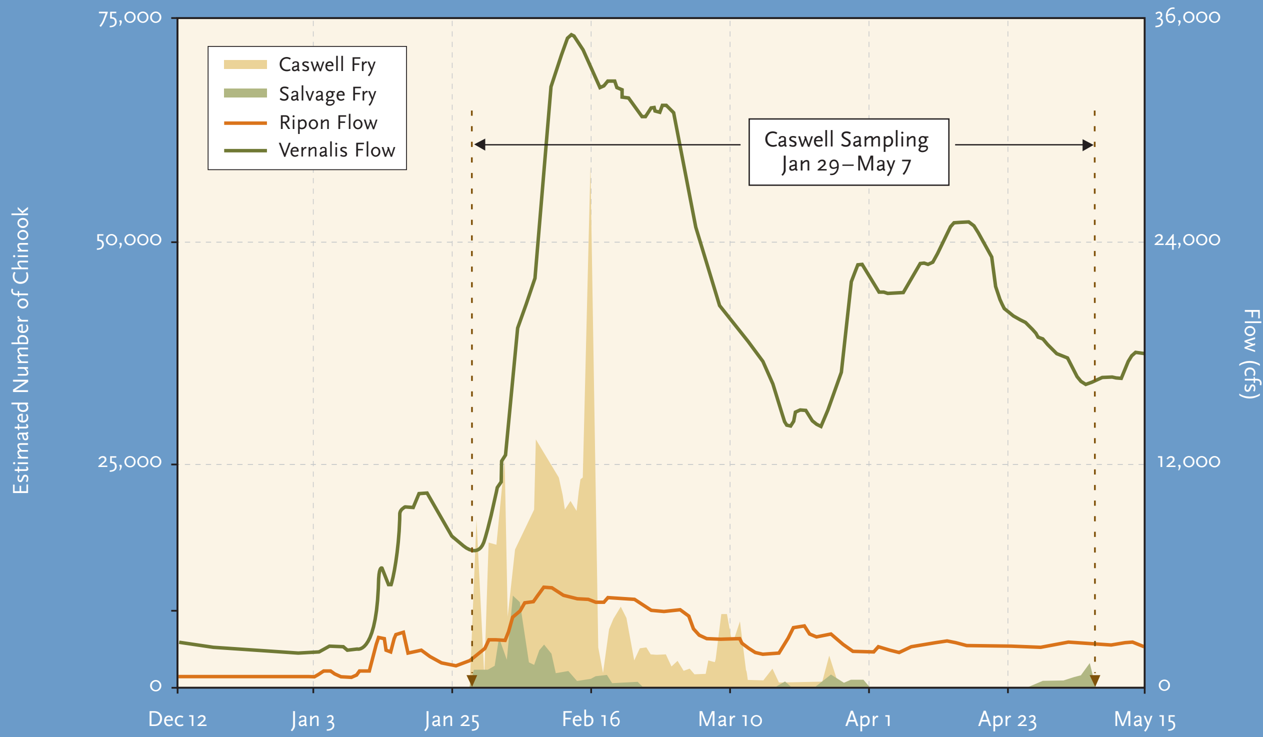
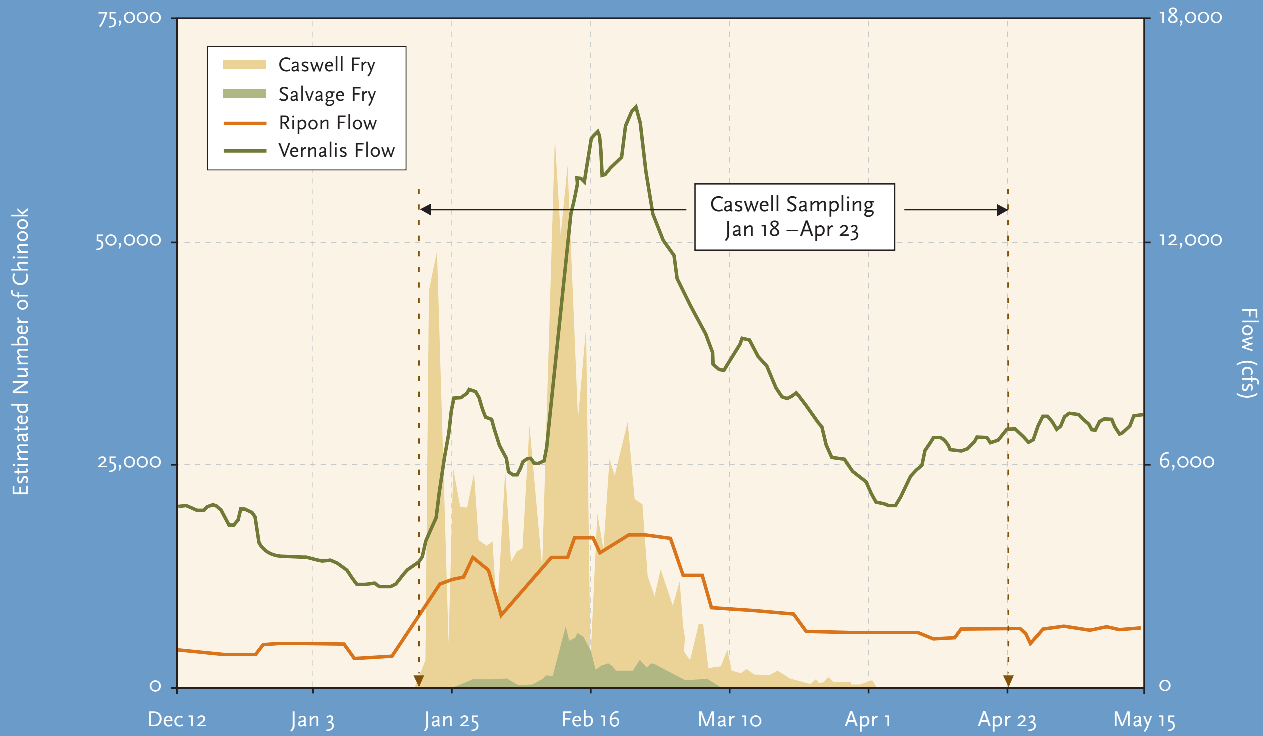


FIGURE 6–3

Passage of Fall-run Chinook salmon fry in 1999 at Caswell and salvage/loss at the CVP and SWP Delta facilities.



fry typically arrive at the facilities during intermediate and wet water years (i.e., 83,029 in 1998; 70,948 in 1999; and 82,299 in 2000) but not in dry years (i.e., 2,123 in 2001; 718 in 2002; and 2,604 in 2003). Although the origin of fry arriving at the Delta facilities can not be confirmed, the observed peaks in fry salvage and loss in intermediate/wet years typically occur within 6 to 14 days after initial flow increases in the Stanislaus River during pulse flow events, and within 2 to 8 days of associated Caswell outmigration peaks (Figures 6-2 thru 6-7).

In 2003, the total fry salvage and loss at the Delta CVP and SWP facilities was 2,604 which is similar to other dry years. However, a majority (i.e., 2,130) were observed between 5 to 10 days following the initial Stanislaus River pulse flow, with the peak (i.e., 1,202) occurring within 7 days of the pulse. This correspondence in timing of fry passage indicates that fry observed at the Delta facilities from February 1 to 6 can be attributed to the Stanislaus River. Further, the data indicate fry were able to successfully migrate from the Stanislaus River, through the lower San Joaquin River, and into the Delta. However, the large numbers of fry observed at the Delta facilities still leave open the possibility that fry during these low flow conditions may not survive in the Delta until they reach the smolt stage.

Since fry were not tagged for this experiment, it is impossible to estimate fry survival through the Delta at this time. Although this evaluation determined that fry can be stimulated to migrate out of the Stanislaus River in dry years with artificial flow releases around 1,000 cfs, additional supplemental winter pulse flow experiments are recommended with the development and implementation of a coordinated fry coded-wire tagging program. Such a program is suggested in order to estimate survival of fry through the Delta and ocean stage of the salmon lifecycle. The long-term survival and relative contribution of fry to the population can only be ascertained through a permanent tagging and recovery program.

RADIO TAGGING STUDIES IN THE LOWER SAN JOAQUIN RIVER

contributed by David Vogel, Natural Resources Scientists, Inc.

During April and May 2003, Natural Resource Scientists, Inc. released and monitored radio-tagged juvenile Chinook salmon in the lower San Joaquin River. Field data collection for this project was designed to acquire information on specific behavior (movements) as juvenile Chinook salmon migrated through delta channels just prior to and during VAMP implementation. The 2003 study expanded upon the techniques NRS developed in prior studies on juvenile salmon using radio telemetry, including recent studies at the Delta Cross Channel and the north, south and central Delta regions.

Juvenile Chinook salmon with surgically-implanted miniature (1 gram) radio transmitters were released in the San Joaquin River near Fourteen-Mile Slough (downstream of Stockton). Twelve to 13 radio-tagged salmon were released on each of the following dates: April 8 (pre-VAMP), April 15, April 22, and April 29 (during VAMP). The radio-tagged fish were tracked for 4 days after release using mobile receivers on two inboard jet boats. Individual fish movements, migration rates, and behavior in response to tidal cycles and flow splits in Delta channels were important parameters assessed from field observations. In particular, the project was intended to evaluate what occurs during the telemetered salmon migration past the flow splits at Turner Cut, Columbia Cut, and lower Middle and Old rivers. Each time a radio-tagged fish was located, the exact position (via GPS), time, and any relevant biological and behavioral observations were recorded. Figures 6-8 through 6-11, and show preliminary data on locations of radio-tagged juvenile Chinook salmon released and tracked in the Delta during the four weeks of experiments.

A report on this project will be completed after receipt of DWR tidal flow data measured in the San Joaquin River near Rough and Ready Island.

FIGURE 6–4

Passage of Fall-run Chinook salmon fry in 1999 at Caswell and salvage/loss at the CVP and SWP Delta facilities.

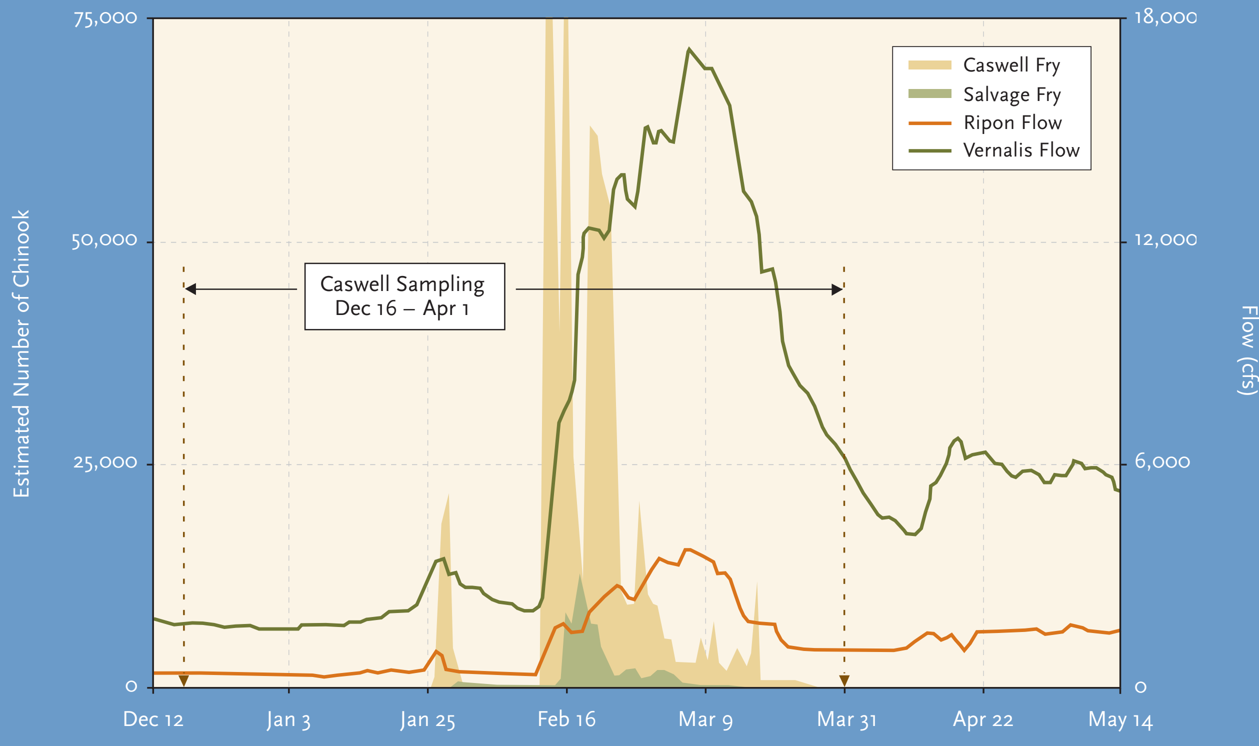


FIGURE 6–5

Passage of fall-run Chinook salmon fry in 2001 at Caswell and salvage/loss at the CVP and SWP Delta facilities

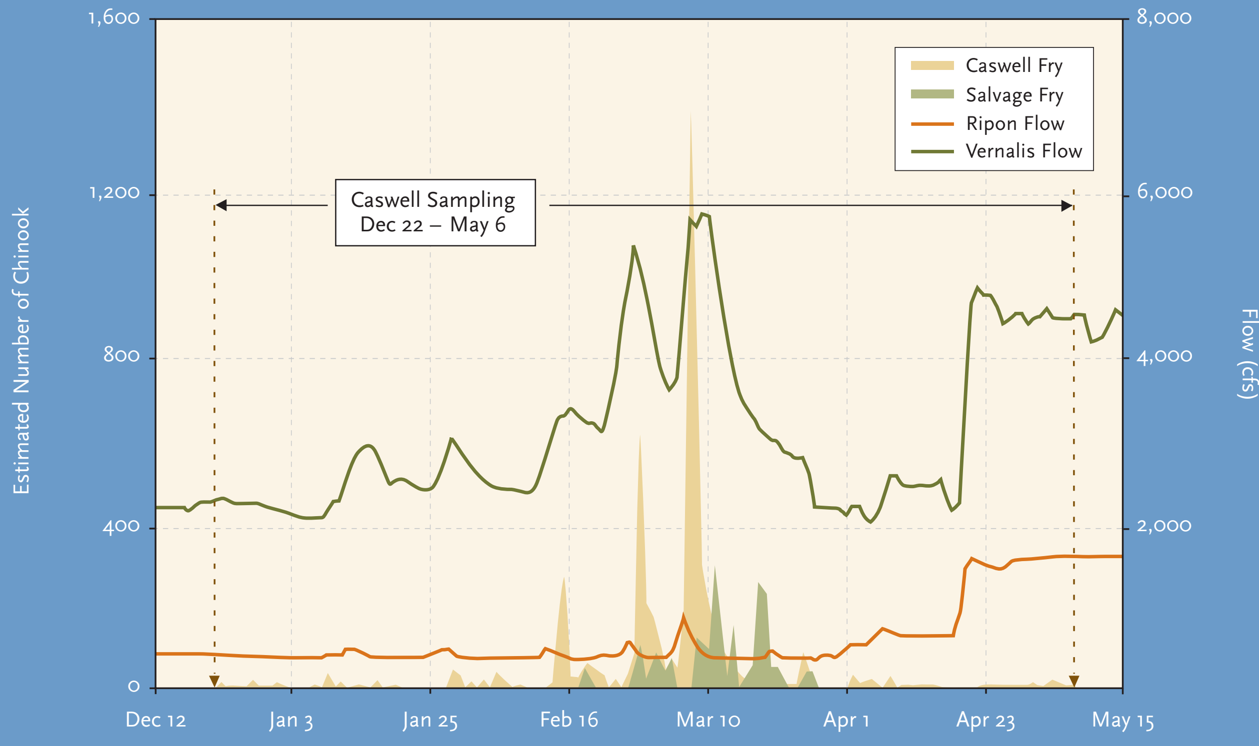


FIGURE 6–6

Passage of fall-run Chinook salmon fry in 2001 at Caswell
and salvage/loss at the CVP and SWP Delta facilities

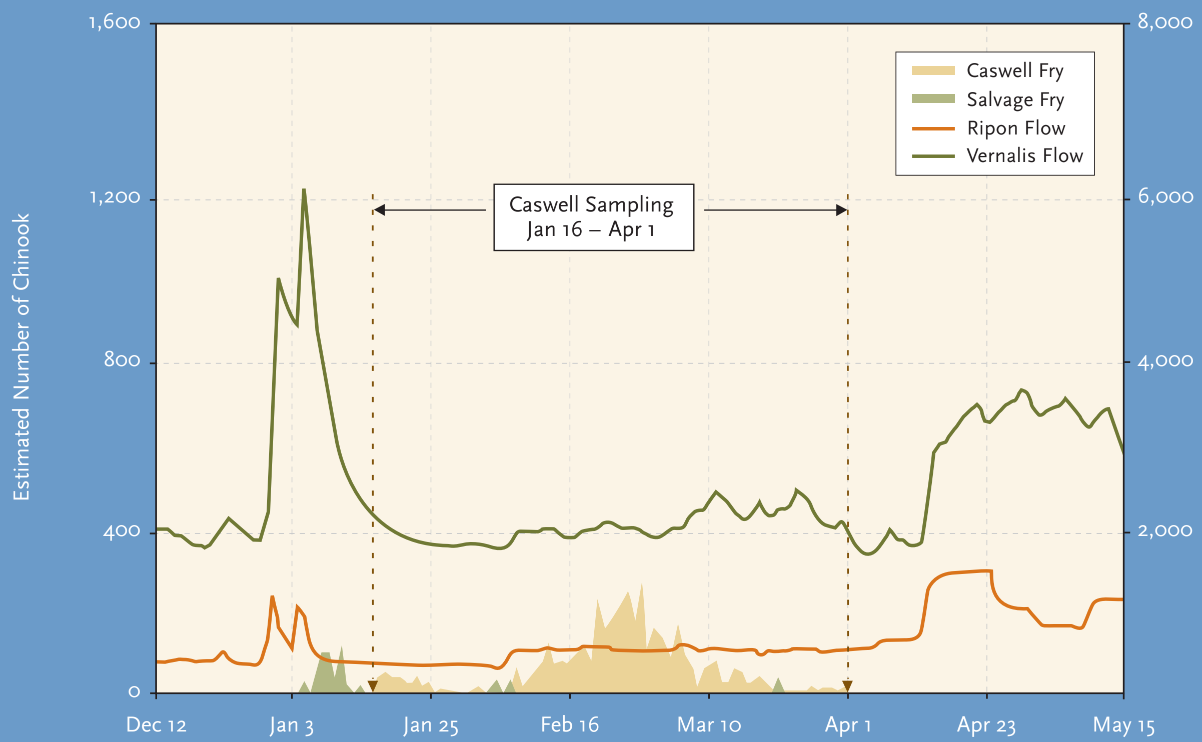


FIGURE 6–7

Passage of fall-run Chinook salmon fry in 2003 at Caswell
and salvage/loss at the CVP and SWP Delta facilities.
Fry passage at Caswell on Feb 14 was 145,565 and 94,358 on Feb 16.

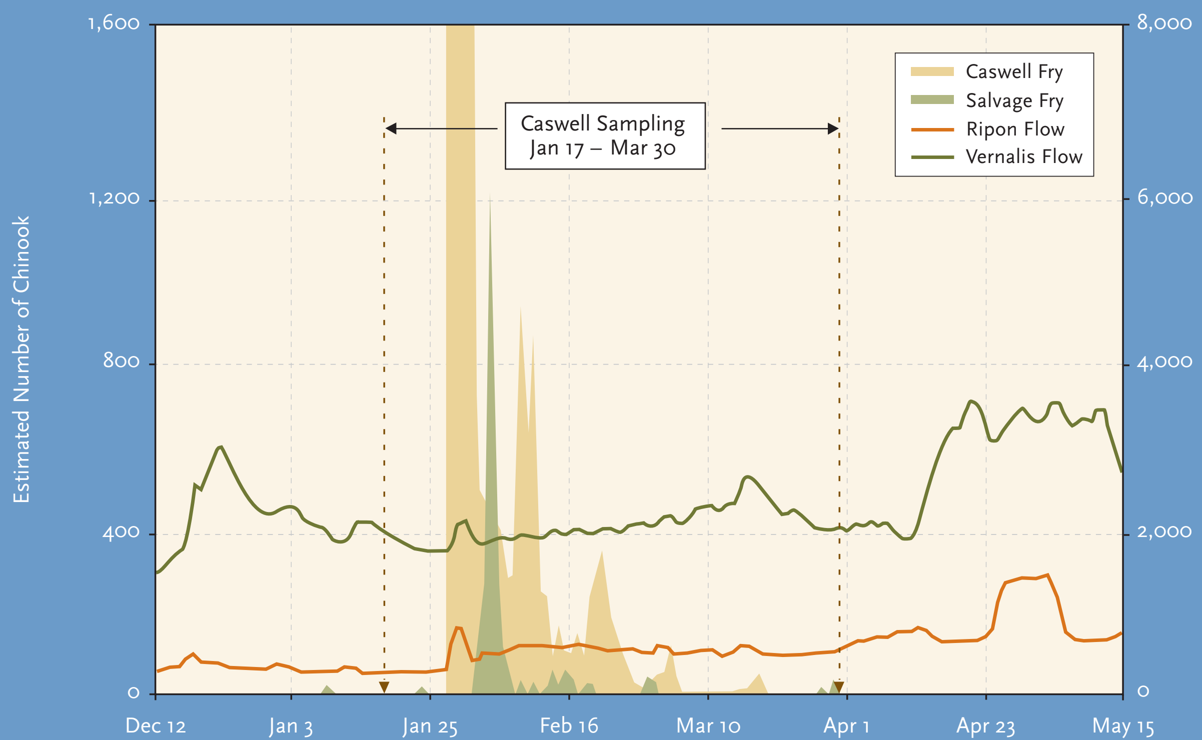


FIGURE 6–8

Locations of Radio-Tagged Juvenile Salmon, Release #1 on April 8, 2003.

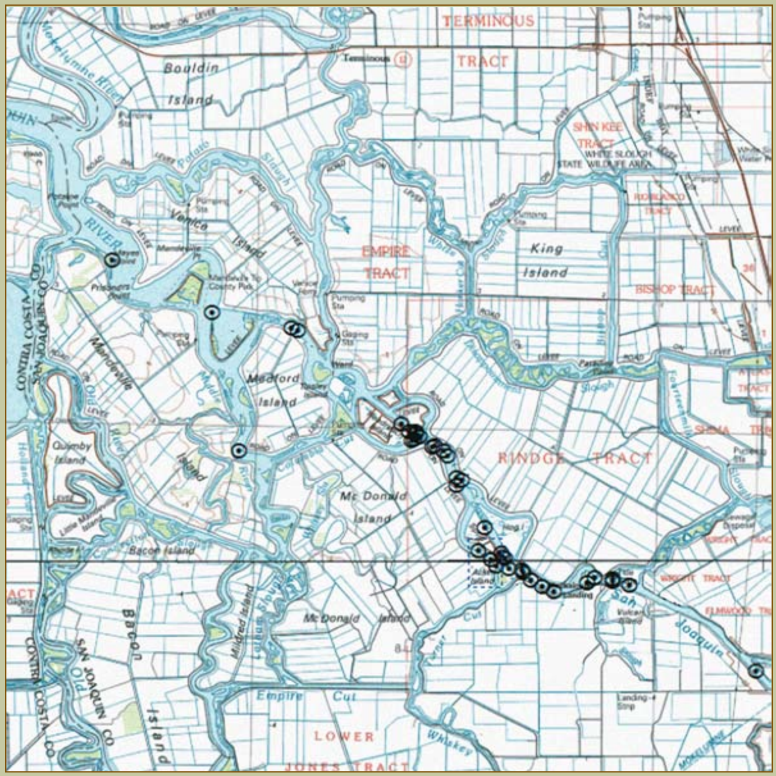


FIGURE 6–9

Locations of Radio-Tagged Juvenile Salmon, Release #2 on April 15, 2003.

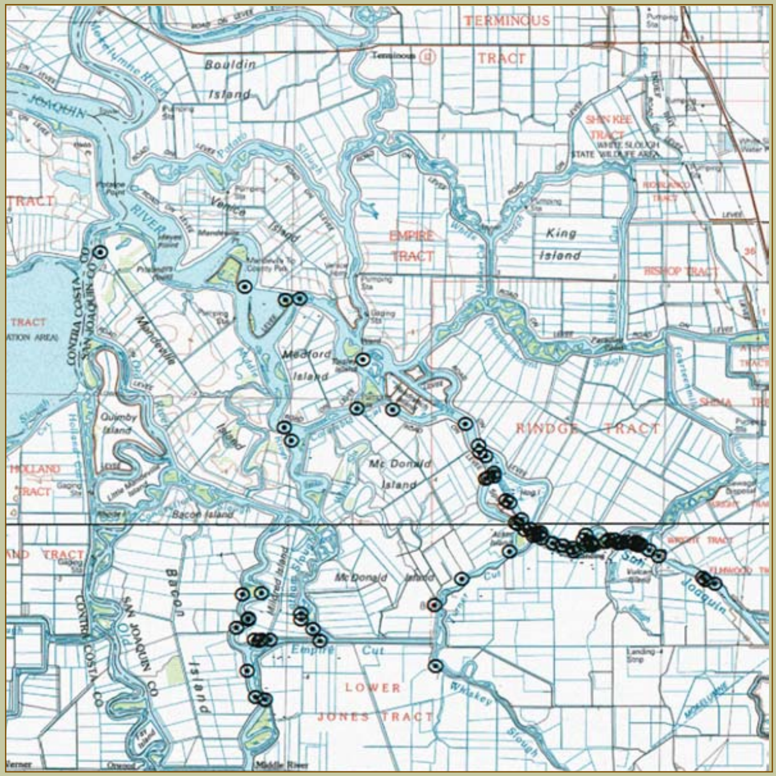


FIGURE 6–10

Locations of Radio-Tagged Juvenile Salmon, Release #3 on April 22, 2003.

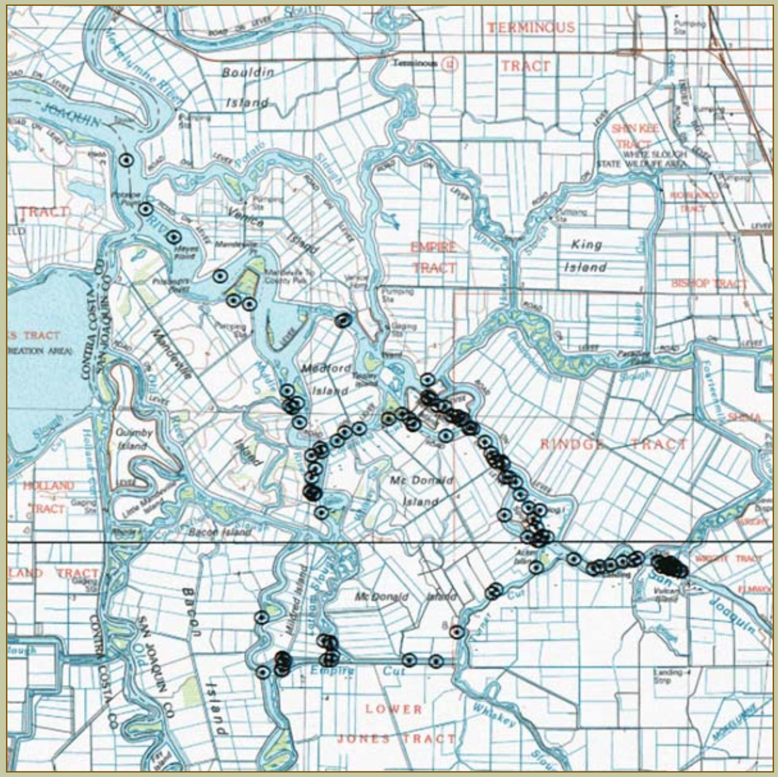
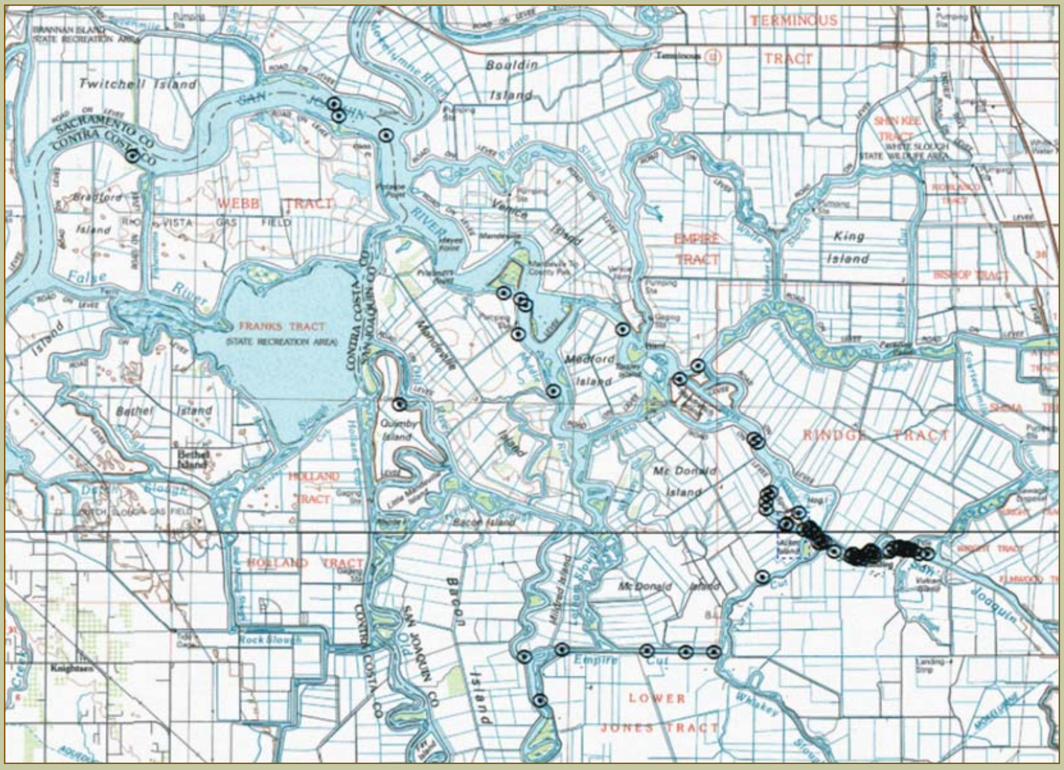


FIGURE 6–11

Locations of Radio-Tagged Juvenile Salmon, Release #4 on April 29, 2003.



CHAPTER 7

Conclusions & Recommendations

The VAMP experimental investigation of juvenile Chinook salmon survival was implemented during spring 2003. The Vernalis target flow was 3200 cfs, with a combined SWP and CVP export rate of 1500 cfs. The HORB was successfully installed and maintained throughout the VAMP test period. Estimates of juvenile Chinook salmon smolt survival were calculated based upon recoveries of CWT juvenile salmon produced in the Merced River Fish Facility and released at Durham Ferry, Mossdale, and Jersey Point. Marked salmon were subsequently recaptured in sampling at the HORB, SWP and CVP export facility salvage, and through intensive fisheries sampling at Antioch and Chipps Island. Based upon the data and experience gained during the VAMP 2003 investigations, conclusions and recommendations have been developed, as summarized in Table 7-1. The conclusions and recommendations include both technical and policy/management issues that will affect the design and implementation of VAMP 2004 operations and investigations.

Based on testing the relationship of salmon survival rates against flow and export conditions in 2000, 2001, 2002, and 2003 it has been shown that survival generally improves as flows increase and flows relative to exports increase. With the addition of the 2003 data, the relationships between salmon survival rates and Vernalis flows to SWP/CVP export ratios are no longer statistically significant. Survival tests at extreme target levels are important to obtain. The VAMP program provides improved protection for juvenile salmon when compared to "pre-VAMP" conditions.

TABLE 7–1
Summary of VAMP 2003 conclusions and recommendations

Conclusions	Recommendations
Hydrologic measurements at Vernalis were improved by weekly verification of rating curves.	Continue weekly flow measurements. Investigate alternative flow measurement methods and/or locations. Obtain additional funding for USGS weekly Vernalis gage verification.
Estimation of ungaged flows (accretions, depletions) at Vernalis was improved.	Continue hydrology investigation to improve predictions of ungaged flows.
Flow in the lower San Joaquin River downstream of Old River is important to evaluating salmon survival.	Calibrate the stage and flow monitoring system prior to the 2004 VAMP test period.
Confusion over forecasting New Melones releases impacted planning for tributary flows and related operations.	Management committee should resolve forecasting issues prior to 2004 VAMP and a set of written procedures for operational planning within each tributary should be established.
Coordination with upstream tributary operations was successful.	Continue coordination among tributary operators.
First release of CWT test fish was delayed five days to allow for completion of construction, clean-up, and flushing of debris from culverts.	Continue to work with DWR and resource agencies on scheduling construction of HORB to facilitate VAMP releases as quickly after barrier closure as possible.

Conclusions Continued	Recommendations Continued
Operation of the HORB was successful in maintaining south delta water levels.	Continue to refine operational criteria for culverts, water level modeling, and groundwater level monitoring.
Closure of HORB is dependent on completion of other barriers. Construction of multiple barriers in south delta channels may delay HORB closure.	Continue to work with DWR and resource agencies on scheduling construction of south Delta barriers to facilitate VAMP releases as quickly after barrier closure as possible.
An estimate of the flow through the culverts was obtained through use of measuring device in culvert #4.	Take flow measurements within each culvert during the 2004 VAMP.
The use of fyke nets was successful in collecting entrained fish at the culverts.	Continue monitoring culverts using fyke nets to document fish entrainment.
The index of salmon entrainment at HORB was substantially higher in 2003 (3.4 salmon per hour) with three culvert operated compared to 2002 (2.5 salmon per hour and 2001 (1.4 salmon per hour) when all six culverts were operated.	Continue barrier monitoring and analysis of factors affecting entrainment.
Most salmon were entrained at night in 2003, similar to prior years. The relationship between tidal condition and salmon entrainment at HORB was variable.	The split releases at Mossdale should be continued to evaluate tidal-diel interactions affecting salmon entrainment.
2003 studies were successful in determining salmon entrainment at HORB culverts, but did not estimate mortality associated with HORB.	Evaluate methods to estimate mortality associated with HORB.
The release at Durham Ferry was improved by having the diversion pump at the site curtail operation.	Continue to curtail diversion pump operations during releases—coordinate release schedule with landowner.
Water temperatures were suitable during both sets of releases.	Avoid seasonal delays in barrier installation and survival testing to allow releases when most suitable water temperatures.
Results of net pen studies showed a $1/2$ percent mortality rate in 2003 compared to no mortality in 2002.	Continue net pen studies and fish health inspections.
Physiological studies provided useful information on fish health and condition and indicated PKD may have been a factor in survival particularly for the second set of releases.	Recommend continued health monitoring to compare within and between year trends of health and condition.
There were few consistent patterns in blood chemistry values among releases groups. Comparisons were complicated by differences in transport time and handling.	Baseline data for blood chemistry analyses should be taken from unstressed fish (not subjected to stress for 24 or more hours).
2003 survival rates were the lowest since the initiation of the VAMP and were significantly lower than those in 2002 under similar flow and export conditions.	Continue to evaluate differences in survival rates between release locations, flows, and export conditions.
Survival from Durham Ferry and Mossdale in 2003 was significantly less then prior years. Further evaluation of survival rate versus flow and export rate is needed to detect differences in survival.	Repeat the 2003 target flow and export condition in the future when conditions allow. Testing 7000 cfs flow and 1500 cfs export rate is recommended to determine survival under higher flow/export ratio. Continue VAMP test program.
Complimentary studies to evaluate mechanisms affecting survival of fish from tributaries and through the Delta were conducted.	Encourage an expansion of complementary studies to provide additional information on factors and mechanisms affecting salmon survival.
Relatively few CWT salmon from VAMP releases were recovered at the SWP and CVP salvage facilities.	Continue salvage monitoring to document direct losses at SWP/CVP export facilities.

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U.S. Bureau of Reclamation

U.S. Fish and Wildlife Service

California Department of Water Resources

California Department of Fish and Game

Oakdale Irrigation District*

South San Joaquin Irrigation District*

Modesto Irrigation District*

Turlock Irrigation District*

Merced Irrigation District*

San Joaquin River Exchange Contractors
Water Authority*
Central California Irrigation District
Firebaugh Canal Water District
Columbia Canal Company
Sal Luis Canal Company

Friant Water Users Authority*

Public Utilities Commission of the City
and County of San Francisco*

Natural Heritage Institute

Metropolitan Water District of Southern California

San Luis and Delta–Mendota Canal Water Authority

San Joaquin River Group Authority

* *San Joaquin River Group Authority Members*

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PAGE 3

San Joaquin River Agreement

www.sjrg.org/agreement.htm

PAGE 3

SWRCB Decision 1641

www.waterrights.ca.gov/hearings/Decisions.htm

PAGE 4

VAMP 2002 Annual Technical Report

www.sjrg.org/technicalreport/2002_tech_report.htm

PAGE 9

VAMP Experimental Design

www.sjrg.org/agreement.htm

PAGE 12

Operation Monitoring, CDEC Hourly

cdec.water.ca.gov/cgi-progs/queryGroup?s=fw1

Operation Monitoring, CDEC Daily

cdec.water.ca.gov/cgi-progs/queryDgroups?s=fw2

Vernalis USGS Real-Time

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Vernalis, USGS Daily

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Newman, USGS Daily

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Cressey, CDEC Daily

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Stevinson, CDEC Daily

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LaGrange, USGS Daily

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Goodwin, USBR Daily

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PAGE 22

Temporary Barrier Program

sdelta.water.ca.gov

PAGE 27

Reclamation District 544 Seepage Monitoring Study

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PAGE 35

HORB on Old River Tidal Stage

cdec.water.ca.gov

PAGE 65

CVP and SWP Salvage Data

www.iep.ca.gov/dfishfa/fmt.html

USFWS Stockton

www.delta.dfg.ca.gov/usfws/monitoring_main/monitoring_main.html

Pacifica States Marine Fisheries Commission Regional Mark Information System

www.rmis.org

HORB on Old River Tidal Stage

cdec.water.ca.gov

COMMON ACRONYMS & ABBREVIATIONS

ACDP	Accoustic Doppler Current Profiler
Bay–Delta	Sacramento and San Joaquin Rivers San Francisco Bay Delta
CDEC	California Data Exchange Center
CDRR	Combined Differential Recovery Rate
CFS	Cubic Feet Per Second
CPUE	Catch Per Unit Effort
CRR	Combined Recovery Rate
CVP	Central Valley Project
CWT	Code Wire Tagged
D–1641	Water Rights Decision 1641 of the SWRCB
DFG	California Department of Fish and Game
DWR	California Department of Water Resources
GLC	Grant Line Canal
HOR	Head of Old River
HORB	Head of Old River Barrier
Merced	Merced Irrigation District
MID	Modesto Irrigation District
MR	Middle River
MSL	Mean Sea Level
NOAA	National Marine Fisheries Service
OID	Oakdale Irrigation District
ORT	Old River at Tracy
PKD	Proliferative Kidney Disease
SDWA	South Delta Water Agency
SJRA	San Joaquin River Agreement
SJREC	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	California State Water Resources Control Board
TBP	Temporary Barriers Project
TID	Turlock Irrigation District
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

APPENDIX A

Hydrology & Operation Plans

Appendix A–1, Table 1

VAMP DAILY OPERATION PLAN, MARCH 12, 2003 (A) • LOW

Target Flow Period: April 15 – May 15 • Flow Target: 3,200 cfs

	San Joaquin River near Vernalis							Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus River below Goodwin				
	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. Flow	Exch Contr VAMP Supp. Flow	VAMP Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol. S=Stan.
	(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	
Apr 01						400	300	250			250	150	150		150	763			763	
Apr 02						397	300	250			250	150	150		150	763			763	
Apr 03						393	300	250			250	150	150		150	763			763	
Apr 04	1,860				1,860	390	300	250			250	150	150		150	763			763	
Apr 05	1,856				1,856	386	300	250			250	150	150		150	763			763	
Apr 06	1,853				1,853	383	300	250			250	150	150		150	763			763	
Apr 07	1,849				1,849	379	300	250			250	150	150		150	763			763	
Apr 08	1,846				1,846	376	300	250			250	150	150		150	763			763	
Apr 09	1,842				1,842	372	300	250			250	150	150		150	763			763	
Apr 10	1,839				1,839	369	300	250			250	150	150		150	763			763	
Apr 11	1,835				1,835	365	300	250	250		500	150	150		150	763			763	
Apr 12	1,832				1,832	362	300	250	501	119	870	275	275		275	763			763	
Apr 13	1,828	0			1,828	360	300	250	571	119	940	400	400	150	550	763	300	0	1,063	
Apr 14	1,950	250			2,200	356	300	250	581	119	950	400	400	150	550	763	300	0	1,063	
Apr 15	2,073	1,070	0	2.12	3,143	352	300	250	531	119	900	386	386	150	536	763	300	0	1,063	
Apr 16	2,069	1,140	0	4.38	3,209	349	300	250	531	119	900	441	441	150	591	763	300	0	1,063	
Apr 17	2,051	1,150	0	6.66	3,201	345	300	250	541	119	910	441	441	150	591	763	300	0	1,063	
Apr 18	2,103	1,100	0	8.85	3,203	341	300	250	541	119	910	441	441	150	591	763	300	0	1,063	
Apr 19	2,099	1,100	0	11.03	3,199	337	300	250	551	119	920	441	441	150	591	763	300	0	1,063	
Apr 20	2,095	1,110	0	13.23	3,205	334	300	250	551	119	920	441	441	150	591	763	300	0	1,063	
Apr 21	2,092	1,110	0	15.43	3,202	330	300	250	551	119	920	441	441	150	591	763	300	0	1,063	
Apr 22	2,088	1,120	0	17.65	3,208	326	300	250	551	119	920	441	441	150	591	763	300	0	1,063	
Apr 23	2,084	1,120	0	19.87	3,204	322	300	250	451	119	820	441	441	150	591	763	300	0	1,063	
Apr 24	2,080	1,120	0	22.10	3,200	319	300	250	451	119	820	718	718	300	1,018	763	0	0	763	
Apr 25	2,077	1,120	0	24.32	3,197	315	300	250	451	119	820	718	718	300	1,018	763	0	0	763	
Apr 26	2,349	870	0	26.04	3,219	311	300	250	451	119	820	718	718	300	1,018	763	0	0	763	
Apr 27	2,346	870	0	27.77	3,216	307	300	250	451	119	820	718	718	300	1,018	763	0	0	763	
Apr 28	2,342	870	0	29.49	3,212	304	300	250	451	119	820	718	718	300	1,018	763	0	0	763	
Apr 29	2,338	870	0	31.22	3,208	300	300	250	451	119	820	718	718	300	1,018	763	0	0	763	
Apr 30	2,334	870	0	32.95	3,204	296	300	250	451	119	820	718	718	300	1,018	763	0	0	763	
May 01	2,330	870	0	34.67	3,200	292	300	250	451	119	820	718	718	300	1,018	733	0	0	733	
May 02	2,327	870	0	36.40	3,197	288	300	250	641	119	1,010	494	494	300	794	733	340	0	1,073	
May 03	2,293	870	0	38.12	3,163	285	300	250	771	119	1,140	331	331	200	531	733	340	0	1,073	
May 04	2,065	1,210	0	40.52	3,275	281	300	250	771	119	1,140	331	331	100	431	733	340	0	1,073	
May 05	1,898	1,300	0	43.10	3,198	277	300	250	771	119	1,140	331	331	100	431	733	340	0	1,073	
May 06	1,895	1,330	0	45.74	3,225	273	300	250	771	119	1,140	331	331	100	431	733	340	0	1,073	
May 07	1,891	1,330	0	48.38	3,221	270	300	250	771	119	1,140	331	331	100	431	733	340	0	1,073	
May 08	1,887	1,330	0	51.01	3,217	266	300	250	771	119	1,140	331	331	100	431	733	340	0	1,073	
May 09	1,883	1,330	0	53.65	3,213	262	300	250	771	119	1,140	317	317	100	417	733	340	0	1,073	
May 10	1,897	1,330	0	56.29	3,209	258	300	250	771	119	1,140	317	317	100	417	733	340	0	1,073	
May 11	1,862	1,330	0	58.93	3,192	255	300	250	771	119	1,140	303	303	100	403	733	340	0	1,073	
May 12	1,858	1,330	0	61.57	3,188	251	300	250	771	119	1,140	303	303	100	403	733	340	0	1,073	
May 13	1,840	1,330	0	64.20	3,170	247	300	250	350		600	303	303	100	403	733	340	0	1,073	
May 14	1,837	1,330	0	66.84	3,167	243	300	250	50		300	225	225		225	733			733	
May 15	1,833	1,330	0	69.48	3,163	240	300	250			250	150	150		150	733			733	
May 16	1,751	350			2,101	236	300	250			250	150	150		150	733			733	
May 17	1,673	50			1,723	232	300	250			250	150	150		150	733			733	
May 18	1,669	0			1,669	229	300	250			250	150	150		150	733			733	
May 19	1,665	0			1,665	225	300	250			250	150	150		150	733			733	
May 20	1,662	0			1,662	221	300	250			250	150	150		150	733			733	
May 21	1,658	0			1,658	217	300	250			250	150	150		150	733			733	
May 22	1,654	0			1,654	214	300	250			250	150	150		150	733			733	
May 23	1,650	0			1,650	210	300	250			250	150	150		150	733			733	
May 24	1,647	0			1,647	206	300	250			250	150	150		150	733			733	
May 25	1,643	0			1,643	203	300	250			250	150	150		150	733			733	
May 26	1,639	0			1,639	199	300	250			250	150	150		150	733			733	
May 27	1,636	0			1,636	195	300	250			250	150	150		150	733			733	
May 28	1,632	0			1,632	192	300	250			250	150	150		150	733			733	
May 29	1,628	0			1,628	188	300	250			250	150	150		150	733			733	
May 30	1,625	0			1,625	184	300	250			250	150	150		150	733			733	
May 31	1,621	0			1,621	180	300	250			250	150	150		150	733			733	
	VAMP period																			
Avg. (cfs):	2,071	1,130			3,201	304	300	250	594	119	963	467	467	179	646	750	238	0	988	
Suppl. Water (TAF)		69.48							36.52	7.32				11.01			14.64			

Target flow period

Period of desired flow stability

Appendix A – 1, Table 2

VAMP DAILY OPERATION PLAN, MARCH 12, 2003 (B) • HIGH

Target Flow Period: April 15 – May 15 • Flow Target: 3,200 cfs

San Joaquin River near Vernalis							Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus River below Goodwin					
Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. Flow	Exch Contr VAMP Supp. Flow	VAMP Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol..	
(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		
					600	600	250			250	150	150		150	746			746		Apr 01
					595	600	250			250	150	150		150	746			746		Apr 02
					590	600	250			250	150	150		150	746			746		Apr 03
2,341				2,341	585	600	250			250	150	150		150	746			746		Apr 04
2,336				2,336	580	600	250			250	150	150		150	746			746		Apr 05
2,331				2,331	575	600	250			250	150	150		150	746			746		Apr 06
2,326				2,326	570	600	250			250	150	150		150	746			746		Apr 07
2,321				2,321	565	600	250			250	150	150		150	746			746		Apr 08
2,316				2,316	560	600	250			250	150	150		150	746			746		Apr 09
2,311				2,311	555	600	250			250	150	150		150	746			746		Apr 10
2,306				2,306	550	600	250	100		350	150	150		150	746			746		Apr 11
2,301				2,301	545	600	250	300	0	550	302	302		302	746			746		Apr 12
2,296	0			2,296	540	600	250	300	0	550	628	660	0	660	746	0	0	746		Apr 13
2,443	100			2,543	535	600	250	220	0	470	628	660	0	660	746	0	0	746		Apr 14
2,796	300	0	0.60	3,096	531	600	250	160	0	410	606	660	0	660	936	0	0	936		Apr 15
2,791	300	0	1.19	3,091	526	600	250	160	0	410	693	730	0	730	936	0	0	936		Apr 16
2,977	220	0	1.63	3,197	522	600	250	160	0	410	693	730	0	730	936	0	0	936		Apr 17
3,042	160	0	1.94	3,202	517	600	250	160	0	410	693	730	0	730	936	0	0	936		Apr 18
3,038	160	0	2.26	3,198	513	600	250	160	0	410	693	730	0	730	936	0	0	936		Apr 19
3,033	160	0	2.58	3,193	508	600	250	160	0	410	693	730	0	730	936	0	0	936		Apr 20
3,029	160	0	2.90	3,189	504	600	250	160	0	410	693	730	0	730	936	0	0	936		Apr 21
3,024	160	0	3.21	3,184	499	600	250	160	0	410	693	730	0	730	936	0	0	936		Apr 22
3,020	160	0	3.53	3,180	495	600	250	0	0	250	693	730	0	730	936	0	0	936		Apr 23
3,015	160	0	3.85	3,175	490	600	250	0	0	250	1,127	1,000	0	1,000	936	0	0	936		Apr 24
3,011	160	0	4.17	3,171	486	600	250	0	0	250	1,127	1,000	0	1,000	936	0	0	936		Apr 25
3,276	0	0	4.17	3,276	481	600	250	0	0	250	1,127	1,000	0	1,000	936	0	0	936		Apr 26
3,272	0	0	4.17	3,272	477	600	250	0	0	250	1,127	1,000	0	1,000	936	0	0	936		Apr 27
3,267	0	0	4.17	3,267	472	600	250	0	0	250	1,127	1,000	0	1,000	936	0	0	936		Apr 28
3,263	0	0	4.17	3,263	467	600	250	0	0	250	1,127	1,000	0	1,000	936	0	0	936		Apr 29
3,258	0	0	4.17	3,258	463	600	250	0	0	250	1,127	1,000	0	1,000	936	0	0	936		Apr 30
3,253	0	0	4.17	3,253	458	600	250	160	0	410	1,127	1,000	0	1,000	936	0	0	936		May 01
3,249	0	0	4.17	3,249	454	600	250	400	0	650	775	800	0	800	936	0	0	936		May 02
3,244	0	0	4.17	3,244	449	600	250	400	0	650	519	570	0	570	936	0	0	936		May 03
3,040	160	0	4.48	3,200	445	600	250	400	0	650	519	570	0	570	936	0	0	936		May 04
2,805	400	0	5.28	3,205	440	600	250	400	0	650	519	570	0	570	936	0	0	936		May 05
2,801	400	0	6.07	3,201	436	600	250	400	0	650	519	570	0	570	936	0	0	936		May 06
2,796	400	0	6.86	3,196	431	600	250	400	0	650	519	570	0	570	936	0	0	936		May 07
2,792	400	0	7.66	3,192	427	600	250	450	0	700	519	570	0	570	936	0	0	936		May 08
2,787	400	0	8.45	3,187	422	600	250	450	0	700	497	530	0	530	936	0	0	936		May 09
2,783	400	0	9.24	3,183	418	600	250	450	0	700	497	530	0	530	936	0	0	936		May 10
2,738	450	0	10.14	3,188	413	600	250	450	0	700	476	530	0	530	936	0	0	936		May 11
2,734	450	0	11.03	3,184	409	600	250	430	0	680	476	530	0	530	936	0	0	936		May 12
2,729	450	0	11.92	3,179	404	600	250	100		350	476	530	0	530	936	0	0	936		May 13
2,725	450	0	12.81	3,175	400	600	250			250	389	389		389	936			936		May 14
2,720	430	0	13.67	3,150	395	600	250			250	302	302		302	936			936		May 15
2,574	100			2,674	391	600	250			250	215	215		215	707			707		May 16
2,483	0			2,483	386	600	250			250	150	150		150	707			707		May 17
2,163	0			2,163	382	600	250			250	150	150		150	707			707		May 18
2,093	0			2,093	377	600	250			250	150	150		150	707			707		May 19
2,089	0			2,089	373	600	250			250	150	150		150	707			707		May 20
2,084	0			2,084	368	600	250			250	150	150		150	707			707		May 21
2,080	0			2,080	364	600	250			250	150	150		150	707			707		May 22
2,075	0			2,075	359	600	250			250	150	150		150	707			707		May 23
2,071	0			2,071	355	600	250			250	150	150		150	707			707		May 24
2,066	0			2,066	350	600	250			250	150	150		150	707			707		May 25
2,062	0			2,062	346	600	250			250	150	150		150	707			707		May 26
2,057	0			2,057	341	600	250			250	150	150		150	707			707		May 27
2,053	0			2,053	337	600	250			250	150	150		150	707			707		May 28
2,048	0			2,048	332	600	250			250	150	150		150	707			707		May 29
2,044	0			2,044	328	600	250			250	150	150		150	707			707		May 30
2,039	0			2,039	323	600	250			250	150	150		150	707			707		May 31
					VAMP period															
2,978	222			3,200	472	600	250	222	0	472	733	732	0	732	924	0	0	924		Avg (cfs):
	13.67							13.67	0.00				0.00			0.00				Suppl. Water (TAF)

Target flow period

Period of desired flow stability

Appendix A–1, Table 3

VAMP DAILY OPERATION PLAN, MARCH 26, 2003 (A) • LOW

Target Flow Period: April 15–May 15 • Flow Target: 3,200 cfs

	San Joaquin River near Vernalis							Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus River below Goodwin				
	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. Flow	Exch Contr VAMP Suppl. Flow	VAMP Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol. S=Stan.
	(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	
Apr 01						342	300	250			250	150	150		150	763			763	
Apr 02						339	300	250			250	150	150		150	763			763	
Apr 03						335	300	250			250	150	150		150	763			763	
Apr 04	1,802				1,802	332	300	250			250	150	150		150	763			763	
Apr 05	1,798				1,798	328	300	250			250	150	150		150	763			763	
Apr 06	1,795				1,795	325	300	250			250	150	150		150	763			763	
Apr 07	1,791				1,791	321	300	250			250	150	150		150	763			763	
Apr 08	1,788				1,788	318	300	250			250	150	150		150	763			763	
Apr 09	1,784				1,784	314	300	250			250	150	150		150	763			763	
Apr 10	1,781				1,781	311	300	250			250	150	150		150	763			763	
Apr 11	1,777				1,777	307	300	250	50		300	150	150		150	763			763	
Apr 12	1,774				1,774	304	300	250	299	81	630	400	400		400	763			763	
Apr 13	1,770	0			1,770	300	300	250	299	81	630	800	800	165	965	763	0	0	763	
Apr 14	2,017	50			2,067	297	300	250	299	81	630	1,100	1,100	165	1,265	763	0	0	763	
Apr 15	2,413	545	0	1.08	2,958	293	300	250	299	81	630	1,100	1,100	165	1,265	763	0	0	763	
Apr 16	2,710	545	0	2.16	3,255	290	300	250	299	81	630	1,100	1,100	165	1,265	763	0	0	763	
Apr 17	2,706	545	0	3.24	3,251	286	300	250	299	81	630	1,100	1,100	165	1,265	763	0	0	763	
Apr 18	2,703	545	0	4.32	3,248	283	300	250	304	81	635	1,100	1,100	165	1,265	763	0	0	763	
Apr 19	2,699	545	0	5.40	3,244	279	300	250	304	81	635	1,100	1,100	165	1,265	763	0	0	763	
Apr 20	2,696	545	0	6.49	3,241	276	300	250	304	81	635	1,100	1,100	165	1,265	763	0	0	763	
Apr 21	2,692	550	0	7.58	3,242	272	300	250	304	81	635	1,100	1,100	165	1,265	763	0	0	763	
Apr 22	2,689	550	0	8.67	3,239	269	300	250	304	81	635	1,100	1,100	165	1,265	763	0	0	763	
Apr 23	2,685	550	0	9.76	3,235	265	300	250	304	81	635	1,100	1,100	165	1,265	763	0	0	763	
Apr 24	2,682	550	0	10.85	3,232	262	300	250	304	81	635	1,100	1,100	165	1,265	763	0	0	763	M
Apr 25	2,678	550	0	11.94	3,228	258	300	250	304	81	635	1,100	1,100	165	1,265	763	0	0	763	M
Apr 26	2,675	550	0	13.03	3,225	255	300	250	304	81	635	900	900	165	1,065	763	137	0	900	M
Apr 27	2,671	550	0	14.12	3,221	251	300	250	429	81	760	600	600	165	765	763	537	0	1,300	M, S
Apr 28	2,468	687	0	15.48	3,155	248	300	250	569	81	900	429	429	165	594	763	537	0	1,300	M, S
Apr 29	2,164	1,087	0	17.64	3,251	244	300	250	569	81	900	300	300	160	460	763	537	0	1,300	M, S
Apr 30	1,990	1,212	0	20.04	3,202	241	300	250	569	81	900	300	300	160	460	763	537	0	1,300	M, S
May 01	1,857	1,347	0	22.72	3,204	237	300	250	569	81	900	300	300	160	460	733	567	0	1,300	S
May 02	1,854	1,347	0	25.39	3,201	234	300	250	569	81	900	300	300	160	460	733	567	0	1,300	S
May 03	1,820	1,377	0	28.12	3,197	230	300	250	569	81	900	300	300	160	460	733	567	0	1,300	S
May 04	1,817	1,377	0	30.85	3,194	227	300	250	869	81	1,200	300	300	160	460	733	567	0	1,300	M, S
May 05	1,813	1,377	0	33.58	3,190	223	300	250	869	81	1,200	300	300	160	460	733	367	0	1,100	M
May 06	1,810	1,377	0	36.31	3,187	220	300	250	869	81	1,200	600	600	160	760	733	127	0	860	M
May 07	1,806	1,477	0	39.24	3,283	216	300	250	869	81	1,200	600	600	160	760	733	0	0	733	M
May 08	2,103	1,237	0	41.70	3,340	213	300	250	869	81	1,200	600	600	160	760	733	0	0	733	M
May 09	2,099	1,110	0	43.90	3,209	209	300	250	869	81	1,200	600	600	160	760	733	0	0	733	M
May 10	2,096	1,110	0	46.10	3,206	206	300	250	869	81	1,200	600	600	160	760	733	0	0	733	M
May 11	2,092	1,110	0	48.30	3,202	202	300	250	869	81	1,200	600	600	160	760	733	0	0	733	M
May 12	2,089	1,110	0	50.50	3,199	199	300	250	669	81	1,000	550	550	160	710	733	0	0	733	
May 13	2,085	1,110	0	52.70	3,195	195	300	250	300		550	450	450	160	610	733	0	0	733	
May 14	2,032	1,110	0	54.91	3,142	192	300	250	50		300	389	389		389	733			733	
May 15	1,928	910	0	56.71	2,838	188	300	250			250	302	302		302	733			733	
May 16	1,863	300			2,163	185	300	250			250	215	215		215	733			733	
May 17	1,773	50			1,823	181	300	250			250	150	150		150	733			733	
May 18	1,683	0			1,683	178	300	250			250	150	150		150	733			733	
May 19	1,614	0			1,614	174	300	250			250	150	150		150	733			733	
May 20	1,611	0			1,611	171	300	250			250	150	150		150	733			733	
May 21	1,607	0			1,607	167	300	250			250	150	150		150	733			733	
May 22	1,604	0			1,604	164	300	250			250	150	150		150	733			733	
May 23	1,600	0			1,600	160	300	250			250	150	150		150	733			733	
May 24	1,597	0			1,597	157	300	250			250	150	150		150	733			733	
May 25	1,593	0			1,593	153	300	250			250	150	150		150	733			733	
May 26	1,590	0			1,590	150	300	250			250	150	150		150	733			733	
May 27	1,586	0			1,586	146	300	250			250	150	150		150	733			733	
May 28	1,583	0			1,583	143	300	250			250	150	150		150	733			733	
May 29	1,579	0			1,579	139	300	250			250	150	150		150	733			733	
May 30	1,576	0			1,576	136	300	250			250	150	150		150	733			733	
May 31	1,572	0			1,572	132	300	250			250	150	150		150	733			733	
	VAMP period																			
Avg (cfs):	2,278	922			3,200	248	300	250	516	81	847	730	730	163	893	750	163	0	913	
Suppl. Water (TAF)		56.71							31.72	4.98				10.00			10.01			

Target flow period

Period of desired flow stability

Appendix A – 1, Table 4

VAMP DAILY OPERATION PLAN, MARCH 26, 2003 (B) • HIGH

Target Flow Period: April 15 – May 15 • Flow Target: 3,200 cfs

San Joaquin River near Vernalis							Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus River below Goodwin					
Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. Flow	Exch Contr VAMP Suppl. Flow	VAMP Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol.	
(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		
					548	500	250			250	150	150		150	746			746		Apr 01
					544	500	250			250	150	150		150	746			746		Apr 02
					540	500	250			250	150	150		150	746			746		Apr 03
2,190				2,190	536	500	250			250	150	150		150	746			746		Apr 04
2,186				2,186	532	500	250			250	150	150		150	746			746		Apr 05
2,182				2,182	528	500	250			250	150	150		150	746			746		Apr 06
2,178				2,178	524	500	250			250	150	150		150	746			746		Apr 07
2,174				2,174	520	500	250			250	150	150		150	746			746		Apr 08
2,170				2,170	516	500	250			250	150	150		150	746			746		Apr 09
2,166				2,166	512	500	250			250	150	150		150	746			746		Apr 10
2,162				2,162	508	500	250	50		300	150	150		150	746			746		Apr 11
2,158				2,158	504	500	250	150	0	400	400	400		400	746			746		Apr 12
2,154	0			2,154	500	500	250	150	0	400	800	800	0	800	746	0	0	746		Apr 13
2,400	50			2,450	496	500	250	150	0	400	1,100	1,100	0	1,100	746	0	0	746		Apr 14
2,796	150	0	0.30	2,946	491	500	250	150	0	400	1,100	1,100	0	1,100	746	0	0	746		Apr 15
3,092	150	0	0.60	3,242	487	500	250	150	0	400	1,100	1,100	0	1,100	746	0	0	746		Apr 16
3,087	150	0	0.89	3,237	483	500	250	150	0	400	1,100	1,100	0	1,100	746	0	0	746		Apr 17
3,083	150	0	1.19	3,233	478	500	250	150	0	400	1,100	1,100	0	1,100	746	0	0	746		Apr 18
3,079	150	0	1.49	3,229	474	500	250	150	0	400	1,100	1,100	0	1,100	746	0	0	746		Apr 19
3,074	150	0	1.79	3,224	469	500	250	150	0	400	1,100	1,100	0	1,100	746	0	0	746		Apr 20
3,070	150	0	2.08	3,220	465	500	250	150	0	400	1,100	1,100	0	1,100	746	0	0	746		Apr 21
3,065	150	0	2.38	3,215	461	500	250	200	0	450	1,100	1,100	0	1,100	746	0	0	746		Apr 22
3,061	150	0	2.68	3,211	456	500	250	200	0	450	1,100	1,100	0	1,100	746	0	0	746		Apr 23
3,057	150	0	2.98	3,207	452	500	250	200	0	450	1,100	1,100	0	1,100	746	0	0	746		Apr 24
3,052	200	0	3.37	3,252	448	500	250	250	0	500	1,100	1,100	0	1,100	746	0	0	746		Apr 25
3,048	200	0	3.77	3,248	443	500	250	250	0	500	900	900	0	900	746	0	0	746		Apr 26
3,044	200	0	4.17	3,244	439	500	250	250	0	500	600	600	0	600	950	0	0	950	M	Apr 27
2,839	250	0	4.66	3,089	435	500	250	250	0	500	429	429	0	429	1,500	0	0	1,500	M, S	Apr 28
2,739	250	0	5.16	2,989	430	500	250	250	0	500	300	300	0	300	1,500	0	0	1,500	M, S	Apr 29
3,114	250	0	5.65	3,364	426	500	250	250	0	500	300	300	0	300	1,500	0	0	1,500	M, S	Apr 30
2,980	250	0	6.15	3,230	421	500	250	250	0	500	300	300	0	300	1,500	0	0	1,500	M, S	May 01
2,976	250	0	6.64	3,226	417	500	250	250	0	500	300	300	0	300	1,500	0	0	1,500	M, S	May 02
2,971	250	0	7.14	3,221	413	500	250	250	0	500	300	300	0	300	1,500	0	0	1,500	S	May 03
2,967	250	0	7.64	3,217	408	500	250	700	0	950	300	300	0	300	1,500	0	0	1,500	S	May 04
2,963	250	0	8.13	3,213	404	500	250	800	0	1,050	300	300	0	300	1,100	0	0	1,100	M	May 05
2,958	250	0	8.63	3,208	400	500	250	800	0	1,050	600	600	0	600	707	0	0	707	M	May 06
2,554	700	0	10.02	3,254	395	500	250	800	0	1,050	600	600	0	600	707	0	0	707	M	May 07
2,457	800	0	11.60	3,257	391	500	250	800	0	1,050	600	600	0	600	707	0	0	707	M	May 08
2,452	800	0	13.19	3,252	386	500	250	800	0	1,050	600	600	0	600	707	0	0	707	M	May 09
2,448	800	0	14.78	3,248	382	500	250	800	0	1,050	600	600	0	600	707	0	0	707	M	May 10
2,443	800	0	16.36	3,243	378	500	250	800	0	1,050	600	600	0	600	707	0	0	707	M	May 11
2,439	800	0	17.95	3,239	373	500	250	550	0	800	550	550	0	550	707	0	0	707		May 12
2,435	800	0	19.54	3,235	369	500	250	150		400	450	450	0	450	707	0	0	707		May 13
2,380	800	0	21.12	3,180	365	500	250			250	389	389		389	707			707		May 14
2,276	550	0	22.21	2,826	361	500	250			250	302	302		302	707			707		May 15
2,211	150			2,361	357	500	250			250	215	215		215	707			707		May 16
2,120	0			2,120	353	500	250			250	150	150		150	707			707		May 17
2,029	0			2,029	349	500	250			250	150	150		150	707			707		May 18
1,960	0			1,960	345	500	250			250	150	150		150	707			707		May 19
1,956	0			1,956	341	500	250			250	150	150		150	707			707		May 20
1,952	0			1,952	337	500	250			250	150	150		150	707			707		May 21
1,948	0			1,948	333	500	250			250	150	150		150	707			707		May 22
1,944	0			1,944	329	500	250			250	150	150		150	707			707		May 23
1,940	0			1,940	325	500	250			250	150	150		150	707			707		May 24
1,936	0			1,936	321	500	250			250	150	150		150	707			707		May 25
1,932	0			1,932	317	500	250			250	150	150		150	707			707		May 26
1,928	0			1,928	313	500	250			250	150	150		150	707			707		May 27
1,924	0			1,924	309	500	250			250	150	150		150	707			707		May 28
1,920	0			1,920	305	500	250			250	150	150		150	707			707		May 29
1,916	0			1,916	301	500	250			250	150	150		150	707			707		May 30
1,912	0			1,912	297	500	250			250	150	150		150	707			707		May 31
VAMP period																				
2,839	361			3,200	435	500	250	361	0	611	730	730	0	730	924	0	0	924		Avg (cfs):
	22.21							22.21	0.00				0.00			0.00				Suppl. Water (TAF)

Target flow period

Period of desired flow stability

Appendix A–1, Table 5

VAMP DAILY OPERATION PLAN, APRIL 4, 2003

Target Flow Period: April 15–May 15 • Flow Target: 3,200 cfs

bold numbers: observed real time

	San Joaquin River near Vernalis							Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus River below Goodwin					
	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. Flow	Exch Contr VAMP Suppl. Flow	VAMP Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	Existing Flow (re-shaped)	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol. S=Stan.
	(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		(cfs)	(cfs)	(cfs)	
Apr 01	**1,940**				**1,940**	**668**	**338**	**225**			**225**	150	**181**		**181**	**606**	**606**			**606**	
Apr 02	**2,000**				**2,000**	**627**	**311**	**229**			**229**	150	**182**		**182**	**604**	**604**			**604**	
Apr 03	**2,040**				**2,040**	**616**	**368**	**249**			**249**	150	**180**		**180**	**650**	**650**			**650**	
Apr 04	2,038				2,038	626	400	250			250	150	150		150	650	650			650	
Apr 05	2,075				2,075	612	400	250			250	150	150		150	650	650			650	
Apr 06	2,075				2,075	598	400	250			250	150	150		150	650	650			650	
Apr 07	2,062				2,062	584	400	250			250	150	150		150	650	650			650	
Apr 08	2,048				2,048	570	400	250			250	150	150		150	650	650			650	
Apr 09	2,034				2,034	556	400	250			250	150	150		150	650	650			650	
Apr 10	2,020				2,020	542	400	250			250	150	150		150	650	650			650	
Apr 11	2,006				2,006	528	400	250	100		350	150	150		150	650	650			650	
Apr 12	1,992				1,992	514	400	250	300	60	610	400	400		400	650	650			650	
Apr 13	1,978	0			1,978	500	400	250	300	60	610	800	800	0	800	763	500	150	0	650	
Apr 14	2,214	100			2,314	496	400	250	300	60	610	1,100	1,100	0	1,100	763	500	150	0	650	
Apr 15	2,450	510	0	1.01	2,960	491	400	250	300	60	610	1,100	1,100	0	1,100	763	500	150	0	650	
Apr 16	2,746	510	0	2.02	3,256	487	400	250	300	60	610	1,100	1,100	0	1,100	763	500	150	0	650	
Apr 17	2,741	510	0	3.03	3,251	483	400	250	300	60	610	1,100	1,100	0	1,100	763	500	150	0	650	
Apr 18	2,737	510	0	4.05	3,247	478	400	250	300	60	610	1,100	1,100	0	1,100	763	500	150	0	650	
Apr 19	2,733	510	0	5.06	3,243	474	400	250	300	60	610	1,100	1,100	0	1,100	763	500	150	0	650	
Apr 20	2,728	510	0	6.07	3,238	469	400	250	300	60	610	1,100	1,100	0	1,100	763	500	150	0	650	
Apr 21	2,724	510	0	7.08	3,234	465	400	250	300	60	610	1,100	1,100	0	1,100	763	500	150	0	650	
Apr 22	2,719	510	0	8.09	3,229	461	400	250	230	60	540	1,100	1,100	0	1,100	763	500	150	0	650	
Apr 23	2,715	510	0	9.10	3,225	456	400	250	130	70	450	1,100	900	0	900	763	500	400	0	900	
Apr 24	2,711	510	0	10.12	3,221	452	400	250	130	70	450	1,100	725	0	725	763	900	300	0	1,200	M
Apr 25	2,506	690	0	11.48	3,196	448	400	250	130	70	450	1,100	500	0	500	763	1,250	250	0	1,500	M, S
Apr 26	2,727	500	0	12.48	3,227	443	400	250	130	70	450	900	450	0	450	763	1,250	250	0	1,500	M, S
Apr 27	2,848	450	0	13.37	3,298	439	400	250	130	70	450	600	450	0	450	763	1,250	250	0	1,500	M, S
Apr 28	2,793	450	0	14.26	3,243	435	400	250	130	70	450	429	450	0	450	763	1,250	250	0	1,500	M, S
Apr 29	2,789	450	0	15.15	3,239	430	400	250	130	70	450	300	450	0	450	737	1,250	250	0	1,500	M, S
Apr 30	2,785	450	0	16.05	3,235	426	400	250	130	70	450	300	450	0	450	737	1,250	250	0	1,500	M, S
May 01	2,780	450	0	16.94	3,230	421	400	250	130	70	450	300	450	0	450	737	1,250	250	0	1,500	S
May 02	2,776	450	0	17.83	3,226	417	400	250	180	60	490	300	500	0	500	737	1,250	250	0	1,500	S
May 03	2,771	450	0	18.72	3,221	413	400	250	500	70	820	300	600	0	600	737	1,100	200	0	1,300	
May 04	2,817	450	0	19.62	3,267	408	400	250	880	70	1,200	300	600	0	600	737	813	192	0	1,005	M
May 05	2,763	440	0	20.49	3,203	404	400	250	880	70	1,200	300	600	0	600	737	550	50	0	600	M
May 06	2,471	762	0	22.00	3,233	400	400	250	880	70	1,200	600	600	0	600	737	550	50	0	600	M
May 07	2,204	1,000	0	23.98	3,204	395	400	250	880	70	1,200	600	600	0	600	737	550	50	0	600	M
May 08	2,200	1,000	0	25.97	3,200	391	400	250	880	70	1,200	600	600	0	600	737	550	50	0	600	M
May 09	2,195	1,000	0	27.95	3,195	386	400	250	880	70	1,200	600	600	0	600	737	550	50	0	600	M
May 10	2,191	1,000	0	29.93	3,191	382	400	250	880	70	1,200	600	600	0	600	737	550	50	0	600	M
May 11	2,186	1,000	0	31.92	3,186	378	400	250	880	70	1,200	600	600	0	600	737	550	50	0	600	M
May 12	2,182	1,000	0	33.90	3,182	373	400	250	480	70	800	550	600	0	600	737	550	50	0	600	
May 13	2,178	1,000	0	35.88	3,178	369	400	250	250	0	500	450	600	0	600	737	550	50	0	600	
May 14	2,173	1,000	0	37.87	3,173	365	400	250	100	0	350	389	389		389	737	737			737	
May 15	2,169	600	0	39.06	2,769	361	400	250			250	302	302		302	737	737			737	
May 16	2,141	250			2,391	357	400	250			250	215	215		215	737	737			737	
May 17	2,050	100			2,150	353	400	250			250	150	150		150	737	737			737	
May 18	1,959	0			1,959	349	400	250			250	150	150		150	737	737			737	
May 19	1,890	0			1,890	345	400	250			250	150	150		150	737	737			737	
May 20	1,886	0			1,886	341	400	250			250	150	150		150	737	737			737	
May 21	1,882	0			1,882	337	400	250			250	150	150		150	737	737			737	
May 22	1,878	0			1,878	333	400	250			250	150	150		150	737	737			737	
May 23	1,874	0			1,874	329	400	250			250	150	150		150	737	737			737	
May 24	1,870	0			1,870	325	400	250			250	150	150		150	737	737			737	
May 25	1,866	0			1,866	321	400	250			250	150	150		150	737	737			737	
May 26	1,862	0			1,862	317	400	250			250	150	150		150	737	737			737	
May 27	1,858	0			1,858	313	400	250			250	150	150		150	737	737			737	
May 28	1,854	0			1,854	309	400	250			250	150	150		150	737	737			737	
May 29	1,850	0			1,850	305	400	250			250	150	150		150	737	737			737	
May 30	1,846	0			1,846	301	400	250			250	150	150		150	737	737			737	
May 31	1,842	0			1,842	297	400	250			250	150	150		150	737	737			737	
	VAMP period																				
Avg (cfs):	2,565	635			3,200	435	400	250	406	66	723	730	730	0	730	750	750	163	0	913	
Suppl. Water (TAF)		39.06							24.99	4.07				0.00				10.00			

Target flow period

Period of desired flow stability

Appendix A – 1, Table 6

VAMP DAILY OPERATION PLAN, APRIL 9, 2003

Target Flow Period: April 15–May 15 • Flow Target: 3,200 cfs

bold numbers: observed real time

San Joaquin River near Vernalis							Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus River below Goodwin						
Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. Flow	Exch Contr VAMP Suppl. Flow	VAMP Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow (flat)	Existing Flow (re-shaped)	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol. S=Stan.	
(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		
1,940				**1,940**	**668**	**338**	**225**			**225**	150	**181**		**181**	650	**606**			**606**		Apr 01
2,000				**2,000**	**627**	**311**	**229**			**229**	150	**182**		**182**	650	**604**			**604**		Apr 02
2,040				**2,040**	**616**	**368**	**249**			**249**	150	**180**		**180**	650	**650**			**650**		Apr 03
2,020				**2,020**	**572**	**382**	**245**			**245**	150	**181**		**181**	650	**709**			**709**		Apr 04
2,070				**2,077**	**555**	**402**	**250**			**250**	150	**183**		**183**	650	**709**			**709**		Apr 05
2,010				**2,010**	**546**	**299**	**245**			**245**	150	**181**		**181**	650	**700**			**700**		Apr 06
2,050				**2,050**	**542**	**358**	**240**			**240**	150	**184**		**184**	650	**757**			**757**		Apr 07
1,990				1,990	510	313	250			250	150	150		150	650	800			800		Apr 08
2,028				2,028	498	300	250			250	150	150		150	650	800			800		Apr 09
2,000				2,000	486	300	250			250	150	150		150	650	800			800		Apr 10
1,998				1,998	474	300	250	100		350	150	150		150	650	800			800		Apr 11
1,986				1,986	462	300	250	320	80	650	425	425		425	650	800			800		Apr 12
1,974	0			1,974	450	300	250	320	80	650	700	700	70	770	763	500	150	0	650		Apr 13
2,237	100			2,337	446	300	250	320	80	650	906	1,000	200	1,200	763	500	150	0	650		Apr 14
2,200	620	0	1.23	2,820	442	300	250	320	80	650	906	1,000	200	1,200	763	500	150	0	650		Apr 15
2,496	750	0	2.72	3,246	438	300	250	320	80	650	906	1,000	200	1,200	763	500	150	0	650		Apr 16
2,492	750	0	4.20	3,242	433	300	250	320	80	650	906	1,000	200	1,200	763	500	150	0	650		Apr 17
2,488	750	0	5.69	3,238	429	300	250	320	80	650	906	1,000	200	1,200	763	500	150	0	650		Apr 18
2,483	750	0	7.18	3,233	425	300	250	320	80	650	906	1,000	200	1,200	763	500	150	0	650		Apr 19
2,479	750	0	8.67	3,229	421	300	250	320	80	650	906	1,000	200	1,200	763	500	150	0	650		Apr 20
2,475	750	0	10.16	3,225	417	300	250	320	80	650	906	1,000	200	1,200	763	500	150	0	650		Apr 21
2,471	750	0	11.64	3,221	413	300	250	230	80	560	906	1,000	200	1,200	763	500	150	0	650		Apr 22
2,467	750	0	13.13	3,217	408	300	250	150	80	480	906	780	270	1,050	763	500	400	0	900		Apr 23
2,463	750	0	14.62	3,213	404	300	250	150	80	480	906	580	250	830	763	900	300	0	1,200	M	Apr 24
2,238	980	0	16.56	3,218	400	300	250	150	80	480	768	430	120	550	763	1,250	250	0	1,500	M, S	Apr 25
2,434	780	0	18.11	3,214	396	300	250	150	80	480	580	430	110	540	763	1,250	250	0	1,500	M, S	Apr 26
2,630	600	0	19.30	3,230	392	300	250	150	80	480	425	430	110	540	763	1,250	250	0	1,500	M, S	Apr 27
2,626	590	0	20.47	3,216	388	300	250	150	80	480	425	430	110	540	763	1,250	250	0	1,500	M, S	Apr 28
2,622	590	0	21.64	3,212	383	300	250	150	80	480	425	430	110	540	737	1,250	250	0	1,500	M, S	Apr 29
2,618	590	0	22.81	3,208	379	300	250	150	80	480	425	430	110	540	737	1,250	250	0	1,500	M, S	Apr 30
2,613	590	0	23.98	3,203	375	300	250	200	80	530	425	430	110	540	737	1,250	250	0	1,500	S	May 01
2,609	590	0	25.15	3,199	371	300	250	350	100	700	425	430	110	540	737	1,250	250	0	1,500	S	May 02
2,605	590	0	26.32	3,195	367	300	250	660	100	1,010	425	430	160	590	737	1,100	135	0	1,235		May 03
2,601	640	0	27.59	3,241	363	300	250	960	80	1,290	425	430	160	590	737	813	122	0	935	M	May 04
2,447	745	0	29.07	3,192	358	300	250	960	80	1,290	425	430	280	710	737	550	50	0	600	M	May 05
2,156	1,042	0	31.13	3,198	354	300	250	960	80	1,290	562	570	140	710	737	550	50	0	600	M	May 06
1,888	1,370	0	33.85	3,258	350	300	250	960	80	1,290	562	570	140	710	737	550	50	0	600	M	May 07
2,024	1,230	0	36.29	3,254	346	300	250	960	80	1,290	562	570	140	710	737	550	50	0	600	M	May 08
2,020	1,230	0	38.73	3,250	342	300	250	960	80	1,290	562	570	140	710	737	550	50	0	600	M	May 09
2,016	1,230	0	41.17	3,246	338	300	250	960	80	1,290	562	570	140	710	737	550	50	0	600	M	May 10
2,012	1,230	0	43.61	3,242	333	300	250	960	80	1,290	562	570	140	710	737	550	50	0	600	M	May 11
2,008	1,230	0	46.05	3,238	329	300	250	550	80	880	528	530	160	690	737	550	50	0	600		May 12
2,003	1,230	0	48.49	3,233	325	300	250	250	0	500	459	460	160	620	737	550	185	0	735		May 13
1,959	1,250	0	50.97	3,209	321	300	250	100	0	350	417	417		417	737	737			737		May 14
1,885	975	0	52.90	3,860	317	300	250			250	357	357		357	737	737			737		May 15
2,025	250			2,275	313	300	250			250	298	298		298	737	737			737		May 16
1,961	100			2,061	309	300	250			250	150	150		150	737	737			737		May 17
1,898	0			1,898	305	300	250			250	150	150		150	737	737			737		May 18
1,746	0			1,746	301	300	250			250	150	150		150	737	737			737		May 19
1,742	0			1,742	297	300	250			250	150	150		150	737	737			737		May 20
1,738	0			1,738	293	300	250			250	150	150		150	737	737			737		May 21
1,734	0			1,734	289	300	250			250	150	150		150	737	737			737		May 22
1,730	0			1,730	285	300	250			250	150	150		150	737	737			737		May 23
1,726	0			1,726	281	300	250			250	150	150		150	737	737			737		May 24
1,722	0			1,722	277	300	250			250	150	150		150	737	737			737		May 25
1,718	0			1,718	273	300	250			250	150	150		150	737	737			737		May 26
1,714	0			1,714	269	300	250			250	150	150		150	737	737			737		May 27
1,710	0			1,710	265	300	250			250	150	150		150	737	737			737		May 28
1,706	0			1,706	261	300	250			250	150	150		150	737	737			737		May 29
1,702	0			1,702	257	300	250			250	150	150		150	737	737			737		May 30
1,698	0			1,698	253	300	250			250	150	150		150	737	737			737		May 31
VAMP period																					
2,340	860			3,200	388	300	250	454	81	785	652	652	163	814	750	750	163	0	913		Avg (cfs):
	52.90							27.91	5.00				10.00				10.00				Suppl. Water (TAF)

Target flow period

Period of desired flow stability

Appendix A–1, Table 7

VAMP DAILY OPERATION PLAN, APRIL 22, 2003

Target Flow Period: April 15–May 15 • Flow Target: 3,200 cfs

bold numbers: observed real time

	San Joaquin River near Vernalis							Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus River below Goodwin					
	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. Flow	Exch Contr VAMP Suppl. Flow	VAMP Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow (flat)	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)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	
Apr 01	**1,940**				**1,950**	**612**	**402**	**225**			**225**	150	**181**		**181**	650	**606**			**606**	
Apr 02	**2,010**				**2,010**	**568**	**377**	**229**			**229**	150	**182**		**182**	650	**604**			**604**	
Apr 03	**2,050**				**2,050**	**548**	**434**	**249**			**249**	150	**180**		**180**	650	**650**			**650**	
Apr 04	**2,030**				**2,030**	**510**	**451**	**245**			**245**	150	**181**		**181**	650	**709**			**709**	
Apr 05	**2,080**				**2,080**	**494**	**473**	**250**			**250**	150	**183**		**183**	650	**709**			**709**	
Apr 06	**2,020**				**2,020**	**484**	**371**	**245**			**245**	150	**181**		**181**	650	**700**			**700**	
Apr 07	**2,060**				**2,060**	**482**	**429**	**240**			**240**	150	**184**		**184**	650	**757**			**757**	
Apr 08	**1,980**				**1,980**	**463**	**365**	**234**			**234**	150	**150**		**182**	650	**800**			**801**	
Apr 09	**1,930**				**1,930**	**442**	**262**	**235**			**235**	150	**150**		**183**	650	**800**			**801**	
Apr 10	**1,880**				**1,880**	**410**	**194**	**239**			**239**	150	**150**		**182**	650	**800**			**802**	
Apr 11	**1,920**				**1,920**	**385**	**260**	**250**	104		**354**	150	**150**		**295**	650	**800**			**808**	
Apr 12	**2,000**				**2,000**	**329**	**371**	**250**	276	80	**606**	425	**425**		**452**	650	**800**			**805**	
Apr 13	**2,290**	0			**2,290**	**277**	**563**	**250**	307	80	**637**	700	**700**	138	**838**	763	**500**	232	0	**732**	
Apr 14	**2,494**	136			**2,630**	**290**	**690**	**250**	324	80	**654**	906	**1,000**	220	**1,220**	763	**500**	147	0	**647**	
Apr 15	**2,133**	726	0	1.44	**2,859**	**325**	**406**	**250**	308	80	**638**	906	**1,000**	240	**1,240**	763	**500**	149	0	**649**	
Apr 16	**2,266**	754	0	2.94	**3,020**	**323**	**226**	**250**	348	80	**678**	906	**1,000**	230	**1,230**	763	**500**	149	0	**649**	
Apr 17	**2,317**	793	0	4.51	**3,110**	**327**	**242**	**250**	343	80	**673**	906	**1,000**	230	**1,230**	763	**500**	149	0	**649**	
Apr 18	**2,423**	767	0	6.03	**3,190**	**374**	**350**	**250**	345	80	**675**	906	**1,000**	250	**1,250**	763	**500**	149	0	**649**	
Apr 19	**2,403**	807	0	7.63	**3,210**	**392**	**326**	**250**	340	80	**670**	906	**1,000**	250	**1,250**	763	**500**	149	0	**649**	
Apr 20	**2,558**	822	0	9.26	**3,380**	**378**	**434**	**250**	333	80	**663**	906	**1,000**	260	**1,260**	763	**500**	152	0	**652**	
Apr 21	**2,686**	824	0	10.90	**3,510**	**362**	**544**	**250**	321	80	**651**	906	**1,000**	250	**1,250**	763	500	152	0	**652**	
Apr 22	2,588	832	0	12.55	3,420	413	460	250	230	80	560	906	1,000	100	1,100	763	500	150	0	650	
Apr 23	2,412	815	0	14.16	3,227	408	300	250	150	80	480	906	780	170	950	763	500	400	0	900	
Apr 24	2,463	651	0	15.45	3,114	404	300	250	150	80	480	906	580	150	730	763	900	300	0	1,200	M
Apr 25	2,238	880	0	17.20	3,118	400	300	250	150	80	480	768	430	120	550	763	1,250	250	0	1,500	M,S
Apr 26	2,434	680	0	18.55	3,114	396	300	250	150	80	480	580	430	110	540	763	1,250	250	0	1,500	M,S
Apr 27	2,630	600	0	19.74	3,230	392	300	250	150	80	480	425	430	110	540	763	1,250	250	0	1,500	M,S
Apr 28	2,626	590	0	20.91	3,216	388	300	250	150	80	480	425	430	110	540	763	1,250	250	0	1,500	M,S
Apr 29	2,622	590	0	22.08	3,212	383	300	250	150	80	480	425	430	110	540	737	1,250	250	0	1,500	M,S
Apr 30	2,618	590	0	23.25	3,208	379	300	250	150	80	480	425	430	110	540	737	1,250	250	0	1,500	M,S
May 01	2,613	590	0	24.42	3,203	375	300	250	200	80	530	425	430	110	540	737	1,250	250	0	1,500	S
May 02	2,609	590	0	25.59	3,199	371	300	250	350	100	700	425	430	110	540	737	1,250	250	0	1,500	S
May 03	2,605	590	0	26.76	3,195	367	300	250	660	100	1,010	425	430	160	590	737	1,100	135	0	1,235	
May 04	2,601	640	0	28.03	3,241	363	300	250	960	80	1,290	425	430	160	590	737	813	122	0	935	M
May 05	2,447	745	0	29.51	3,192	358	300	250	960	80	1,290	425	430	280	710	737	550	50	0	600	M
May 06	2,156	1,042	0	31.57	3,198	354	300	250	960	80	1,290	562	570	140	710	737	550	50	0	600	M
May 07	1,888	1,370	0	34.29	3,258	350	300	250	960	80	1,290	562	570	140	710	737	550	50	0	600	M
May 08	2,024	1,230	0	36.73	3,254	346	300	250	960	80	1,290	562	570	140	710	737	550	50	0	600	M
May 09	2,020	1,230	0	39.17	3,250	342	300	250	960	80	1,290	562	570	140	710	737	550	50	0	600	M
May 10	2,016	1,230	0	41.61	3,246	338	300	250	960	80	1,290	562	570	140	710	737	550	50	0	600	M
May 11	2,012	1,230	0	44.05	3,242	333	300	250	960	80	1,290	562	570	140	710	737	550	50	0	600	M
May 12	2,008	1,230	0	46.49	3,238	329	300	250	550	80	880	528	530	160	690	737	550	50	0	600	
May 13	2,003	1,230	0	48.93	3,233	325	300	250	250	0	500	459	460	160	620	737	550	185	0	735	
May 14	1,959	1,250	0	51.41	3,209	321	300	250	100	0	350	417	417		417	737	737			737	
May 15	1,885	975	0	53.34	2,860	317	300	250			250	357	357		357	737	737			737	
May 16	2,025	250			2,275	313	300	250			250	298	298		298	737	737			737	
May 17	1,961	100			2,061	309	300	250			250	150	150		150	737	737			737	
May 18	1,898	0			1,898	305	300	250			250	150	150		150	737	737			737	
May 19	1,746	0			1,746	301	300	250			250	150	150		150	737	737			737	
May 20	1,742	0			1,742	297	300	250			250	150	150		150	737	737			737	
May 21	1,738	0			1,738	293	300	250			250	150	150		150	737	737			737	
May 22	1,734	0			1,734	289	300	250			250	150	150		150	737	737			737	
May 23	1,730	0			1,730	285	300	250			250	150	150		150	737	737			737	
May 24	1,726	0			1,726	281	300	250			250	150	150		150	737	737			737	
May 25	1,722	0			1,722	277	300	250			250	150	150		150	737	737			737	
May 26	1,718	0			1,718	273	300	250			250	150	150		150	737	737			737	
May 27	1,714	0			1,714	269	300	250			250	150	150		150	737	737			737	
May 28	1,710	0			1,710	265	300	250			250	150	150		150	737	737			737	
May 29	1,706	0			1,706	261	300	250			250	150	150		150	737	737			737	
May 30	1,702	0			1,702	257	300	250			250	150	150		150	737	737			737	
May 31	1,698	0			1,698	253	300	250			250	150	150		150	737	737			737	
	VAMP period																				
Avg (cfs):	2,331	868			3,199	360	319	250	455	81	787	652	652	166	817	750	750	165	0	916	
Suppl. Water (TAF)		53.34							28.00	5.00				10.19					10.16		

Target flow period

Period of desired flow stability

Appendix A–1, Table 8

VAMP DAILY OPERATION PLAN, APRIL 30, 2003

Target Flow Period: April 15–May 15 • Flow Target: 3,200 cfs

bold numbers: observed real time

San Joaquin River near Vernalis							Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus River below Goodwin						
Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. Flow	Exch Contr VAMP Suppl. Flow	VAMP Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow (flat)	Existing Flow (re-shaped)	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol. S=Stan.	
(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		
1,940				**1,950**	**612**	**402**	225			**225**	150	181		**181**	650	606			**606**		Apr 01
2,010				**2,010**	**568**	**377**	229			**229**	150	182		**182**	650	604			**604**		Apr 02
2,050				**2,050**	**548**	**434**	249			**249**	150	180		**180**	650	650			**650**		Apr 03
2,030				**2,030**	**510**	**451**	245			**245**	150	181		**181**	650	709			**709**		Apr 04
2,080				**2,080**	**494**	**473**	250			**250**	150	183		**182**	650	709			**709**		Apr 05
2,020				**2,020**	**484**	**371**	245			**245**	150	181		**181**	650	700			**700**		Apr 06
2,060				**2,060**	**482**	**429**	240			**240**	150	184		**184**	650	757			**757**		Apr 07
1,980				**1,980**	**463**	**365**	234			**234**	150	150		**182**	650	800			**801**		Apr 08
1,930				**1,930**	**442**	**262**	235			**235**	150	150		**183**	650	800			**801**		Apr 09
1,880				**1,880**	**410**	**194**	239			**239**	150	150		**182**	650	800			**802**		Apr 10
1,920				**1,920**	**385**	**260**	250	104		**354**	150	150		**303**	650	800			**808**		Apr 11
2,000				**2,000**	**329**	**371**	250	276	80	**606**	425	425		**472**	650	800			**805**		Apr 12
2,290	0			**2,290**	**277**	**563**	250	307	80	**637**	700	700	191	**891**	763	500	232	0	**732**		Apr 13
2,494	136			**2,630**	**290**	**690**	250	324	80	**654**	906	1,000	300	**1,300**	763	500	147	0	**647**		Apr 14
2,133	779	0	1.55	**2,859**	**325**	**406**	250	308	80	**638**	906	1,000	310	**1,310**	763	500	149	0	**649**		Apr 15
2,266	834	0	3.20	**3,020**	**323**	**226**	250	348	80	**678**	906	1,000	310	**1,310**	763	500	149	0	**649**		Apr 16
2,317	863	0	4.91	**3,110**	**327**	**242**	250	343	80	**673**	906	1,000	310	**1,310**	763	500	149	0	**649**		Apr 17
2,423	847	0	6.59	**3,190**	**374**	**350**	250	345	80	**675**	906	1,000	330	**1,330**	763	500	149	0	**649**		Apr 18
2,403	887	0	8.35	**3,210**	**392**	**326**	250	340	80	**670**	906	1,000	330	**1,330**	763	500	149	0	**649**		Apr 19
2,558	902	0	10.14	**3,380**	**378**	**434**	250	333	80	**663**	906	1,000	340	**1,340**	763	500	152	0	**652**		Apr 20
2,686	904	0	11.93	**3,510**	**362**	**544**	250	321	80	**651**	906	1,000	330	**1,330**	763	500	152	0	**652**		Apr 21
2,508	912	0	13.74	**3,420**	**348**	**380**	250	241	80	**571**	906	1,000	270	**1,270**	763	500	152	0	**652**		Apr 22
2,425	895	0	15.52	**3,320**	**325**	**313**	250	177	80	**507**	906	780	250	**1,030**	763	500	281	0	**781**		Apr 23
2,227	823	0	17.15	**3,050**	**311**	**129**	250	163	80	**493**	906	580	238	**818**	763	900	321	0	**1,221**	M	Apr 24
2,228	852	0	18.84	**3,080**	**288**	**373**	250	182	80	**512**	768	430	176	**606**	763	1,250	262	0	**1,512**	M,S	Apr 25
2,394	816	0	20.46	**3,210**	**313**	**353**	250	187	80	**517**	580	430	149	**579**	763	1,250	251	0	**1,501**	M,S	Apr 26
2,569	681	0	21.81	**3,250**	**316**	**351**	250	182	80	**512**	425	430	151	**581**	763	1,250	253	0	**1,503**	M,S	Apr 27
2,668	662	0	23.12	**3,330**	**308**	**425**	250	196	80	**526**	425	430	153	**583**	763	1,250	256	0	**1,506**	M,S	Apr 28
2,759	671	0	24.45	**3,430**	**320**	**513**	250	180	80	**510**	425	430	130	**560**	737	1,250	253	0	**1,503**	M,S	Apr 29
2,638	671	0	25.78	3,309	379	400	250	150	80	480	425	430	110	540	737	1,250	250	0	1,500	M,S	Apr 30
2,550	659	0	27.09	3,209	375	300	250	200	80	530	425	430	110	540	737	1,250	250	0	1,500	S	May 01
2,609	620	0	28.32	3,229	371	300	250	350	100	700	425	430	110	540	737	1,250	250	0	1,500	S	May 02
2,605	590	0	29.49	3,195	367	300	250	660	100	1,010	425	430	110	540	737	1,100	135	0	1,235		May 03
2,601	640	0	30.76	3,241	363	300	250	1,000	80	1,330	425	430	110	540	737	813	122	0	935	M	May 04
2,447	695	0	32.14	3,142	358	300	250	1,000	80	1,330	425	430	110	540	737	550	50	0	600	M	May 05
2,156	992	0	34.11	3,148	354	300	250	1,000	80	1,330	562	570	30	600	737	550	50	0	600	M	May 06
1,888	1,240	0	36.57	3,128	350	300	250	1,000	80	1,330	425	570	30	600	737	550	50	0	600	M	May 07
2,024	1,160	0	38.87	3,184	346	300	250	1,000	80	1,330	425	570	30	600	737	550	50	0	600	M	May 08
2,020	1,160	0	41.17	3,180	342	300	250	1,000	80	1,330	425	570	30	600	737	550	50	0	600	M	May 09
2,016	1,160	0	43.47	3,176	338	300	250	1,000	80	1,330	425	570	30	600	737	550	50	0	600	M	May 10
2,012	1,160	0	45.77	3,172	333	300	250	1,000	80	1,330	425	570	30	600	737	550	50	0	600	M	May 11
2,008	1,160	0	48.07	3,168	329	300	250	550	80	880	528	530	30	560	737	550	50	0	600		May 12
2,003	1,160	0	50.37	3,163	325	300	250	250	0	500	459	460	30	490	737	550	185	0	735		May 13
1,959	1,160	0	52.67	3,119	321	300	250	100	0	350	417	417		417	737	737			737		May 14
1,885	845	0	54.35	2,730	317	300	250			250	357	357		357	737	737			737		May 15
2,025	250			2,275	313	300	250			250	298	298		298	737	737			737		May 16
1,961	100			2,061	309	300	250			250	150	150		150	737	737			737		May 17
1,898	0			1,898	305	300	250			250	150	150		150	737	737			737		May 18
1,746	0			1,746	301	300	250			250	150	150		150	737	737			737		May 19
1,742	0			1,742	297	300	250			250	150	150		150	737	737			737		May 20
1,738	0			1,738	293	300	250			250	150	150		150	737	737			737		May 21
1,734	0			1,734	289	300	250			250	150	150		150	737	737			737		May 22
1,730	0			1,730	285	300	250			250	150	150		150	737	737			737		May 23
1,726	0			1,726	281	300	250			250	150	150		150	737	737			737		May 24
1,722	0			1,722	277	300	250			250	150	150		150	737	737			737		May 25
1,718	0			1,718	273	300	250			250	150	150		150	737	737			737		May 26
1,714	0			1,714	269	300	250			250	150	150		150	737	737			737		May 27
1,710	0			1,710	265	300	250			250	150	150		150	737	737			737		May 28
1,706	0			1,706	261	300	250			250	150	150		150	737	737			737		May 29
1,702	0			1,702	257	300	250			250	150	150		150	737	737			737		May 30
1,698	0			1,698	253	300	250			250	150	150		150	737	737			737		May 31
VAMP period																					
2,322	884			3,189	339	331	250	473	81	804	652	652	167	818	750	750	163	0	913		Avg (cfs):
	54.35							29.08	5.00				10.25				10.01				Suppl. Water (TAF)

Target flow period

Period of desired flow stability

Appendix A–2, Table 1

2003 VERNALIS ADAPTIVE MANAGEMENT PLAN (VAMP)

Final Accounting of Supplemental Water Contributions

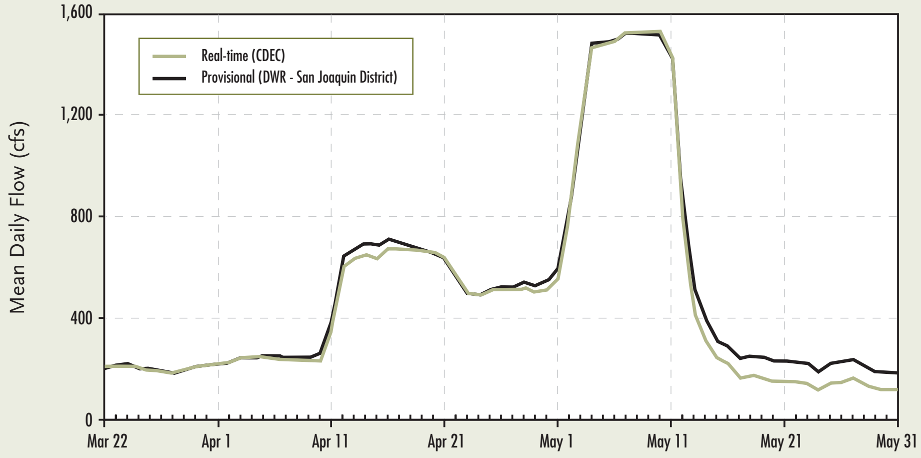
Target Flow Period: April 15–May 15 • Target Flow: 3,200 cfs

	Merced R. at Cressey (3 Day Travel Time to Vernalis)			Tuolumne R. below LaGrange Dam (2 Day Travel Time to Vernalis)			Stanislaus R. below Goodwin Dam (2 Day Travel Time to Vernalis)			SJRECWA (3 Day)	San Joaquin River at Vernalis		
	Existing Flow	Observed Flow	VAMP Suppl. Water	Existing Flow	Observed Flow	VAMP Suppl. Water	Existing Flow	Observed Flow	VAMP Suppl. Water	VAMP Suppl. Water	Existing Flow	Observed Flow	VAMP Suppl. Water
	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
Apr 01	228	228		181	181		606	606			1,950	1,950	
Apr 02	232	232		182	182		604	604			2,010	2,010	
Apr 03	253	253		180	180		650	650			2,050	2,050	
Apr 04	252	252		181	181		709	709			2,030	2,030	
Apr 05	259	259		182	182		709	709			2,080	2,080	
Apr 06	257	257		181	181		700	700			2,010	2,010	
Apr 07	253	253		184	184		757	757			2,050	2,050	
Apr 08	250	250		182	182		801	801			1,970	1,970	
Apr 09	254	254		183	183		801	801			1,920	1,920	
Apr 10	261	261		182	182		802	802			1,850	1,850	
Apr 11	250	386		303	303		808	808			1,880	1,880	
Apr 12	250	649	399	472	472		805	805		0	1,980	1,980	
Apr 13	250	681	431	700	891	191	500	732	232	0	2,260	2,260	
Apr 14	250	701	451	1,000	1,300	300	500	647	147	0	2,610	2,610	
Apr 15	250	688	438	1,000	1,310	310	500	649	149	0	2,017	2,839	822
Apr 16	250	719	469	1,000	1,310	310	500	649	149	0	2,132	3,010	878
Apr 17	250	702	452	1,000	1,310	310	500	649	149	0	2,190	3,100	910
Apr 18	250	693	443	1,000	1,330	330	500	649	149	0	2,283	3,180	897
Apr 19	250	678	428	1,000	1,330	330	500	649	149	0	2,272	3,200	928
Apr 20	250	658	408	1,000	1,340	340	500	652	152	0	2,439	3,370	931
Apr 21	250	637	387	1,000	1,330	330	500	652	152	0	2,578	3,500	922
Apr 22	250	559	309	1,000	1,270	270	500	652	152	0	2,490	3,410	920
Apr 23	250	502	252	780	1,030	250	500	781	281	0	2,420	3,310	890
Apr 24	250	495	245	580	818	238	900	1,221	321	0	2,241	3,050	809
Apr 25	250	519	269	430	602	172	1,250	1,512	262	0	2,230	3,070	840
Apr 26	250	527	277	430	574	144	1,250	1,501	251	0	2,389	3,200	811
Apr 27	250	527	277	430	573	143	1,250	1,503	253	0	2,561	3,240	679
Apr 28	250	547	297	430	575	145	1,250	1,506	256	0	2,656	3,320	664
Apr 29	250	536	286	430	551	121	1,250	1,503	253	0	2,747	3,420	673
Apr 30	250	549	299	430	522	92	1,250	1,502	252	0	2,642	3,320	678
May 01	250	598	348	430	524	94	1,250	1,502	252	0	2,609	3,280	671
May 02	250	846	596	430	525	95	1,250	1,506	256	0	2,630	3,260	630
May 03	250	1,190	940	430	525	95	1,100	1,268	168	0	2,685	3,330	645
May 04	250	1,490	1,240	430	524	94	813	950	137	0	2,790	3,489	699
May 05	250	1,490	1,240	430	524	94	550	598	48	0	2,600	3,459	859
May 06	250	1,500	1,250	570	589	19	550	600	50	0	2,149	3,320	1,171
May 07	250	1,530	1,280	570	585	15	550	604	54	0	1,828	3,210	1,382
May 08	250	1,520	1,270	570	583	13	550	600	50	0	1,941	3,250	1,309
May 09	250	1,520	1,270	570	574	4	550	607	57	0	1,981	3,300	1,319
May 10	250	1,520	1,270	570	577	7	550	603	53	0	1,947	3,290	1,343
May 11	250	1,420	1,170	570	579	9	550	603	53	0	2,059	3,390	1,331
May 12	250	847	597	530	542	12	550	603	53	0	2,070	3,400	1,330
May 13	250	524		460	488	28	550	691	141		1,898	3,230	1,332
May 14	250	407		407	407		741	741			1,645	2,880	1,235
May 15	250	315		353	353		733	733			1,884	2,650	766
May 16	254	292		306	306		751	751			2,216	2,490	
May 17	249	249		228	228		914	914			2,183	2,340	
May 18	257	257		185	185		1,004	1,004			2,225	2,290	
May 19	252	252		184	184		998	998			2,332	2,370	
May 20	235	235		348	348		1,004	1,004			2,250	2,250	
May 21	236	236		563	563		772	772			2,110	2,110	
May 22	233	233		565	565		599	599			2,120	2,120	
May 23	227	227		569	569		603	603			2,070	2,070	
May 24	196	196		567	567		606	606			2,060	2,060	
May 25	228	228		568	568		605	605			2,080	2,080	
May 26	230	230		568	568		604	604			2,150	2,150	
May 27	243	243		569	569		740	740			2,050	2,050	
May 28	215	215		566	566		976	976			1,950	1,950	
May 29	196	196		512	512		1,046	1,046			2,039	2,039	
May 30	188	188		323	323		1,051	1,051			2,160	2,160	
May 31	189	189		266	266		1,051	1,051			2,190	2,190	
Total Supplemental Water (acre-feet):			38,257			9,729			10,078	0			58,065
Target Flow Period Average											2,290	3,235	

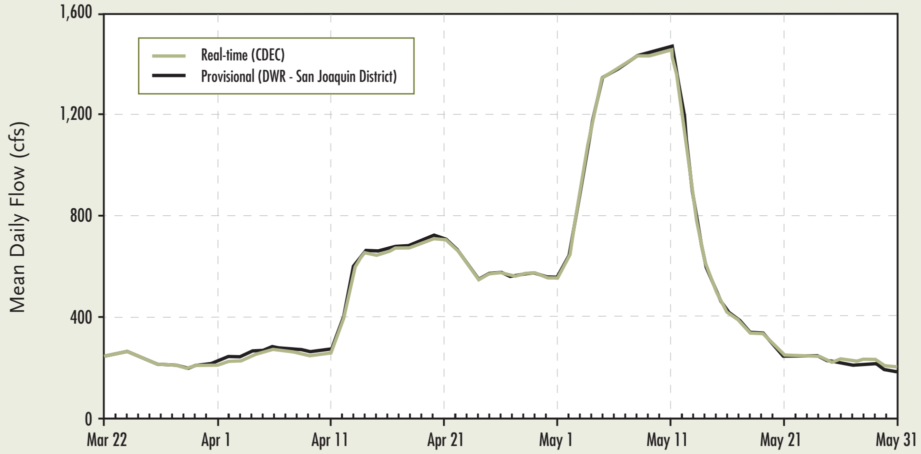
Observed Flow Sources (best available data as of July 31, 2003):
Merced River at Cressey (CA DWR B05155): California DWR, San Joaquin District • Tuolumne River below LaGrange Dam near LaGrange (USGS 11289650): USGS Stanislaus River below Goodwin Dam: USBR, Goodwin Reservoir Daily Operations Report – OID/SSJID/Tri-Dams • San Joaquin River near Vernalis (USGS 11303500): USGS

A–3. COMPARISON OF "REAL-TIME" AND PROVISIONAL FLOWS

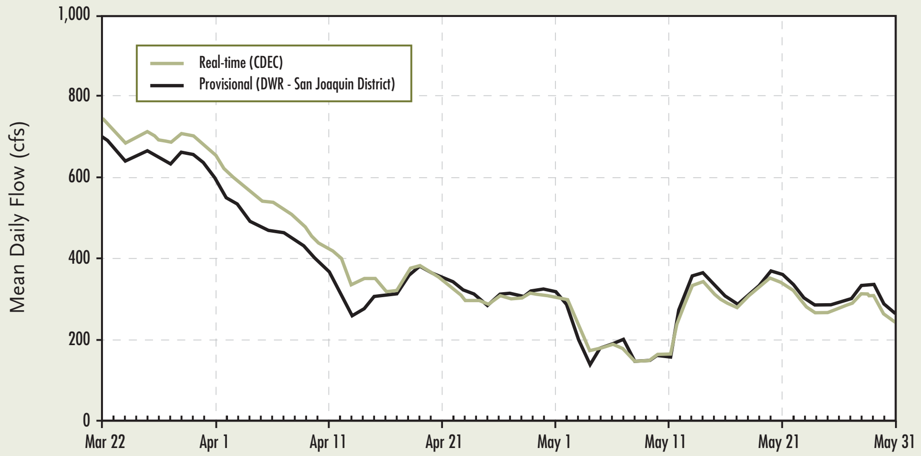
Merced River Near Cressey



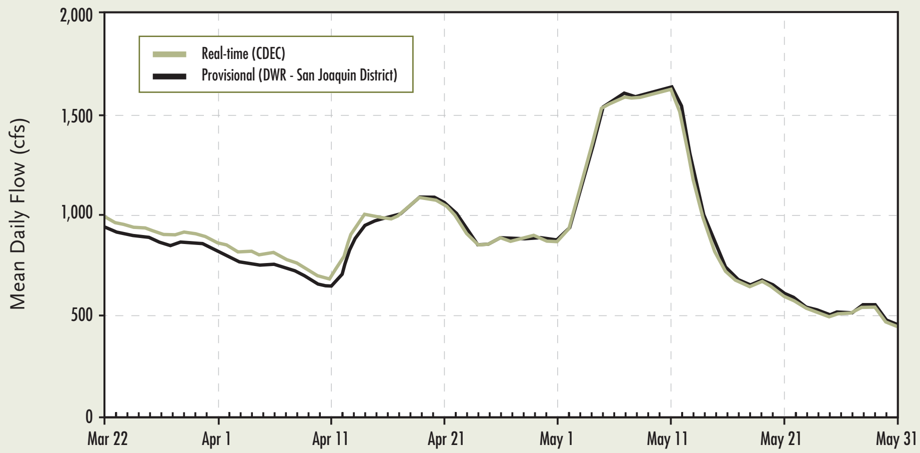
Merced River Near Stevinson



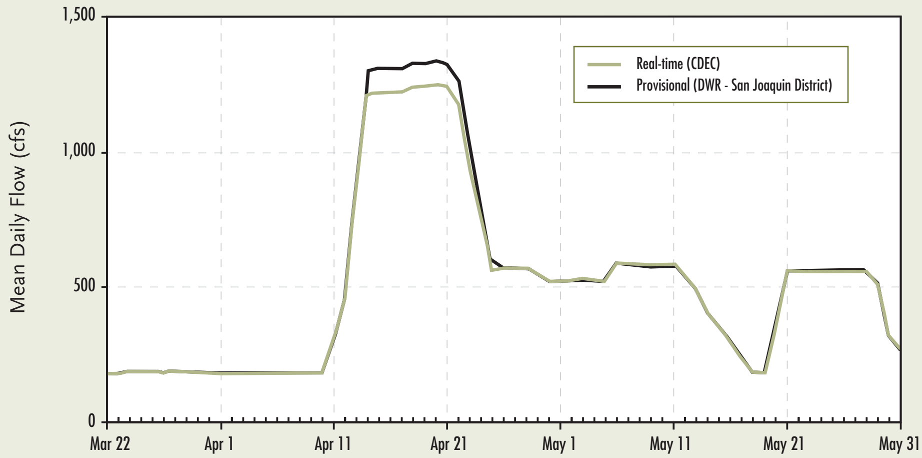
San Joaquin River Above Merced River



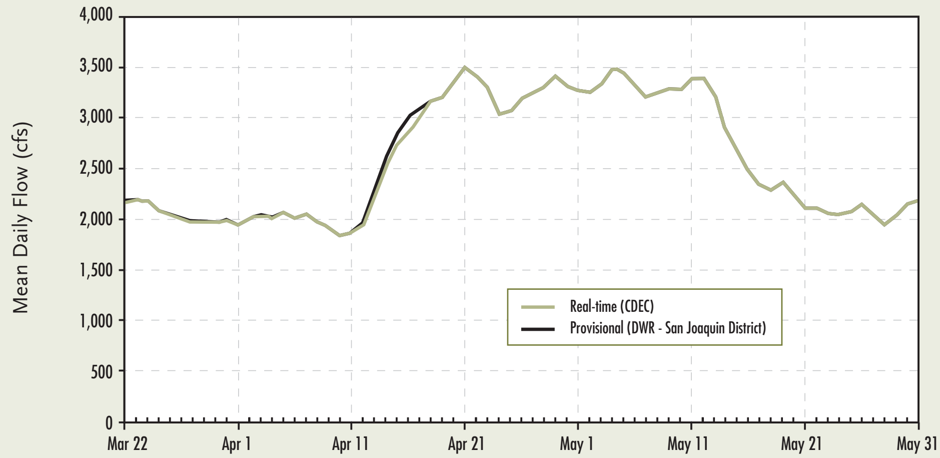
San Joaquin River near Newman



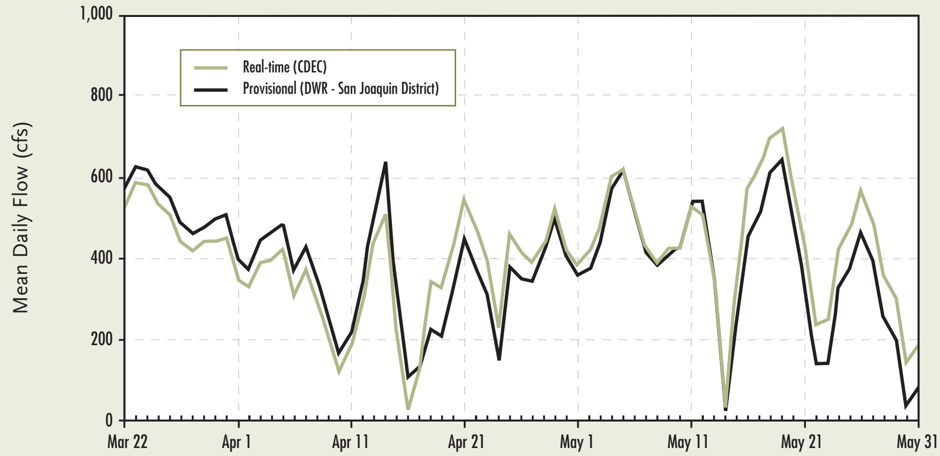
Tuolumne River below LaGrange Dam



San Joaquin River near Vernalis



Ungaged Flow in San Joaquin near Vernalis



Appendix A–4

FLOW IN SAN JOAQUIN RIVER AND OLD RIVER NEAR HORB

All values in cfs

	San Joaquin River near Vernalis (1)	Old River at Head (2)	San Joaquin River below Old River (3)	Through HORB Culverts (4)	Estimated HORB Seepage (5)
Mar 01	2,020	1,081	939		
Mar 02	2,050	1,032	1,018		
Mar 03	2,120	1,102	1,018		
Mar 04	2,130	1,005	1,125		
Mar 05	2,050	1,007	1,043		
Mar 06	2,070	974	1,096		
Mar 07	2,130	1,046	1,084		
Mar 08	2,210	938	1,272		
Mar 09	2,240	916	1,324		
Mar 10	2,260	945	1,315		
Mar 11	2,200	969	1,231		
Mar 12	2,200	1,016	1,184		
Mar 13	2,280	1,101	1,179		
Mar 14	2,270	1,070	1,200		
Mar 15	2,470	1,179	1,291		
Mar 16	2,620	1,224	1,396		
Mar 17	2,540	1,292	1,248		
Mar 18	2,500	1,302	1,198		
Mar 19	2,420	1,138	1,282		
Mar 20	2,320	1,095	1,225		
Mar 21	2,230	1,037	1,193		
Mar 22	2,180	1,011	1,169		
Mar 23	2,200	992	1,208		
Mar 24	2,180	1,032	1,148		
Mar 25	2,100	973	1,127		
Mar 26	2,060	1,020	1,040		
Mar 27	2,010	1,135	875		
Mar 28	1,980	1,039	941		
Mar 29	1,980	879	1,101		
Mar 30	1,970	953	1,017		
Mar 31	2,000	932	1,068		
Apr 01	1,950	1,017	933		
Apr 02	2,010	820	1,190		
Apr 03	2,050	846	1,204		
Apr 04	2,030	838	1,192		
Apr 05	2,080	862	1,218		
Apr 06	2,010	832	1,178		
Apr 07	2,050	709	1,341		
Apr 08	1,970	649	1,321		
Apr 09	1,920	507	1,413		
Apr 10	1,850	617	1,233		
Apr 11	1,880	368	1,512		
Apr 12	1,970	262	1,708		
Apr 13	2,260	379	1,881		
Apr 14	2,600	415	2,185	138	277
Apr 15	2,839	354	2,485	153	201
Apr 16	3,000	388	2,612	186	202
Apr 17	3,090	467	2,623	198	269
Apr 18	3,160	427	2,733	195	232
Apr 19	3,180	469	2,711	192	277
Apr 20	3,350	459	2,891	186	273
Apr 21	3,469	409	3,060	174	235
Apr 22	3,390	280	3,110	180	100
Apr 23	3,300	291	3,009	180	111
Apr 24	3,050	207	2,843	168	39
Apr 25	3,070	179	2,891	177	2
Apr 26	3,200	270	2,930	177	93
Apr 27	3,240	284	2,956	177	107
Apr 28	3,320	218	3,102	165	53
Apr 29	3,420	285	3,135	171	114
Apr 30	3,320	322	2,998	174	148

	San Joaquin River near Vernalis (1)	Old River at Head (2)	San Joaquin River below Old River (3)	Through HORB Culverts (4)	Estimated HORB Seepage (5)
May 01	3,280	258	3,022	168	90
May 02	3,260	189	3,071	168	21
May 03	3,330	192	3,138	162	30
May 04	3,489	326	3,163	168	158
May 05	3,459	341	3,118	177	164
May 06	3,320	354	2,966	168	186
May 07	3,210	325	2,885	159	166
May 08	3,240	388	2,852	156	232
May 09	3,290	360	2,930	171	189
May 10	3,270	334	2,936	171	163
May 11	3,370	305	3,065	171	134
May 12	3,360	316	3,044	171	145
May 13	3,190	359	2,831	171	188
May 14	2,829	434	2,395	162	272
May 15	2,600	389	2,211	159	230
May 16	2,430	372	2,058	153	219
May 17	2,270	385	1,885		
May 18	2,210	373	1,837		
May 19	2,290	661	1,629		
May 20	2,160	462	1,698		
May 21	2,020	432	1,588		
May 22	2,010	500	1,510		
May 23	1,960	603	1,357		
May 24	1,940	721	1,219		
May 25	1,950	756	1,194		
May 26	2,020	675	1,345		
May 27	1,900	613	1,287		
May 28	1,810	663	1,147		
May 29	1,890	822	1,068		
May 30	2,000	945	1,055		
May 31	2,020	906	1,114		
Jun 01	2,000	881	1,119		
Jun 02	1,980	858	1,122		
Jun 03	1,920	957	963		
Jun 04	1,840	1,048	792		
Jun 05	1,870	999	871		
Jun 06	1,920	1,025	895		
Jun 07	2,070	1,067	1,003		
Jun 08	2,150	1,026	1,124		
Jun 09	2,200	1,086	1,114		
Jun 10	2,130	956	1,174		
Jun 11	2,080	742	1,338		
Jun 12	1,990	554	1,436		
Jun 13	1,980	678	1,302		
Jun 14	2,010	650	1,360		
Jun 15	2,150	620	1,530		
Jun 16	2,200	663	1,537		
Jun 17	2,150	683	1,467		
Jun 18	2,120	738	1,382		
Jun 19	2,030	622	1,408		
Jun 20	1,970	635	1,335		
Jun 21	1,960	545	1,415		
Jun 22	2,000	473	1,527		
Jun 23	2,020	515	1,505		
Jun 24	2,020	501	1,519		
Jun 25	1,990	507	1,483		
Jun 26	1,980	529	1,451		
Jun 27	2,039	599	1,440		
Jun 28	2,050	604	1,446		
Jun 29	2,090	649	1,441		
Jun 30	2,100	652	1,448		

VAMP target flow period highlighted

(1) USGS provisional data as of 11/6/2003
(2) DWR Acoustic Doppler Current Meter located 840 ft. downstream of HORB
(3) (1)–(2)
(4) Three times the measured flow in HORB Culvert #4
(5) (2)–(4)

APPENDIX B

Fall Water Transfer & Delivery Information

B–1. MERCED IRRIGATION DISTRICT

SJRA Fall 2003 Water Transfer · Daily Summary

	SCHEDULED			
	BASE FLOW – Merced River at Cressey	SJRA Transfer Water	TARGET FLOW – Merced River at Cressey	SJRA Transfer Water Cumulative Volume
	(cfs)	(cfs)	(cfs)	(acre-feet)
Oct 01	30	70	100	139
Oct 02	30	70	100	278
Oct 03	30	125	155	526
Oct 04	30	125	155	774
Oct 05	30	125	155	1,021
Oct 06	30	125	155	1,269
Oct 07	30	125	155	1,517
Oct 08	30	125	155	1,765
Oct 09	30	125	155	2,013
Oct 10	30	125	155	2,261
Oct 11	30	125	155	2,509
Oct 12	30	125	155	2,757
Oct 13	30	125	155	3,005
Oct 14	30	125	155	3,253
Oct 15	30	125	155	3,501
Oct 16	85	125	210	3,749
Oct 17	85	185	270	4,116
Oct 18	85	315	400	4,740
Oct 19	85	515	600	5,762
Oct 20	85	515	600	6,783
Oct 21	85	515	600	7,805
Oct 22	85	515	600	8,826
Oct 23	85	515	600	9,848
Oct 24	85	315	400	10,473
Oct 25	85	215	300	10,899
Oct 26	85	135	220	11,167
Oct 27	85	135	220	11,435
Oct 28	85	135	220	11,702
Oct 29	85	135	220	11,970
Oct 30	85	135	220	12,238
Oct 31	85	135	220	12,506

B–2. MERCED IRRIGATION DISTRICT

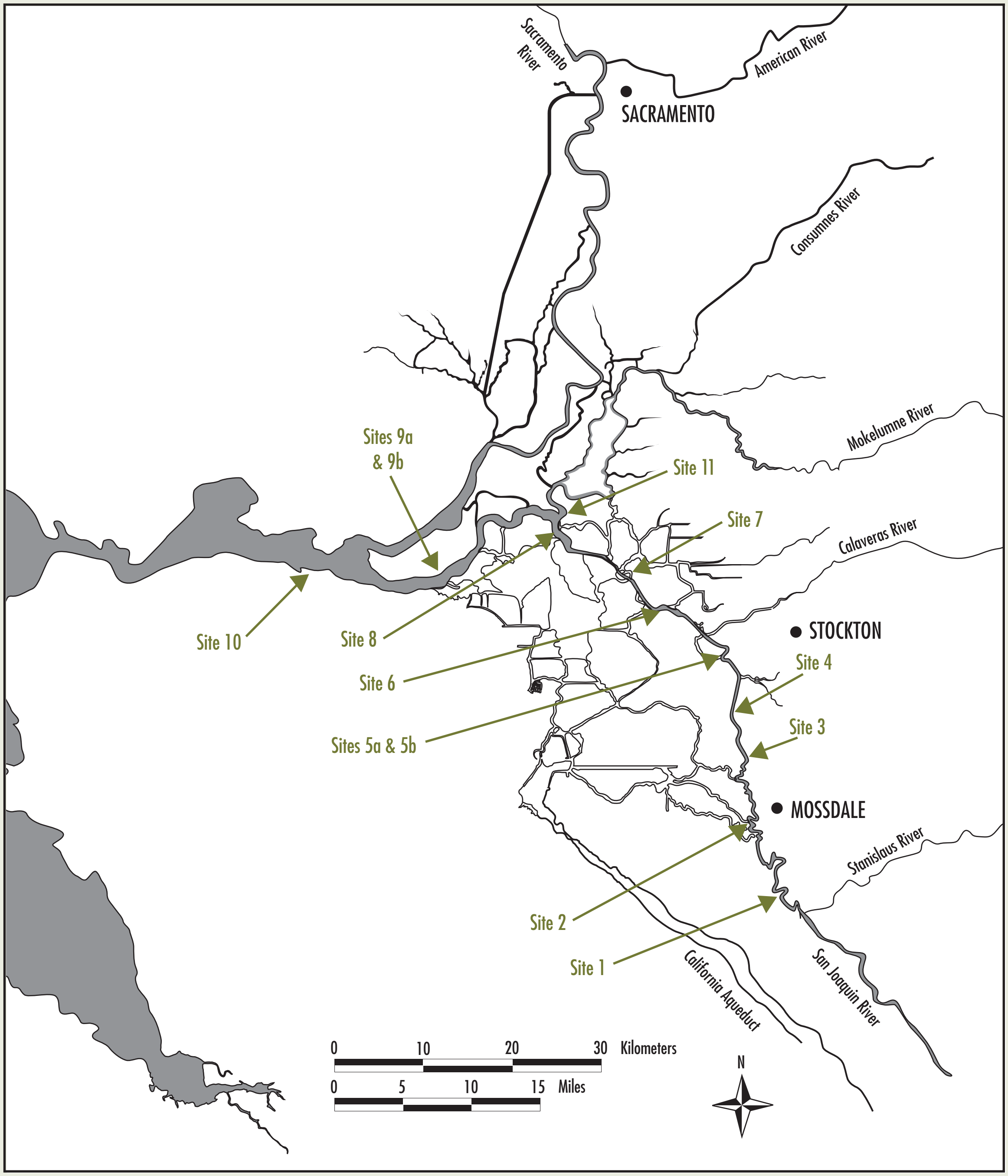
SJRA Fall 2002 Water Transfer · Daily Summary (FINAL)

	SCHEDULED				OBSERVED		
	BASE FLOW – Merced River at Cressey	SJRA Transfer Water	SJRA Transfer Water Cumulative Volume	TARGET FLOW – Merced River at Cressey	FLOW – Merced River at Cressey	SJRA Transfer Water	SJRA Transfer Water Cumulative Volume
	(cfs)	(cfs)	(acre-feet)	(cfs)	(cfs)	(cfs)	(acre-feet)
Oct 01	30	0	0	30	93	0	0
Oct 02	30	0	0	30	104	0	0
Oct 03	30	0	0	30	108	0	0
Oct 04	30	0	0	30	100	0	0
Oct 05	30	0	0	30	99	0	0
Oct 06	30	0	0	30	100	0	0
Oct 07	30	0	0	30	119	0	0
Oct 08	30	0	0	30	101	0	0
Oct 09	30	0	0	30	102	0	0
Oct 10	30	0	0	30	108	0	0
Oct 11	30	0	0	30	122	0	0
Oct 12	30	0	0	30	124	0	0
Oct 13	30	0	0	30	138	0	0
Oct 14	30	0	0	30	146	0	0
Oct 15	30	220	436	250	312	220	436
Oct 16	85	350	1,131	435	481	350	1,131
Oct 17	85	625	2,370	710	702	617	2,354
Oct 18	85	625	3,610	710	747	625	3,594
Oct 19	85	625	4,850	710	787	625	4,834
Oct 20	85	625	6,089	710	810	625	6,073
Oct 21	85	625	7,329	710	815	625	7,313
Oct 22	85	625	8,569	710	760	625	8,553
Oct 23	85	625	9,808	710	745	625	9,792
Oct 24	85	390	10,582	475	543	390	10,566
Oct 25	85	240	11,058	325	420	240	11,042
Oct 26	85	120	11,296	205	335	120	11,280
Oct 27	85	120	11,534	205	303	120	11,518
Oct 28	85	120	11,772	205	296	120	11,756
Oct 29	85	120	12,010	205	280	120	11,994
Oct 30	85	120	12,248	205	258	120	12,232
Oct 31	85	120	12,486	205	224	120	12,470

APPENDIX C

Chinook Salmon Survival Investigations

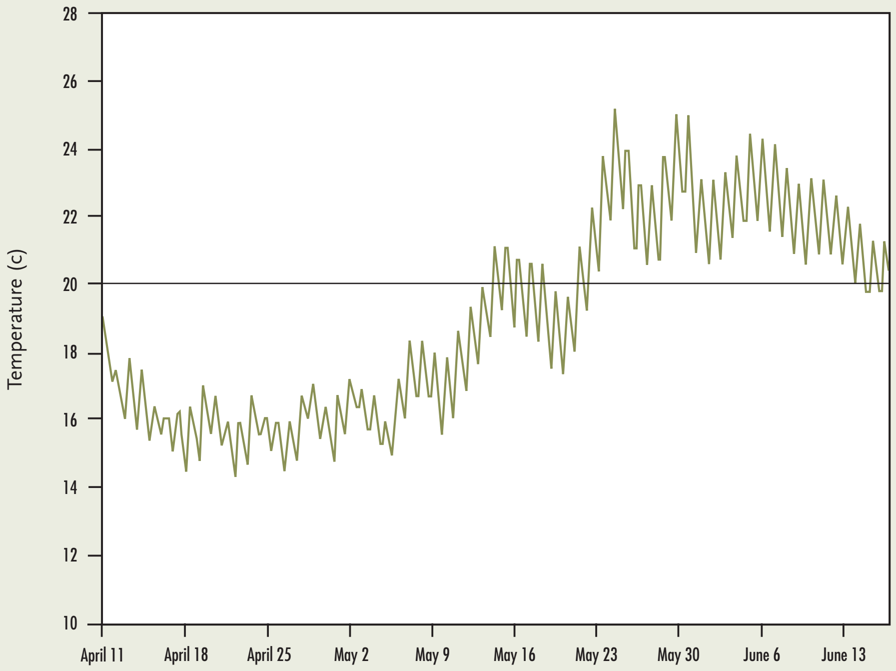
C–1. WATER TEMPERATURE MONITORING LOCATIONS DURING THE VAMP 2003 EXPERIMENT SACRAMENTO-SAN JOAQUIN ESTUARY



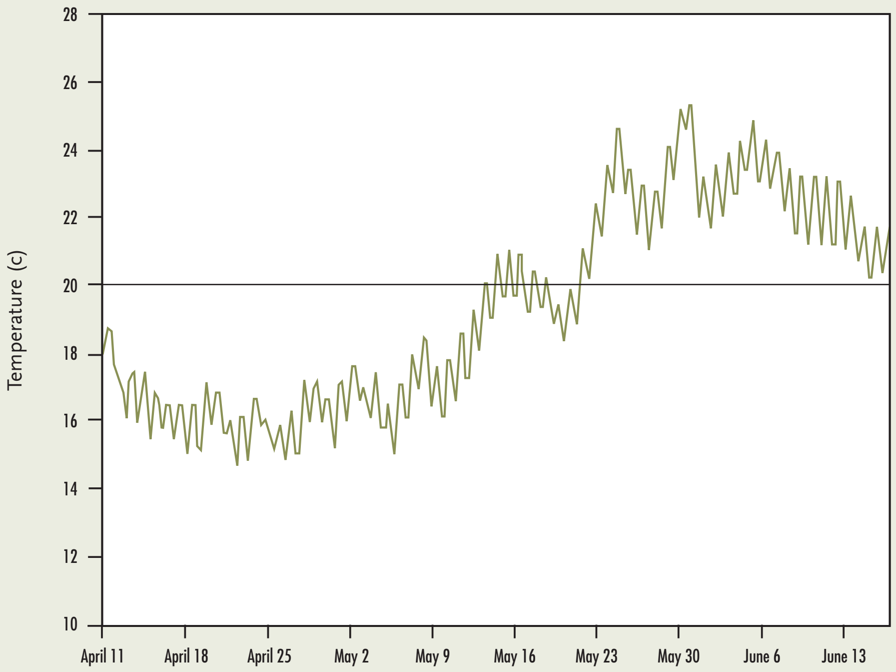
C–1. VAMP 2003 WATER TEMPERATURE MONITORING LOCATIONS

	Temperature Monitoring Location	Latitude	Longitude	Distance from Durham Ferry (mi)	Date Deployed	Date Retrieved	Notes
	Merced River Hatchery–1			n/a	March 21	April 23	In river April 21
	Merced River Hatchery–1			n/a	March 21	April 30	In river April 28
1	Durham Ferry	N 37 41.381	W 121 15.657	n/a	April 11	June 15	Logger was buried in silt when retrieved
2	Mossdale	N 37 47.180	W 121 18.425	11.2	April 11	June 15	3-1/2 feet below surface
3	Dos Reis	N 37 49.808	W 121 18.665	16.4	April 11	June 15	3 feet below surface
4	DWR Monitoring Station	N 37 51.869	W 121 19.376	19.4	April 11	June 15	3 feet below surface
5a	Confluence–Top	N 37 56.818	W 121 20.285	26.5	April 11	Logger Malfunction	3 feet below surface
5b	Confluence–Bottom	N 37 56.818	W 121 20.285	26.5	April 11		Located on bottom
6	Downstream of Channel Marker 30	N 37 59.776	W 121 25.569	33.3	April 11	June 15	3 feet below surface
7	1/2 mile Upstream of Channel Marker 13	N 38 01.940	W 121 28.769	37.3	April 11	June 15	3 feet below surface
8	Downstream of Channel Marker 36	N 38 04.522	W 121 34.413	44.7	April 11	June 15	3 feet below surface
9a	Jersey Point USGS Gauging Station–top	N 38 03.172	W121 41.637	56	April 11	Logger Lost	3 feet below surface
10	Chipps Island	N 38 03.084	W 121 55.463	71.5	April 11	June 15	4-1/2 feet below surface
11	Mokelumne River–Lighthouse Marina	N 38 06.334	W 121 34.213	40	April 11	June 15	Under pier in 3 feet of water

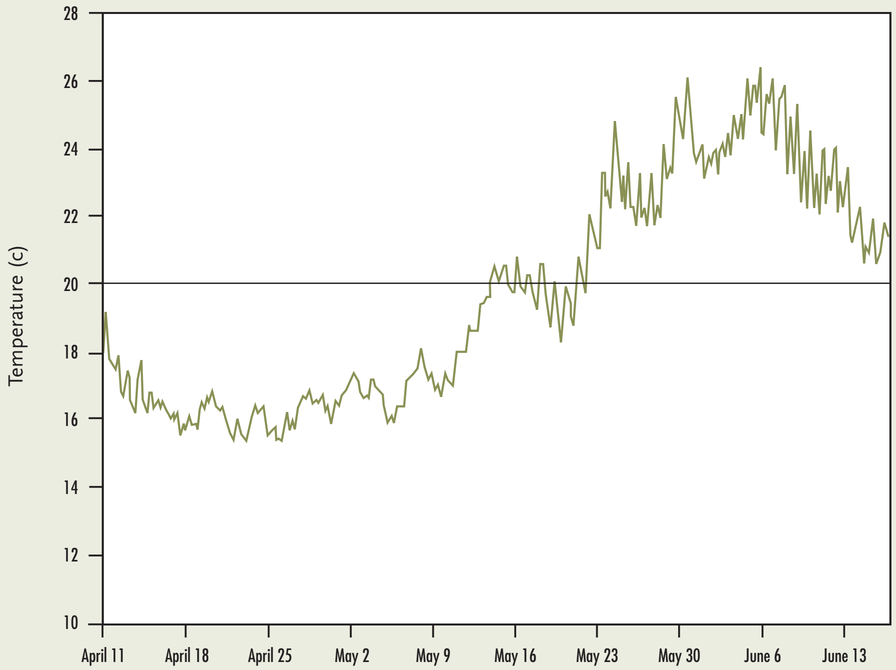
Site 1 • Durham Ferry



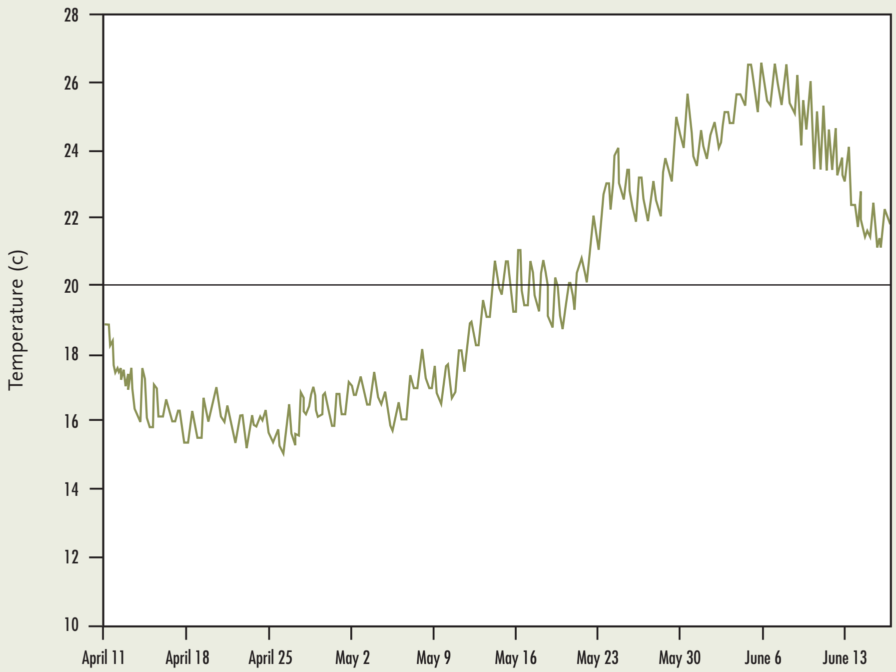
Site 2 • Mossdale



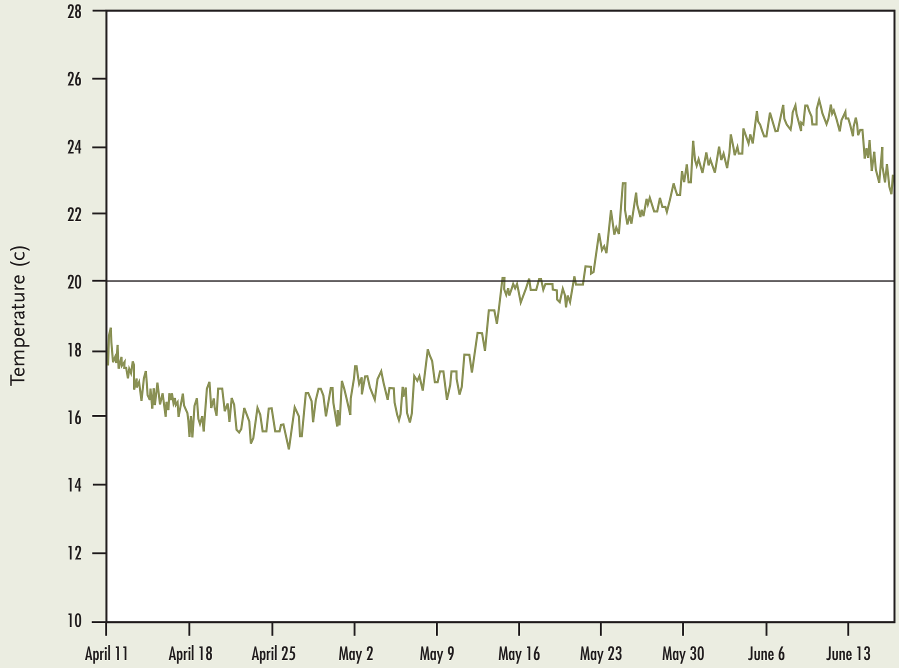
Site 3 • Dos Reis



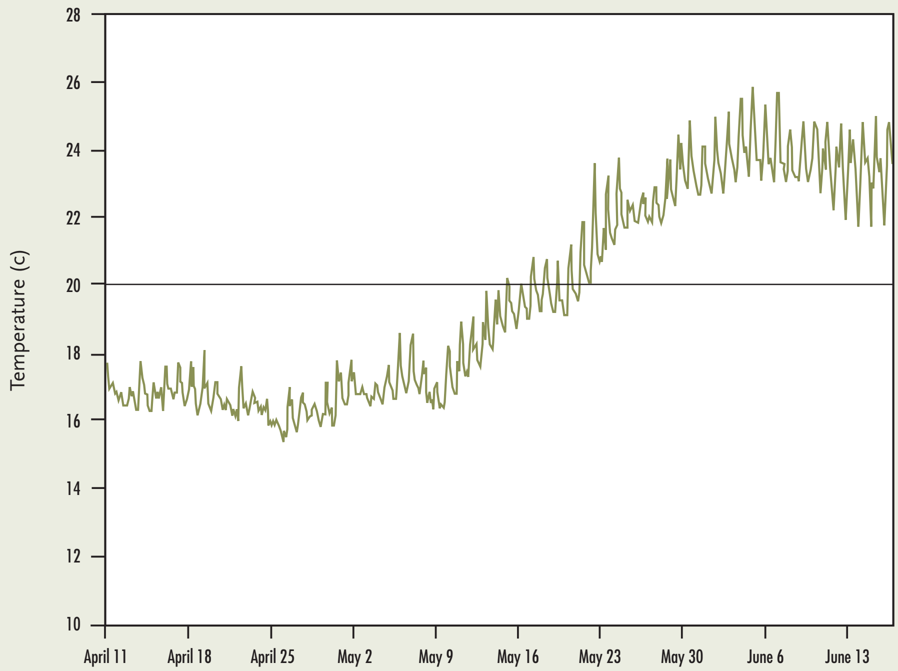
Site 4 • DWR Monitoring Station



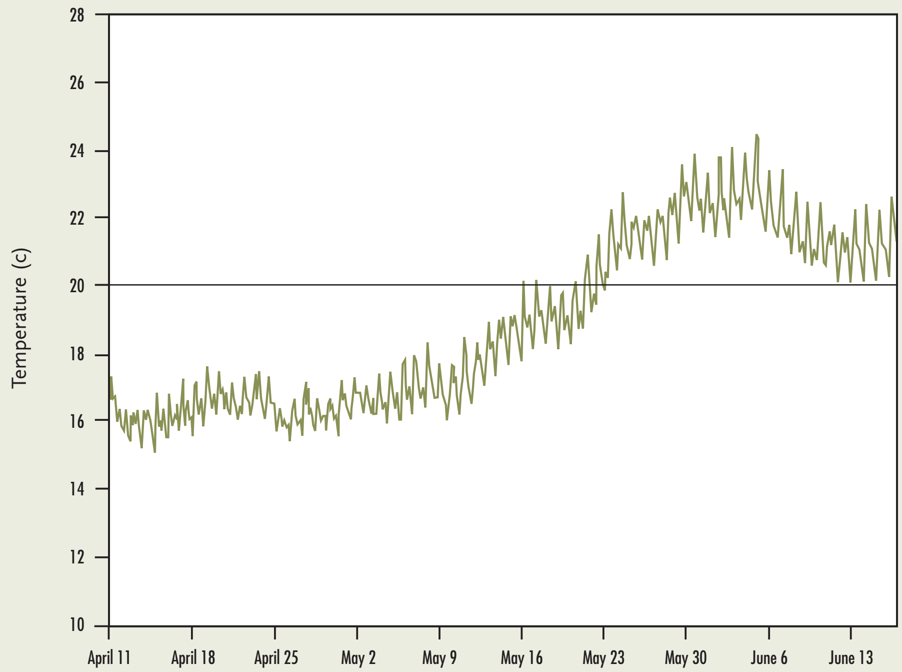
Site 5b • Confluence-Bottom



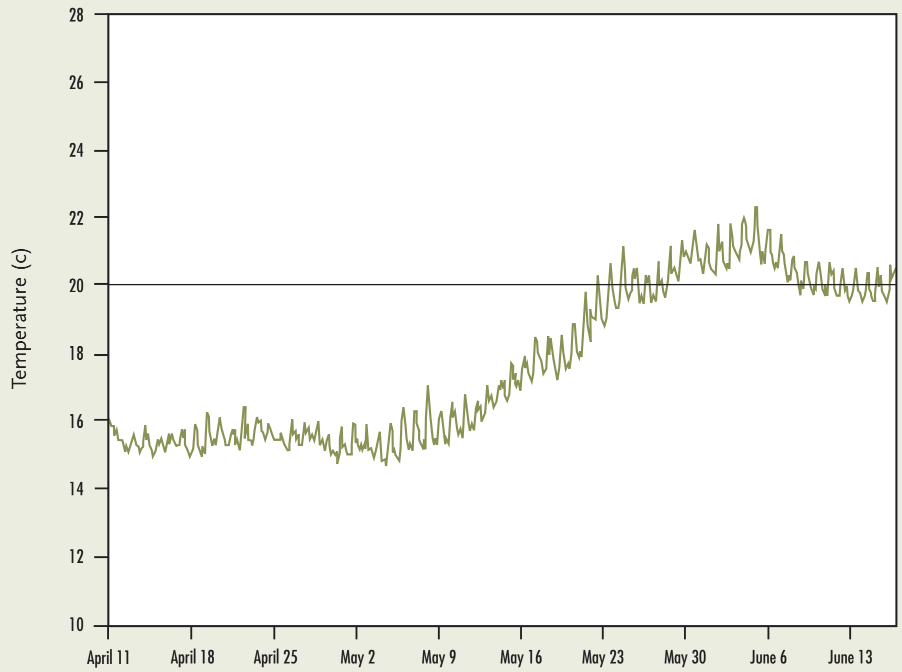
Site 6 • Downstream of Channel Marker 30



Site 7 • 1/2 Mile Upstream of Channel Marker 13

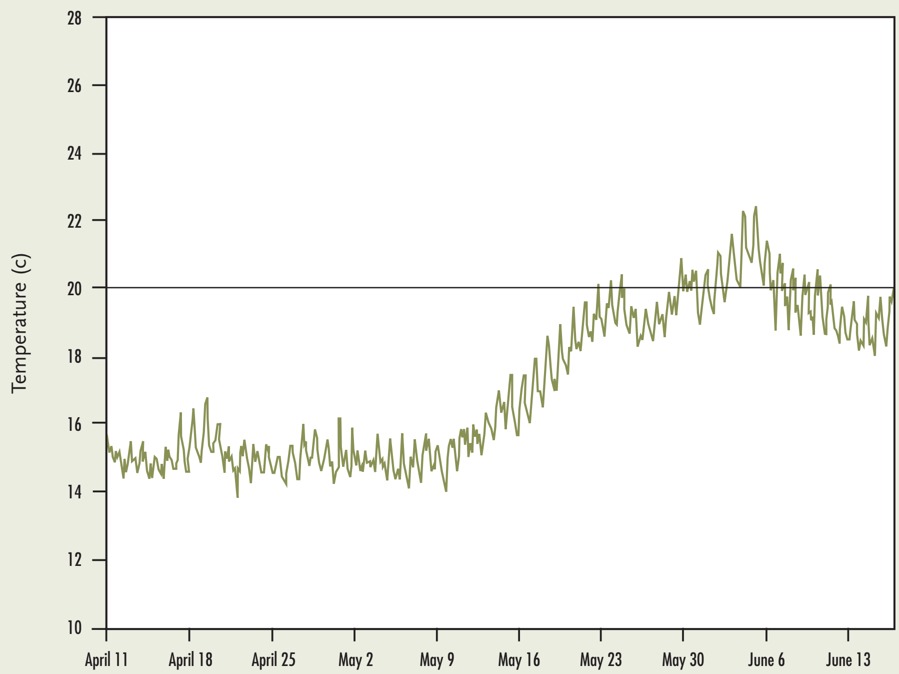


Site 8 • Downstream of Channel Marker 36



C–2. WATER TEMPERATURE MONITORING

Site 10 • Chipps Island



C–3. RESULTS OF NET PEN SAMPLING

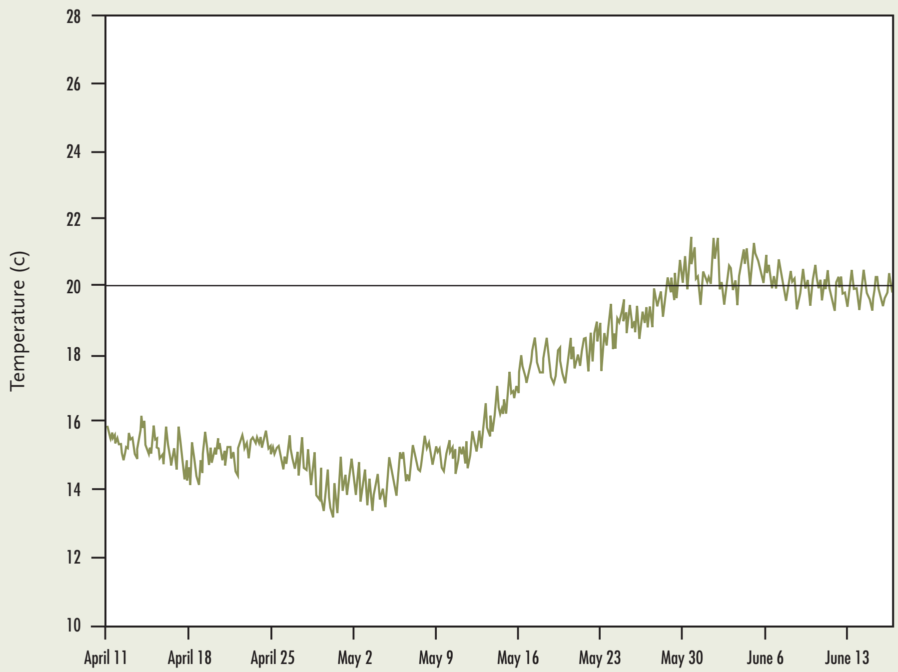
a. Conducted After First Set Juvenile Chinook Salmon Releases, VAMP 2003

	Release Date	Release Location and Number	Coded-wire tag codes(s)	Number in sample	Mean fork length (and range in mm)	Mean weight (and range in g)	Mean scale loss (and range in %)
Samples at 00 Hours	21 Apr	Durham Ferry I[1]	06-02-82 06-02-83 06-27-42	50	85 (72-96)	6.6 (4.2-9.2)	9 (3-25)
	22 Apr	Mossdale I	06-27-43 06-27-48	25 25	86 (74-101) 88 (78-92)	6.9 (4.3-12.1) 7.0 (4.5-9.2)	3 (1-6) 3 (1-8)
	25 Apr	Jersey Point I	06-27-44	25	89 (77-98)	7.5 (4.9-9.9)	3 (2-6)
Samples at 48 Hours	21 Apr	Durham Ferry I[1,2]	06-02-82 06-02-83 06-27-42	265	86 (68-99)	6.7 (3.3-10.3)	11 (5-30)
	22 Apr	Mossdale I[2]	06-27-43 06-27-48	234 267	88 (72-104) 85 (65-99)	7.2 (3.7-12.0) 7.1 (3.0-10.7)	8 (4-15) 7 (3-15)
	25 Apr	Jersey Point I[2]	06-27-44	200	88 (69-103)	7.5 (2.7-11.3)	4 (2-10)

[1] *Coded-wire tag codes for Durham Ferry releases were combined at the hatchery, so reported values are for all three tag codes.*

[2] *Color, fin hemorrhaging, eye appearance, and gill color were assessed from the first 25 fish for Mossdale and Jersey Point releases at 48 hours. These characteristics were assessed using the first 50 fish from the first Durham Ferry release at 48 hours.*

Site 1 • Mokelumne River



Color (% normal)	Fin Hemorrhaging (% none)	Eye appearance (% normal)	Gill color (% normal)	Missing adipose fin clips (%)	Partial adipose fin clips (%)	Number of mortalities	Other deformities and comments
98	100	100	100	0	10	0	2 fish had ragged dorsal fins
100	100	100	100	4	8	0	
100	100	100	100	0	0	0	1 fish with stunted pectoral fin and partial operculum
100	100	100	96	0	0	0	1 fish with caudal fin rot
100	100	98	100	1.5	9.4	1	2 fish with caudal fin rot, 1 fish with left eye missing, 5 fish with ragged fins, 1 fish with partial operculum
100	100	96	96	1.7	10.7	1	
100	100	100	96	0.4	1.9	0	1 fish with a split dorsal fin, 2 fish with a partial operculum
100	100	100	96	0.0	0.5	7	26 additional fish were released on 4/27/03 without being measured

C–3. RESULTS OF NET PEN SAMPLING

b. Conducted After Second Set Juvenile Chinook Salmon Releases, VAMP 2003

	Release Date	Release Location and Number	Coded-wire tag codes(s)	Number in sample	Mean fork length (and range in mm)	Mean weight (and range in g)	Mean scale loss (and range in %)
Samples at 00 Hours	28 Apr	Durham Ferry II[1]	06-27-45 06-27-46 06-27-47	50	87 (73-93)	6.9 (3.7-8.4)	14 (3-35)
	29 Apr	Mossdale II	06-27-49	25	86 (78-92)	7.0 (4.4-9.7)	12 (5-35)
			06-27-50	25	88 (78-92)	7.3 (4.8-8.7)	12 (3-25)
	2 May	Jersey Point II	06-27-51	25	88 (79-97)	7.3 (5.0-9.5)	19 (10-35)
Samples at 48 Hours	28 Apr	Durham Ferry II[1,2]	06-27-45 06-27-46 06-27-47	358	87 (73-100)	6.9 (3.6-10.4)	3 (1-5)
	29 Apr	Mossdale II[2]	06-27-49	33	89 (73-98)	7.5 (3.9-9.4)	10 (5-20)
			06-27-50	144	88 (70-102)	7.3 (3.8-10.4)	14 (5-30)
	2 May	Jersey Point II[2]	06-27-51	236	90 (71-102	7.8 (4.0-11.3)	4 (2-10)

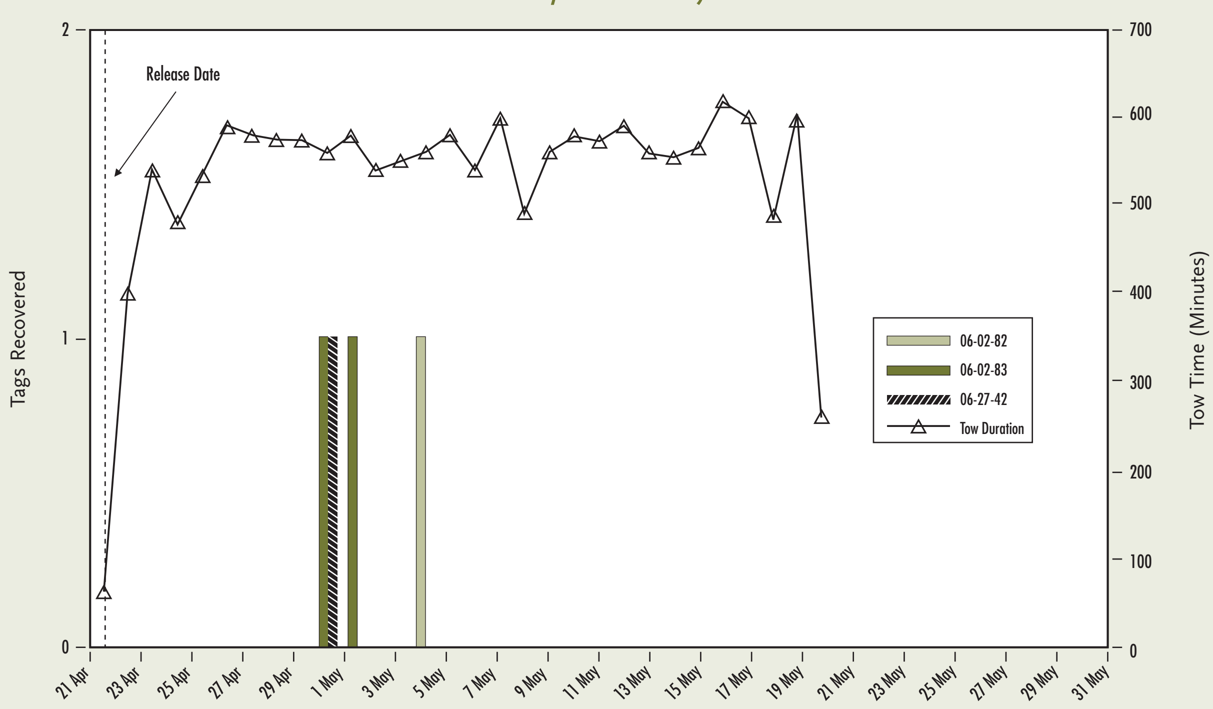
[1] *Coded-wire tag codes for Durham Ferry releases were combined at the hatchery, so reported values are for all three tag codes.*

[2] *Color, fin hemorrhaging, eye appearance, and gill color were assessed from the first 25 fish for Mossdale and Jersey Point releases at 48 hours. These characteristics were assessed using the first 49 fish from the second Durham Ferry release at 48 hours.*

C–4. VAMP 2003 CODED-WIRE TAG RECOVERIES

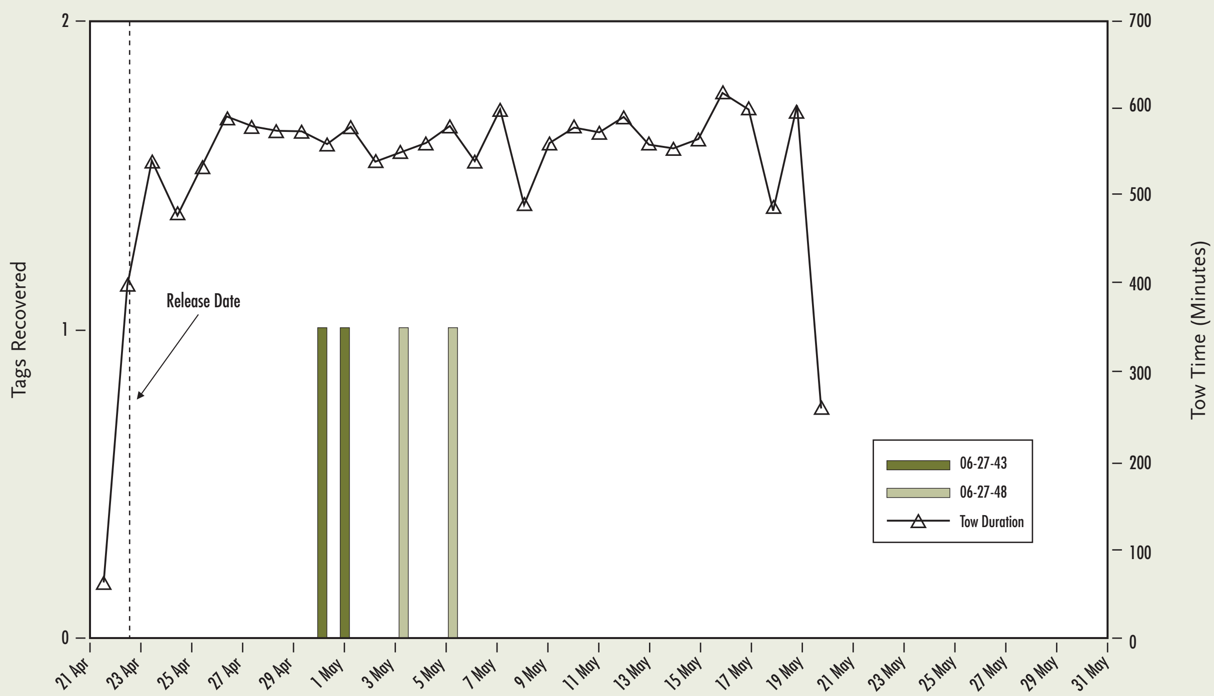
The following graphs are of coded-wire tagged juvenile chinook salmon, from the two sets of VAMP 2003, releases recovered during trawling at Antioch. No coded-wire tagged juveniles were recovered at Antioch from the second Durham Ferry release (on April 28, 2003) or the second Mossdale release (on April 29, 2003).

Antioch/Durham Ferry I

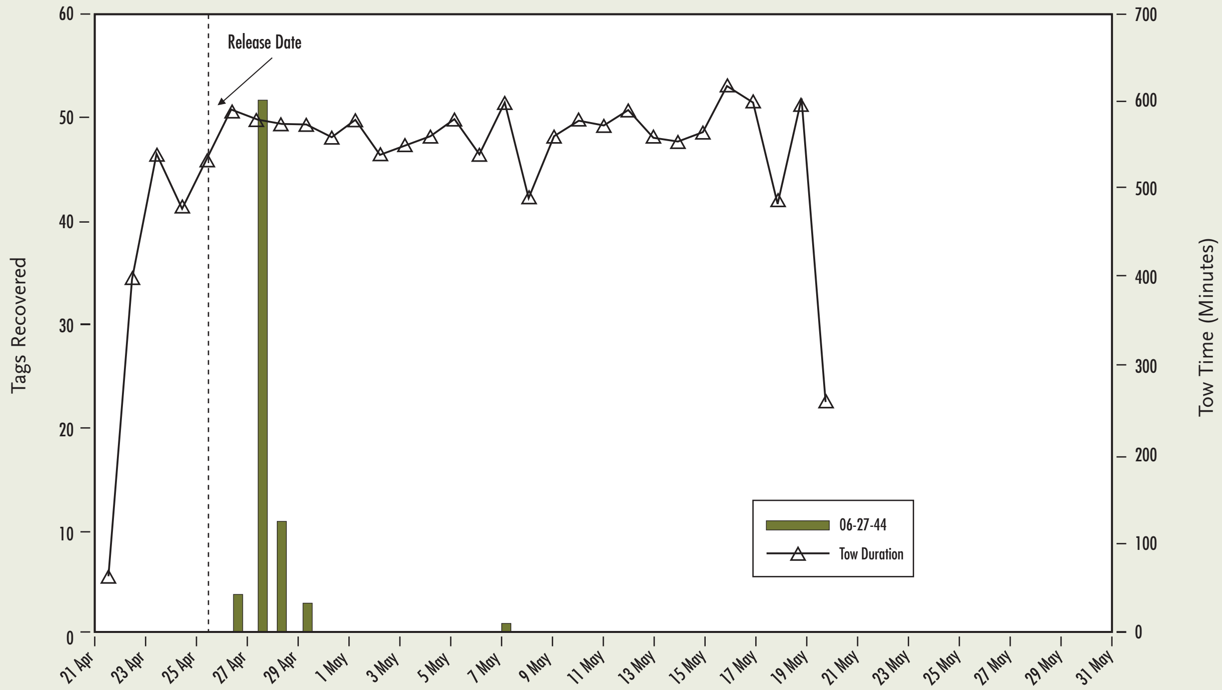


Color (% normal)	Fin Hemorrhaging (% none)	Eye appearance (% normal)	Gill color (% normal)	Missing adipose fin clips (%)	Partial adipose fin clips (%)	Number of mortalities	Other deformities and comments
100	100	98	98	2	2	0	
100	100	100	88	0	8	0	
100	100	96	100	4	0	0	left eye was missing
100	100	100	88	4	8	0	
100	100	100	98	0.0	1.7	2	
100	100	100	100	0	0	0	small holes in net pen may have allowed fish to escape
100	100	100	100	0.7	3.5	0	
100	100	100	100	0.8	3.4	0	

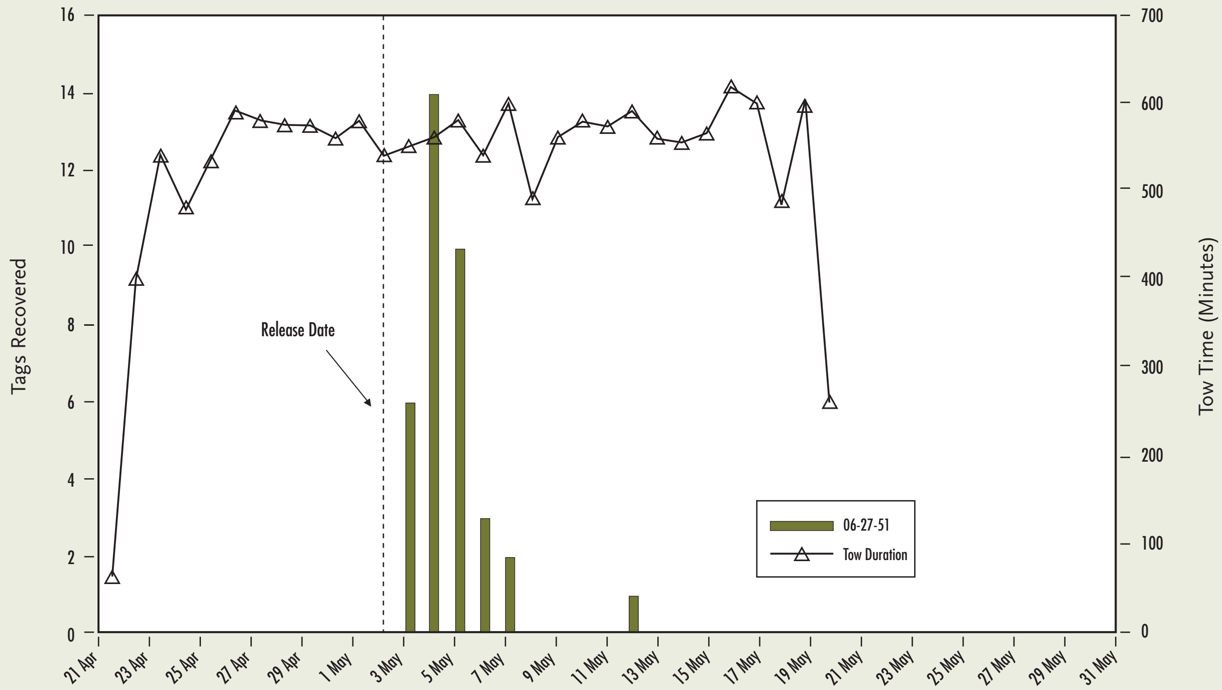
Antioch/Mossdale I



Antioch/Jersey Point I



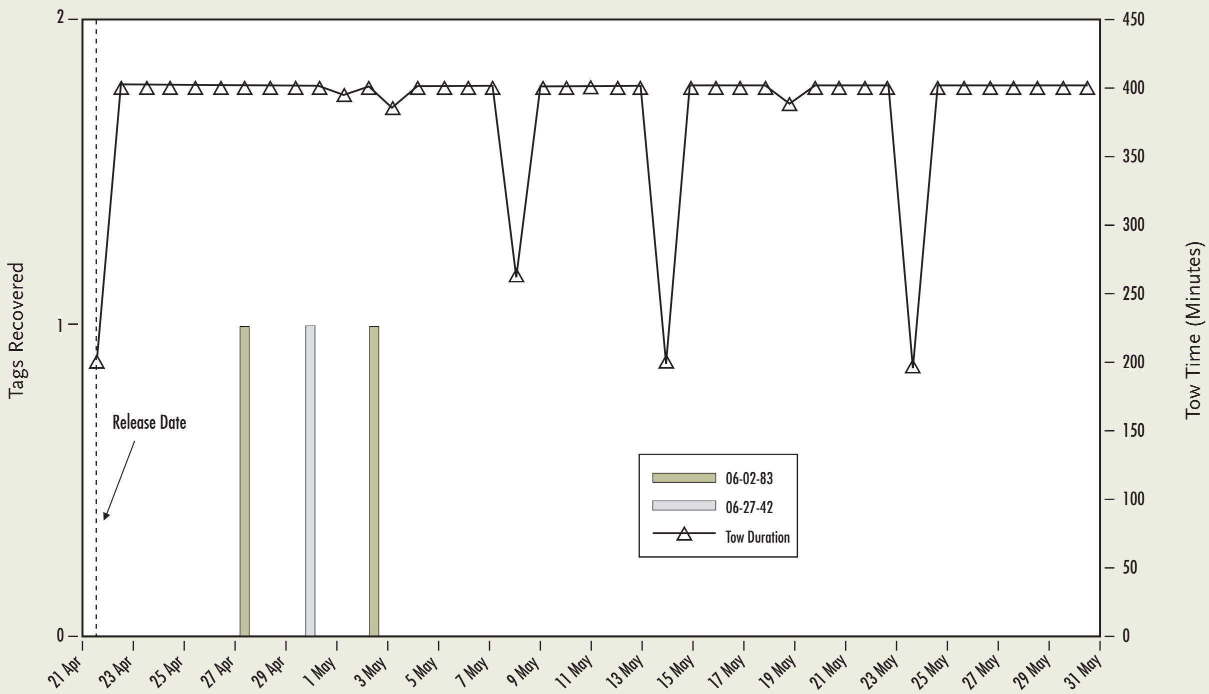
Antioch/Jersey Point II



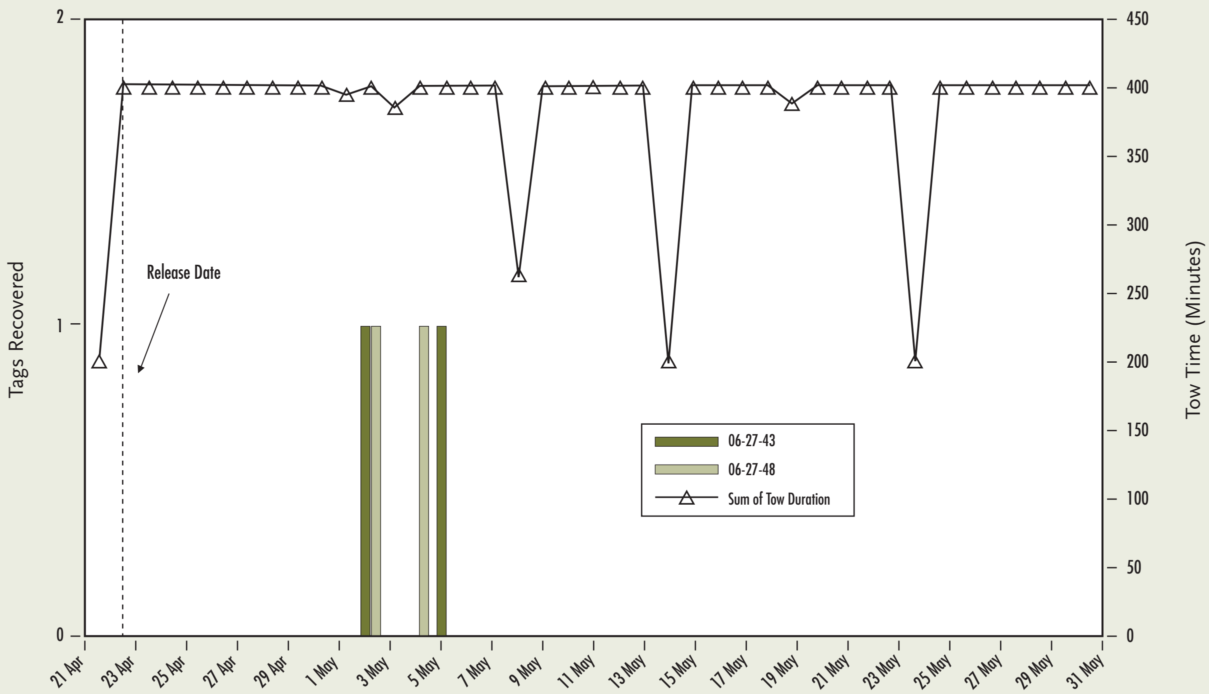
C–4. VAMP 2003 CODED-WIRE TAG RECOVERIES

The following graphs are of coded-wire tagged juvenile chinook salmon, from the two sets of VAMP 2003, releases recovered during trawling at Chipps Island. No coded-wire tagged juveniles were recovered at Chipps Island from the second Durham Ferry release (on April 28, 2003).

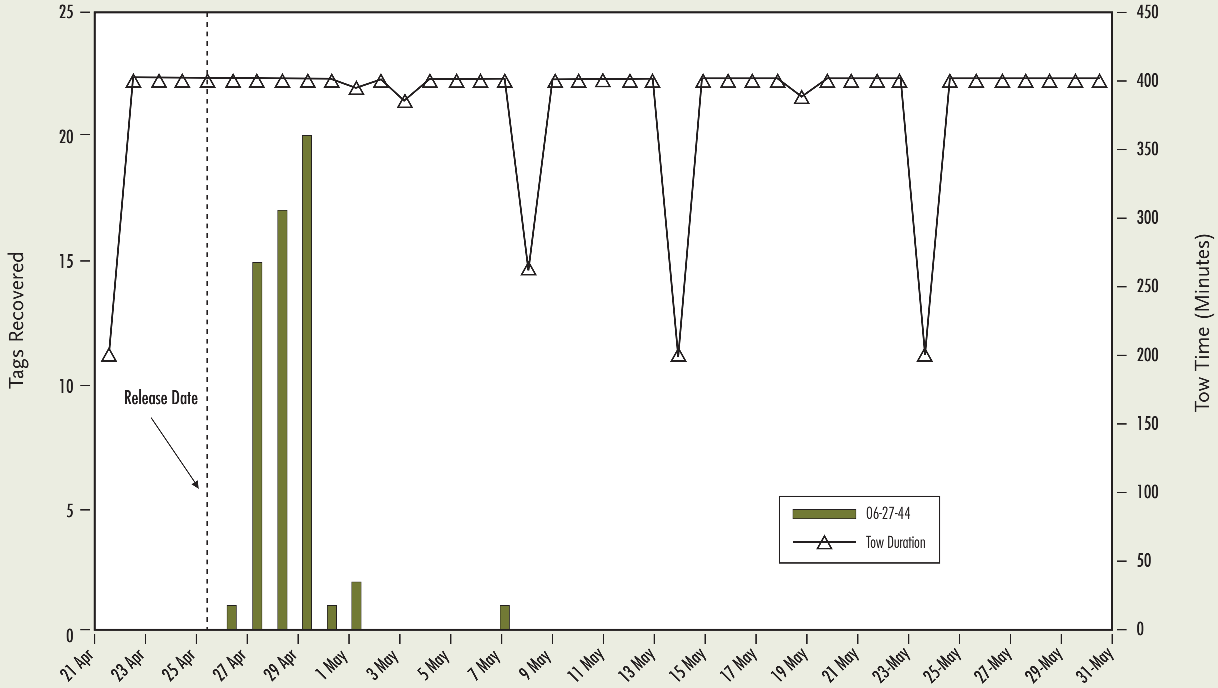
Chipps Island/Durham Ferry I



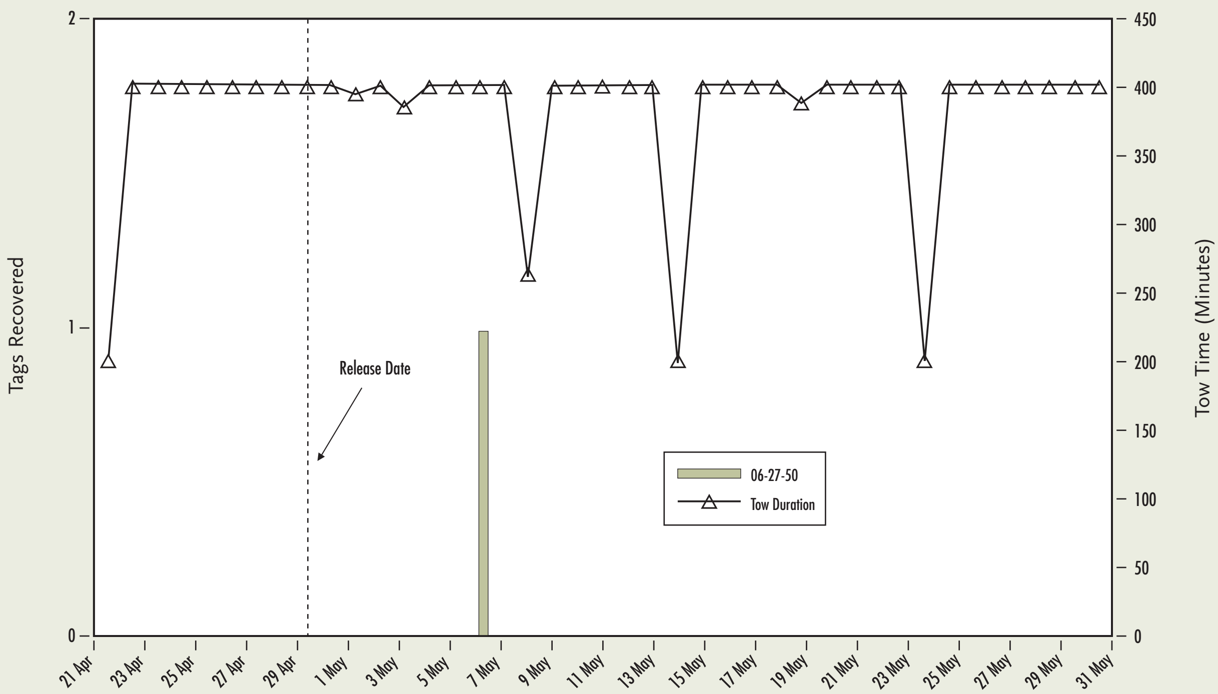
Chipps Island/Mossdale I

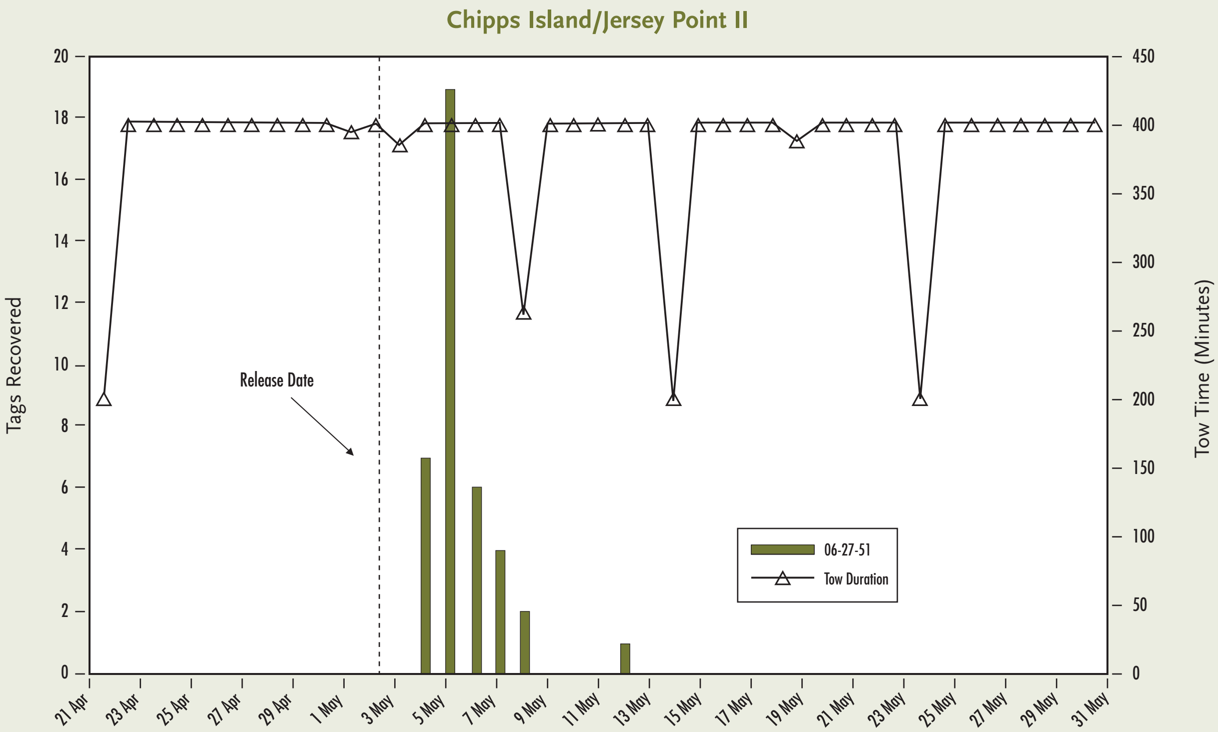


Chipps Island/Jersey Point I



Chipps Island/Mossdale II




Chipps Island/Jersey Point II
Tags Recovered
Tow Time (Minutes)
Release Date
06-27-51
Tow Duration
0
2
4
6
8
10
12
14
16
18
20
0
50
100
150
200
250
300
350
400
450
21 Apr
23 Apr
25 Apr
27 Apr
29 Apr
1 May
3 May
5 May
7 May
9 May
11 May
13 May
15 May
17 May
19 May
21 May
23 May
25 May
27 May
29 May
31 May

C–5. RECOVERY TIMING OF CWT RELEASED AS SAN JOAQUIN TRIBUTARY STUDIES IN 2003

	Tag code	Release Site/Release Stock	Release Date	Antioch			Chipps Island		
				First day recovered	Last day recovered	Days at large	First day recovered	Last day recovered	Days at large
Merced River	06-44-89	Merced River Fish Facility		4/24/03	4/27/03	14	4/25/03	4/25/03	12
	06-44-90	Merced River Fish Facility		4/26/03	4/26/03	13	4/23/03	4/23/03	10
	06-44-91	Merced River Fish Facility		4/26/03	5/04/03	21	—	—	—
	06-44-92	Merced River Fish Facility		—	—	—	4/29/03	4/29/03	16
		Total	4/13/03	4/24/03	5/04/03	21	4/23/03	4/29/03	16
	06-44-93	Hatfield State Park (lower Merced)		4/24/03	4/27/03	11	4/24/03	4/26/03	10
	06-44-94	Hatfield State Park (lower Merced)		4/25/03	5/03/03	17	4/26/03	4/26/03	10
	06-44-95	Hatfield State Park (lower Merced)		4/23/03	4/26/03	10	4/25/03	5/05/03	19
		Total	4/16/03	4/23/03	5/03/03	17	4/24/03	5/05/03	19
	06-44-96	Merced River Fish Facility		—	—	—	—	—	—
	06-44-97	Merced River Fish Facility		—	—	—	—	—	—
	06-44-98	Merced River Fish Facility		5/11/03	5/11/03	16	—	—	—
	06-44-99	Merced River Fish Facility		—	—	—	—	—	—
		Total	4/25/03	5/11/03	5/11/03	16	—	—	—
	06-45-64	Hatfield State Park (lower Merced)		—	—	—	—	—	—
	06-45-65	Hatfield State Park (lower Merced)		—	—	—	5/07/03	5/10/03	11
	06-45-66	Hatfield State Park (lower Merced)		5/12/03	5/12/03	13	—	—	—
		Total	4/29/03	5/12/03	5/12/03	13	5/07/03	5/10/03	11
	06-27-77	Merced River Fish Facility		—	—	—	5/20/03	5/20/03	16
	06-27-78	Merced River Fish Facility		—	—	—	—	—	—
	06-44-49	Merced River Fish Facility		5/18/03	5/18/03	14	5/17/03	5/17/03	13
	06-44-50	Merced River Fish Facility		—	—	—	5/15/03	5/18/03	14
		Total	5/04/03	5/18/03	5/18/03	14	5/15/03	5/20/03	16
	06-45-46	Hatfield State Park (lower Merced)		—	—	—	5/17/03	5/17/03	10
	06-45-47	Hatfield State Park (lower Merced)		5/15/03	5/17/03	10	—	—	—
	06-45-72	Hatfield State Park (lower Merced)		—	—	—	5/15/03	5/15/03	8
		Total	5/07/03	5/15/03	5/17/03	10	5/15/03	5/17/03	10
Stanislaus River	06-45-67	Knight's Ferry		5/17/03	5/17/03	22	—	—	—
	06-45-68	Knight's Ferry		—	—	—	5/11/03	5/11/03	16
	06-45-69	Knight's Ferry		5/04/03	5/04/03	9	—	—	—
		Total	4/25/03	5/04/03	5/17/03	22	5/11/03	5/11/03	16
	06-45-70	Two Rivers		5/05/03	5/05/03	8	—	—	—
	06-45-71	Two Rivers		5/07/03	5/12/03	15	—	—	—
		Total	4/27-4/28/03	5/05/03	5/12/03	15	—	—	—

APPENDIX D

Errata

ERRATA FOR THE YEAR 2002
ANNUAL TECHNICAL REPORT

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

1. Page 38: VAMP Chinook Salmon CWT Survival Indices, 2nd Sentence: Should be replaced with "Survival indices were calculated by dividing the number of CWT salmon recovered by the product of the effective number released (E) multiplied by the fraction of time (T) and channel Width (W) sampled as shown by the formula: SI = R/(E*T*W).

2. Page 54, Figure 5–14: Legend should read "Catch per Minute of all Unmarked Juvenile Chinook Salmon in the Mossdale Kodiak Trawl, March 15, 2002 through June 30, 2002."

3. Page 108–113, Appendix C: The title "Net Pen Sampling Results" should be deleted at the top of each page.

2003 ANNUAL TECHNICAL REPORT

SAN JOAQUIN RIVER GROUP AUTHORITY

Salmon Smolt Released at Durham Ferry, April 21, 2003

2003 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

January 2004

TABLE OF CONTENTS

EXECUTIVE SUMMARY 3

CHAPTER 1:

Introduction 7

Experimental Design Elements 7

CHAPTER 2:

VAMP Hydrologic Planning & Implementation 9

VAMP flow and SWP/CVP Exports 9

Hydrologic Planning 10

Implementation 12

Results of Operations 15

CHAPTER 3:

Additional Water Supply Arrangements & Deliveries 20

Merced Irrigation District 20

Oakdale Irrigation District 20

CHAPTER 4:

Head of Old River Barrier 22

Barrier Design, Installation and Operation 22

Materials and Methods 29

Results 31

Discussion 34

CHAPTER 5:

Salmon Smolt Survival Investigations 37

Coded-Wire Tagging 37

Coded-Wire Tag Releases 37

Water Temperature Monitoring 39

Post-Release Net Pen Studies 41

Coded-Wire Tag Recovery Efforts 44

VAMP Chinook Salmon CWT Survival 46

Transit Time 50

Comparison with Past Years 51

Ocean Recovery Information from Past Years 57

San Joaquin River Salmon Protection 60

Summary & Recommendations 66

CHAPTER 6:

Complimentary Studies Related to the VAMP 72

Survival Estimates for the Tributaries 72

Evaluation of Chinook Salmon Fry Survival 72

Radio Tagging Studies in the Lower River 77

CHAPTER 7:

Conclusions & Recommendations 82

References Cited 84

Contributing Authors 85

Signatories to the San Joaquin River Agreement 86

Useful Web Pages 87

Acronyms & Abbreviations 88

APPENDICES 89

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). Using a consensus-based approach, the SJRA united a large and diverse group of agricultural, urban, environmental and governmental interests.

The 2003 Annual Technical Report comprises the consolidated annual SJRA Operations Report and Vernalis Adaptive Management Plan (VAMP) Monitoring Report. The VAMP 2003 program represents the fourth 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 VAMP program. Specifically, this report includes the following information on the implementation of the SJRA: the hydrologic chronicle; management of the additional SJRA water; installation, operation, and monitoring of the Head of Old River Barrier (HORB); results of the juvenile Chinook salmon smolt survival investigations; discussion of complementary investigations; and, conclusions and recommendations. Condition 4.b of D-1641 directs the Department of Water Resources (DWR) and the U.S. Bureau of Reclamation (USBR) to send the Executive Director of the State Board the results of the fishery monitoring studies on an annual basis and Condition 7 of D-1641 directs Merced, Modesto, Turlock, South San Joaquin and Oakdale irrigation districts to submit a report detailing district operations as a result of the SJRA. By letter dated September 8, 2000, the SWRCB approved combining these two reports into a single comprehensive report due the SWRCB on January 31 of each year.

The 2003 Annual Technical Report comprises the consolidated annual SJRA Operations Report and Vernalis Adaptive Management Plan (VAMP) Monitoring Report.

A key part of this landmark agreement is the VAMP. VAMP is designed to protect juvenile Chinook salmon migrating from the San Joaquin River through the Sacramento—San Joaquin Delta. VAMP is also a scientifically recognized 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 HORB.

VAMP employs an adaptive management strategy to use current knowledge of hydrology and environmental conditions to protect Chinook salmon smolt passage, while gathering information to allow more efficient protection in the future. In addition to providing improved protection for juvenile Chinook salmon emigrating from the San Joaquin River system, specific experimental objectives of VAMP 2003 included:

- Quantification of Chinook salmon smolt survival from Durham Ferry and Mossdale to Jersey Point using recapture locations at Antioch and Chipps Island, under conditions of a San Joaquin River flow at Vernalis of 3,200 cfs, with an installed HORB, and SWP/CVP export rates of 1,500 cfs; and
- Comparison of juvenile Chinook salmon survival between Durham Ferry and Mossdale for use in comparing results of VAMP 2003 with results from earlier survival studies where coded-wire tagged salmon releases occurred at Mossdale.

See Useful Web Pages

The VAMP 2002 Annual Technical Report presented a series of conclusions and recommended modifications to the VAMP experimental design and/or program implementation. The 2002 recommendations were used, in part, as the basis for developing the 2003 VAMP test program. For example, the 2002 report recommended weekly measurements of San Joaquin River flow at the Vernalis gage, continued hydrology investigations to estimate ungaged flows (accretions, depletions) to improve hydrologic predictions, and continued coordination among tributary operators to facilitate implementation of the VAMP test flow conditions. As part of the 2003 program, the hydrology technical committee, working in cooperation with tributary operators and USGS, was able to improve our understanding of San Joaquin River hydrology, provide measurements of Vernalis flow, and provide effective coordination of releases from upstream tributaries. The 2002 report also recommended modifications to the Head of Old River Barrier (HORB) and entrainment monitoring program including a delay in salmon releases at Durham Ferry and Mossdale for approximately five days after barrier closure to allow time for gravel and rock to flush from the culverts and improve fishery sampling, measure flows within the culverts, continue monitoring to evaluate potential impacts of seepage, monitor fish entrainment at the culverts, and improve the experimental design of Head of Old River Barrier investigations. These recommendations were addressed as part of the 2003 VAMP program through delayed salmon releases at Durham Ferry and Mossdale after barrier closure, continued water level monitoring to refine the operational criteria for the culverts and evaluate potential seepage through groundwater well monitoring, and improved fisheries monitoring at the culverts to provide information on the percentage of VAMP CWT salmon released at Mossdale and Durham Ferry, in addition to unmarked salmon, subsequently entrained into the barrier culverts. The Department of Water Resources (DWR) was successful in securing all of the necessary permits and approvals for the installation of the Head of Old River Barrier over the next five years. However, landowner access remains to be negotiated annually.

A quality assurance/quality control program has been used as a routine part of VAMP tests. The 2003 CWT tagging at the Merced River Fish Facility included information useful in quantifying CWT retention and tag efficiency. During the 2003 program, coordination with the local landowner was continued to curtail operation of an agricultural diversion pump located immediately downstream of Durham Ferry, coincident with each of the two releases. In addition, the 2003 VAMP program continued use of the net pen studies and a fish health assessment to determine the health and survival of test fish released as part of VAMP. Additional measurements are needed of flow passing through the Head of Old River Barrier culverts and in the San Joaquin River downstream of the confluence with Old River. In the future measurements of San Joaquin River flow downstream of the Old River Barrier will be used in the relationship between San Joaquin River flow and juvenile Chinook salmon survival. Additional complimentary studies, including survival studies for juvenile Chinook salmon emigrating from San Joaquin River tributaries, were incorporated into the 2003 VAMP investigations.

Recommendations from the 2002 VAMP program were used to improve the overall experimental design and implementation of the 2003 VAMP investigations.

The estimated survival of CWT salmon released from Durham Ferry and Mossdale was the lowest measured to date and the lowest since initiation of the VAMP. An elevated percentage of Proliferative Kidney Disease when combined with low flow conditions may have contributed to an increase in mortality but it is uncertain based on only the 2003 data. The 2002 report recommended that, to the extent possible, VAMP survival testing be conducted at flow and export extremes to improve the ability of the program to detect differences in juvenile Chinook salmon survival among target flow and export conditions. Hydrologic conditions within the San Joaquin River watershed did not provide conditions suitable for testing extreme target conditions as part of the VAMP 2003 program. These and other recommendations from the 2002 VAMP program were used to improve the overall experimental design and implementation of the 2003 VAMP investigations. Recommendations made based upon analyses of the VAMP 2003 program will also be used, in a similar way, by the hydrology and fisheries technical committees in developing and implementing the experimental design for the 2004 VAMP studies.

Based on data gathered during the experimental mark-recapture studies that occurred over a 31-day period in April and May 2003, a set of conclusions and recommendations has been developed. These conclusions and recommendations provide guidance and a foundation for design and implementation of future VAMP operations. Key conclusions and recommendations derived from VAMP 2003 include:

- VAMP 2003 is the fourth year of full implementation of the program. Average Vernalis flow during the VAMP period was 3,235 cfs. SWP and CVP export rates averaged 1,446 cfs. The VAMP period was between April 15 and May 15, 2003.
- Recovery rates of the Durham Ferry and Mossdale groups relative to the Jersey Point groups using recaptures at Antioch and Chipps Island indicated that there was no statistical ($p>0.05$) difference between the two replicates or release locations in 2003. The number of CWT salmon recovered from the second set of release groups, however, was lower than recoveries from the first release groups with no recoveries made for the second Durham Ferry release group at either Antioch or Chipps Island. The second set of release groups was found to have a significantly higher incidence of PKD infection, than the first set of releases.
- The combined differential recovery rate of CWT salmon recovered from Durham Ferry and Mossdale groups relative to the Jersey Point groups showed that the relative survival in 2003 was significantly lower than survival results from the 2002 VAMP although flow and export conditions (target flow 3200 cfs and exports of 1500 cfs in both years) were comparable for the two years. The factors contributing to the significantly lower survival in 2003 are unknown, although may be related to the combined effects of PKD infection and the lower flows.
- The relationships between salmon survival, Vernalis flow, and SWP/CVP exports are no longer statistically significant.
- Streamflow data at Vernalis were improved by weekly flow measurements and rating curve verification, however estimation of ungaged flow (accretions and depletions) requires further investigation for use in establishing annual VAMP target flows. Alternative methods of measuring flow at Vernalis and/or alternative measurement locations should also be investigated. DWR installed a stage recorder and fixed acoustic Doppler velocity meter in the San Joaquin River downstream of the confluence with Old River for use in measuring river flow. The monitoring station is being calibrated and is anticipated to be available for flow measurements associated with the VAMP 2004 studies.
- The design, construction, and operation of the HORB were successful in 2003. Salmon releases at Durham Ferry and Mossdale were delayed approximately five days after HORB closure to allow time for gravel and rock to flush from the culverts and to assure the safety of personnel conducting fisheries sampling at the site. Operation of the HORB with three culverts open was successful in maintaining south Delta water levels.
- The index of salmon entrainment at the HORB in 2003 with three culverts open was substantially greater then in 2001 and 2002 with all six culverts open.
- Construction of multiple barriers within the south Delta during the spring has the potential to delay completion of the construction of HORB, which may contribute to exposure of juvenile Chinook salmon to elevated water temperatures. Due to the high risk of losing major salmon protection benefits and biasing experimental conditions, it is strongly recommended that construction of the HORB be completed on schedule to avoid delays in implementing survival investigations. The report also recommends that flow measurements be made to document flow through HORB culverts and the resultant flow within the San Joaquin River downstream of the confluence with Old River.
- The variability inherent in measuring salmon smolt survival in the lower San Joaquin River and Delta makes it difficult to detect statistically significant differences in salmon survival between VAMP flow and export target conditions, which are relatively similar. It is strongly recommended that, conditions be tested at 7000 cfs flow and 1500 cfs export to improve ability to detect potential differences in salmon smolt survival among test conditions.

- Approximately 80 percent of the unmarked salmon migrating past Mossdale in 2003 migrated during the VAMP period (April 15 through May 15) and were, therefore protected by increased San Joaquin River flow, installation of the HORB and decreased export pumping.
- The selection and management of VAMP flow conditions should, if possible, minimize or avoid requiring upstream tributary flows that adversely affect potential habitat quality or survival of natural salmon produced within the tributaries. It is therefore recommended that upstream tributary and VAMP studies be coordinated as much as possible. Coordination during 2003 with upstream tributary operations was successful and coordination among tributary operators should continue in the future.
- The report encourages expansion of complementary studies to provide additional information on factors and mechanisms affecting salmon survival during migration from the lower San Joaquin River through the delta.
- Past data indicates that survival improves as flows increase and flows relative to exports increase. With the addition of the 2003 data the relationships between salmon survival rates and Vernalis flow and flow relative to SWP/CVP export conditions are no longer statistically significant. The VAMP program provides improved protection for juvenile salmon when compared to “pre-VAMP” conditions. Further tests, over a wider range of flow and export conditions, are needed to evaluate the respective roles of San Joaquin River flow and SWP/CVP exports on juvenile Chinook salmon smolt survival. The report recommends that the VAMP experimental test program be continued.

The relationships between salmon survival rates and Vernalis flow and flow relative to SWP/CVP export conditions are no longer statistically significant. The VAMP program provides improved protection for juvenile salmon when compared to “pre-VAMP” conditions. The report recommends that the VAMP experimental test program be continued.

CHAPTER 1

Introduction

Actions associated with the Vernalis Adaptive Management Plan (VAMP) were implemented between April 15 and May 15, 2003 to protect juvenile Chinook salmon and evaluate the relationship between San Joaquin River flow and State Water Project (SWP) and federal Central Valley Project (CVP) water project exports on the survival of marked juvenile Chinook salmon migrating through the Sacramento-San Joaquin Delta. Studies conducted in 2003, represent the fourth year of the VAMP experiment. Results from previous VAMP experiments are available in San Joaquin River Agreement 2000 Technical Report and San Joaquin River Group Authority, Technical Reports 2001 and 2002. Similar experiments were conducted prior to the official implementation of VAMP with results available in South Delta Temporary Barriers Annual Reports (DWR, 2001, 1999, 1998). This report will describe the experimental design of VAMP, the hydrologic planning and implementation, the additional water supply arrangements and deliveries, the Head of Old River Barrier (HORB) design, installation, operation and fisheries monitoring, the smolt survival investigation and complimentary studies related to VAMP. Conclusions and Recommendations for future VAMP studies are also included.

EXPERIMENTAL DESIGN ELEMENTS

The VAMP experimental design measures 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 mid-April to mid-May juvenile salmon outmigration period that provide estimates of salmon survival under each set of conditions. Chinook salmon survival indices under each of the experimental conditions are then calculated based on the numbers of marked salmon released and the number recaptured. Absolute survival estimates and combined differential recovery rates were also calculated and used in relationships between survival and San Joaquin River flow and CVP and SWP exports.

The VAMP 2003 experimental design included both multiple release locations (Durham Ferry, Mossdale, and Jersey Point), and multiple recapture locations (Antioch, Chipps Island, SWP and CVP salvage operations, and in the ocean fisheries; Figure 1-1). Two sets of releases were made at Durham Ferry, Mossdale, and Jersey Point. The use of data from multiple release and recapture locations allows for a more thorough evaluation of juvenile Chinook salmon survival as compared to recapture data from only one sampling location and/or one series of releases. The VAMP coded-wire tag (CWT) releases (Durham Ferry, Mossdale, and Jersey Point) and recapture locations (Antioch and Chipps Island) are consistent from one year to the next, providing a greater opportunity to assess salmon smolt survival over the range of Vernalis flows, SWP/CVP exports, and with and without the presence of the Head of Old River Barrier (HORB). Releases at Jersey Point serve as controls for recaptures at Antioch and Chipps Island, thereby allowing the calculation of survival estimates based on the ratio of survival indices from marked salmon recaptured from upstream (e.g., Durham Ferry and Mossdale) and downstream (control release at Jersey Point) releases. The combined differential recovery rates are calculated in a similar manner. The use of ratio estimates as part of the VAMP study design factors out the potential differential gear efficiency at Antioch and Chipps Island within and among years.

The added recovery numbers from recapturing marked fish at both Antioch and Chipps Island improves the precision associated with the individual survival estimates, and improves confidence in detecting differences in salmon smolt survival as a function of Vernalis flows and SWP/CVP exports.

A quality assurance/quality control program has been used as a routine part of VAMP tests, and includes quantifying the number of marked fish successfully clipped and tagged. Coordination with the local landowner to curtail operation of an agricultural diversion pump located immediately downstream of Durham Ferry, coincident with each of the two Durham Ferry releases was continued in 2003. In addition, the 2003 VAMP program continued use of the net pen studies and physiological testing to assess overall condition and health of marked fish used in VAMP experiments. Additional improvements are needed relative to measuring and reporting flow in San Joaquin River downstream of the confluence with Old River. Measurements of San Joaquin River flow downstream of the HORB will be used to evaluate the relationship between San Joaquin River flow and juvenile Chinook salmon survival in the future.

FIGURE 1–1

Sacramento—San Joaquin Estuary

Location of VAMP 2003 Release Sites (Durham Ferry, Mossdale and Jersey Point), Recovery Locations (Antioch and Chipps Island), and Head of Old River Barrier Location Within the Sacramento-San Joaquin River Delta/Estuary.

CHAPTER 2

VAMP Hydrologic Planning & Implementation

This section documents the planning and implementation undertaken by the Hydrology Group of the San Joaquin River Technical Committee (SJRTC) for the 2003 VAMP investigations. Implementation of VAMP is guided by the framework provided in the San Joaquin River Agreement (SJRA) and anticipated hydrologic conditions within the watershed.

The Hydrology Group 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 2003, the agencies belonging to the Hydrology Group included: Merced Irrigation District (Merced), Turlock Irrigation District (TID), Modesto Irrigation District (MID), Oakdale Irrigation District (OID), South San Joaquin Irrigation District (SSJID), San Joaquin River Exchange Contractors Water Authority (SJREC), 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 installation of the HORB and the planning of Delta exports consistent with the VAMP.

VAMP FLOW AND SWP/CVP EXPORTS

The VAMP provides for a 31-day pulse flow (target flow) in the San Joaquin River at the Vernalis gage during the months of April and May, along with a corresponding reduction in SWP/CVP exports, as shown in Table 2-1. The magnitude of the pulse flow is based on flow that would occur during the pulse period absent the VAMP, referred to as the existing flow.

As part of the development of the VAMP experimental design, the VAMP Hydrology and Biology Groups jointly 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 VAMP Hydrology and Biology Groups 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 technical committees 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

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	

The ability to manage and regulate San Joaquin River flows is difficult due to variation in unregulated flows, uncertainty 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 technical committees 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 joint Hydrology and Biology Groups agreed to a target range variation of plus or minus 7% of the Vernalis flow target. It was recognized by the Hydrology and Biology Groups that these guidelines were not absolute conditions, but was to be used by the VAMP hydrology and biology workgroups to evaluate experimental test conditions and the potential effect of flow and export variation on our ability to detect and assess variation in juvenile Chinook salmon survival rates among VAMP test conditions.

Under the SJRA, the following SJRGA agencies have agreed to provide the supplemental water, limited to a maximum of 110,000 acre-feet, needed to achieve the VAMP target flows shown in Table 2-1: Merced, OID, SSJID, SJREC, MID and TID.

The 2,000 cubic feet per second (cfs) VAMP target flow shown in Table 2-1 does not represent a VAMP experiment data point but is used to define the supplemental water volume to be provided by the SJRGA agencies in critically dry years 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 2000 cfs, the USBR, in accordance with the SJRA, shall act to purchase additional water from willing sellers to fulfill the requirements of existing biological opinions.

Based upon hydrologic conditions, the target flow in a given year could either be increased to the next highest value ("double-step") or the supplemental water requirement could be eliminated entirely. A numerical procedure has been established in the SJRA to determine the target flow. The SWRCB San Joaquin Valley Water Year Hydrologic Classification ("60-20-20" classification) is given a numerical indicator as shown in Table 2-2.

TABLE 2–2

San Joaquin Valley Water Year Hydrologic Classifications Used in VAMP

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

"Double-step" flow years occur when the sum of last year's numerical indicator and the 90 percent exceedence forecast of the current year's numerical indicator is seven (7) or greater.

If the sum of the two previous years' numerical indicators and the 90 percent exceedence forecast of the current year's numerical indicator is four (4) or less, indicative of an extended dry period, no VAMP supplemental water will be provided. The USBR, however, has a continuing obligation to meet San Joaquin River flows pursuant to the March 6, 1995 Delta smelt Biological Opinion.

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. Based on the targets outlined in Table 2-1, in a double-step year up to 157,000 acre-feet of supplemental water may be required. If the VAMP target flow requires more than 110,000 acre-feet of supplemental water, then additional water may be acquired on a willing seller basis.

HYDROLOGIC PLANNING

Hydrology Group Meetings

Beginning in February 2003, and continuing until early April, the Hydrology Group held four planning and coordination meetings (February 19, March 12, March 26 and April 9). At these meetings, forecasts of hydrologic and operational conditions on the San Joaquin River and its tributaries were discussed and refined.

Monthly Operation Forecasts

As part of the early planning efforts, monthly operation forecasts were developed by the Hydrology Group to estimate the existing flow at Vernalis. Inflows to the tributary reservoirs used in these forecasts were based on DWR Bulletin 120 runoff forecasts. The monthly operation forecasts used the 90 percent and 50 percent probability of exceedence runoff forecasts. The initial monthly operation forecast was presented at the February 19 Hydrology Group meeting. The 90 percent exceedence forecast called for a VAMP target flow of 3,200 cfs and the 50 percent exceedence forecast called for a VAMP target flow of 5,700 cfs. Hydrologic projections and planning were subsequently refined as additional information became available in March and April.

Daily Operation Plan

Starting in mid-March, the Hydrology Group began development of a daily operation plan, updating it as hydrologic conditions and operational requirements changed. The daily operation plan calculated an estimated mean daily flow at Vernalis based on estimates 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 major tributaries. The following key assumptions were used in the development of the daily operation plan:

(1) The travel times for flows from the tributary control points and upper San Joaquin River to the Vernalis gauge are assumed as follows:

a. Merced River at Cressey to Vernalis	3 days
b. San Joaquin River above Merced River to Vernalis	2 days
c. Tuolumne River at LaGrange to Vernalis	2 days
d. Stanislaus River below Goodwin Dam to Vernalis	2 days

(2) Based upon a review of the historical flow record, the ungaged flow at Vernalis was assumed to be constant throughout the VAMP period and based upon the value entering the period. By definition, the ungaged flow is the unmeasured flow entering the system between Vernalis and the upstream measuring points and is calculated as follows:

Vernalis Ungauged =

VNS – GDWlag – LGNlag – CRSlag – USJRlag

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 gauged flow but is the calculated difference between the gauged flows at the San Joaquin River at Newman (NEW) and the Merced River near Stevinson (MST)).

By definition, the VAMP 31-day pulse flow period can occur anytime between April 1 and May 31. Factors needed to be considered in determining the timing of the VAMP period include installation of the HORB, availability of juvenile salmon at the hatchery, and manpower and equipment availability for salmon releases and recapture. Until a specific start date is defined, a default target flow period of April 15 to May 15 is used for the VAMP operation planning. The current installation and operational constraints for the HORB are described in Chapter 4.

The previous two years, 2001 and 2002, were both classified as "dry" years using the 60-20-20 water year classification, giving each a VAMP numerical indicator of two. Therefore, there was no possibility of 2003 being a dry period offramp year (numerical indicator of previous two plus current year total of 4 or less). Conversely, in order for 2003 to be a "double-step" year, 2003 would need to be classified as a "wet" year based on the 90 percent exceedence forecast as of April 1, with a VAMP numerical indicator of 5. The early 90% exceedence forecasts (Jan., Feb. and Mar.) were indicating a "dry" or "critical" year, making it very unlikely that 2003 would be a "double-step" year; therefore, planning efforts concentrated on the "single step" criteria. In fact, the 90% exceedence forecast on April 1 for the San Joaquin Valley was for a "critical" year, resulting in the 2003 VAMP following the "single step" criteria.

The initial Daily Operation Plan was prepared on March 12, and was modified as hydrologic conditions and operational requirements changed. Table 2-3 summarizes the various iterations of, and demonstrates the evolutionary nature of the daily operation plan. Copies of the daily operation plans are provided in Appendix A-1.

The SJRTC Biology Group was interested in setting a VAMP target flow start date earlier than April 15. DWR noted that due to regulatory and construction limitations it was highly unlikely that the HORB could be closed prior to April 15, but that it was on schedule for closure by April 15. Therefore the period of April 15 through May 15 was designated as the target flow period.

Normally, the USGS measures the flow at Vernalis to check the current rating shift on a monthly basis. The real-time flows reported by the USGS and CDEC are dependent on the most current rating shift, therefore a new measurement and 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 2 and May 7. The results of these measurements

> ***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 operation is that the flows scheduled on the Merced, Tuolumne and Stanislaus Rivers to achieve this goal do not conflict with studies or flow requirements on the individual tributaries, and to the degree possible, provide benefits on the tributaries.***

are summarized in Table 2-4. A shift was applied to the Vernalis rating curve as a result of the April 16 measurement, which indicated that the actual flow was approximately 150 cfs higher than what was being reported real-time (3,040 cfs actual flow verses 2,890 cfs reported flow). This shift did not result in any changes to the planned VAMP operation.

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 operation is that the flows scheduled on the Merced, Tuolumne and Stanislaus Rivers to achieve this goal do not conflict with studies or flow requirements on the individual tributaries, and to the degree possible, provide benefits on the tributaries. During the development of the daily operation plan, the Hydrology group consults with DFG and the tributary biological teams to determine periods of time when stable flows are desirable on the tributaries, what flow rates are desired, and what flow limitation exist, specifically in regards to ramping, minimum and maximum flows. The periods of desired stable flow are highlighted with bold outlines in the daily operation plans in Appendix A-1.

For the 2003 VAMP operation there were two periods of desired stable flow on the Merced River, one on the Stanislaus River, but none on the Tuolumne River. On the Merced River the desire was to have a period with a stable flow of about 500 cfs and a stable pulse flow in excess of 1000 cfs for a period of 8 to 9 days. On the Stanislaus River the desire was to have a pulse flow of 1500 cfs for as long a period as possible. The coordination of these desired flows resulted in an initial pulse in the Tuolumne River, followed by an eight day 1500 cfs pulse flow on the Stanislaus, which was followed by an eight day 1500 cfs pulse flow on the Merced River. Plots of the individual tributary flows are provided in Appendix A-3.

IMPLEMENTATION

Operation Conference Calls

During implementation of the VAMP pulse flow, conference calls were conducted on a regular basis among members of the Hydrology Group and SJRGA member staff to discuss the status of the pulse flow and to make changes to the operation plan if needed. The calls were held at 6:30 a.m. so that potential operational changes could be implemented on that day. The conference calls were held every Monday, Wednesday and Friday, starting on April 16 and ending on May 9.

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 2-5. The CDEC real-time data has not been reviewed for accuracy or adjusted for rating shifts; 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 were continuously monitored. Similarly, the computed ungaged flow at Vernalis and the flow in the San Joaquin River upstream of the Merced River were continuously updated. The monitoring was necessary to verify that supplemental water deliveries were adhering to tributary allocations contained in the SJRA Division Agreement to the extent possible, as well as to determine if changes in hydrologic conditions would require changes to the operation plan.

The daily operation plan was updated throughout the VAMP flow period. A summary of the updated daily operation plans is provided in Table 2-6. Copies of the updated daily operation plans are provided in Appendix A-2.

TABLE 2–3
Summary of Daily Operation Plans Prepared During Planning Phase

VAMP Forecast Date	VAMP Target Flow Period	Assumed Ungaged Flow at Vernalis (cfs)*	Existing Flow (cfs)*	VAMP Target Flow (cfs)*	Supplemental Water needed to meet Target Flow (1,000 AF)*
March 12	April 15 - May 15	300 - 600	2,070 - 2,980	3,200	69.42 - 13.67
March 26	April 15 - May 15	300 - 500	2,280 - 2,840	3,200	56.70 - 22.22
April 4	April 15 - May 15	400	2,565	3,200	39.06
April 9	April 15 - May 15	300	2,340	3,200	52.91

*Figures represent the most probable range of low and high hydrologic conditions.

TABLE 2–4
Summary of USGS Flow Measurements at the San Joaquin River near Vernalis Gage

Date	River Stage (ft)	Measured Flow (cfs)	CDEC Reported Real-time Flow (cfs)	Percent Difference	Rating Shift
March 4 (9:22)	9.87	2,140	2,150	-0.5%	No
April 2 (10:09)	9.68	2,070	2,000	3.5%	No
April 9 (9:46)	9.6	2,000	1,950	2.6%	No
April 16 (10:00)	10.74	3,040	2,890	5.2%	Yes
April 23 (9:17)	11.07	3,320	3,350	-0.9%	No
April 30 (10:01)	11.04	3,390	3,320	2.1%	No
May 7 (9:50)	10.92	3,100	3,210	-3.4%	No

TABLE 2–5
Real-time Flow Data and Sources

Measurement Location	Real-time Data Source
San Joaquin River near Vernalis	USGS, station 11303500 (http://waterdata.usgs.gov/ca/nwis/dv?format=pre&period=31&site_no=11303500)
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?format=pre&period=31&site_no=11289650)
Merced River at Cressey	CDEC, station CRS (http://cdec.water.ca.gov/cgi-progs/queryF?s=crs)
Merced River near Stevinson	CDEC, station MST (http://cdec.water.ca.gov/cgi-progs/queryF?s=mst)
San Joaquin River at Newman	USGS, station 11274000 (http://waterdata.usgs.gov/ca/nwis/dv?format=pre&period=31&site_no=11274000)

TABLE 2–6
Summary of Daily Operation Plans Prepared During Implementation Phase

VAMP Forecast Date	VAMP Target Flow Period	Assumed Ungaged Flow at Vernalis (cfs)	Existing Flow (cfs)	VAMP Target Flow (cfs)	Supplemental Water needed to meet Target Flow (1,000 AF)
April 22	April 15 - May 15	300	2,331	3,200	53.43
April 30	April 15 - May 15	300	2,322	3,200	53.98

FIGURE 2–1

2003 VAMP—San Joaquin River near Vernalis with and without VAMP.

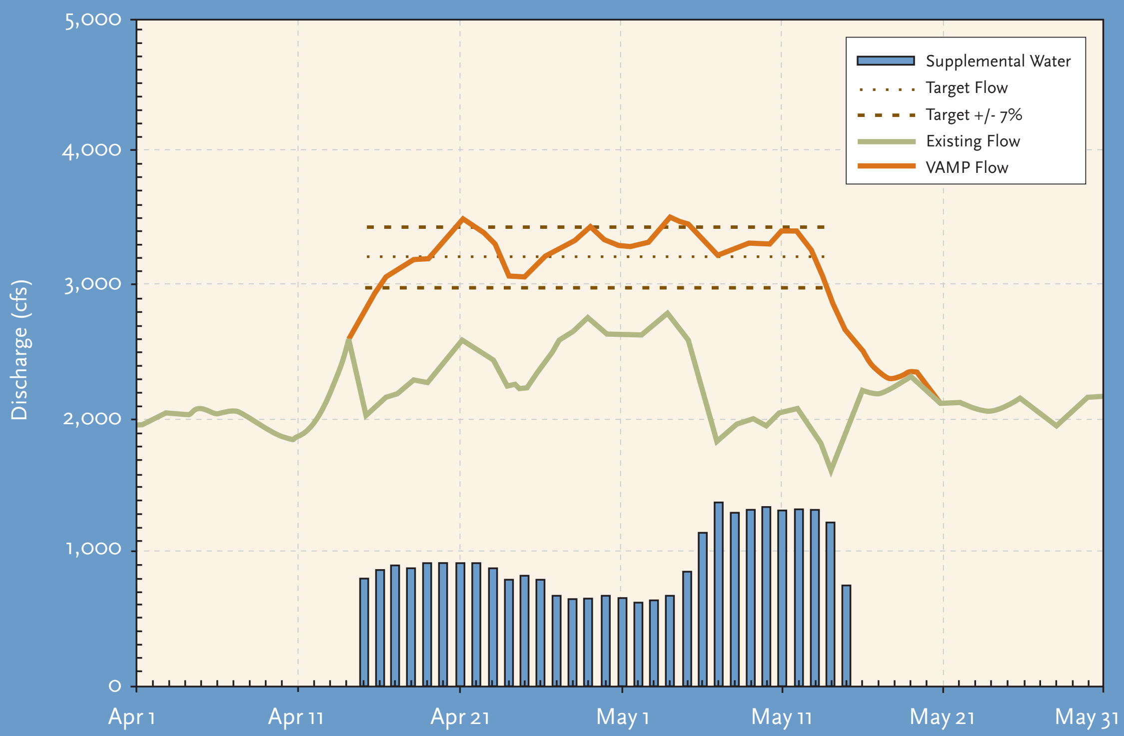
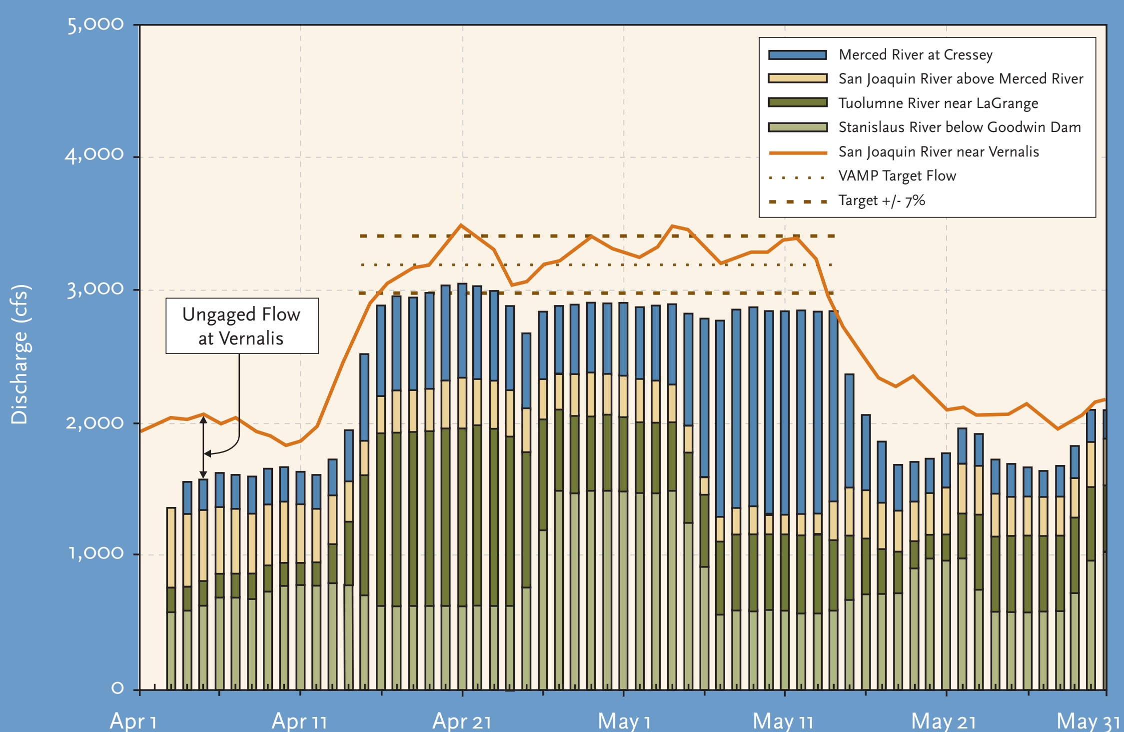


FIGURE 2–2

2003 VAMP—San Joaquin River near Vernalis with lagged contributions from primary sources.



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 the end of July.[I] Provisional data 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 to illustrate the differences between the real-time and the provisional data.

The mean daily flow at the Vernalis gage averaged 3,235 cfs during the April 15 – May 15 VAMP test flow period, with a maximum of 3,500 cfs and a minimum of 2,650 cfs. The average flow for the test flow period absent the VAMP supplemental water (existing flow) was estimated to be 2,290 cfs. The VAMP operation resulted in a 41 percent increase in flow at Vernalis during the target flow period. Figure 2-1 shows the flow at Vernalis with and without the VAMP pulse flow. Figure 2-2 shows the sources of the flow at Vernalis. A total of 58,065 acre-feet of supplemental water was provided during the VAMP test flow period.

In planning for the VAMP operation the ungaged flow in the San Joaquin River at Vernalis is the most difficult factor to forecast for the test flow period. The Daily Operation Plan is developed assuming a steady ungaged flow during the test flow period, but in reality there will be day to day fluctuations due to a number of unpredictable factors including weather, pre-existing conditions, irrigation operations, as well as mathematical uncertainties introduced by using mean daily flows and assumed travel times rounded to the nearest day. During the implementation phase of the VAMP operation, the forecasted ungaged flow were not necessarily adjusted as a result of the day to day fluctuations, but were adjusted if the general trend appeared to be deviating from the existing forecast. This is best illustrated in Figure 2-3, which shows in hindsight the observed ungaged flow along with that forecast prior to the test flow period on April 4 and the adjusted forecast that was modified on an ongoing basis in an attempt to account for deviation from the existing forecast.

Another unknown in the forecast equation similar to the ungaged flow is the flow in the San Joaquin River upstream of the Merced River. This unknown tends not to be as variable as the ungaged flow, but, like the ungaged flow, may be adjusted if the observed flow warrants it. Figure 2-4 shows the observed upper San Joaquin River flow along with the forecasts made just prior to the test flow period and during the VAMP implementation.

[I] The SJRA Division Agreement Technical Appendix specifies that "By July 31st of each year, each SJTA participant shall provide the records necessary to calculate the flow contribution by each entity to the San Joaquin River Group co-coordinator."

In planning for the VAMP operation the ungaged flow in the San Joaquin River at Vernalis is the most difficult factor to forecast for the test flow period. The Daily Operation Plan is developed assuming a steady ungaged flow during the test flow period, but in reality there will be day to day fluctuations due to a number of unpredictable factors including weather, pre-existing conditions, irrigation operations, as well as mathematical uncertainties introduced by using mean daily flows and assumed travel times rounded to the nearest day.

The target combined CVP and SWP export rate for the 2003 VAMP was 1,500 cfs. The observed export rate averaged 1,446 cfs during the 31-day period, about 4 percent below the 1,500 cfs target. The daily SWP and CVP exports during the VAMP test period are shown in Figure 2-5.

SJRG member agencies have entered into the Division Agreement, which allocates responsibility of the member agencies for providing VAMP supplemental water. The member agencies may also enter into additional agreements among themselves regarding delivery of the supplemental water. For the 2003 VAMP Merced I.D and the Exchange Contractors entered into an agreement whereby the Exchange Contractors supplemental water would be provided by Merced I.D. The distribution of supplemental water for the 2003 VAMP operation, compared to the distribution called for under the Division Agreement, is summarized in Table 2-7.

FIGURE 2–3

2003 VAMP—Ungaged flow in San Joaquin River near Vernalis.
Comparison of forecast and observed.

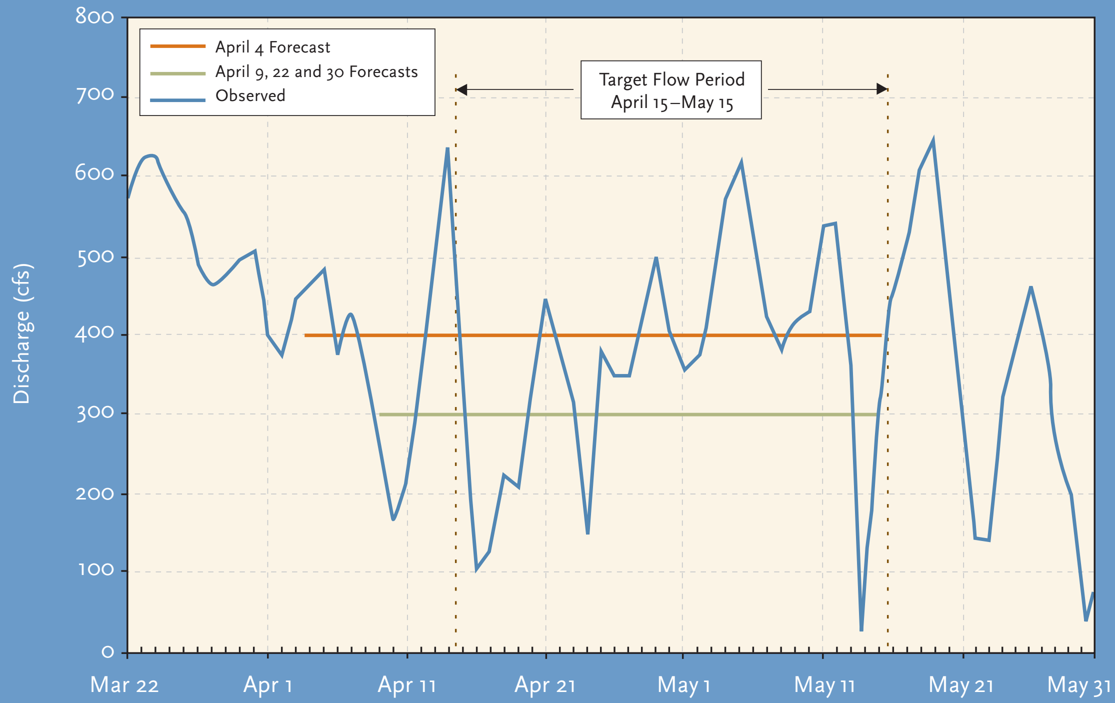
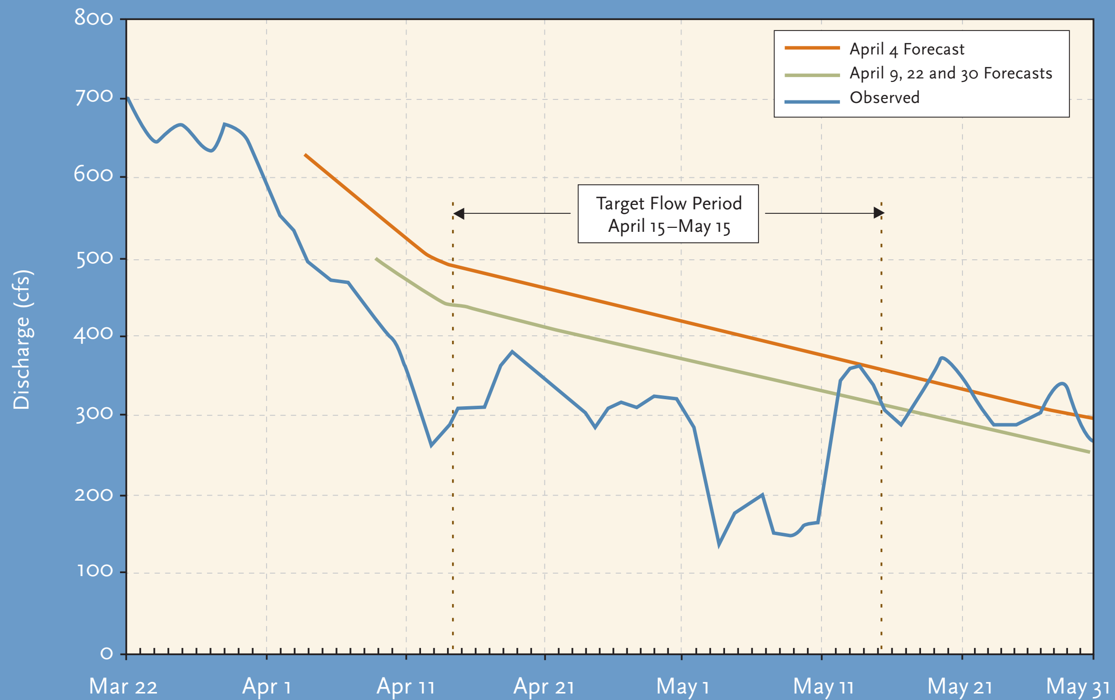


FIGURE 2–4

2003 VAMP—San Joaquin River above Merced River.
Comparison of forecast and observed.



Hydrologic Impacts

The VAMP supplemental water contributions, with the exception of that provided by the Exchange Contractors and OID/SSJID, are supplied from reservoir storage: Lake McClure on the Merced River and New Don Pedro Reservoir on the Tuolumne River. 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.

As noted in the 2002 Annual Technical Report, the storage impact in Lake McClure on the Merced River following the April 15 to May 15, 2002 VAMP operation was 95,262 acre-feet. As per the SJRA, Merced provided 12,470 acre-feet of supplemental water in the Fall of 2002 (see Chapter 3), resulting in a total SJRA storage impact on Lake McClure as of October 31, 2002 of 107,732 acre-feet. There were no opportunities to make up for any of this impact during the winter, therefore the entire impact of 107,732 acre-feet carried over into the 2003 VAMP

TABLE 2–7
Distribution of Supplemental Water

Agency	Division Agreement Distribution (acre-feet)	Supplemental Water Provided (acre-feet)	Deviation from Division Agreement (acre-feet)
Merced I.D.	33,065	33,257	+ 192
Oakdale I.D./South San Joaquin I.D.	10,000	10,078	+ 78
Exchange Contractors	5,000	5,000[a]	0
Modesto I.D./Turlock I.D.	10,000	9,729	- 271

[a]The Exchange Contractors supplemental water was provided by Merced I.D.

FIGURE 2–5

2003 VAMP—Federal and State Exports. (Source: USBR Delta Operations Report)

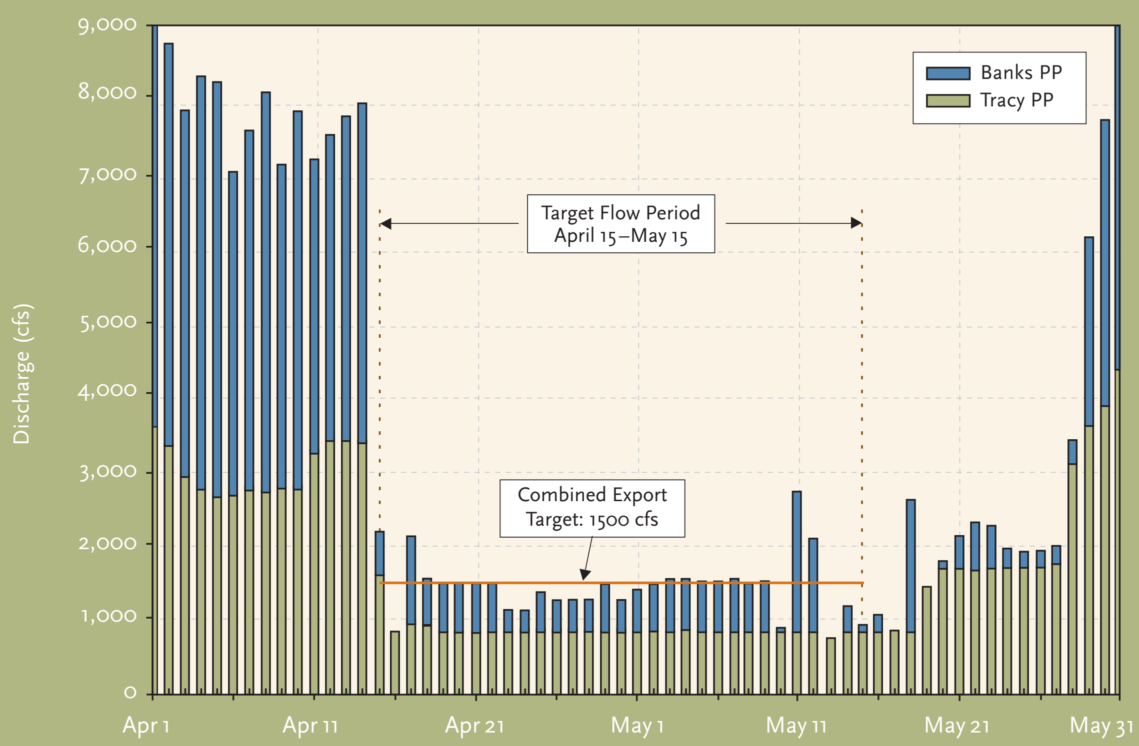


FIGURE 2–6

SJRA storage impacts—Lake McClure (Merced River).
October 2002 through November 2003.

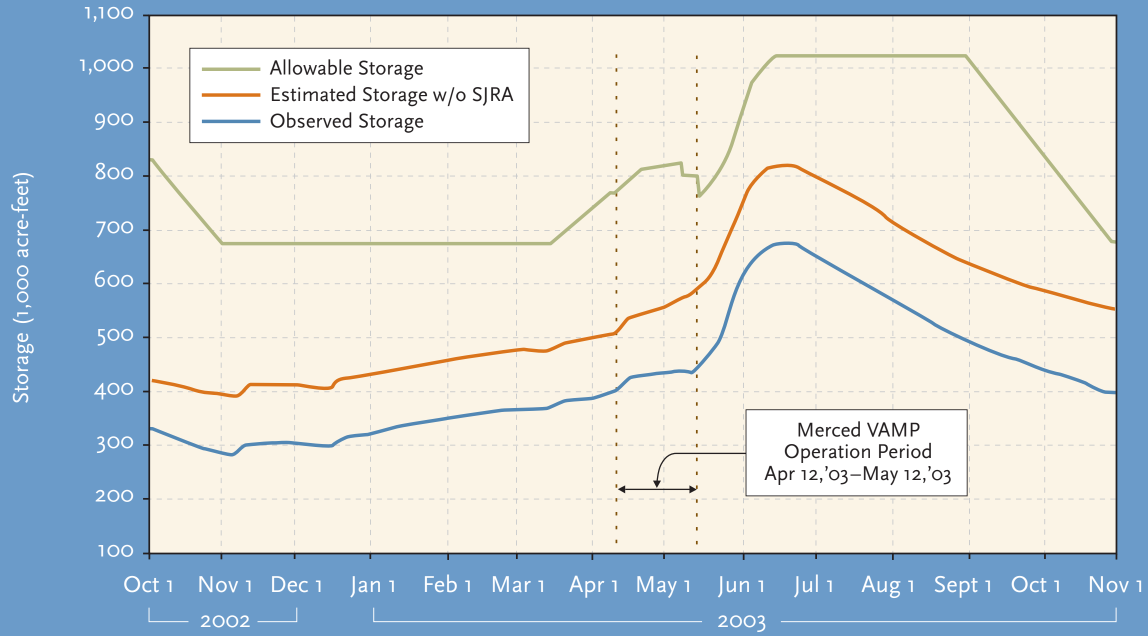


FIGURE 2–7

SJRA storage impacts—New Don Pedro Reservoir (Tuolumne River).
October 2002 through November 2003.

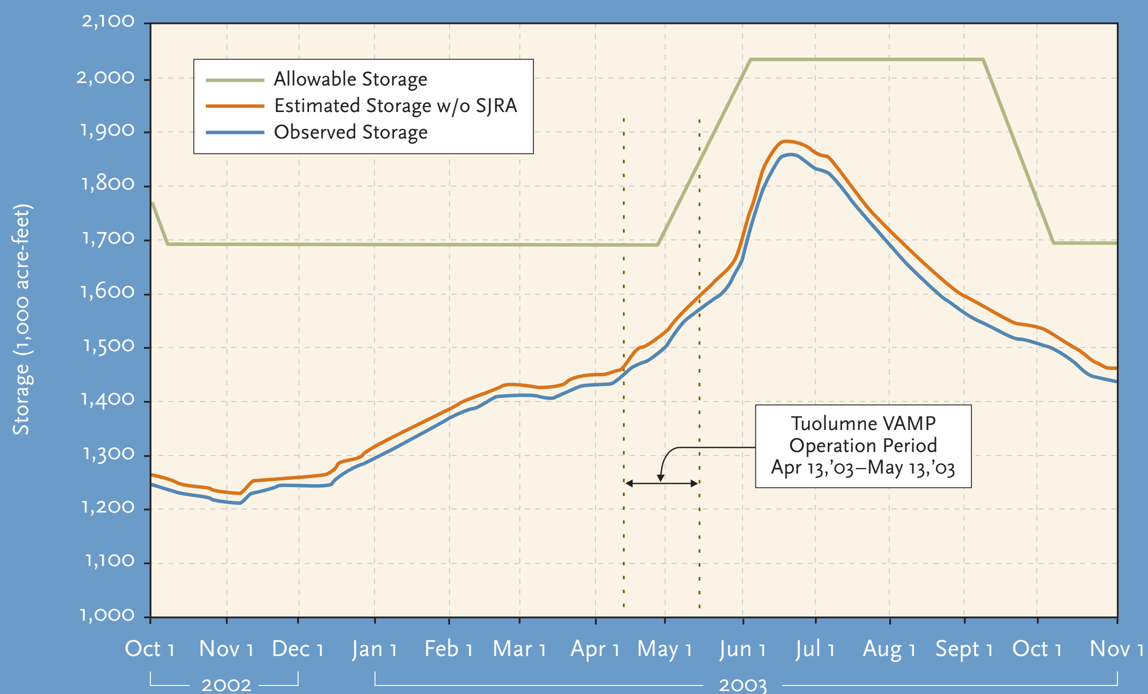


TABLE 2–8
Storage Impact History, Lake McClure (Merced River)

Year	VAMP Supplemental Water (acre-feet)[a]	Fall Supplemental Water (acre-feet)	SJRA Storage Impact Replenishment (acre-feet)	Cumulative Storage Impact (acre-feet)
1998	0	0	0	0
1999	85,339	11,998	48,025 (Jun.–Sep. 1999) 49,312 (Jan.–Feb. 2000)	0
2000	46,750	12,500	46,750 (May 2000)	-12,500
2001	43,146	12,496	0	-68,142
2002	27,120	12,470	0	-107,732
2003	39,586	12,500[b]		-147,318[c]

[a] Includes ramping flows [b] Scheduled as of Sep.30, 2003 [c] As of Sep. 30, 2003

TABLE 2–9
Storage Impact History, New Don Pedro Reservoir (Tuolumne River)

Year	VAMP Supplemental Water (acre-feet)	SJRA Storage Impact Replenishment (acre-feet)	Cumulative Storage Impact (acre-feet)
1998	0	0	0
1999	54,268	54,268 (Feb. 2000)	0
2000	22,651	14,955 (Sep.–Oct. 2000) 7,696 (Jan.–Feb. 2001)	0
2001	14,061	0	-14,061
2002	0	0	-14,061
2003	9,729		-23,790[a]

[a] As of Sep. 30, 2003

operation period. With the 38,257 acre-feet of supplemental water provided by Merced for the 2003 VAMP operation along with 1,329 acre-feet of operational ramp-up and ramp-down water, the current impact of the SJRA on Lake McClure storage as of May 15, 2003 was 147,318 acre-feet (Table 2-8). Figure 2-6 shows Lake McClure storage for water year 2003 with and without the SJRA.

As noted in the 2002 Annual Technical Report, the storage impact in New Don Pedro Reservoir on the Tuolumne River following the 2002 VAMP operation was 14,061 acre-feet. There were no opportunities to make up for any of this impact during the winter, therefore the entire impact of 14,061 acre-feet carried over into the 2003 VAMP operation period. With the 9,729 acre-feet of supplemental water provided by Modesto I.D. and Turlock I.D. for the 2003 VAMP operation, the current impact of the SJRA on the New Don Pedro Reservoir storage is 23,790 acre-feet (Table 2-9). Figure 2-7 shows New Don Pedro Reservoir storage for water year 2003 with and without the SJRA.

The supplemental water provided by OID/SSJID is made available from their diversion entitlements; therefore there are no storage impacts in New Melones Reservoir on the Stanislaus River due to the SJRA.

CHAPTER 3

Additional Water Supply Arrangements & Deliveries

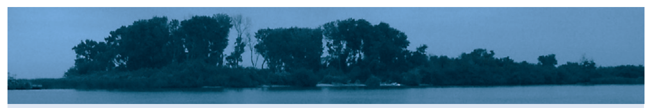
The SJRA includes a provision (Paragraph 8.4) stating that "Merced Irrigation District (Merced) shall provide, and the USBR shall purchase 12,500 acre-feet of water…during October of all years." The SJRA also states in Paragraph 8.4.4 that "Water purchased pursuant to Paragraph 8.4 may be scheduled for months other than October provided Merced, DFG and USFWS all agree." Pursuant to Paragraph 8.5 of the SJRA, "Oakdale Irrigation District (OID) shall sell 15,000 acre-feet of water to the USBR in every year of (the) Agreement…In addition to the 15,000 acre-feet, Oakdale will sell the difference between the water made available to VAMP under the SJRGA agreement and 11,000 acre-feet." This water 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 SJRA includes a provision (Paragraph 8.4) stating that "Merced Irrigation District (Merced) 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." This water is referred to as the Fall SJRA Transfer Water. The daily schedule for the Fall SJRA Transfer Water is to be developed by Department of Fish and Game (DFG), United States Fish and Wildlife Services (USFWS) and Merced ID.

The schedule for the 2003 Fall SJRA Transfer was finalized on October 1, 2003, with the transfer commencing on October 1, 2003. The schedule is provided in Appendix B, Table B-1. As with the VAMP operation, the final accounting for the Fall Transfer will be done using provisional flow data.

The 2002 Fall SJRA Transfer was in progress at the time of publication of the 2002 Annual Technical Report and therefore only preliminary data was provided in that report. The final data for the 2002 Fall SJRA Transfer are included in Appendix B, Table B-2, of this report.



The schedule for the 2003 Fall SJRA Transfer was finalized on October 1, 2003, with the transfer commencing on October 1, 2003.

OAKDALE IRRIGATION DISTRICT

Pursuant to Paragraph 8.5 of the SJRA, "Oakdale Irrigation District (OID) shall sell 15,000 acre-feet of water to the USBR in every year of (the) Agreement…In addition to the 15,000 acre-feet, Oakdale will sell the difference between the water made available to VAMP under the SJRGA agreement and 11,000 acre-feet." This water is referred to as the Difference water.

OID provided 5,039 acre-feet of supplemental water for the 2003 VAMP operation, resulting in 5,961 acre-feet of Difference water (11,000 minus 5,039). Therefore, pursuant to Paragraph 8.5 of the Agreement, OID sold a total of 20,961 acre-feet of water (15,000 plus 5,961) to the USBR in 2003.

The USBR released 6,613 acre-feet of the OID additional water in early June 2003 to support Vernalis flow objectives. The remainder of the OID additional water, 14,348 acre-feet, was released between October 19, 2003 and October 29, 2003, as shown in Table 3-1.

TABLE 3–1
USBR Release of Oakdale Irrigation District SJRA Additional Water (not including 6,613 acre-feet released in June 2003).

Date	Base Flow (cfs)	Total River Flow (cfs)	Supplemental Water (cfs)	Cumulative Supplemental Water (acre-ft)
19 Oct 03	200	227	27	54
20 Oct 03	200	917	717	1,476
21 Oct 03	200	977	777	3,017
22 Oct 03	200	979	779	4,562
23 Oct 03	200	977	777	6,103
24 Oct 03	200	976	776	7,642
25 Oct 03	200	976	776	9,181
26 Oct 03	200	979	779	10,727
27 Oct 03	200	976	776	12,266
28 Oct 03	200	976	776	13,805
29 Oct 03	200	876	676	15,146[a]

[a]14,348 acre-feet of Oakdale I.D. SJRA Additional Water was released in this period. Supplemental water in excess of this is non-SJRA water.

CHAPTER 4

Head of Old River Barrier

A key component to the VAMP design is the operation of a fish barrier at the Head of Old River. The purpose of the barrier is to prevent migrating salmon smolts from entering Old River. The Old River leads to the SWP/CVP export pumps. A study conducted by the California Department of Fish and Game investigates the entrainment of salmon smolt as part of the Old River barrier evaluation. Monitoring is performed to document juvenile Chinook salmon entrainment through the operable culverts of the HORB.

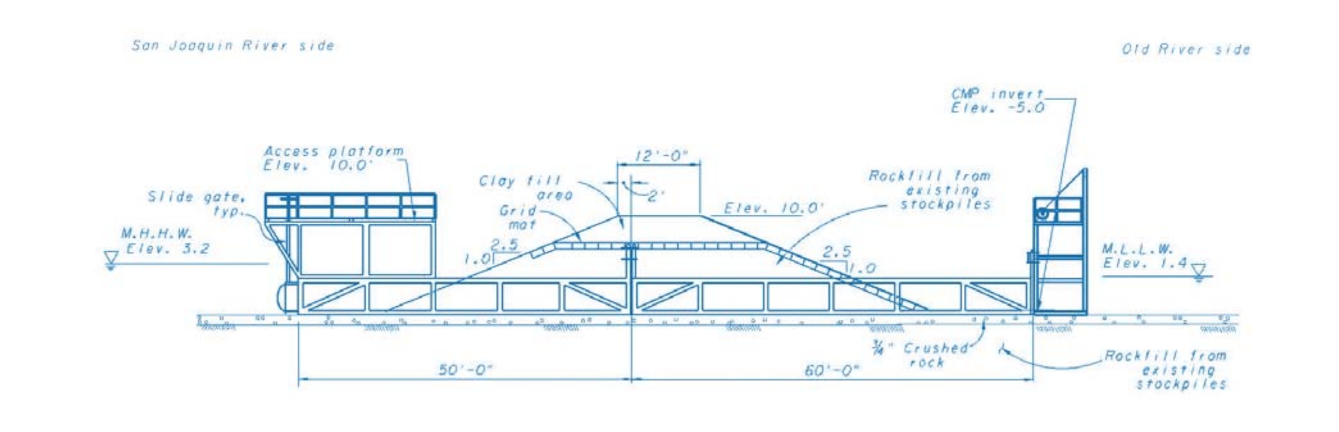
BARRIER DESIGN, INSTALLATION AND OPERATION

In early April 2003, DWR installed and operated the temporary Head of Old River Barrier (HORB). The spring HORB is a component of the south Delta Temporary Barriers Project (TBP). The TBP mitigates for low water levels in the south Delta and improves water circulation and quality for agricultural purposes. The HORB, as currently configured, is fully permitted though 2005, but must get annual landowner access approval.

The spring HORB was first constructed in 1992. Since then, the barrier has been installed in 1994, 1996, 1997 (w/two culverts), and 2000—2003 (six culverts). The HORB was not installed in 1993, 1995 and 1998 due to high San Joaquin River flows. The HORB was not installed in 1999 due to landowner access problems. The HORB, a key component of VAMP, is intended to increase San Joaquin River Chinook salmon smolt survival by preventing them from entering Old River.

The HORB was originally designed to withstand a San Joaquin River flow of about 3,000 cfs. Through the years, the design and installation of the HORB has been revised on several occasions to accommodate different needs. Beginning in 2001, the barrier design included two versions. A "low-flow" barrier, when San Joaquin River target flows are below 7,000 cfs would be built to a height of 10 feet mean sea level (MSL). A "high-flow" barrier, for target flow of 7,000 cfs, would be built to a height of 11 feet MSL and additional material would be placed to raise the abutments to 13 feet MSL. Both barrier versions are equipped with six 48-inch diameter operable culverts and an overflow weir back-filled with clay. In 2003, the low-flow version of the HORB was installed.

FIGURE 4–1
Head of Old River Barrier (HORB)



The dimensions of the 2003 HORB (Figure 4-1) were similar to the 2000, 2001 and 2002 HORB. The base width of the HORB in 2003 was 100 feet and the crest elevation was 10 feet MSL. The top of HORB was constructed with a 75-foot wide notch, protected with concrete grid mats and back-filled with clay. The HORB was designed to safely operate with flows corresponding to stages up to 8.5 feet MSL.

To help mitigate anticipated low water levels in the south Delta (downstream of the HORB) caused by the operation of the HORB, two open culverts were installed in the barrier in 1997, and six operable culverts were installed beginning in 2000. Operation of the culverts is controlled by a slide gate control structure located on the upstream side of HORB. DWR relied on daily modeling and field data collection to monitor water levels at three locations within the south Delta to determine when and how long to operate the culverts. Generally, the model would forecast lower low-low water levels lower than actual levels observed in the field. Consequently, DWR would make decisions regarding the culvert operations that would take this into consideration.

The downstream outlet of each culvert was designed so fyke nets could be attached to evaluate fish entrainment. DFG staff conducted a fishery-monitoring program as part of the 2003 HORB operations.

Permitting and Construction

The various permit conditions that are placed on the Temporary Barriers Program, by the USFWS, National Marine Fisheries Service (NOAA Fisheries), and DFG, require that the spring in-water construction activities begin no earlier than April 7 on the Head of Old River (HOR), Middle River (MR), and Old River at Tracy (ORT) barriers. In addition, construction of the northern abutment and boat ramps of the Grant Line Canal (GLC) barrier and construction of out-of-water portions of the HORB, MR, and ORT barriers may not be started any earlier than April 1. Full closure of the GLC barrier is not required but construction of the north abutment and boat ramps must be completed to the extent that full barrier closure and operation can be readily achieved in a reasonable time frame, if and when directed by DWR. The permit conditions also require that all the above work be completed by April 15th, a total of 15 working days. The various permit conditions are as follows:

A key component to the VAMP design is the operation of a fish barrier at the Head of Old River. The purpose of the barrier is to prevent migrating salmon smolts from entering Old River.

USFWS Biological Opinion

1) The spring HORB barrier installation may begin on April 1 but in-water work shall not occur until April 7, except for construction necessary to place the scour pad and the pad for the culverts;
2) DWR may begin construction of the Middle River barrier on April 1 but in-water work shall not occur until after April 7;
3) DWR may begin construction of the Old River at Tracy barrier on April 1 but in-water work shall not commence before April 7;
4) DWR may begin construction of the northern abutment and the boat ramp of the GLC barrier on April 1 provided that the HORB barrier is being constructed concurrently.

NOAA Fisheries Biological Opinion

1) The spring HORB installation shall begin on April 1;
2) The Middle River barrier construction may begin on April 7;
3) The Old River at Tracy barrier construction may begin on April 1;
4) The northern abutment and boat ramp of the GLC barrier may begin construction on April 1 provided that the HORB is being constructed concurrently.

DFG 1601—HORB

1) HORB Spring Installation—All work in or near the stream zone will be confined to the period beginning no earlier than April.
2) DFG 1601—Agricultural Barriers

   MR—All work in or near the stream zone will be confined to the period beginning no earlier than March 1.

   ORT—All work in or near the stream zone will be confined to the period beginning no earlier than April 1.

   GLC—All work in or near the stream zone will be confined to the period beginning no earlier than April 1.

In addition to the above conditions, water users of the South Delta Water Agency (SDWA) and the fisheries agencies impose separate mitigation requirements on DWR for installation and operation of the HORB by itself. As a result, DWR's contractor must sequentially close and start operation of the MR and ORT barriers, and complete as much construction of north abutment and boat ramps on the GLC barrier as possible, before they can close and operate the HORB.

From the contractors point of view there are really two milestones that must be completed in sequence. First and foremost is to obtain closure and operation of the barriers in accordance with the conditions imposed by the project permits/biological opinions and mitigation requirements. The second is to satisfy DWR's contract specifications. The first milestone can be achieved within the required 15 working days but it is unlikely that the contractor can complete the entire amount of work required to satisfy DWR's contract specifications within the same time period. Therefore, the contractor's construction activities consist of placing enough materials to make sure they obtain closure and operation by April 15th, then following closure they continue placing barrier material above the water line until barrier construction is completed in accordance with DWR's contract specifications. The contractor then conducts site cleanup and demobilizes from the site. This is why work usually continues beyond the April 15 deadline.

The current permits allow for in-water work to begin April 1 with barrier closure no earlier than April 15th. Once the HORB is closed, typically on April 15, construction crews remain on site to install a clay plug, lay down concrete mats, put up fencing and lighting and perform general site clean-up. Post barrier closure work can take up to a week to complete.

The Department of Fish and Game (DFG), who monitors fish entrainment through the barrier culverts, does not begin sampling efforts (for safety reasons) until the crews have finished their work and moved heavy equipment out of the area. A delay in beginning sampling at the barrier, in turn, delays VAMP releases of salmon smolts. Knowing how many smolts are entrained at the barrier is important in interpreting the survival data from VAMP tagged salmon. VAMP usually conducts two sets of releases. Optimally, salmon releases would occur a week apart to measure survival under replicate conditions. Delaying releases can result in increased river temperatures for the latter replicate, making it difficult to have similar water temperature conditions for the two sets of releases.

Numerous discussions with DWR, NOAA Fisheries, USFWS, and DFG biologists explored every aspect of HORB installation, timing, and fishery concerns. Construction and complete closure of HORB takes two weeks, not including site clean-up. Concurrent installation of Old River at Tracy, Middle River and Grant Line Canal barriers requires substantial effort because the Middle River and Old River at Tracy barriers must be available along with the HORB to protect water levels downstream.

In February of 2003, the VAMP technical committee wanted to explore the possibility of changing the Head of Old river Barrier operating permits to allow flexibility on a year-to-year basis to install and operate the barrier prior to April 15th. At this time, changing the permits to allow for early construction of the HORB is not feasible. The following are constraints to closure and operating the HORB prior to April 15th:

(1) The DFG and USFWS will not allow in-water work to begin any earlier than April 1 due to Delta smelt concerns. When the HORB is closed and the State Water Project and Central Valley Project are pumping at rates higher than the San Joaquin River flows, reverse flows occur in the central Delta. During reverse flows, Delta smelt that have migrated upriver may have increased vulnerability to entrainment in the south Delta. Conditions may be better for Delta smelt that spawn in early spring when barrier closure is delayed.

(2) With an experienced construction crew, the HORB takes two weeks to close. If the culverts were to be semi-permanently installed, the barrier could be constructed in approximately a week. The current HORB permits allow for the culverts to be semi-permanently installed, however, there are difficulties in accomplishing this. Entry permits for the south side of the river are difficult to obtain and are granted for a limited period of time each year, and the culverts would partially protrude into the river. DWR would have to cut into the bank and dredge the river and mitigation would be costly.

(3) If the HORB were to be installed early, the three agricultural barriers would also have to be installed early. The South Delta Water Agency would have to be involved to renegotiate the terms of barrier operations on a yearly basis.

Optimally, salmon releases would occur a week apart to measure survival under replicate conditions. Delaying releases can result in increased river temperatures for the latter replicate, making it difficult to have similar water temperature conditions for the two sets of releases.

Barrier Operations and Monitoring Plan

A barrier operations and monitoring plan was developed based on forecasting and monitoring of tidal conditions. DWR determined the number of culverts to be opened at the HORB so that water levels at Old River near Tracy Road Bridge and Grant Line above Doughty Cut would remain above 0.0 feet MSL and Middle River near Howard Road above 0.3 feet MSL. Based on modeling results and field monitoring of water levels in the south delta, three of the six culvert slide gates remained open during the VAMP target flow period.

Flow Measurement At and Around Barrier

This year DWR installed a Doppler "Argonaut" flow measuring device inside culvert #4. Data was recorded every 15 minutes during the period when the HORB was in operation. Table 4-1 displays the daily average, maximum and minimum flows measured in culvert #4. The mean daily flow through the culverts varied in response to tidal and San Joaquin River flow conditions. The characteristics of the flow through the culverts are complicated in that the flow rate is influenced by many variables, including the culvert inlet geometry, slope, size, culvert roughness, and approach and tail water conditions. Since the culverts are similar in configuration and size, the total flow through the three culverts can be estimated by using three times the measured flow through culvert #4. Under this assumption the mean daily flow through the culverts during the target flow period ranged from 139 cfs to 198 cfs, with an average of 171 cfs.

In addition to the Doppler "Argonaut" in culvert #4, a fixed Acoustic Doppler Current Meter was operated approximately 840 feet downstream of the HORB. The Acoustic Doppler Current Meter records velocity measurements every 15 minutes, from

TABLE 4–1
Measured flows Through Culvert #4 of HORB

Date	Flow (cfs)		
	Average	Minimum	Maximum
4/14/03	46	32	63
4/15/03	51	33	69
4/16/03	62	13	81
4/17/03	66	47	85
4/18/03	65	44	81
4/19/03	64	45	83
4/20/03	62	42	81
4/21/03	58	11	79
4/22/03	60	13	83
4/23/03	60	13	79
4/24/03	56	12	78
4/25/03	59	20	75
4/26/03	59	12	76
4/27/03	59	10	77
4/28/03	55	12	72
4/29/03	57	12	73
4/30/03	58	11	74
5/1/03	56	11	75
5/2/03	56	8	76
5/3/03	54	14	72
5/4/03	56	9	77
5/5/03	59	13	77
5/6/03	56	12	78
5/7/03	53	8	73
5/8/03	52	12	72
5/9/03	57	15	78
5/10/03	57	10	75
5/11/03	57	12	77
5/12/03	57	7	77
5/13/03	57	7	73
5/14/03	54	37	71
5/15/03	53	37	68
5/16/03	51	32	68

TABLE 4–2
Flow in San Joaquin River and Old River Downstream of the HORB – 2003 (values in CFS)

Date	San Joaquin River near Vernalis (1)	Old River at Head (2)	San Joaquin River below Old River (3)	Through HORB Culverts (4)	Estimated HORB Seepage (5)	Date	San Joaquin River near Vernalis (1)	Old River at Head (2)	San Joaquin River below Old River (3)	Through HORB Culverts (4)	Estimated HORB Seepage (5)
4/01/03	1,950	1,017	933			5/01/03	3,280	258	3,022	168	90
4/02/03	2,010	820	1,190			5/02/03	3,260	189	3,071	168	21
4/03/03	2,050	846	1,204			5/03/03	3,330	192	3,138	162	30
4/04/03	2,030	838	1,192			5/04/03	3,489	326	3,163	168	158
4/05/03	2,080	862	1,218			5/05/03	3,459	341	3,118	177	164
4/06/03	2,010	832	1,178			5/06/03	3,320	354	2,966	168	186
4/07/03	2,050	709	1,341			5/07/03	3,210	325	2,885	159	166
4/08/03	1,970	649	1,321			5/08/03	3,240	388	2,852	156	232
4/09/03	1,920	507	1,413			5/09/03	3,290	360	2,930	171	189
4/10/03	1,850	617	1,233			5/10/03	3,270	334	2,936	171	163
4/11/03	1,880	368	1,512			5/11/03	3,370	305	3,065	171	134
4/12/03	1,970	262	1,708			5/12/03	3,360	316	3,044	171	145
4/13/03	2,260	379	1,881			5/13/03	3,190	359	2,831	171	188
4/14/03	2,600	415	2,185	138	277	5/14/03	2,829	434	2,395	162	272
4/15/03	2,839	354	2,485	153	201	5/15/03	2,600	389	2,211	159	230
4/16/03	3,000	388	2,612	186	202	5/16/03	2,430	372	2,058	153	219
4/17/03	3,090	467	2,623	198	269	5/17/03	2,270	385	1,885		
4/18/03	3,160	427	2,733	195	232	5/18/03	2,210	373	1,837		
4/19/03	3,180	469	2,711	192	277	5/19/03	2,290	661	1,629		
4/20/03	3,350	459	2,891	186	273	5/20/03	2,160	462	1,698		
4/21/03	3,469	409	3,060	174	235	5/21/03	2,020	432	1,588		
4/22/03	3,390	280	3,110	180	100	5/22/03	2,010	500	1,510		
4/23/03	3,300	291	3,009	180	111	5/23/03	1,960	603	1,357		
4/24/03	3,050	207	2,843	168	39	5/24/03	1,940	721	1,219		
4/25/03	3,070	179	2,891	177	2	5/25/03	1,950	756	1,194		
4/26/03	3,200	270	2,930	177	93	5/26/03	2,020	675	1,345		
4/27/03	3,240	284	2,956	177	107	5/27/03	1,900	613	1,287		
4/28/03	3,320	218	3,102	165	53	5/28/03	1,810	663	1,147		
4/29/03	3,420	285	3,135	171	114	5/29/03	1,890	822	1,068		
4/30/03	3,320	322	2,998	174	148	5/30/03	2,000	945	1,055		
						5/31/03	2,020	906	1,114		

VAMP target flow period highlighted

(1) USGS provisional data as of 11/6/2003
(2) DWR Acoustic Doppler Current Meter located 840 ft. downstream of HORB
(3) (1) – (2)
(4) Three times the measured flow in HORB Culvert #4.
(5) (2) – (4)

which the flow is calculated using the known cross-sectional area of the channel as a function of the stage elevation at that location. The mean daily flow measured in Old River during the target flow period ranged from 179 to 469 cubic feet per second as shown in Table 4-2 and Appendix A-4.

Hydraulic modeling of the San Joaquin River between Vernalis and Old River[1] shows that the tidal effects on flow at the Head of Old River are insignificant when mean daily flows are used, and that the mean daily flow in the San Joaquin River near Vernalis is essentially the same as the mean daily flow in the San Joaquin River at Old River. Therefore the mean daily flow in the San Joaquin River downstream of Old River can be estimated as the difference between the mean daily flow near Vernalis and the mean daily flow measured by the Acoustic Doppler in Old River downstream of the HORB. The difference between the Old River flow and the flow through the culverts is representative of the seepage through the HORB. The flows at and around the HORB are summarized in Table 4-2.

The Department also installed a stage monitoring station on the San Joaquin River approximately 1000 feet downstream of the confluence with Old River. At this station, they installed an acoustical fixed Doppler as well as a satellite transmission devices required to post the data on the website. At this time, the Department is in the process of calibrating this station by establishing a stage-flow relationship. The station is expected to be fully operational and transmitting flow data by February 2004. Currently the mean daily flow in the San Joaquin River can be estimated as the mean daily flow at Vernalis minus the mean daily flow measured by the Acoustic Doppler in Old River.

Barrier Emergency Response Plan

In addition to the operations and monitoring plan, DWR has also prepared an "Emergency Operations Plan for the Spring HORB". The plan provided that if the daily measured or forecasted flow at Vernalis exceeded a flow that would correspond to stage at the HORB of 10.0 feet MSL, and the stage was likely to exceed 11.0 feet MSL (the height of the barrier under the "high-flow" target), the barrier would be removed. Vernalis flows and stages at the barrier were not high enough in 2003 to warrant action under the emergency operations plan.

Levee Seepage Monitoring

A seepage-monitoring program on adjacent lands was initiated in April 2000 and continued this year, to evaluate the effects of HORB operations on seepage and groundwater on Upper Roberts Island.

Three seepage monitoring well sites were chosen in 2000 on Upper Roberts Island. Each site has two shallow wells, positioned 10 feet and 100 feet from the toe of the levee to monitor the seepage gradient to and from the San Joaquin River. In addition, a deeper well was drilled at Site 1 (near the Head of Old River) to determine vertical gradients.

In addition to the groundwater monitoring wells, a temporary gage was installed in April 2000 to record water surface elevations in the San Joaquin River, about 1,500 feet downstream of the HORB. Installation of a permanent tide gage was completed in early 2002. Flow data will be generated as staff resources permit. The water surface elevations in the San Joaquin River are compared to groundwater levels on Upper Roberts Island to determine how groundwater levels change relative to changing water level conditions in the river.

As reported in the 2002 VAMP Technical Report DWR produced a seepage report for the 2001—2002 period. DWR will be releasing the latest annual (2002—2003) report in late 2003 once the current data analysis is completed. Based on the 2000 and 2001 data it is apparent that the San Joaquin River stage influences groundwater levels on Upper Roberts Island. When stage increases in the river, groundwater levels will rise toward the land surface, but not as rapidly as the river stage rises. However, over the monitoring period, river stage did not reach levels sufficient to raise groundwater levels to the point where seepage into crop root zones might occur.

Given the results of the seepage monitoring since April 2000, DWR staff expects that if a VAMP target flow of 7,000 was implemented, stages near the HORB would rise to about $7\frac{1}{2}$ to 8 feet MSL. This would translate to groundwater levels in the monitoring well closest to the levee of about $6\frac{1}{2}$ to 7 feet MSL. Because the ground surface elevation is 13 feet MSL near site 1, DWR concludes that seepage should not impact the root zone of crops that could be planted in this area.

The monitoring program will be continued in order to gather more data, particularly during high flow periods in the spring.

Fishery Monitoring At The Head Of Old River Barrier

During the VAMP 2003 test period, all six culverts in the Head of Old River Barrier (HORB) were installed; however, only three of the culverts were open. The six culverts are installed to maintain water quality and water levels in the south Delta downstream of the HORB. Since the culverts are not screened, juvenile

1 UNET (one-dimensional unsteady flow computer model) analysis of lower San Joaquin River by MBK Engineers.

Chinook salmon and other fish species that pass near the culverts are vulnerable to entrainment. An entrainment monitoring study was designed and implemented by the DFG to evaluate and quantify fish entrainment at the HORB. The specific objectives of the 2003 fishery investigations were:

- Determine the total number of juvenile Chinook salmon and other fish species entrained through the culverts at the HORB (Entrainment Monitoring);
- Determine the percentage of coded-wire tagged (CWT) salmon released at Mossdale and Durham Ferry entrained into Old River (Entrainment Monitoring); and
- Determine tidal and diel effects on juvenile Chinook salmon entrainment (Entrainment Special Study).

Results of these fishery investigations are intended, in part, to provide information on the design and operation of a future permanent operable barrier at the head of Old River.

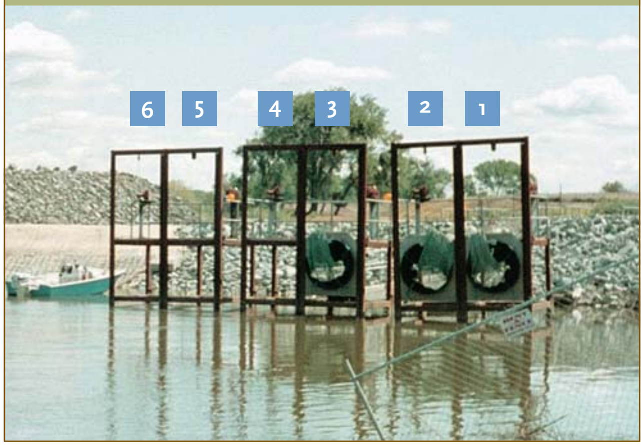
MATERIALS AND METHODS

As part of the VAMP 2003 studies, approximately 75,000 VAMP CWT salmon were released at Durham Ferry on April 21 and approximately 50,000 CWT salmon were released at Mossdale on April 22. The Mossdale release was split in half with 25,000 CWT salmon released around noon and a second group of 25,000 CWT salmon released at 6 pm. The same size releases were repeated on April 28 and 29 at Durham Ferry and Mossdale, respectively. Salmon from the VAMP releases were used in the Entrainment Monitoring studies. For the Entrainment Special Study, 8 uniquely color-marked groups of juvenile Chinook salmon (approximately 3,000 fish per group) were marked with photonic fluorescent microspheres at the Merced River Hatchery. The salmon were transported to the HORB and placed in live cages where they were held at least 10 hours before release. Each color-marked group was released approximately one mile upstream of the HORB, in the middle of the San Joaquin River. The color-marked releases coincided with the two VAMP salmon releases. On the night of April 22, one group was released on the ebb tide and one group on the flood tide. The following day, a group was released on the subsequent ebb and flood tides. The process was repeated on April 29.

Fish entrained into the culverts were caught with fyke nets. The nets have a 48 inch cylindrical mouth tapering down to a 1-foot square cod-end, are made of 1/4 inch braided mesh, and are 60 feet long. A live-box (15.5 x 19.5 x 36 inches), constructed of perforated aluminum sheet metal, was attached to the cod-end of each net. Each live-box has an aluminum baffle designed to reduce water velocities within the live-box and improve survival of captured fish. The fyke nets were attached to the culvert flanges on April 17. The culverts were numbered 1 through 6 with number 1 located next to the shoreline and number 6 located mid-channel (Figure 4-2). The nets were attached to culvert number 4, 5 and 6. They were attached to the culverts by closing the culvert slide gates on the upstream side of the barrier, raising the flanges that slide over the culvert outfalls, and then strapping the nets over the flanges. On April 21, the flanges, with the attached fyke nets, were lowered down to the culvert outfalls and the live-boxes were attached to the cod-end of the nets to commence sampling.

FIGURE 4–2

Culverts in the HORB. Culverts 1-3 were closed in 2003.



The fyke nets were checked on every tide change until May 10. From May 10 through May 12, the nets were checked at 04:00, 08:00, 18:00 and 22:00 hours. On May 13, the nets were removed. The nets were checked by closing the culvert slide gate for about 30 minutes which enabled the live-boxes to be pulled onto a boat so that the fish could be removed and placed into buckets. Once all the nets had been checked and reset, the collected fish were processed. The fish were speciated and counted. Fork lengths (mm) were recorded for up to 50 salmon per live-box. Salmon were checked for a clipped adipose fin and for the presence of a color mark on the dorsal, anal, or caudal fin. Salmon that had a clipped adipose fin were saved for CWT processing. The color and location of the dyed fin was noted for each color-marked salmon. Culvert number, date, time, water temperature, tidal stage, and diel-period were

FIGURE 4–3

Daily average number of salmon entrained per hour at the HORB in 2003. The total catch is divided into CWT and unmarked salmon.

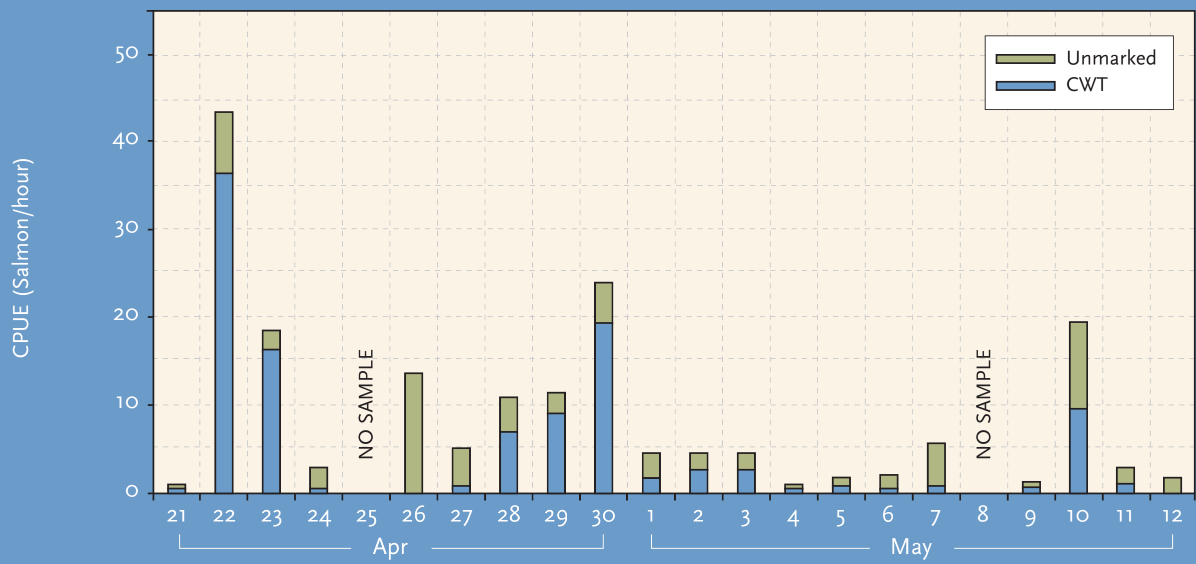
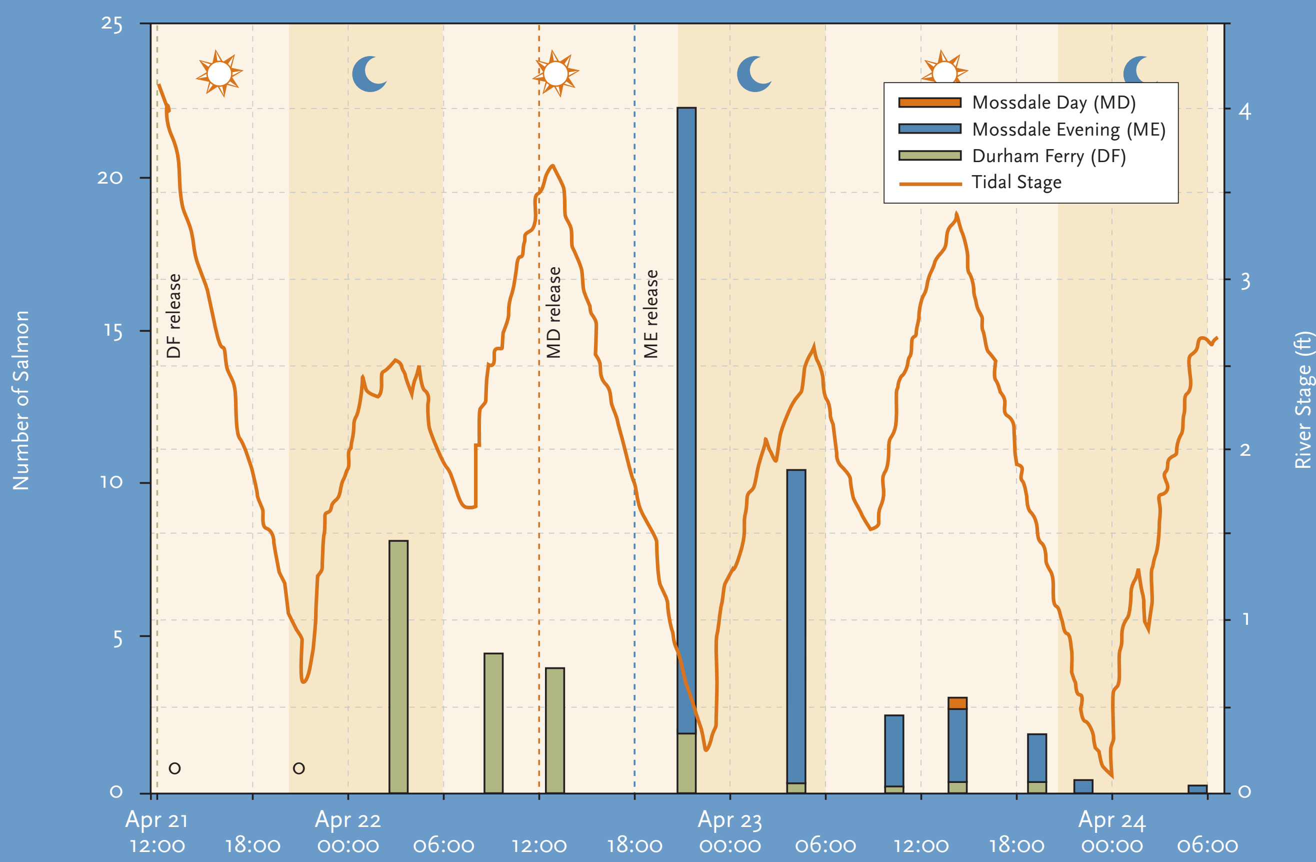


FIGURE 4–4

The average number of salmon per hour entrained at the HORB, by tidal stage, for the first VAMP salmon release. Salmon release times are marked by dashed lines. River stage for Old River is indicated by solid line.



recorded for each net check. Except for the CWT smolts, all processed fish were released downstream of the fyke nets into Old River.

Loss indices for the CWT salmon released as part of the VAMP survival studies at Durham Ferry and Mossdale were calculated based on data collected from April 21 to May 12. The loss index represents the percentage of CWT salmon entrained into the HORB culverts. The loss index (I) is calculated using the equation:

$$I = (TC / TR)$$

Where:
TC = Total number of CWT salmon collected in fyke nets, and
TR = Total number of CWT released

For the two occasions when all three nets were pulled and the culverts were still open, the number of salmon entrained was estimated by averaging the salmon entrainment the day before and after the time period the nets were pulled. Catch-Per-Unit-Effort (CPUE) for salmon was calculated as the number of fish collected per hour. The percentage of color-marked salmon recovered in the fyke nets compared to the total number released was used as an index of entrainment vulnerability at the HORB.

RESULTS

The HORB was closed on April 15; however, construction on the barrier continued for another week. The DFG monitored the HORB culverts for 22 days and collected 246 samples. The nets sampled 1,421 hours out of a possible 1,581 hours. Approximately 7,000 fish were collected representing at least 25 species from 12 families of fish. No delta smelt (Hypomesus transpacificus), 2 juvenile steelhead (Oncorhynchus mykiss), and 45 adult splittail (Pogonichthys macrolepidotus) were collected. The most abundant species was Chinook salmon, followed by white catfish (Ictalurus catus) and common carp (Cyprinus carpio) (Table 4-3). These 3 fish comprised 90% of the total entrainment. Of the 4,872 salmon caught; 2,511 had a CWT; 1,937 were unmarked; and 424 had a color-mark. Overall, the amount of salmon entrained per hour (3.4) with the 3 culverts was higher than the 6 culverts in 2003 (2.5 salmon/hour) and in 2002 (1.4 salmon/hour).

Salmon smolts were caught throughout the monitoring period (Figure 4-3). Most of the VAMP released salmon were caught within two days of their release. During the first set of VAMP salmon release, CWT salmon entrainment was the highest on the evening of April 22, especially for the Mossdale

TABLE 4–3
The raw abundance and composition of fishes entrained at the HORB in 2003. Chinook salmon catch is divided into CWT salmon, unmarked salmon, and color-marked salmon.

Species	Catch
American Shad	1
Western Mosquitofish	1
Spotted Bass	1
Warmouth Bass	1
Yellowfin Goby	1
Petromyzontidae	2
Golden Shiner	2
Prickly Sculpin	2
Steelhead	**2**
Black Crappie	4
Tule Perch	4
Largemouth Bass	5
Bigscale Logperch	6
Striped Bass	7
Green Sunfish	9
Ameiurus Spp.	12
Inland Silverside	13
Redear Sunfish	13
Bluegill	37
Splittail	**45**
Goldfish	58
Sacramento Sucker	65
Channel Catfish	161
Threadfin Shad	273
Common Carp	383
White Catfish	1,170
Total Chinook Salmon	**4,872**
CWT VAMP Salmon	1,819
CWT NonVAMP Salmon	692
Unmarked Salmon	1,937
Color-Marked Chinook Salmon	308
TOTAL	**7,150**

evening released fish (Figure 4-4). For the set of second VAMP release, the highest salmon entrainment occurred during the night of April 29 (Figure 4-5). The loss indices for the first Durham Ferry and Mossdale releases were 0.5% and 1.6%, respectively. The loss indices for the second Durham Ferry and Mossdale releases were 0.3% and 0.8%, respectively. Within the Mossdale releases, the highest loss indices were for the releases that occurred in the evening: 3.1% for the first release and 1.5% for the second release. Both of the day releases at Mossdale had a loss index of 0.1%. The overall loss index for VAMP CWT salmon was 0.7%. This year's overall loss index was lower than in 2002 (1.5%) but similar to 2001 (0.5%) and 2000 (0.8%) loss indices.

For the entire monitoring duration, the mean ±SD CPUE for VAMP salmon per culvert was 1.1 ± 3.3 fish/hour. The highest CPUEs occurred soon after the VAMP releases, with a maximum CPUE of 25.1 fish/hour on April 22. The mean unmarked smolt CPUE (1.2 ± 2.2) was similar to the VAMP CPUE. The highest unmarked CPUE (12.2) occurred April 27. VAMP mean salmon CPUE was similar between the flood (1.3 ± 4.0) and ebb (1.2 ± 3.0) tides, and slightly higher at night (1.2 ± 3.0) than during the day (0.8 ± 3.2). Unmarked mean CPUE was similar between the flood (1.1 ± 2.2) and ebb (1.3 ± 2.2) tides, and higher at night (2.6 ± 2.8) than during the day (0.5 ± 0.4).

To address tidal and diel effects, color-marked smolts were released on various tidal and diel period combinations. The first releases went well; however, like last year, some problems were encountered during the second release when an unknown number of smolts escaped from the holding pens before their intended release. Although some salmon escaped, entrainment rates were higher for the second releases (1.7%) than the first releases (0.8%) (Table 4-4). The overall color-marked salmon entrainment rate was 1.3%. More smolts were caught at night than during the day, and more smolts were entrained during the flood than the ebb tide.

Culvert number 4 entrained about half as many salmon as culvert numbers 5 and 6. (Figure 4-6). This is in contrast to 2002 results in which culvert number 4 entrained the most salmon and culvert number 6 the least. While the mean CPUE for unmarked fish caught at night was about 5 times greater than during the day, the total number of unmarked fish entrained was almost 11 times more during the night than during the day.In contrast to the unmarked salmon, only twice as many CWT salmon and 3.5 times as many color-marked salmon were entrained at night (Table 4-5).

TABLE 4–4
The percentage of color-marked salmon entrained for various diel and tidal stages. Due to some salmon escaping from their live-cages the number of salmon released was estimated for the second releases.

	No. Release	Diel	Tide	Entrained	Percent Recovered
First Releases (22 & 23 April)	3,005	Night	Flood	91	3.0%
	3,008	Night	Ebb	3	0.1%
	2,997	Day	Flood	1	0.0%
	3,014	Day	Ebb	6	0.2%
Total	12,024			101	0.8%
Second Releases (29 & 30 April)	3,000	Night	Flood	80	2.7%
	2,990	Night	Ebb	104	3.5%
	3,000	Day	Flood	18	0.6%
	2,980	Day	Ebb	6	0.2%
Total	11,992			208	1.7%

TABLE 4–5
The total number of CWT and Unmarked salmon caught per culvert by diel period.

		Culvert Number			
		4	5	6	Total
CWT	Day	141	407	313	861
	Night	356	569	801	1,726
Unmarked	Day	22	59	54	135
	Night	261	603	701	1,565
Color-marked	Day	16	32	20	68
	Night	27	101	112	240

No current velocity meter was used this year; however, DWR installed a flowmeter in culvert number 4. Flow data for culvert number 4 was recorded throughout the monitoring period. Simple linear regression analysis indicated CWT salmon showed no significant relationship between CPUE and flow (df=65, P=0.11, r2=0.04) and unmarked salmon showed a weak positive relationship (df=65, P<.01, r2=0.10) (Figure 4-7).

FIGURE 4–5

The average number of salmon per hour entrained at the HORB, by tidal stage, for the second VAMP salmon release. Salmon release times are marked by dashed lines. River stage for Old River is indicated by solid line.

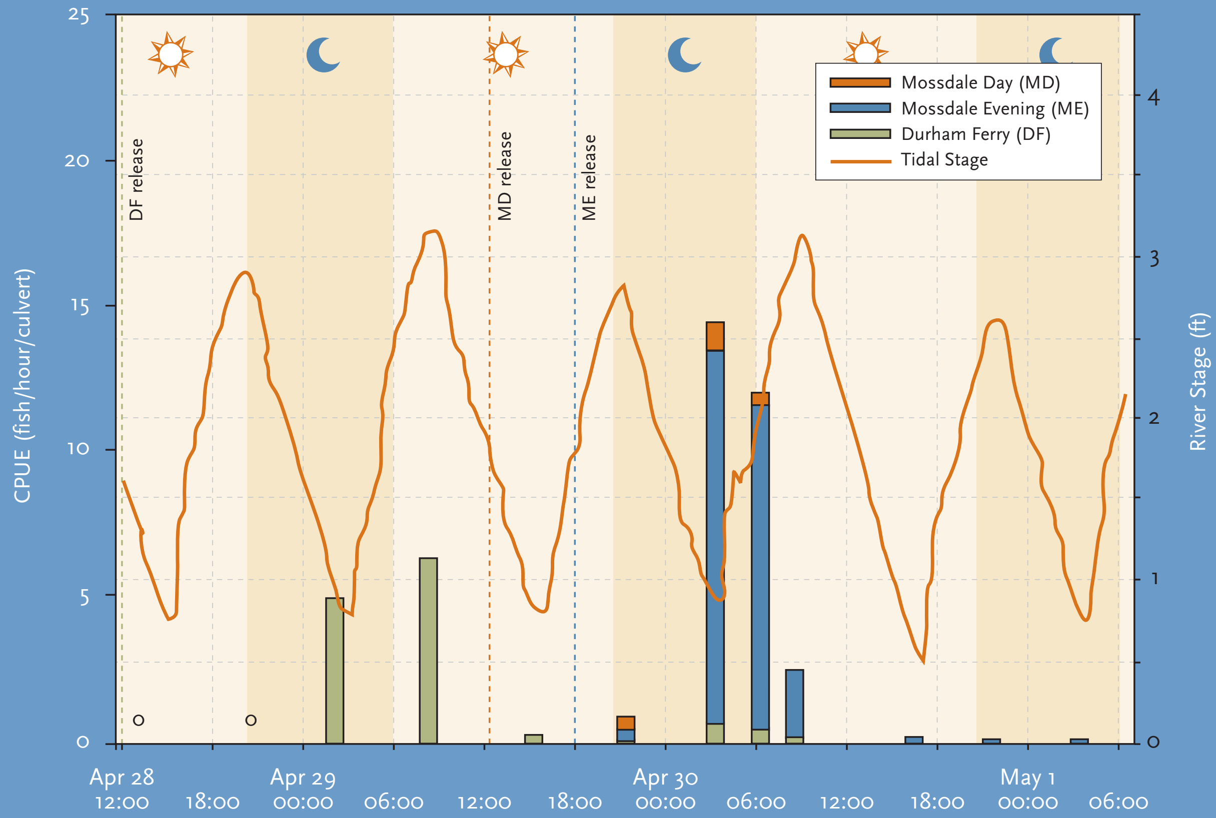


FIGURE 4–6

The total number of unmarked, color marked, and VAMP salmon caught by culvert. Culvert numbers 1–3 were closed in 2003.

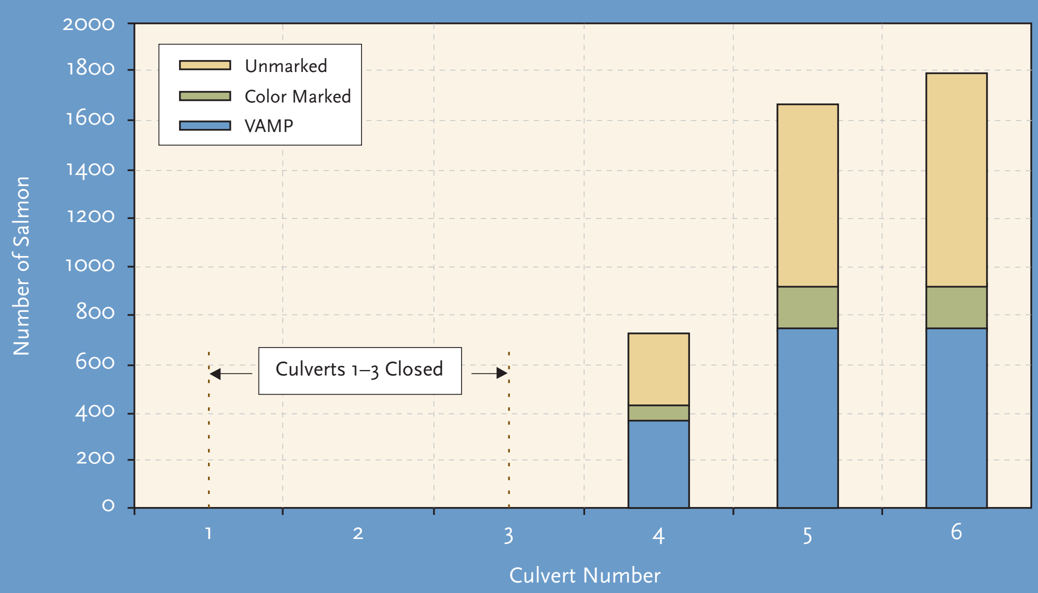
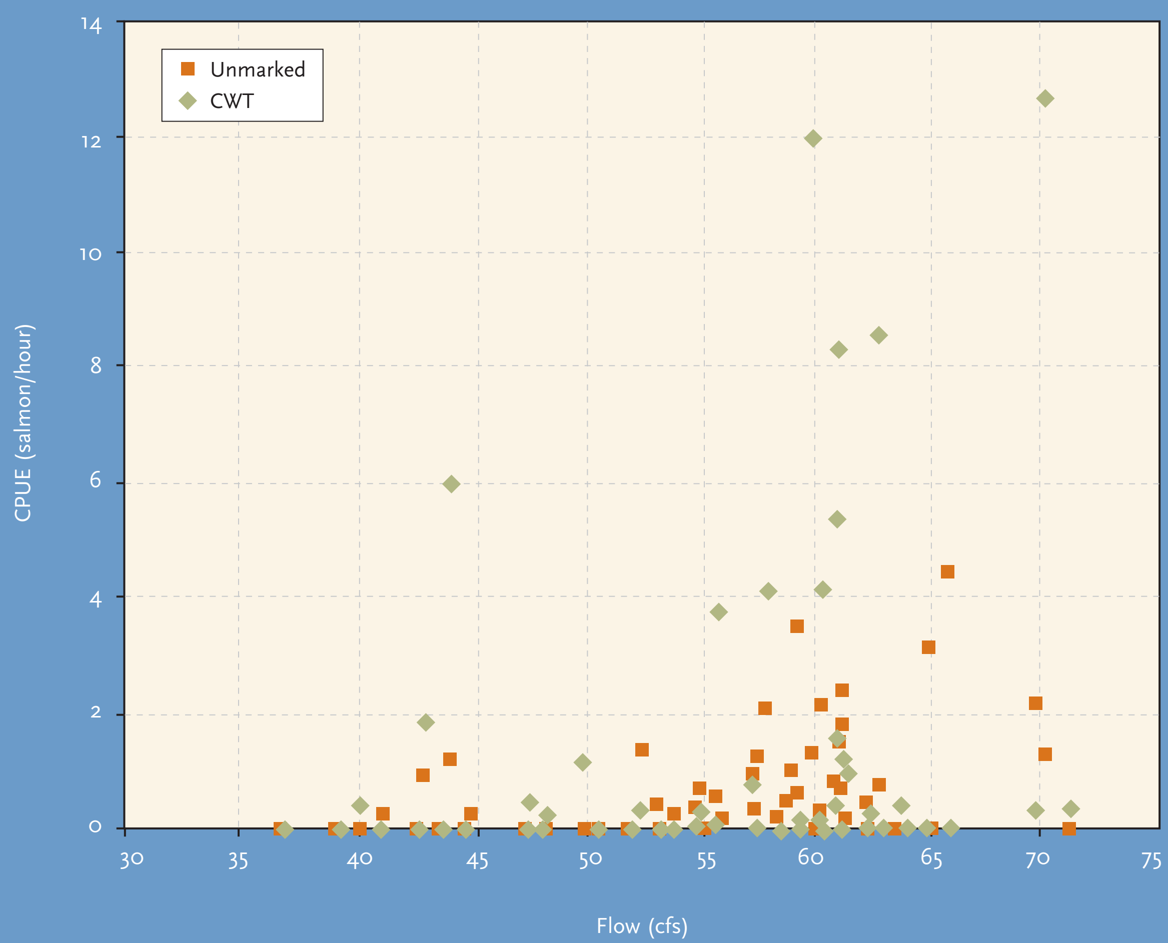


FIGURE 4–7

Relationship between salmon entrainment and flow in culvert number 4.



DISCUSSION

Although only half of the culverts were open during the VAMP experiment, some patterns in salmon entrainment were similar to previous years, e.g. higher entrainment at night, and more salmon were entrained from the first releases than the second releases. Interestingly, with fewer open culverts, the overall mean salmon entrainment rate was higher this year than in previous years. The higher entrainment rate was mostly due to the non VAMP salmon. It is possible that the salmon that would normally be entrained in the first three culverts, which were closed, were lingering around the culvert structure and some were subsequently entrained in the three open culverts. Even though the VAMP released salmon loss index was lower than in 2002, the rate at which the salmon were entrained was similar. If all six culverts were open in 2003, the estimated VAMP salmon loss index of 1.4% (estimated by multiplying the 3 culvert loss index by 2) would be similar to last year's loss index.

Tidal stage may affect salmon entrainment. Although the mean entrainment rate between the flood and ebb tides was similar, a closer look at when the salmon were released and when they first arrived at the HORB reveals that there are some tidal entrainment differences. As in previous years, more salmon were entrained from the first set of VAMP releases than the second set of releases. This difference could be due to the tides, assuming the survival rate to the HORB was the same for each of the releases. The first evening release at Mossdale resulted in the highest entrainment near dusk: 469 of the Mossdale salmon were entrained within 3.5 hours of their release.

However, seven days later, only 5 of the evening released Mossdale salmon were entrained within 3 hours of their release. The highest entrainment occurred closer to dawn: 240 salmon. After the first VAMP Mossdale release, a relatively strong ebb tide occurred during the afternoon and evening. Low slack water occurred soon after dark. The low tide caused a relatively large head difference between upstream and downstream water levels as salmon arrived at the HORB. The resulting increase in flow through the culverts, due to the head difference, probably played a role in the high entrainment of Mossdale salmon. In contrast, a week later, high slack water occurred at dusk. Consequently, there was less head difference between upstream and downstream water levels which may have contributed to the lower salmon entrainment. The following morning, when the low tide occurred, salmon entrainment increased considerably. The Mossdale evening results are similar to last year's VAMP results which suggested entrainment is affected by tidal stage near the HORB.

The results for the Mossdale evening releases were different than the day releases. More salmon were entrained from the two evening releases than for all the other VAMP releases combined. Very few of the Mossdale day released fish were caught. This is also in contrast to the previous years when the daytime released fish at Mossdale were typically entrained at a slightly higher rate (1.2%) than they were in 2003 (0.1%). The Mossdale day released salmon that were entrained followed the same pattern as the evening released fish. More salmon were entrained during the evening for the first release and more during the early morning for the second release. It is also possible the day and evening released fish are behaving differently as they move downstream. The day released fish could be migrating down the main channel as they pass the barrier. The evening released fish could be migrating closer to shore, and lower in the water column, where they are more vulnerable to entrainment. The overall higher salmon entrainment at night, than during the day, is similar to previous years' results. The higher nighttime entrainment results of VAMP salmon could be confounded by the daytime release of the salmon. Due to the timing of the VAMP release and the distance of the release sites from the HORB, a majority of the fish may pass by the barrier at night.

Diel entrainment of unmarked salmon differed from the VAMP salmon. Overall, 59% of the entrained VAMP salmon were caught at night compared to 92% of the unmarked salmon. In 2002, about 75% of both the entrained VAMP and unmarked salmon were caught at night. The proportionately higher

The results for the Mossdale evening releases were different than the day releases. More salmon were entrained from the two evening releases than for all the other VAMP releases combined. Very few of the Mossdale day released fish were caught.

entrainment of unmarked salmon at night, when compared to the VAMP salmon, suggests the VAMP released fish are not behaving the same as the unmarked fish at the HORB. However, without knowing how many unmarked salmon passed the barrier and what percent was entrained, we can only speculate whether this difference is meaningful. In contrast to the diel results, the tidal results were similar to the overall VAMP salmon tidal results. Entrainment on the flood and ebb tides was similar.

Results from the Entrainment Special Study are similar to last year's Entrainment Special Study results. More color-marked salmon were entrained on a flood tide than on an ebb tide, and more were entrained at night than during the day. Marked salmon were entrained at the highest rate during a night-flood for the first release. Very few color-marked salmon were entrained on the night-ebb, day-flood and day-ebb. During the second release, slightly more salmon were caught on the night-ebb. The reason for the low entrainment during the first release is unknown. Although only three culverts were open, the overall color-marked salmon entrainment was similar to last year (1.3% compared to 1.7%). It is possible attraction to the culvert structure, or localized current patterns caused the salmon to linger near the culverts and be entrained.

The low fish entrainment in culvert number 4 was surprising. Salmon entrainment was roughly half of the entrainment in culvert numbers 5 and 6. Debris or something could have been partially obstructing culvert number 4. The measured flows through the culvert were lower than the calculated flows. However, the lower flows in the culvert could be due to net resistance or other factors that affected all three culverts equally. We were unable to measure flows in all three culverts to see if there was a difference among culverts. If entrainment is

It is recommended that VAMP continue delaying the first salmon release by at least 5 days after the closure of the HORB. The delay allows for the completion of the barrier and minimizes the field crew's exposure to heavy equipment operation. The split releases at Mossdale should also be continued to help us better understand how tidal-diel interactions affect salmon entrainment at the HORB.

affected by the amount of flow through the culvert, then higher salmon entrainment should occur at higher flows. In culvert number 4, there was no relationship between CWT salmon entrainment and flow, and only a slight positive relationship between increasing flow and entrainment of unmarked salmon. The reduced catch of salmon in culvert number 4 relative to the other culverts suggest something might have been affecting the flow through the culvert and thus affecting the flow-entrainment relationship.

In summary, the results from the 2003 Entrainment Monitoring Study and the Entrainment Special Study suggest salmon are more vulnerable to entrainment at night. The tidal effects on entrainment are still unclear. Water velocities through the culverts are greatest on a low tide, near slack water. Salmon entrainment should be highest at this time which was somewhat evident for the Mossdale released fish. However, no significant relationship was found between CWT salmon entrainment and flow through culvert number 4. Only a weak positive relationship was found for unmarked salmon entrainment and flow in culvert number 4. The changing hydraulics surrounding the barrier as the tide changes effects flows near the culverts which may affect entrainment. Salmon smolt behavior and relative abundance near the barrier may play an important role in entrainment vulnerability.

It is recommended that VAMP continue delaying the first salmon release by at least 5 days after the closure of the HORB. The delay allows for the completion of the barrier and minimizes the field crew's exposure to heavy equipment operation. The delayed VAMP salmon releases also allows time for any loose material near the culverts to pass through the culverts before the nets are attached. In 2003, no samples were lost to gravel accumulation in the nets. The split releases at Mossdale should also be continued to help us better understand how tidal-diel interactions affect salmon entrainment at the HORB. If feasible, a release should be made at noon and midnight.

CHAPTER 5

Salmon Smolt Survival Investigations

One of the primary objectives of the VAMP program is to identify how San Joaquin River flows and SWP and CVP export rates, with the HORB in place, affect the survival of juvenile Chinook salmon emigrating from San Joaquin River system. This section describes the methods used to conduct the VAMP 2003 Chinook salmon smolt survival investigations, and presents the calculated survival indices, absolute survival estimates and combined differential recovery rates for coded-wire tagged juvenile Chinook salmon released during the VAMP 2003 test period. We also analyzed how the survival varied with flow, and flow relative to exports, with and without the HORB. Ocean recovery information on past releases and catches of unmarked juvenile salmon at Mossdale and in CVP/SWP salvage are also discussed. Additional data and information related to the salmon survival investigations are presented in Appendix C.

CODED-WIRE TAGGING

Merced River Fish Facility Chinook salmon smolts, released as part of VAMP 2003, were coded-wire tagged (CWT) between March and early April. After the salmon were tagged, they were held in the hatchery for at least 21 days before being released. Sub-samples of these salmon were measured (for fork length) and checked for retention of tags a day or two prior to release. Sub-samples were comprised of approximately 200 salmon collected from the top, middle, and bottom of the release group's raceway. Although tag detection is usually high, all salmon from the sub-samples without a detected tag were sacrificed to verify the accuracy of the CWT detection process. Sacrificed salmon were dissected to determine whether they contained a non-magnetized tag, an undetected tag, or no tag. Each CWT code within a release group was held separately at the hatchery with the exception of the two Durham Ferry releases. Each of these releases was comprised of three CWT codes that were held together at the hatchery.

At release, an additional sub-sample of 25 salmon was sacrificed from each tag group to verify CWT code, except at Durham Ferry. Fifty fish were sampled from each of the Durham Ferry releases because tag codes were combined prior to release.

Coded-wire tag retention rates were typical in 2003, ranging between 93 and 97.5% (Table 5-1). Coded-wire tag retention rates appeared higher than last year, with an overall retention rate of 94.5% for 2003 VAMP groups compared to 90.5% for 2002. Coded-wire tag retention rates were used to estimate the effective release size used in calculating survival indices (Table 5-1). The effective number released (ER) was calculated using the following equation:

$$ER = (T - M) \times TR$$

Where:

T = *estimated number transported,*

M = *number of mortalities during release and transport (includes those sacrificed as part of the net pen evaluations), and*

TR = *CWT retention rate*

CODED-WIRE TAG RELEASES

Two sets of CWT salmon releases were made as part of the 2003 VAMP experiment. The first set occurred on April 21 at Durham Ferry, April 22 at Mossdale, and April 25 at Jersey Point. The second set of releases occurred on April 28 at Durham Ferry, April 29 at Mossdale, and May 2 at Jersey Point.

For each set of releases approximately 75,000 salmon, divided among three CWT codes with approximately 25,000 fish, were released at Durham Ferry. Approximately 50,000 fish, divided between two CWT codes, were released at Mossdale. Approximately 25,000 fish with one CWT code were released at Jersey Point (Table 5-1). Prior to VAMP 2000, all CWT groups were trucked from the hatchery and released as a single group. However, since VAMP 2000, a new transport trailer with three tanks has allowed each CWT group to be transported to its

TABLE 5–1
Coded-wire tag (CWT) retention rates and estimated release numbers for juvenile chinook salmon released for VAMP 2003

Release Site	Release Date	CWT Code	CWT Retention Sample Size	CWT Retention %	Estimated Number Transported	Mortalities After Transport[1]	Estimated Number Released	Effective Number Released
Durham Ferry[2]	4/21/03	06-02-82	199	94.97	25,862	114	25,748	24,453
		06-02-83		94.97	27,414	114	27,300	25,927
		06-27-42		94.97	25,458	114	25,344	24,069
Mossdale	4/22/03	06-27-43	201	94.53	26,955	284	26,671	25,212
		06-27-48	200	93.50	26,464	292	26,172	24,471
Jersey Point	4/25/03	06-27-44	200	93.00	26,504	252	26,252	24,414
Durham Ferry[2]	4/28/03	06-27-45	200	95.00	26,121	137	25,984	24,685
		06-27-46		95.00	26,651	137	26,514	25,189
		06-27-47		95.00	26,061	137	25,924	24,628
Mossdale	4/29/03	06-27-49	189	93.12	26,028	61	25,967	24,180
		06-27-50	201	94.03	26,061	169	25,892	24,346
Jersey Point	5/2/03	06-27-51	200	97.50	26,615	264	26,351	25,692

[1] Mortalities include juvenile Chinook salmon held and later sacrificed for the net pen studies.
[2] Coded-wire tag codes were combined at the hatchery. Therefore, CWT retentions are for all three tag codes combined and mortalities were divided equally among the three tag codes.

TABLE 5–2
Release time, temperatures, fork length (FL), and effective number released for juvenile Chinook salmon released for VAMP 2003, by coded-wire tag (CWT) code.

Release Site	Date	CWT Code	Release Time	Truck Temp (°F)	Release Temp (°F)	Average FL (mm)	Effective Number Released
Durham Ferry	4/21/03	06-02-82	1245	51.8	59.0	86	24,453
		06-02-83		51.8	59.0		25,927
		06-27-42		51.8	59.0		24,069
Total							74,449
Mossdale	4/22/03	06-27-43	1200	51.8	58.6	86	25,212
		06-27-48	1800	55.4	59.9	86	24,471
Total							49,683
Jersey Point	4/25/03	06-27-44	1800	56.0	62.0	88	24,414
Durham Ferry	4/28/03	06-27-45	1215	53.0	62.0	86	24,685
		06-27-46		53.0	62.0		25,189
		06-27-47		53.0	62.0		24,628
Total							74,502
Mossdale	4/29/03	06-27-49	1245	55.0	60.0	87	24,180
		06-27-50	1800	55.0	61.0	88	24,346
Total							48,527
Jersey Point	5/02/03	06-27-51	1145	55.0	59.0	89	25,692

release site in a separate tank and released. As mentioned earlier, each Durham Ferry group consisted of three tag codes which were already mixed at the hatchery and were therefore transported in a large, single tank, release truck.

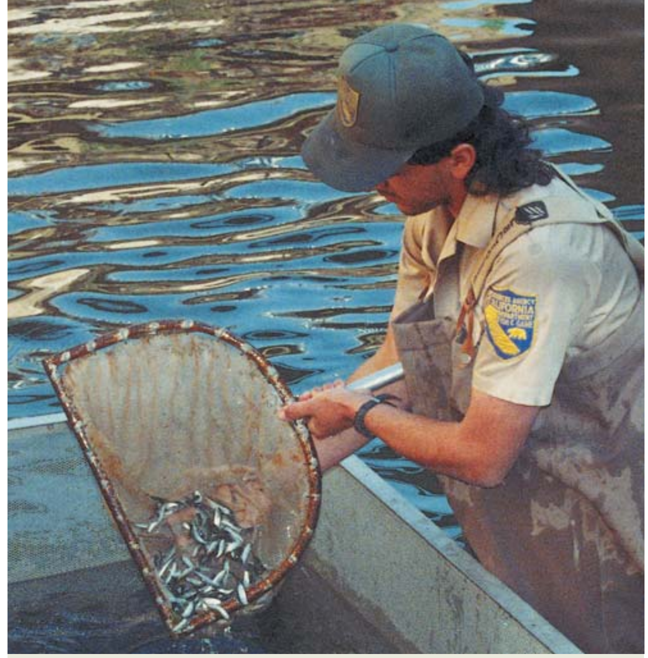
Release strategies were similar to VAMP 2002, except at Mossdale. Both Durham Ferry releases were made from the more desirable location alongside the river, instead of from the top of the levee. The nearby agricultural diversion was turned off from the time of the releases until several hours after each release to allow the tagged salmon time to disperse from the release site. Releases at Jersey Point were made one hour prior to the beginning of the flood tide to increase dispersion of the tagged fish before they passed Antioch and Chipps Island. Water temperatures in the hatchery trucks and at the release sites were measured immediately prior to release (Table 5-2). In all cases, differences between water temperatures in the transport trucks and the release site were less than 5°C (9°F). Releases at Mossdale and Durham Ferry were not made on any specific tidal condition.

Both of the Mossdale releases were divided by CWT code, into afternoon (around 1200) and evening (around 1800) releases (Table 5-2). The two tag groups were released at different times to test day and night differences in entrainment at the HORB (see Chapter 4). We also planned to test if survival differed between the two release strategies; however, low recoveries prevented evaluation of survival by release time this year. If this release strategy is continued, we may be able to test for differences in survival in the future.

WATER TEMPERATURE MONITORING

Water temperature was monitored during the VAMP 2003 study using individual computerized temperature recorders (e.g., Onset Stowaway Temperature Monitoring/Data Loggers). 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). Water temperature was recorded at 24-minute intervals throughout the period of the VAMP 2003 investigations. Water temperatures were also recorded within the hatchery raceways at the Merced River Hatchery coincident with the period when juvenile Chinook salmon were being tagged. These temperature recorders were later transported with the juvenile salmon released at Durham Ferry.

Results of water temperature monitoring within the Merced River Fish Facility showed that juvenile Chinook salmon were



Results of water temperature monitoring showed that water temperatures at the release locations and throughout the lower San Joaquin River and Delta (Appendix C-2) were higher than those at the hatchery.

reared in, and acclimated to, water temperatures of approximately 10.5°–14°C (51°–57°F) prior to release into the lower San Joaquin River (Figures 5-1 and 5-2). Results of water temperature monitoring at Durham Ferry and Mossdale following the first and second sets of VAMP 2003 releases are compared in Figures 5-3 and 5-4. No temperature data were available for Jersey Point (the recorder was lost). Results of water temperature monitoring showed that water temperatures at the release locations and throughout the lower San Joaquin River and Delta (Appendix C-2) were higher than those at the hatchery. Water temperatures measured within the lower San Joaquin River and Delta were not expected to result in mortality or adverse effects to emigrating juvenile Chinook salmon released as part of the VAMP 2003 investigations. A comparison of water temperatures measured at Durham Ferry during VAMP 2002 and VAMP 2003 (Figure 5-5a) showed that temperatures were similar during the two years. A comparison of temperatures at downstream locations showed that temperatures were generally higher during VAMP 2002 when compared to the VAMP 2003 test period (Figures 5-5b–5-5d).

WATER TEMPERATURE MONITORING RESULTS:

Water temperatures measured within the lower San Joaquin River and Delta were not expected to result in mortality or adverse effects to emigrating juvenile Chinook salmon released as part of the VAMP 2003 investigations.

FIGURE 5–1

Merced River Fish Hatchery —1.

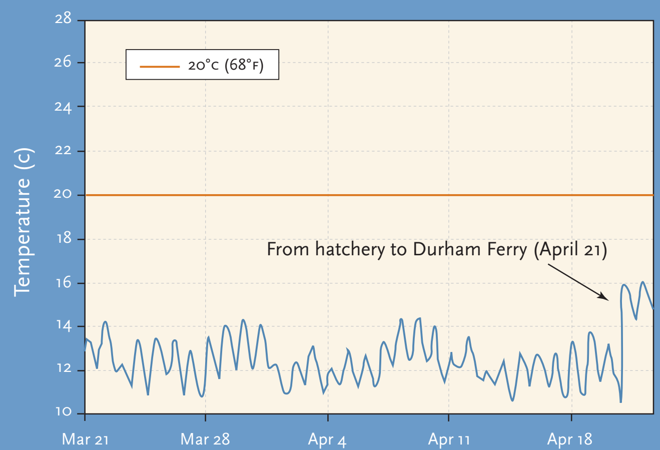


FIGURE 5–2

Merced River Fish Hatchery —2.

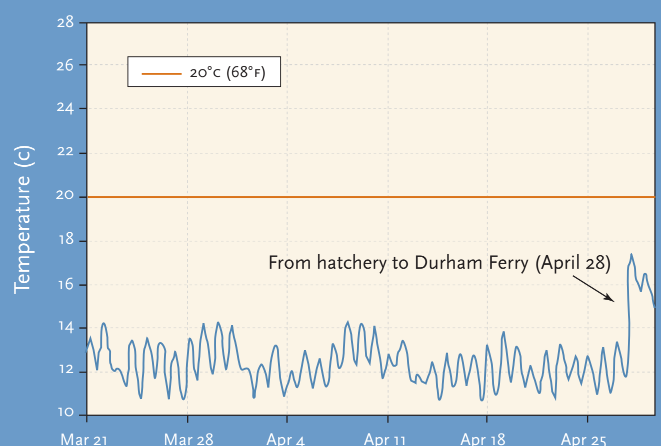


FIGURE 5–3

Site 1—Durham Ferry.

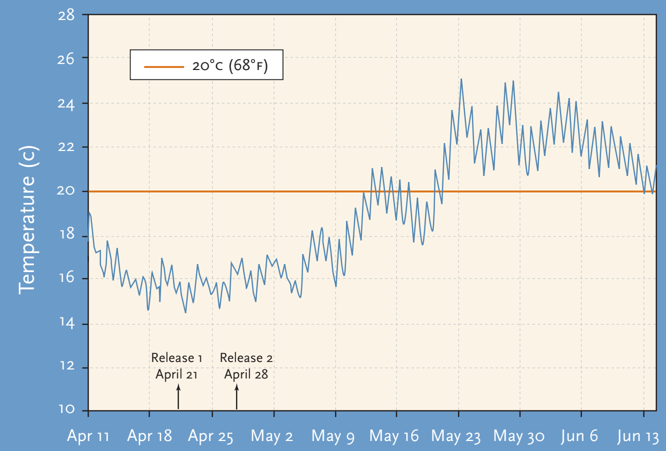


FIGURE 5–4

Site 2—Mossdale.

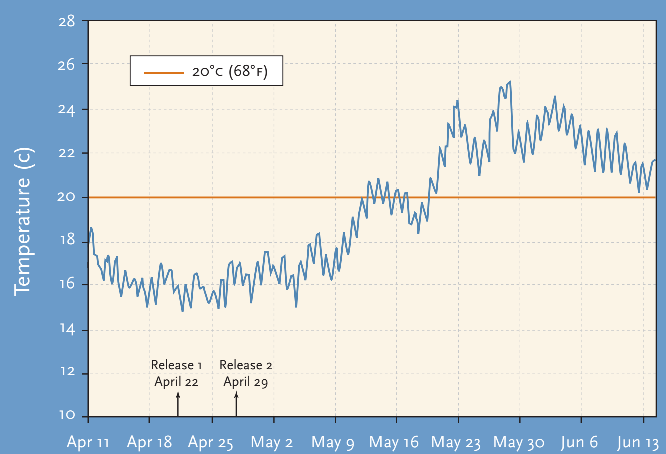


FIGURE 5–5A

Site 1—Durham Ferry.

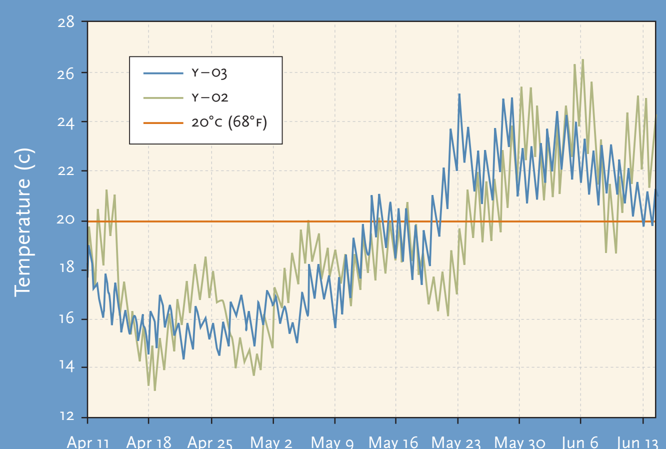


FIGURE 5–5B

Site 4—DWR Monitoring Station.

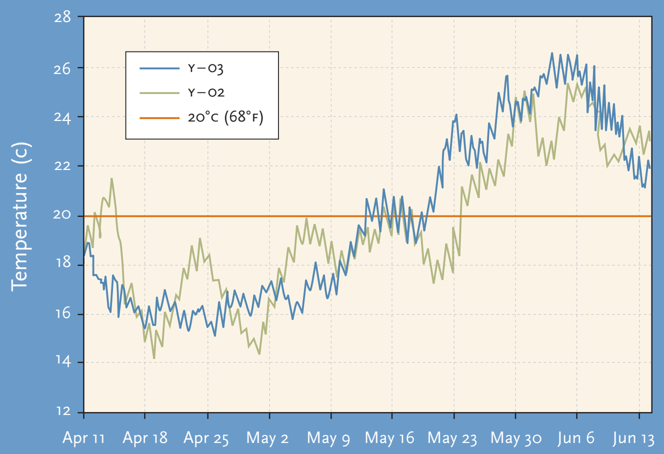


FIGURE 5–5C

Site 7—$^1/_2$ mile upstream of Channel Marker 13.

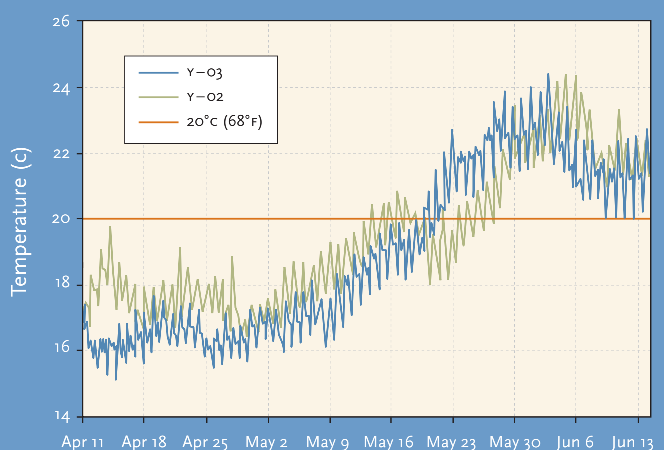
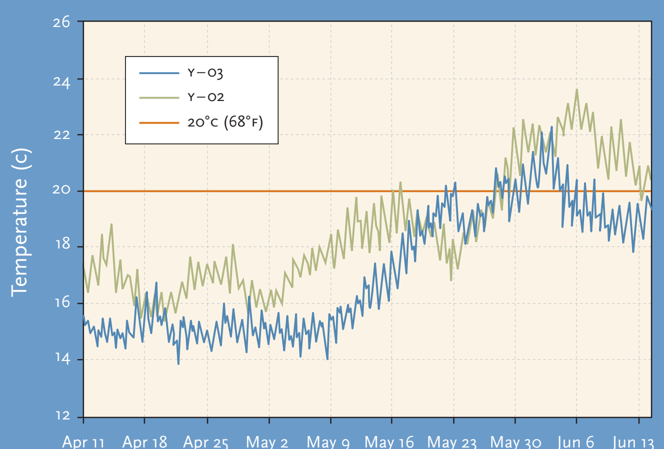


FIGURE 5–5D

Site 10—Chipps Island.



POST-RELEASE NET PEN STUDIES

Survival and Condition

Post-release survival and condition of marked salmon were evaluated as part of the VAMP program using sub-samples of marked salmon from each release group. Twenty-five salmon from each CWT group were evaluated for general condition immediately after release. To assess general condition, fork length in millimeters, weight in grams, and six other characteristics were examined (Table 5-3). Other obvious abnormalities or deformities were also noted. To assess short-term effects of handling, transport, and release, an additional sub-sample of approximately 200 salmon from each tag code were held at the respective release sites for 48 hours. Of these, 25 were measured, weighed, and examined for the six general condition characteristics. The remaining fish were measured, weighed, and evaluated for adipose fin clips and short-term mortality. Because CWT codes were held together for the Durham Ferry releases, 50 fish from these release groups (all three CWT codes combined) were evaluated for general condition immediately and 48 hours after release, and two net pens with approximately 200 fish each were held in order to maintain consistency with the other release groups. In all, 499 juvenile Chinook salmon were examined for the six general condition characteristics, and 2,038 (including the 499 examined for general condition) were measured, weighed, and assessed for mortality and presence/absence of an adipose fin clip.

Results of the evaluations of the 499 marked salmon examined for the six general condition characteristics showed few abnormalities (see Appendix C-3). The majority of fish examined had normal coloration (99.2%), no fin hemorrhaging (100%), normal eye characteristics (99.2%), and normal gill color (92.4%). Scale loss ranged from 1% to 35% and averaged 8.6%. Other abnormalities included: fin rot (1%), dorsal fin splitting (0.8%), partial operculum (1%) and ragged dorsal fins (1%). In addition, this year 65 (3%) Chinook salmon had a poor or incomplete adipose fin clip, while 11 (0.5%) had no fin clip. Of the 2,038 juvenile Chinook salmon examined, there were 11 mortalities. In contrast, we observed no mortalities in 2002.

Tag Quality Control

Though rare, in the past, salmon from different release groups have been unintentionally mixed at some point prior to release. The subset of 25 salmon from each tag group (a total of 25 from each of the Durham Ferry net pens) evaluated for condition as described above were sacrificed to verify purity of tag codes.

TABLE 5–3
Smolt condition characteristics assessed for post-release net pen studies.

	Normal	Abnormal
Eyes	Normally shaped	Bulging
Color	High contrast dark dorsal surface and light sides	Low contrast dorsal surface and sides, coppery color
Fin Hemorrhaging	No blood or red at base of fins	Blood at base of fins
Percent Scale Loss	Lower relative numbers better based on 0–100% scale loss	Higher relative numbers worse based on 0–100% scale loss
Gill Color	Dark beet red to cherry red gill filaments	Light red to gray gill filaments
Vigor	Active swimming (prior to anesthesia)	Lethargic or motionless (prior to anesthesia)

In 2003, there were no errant tags codes associated with the VAMP 2003 net pen study. The remaining fish from each release group that were held in the net pens were archived in a freezer for further evaluation of tag code mixing if deemed necessary.

Health and Physiology

Personnel from the USFWS's California-Nevada Fish Health Center conducted physiological studies on a sub-sample of the juvenile Chinook salmon used in the VAMP study (Nichols and Foott 2003). Results of this work are summarized below.

A total of 284 Merced River Fish Facility fish were examined from the six release groups following transport to release sites at Durham Ferry, Mossdale, and Jersey Point. A general health inspection for viral, *Renibacterium salmoninarum* (Bacterial Kidney Disease agent) and systemic bacterial infection was performed on 60 fish from the first Mossdale release. Additional assays were conducted on the remaining 224 fish including: (1) internal and external abnormalities were recorded for each smolt; (2) smolt development was assessed (gill tissue was analyzed for ATPase activity from 64 fish, spread out over all release groups); and, (3) kidney tissue from 48 fish was examined for presence of *Tetracapsula bryosalmonae*, the parasite responsible for Proliferative Kidney Disease (PKD). To assess stress recovery, blood plasma levels of chloride, sodium, lactate, glucose, total protein, and cortisol were measured. At each release site, blood samples were taken from 7 to 16 fish directly out of the transport truck, and after being held in net pens for two and four hours after release. Because of time and personnel constraints, samples were not taken for fish held two and four hours after release for the second Mossdale release. Additional blood samples were taken and analyzed at 24 hours post-release for both Durham Ferry releases and for the second Jersey Point release.

No viral pathogens or *R. salmoninarum* were detected in the 60 fish sample. Low levels of bacteria common in the skin and gastrointestinal tract of fish were isolated from 30% of these fish. These isolations were not considered to be significant health risks. *Tetracapsula bryosalmonae* was detected in 63% of the 48 kidneys examined by histology and 21% showed severe inflammation caused by the parasite. Gross clinical signs (swollen kidney or spleen) of PKD were observed in 11% of the 222 smolts examined. Proliferative Kidney Disease infection was more prevalent in the second set of releases (21% for second releases combined) than the first set (3% for first releases combined; $p<0.001$, z-test). Because PKD can reduce performance due to associated kidney dysfunction and anemia, smolts in the first release groups may have had higher survival than cohorts in the second release groups.

All sample groups demonstrated similar levels of smolt development as demonstrated by gill ATPase activity. Observed ATPase levels were consistent with fish undergoing smoltification.

There were few consistent patterns in blood chemistry values among the release groups. It appears that net pen confinement failed to reduce stress on the transported fish as indicators of stress (cortisol, glucose, and lactate) tended to remain altered throughout sampling (up to 24 hours). Plasma chloride was below normal in four of five groups at four hours post-release, but did return to normal in the 24 hour samples. No biologically significant shifts in plasma protein levels were detected in any group. Comparisons of the release groups are complicated by differences in transport time and handling prior to placement in net pens. The variations created by these differences may hide some trends in blood chemistry values that signal survival differences in the release groups. There may also be problems with extrapolating blood chemistry values of smolts held in net pens to those released into the river.

TABLE 5–4

Survival Indices at Antioch and Chipps Island and expanded salvage at the Central Valley Project (CVP) and State Water Project (SWP) Fish Facilities for the 2003 VAMP Study (drafted: 10/22/03)

Tag Code	Release Site	Date	Effective Number Released[1]	ANTIOCH Number Recovered	Minutes Fished[2]	Fraction of Time Sampled[3]	Survival Index[4]	Group Index
San Joaquin								
06-02-82	Durham Ferry		24,453	1	560	0.389	0.008	
06-02-83	Durham Ferry		25,927	4	1140	0.396	0.028	
06-27-42	Durham Ferry		24,069	1	560	0.389	0.008	
Total		4/21/03	74,449	6	2790	0.388		0.015
06-27-43	Mossdale		25,212	2	1140	0.396	0.014	
06-27-48	Mossdale		24,471	2	1690	0.391	0.015	
Total		4/22/03	49,683	4	3370	0.390		0.015
06-27-44	Jersey Point	4/25/03	24,414	71	6828	0.395	0.530	
06-27-45	Durham Ferry		24,685	0	–	–		
06-27-46	Durham Ferry		25,189	0	–	–		
06-27-47	Durham Ferry		24,628	0	–	–		
Total		4/28/03	74,502	0			–	–
06-27-49	Mossdale		24,180	0	–	–		
06-27-50	Mossdale		24,346	0	–	–		
Total		4/29/03	48,526	0			–	–
06-27-51	Jersey Point	5/02/03	25,692	36	5622	0.390	0.258	

In summary, the incidence of clinical PKD was notably higher in smolts used for the second set of releases compared to smolts from the first set of releases. Consequently, survival of smolts from the second set of releases may be reduced in comparison to cohorts from the first releases. No biologically significant differences in smolt development or stress response were detected among fish from the different release times or sites. Plasma ion balance was disturbed in fish held in net pens for up to four hours post-release but returned to normal by 24 hours.

CODED-WIRE TAG RECOVERY EFFORTS

Coded-wire tagged salmon were recaptured at Antioch and Chipps Island, at CVP and SWP fish salvage facilities, and during sampling at HORB (for locations see Figure 1-1). Coded-wire tagged salmon released upstream of, and at, Mossdale were also recovered in DFG Kodiak trawls at Mossdale but are not discussed in this report. Juvenile Chinook salmon with an adipose fin clip (which identifies CWT salmon) caught at any of these sampling locations were sacrificed, labeled, and frozen for CWT processing. Coded-wire tag processing was done by USFWS (Stockton) for fish recovered at Chipps Island, Antioch, and SWP and CVP salvage facilities. DFG Region IV processed salmon captured in the HORB fyke net sampling.

Coded-wire tags are processed by dissecting each tagged fish to obtain the half (0.5 millimeters) or full (1 millimeter) cylindrical CWT from the snout. Tags are then placed under a dissecting microscope and the numbers are read and recorded in a database. All tags were read twice, and any discrepancies

CHIPPS ISLAND					Expanded Salvage Numbers[5]	
Number Recovered	Minutes Fished[2]	Fraction of Time Sampled[3]	Survival Index[4]	Group Index	CVP	SWP
0	–	–	–		24	0
2	2394	0.277	0.036		12	0
1	400	0.278	0.019		12	3
3	2394	0.277		0.019		
3	2379	0.275	0.056		0	0
2	1185	0.274	0.039		0	0
5	2379	0.275		0.048		
57	4779	0.277	1.097		0	0
0	–	–	–		12	0
0	–	–	–		12	0
0	–	–	–		0	0
0						
0	–	–	–		12	0
1	400	0.278	0.019		0	0
1	400	0.278		0.010		
39	3460	0.267	0.739		0	0

[1] The Effective Number Released is an estimate of the number of fish released with an adipose fin clip and CWT.

[2] The Minutes Fished is the number of minutes sampled between the first and last day of recovery.

[3] The fraction of time sampled is between the first and last day of recovery.

[4] The survival index is calculated using the formula: # recovered /(# released x fraction of time sampled x fraction of channel sampled)

[5] Expanded salvage numbers are: the number recovered in salvage/(minutes sampled/total minutes between samples)

were resolved by a third reader. Tags were archived for future reference. VAMP releases comprise a small portion of the total tagged salmon released in the Sacramento and San Joaquin system. Consequently, many tags recovered at Chipps Island, Antioch, the SWP and CVP salvage facilities, and other locations are from CWT releases not affiliated with VAMP. It is necessary to read all recovered tags to identify CWT recoveries related to VAMP.

SWP and CVP Salvage Recapture Sampling

Sampling at the CVP and SWP fish salvage facilities was conducted approximately every two hours. The number of marked salmon collected (raw salvage) was expanded based on the number of minutes sampled during each two hour time period.

The estimated expanded total number of CWT salmon, from each release group, was obtained by adding together the expanded number of each tag group for all time periods. Only CWT salmon recovered in the raw salvage collections were sacrificed for tag processing. Expanded salvage is only a portion of the direct loss experienced by juvenile salmon at the facilities as it does not include losses prior to, and associated with, pre-screen predation, screening, handling and trucking.

Expanded salvage numbers were low at the CVP (n = 84), and only three Chinook salmon were salvaged at the SWP (Table 5-4). These results are consistent with earlier studies showing that the HORB reduces the number of CWT salmon entrained at the fish facilities (Brandes and McLain, 2001). Additional VAMP fish were recovered during special studies at the SWP (n = 13).

Antioch Recapture Sampling

Fish sampling was conducted in the vicinity of Antioch on the lower San Joaquin River (Figure 1-1) using a Kodiak trawl. The Kodiak trawl has a graded stretch mesh, from 2-inch mesh at the mouth to 1/2-inch mesh at the cod-end. Its overall length is 65 feet, and the mouth opening is 6 feet deep and 25 feet wide. The net was towed between two boats, sampling in an upstream direction. Trawls were performed parallel to the left bank, mid-channel, and right bank to sample CWT salmon emigrating from the San Joaquin River. Each tow was approximately 20 minutes in duration.

All captured fish were transferred immediately from the Kodiak trawl to buckets filled with river water, where they were held for processing. Data collected during each trawl included: species identification and fork length for each fish captured, tow start time and duration, and location in the channel. Any fish mortalities or injuries were documented to comply with the Endangered Species Act permit requirements.

Juvenile Chinook salmon with an adipose fin clip were retained for later CWT processing while other fish were released at a location downstream of the sampling site immediately after identification, enumeration, and measurement.

Sampling at Antioch began April 21 and continued through May 20. Each day between 5:00 a.m. and 9:00 p.m., anywhere from 3 to 32 tows were conducted. In all, 800 Kodiak trawl samples were collected, for a total of 15,877 tow minutes. During sampling, 6,971 unmarked juvenile Chinook salmon were captured; 341 salmon with an adipose fin clip (and CWT) were collected, 117 from VAMP releases (Table 5-4) and 214 from other hatchery releases. In addition, 1,328 delta smelt, 16 Sacramento splittail, 29 unmarked steelhead, and 43 adipose fin clipped steelhead were caught during sampling.

Chipps Island Recapture Sampling

As part of VAMP 2003 recovery efforts at Chipps Island, trawling shifts were conducted twice daily between April 21 and May 31. This second shift has been conducted during the spring releases since 1998. The first shift began at sunrise, while the second shift ended at or after sunset, to incorporate the crepuscular periods of the day. Based on analysis of 24-hour sampling at Jersey Point in 1997 (Hanson, Hanson Environmental, unpublished data), greater numbers of juvenile Chinook salmon appear to be caught around sunrise and sunset. Therefore, targeting this crepuscular period and doubling total trawl effort at Chipps Island should increase the number of CWT salmon recaptured and reduce variability in VAMP survival indices. Sampling for other studies occurs once daily between June 1 and June 14, and three days per week after June 16 and prior to April 21.

Midwater trawls were conducted at Chipps Island by towing the trawl net at the surface. The mouth of the net was 10 feet deep by 30 feet wide, and the total length was 82 feet. Aluminum hydrofoils were used on the top bridles and steel depressors, along with a weighted lead line, were used on the bottom bridles to keep the mouth of the net open. The net consisted of graded mesh starting with 4-inch mesh at the mouth and ending with a 1/4-inch cod end mesh.

To sample across the channel, trawling at Chipps Island was conducted in three distinct lanes: the north, south, and middle of the channel. Each lane was generally sampled at least three times per shift, with one lane sampled a fourth time during each shift. The lane sampled four times was chosen at random or selected by the boat operator based on flow conditions.

During the VAMP recovery period, 105 VAMP CWT Chinook salmon were recovered at Chipps Island (Table 5-4). In addition, 11,226 unmarked salmon, 711 CWT salmon from non VAMP experiments, 15 delta smelt, 11 Sacramento splittail, 12 unmarked steelhead, and 17 adipose fin clipped steelhead were collected.

VAMP CHINOOK SALMON CWT SURVIVAL

Survival Indices

Survival indices were calculated for marked salmon released at Durham Ferry, Mossdale, and Jersey Point and recovered at Antioch and Chipps Island. Survival indices (SI) were calculated using the formula:

$$SI = (R / (E*T*W))$$

Where:
R = the number recovered,
E = the effective number released,
T = the fraction of time sampled, and
W = the fraction of channel width sampled

The fraction of the channel width sampled at Chipps Island (0.00769) was calculated by dividing the net width (30 feet) by the estimated channel width (3,900 feet). The fraction of the channel width sampled at Antioch (0.01388) was calculated in the same manner, with the net width being 25 feet and the channel width being 1,800 feet. The fraction of time sampled at both locations was calculated based on the number of minutes sampled between the first and last day of catching each particular tag code or group, divided by the total number of minutes

Survival indices were calculated for each tag code to provide a sense of the variability associated with the group survival index.

in the time period. The fraction of time sampled for the VAMP 2003 release groups at Chipps Island was about 0.28, while at Antioch it was about 0.39 (Table 5-4).

Survival indices were calculated for each tag code to provide a sense of the variability associated with the group survival index. To generate the group survival index, the recovery numbers and release numbers were combined for the tag codes within a release group.

Individual and group survival indices to Antioch and Chipps Island of the CWT salmon released as part of VAMP 2003 are shown in Table 5-4. Survival indices have been reported to three significant digits, but we realize indices were not likely that precise. Survival indices were not corrected for the number of CWT fish recovered at the HORB or in sampling at Mossdale conducted by DFG Region IV.

The first set of VAMP releases appeared to survive at a higher rate than the second set of releases. The first Durham Ferry releases had survival indices to Antioch and Chipps Island of 0.015 and 0.019, respectively. The second Durham Ferry group had an unknown but likely lower survival rate since none were recovered at either location. The first releases at Mossdale had survival indices to Antioch of 0.015 and 0.048 to Chipps Island. No fish were recovered at Antioch from the second Mossdale release and the survival index to Chipps Island was 0.010. Survival indices for the two Jersey Point groups were 0.530 and 0.258 at Antioch and 1.097 and 0.739 at Chipps Island for the first and second releases respectively. Why survival was lower for the second groups relative to the first groups is unknown but may be related to the higher incidence of PKD.

Survival indices for both sets of releases made at Durham Ferry and Mossdale were very low relative to releases made at Jersey Point (Table 5-4).

Chinook Salmon Survival Estimates and Combined Differential Recovery Rates

More important than the differences in survival indices between sets of releases is the comparison of absolute survival estimates and combined differential recovery rates (CDRR). Absolute survival estimates (AS_i) are calculated by the formula:

$$AS_i = SI_u / SI_d$$

Where:

SI_u = *the survival index of the upstream group (Durham Ferry or Mossdale), to the recovery location*

SI_d = *the survival index of the downstream group (Jersey Point) to the recovery location and*

i = *recovery location (Antioch or Chipps Island).*

Although referred to throughout this document as absolute survival estimates they are more aptly described as standardized or relative survival estimates. The combined recovery rate (CRR) is estimated by the formula:

$$CRR = R_{C+A} / ER$$

Where:

R_{C+A} = *the combined recoveries at Antioch and Chipps Island of a CWT group, and*

ER = *the effective number released.*

The combined differential recovery rate (CDRR) is calculated by the formula:

$$CDRR = CRR_u / CRR_d$$

Where:

CRR_u = *the combined recovery rate for the upstream group (Durham Ferry or Mossdale), and*

CRR_d = *the combined recovery rate for the downstream group (Jersey Point).*

The CDRR is another way to estimate survival between the upstream and downstream release locations. It is similar to calculating absolute survival estimates, but does not expand estimates

FIGURE 5–6

Combined Differential Recovery Rates (CDRR) and (+/- 1 and 2 standard errors) of coded wire tagged (CWT) smolts released in 2003 at Mossdale and Jersey Point (Mossdale) and Durham Ferry and Jersey Point (Durham Ferry) for the first (1) and second (2) release groups. CWT smolts were recovered at Antioch and Chipps Island.

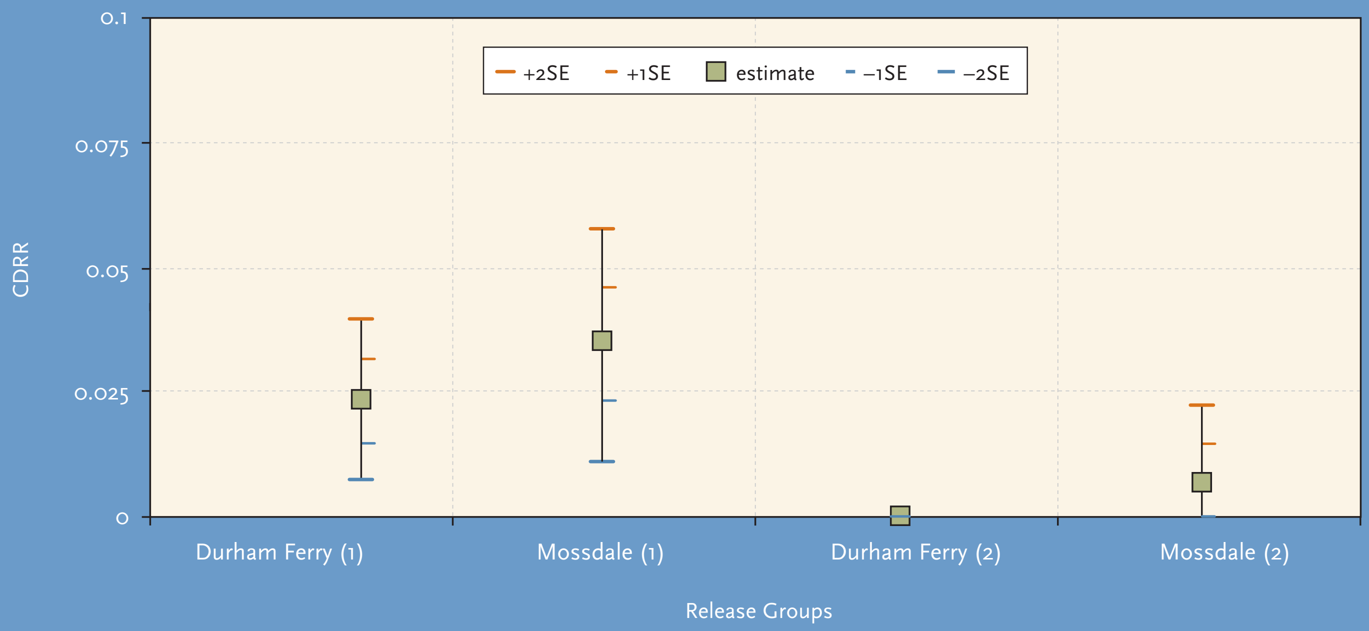
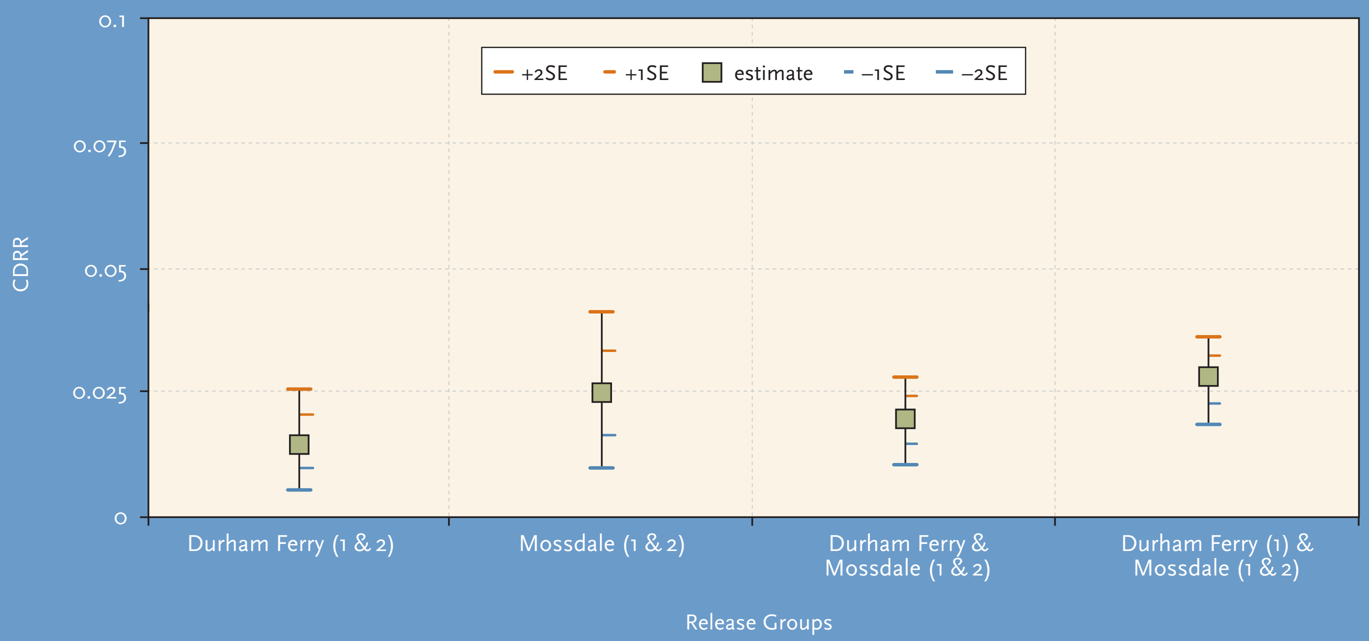


FIGURE 5–7

Pooled, Combined Differential Recovery Rates (CDRR) and (+/- 1 and 2 standard errors) of CWT smolts released in 2003 at Durham Ferry and Jersey Point (Durham Ferry) and Mossdale and Jersey Point (Mossdale) for the first (1) and second (2) release groups and for the combined Durham Ferry and Mossdale release groups (with and without the second Durham Ferry release group).Recoveries were made at Antioch and Chipps Island.



based on the fraction of the time and space sampled. At times the differential recovery rate (DRR) is reported which is similar to the CDRR but only uses recovery numbers from one recovery location—either Chipps Island or the ocean fishery.

The CDRR and the absolute survival estimates should not be very different as (1) the fraction of the time sampled is similar between groups for a recovery location and (2) the fraction of the channel width sampled at each recovery location is a constant. Neither would change the relative differences between groups. However, combining the recovery numbers from Antioch and Chipps Island could result in different survival estimates between the two methods.

Variance and standard errors were calculated for the CDRRs based on the Delta method recommended by Dr. Ken Newman. Plus or minus two standard errors are roughly equivalent to the 95% confidence intervals around the CDRR. Plus or minus one standard error equates to roughly the 68% confidence intervals for normally distributed data (Ken Newman, University of St. Andrews, Scotland, personal communication). In comparing survival between reaches and replicates, the confidence intervals were used to determine if CDRRs were significantly different from each other. If the 95% confidence intervals overlapped CDRRs were not considered statistically different from each other. Differences observed using the lower level of confidence (68%) are noted. It is not clear how variances, standard errors, or confidence intervals could be generated for absolute survival estimates.

Absolute survival estimates and CDRRs should be more robust for comparing survival between groups, recovery locations, and years, since using ratios between upstream and downstream groups theoretically standardizes for differences in catch efficiency between recovery locations and years. Both estimates of absolute survival and CDRRs were calculated for CWT releases as part of VAMP 2003, as in past years. An additional estimate of absolute survival will be possible from recoveries made in the ocean fishery, two to four years following release.

Although the first groups released at Durham Ferry and Mossdale appeared to survive slightly better than the second groups when evaluated using the absolute survival estimates and CDRRs (Table 5-5), the CDRRs of the two Mossdale groups were not statistically different at the 95% confidence level ($p<0.05$ level). They were significantly different using the 68% confidence level (Figure 5-6). No recoveries were made for the second Durham Ferry group at either recovery location, thus the second groups appeared to survive at a lower rate than the first groups. In addition, no recoveries were made at Antioch for the second Mossdale group.

The first Mossdale group appeared to survive slightly better than the first Durham Ferry group using the absolute survival estimates generated using Chipps Island recoveries and CDRR (Table 5-5). The first Mossdale group appeared to survive about the same as the first Durham Ferry group using the Antioch recoveries (Table 5-5). The CDRR indicated that differences were not significant (Figure 5-6). Fish released at Durham Ferry are thought to incur additional mortality since it is 11 miles farther upstream than Mossdale.

Because there were no significant differences between the CDRRs of the two Mossdale release groups, the groups were pooled and a new CDRR (0.025) and standard error were calculated (Figure 5-7). The first Durham Ferry group was also

TABLE 5–5

Group survival indices (SI) and absolute survival estimates (AS) combined differential recovery rates (CDRR) using recoveries at Antioch, Chipps Island or both for coded wire tagged Chinook salmon released as part of VAMP 2003.

Release Site	Date	Antioch Group SI	Antioch Group AS	Chipps Group SI	Chipps Group AS	Combined Differential Recovery Rate
Durham Ferry	4/21/03	0.015	0.028	0.019	0.017	0.023
Mossdale	4/22/03	0.015	0.028	0.048	0.043	0.035
Jersey Point	4/25/03	0.530		1.097		
Durham Ferry	4/28/03	–	–	–	–	–
Mossdale	4/29/03	–	–	0.010	0.014	0.007
Jersey Point	5/02/03	0.258		0.739		

TABLE 5–6
Recovery timing of juvenile CWT salmon released as part of VAMP 2003

Tag Code	Release Site	Release Date	ANTIOCH				
			Number Recovered	First Day Recovered	Last Day Recovered	Days to First Rec.	Days at Large
06-02-82	Durham Ferry		1	5/4	5/4		13
06-02-83	Durham Ferry		4	4/30	5/1		10
06-27-42	Durham Ferry		1	4/30	4/30		9
Total		4/21/03	6	4/30	5/4	9	13
06-27-43	Mossdale		2	4/30	5/1		9
06-27-48	Mossdale		2	5/3	5/5		13
Total		4/22/03	4	4/30	5/5	8	13
06-27-44	Jersey Point	4/25/03	71	4/26	5/7	1	12
06-27-45	Durham Ferry		0	–	–		
06-27-46	Durham Ferry		0	–	–		
06-27-47	Durham Ferry		0	–	–		
Total		4/28/03	0				
06-27-49	Mossdale		0	–	–		
06-27-50	Mossdale		0	–	–		
Total		4/29/03	0				
06-27-51	Jersey Point	5/02/03	36	5/3	5/12	1	10

combined with the two Mossdale groups (Figure 5-7) since there were no statistical differences in the CDRRs at the 95% level between groups (Figure 5-6). Since no recoveries were made for the second Durham Ferry group, we were uncertain whether it was appropriate to combine Durham Ferry groups and include the second Durham Ferry group in the pooling with the Mossdale groups. To address this, CDRRs were calculated using the two sets of pooled data to determine if they were statistically different. The CDRR for the pooled two Durham Ferry and Mossdale releases was 0.019. Without the second Durham Ferry release included the CDRR was 0.027. CDRRs of the two sets of pooled data were not significantly different. The pooled CDRR for the two Durham Ferry releases was 0.015 (Figure 5-7).

TRANSIT TIME

Data on transit times for marked salmon from release to recapture sites during VAMP 2003 is summarized in Table 5-6. The transit time (from release location to Antioch and Chipps Island) for both sets of releases was similar. Recoveries of all groups were made within 13 days after release. It is interesting that the Jersey Point groups were still recovered 10 to 12 days after release, similar to groups released upstream. Daily recovery of each release group by tag code and sampling effort is shown in Appendix C-4.

Transit time for the CWT groups to the CVP and SWP fish facilities varied more than transit times to Antioch and Chipps Island. Coded wire tagged fish released as part of the first Durham Ferry group arrived at the facilities earlier (tag group: 06-02-82), at roughly the same time (tag group: 06-02-83) or

CHIPPS ISLAND					CVP	SWP
Number Recovered	First Day Recovered	Last Day Recovered	Days to First Rec.	Days at Large	First and Last Day Recovered	First and Last Day Recovered
0	–	–			4/29-5/1	
2	4/27	5/2		11	5/1	
1	4/29	4/29		8	5/7	5/12
3	4/27	5/2	6	11		
3	4/30	5/5		13		
2	5/2	5/4		12		
5	4/30	5/5	8	13		
57	4/26	5/7	1	12		
0	–	–			5/1	
0	–	–			5/7	
0	–	–				
0						
0	–	–			5/7	
1	5/6	5/6		7		
1	5/6	5/6	7	7		
39	5/4	5/12	2	10		

much later (tag group: 06-27-42) than they reached Antioch or Chipps Island (Table 5-6). Fish from the second Durham Ferry group and one tag group from the second Mossdale release were observed during salvage operations but were never recovered at Chipps Island or Antioch. Variability in recovery timing could an artifact of low recoveries at all recovery locations.

COMPARISON WITH PAST YEARS

Survival between Durham Ferry and Mossdale appeared high in 2003 as in past years. In 2000 through 2003, CDRRs indicated that survival between Durham Ferry and Jersey Point and Mossdale and Jersey Point was not statistically different ($p<0.05$) (SJRG, 2002 and Figure 5-6), thus we can infer survival between Durham Ferry and Mossdale was generally high in these years. However, low recovery numbers may hinder our ability to detect differences. Continued releases of CWT fish at both sites may allow estimates of mortality between Durham Ferry and Mossdale if it becomes great enough to detect in the future. If survival between locations is shown to be similar (not statistically different) then groups can be combined. When ocean recovery information becomes available it may also provide a means to assess mortality between Durham Ferry and Mossdale.

Survival from Durham Ferry and Mossdale to Jersey Point was much lower in 2003 than in the past. In 2003 the pooled CDRR from Durham Ferry and Mossdale to Jersey Point was 0.019 (or 0.027 including only the first Durham Ferry release). The pooled CDRR in 2003 was the lowest measured to date, and significantly lower than any pooled CDRR estimated since 2000 (Table 5-7). Even prior to VAMP, with only Chipps Island recoveries, the lowest differential recovery rate with the HORB in place was 0.133 in 1994.

TABLE 5–7
Combined Differential Recovery Rate (CDRR) and standard errors for CWT salmon released at Mossdale and Durham Ferry in relation to those released at Jersey Point

Year	CDRR	Standard Error
1994	0.133	0.099
1997	0.186	0.064
2000	0.187	0.019
2001	0.191	0.014
2002	0.151	0.013
2003	0.019*	0.005

*significantly lower than values in other years

TABLE 5–8
Severity of PKD infection in VAMP fish between 2000 and 2003. Number positive divided by the sample size is shown in parentheses.

Year	Percent Infected	Percent with Severe Infection
2000	4 (2/45)	0 (0/45)
2001	100 (34/34)	29 (10/34)
2002	46 (92/201)	1 (2/201)
2003	63 (30/48)	21 (10/48)

TABLE 5–9
Number of days after release of first and last recovery at Chipps Island and the duration of recovery (in days) for VAMP released fish in 2000-2003. Mean duration of recovery period and mean flow in cubic feet per second (cfs) at Vernalis during the two upstream Durham Ferry releases is included.

Release Location	Year (San Joaquin Flow Target)			
	2000	2001	2002	2003
Durham Ferry (1)	5-32 (27)	5-11(6)	8-22(14)	6-11(5)
Mossdale (1)	5-16(11)	4-11(7)	7-17(10)	8-13(5)
Jersey Point (1)	2-12(10)	1-7(6)	2-21(19)	1-12(11)
Durham Ferry (2)	5-23(18)	5-13(8)	7-15(8)	–
Mossdale (2)	N/R	5-10(5)	9-19(10)	7(0)
Jersey Point (2)	1-16(15)	1-11(16)	1-19(18)	2-10(8)
Mean Duration (in days)	16.2	7	13.1	6
Mean Flow (in cfs)	6020	4211	3341	3298

N/R = No second release was made
– = no fish were recovered

The health of the CWT fish in of itself did not appear to account for the low survival observed in 2003. Indices of fish health for VAMP fish used in 2003 were compared with VAMP fish used in earlier years to determine if the incidence and severity of PKD was greater in 2003 than in past years. The severity of PKD infection was determined by examining the kidney tissue. If the parasite was observed the fish was classified as infected. If the parasite had reached a stage where a reaction to the parasite (inflammation) was observed the fish was classified as severely infected.

In 2003, both infection and severe infection were observed in a high percentage of fish used in the VAMP experiments (Table 5-8). However, both the infection and severe infection rates were greater for the VAMP fish released in 2001, when survival through the Delta was estimated to be an order of magnitude higher (0.191 in 2001 versus 0.019 in 2003) (Table 5-8). These data indicate that the PKD infection in and of itself probably did not cause the high mortality of the VAMP fish observed in 2003.

The high level of PKD infection in combination with the lower flows could have increased the mortality of VAMP fish in 2003. PKD in the field likely compromises the fish's performance in many areas (swimming, salt water entry and disease resistance) and could decrease their survival through the Delta (Nichols and Foott, 2002). Nichols and Foott (2002) speculate that differences in the rate of PKD infection could be due to environmental conditions—namely flow and water temperature and that the small number of infected fish in 2000 may have been caused by the lower concentration of the infectious stage of the parasite because of the dilution effect of higher flows. Thus in contrast the lower flows in 2003 may have concentrated the infectious stage of the parasite.

The transit time (the span of time fish were recovered) at Chipps Island for VAMP groups in 2003 was shorter than in past years and may be a reflection of the lower flows and higher incidence of PKD infection. The mean number of days between the first and last day of recovery at Chipps Island for all VAMP groups was less in 2003 (6) compared to past years (Table 5-9).

The number of days until first recovery to Chipps Island appears to be related to San Joaquin River flow. In 2003 the number of days until first recovery was longer (1 to 8 days) when flows were lower (3298 cfs) than in 2000 and 2001 (1 to 5 days and 6020 and 4211 cfs flow respectively). The number of days until first recovery (1 to 9 days) and flow (3341 cfs) (in 2002) was similar to that observed in 2003 (Table 5-9).

In contrast, the number of days until last recovery was sooner in 2003 (7 to 13 days) than in 2002 (ranged from 15 to 22 days after release) and 2000 (12 to 32 days) when PKD infection rate was lower. The number of days until last recovery in 2003 was similar to that observed in 2001 (Table 5-9). Both 2003 and 2001 had the highest percentage of fish infected with PKD (Table 5-8). Differences in the number of days until last recovery may reflect increased mortality over time. Individuals that took longer than the 7 to 13 days to reach the western Delta had higher mortality due to the higher incidence of PKD in 2003 and 2001. It is possible that the combination of the first fish taking longer to reach Chipps Island due to the lower flows and the increased mortality due to the direct or indirect effects of PKD infection for the later migrants may in part explain why survival was so much lower in 2003 than in past years.

The high level of PKD infection in combination with the lower flows could have increased the mortality of VAMP fish in 2003. PKD in the field likely compromises the fish's performance in many areas and could decrease their survival through the Delta.

Role of Flow and Exports

San Joaquin River flow and flow relative to exports between April and June is correlated to adult escapement in the San Joaquin basin 2 1/2 years later (SJRG 2003). Both relationships are statistically significant ($p<0.01$) with the ratio of flow to exports accounting for slightly more of the variability in escapement than flow alone ($r^2 = 0.58$ versus $r^2 = 0.42$) (SJRG, 2003). These relationships suggest that adult escapement in the San Joaquin basin is affected by flow in the San Joaquin River and exports from the CVP and SWP during the spring months when juveniles migrate through the river and Delta to the ocean. VAMP was designed to further define the mechanisms behind these relationships by testing how San Joaquin River flows and exports with the HORB affect smolt survival through the Delta.

Survival of juvenile Chinook salmon emigrating from the San Joaquin River system has been evaluated within the framework established by the VAMP experimental design since the spring of 2000. Similar South Delta studies were conducted in 1994 and 1997, prior to the official implementation of VAMP. Fish from the Feather River Hatchery have been used in south Delta studies conducted prior to 1999 (SJRG, 2002).

To assess the relationship between San Joaquin River flows and survival, pooled CDRRs from 2000 through 2003 were plotted. The CDRRs of all Durham Ferry and Mossdale releases within a year were pooled as they were not significantly different from each other at the 95% confidence level. These pooled estimates and their 68% and 95% confidence intervals for 2003 (including the second Durham Ferry release) and the past three years of VAMP releases (2000–2002) are shown in relation to the average San Joaquin River flow at Vernalis for the two, ten-day periods after each release in Figure 5-8. Similar data obtained from releases made at Mossdale in 1994 and 1997 are included but have much wider confidence intervals because fewer recoveries were made since tagged fish were recovered at only one location (Chipps Island) in these years. It is obvious that the 2003 CDRR is much lower than would have been predicted based on past data.

The CDRRs with confidence intervals are also shown in comparison to average Vernalis flow relative to combined CVP and SWP exports for the averaged two, ten-day periods after release for each year (Figure 5-9). Prior to 2003, the relationship of CDRRs to San Joaquin River flow was improved by incorporating exports. The CDRR obtained in 2003 is much lower than what would have been predicted from past data and has weakened the benefit of adding exports into the relationship.

In general, the CDRRs do appear to increase as flows and flows relative to exports increase, but the addition of the 2003 data has resulted in these relationships no longer being statistically significant. As mentioned last year, even when the relationships were statistically significant ($p<0.10$), confidence intervals indicated data points were not significantly different from each other (SJRG, 2003).

FIGURE 5–8

Combined Differential Recovery Rates (CDRR) and (+/- 1 and 2 standard errors) of CWT smolts released at Durham Ferry and Mossdale relative to Jersey Point releases (with HORB in place) versus San Joaquin River flow at Vernalis in cfs, 2000–2003. 1994 and 1997 releases were made at Mossdale and Jersey Point.

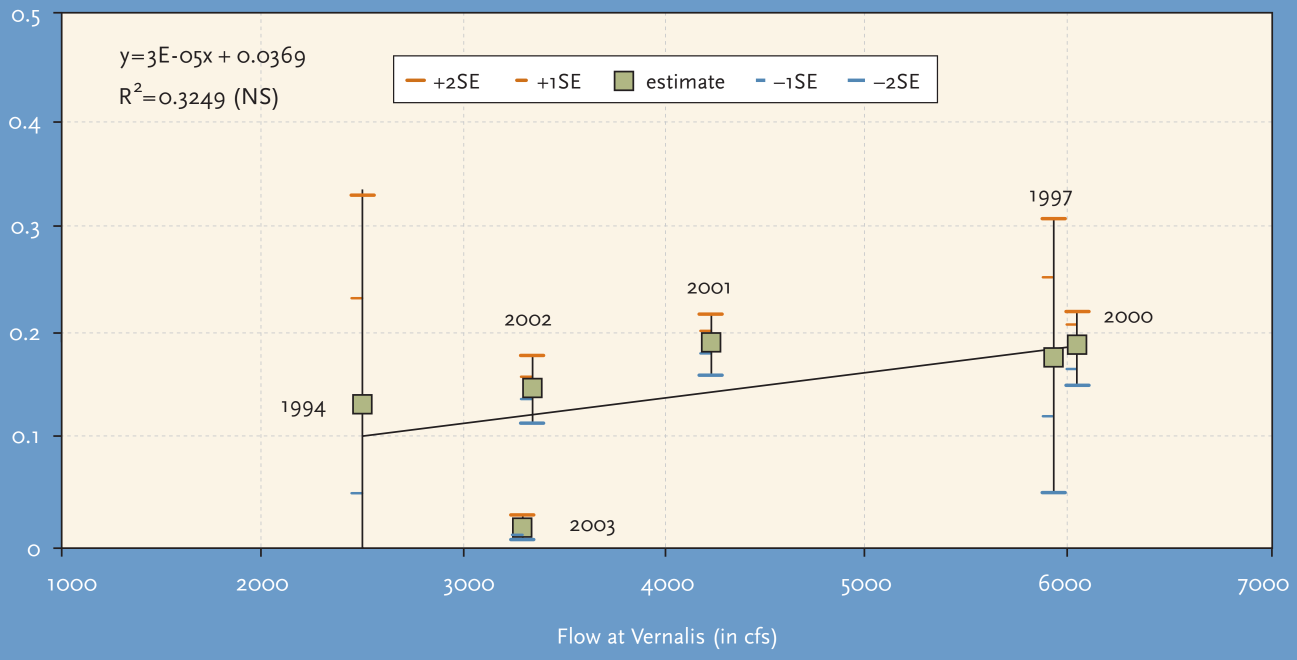
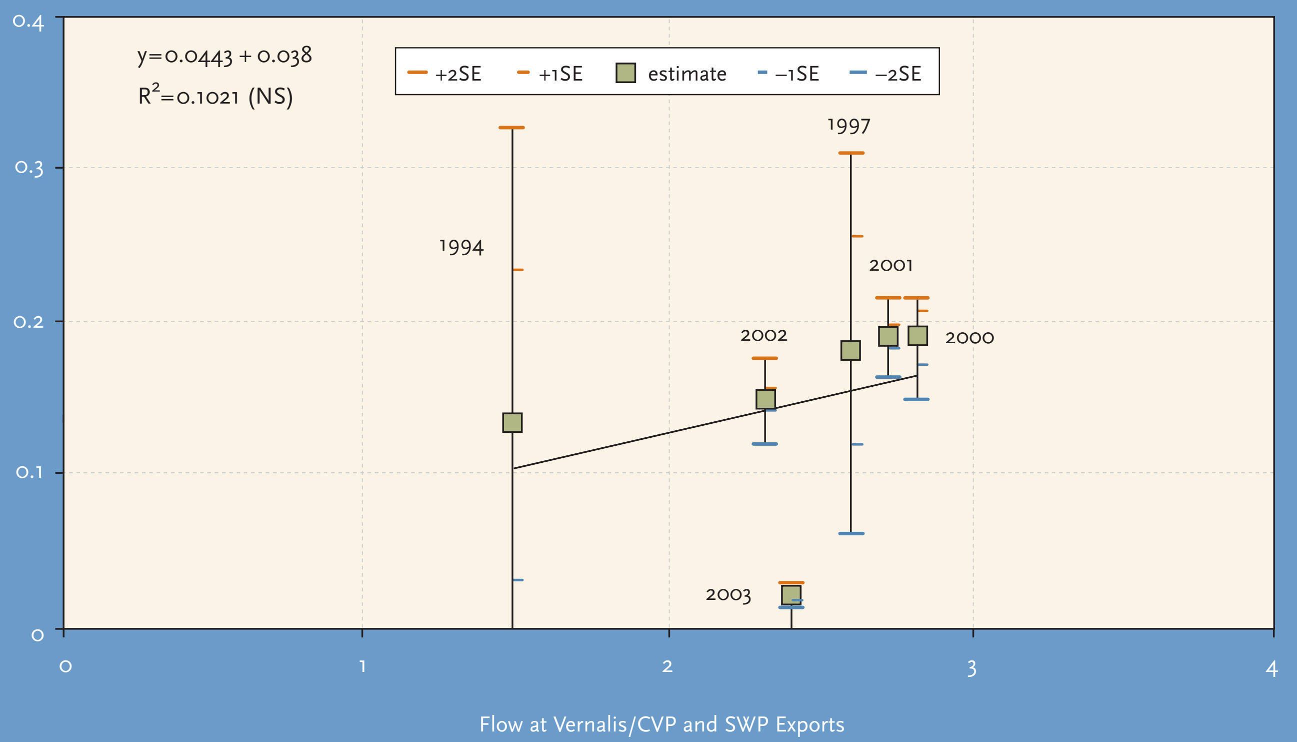


FIGURE 5–9

Combined Differential Recovery Rates (CDRR) and (+/- 1 and 2 standard errors) of CWT smolts released at Durham Ferry and Mossdale relative to Jersey Point releases (with HORB in place) versus the ratio of inflow at Vernalis and CVP and SWP exports, 2000–2003. 1994 and 1997 releases were made at Mossdale and Jersey Point.



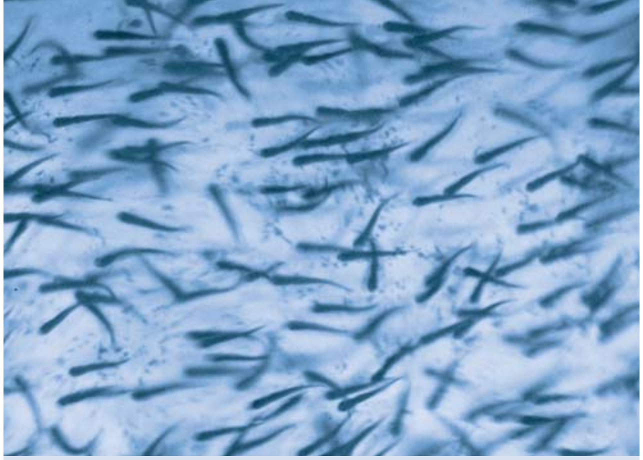
It does not appear that flow and exports in 2003 accounted for the low survival observed. As mentioned earlier, San Joaquin River flows and CVP and SWP exports were similar in 2002, but survival was significantly higher in 2002 as shown using the CDRRs and respective confidence intervals (Figure 5-10).

The Role of HORB on Survival

In 2003, the HORB was in place with three culverts operating during the VAMP study period. The barrier is assumed to improve survival based on studies conducted in the 1980s and 1990s (Brandes and McLain, 2001). These studies indicated that smolts released downstream of the Head of Old River survived at about twice the rate of those released upstream. And while those data were not statistically significant, placing a temporary barrier at the Head of Old River appeared to be a management action that would improve survival through the Delta for smolts originating from the San Joaquin basin.

The relationships of absolute survival estimates between Mossdale and Jersey Point and the ratio of San Joaquin River flow at Vernalis to exports with and without the HORB are shown in Figure 5-11. Differential recovery rates (using Chipps Island recoveries only) were not reported since they have not been calculated for past releases without the barrier in place. We assume absolute survival estimates would be comparable to the differential recovery rates. Thus, while comparisons can be made between regression lines, variance around each data point has not been estimated. The two regression lines have been developed based on survival data with and without the HORB. The barrier appears to generally increase survival at any one flow to export ratio, although estimated survival in 2003 was lower than would have been predicted from the model and is similar to levels observed without a barrier in place at the lower inflow to export ratios. In addition there hasn't been much variability in the Vernalis flow to export ratios to test with the barrier in place.

The differences in the target conditions tested in VAMP so far have been small, making it difficult to measure differences in survival due to changes in target conditions. In the six years of measuring survival with the HORB in place, the flow to export ratio has only varied from 1.5 (1994) to 2.9 (2000) (Figures 5-9 and 5-11). The maximum flow to export ratio within the VAMP targets is 4.7, but as of yet has not been tested. The ratios in the relationship between flow to export and adult escapement vary from 0.1 to 1000 (SJRG, 2003); a broader representation of how flows relative to exports, during the spring, have varied since 1951.



Placing a temporary barrier at the Head of Old River appeared to be a management action that would improve survival through the Delta for smolts originating from the San Joaquin basin.

Varying designs and changes in the culvert operations of the HORB also make it more difficult to detect significant differences in salmon smolt survival at similar flow to export ratios. During the six years the HORB has been installed (and comparable survival studies conducted) the design and permeability of the HORB have changed. In 1994, the HORB was installed without culverts, while in 1997 the barrier had two open culverts that diverted approximately 300 cfs into upper Old River. In 2000, the HORB had six gated culverts, with two open during the Mossdale and first Durham Ferry releases and four open during the second Durham Ferry release. In 2001 and 2002, six culverts were installed and operated throughout the VAMP test period. It was estimated that approximately 400 cfs from the San Joaquin River moved through the culverts in 2001 and 2002 (Simon Kwan, DWR, personal communication). In 2003, three culverts were open during the studies.

The amount of water flowing through the culverts is based on the head differential between the San Joaquin River and Old River. The amount of water flow moving from the San Joaquin River into Old River would change as flow, stage and the tides change, even if all six culverts remained open for the remaining nine years of the study. These changes in the amount of flow through the culverts and number of culverts operating between years likely affects the entrainment and resulting survival at this point in the river, adding variability in survival from factors other than flow or exports.

FIGURE 5–10

Combined Differential Recovery Rates (CDRR) and (+/- 1 and 2 standard errors) of CWT smolts released at Mossdale and Jersey Point (Mossdale) and Durham Ferry And Jersey Point (Durham Ferry) for the first (1) and second (2) release groups in 2003 (black) and 2002 (red). CDRR were based on the sum of recoveries at Antioch and Chipps Island. Estimates for pooled CDRR's for the two Durham Ferry and Mossdale releases are also provided.

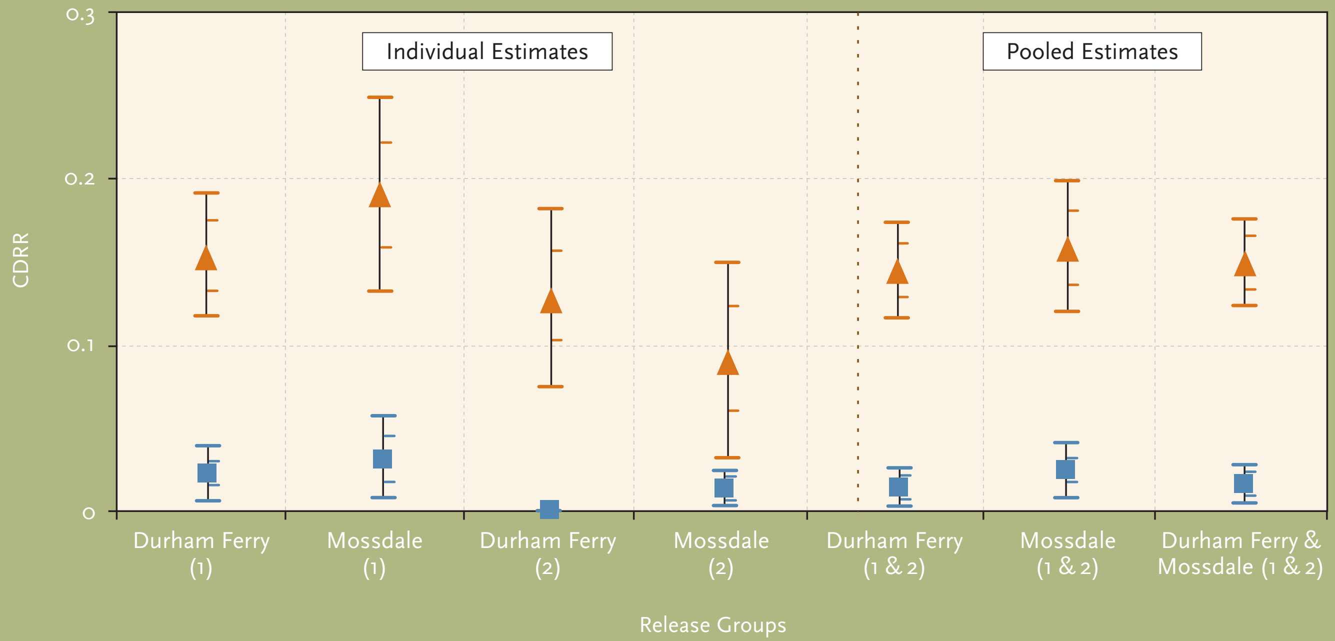
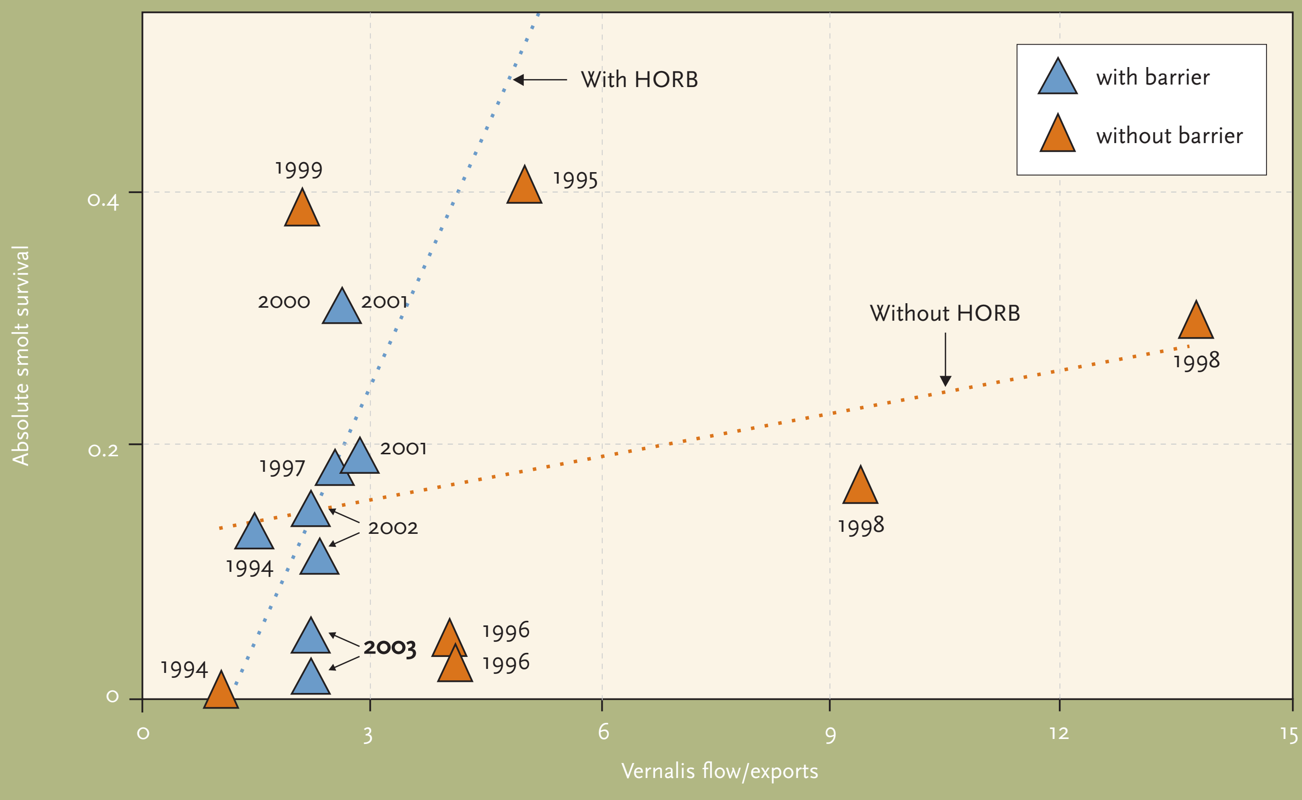


FIGURE 5–11

Estimates of survival of CWT fish released at Mossdale relative to those released at Jersey Point and recovered at Chipps Island with and without a HORB between 1994 and 2003. Similar values were obtained for one 2000 and one 2001 release. HORB can not be installed at Vernalis flow/export levels >4.6



Survival indices of the downstream tributary groups were comparable to indices from the upstream VAMP releases.

The flow through the culverts and the seepage through the rock barrier and would affect the amount of remaining flow left in the San Joaquin River of which the salmon smolts are exposed. Using flow in the San Joaquin River at Vernalis as the estimate of flow the fish are exposed to instead of flow in the San Joaquin River downstream of the HORB adds additional variation to the relationships we are trying to identify and refine. A better estimate of flow to use in these relationships would be the net flow on the San Joaquin River downstream of upper Old River. An estimate of flow in the San Joaquin River downstream of Old River has been made by subtracting the estimated mean daily flow in upper Old River 840 feet downstream of the barrier from the USGS gauged mean daily flow at Vernalis (Chapter 4). In addition in 2003, an Acoustic Doppler Current Profiler (ACDP) was placed in the San Joaquin River downstream of the HORB for the purpose of estimating the flow. This method was deemed the best way to estimate flow at this location. Data from the ACDP are not yet available to use in our analyses. The ACDP data will be compared to that estimated using the mean daily flow in Old River to see how they compare and determine if it is possible to estimate San Joaquin flow downstream of Old River in past years. Future analyses will attempt to use these estimates in comparing smolt survival to San Joaquin River flow.

Comparison with other marked fish released from Merced River Fish Facility

Coded wire tagged salmon from Merced River Fish Facility were released in the San Joaquin River tributaries between April 13 and May 7 as part of independent (complimentary) fishery investigations. Releases were made in the Merced and Stanislaus Rivers at the upper and lower reaches of the rivers below the dams. These studies are reported in more detail in Chapter 6, but are discussed here as they relate to VAMP releases.

Survival indices of the downstream tributary groups to Antioch or Chipps Island would include mortality down the mainstem San Joaquin River as well as through the Delta. While the survival indices of these lower tributary released groups would include some additional river mortality, if mainstem mortality was low then the indices would be comparable to survival indices of fish released at Durham Ferry and Mossdale as part of VAMP.

Survival indices of the downstream tributary groups were comparable to indices from the upstream VAMP releases. Group survival indices for salmon released in the lower tributaries and recovered at Antioch ranged between 0.002 and 0.032 (Table 5-10). Group survival indices ranged between 0.014 and 0.060 for recoveries made at Chipps Island (Table 5-10). No recoveries were made from the downstream group on the Stanislaus River (Two Rivers) at Chipps Island. Survival indices to Antioch and Chipps Island of VAMP released fish at Mossdale and Durham Ferry ranged from 0.010 to 0.048 (Table 5-4).

These data would indicate that whatever variable affected the survival of upstream released VAMP fish may have affected survival of the lower tributary released fish. It is also likely, that the tributary released fish from Merced River Fish Facility also were infected with PKD.

The survival indices using Antioch and Chipps Island recoveries of releases made in the upper tributaries were also low (Table 5-11) ranging between 0.002 and 0.020. No recoveries were made at Chipps Island for one of the upstream groups released in the Merced River. Again these indices are similar to those obtained for VAMP fish released at Durham Ferry and Mossdale indicating that low survival was not specific to upstream VAMP releases.

Comparison with Sacramento River Delta releases

Average survival indices for three groups of Feather River Hatchery smolts released at Sacramento on April 15, April 30 and May 15, 2003 averaged 0.51. This is within the range and near the average observed in past years (Brandes and McLain, 2001). It appears that whatever factor contributed to the low survival observed for all Durham Ferry and Mossdale CWT fish released from Merced River Fish Facility in 2003 was limited to the San Joaquin basin or Merced River Fish Facility and did not have a similar affect on marked fish released at Sacramento that originated from Feather River Hatchery.

OCEAN RECOVERY INFORMATION FROM PAST YEARS

Ocean recovery data of CWT salmon groups can contribute to a more thorough understanding and evaluation of salmon smolt survival studies. These data can provide another independent estimate of the ratio of recovery rate of a test release group relative to a control release group. Differential recovery rates using ocean recovery information can be compared with

TABLE 5–10
Survival indices at Antioch and Chipps Island of CWT fish released in the lower Merced and Stanislaus Rivers in 2003. Expanded salvage at the CVP and SWP are also included.

Tag Code	Release Site	Date	Number Released	ANTIOCH Number Recovered	Minutes Fished	Percent Sampled	Survival Index	Group Index
Merced River								
06-44-93	Hatfield State Park (lower Merced)		23274	6	2185	0.379	0.049	
06-44-94	Hatfield State Park (lower Merced)		23872	2	5083	0.392	0.015	
06-44-95	Hatfield State Park (lower Merced)		23833	4	2145	0.372	0.032	
Total		4/16/03	70979	12	6103	0.385		0.032
06-45-64	Hatfield State Park (lower Merced)		24545	0	–	–	–	
06-45-65	Hatfield State Park (lower Merced)		24483	0	–	–	–	
06-45-66	Hatfield State Park (lower Merced)		24358	1	590	0.410	0.007	
Total		4/29/03	73386	1	590	0.410		0.002
06-45-46	Hatfield State Park (lower Merced)		22603	0	–	–	–	
06-45-47	Hatfield State Park (lower Merced)		22714	2	1780	0.412	0.015	
06-45-72	Hatfield State Park (lower Merced)		22649	0	–	–	–	
Total		5/7/03	67966	2	1780	0.412		0.005
Stanislaus River								
06-45-70	Two Rivers		26101	1	580	0.403	0.007	
06-45-71	Two Rivers		26632	3	3392	0.393	0.021	
Total		4/27–4/28/03	52733	4	4512	0.392		0.014

TABLE 5–11
Survival indices at Antioch and Chipps Island for coded wire tag releases made in the upper Merced and Stanislaus Rivers in 2003. Expanded salvage at the CVP and SWP are also included.

Tag Code	Release Site	Date	Number Released	ANTIOCH Number Recovered	Minutes Fished	Percent Sampled	Survival Index	Group Index
Merced River								
06-44-89	Merced River Fish Facility		22677	3	2185	0.379	0.025	
06-44-90	Merced River Fish Facility		22816	1	590	0.410	0.008	
06-44-91	Merced River Fish Facility		22946	2	5108	0.394	0.016	
06-44-92	Merced River Fish Facility		21725	0	–	–	–	
Total		4/13/03	90164	6	6123	0.387		0.012
06-44-96	Merced River Fish Facility		24232	0	–	–	–	
06-44-97	Merced River Fish Facility		23869	0	–	–	–	
06-44-98	Merced River Fish Facility		23757	1	572	0.397	0.008	
06-44-99	Merced River Fish Facility		23950	0	–	–	–	
		4/25/03	95808	1	572	0.397		0.002
06-27-77	Merced River Fish Facility		23590	0	–	–	–	
06-27-78	Merced River Fish Facility		23862	0	–	–	–	
06-44-49	Merced River Fish Facility		23512	1	487	0.338	0.009	
06-44-50	Merced River Fish Facility		24330	0	–	–	–	
Total		5/4/03	95294	1	487	0.338		0.002
Stanislaus River								
06-45-67	Knight's Ferry		25599	1	600	0.417	0.007	
06-45-68	Knight's Ferry		26226	0	–	–	–	
06-45-69	Knight's Ferry		26136	1	560	0.389	0.007	
Total		4/25/03	77961	2	7967	0.395		0.005

CHIPPS ISLAND					Expanded Salvage Numbers	
Number Recovered	Minutes Fished	Percent Sampled	Survival Index	Group Index	CVP	SWP
4	1200	0.278	0.080		12	18
1	400	0.278	0.020		12	9
4	4379	0.276	0.079		12	0
9	4779	0.277		0.060		
0	–	–	–		0	0
2	1460	0.253	0.042		0	0
0	–	–	–		0	6
2	1460	0.253		0.014		
1	400	0.278	0.021		0	0
0	–	–	–		0	0
2	400	0.278	0.041		0	0
3	1200	0.278		0.021		
0	–	–	–		0	0
0	–	–	–		0	0
0				–		

CHIPPS ISLAND					Expanded Salvage Numbers	
Number Recovered	Minutes Fished	Percent Sampled	Survival Index	Group Index	CVP	SWP
1	400	0.278	0.021		24	6
1	400	0.278	0.021		0	0
0	–	–	–		0	6
1	400	0.278	0.022		0	6
3	2800	0.278		0.016		
0	–	–	–		0	0
0	–	–	–		0	0
0	–	–	–		0	0
0	–	–	–		12	0
0				–		
1	400	0.278	0.020		0	0
0	–	–	–		12	0
1	400	0.278	0.020		12	0
2	1600	0.278	0.038		0	6
4	2387	0.276		0.020		
0	–	–	–		0	0
1	400	0.278	0.018		0	0
0	–	–	–		0	0
1	400	0.278		0.006		

These data would indicate that whatever variable affected the survival of upstream released VAMP fish may have affected survival of the lower tributary released fish. It is also likely, that fish released from Merced River Fish Facility into tributaries also were infected with PKD.

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.

absolute survival estimates and the differential or combined differential recovery rates of juvenile salmon recovered at Chipps Island or Chipps Island and Antioch, respectively. The ocean harvest data may be particularly reliable due to the number of CWT recoveries and the extended recovery period.

Adult 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 2002. The ocean CWT recovery data accumulate over a one to four year period after the year a study release is made as nearly all given year-classes of salmon have been either harvested or spawned by age five. Consequently, these data are essentially complete for releases made through 1998 and partially available for CWT releases made from 1999 to 2001.

Differential recovery rates based on ocean recoveries, Chipps Island recoveries or combined differential recovery rates using Antioch and Chipps Island recoveries for salmon produced at the Merced River Hatchery are shown in Table 5-12. 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 – 2001). Releases have been made at several locations: Dos Reis (on the San Joaquin River downstream of the upper Old River junction), 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 5-12.

Results of this comparative analysis of survival estimates and differential recovery rates for Chinook salmon produced in the Merced River Hatchery show: (1) to date, there is general, but variable, agreement between survival estimates and differential recovery rates based on juvenile CWT salmon recoveries in Chipps Island and Antioch trawling and adult recoveries from the ocean fishery, (2) absolute survival estimates using Chipps Island or Antioch recoveries were either lower or similar to estimates based on ocean recoveries, with the exception of first releases in 2001, and (3) additional comparisons need to be made, as more data becomes available from VAMP releases for recoveries at Antioch, Chipps Island, and the ocean fishery. Information on survival of juvenile salmon and the contribution to the adult salmon population will be essential to evaluate the biological benefits of changes in flow and export rates under VAMP.

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 assumed that these actions to improve conditions for the juveniles will translate into greater adult abundance and escapement in future years, especially during low flows, when corresponding adult escapement ($2\,^1/_2$ years later) has been extremely low (SJRG, 2003).

To determine if VAMP in 2003 was successful in targeting the migration period of naturally produced juvenile salmon, catches of unmarked salmon at Mossdale and in salvage at the CVP and SWP facilities were compared prior to and during the VAMP period.

Unmarked Salmon Recovered at Mossdale

The time period for VAMP (April 15 to May 15) was chosen based on historical data that indicated a high percentage of the juvenile salmon emigrating from the San Joaquin tributaries passed into the Delta at Mossdale during that time. The average catch per minute per day of unmarked juvenile salmon caught in kodiak trawling at Mossdale between March 15 and June 30, 2003 is shown in Figure 5-13. Unmarked salmon do not have an adipose clip and could be unmarked fish from the Merced River

FIGURE 5–12

Comparison of Antioch and Chipps Island survival estimates and differential or combined differential recovery rates compared to differential ocean recovery rates. The one to one line is also included.

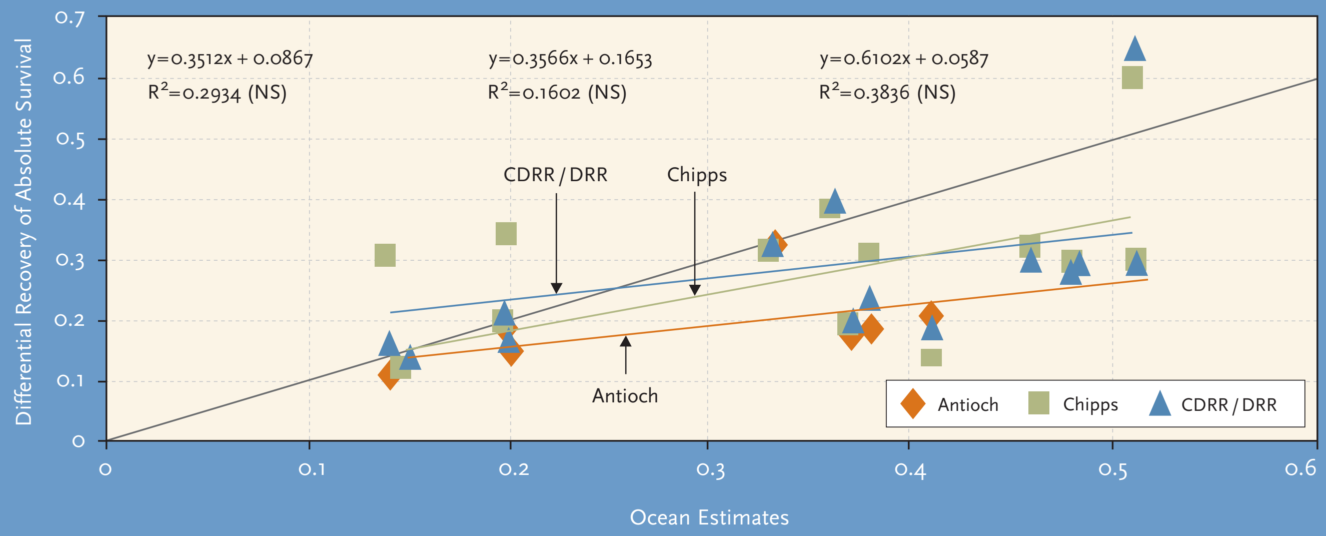


FIGURE 5–13

Standardized catch per cubic meter of all unmarked juvenile Chinook salmon in the Mossdale Kodiak trawl, March 15, 2003 through June 30, 2003.

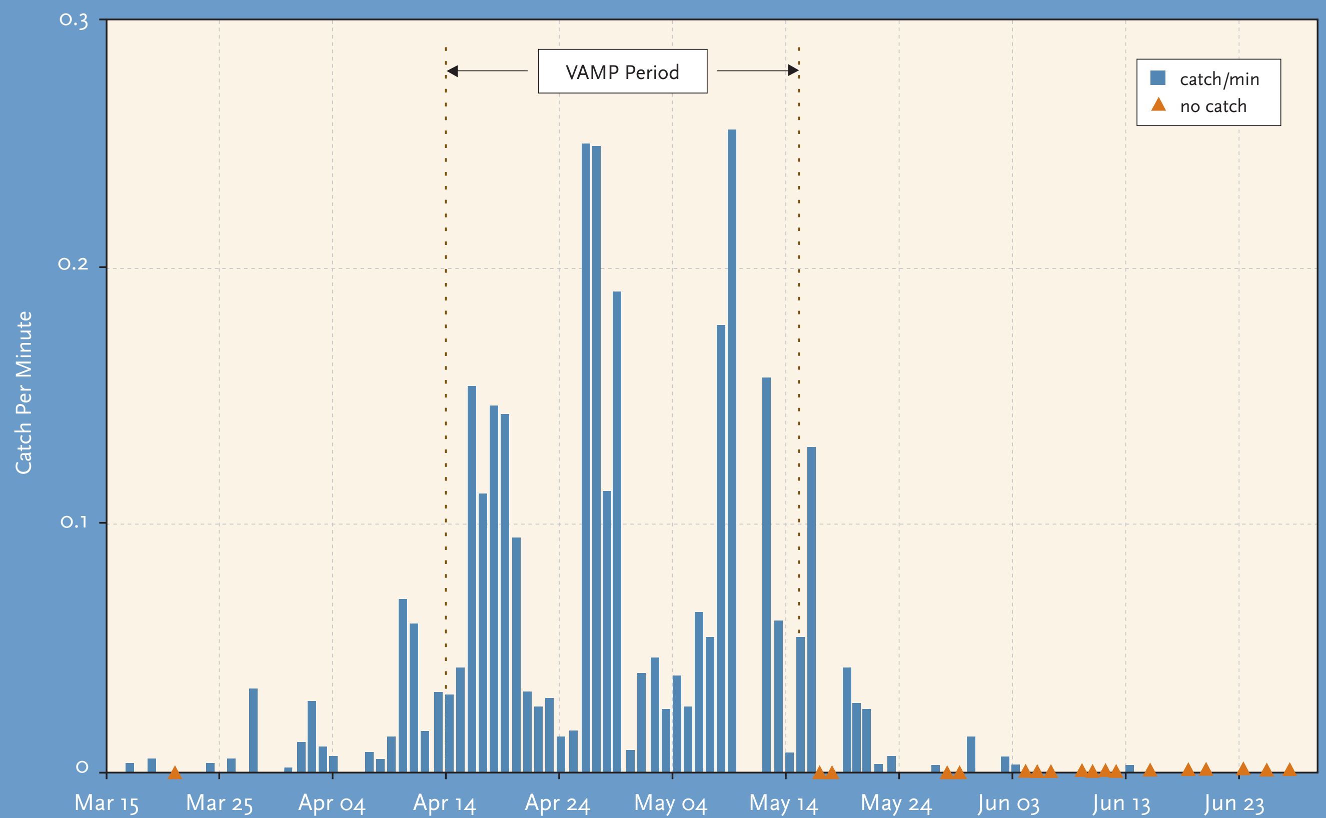


TABLE 5–12

Survival indices based on Chipps Island, Antioch, and ocean recoveries of Merced River Fish Facility salmon released as part of South Delta studies between 1996 and 2001.

Release Year	San Joaquin River (Merced River origin) Tag No.	Release Number (Juvenile Salmon CWT Releases)	Release Site (Juvenile Salmon CWT Releases)	Release Date (Juvenile Salmon CWT Releases)	Chipps Island Recovs.	Antioch Recovs.	Expanded Adult Ocean Recovs. (age 1+ to 4+) Total	Chipps Island (Absolute Survival Estimates)	Antioch (Absolute Survival Estimates)	DRR or CDRR (Differential Recovery Rates)	Ocean Catch (Differential Recovery Rates)
1996	H61110412	25,633	Dos Reis	1 May 96	2		3				
	H61110413	28,192	Dos Reis	1 May 96	3		37				
	H61110414	18,533	Dos Reis	1 May 96	1		8				
	H61110415	36,037	Dos Reis	1 May 96	5		10				
	H61110501	53,337	Jersey Pt	3 May 96	39		187				
	Effective Release	107,961	Dos Reis		11		58	0.12		0.14	0.15
	Effective Release	51,737	Jersey Pt		39		187				
1997	H62545	50,695	Dos Reis	29 Apr 97	9		183				
	H62546	55,315	Dos Reis	29 Apr 97	7		167				
	H62547	51,588	Jersey Pt	2 May 97	27		355				
	Effective Release	106,010	Dos Reis		16		350	0.29		0.29	0.48
	Effective Release	51,588	Jersey Pt		27		355				
	H62548	46,728	Dos Reis	8 May 97	5		91	0.30		0.28	0.48
	H62549	47,254	Jersey Pt	12 May 97	18		192				
1998	61110809	26,465	Mossdale	16 Apr 98	25		61				
	61110810	25,264	Mossdale	16 Apr 98	31		40				
	61110811	25,926	Mossdale	16 Apr 98	32		58				
	61110806	26,215	Dos Reis	17 Apr 98	33		47				
	61110807	26,366	Dos Reis	17 Apr 98	23		35				
	61110808	24,792	Dos Reis	17 Apr 98	34		61				
	61110812	24,598	Jersey Pt	20 Apr 98	87		110				
	61110813	25,673	Jersey Pt	20 Apr 98	100		91				
	Effective Release	77,655	Mossdale		88		159	0.30		0.30	0.51
	Effective Release	77,373	Dos Reis		90		143	0.32		0.31	0.46
	Effective Release	50,271	Jersey Pt		187		201				
1999	062642	24,715	Mossdale	19 Apr 99	8		128				
	062643	24,725	Mossdale	19 Apr 99	15		134				
	062644	25,433	Mossdale	19 Apr 99	13		130				
	062645	25,014	Dos Reis	19 Apr 99	20		151				
	062646	24,841	Dos Reis	19 Apr 99	19		218				
	0601110815	24,927	Jersey Pt	21 Apr 99	34		333				
	062647	24,193	Jersey Pt	21 Apr 99	25		379				
	Effective Release	74,873	Mossdale		36		392	0.38		0.40	0.36
	Effective Release	49,855	Dos Reis		39		369	0.60		0.65	0.51
	Effective Release	49,120	Jersey Pt		59		712				

TABLE 5–12 (continued)

Survival indices based on Chipps Island, Antioch, and ocean recoveries of Merced River Fish Facility salmon released as part of South Delta studies between 1996 and 2001.

Release Year	San Joaquin River (Merced River origin) Tag No.	Release Number	Release Site	Release Date	Chipps Island Recovs.	Antioch Recovs.	Expanded Adult Ocean Recovs. (age 1+ to 4+) Total	Chipps Island	Antioch	DRR or CDRR	Ocean Catch
		Juvenile Salmon CWT Releases						Absolute Survival Estimates		Differential Recovery Rates	
2000	06-45-63	24,457	Durham Ferry	17 Apr 00	11	11	235				
	06-04-01	23,529	Durham Ferry	17 Apr 00	7	6	190				
	06-04-02	24,177	Durham Ferry	17 Apr 00	10	10	225				
	06-44-01	23,465	Mossdale	18 Apr 00	9	14	198				
	06-44-02	22,784	Mossdale	18 Apr 00	9	16	159				
	06-44-03	25,527	Jersey Pt	20 Apr 00	24	50	592				
	06-44-04	25,824	Jersey Pt	20 Apr 00	41	47	617				
	Effective Release	72,163	Durham Ferry		28	27	650	0.31	0.19	0.24	0.38
	Effective Release	46,249	Mossdale		18	30	357	0.31	0.33	0.33	0.33
	Effective Release	51,351	Jersey Pt		65	97	1209				
	601060914	23,698	Durham Ferry	28 Apr 00	7	8	43				
	601060915	26,805	Durham Ferry	28 Apr 00	5	15	36				
	0601110814	23,889	Durham Ferry	28 Apr 00	10	8	70				
	0601061001	25,572	Jersey Pt	1 May 00	48	76	300				
	0601061002	24,661	Jersey Pt	1 May 00	30	76	215				
	Effective Release	74,392	Durham Ferry		22	31	149	0.19	0.14	0.16	0.20
	Effective Release	50,233	Jersey Pt		78	152	515				
2001	06-44-29	23,354	Durham Ferry	30 Apr 01	14	28	4				
	06-44-30	22,837	Durham Ferry	30 Apr 01	22	30	26				
	06-44-31	22,491	Durham Ferry	30 Apr 01	17	18	4				
	06-44-32	23,000	Mossdale	1 May 01	17	18	16				
	06-44-33	22,177	Mossdale	1 May 01	14	15	0				
	06-44-34	24,443	Jersey Pt	4 May 01	50	156	50				
	06-44-35	24,992	Jersey Pt	4 May 01	61	173	72				
	Effective Release	68,682	Durham Ferry		53	76	34	0.34	0.17	0.21	0.20
	Effective Release	45,177	Mossdale		31	33	16	0.31	0.11	0.16	0.14
	Effective Release	49,435	Jersey Pt		111	329	122				
	06-44-36	24,025	Durham Ferry	7 May 01	2	8	5				
	06-44-37	24,029	Durham Ferry	7 May 01	5	11	9				
	06-44-38	24,177	Durham Ferry	7 May 01	2	10	4				
	06-44-39	23,878	Mossdale	8 May 01	4	8	11				
	06-44-40	25,308	Mossdale	8 May 01	4	11	0				
	06-44-41	25,909	Jersey Pt	11 May 01	17	43	18				
	06-44-42	25,465	Jersey Pt	11 May 01	27	53	13				
	Effective Release	72,231	Durham Ferry		9	29	18	0.13	0.20	0.19	0.41
	Effective Release	49,186	Mossdale		8	19	11	0.19	0.18	0.20	0.37
	Effective Release	51,374	Jersey Pt		44	96	31				

Note: Ocean recoveries are based on data through 2002

FIGURE 5–14

Individual fork lengths (mm) of all unmarked juvenile Chinook salmon in the Mossdale Kodiak trawl, March 15, 2003 through June 30, 2003.

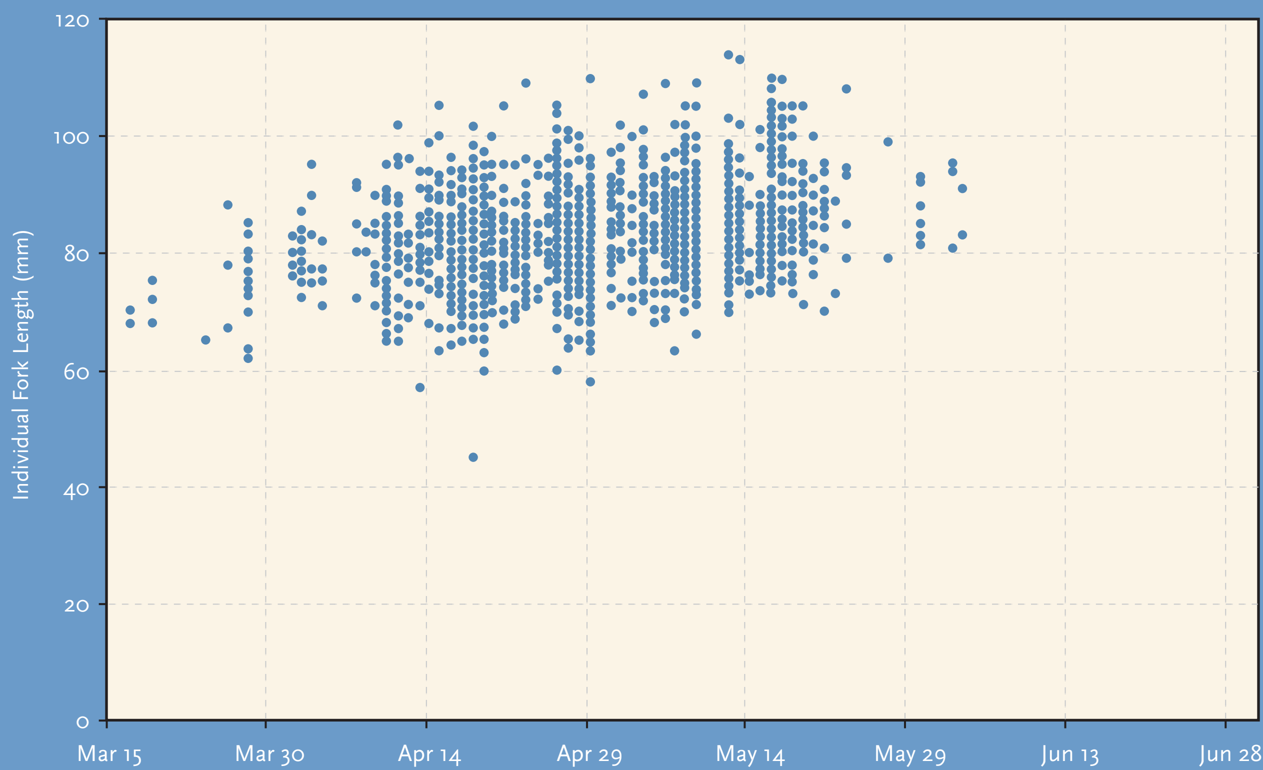
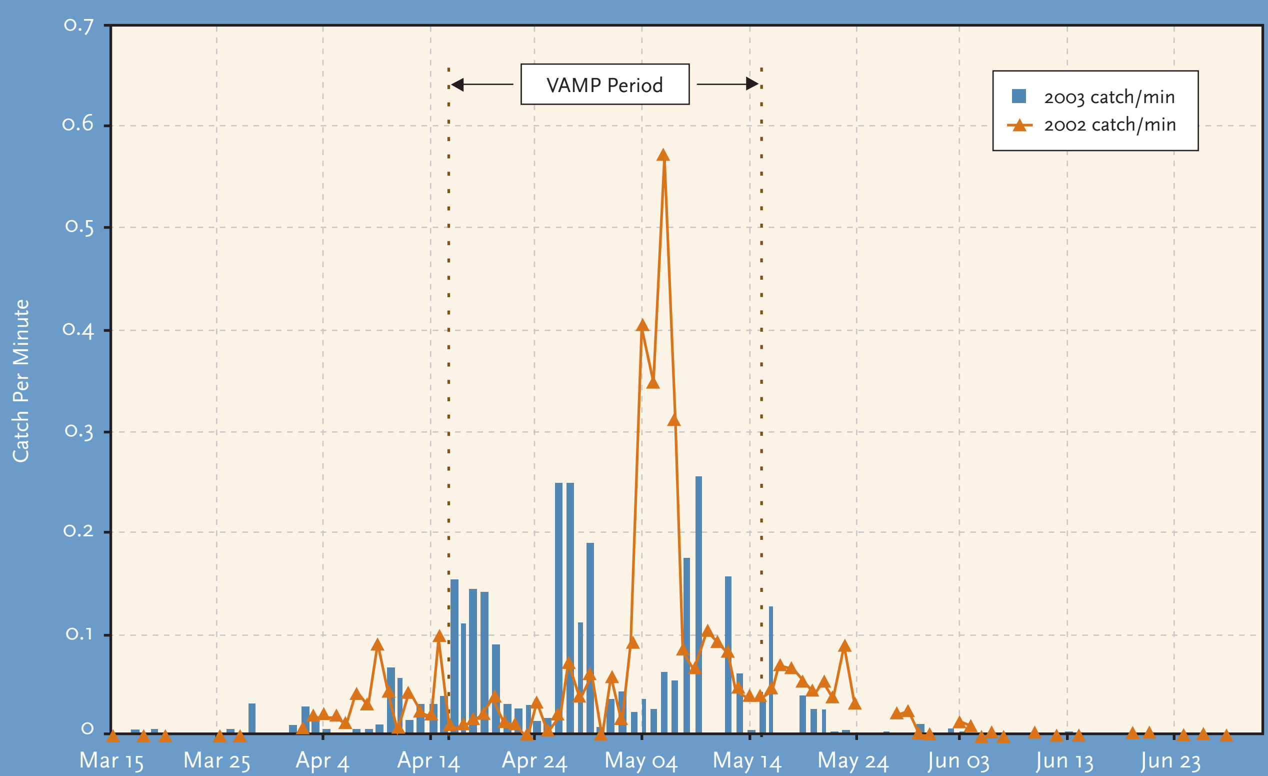


FIGURE 5–15

Standardized catch per minute of all unmarked juvenile Chinook salmon in the Mossdale Kodiak trawl, March 15 through June 30, 2002 and 2003.



Fish Facility or juveniles from natural spawning. Approximately 80% of the unmarked catch that passed Mossdale between March 15 and June 30 passed during the VAMP period: April 15 to May 15. The size of the juvenile salmon migrating past Mossdale between March 15 and June 30, 2003 is shown in Figure 5-14.

The pattern of unmarked juvenile salmon caught at Mossdale in 2003 was different than that observed in 2002, and did not obviously show that the number of fish passing Mossdale was less in 2003 than it was in 2002 (Figure 5-15). The peak in early May of 2002 was greater than any peak observed in 2003, but catches in 2003 were greater than 2002 during other times.

Salmon Salvage and Losses at Delta Export Pumps

Fish salvage operations at the CVP and SWP export facilities capture unmarked salmon for transport by tanker truck and release them downstream in the western Sacramento – San Joaquin Delta. The untagged salmon are either naturally produced or untagged hatchery salmon, 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 CWT recovery data for Merced River Fish Facility smolts at the facilities to provide some general indications.

The salvage at the facilities is based on expansions from sub-samples taken throughout the day. Four to five salmon are estimated to be lost per salvaged salmon in the SWP Clifton Court Forebay based on high predation rates. The CVP pumps divert directly from the Old River channel and the loss estimates range from about 50 to 80% of the number salvaged, or about six to eight times less per salvaged salmon than for the SWP. The loss estimates do not include any indirect mortality in the Delta due to water export operations, additional mortality associated with trucking and handling, or post-release predation. Salvage density of salmon is the number of salvaged salmon per acre-foot of water pumped. The California Department of Water Resources maintains 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 the best indicator of when concentrations of juvenile salmon are most susceptible to the export facilities and salvage system.

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.

The weekly data covering the period of April 13 to May 17 encompassed the 2003 VAMP period. A review of weekly data for March through May indicates that the highest salvage and losses occurred during the three weeks prior to VAMP (period of March 23 to April 12), with the exception of the highest CVP losses being recorded in the second VAMP week, April 20 to 26 (Figures 5-16 and 5-17). Combined CVP and SWP weekly export rates during those three weeks proceeding VAMP averaged 7,500 – 10,900 cfs (Figure 5-18). Salmon density was highest in the second week of the VAMP period at both the CVP and SWP facilities, and continued to be relatively high during the VAMP period (Figure 5-19), indicating the VAMP export reductions were in place when the density of salmon was the highest. Based on comparisons with Mossdale data in Figure 5-13, it appears that most of the salmon salvaged in early April may not have been of San Joaquin basin origin. Reducing exports earlier in April may provide better conditions for juvenile spring-, winter-, and fall- run Chinook salmon migrating through the Delta from the Sacramento River basin.

The size distribution of unmarked salmon during April and May in the Mossdale trawl (Figure 5-14) is a subset of the size distribution of those salvaged at the fish facilities (Figure 5-20: Source E. Chappell, DWR). In 2003, the fish facilities salvaged some juvenile salmon between March 15 and early May that were larger (winter run sized) than any observed at Mossdale.

Results of these analyses showed that the 2003 VAMP test period coincided with much of the peak period of San Joaquin River salmon smolt emigration. Reductions in SWP and CVP exports and increased San Joaquin River flow likely provided improved conditions for salmon survival, although starting the VAMP period two to three weeks earlier may have had substantial benefits for other salmon races and stocks.

FIGURE 5–16

2003 SWP salmon salvage and loss.

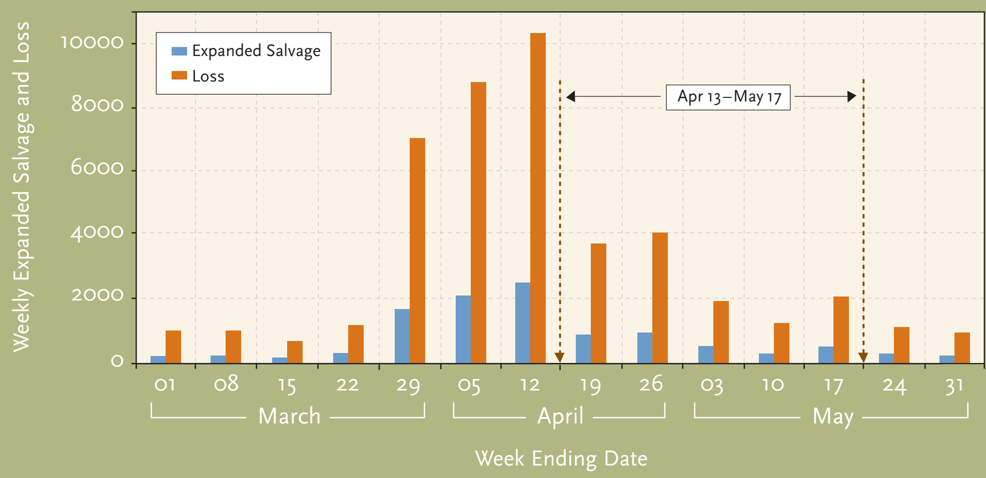
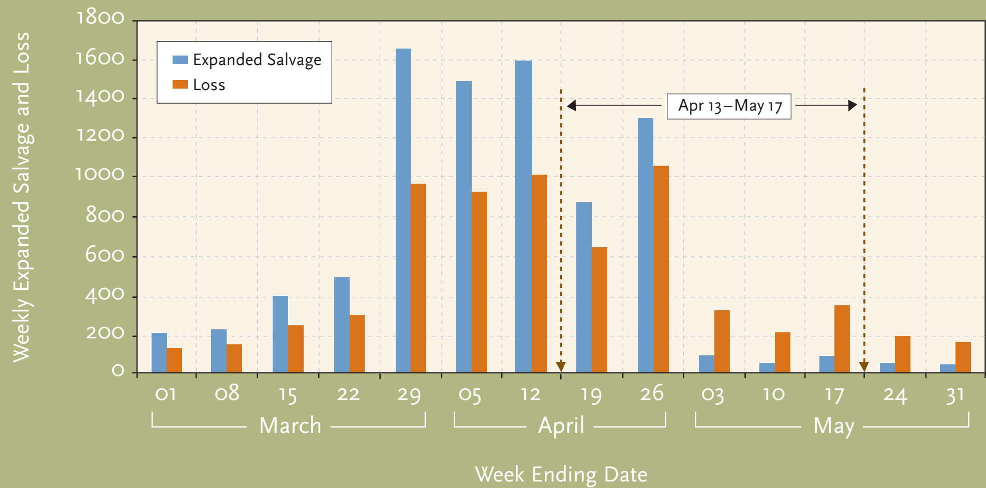


FIGURE 5–17

2003 CVP salmon salvage and loss.



SUMMARY AND RECOMMENDATIONS

The survival estimates and CDRRs measured in 2003 were low compared to past years. It is unclear why survival in 2003 was so low but it does not seem to be directly related to San Joaquin River flow, CVP and SWP exports or water temperature. The hatchery fish were infected with the parasite that causes PKD. Fish have been infected in past VAMP study years and it does not appear that the incidence of PKD was actually higher in 2003. However, the combination of the lower flows and PKD infection may have affected the mortality of the VAMP fish in 2003 resulting in shorter transit duration and higher mortality relative to past VAMP releases.

Some rain occurred during the studies, which was somewhat unusual, and possibly agricultural and/or urban run-off from the storm caused mortality, but a toxic event due to storm-water run-off should be episodic and not be a long-term event affecting all the releases made at Merced River Fish Facility over a three week period. The high and similar mortality of the tributary CWT groups released from Merced River Fish Facility indicates that whatever increased the mortality of the VAMP fish was some condition that was common to the Merced River Fish Facility (with the exception of the Jersey Point releases) and lasted for several weeks. This condition also appeared to be restricted to the Delta or differences in the survival indices for the upstream

FIGURE 5–18

2003 weekly SWP/CVP export rates and Vernalis flow.

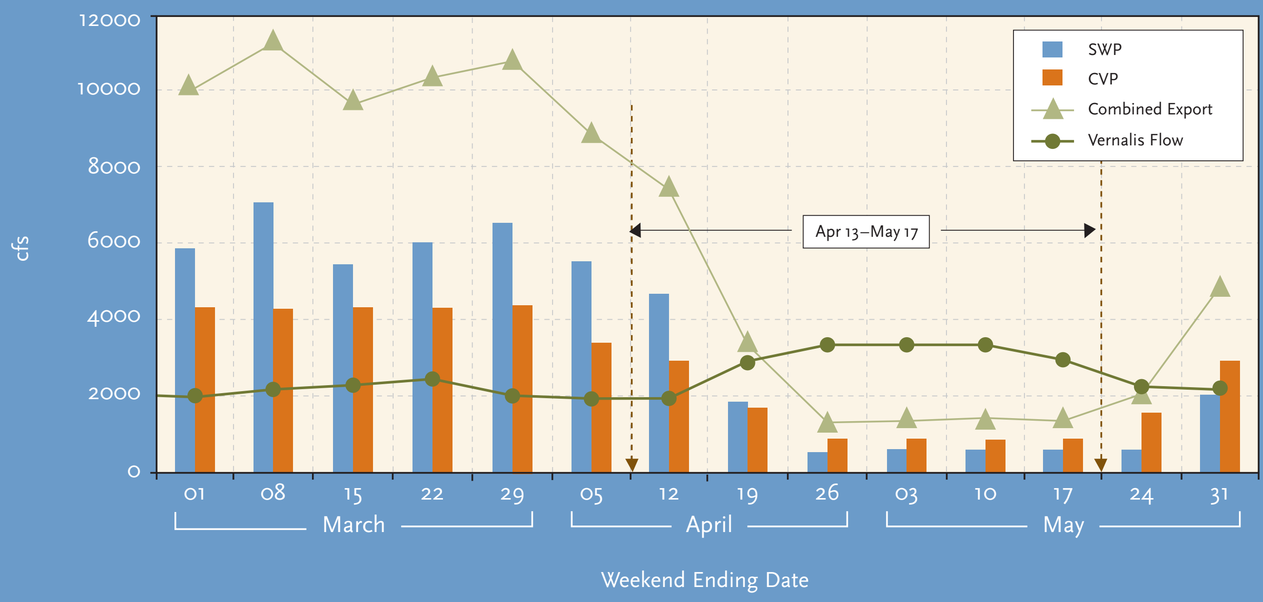


FIGURE 5–19

2003 SWP/CVP expanded salmon salvage density.

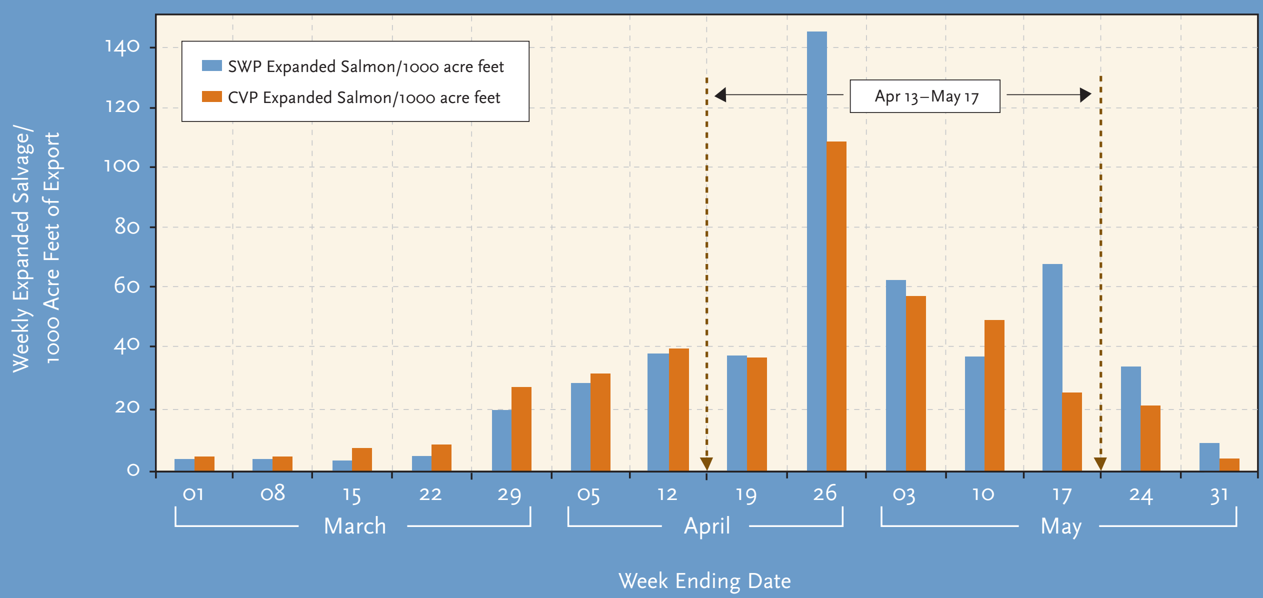
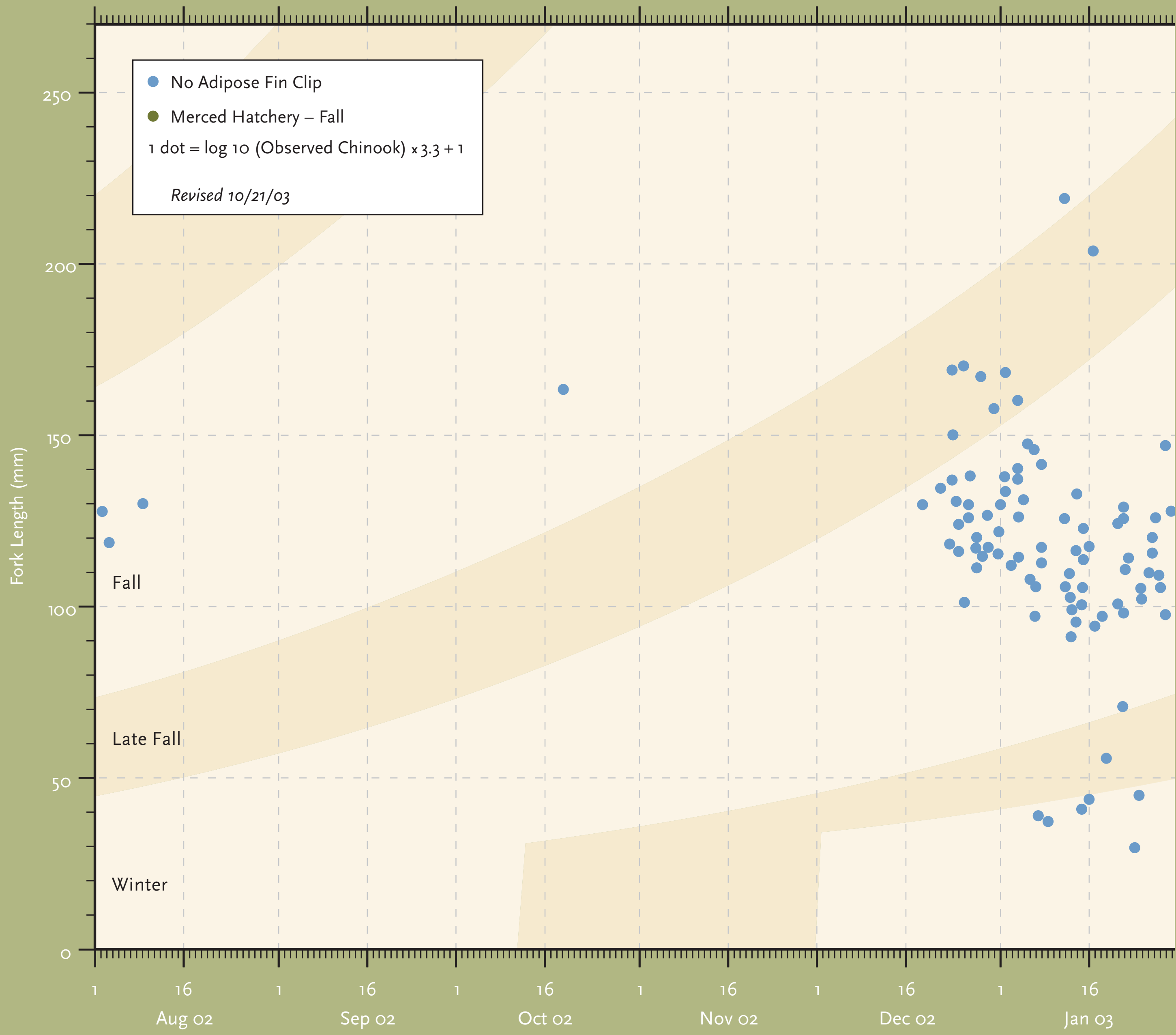
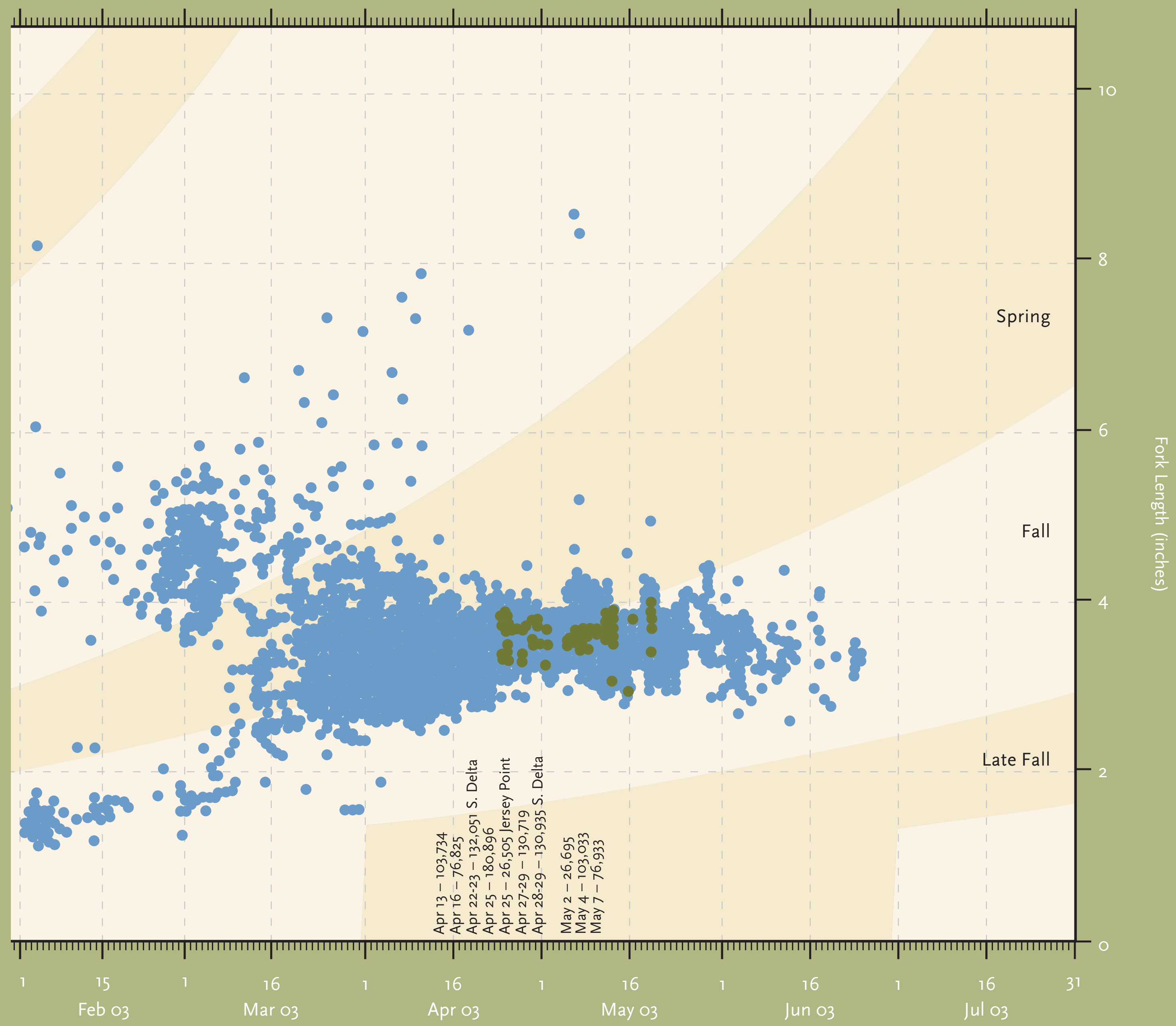


FIGURE 5–20

Observed Chinook Salvage at the SWP & CVP Delta Fish Facilities 8/1/02 through 7/31/03





Spring
Fall
Late Fall
Fork Length (inches)
0
2
4
6
8
10
Apr 13 – 103,734
Apr 16 – 76,825
Apr 22-23 – 132,051 S. Delta
Apr 25 – 180,896
Apr 25 – 26,505 Jersey Point
Apr 27-29 – 130,719
Apr 28-29 – 130,935 S. Delta
May 2 – 26,695
May 4 – 103,033
May 7 – 76,933
1
15
Feb 03
1
16
Mar 03
1
16
Apr 03
1
16
May 03
1
16
Jun 03
1
16
Jul 03
31

and downstream tributary releases would have been greater. While the causes are unclear, it would appear the VAMP data in 2003 are outliers and repeating the study in future years will determine if this anomaly is limited to 2003 or is a change in overall conditions.

Even without the 2003 data, there have been several impediments to defining and refining the relationships between smolt survival and San Joaquin River flow and CVP and SWP exports. These impediments have been discussed in this and previous VAMP reports. The different permeability of the HORB and not having estimates of flow in the San Joaquin River downstream of the barrier add noise to our estimates of flow. In addition, using diseased hatchery fish in VAMP experiments adds a potential bias to our estimates of survival, even though PKD is also present in wild stocks (Ken Nichols, USFWS internal memo, 12/6/02). Measuring survival within the narrowly defined flow and export VAMP targets further exacerbates the problem of noise in the variables of interest. The level of precision of our survival estimates and the noise in flow measurements limits our ability to precisely define the relationship of survival to flow and exports. Yearly, pooled estimates are now based on releases of 300,000 to 400,000 fish with two recovery locations, sampling roughly seven to ten hours per day, yet recoveries have not been great enough to statistically differentiate between survival estimates measured at VAMP target flow and exports levels obtained to date. Differences in survival may be occurring but our ability to detect them is limited.

To address this dilemma, future studies should prioritize measuring survival at the highest VAMP target flow and lowest export levels. Flows of 7000 cfs and exports of 1500 cfs would achieve the highest inflow to export ratio (4.7) within the VAMP design and provide a new target to test. Based on information to date, the higher flow would be probably increase survival and may lessen any effects or infection rate of PKD. The higher survival should increase recovery numbers such that CDRRs and confidence intervals may show statistical differences when compared to previously obtained CDRRs. It is uncertain how such a condition can be prescribed, independent of the hydrology, within the existing San Joaquin River Agreement, but the idea should be explored by the VAMP Management Team.

Further confidence in defining and refining the relationship of smolt survival to flow and exports could be obtained by increasing the length of the study. The fourth year of VAMP was completed in 2003 with eight years remaining in the study. Additional replication can resolve uncertainty when variation is high.

Continued assessment of past data is also recommended such that other methodologies or criteria for determining statistical differences between groups may be developed.

Even without the 2003 data, there have been several impediments to defining and refining the relationships between smolt survival and San Joaquin River flow and CVP and SWP exports.

CHAPTER 6

Complimentary Studies Related to the VAMP

Throughout 2003 several fishery studies were conducted that were considered to be important to the overall understanding of the salmon life cycle and survival in the San Joaquin River. These are presented below to provide the reader with summary information on each study. More information can be obtained from each study manager or report author.

SURVIVAL ESTIMATES FOR CWT RELEASES MADE IN THE SAN JOAQUIN TRIBUTARIES

contributed by Pat Brandes, U.S. Fish and Wildlife Service

As discussed previously, CWT salmon releases were made in the San Joaquin River tributaries between April 13 and May 7 as part of independent (complimentary) fishery investigations. Three sets of releases were made in the upper Merced River (Merced River Fish Facility) and lower Merced River (Hatfield State Park). One additional set of CWT salmon were also released in the upper (Knights Ferry) and lower (Two Rivers) Stanislaus River.

Group survival indices for salmon released in the tributaries and recovered at Antioch ranged between 0.002 and 0.032 (Tables 5-10 and Table 5-11). Group survival indices ranged between 0.014 and 0.060 to Chipps Island (Tables 5-10 and 5-11). These indices were similar to those in 2002, but much lower than in 2001, where indices ranged from 0.03 to 0.20. Vernalis flow targets were lower in 2002 and 2003 than in 2001 (3300 cfs vs. 4200 cfs). The tributary flows were also likely lower. No recoveries at Chipps Island were made for the second upper Merced and lower Stanislaus releases.

Comparison of survival indices of the upstream tributary groups relative to the downstream groups provides an estimate of survival through the tributaries. The survival estimates through the tributaries are provided in Table 6-1. Survival through the Merced River ranged between 0.26 and 0.96, although there were instances where no recoveries were made at Chipps Island. Survival through the Stanislaus was estimated at 0.34 using Antioch recoveries. No recoveries were made of the lower Stanislaus group at Chipps Island. It appeared survival through the tributaries was generally high using this method of comparison. Confidently estimating survival through the tributaries, is not likely using this method because the number of recoveries is so low.

CWT smolts released on the tributaries took between 7 to 22 days to arrive at Antioch and 8 and 16 days to arrive at Chipps Island. The groups released on the Stanislaus appeared to take the longest to arrive at Antioch and Chipps Island. Information on the transit time between release and recovery of the CWT groups released in the San Joaquin River mainstem and tributaries at both Antioch and Chipps Island is summarized in Appendix C-5. As observed for VAMP releases, recovery times were generally similar between Antioch and Chipps Island for the various groups released upstream in the mainstem San Joaquin and tributaries.

EVALUATION OF CHINOOK SALMON FRY SURVIVAL IN THE STANISLAUS RIVER: BIOLOGICAL RESPONSE TO SUPPLEMENTAL WINTER FLOW PULSE

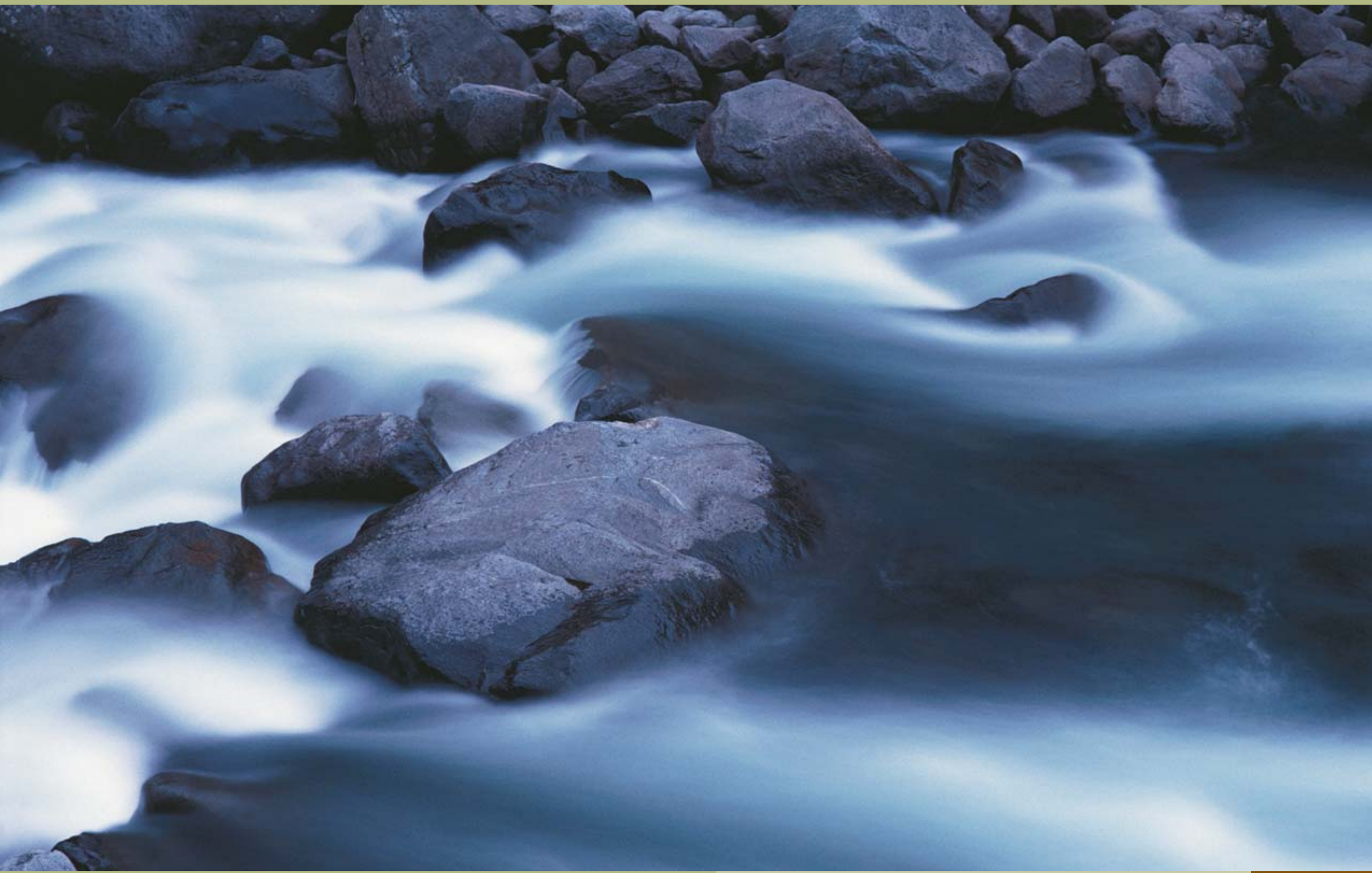
contributed by Doug Demko, S.P. Cramer Consultant

Previous monitoring of juvenile salmon migration (1998–2002) from the Stanislaus River at Oakdale (RM 40.1) and Caswell (RM 8.6) indicates that survival of fall-run Chinook salmon fry (<45mm fork length) is greater under moderate winter flow conditions than under low winter flows. During intermediate to wet years (1998 through 2000), 75% or more of fry migrants passing Oakdale also passed Caswell during pulse flow events above 750 cfs. Flow pulses included natural freshets (i.e., short pulses in flow due to a rainfall event) and flood control releases. During dry years (i.e., 2001 and 2002), relatively small changes

TABLE 6-1

Survival indices and absolute survival estimates through the tributaries using recoveries at Antioch and Chipps Island for coded wire tagged smolts released as part of San Joaquin tributary studies in the spring of 2003.

Release Site	Date	Antioch Survival Indices	Antioch Absolute Survival	Chipps Survival Indices	Chipps Absolute Survival
Merced River Fish Facility (upper Merced)	4/13/03	0.012	0.38	0.016	0.26
Hatfield State Park (lower Merced)	4/16/03	0.032		0.060	
Merced River Fish Facility	4/25/03	0.00189	0.79	–	–
Hatfield State Park	4/29/03	0.00239		0.014	
Merced River Fish Facility	5/04/03	0.002	0.43	0.01977	0.96
Hatfield State Park	5/07/03	0.005		0.02064	
Knight's Ferry (upper Stanislaus)	4/25/03	0.005	0.34	0.006	–
Two Rivers (lower Stanislaus)	4/27–4/28/03	0.014		–	



The objective of the flow experiment in the Stanislaus River during 2003 was to determine whether fry survival during dry or low flow years could be increased by managed flow pulses in winter.

in flow (e.g., 50 cfs) and turbidity had the ability to stimulate fish migration past Oakdale, however, less than 10% migrated as far downstream as Caswell. In years when low proportions of fry were observed passing between Oakdale and Caswell, there was no corresponding increase in the proportion of parr (45–70mm) and smolts (>70mm) passing between the two sites which indicates that fry did not rear in the river below Oakdale and subsequently migrate as older fish. Rather, in-river fry survival during these dry years was reduced. Although high winter flows during intermediate to wet years were found to increase fry migration and survival past Caswell, the subsequent fate of fry downstream in the San Joaquin River and Delta is unknown. In addition, it is uncertain whether high supplemental flows provided during dry years would result in increased in-river and/or downstream survival.

The objective of the flow experiment in the Stanislaus River during 2003 was to determine whether fry survival during dry, or low, (i.e., no natural freshets in excess of 1,000 cfs) flow years could be increased by managed flow pulses in winter. The purpose of the study was to evaluate whether a supplemental winter flow of approximately 1,000 cfs during a dry year could both stimulate and sustain fry migration out of the Stanislaus River. The effectiveness of artificial freshets at increasing in-river fry survival was determined by estimating the proportion of fry that passed Caswell after passing Oakdale. Potential mortality through the San Joaquin River and Delta was assessed from fry salvage and loss rates at the CVP and SWP Delta export facilities during 1998–2003.

Studies of juvenile outmigration in 1998–2002 indicated that flow increases to less than 750 cfs for 1 to 2 days during January and February, stimulated fry passage at Oakdale, but few fish subsequently reached Caswell 31.5 miles downstream. In contrast, short duration flow increases above 750 cfs resulted in increased fry passage past both Oakdale and Caswell indicating that more than 750 cfs is needed to sustain fry migration from the upper river through the lower river and past Caswell (Table 6-2). In addition, fry migration past Caswell begins within 1 to 2 days of initial flow increases during a pulse event and peak passage typically occurs within 3 days.

In addition to flow fluctuations, turbidity was considered to be an important factor in stimulating migration and protecting outmigrants from predators (Gregory and Levings 1998, Ginetz and Larkin 1976). In dry years on the Stanislaus River, some turbidity is created by run-off, but is typically 25% or less of that created by run-off in wet years. Therefore, the 2003 flow experiment was intended to occur simultaneously with a rain event to take advantage of turbidity created by natural run-off.

During 2003, circumstances (i.e., hydropower facility maintenance) did not allow the experiment to coincide with a rain event as originally designed. Instead, the 2-day experiment began in late January when daily average flow, as measured at Goodwin Dam (RM 58.5), was increased from 280 cfs on the 26th to 1,003 cfs on the 28th and ramped down to 350 cfs by

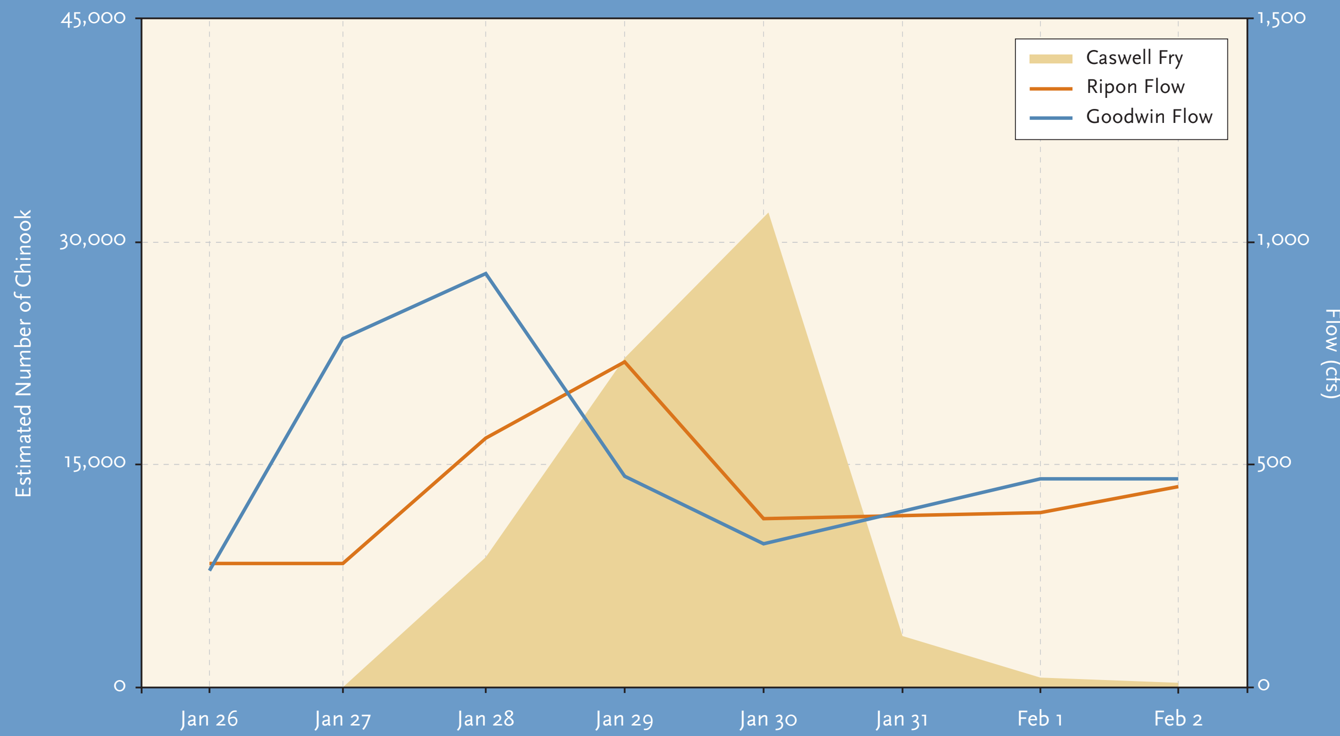
TABLE 6–2

Observed Fry Response to Freshet Flows at Oakdale and Caswell during 1998 to 2002.

Daily Average Pulse Flow	Pulse Flow Duration	Fry Response
< 750	1 Day	Substantial passage at Oakdale No passage at Caswell
750	1 Day	Substantial pass at Oakdale Increased passage at Caswell
750 to 1,500	2 Days	Substantial passage at Oakdale Substantial passage at Caswell

FIGURE 6–1

2003 Supplemental pulse flow event of 1,000 cfs released from Goodwin Dam (RM58.4) including corresponding flows at Ripon (RM15.8) and fry passage at Caswell (RM8.6).



the 30th (Figure 6-1). Flow at Ripon followed a similar pattern, with a one day lag. Turbidity was measured at Ripon on the 29th and 30th and was 8.2 and 4.1 NTUs, respectively. Water temperature at Ripon decreased from 54.6°F on the 28th to 52.1°F on the 30th.

Throughout the 2003 supplemental flow period, rotary screw traps at Oakdale and Caswell were monitored frequently to ensure proper trap function and limit overcrowding of captured fish. Catch at Caswell increased within 1 day and peaked in 3 days of the beginning of the 2 day pulse event (Figure 6-1). When flows began to decrease, passage dropped sharply, but did not drop as low as levels observed in 2001 and 2002. During 2003, an estimated total of 79,137 fry moved past Caswell compared with fry passage in other low flow winters such as 6,376 in 2001 and 4,470 in 2002. However, in high flow winters, estimated totals of 809,614 fry and 1,018,946 fry moved past Caswell in 2000 and 1999, respectively. During January 2003, the artificial pulse flow and corresponding migratory response were similar in magnitude and duration to a natural (i.e., freshet) pulse flow event that occurred during January 2000, which indicates that managed flow releases from reservoir storage can stimulate fry migration comparable to natural flows with similar characteristics.

Passage estimates for 2003 suggest that 5.1% of fry passing Oakdale also passed Caswell as fry. This represents approximately a five to 12-fold increase in the proportion of fry that reached Caswell during the same period in previous dry years including 2001 (0.9%) and 2002 (0.4%). Passage estimates indicate that providing supplemental winter flow releases of at least 750 cfs for 2 days stimulates and sustains migration of some fry past Caswell.

While the flow test indicates that additional fry can be moved out of the Stanislaus River, it still remains to be determined whether those fry survive to smolt through the Delta in a low flow year. Based on fish salvage and loss data at the CVP and SWP Delta export facilities from 1998–2002, large numbers of

FIGURE 6–2

Passage of fall-run Chinook salmon fry in 1998 at Caswell and salvage/loss at the CVP and SWP Delta facilities.

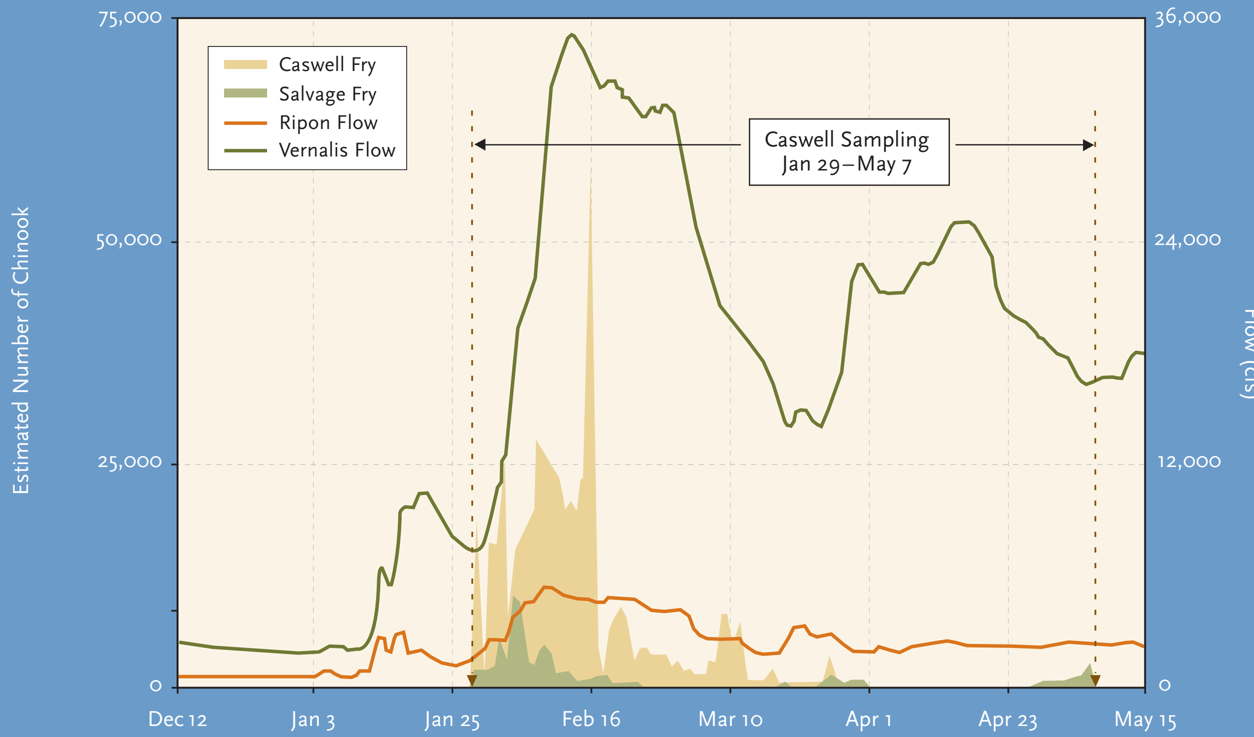
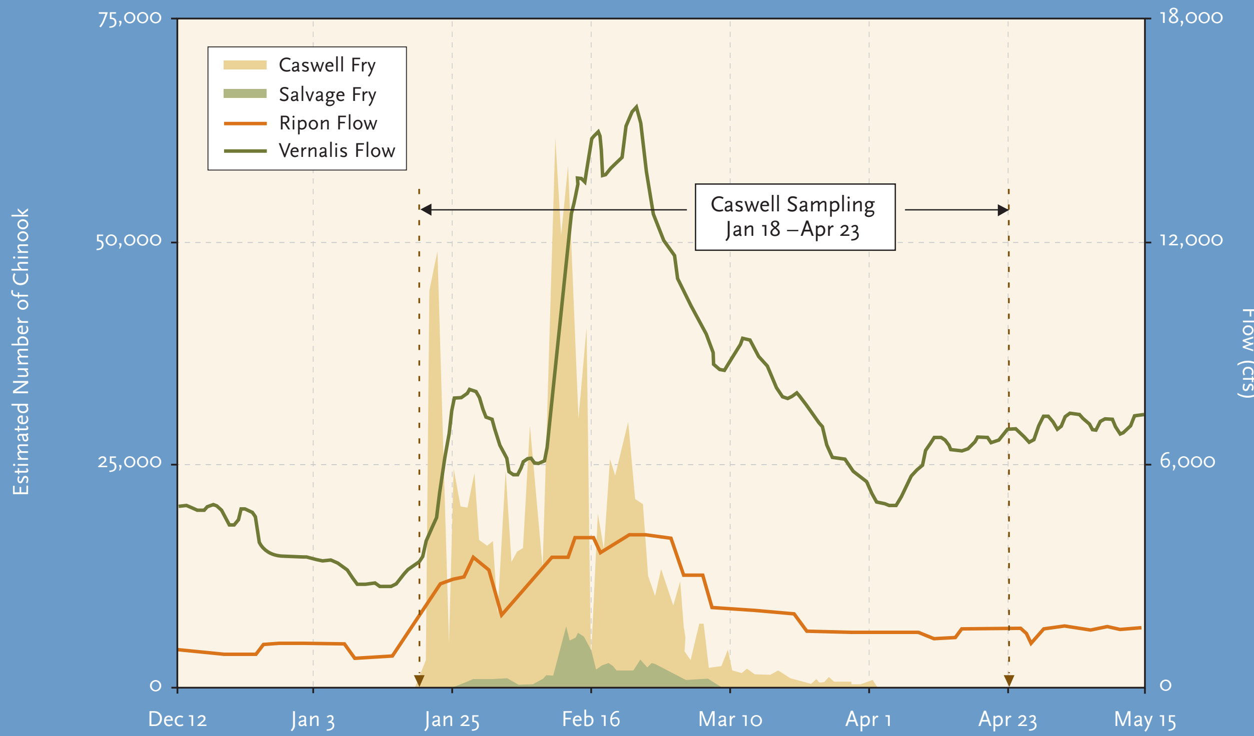


FIGURE 6–3

Passage of Fall-run Chinook salmon fry in 1999 at Caswell and salvage/loss at the CVP and SWP Delta facilities.



fry typically arrive at the facilities during intermediate and wet water years (i.e., 83,029 in 1998; 70,948 in 1999; and 82,299 in 2000) but not in dry years (i.e., 2,123 in 2001; 718 in 2002; and 2,604 in 2003). Although the origin of fry arriving at the Delta facilities can not be confirmed, the observed peaks in fry salvage and loss in intermediate/wet years typically occur within 6 to 14 days after initial flow increases in the Stanislaus River during pulse flow events, and within 2 to 8 days of associated Caswell outmigration peaks (Figures 6-2 thru 6-7).

In 2003, the total fry salvage and loss at the Delta CVP and SWP facilities was 2,604 which is similar to other dry years. However, a majority (i.e., 2,130) were observed between 5 to 10 days following the initial Stanislaus River pulse flow, with the peak (i.e., 1,202) occurring within 7 days of the pulse. This correspondence in timing of fry passage indicates that fry observed at the Delta facilities from February 1 to 6 can be attributed to the Stanislaus River. Further, the data indicate fry were able to successfully migrate from the Stanislaus River, through the lower San Joaquin River, and into the Delta. However, the large numbers of fry observed at the Delta facilities still leave open the possibility that fry during these low flow conditions may not survive in the Delta until they reach the smolt stage.

Since fry were not tagged for this experiment, it is impossible to estimate fry survival through the Delta at this time. Although this evaluation determined that fry can be stimulated to migrate out of the Stanislaus River in dry years with artificial flow releases around 1,000 cfs, additional supplemental winter pulse flow experiments are recommended with the development and implementation of a coordinated fry coded-wire tagging program. Such a program is suggested in order to estimate survival of fry through the Delta and ocean stage of the salmon lifecycle. The long-term survival and relative contribution of fry to the population can only be ascertained through a permanent tagging and recovery program.

RADIO TAGGING STUDIES IN THE LOWER SAN JOAQUIN RIVER

contributed by David Vogel, Natural Resources Scientists, Inc.

During April and May 2003, Natural Resource Scientists, Inc. released and monitored radio-tagged juvenile Chinook salmon in the lower San Joaquin River. Field data collection for this project was designed to acquire information on specific behavior (movements) as juvenile Chinook salmon migrated through delta channels just prior to and during VAMP implementation. The 2003 study expanded upon the techniques NRS developed in prior studies on juvenile salmon using radio telemetry, including recent studies at the Delta Cross Channel and the north, south and central Delta regions.

Juvenile Chinook salmon with surgically-implanted miniature (1 gram) radio transmitters were released in the San Joaquin River near Fourteen-Mile Slough (downstream of Stockton). Twelve to 13 radio-tagged salmon were released on each of the following dates: April 8 (pre-VAMP), April 15, April 22, and April 29 (during VAMP). The radio-tagged fish were tracked for 4 days after release using mobile receivers on two inboard jet boats. Individual fish movements, migration rates, and behavior in response to tidal cycles and flow splits in Delta channels were important parameters assessed from field observations. In particular, the project was intended to evaluate what occurs during the telemetered salmon migration past the flow splits at Turner Cut, Columbia Cut, and lower Middle and Old rivers. Each time a radio-tagged fish was located, the exact position (via GPS), time, and any relevant biological and behavioral observations were recorded. Figures 6-8 through 6-11, and show preliminary data on locations of radio-tagged juvenile Chinook salmon released and tracked in the Delta during the four weeks of experiments.

A report on this project will be completed after receipt of DWR tidal flow data measured in the San Joaquin River near Rough and Ready Island.

FIGURE 6–4

Passage of Fall-run Chinook salmon fry in 1999 at Caswell and salvage/loss at the CVP and SWP Delta facilities.

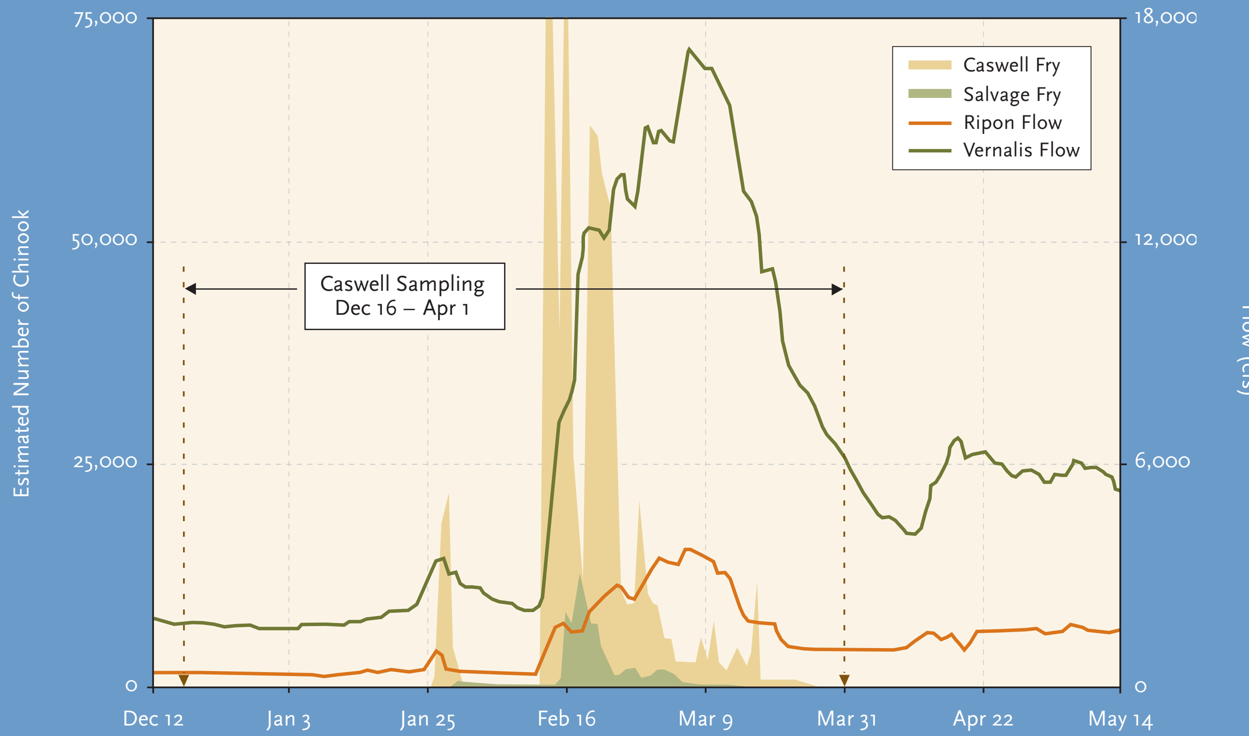


FIGURE 6–5

Passage of fall-run Chinook salmon fry in 2001 at Caswell and salvage/loss at the CVP and SWP Delta facilities

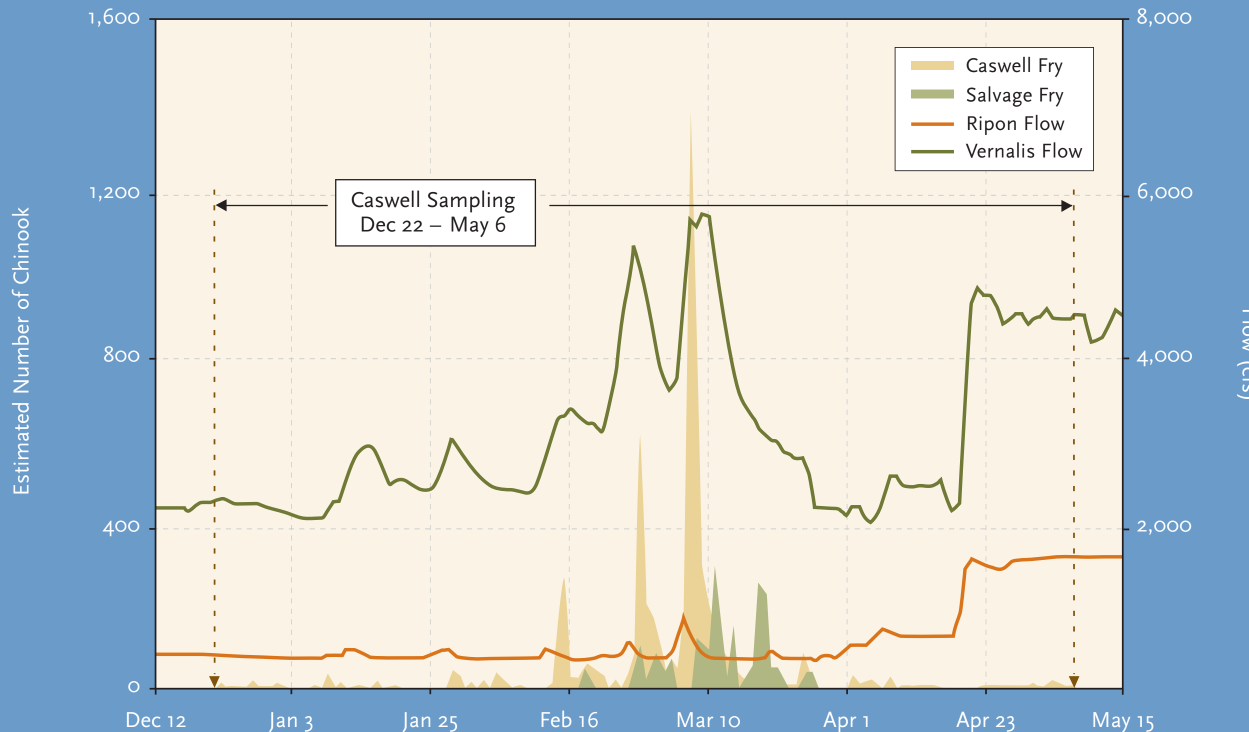


FIGURE 6–6

Passage of fall-run Chinook salmon fry in 2001 at Caswell
and salvage/loss at the CVP and SWP Delta facilities

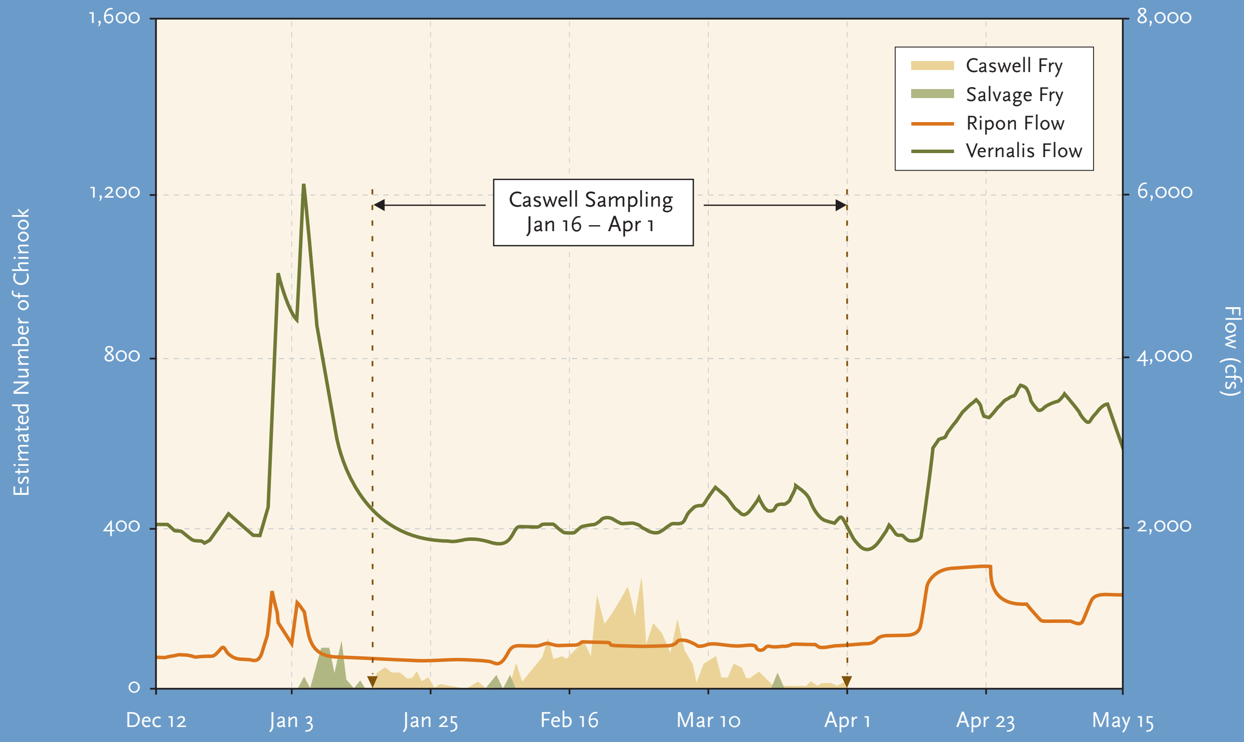


FIGURE 6–7

Passage of fall-run Chinook salmon fry in 2003 at Caswell
and salvage/loss at the CVP and SWP Delta facilities.
Fry passage at Caswell on Feb 14 was 145,565 and 94,358 on Feb 16.

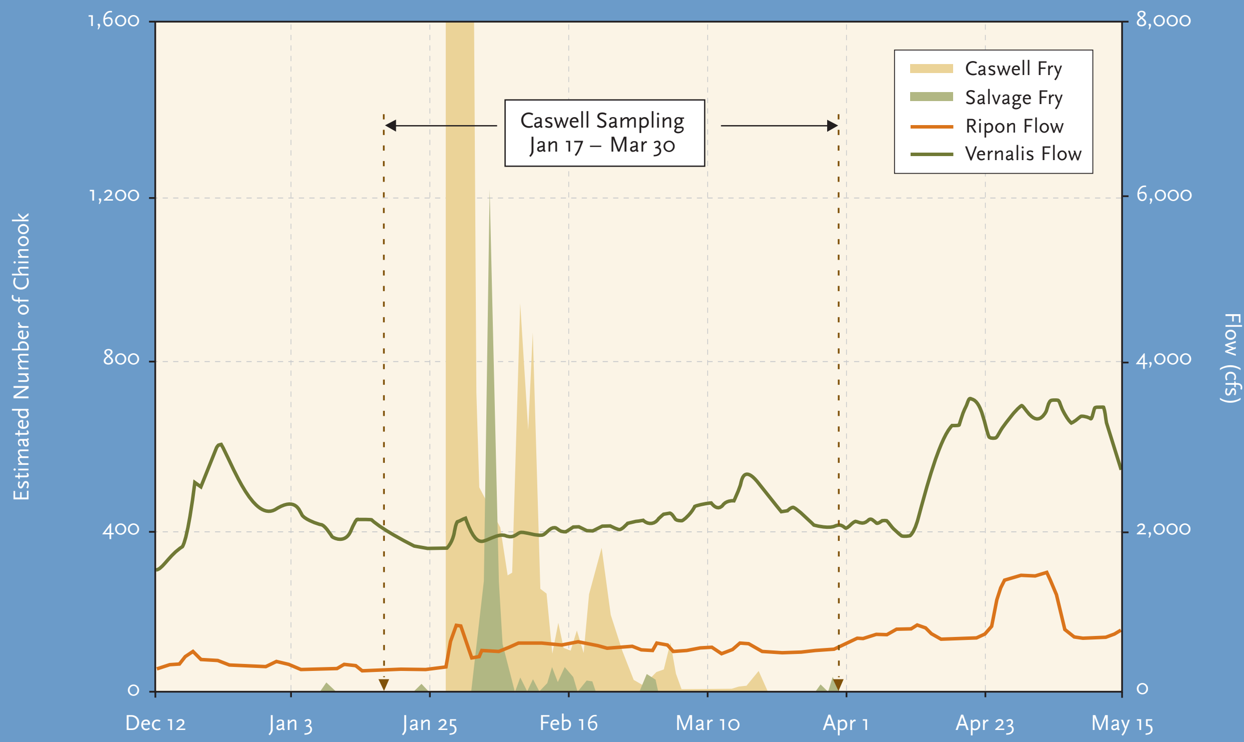


FIGURE 6–8

Locations of Radio-Tagged Juvenile Salmon, Release #1 on April 8, 2003.

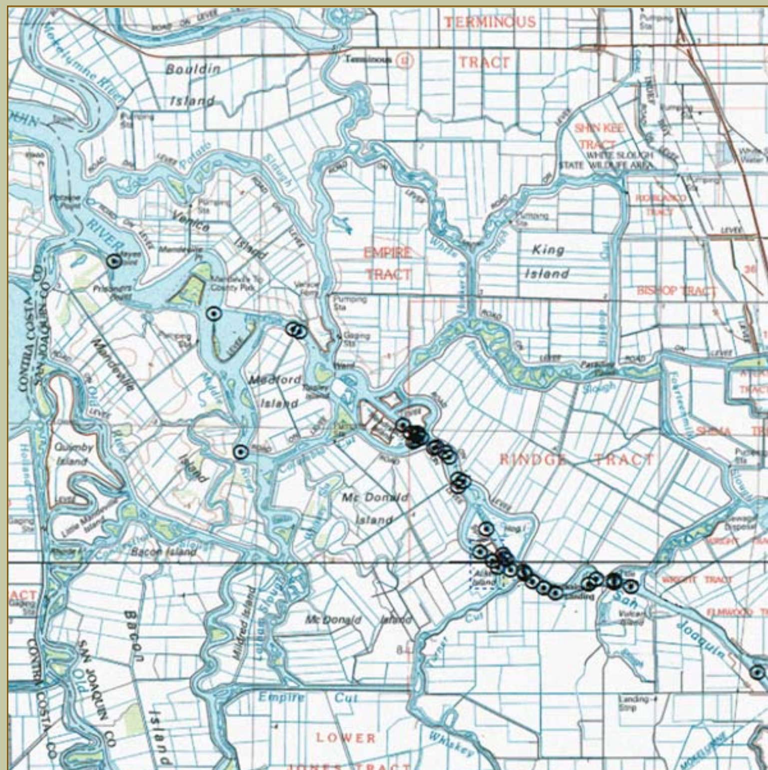


FIGURE 6–9

Locations of Radio-Tagged Juvenile Salmon, Release #2 on April 15, 2003.

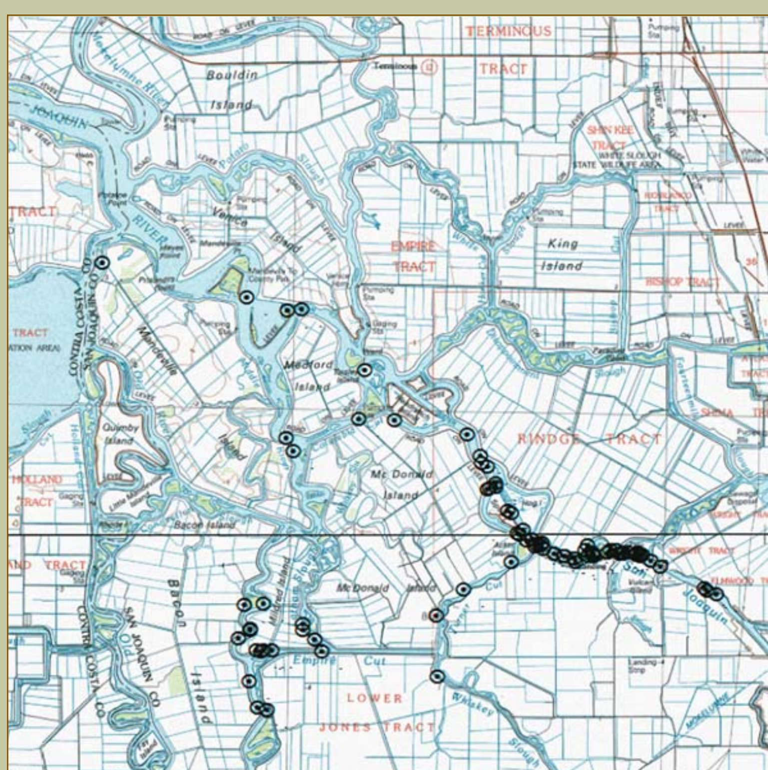


FIGURE 6–10

Locations of Radio-Tagged Juvenile Salmon, Release #3 on April 22, 2003.

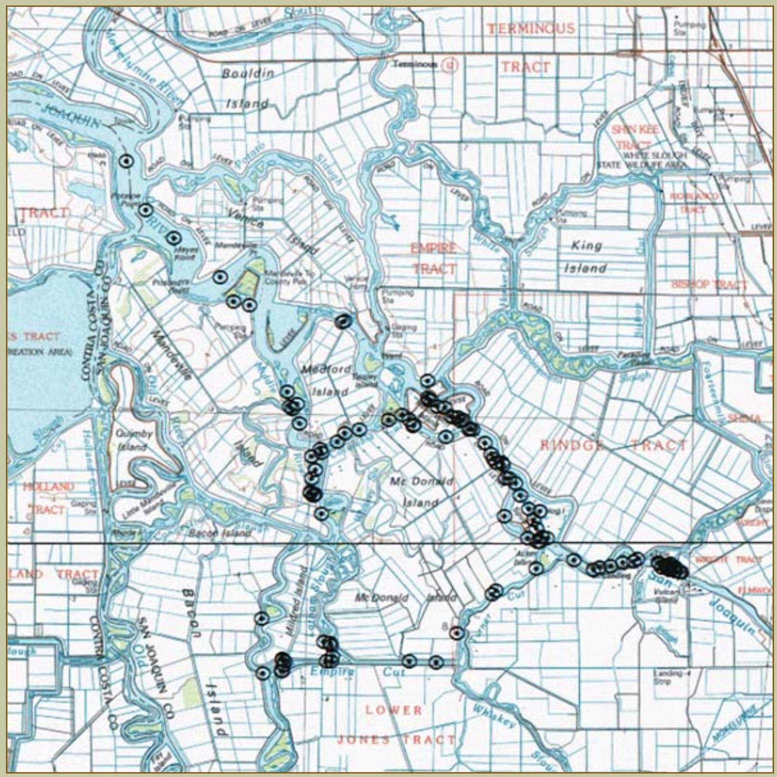
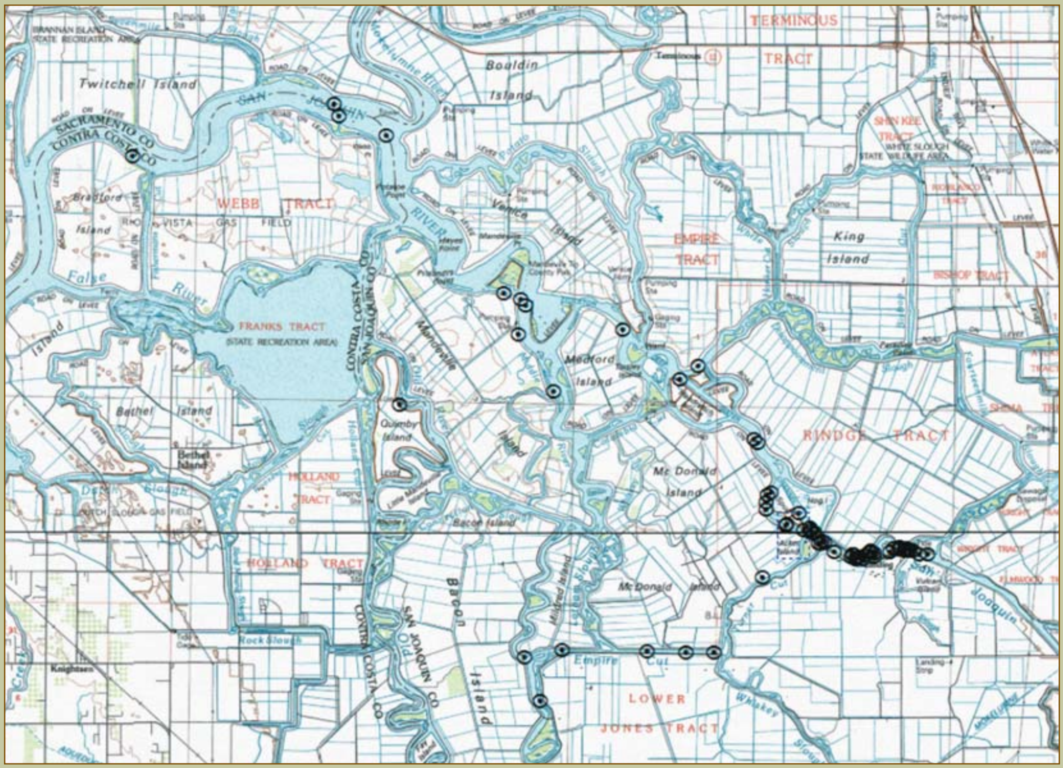


FIGURE 6–11

Locations of Radio-Tagged Juvenile Salmon, Release #4 on April 29, 2003.



CHAPTER 7

Conclusions & Recommendations

The VAMP experimental investigation of juvenile Chinook salmon survival was implemented during spring 2003. The Vernalis target flow was 3200 cfs, with a combined SWP and CVP export rate of 1500 cfs. The HORB was successfully installed and maintained throughout the VAMP test period. Estimates of juvenile Chinook salmon smolt survival were calculated based upon recoveries of CWT juvenile salmon produced in the Merced River Fish Facility and released at Durham Ferry, Mossdale, and Jersey Point. Marked salmon were subsequently recaptured in sampling at the HORB, SWP and CVP export facility salvage, and through intensive fisheries sampling at Antioch and Chipps Island. Based upon the data and experience gained during the VAMP 2003 investigations, conclusions and recommendations have been developed, as summarized in Table 7-1. The conclusions and recommendations include both technical and policy/management issues that will affect the design and implementation of VAMP 2004 operations and investigations.

Based on testing the relationship of salmon survival rates against flow and export conditions in 2000, 2001, 2002, and 2003 it has been shown that survival generally improves as flows increase and flows relative to exports increase. With the addition of the 2003 data, the relationships between salmon survival rates and Vernalis flows to SWP/CVP export ratios are no longer statistically significant. Survival tests at extreme target levels are important to obtain. The VAMP program provides improved protection for juvenile salmon when compared to "pre-VAMP" conditions.

TABLE 7–1
Summary of VAMP 2003 conclusions and recommendations

Conclusions	Recommendations
Hydrologic measurements at Vernalis were improved by weekly verification of rating curves.	Continue weekly flow measurements. Investigate alternative flow measurement methods and/or locations. Obtain additional funding for USGS weekly Vernalis gage verification.
Estimation of ungaged flows (accretions, depletions) at Vernalis was improved.	Continue hydrology investigation to improve predictions of ungaged flows.
Flow in the lower San Joaquin River downstream of Old River is important to evaluating salmon survival.	Calibrate the stage and flow monitoring system prior to the 2004 VAMP test period.
Confusion over forecasting New Melones releases impacted planning for tributary flows and related operations.	Management committee should resolve forecasting issues prior to 2004 VAMP and a set of written procedures for operational planning within each tributary should be established.
Coordination with upstream tributary operations was successful.	Continue coordination among tributary operators.
First release of CWT test fish was delayed five days to allow for completion of construction, clean-up, and flushing of debris from culverts.	Continue to work with DWR and resource agencies on scheduling construction of HORB to facilitate VAMP releases as quickly after barrier closure as possible.

Conclusions Continued	Recommendations Continued
Operation of the HORB was successful in maintaining south delta water levels.	Continue to refine operational criteria for culverts, water level modeling, and groundwater level monitoring.
Closure of HORB is dependent on completion of other barriers. Construction of multiple barriers in south delta channels may delay HORB closure.	Continue to work with DWR and resource agencies on scheduling construction of south Delta barriers to facilitate VAMP releases as quickly after barrier closure as possible.
An estimate of the flow through the culverts was obtained through use of measuring device in culvert #4.	Take flow measurements within each culvert during the 2004 VAMP.
The use of fyke nets was successful in collecting entrained fish at the culverts.	Continue monitoring culverts using fyke nets to document fish entrainment.
The index of salmon entrainment at HORB was substantially higher in 2003 (3.4 salmon per hour) with three culvert operated compared to 2002 (2.5 salmon per hour and 2001 (1.4 salmon per hour) when all six culverts were operated.	Continue barrier monitoring and analysis of factors affecting entrainment.
Most salmon were entrained at night in 2003, similar to prior years. The relationship between tidal condition and salmon entrainment at HORB was variable.	The split releases at Mossdale should be continued to evaluate tidal-diel interactions affecting salmon entrainment.
2003 studies were successful in determining salmon entrainment at HORB culverts, but did not estimate mortality associated with HORB.	Evaluate methods to estimate mortality associated with HORB.
The release at Durham Ferry was improved by having the diversion pump at the site curtail operation.	Continue to curtail diversion pump operations during releases—coordinate release schedule with landowner.
Water temperatures were suitable during both sets of releases.	Avoid seasonal delays in barrier installation and survival testing to allow releases when most suitable water temperatures.
Results of net pen studies showed a $^1/_2$ percent mortality rate in 2003 compared to no mortality in 2002.	Continue net pen studies and fish health inspections.
Physiological studies provided useful information on fish health and condition and indicated PKD may have been a factor in survival particularly for the second set of releases.	Recommend continued health monitoring to compare within and between year trends of health and condition.
There were few consistent patterns in blood chemistry values among releases groups. Comparisons were complicated by differences in transport time and handling.	Baseline data for blood chemistry analyses should be taken from unstressed fish (not subjected to stress for 24 or more hours).
2003 survival rates were the lowest since the initiation of the VAMP and were significantly lower than those in 2002 under similar flow and export conditions.	Continue to evaluate differences in survival rates between release locations, flows, and export conditions.
Survival from Durham Ferry and Mossdale in 2003 was significantly less then prior years. Further evaluation of survival rate versus flow and export rate is needed to detect differences in survival.	Repeat the 2003 target flow and export condition in the future when conditions allow. Testing 7000 cfs flow and 1500 cfs export rate is recommended to determine survival under higher flow/export ratio. Continue VAMP test program.
Complimentary studies to evaluate mechanisms affecting survival of fish from tributaries and through the Delta were conducted.	Encourage an expansion of complementary studies to provide additional information on factors and mechanisms affecting salmon survival.
Relatively few CWT salmon from VAMP releases were recovered at the SWP and CVP salvage facilities.	Continue salvage monitoring to document direct losses at SWP/CVP export facilities.

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U.S. Bureau of Reclamation

U.S. Fish and Wildlife Service

California Department of Water Resources

California Department of Fish and Game

Oakdale Irrigation District*

South San Joaquin Irrigation District*

Modesto Irrigation District*

Turlock Irrigation District*

Merced Irrigation District*

San Joaquin River Exchange Contractors
Water Authority*

Central California Irrigation District
Firebaugh Canal Water District
Columbia Canal Company
Sal Luis Canal Company

Friant Water Users Authority*

Public Utilities Commission of the City
and County of San Francisco*

Natural Heritage Institute

Metropolitan Water District of Southern California

San Luis and Delta–Mendota Canal Water Authority

San Joaquin River Group Authority

** San Joaquin River Group Authority Members*

USEFUL WEB PAGES

PAGE 3

San Joaquin River Agreement

www.sjrg.org/agreement.htm

PAGE 3

SWRCB Decision 1641

www.waterrights.ca.gov/hearings/Decisions.htm

PAGE 4

VAMP 2002 Annual Technical Report

www.sjrg.org/technicalreport/2002_tech_report.htm

PAGE 9

VAMP Experimental Design

www.sjrg.org/agreement.htm

PAGE 12

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cdec.water.ca.gov/cgi-progs/queryGroup?s=fw1

Operation Monitoring, CDEC Daily

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Vernalis USGS Real-Time

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PAGE 22

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sdelta.water.ca.gov

PAGE 27

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sdelta.water.ca.gov

PAGE 35

HORB on Old River Tidal Stage

cdec.water.ca.gov

PAGE 65

CVP and SWP Salvage Data

www.iep.ca.gov/dfishfa/fmt.html

USFWS Stockton

www.delta.dfg.ca.gov/usfws/monitoring_main/monitoring_main.html

Pacifica States Marine Fisheries Commission Regional Mark Information System

www.rmis.org

HORB on Old River Tidal Stage

cdec.water.ca.gov

COMMON ACRONYMS & ABBREVIATIONS

ACDP Accoustic Doppler Current Profiler

Bay–Delta Sacramento and San Joaquin Rivers San Francisco Bay Delta

CDEC California Data Exchange Center

CDRR Combined Differential Recovery Rate

CFS Cubic Feet Per Second

CPUE Catch Per Unit Effort

CRR Combined Recovery Rate

CVP Central Valley Project

CWT Code Wire Tagged

D–1641 Water Rights Decision 1641 of the SWRCB

DFG California Department of Fish and Game

DWR California Department of Water Resources

GLC Grant Line Canal

HOR Head of Old River

HORB Head of Old River Barrier

Merced Merced Irrigation District

MID Modesto Irrigation District

MR Middle River

MSL Mean Sea Level

NOAA National Marine Fisheries Service

OID Oakdale Irrigation District

ORT Old River at Tracy

PKD Proliferative Kidney Disease

SDWA South Delta Water Agency

SJRA San Joaquin River Agreement

SJREC 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 California State Water Resources Control Board

TBP Temporary Barriers Project

TID Turlock Irrigation District

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

APPENDIX TABLE OF CONTENTS

APPENDIX A:

Hydrology & Operation Plans 90

A–1 VAMP Daily Operation Plan, Tables 1–8 91

A–2 Final Accounting of Supplemental Water Contributions, Table 1 99

A–3 Comparison of "Real-time" and Provisional Flows, Figures 1–7 100

A–4 Daily Measured Flow in Old River 103

APPENDIX B:

Fall Water Transfer and Delivery Information 104

B–1 Merced I.D. 2003 Fall SJRA Water Transfer Daily Summary 105

B–2 Merced I.D. 2002 Fall Water Transfer Daily Summary, FINAL 106

APPENDIX C:

Chinook Salmon Survival Investigations 107

C–1 Water Temperature Location Map 108

C–1 Water Temperature Monitoring Locations 109

C–2 Water Temperature Monitoring Data, Plots 1–11 110

C–3 Net Pen Sampling Results, Tables C–3a, C–3b 114

C–4 Coded Wire Tag Recovery Data — Antioch 116

C–4 Coded Wire Tag Recovery Data — Chipps Island 119

C–5 Coded Wire Tag Recovery Information, Table C–5 . . . 122

APPENDIX D:

Errata 123

Errata for the 2002 Annual Technical Report 123

APPENDIX A

Hydrology & Operation Plans

Appendix A–1, Table 1

VAMP DAILY OPERATION PLAN, MARCH 12, 2003 (A) • LOW

Target Flow Period: April 15 – May 15 • Flow Target: 3,200 cfs

	San Joaquin River near Vernalis							Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus River below Goodwin				
	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. Flow	Exch Contr VAMP Supp. Flow	VAMP Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol. S=Stan.
	(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	
Apr 01						400	300	250			250	150	150		150	763			763	
Apr 02						397	300	250			250	150	150		150	763			763	
Apr 03						393	300	250			250	150	150		150	763			763	
Apr 04	1,860				1,860	390	300	250			250	150	150		150	763			763	
Apr 05	1,856				1,856	386	300	250			250	150	150		150	763			763	
Apr 06	1,853				1,853	383	300	250			250	150	150		150	763			763	
Apr 07	1,849				1,849	379	300	250			250	150	150		150	763			763	
Apr 08	1,846				1,846	376	300	250			250	150	150		150	763			763	
Apr 09	1,842				1,842	372	300	250			250	150	150		150	763			763	
Apr 10	1,839				1,839	369	300	250			250	150	150		150	763			763	
Apr 11	1,835				1,835	365	300	250	250		500	150	150		150	763			763	
Apr 12	1,832				1,832	362	300	250	501	119	870	275	275		275	763			763	
Apr 13	1,828	0			1,828	360	300	250	571	119	940	400	400	150	550	763	300	0	1,063	
Apr 14	1,950	250			2,200	356	300	250	581	119	950	400	400	150	550	763	300	0	1,063	
Apr 15	2,073	1,070	0	2.12	3,143	352	300	250	531	119	900	386	386	150	536	763	300	0	1,063	
Apr 16	2,069	1,140	0	4.38	3,209	349	300	250	531	119	900	441	441	150	591	763	300	0	1,063	
Apr 17	2,051	1,150	0	6.66	3,201	345	300	250	541	119	910	441	441	150	591	763	300	0	1,063	
Apr 18	2,103	1,100	0	8.85	3,203	341	300	250	541	119	910	441	441	150	591	763	300	0	1,063	
Apr 19	2,099	1,100	0	11.03	3,199	337	300	250	551	119	920	441	441	150	591	763	300	0	1,063	
Apr 20	2,095	1,110	0	13.23	3,205	334	300	250	551	119	920	441	441	150	591	763	300	0	1,063	
Apr 21	2,092	1,110	0	15.43	3,202	330	300	250	551	119	920	441	441	150	591	763	300	0	1,063	
Apr 22	2,088	1,120	0	17.65	3,208	326	300	250	551	119	920	441	441	150	591	763	300	0	1,063	
Apr 23	2,084	1,120	0	19.87	3,204	322	300	250	451	119	820	441	441	150	591	763	300	0	1,063	
Apr 24	2,080	1,120	0	22.10	3,200	319	300	250	451	119	820	718	718	300	1,018	763	0	0	763	
Apr 25	2,077	1,120	0	24.32	3,197	315	300	250	451	119	820	718	718	300	1,018	763	0	0	763	
Apr 26	2,349	870	0	26.04	3,219	311	300	250	451	119	820	718	718	300	1,018	763	0	0	763	
Apr 27	2,346	870	0	27.77	3,216	307	300	250	451	119	820	718	718	300	1,018	763	0	0	763	
Apr 28	2,342	870	0	29.49	3,212	304	300	250	451	119	820	718	718	300	1,018	763	0	0	763	
Apr 29	2,338	870	0	31.22	3,208	300	300	250	451	119	820	718	718	300	1,018	763	0	0	763	
Apr 30	2,334	870	0	32.95	3,204	296	300	250	451	119	820	718	718	300	1,018	763	0	0	763	
May 01	2,330	870	0	34.67	3,200	292	300	250	451	119	820	718	718	300	1,018	733	0	0	733	
May 02	2,327	870	0	36.40	3,197	288	300	250	641	119	1,010	494	494	300	794	733	340	0	1,073	
May 03	2,293	870	0	38.12	3,163	285	300	250	771	119	1,140	331	331	200	531	733	340	0	1,073	
May 04	2,065	1,210	0	40.52	3,275	281	300	250	771	119	1,140	331	331	100	431	733	340	0	1,073	
May 05	1,898	1,300	0	43.10	3,198	277	300	250	771	119	1,140	331	331	100	431	733	340	0	1,073	
May 06	1,895	1,330	0	45.74	3,225	273	300	250	771	119	1,140	331	331	100	431	733	340	0	1,073	
May 07	1,891	1,330	0	48.38	3,221	270	300	250	771	119	1,140	331	331	100	431	733	340	0	1,073	
May 08	1,887	1,330	0	51.01	3,217	266	300	250	771	119	1,140	331	331	100	431	733	340	0	1,073	
May 09	1,883	1,330	0	53.65	3,213	262	300	250	771	119	1,140	317	317	100	417	733	340	0	1,073	
May 10	1,897	1,330	0	56.29	3,209	258	300	250	771	119	1,140	317	317	100	417	733	340	0	1,073	
May 11	1,862	1,330	0	58.93	3,192	255	300	250	771	119	1,140	303	303	100	403	733	340	0	1,073	
May 12	1,858	1,330	0	61.57	3,188	251	300	250	771	119	1,140	303	303	100	403	733	340	0	1,073	
May 13	1,840	1,330	0	64.20	3,170	247	300	250	350		600	303	303	100	403	733	340	0	1,073	
May 14	1,837	1,330	0	66.84	3,167	243	300	250	50		300	225	225		225	733			733	
May 15	1,833	1,330	0	69.48	3,163	240	300	250			250	150	150		150	733			733	
May 16	1,751	350			2,101	236	300	250			250	150	150		150	733			733	
May 17	1,673	50			1,723	232	300	250			250	150	150		150	733			733	
May 18	1,669	0			1,669	229	300	250			250	150	150		150	733			733	
May 19	1,665	0			1,665	225	300	250			250	150	150		150	733			733	
May 20	1,662	0			1,662	221	300	250			250	150	150		150	733			733	
May 21	1,658	0			1,658	217	300	250			250	150	150		150	733			733	
May 22	1,654	0			1,654	214	300	250			250	150	150		150	733			733	
May 23	1,650	0			1,650	210	300	250			250	150	150		150	733			733	
May 24	1,647	0			1,647	206	300	250			250	150	150		150	733			733	
May 25	1,643	0			1,643	203	300	250			250	150	150		150	733			733	
May 26	1,639	0			1,639	199	300	250			250	150	150		150	733			733	
May 27	1,636	0			1,636	195	300	250			250	150	150		150	733			733	
May 28	1,632	0			1,632	192	300	250			250	150	150		150	733			733	
May 29	1,628	0			1,628	188	300	250			250	150	150		150	733			733	
May 30	1,625	0			1,625	184	300	250			250	150	150		150	733			733	
May 31	1,621	0			1,621	180	300	250			250	150	150		150	733			733	
	VAMP period																			
Avg. (cfs):	2,071	1,130			3,201	304	300	250	594	119	963	467	467	179	646	750	238	0	988	
Suppl. Water (TAF)		69.48							36.52	7.32				11.01			14.64			

Target flow period

Period of desired flow stability

Appendix A–1, Table 2

VAMP DAILY OPERATION PLAN, MARCH 12, 2003 (B) • HIGH

Target Flow Period: April 15–May 15 • Flow Target: 3,200 cfs

San Joaquin River near Vernalis							Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus River below Goodwin					
Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. Flow	Exch Contr VAMP Supp. Flow	VAMP Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol..	
(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		
					600	600	250			250	150	150		150	746			746		Apr 01
					595	600	250			250	150	150		150	746			746		Apr 02
					590	600	250			250	150	150		150	746			746		Apr 03
2,341				2,341	585	600	250			250	150	150		150	746			746		Apr 04
2,336				2,336	580	600	250			250	150	150		150	746			746		Apr 05
2,331				2,331	575	600	250			250	150	150		150	746			746		Apr 06
2,326				2,326	570	600	250			250	150	150		150	746			746		Apr 07
2,321				2,321	565	600	250			250	150	150		150	746			746		Apr 08
2,316				2,316	560	600	250			250	150	150		150	746			746		Apr 09
2,311				2,311	555	600	250			250	150	150		150	746			746		Apr 10
2,306				2,306	550	600	250	100		350	150	150		150	746			746		Apr 11
2,301				2,301	545	600	250	300	0	550	302	302		302	746			746		Apr 12
2,296	0			2,296	540	600	250	300	0	550	628	660	0	660	746	0	0	746		Apr 13
2,443	100			2,543	535	600	250	220	0	470	628	660	0	660	746	0	0	746		Apr 14
2,796	300	0	0.60	3,096	531	600	250	160	0	410	606	660	0	660	936	0	0	936		Apr 15
2,791	300	0	1.19	3,091	526	600	250	160	0	410	693	730	0	730	936	0	0	936		Apr 16
2,977	220	0	1.63	3,197	522	600	250	160	0	410	693	730	0	730	936	0	0	936		Apr 17
3,042	160	0	1.94	3,202	517	600	250	160	0	410	693	730	0	730	936	0	0	936		Apr 18
3,038	160	0	2.26	3,198	513	600	250	160	0	410	693	730	0	730	936	0	0	936		Apr 19
3,033	160	0	2.58	3,193	508	600	250	160	0	410	693	730	0	730	936	0	0	936		Apr 20
3,029	160	0	2.90	3,189	504	600	250	160	0	410	693	730	0	730	936	0	0	936		Apr 21
3,024	160	0	3.21	3,184	499	600	250	160	0	410	693	730	0	730	936	0	0	936		Apr 22
3,020	160	0	3.53	3,180	495	600	250	0	0	250	693	730	0	730	936	0	0	936		Apr 23
3,015	160	0	3.85	3,175	490	600	250	0	0	250	1,127	1,000	0	1,000	936	0	0	936		Apr 24
3,011	160	0	4.17	3,171	486	600	250	0	0	250	1,127	1,000	0	1,000	936	0	0	936		Apr 25
3,276	0	0	4.17	3,276	481	600	250	0	0	250	1,127	1,000	0	1,000	936	0	0	936		Apr 26
3,272	0	0	4.17	3,272	477	600	250	0	0	250	1,127	1,000	0	1,000	936	0	0	936		Apr 27
3,267	0	0	4.17	3,267	472	600	250	0	0	250	1,127	1,000	0	1,000	936	0	0	936		Apr 28
3,263	0	0	4.17	3,263	467	600	250	0	0	250	1,127	1,000	0	1,000	936	0	0	936		Apr 29
3,258	0	0	4.17	3,258	463	600	250	0	0	250	1,127	1,000	0	1,000	936	0	0	936		Apr 30
3,253	0	0	4.17	3,253	458	600	250	160	0	410	1,127	1,000	0	1,000	936	0	0	936		May 01
3,249	0	0	4.17	3,249	454	600	250	400	0	650	775	800	0	800	936	0	0	936		May 02
3,244	0	0	4.17	3,244	449	600	250	400	0	650	519	570	0	570	936	0	0	936		May 03
3,040	160	0	4.48	3,200	445	600	250	400	0	650	519	570	0	570	936	0	0	936		May 04
2,805	400	0	5.28	3,205	440	600	250	400	0	650	519	570	0	570	936	0	0	936		May 05
2,801	400	0	6.07	3,201	436	600	250	400	0	650	519	570	0	570	936	0	0	936		May 06
2,796	400	0	6.86	3,196	431	600	250	400	0	650	519	570	0	570	936	0	0	936		May 07
2,792	400	0	7.66	3,192	427	600	250	450	0	700	519	570	0	570	936	0	0	936		May 08
2,787	400	0	8.45	3,187	422	600	250	450	0	700	497	530	0	530	936	0	0	936		May 09
2,783	400	0	9.24	3,183	418	600	250	450	0	700	497	530	0	530	936	0	0	936		May 10
2,738	450	0	10.14	3,188	413	600	250	450	0	700	476	530	0	530	936	0	0	936		May 11
2,734	450	0	11.03	3,184	409	600	250	430	0	680	476	530	0	530	936	0	0	936		May 12
2,729	450	0	11.92	3,179	404	600	250	100		350	476	530	0	530	936	0	0	936		May 13
2,725	450	0	12.81	3,175	400	600	250			250	389	389		389	936			936		May 14
2,720	430	0	13.67	3,150	395	600	250			250	302	302		302	936			936		May 15
2,574	100			2,674	391	600	250			250	215	215		215	707			707		May 16
2,483	0			2,483	386	600	250			250	150	150		150	707			707		May 17
2,163	0			2,163	382	600	250			250	150	150		150	707			707		May 18
2,093	0			2,093	377	600	250			250	150	150		150	707			707		May 19
2,089	0			2,089	373	600	250			250	150	150		150	707			707		May 20
2,084	0			2,084	368	600	250			250	150	150		150	707			707		May 21
2,080	0			2,080	364	600	250			250	150	150		150	707			707		May 22
2,075	0			2,075	359	600	250			250	150	150		150	707			707		May 23
2,071	0			2,071	355	600	250			250	150	150		150	707			707		May 24
2,066	0			2,066	350	600	250			250	150	150		150	707			707		May 25
2,062	0			2,062	346	600	250			250	150	150		150	707			707		May 26
2,057	0			2,057	341	600	250			250	150	150		150	707			707		May 27
2,053	0			2,053	337	600	250			250	150	150		150	707			707		May 28
2,048	0			2,048	332	600	250			250	150	150		150	707			707		May 29
2,044	0			2,044	328	600	250			250	150	150		150	707			707		May 30
2,039	0			2,039	323	600	250			250	150	150		150	707			707		May 31
					VAMP period															
2,978	222			3,200	472	600	250	222	0	472	733	732	0	732	924	0	0	924		Avg (cfs):
	13.67							13.67	0.00				0.00			0.00				Suppl. Water (TAF)

Target flow period

Period of desired flow stability

Appendix A–1, Table 3

VAMP DAILY OPERATION PLAN, MARCH 26, 2003 (A) • LOW

Target Flow Period: April 15–May 15 • Flow Target: 3,200 cfs

	San Joaquin River near Vernalis							Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus River below Goodwin				
	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. Flow	Exch Contr VAMP Suppl. Flow	VAMP Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol. S=Stan.
	(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	
Apr 01						342	300	250			250	150	150		150	763			763	
Apr 02						339	300	250			250	150	150		150	763			763	
Apr 03						335	300	250			250	150	150		150	763			763	
Apr 04	1,802				1,802	332	300	250			250	150	150		150	763			763	
Apr 05	1,798				1,798	328	300	250			250	150	150		150	763			763	
Apr 06	1,795				1,795	325	300	250			250	150	150		150	763			763	
Apr 07	1,791				1,791	321	300	250			250	150	150		150	763			763	
Apr 08	1,788				1,788	318	300	250			250	150	150		150	763			763	
Apr 09	1,784				1,784	314	300	250			250	150	150		150	763			763	
Apr 10	1,781				1,781	311	300	250			250	150	150		150	763			763	
Apr 11	1,777				1,777	307	300	250	50		300	150	150		150	763			763	
Apr 12	1,774				1,774	304	300	250	299	81	630	400	400		400	763			763	
Apr 13	1,770	0			1,770	300	300	250	299	81	630	800	800	165	965	763	0	0	763	
Apr 14	2,017	50			2,067	297	300	250	299	81	630	1,100	1,100	165	1,265	763	0	0	763	
Apr 15	2,413	545	0	1.08	2,958	293	300	250	299	81	630	1,100	1,100	165	1,265	763	0	0	763	
Apr 16	2,710	545	0	2.16	3,255	290	300	250	299	81	630	1,100	1,100	165	1,265	763	0	0	763	
Apr 17	2,706	545	0	3.24	3,251	286	300	250	299	81	630	1,100	1,100	165	1,265	763	0	0	763	
Apr 18	2,703	545	0	4.32	3,248	283	300	250	304	81	635	1,100	1,100	165	1,265	763	0	0	763	
Apr 19	2,699	545	0	5.40	3,244	279	300	250	304	81	635	1,100	1,100	165	1,265	763	0	0	763	
Apr 20	2,696	545	0	6.49	3,241	276	300	250	304	81	635	1,100	1,100	165	1,265	763	0	0	763	
Apr 21	2,692	550	0	7.58	3,242	272	300	250	304	81	635	1,100	1,100	165	1,265	763	0	0	763	
Apr 22	2,689	550	0	8.67	3,239	269	300	250	304	81	635	1,100	1,100	165	1,265	763	0	0	763	
Apr 23	2,685	550	0	9.76	3,235	265	300	250	304	81	635	1,100	1,100	165	1,265	763	0	0	763	
Apr 24	2,682	550	0	10.85	3,232	262	300	250	304	81	635	1,100	1,100	165	1,265	763	0	0	763	M
Apr 25	2,678	550	0	11.94	3,228	258	300	250	304	81	635	1,100	1,100	165	1,265	763	0	0	763	M
Apr 26	2,675	550	0	13.03	3,225	255	300	250	304	81	635	900	900	165	1,065	763	137	0	900	M
Apr 27	2,671	550	0	14.12	3,221	251	300	250	429	81	760	600	600	165	765	763	537	0	1,300	M, S
Apr 28	2,468	687	0	15.48	3,155	248	300	250	569	81	900	429	429	165	594	763	537	0	1,300	M, S
Apr 29	2,164	1,087	0	17.64	3,251	244	300	250	569	81	900	300	300	160	460	763	537	0	1,300	M, S
Apr 30	1,990	1,212	0	20.04	3,202	241	300	250	569	81	900	300	300	160	460	763	537	0	1,300	M, S
May 01	1,857	1,347	0	22.72	3,204	237	300	250	569	81	900	300	300	160	460	733	567	0	1,300	S
May 02	1,854	1,347	0	25.39	3,201	234	300	250	569	81	900	300	300	160	460	733	567	0	1,300	S
May 03	1,820	1,377	0	28.12	3,197	230	300	250	569	81	900	300	300	160	460	733	567	0	1,300	S
May 04	1,817	1,377	0	30.85	3,194	227	300	250	869	81	1,200	300	300	160	460	733	567	0	1,300	M, S
May 05	1,813	1,377	0	33.58	3,190	223	300	250	869	81	1,200	300	300	160	460	733	367	0	1,100	M
May 06	1,810	1,377	0	36.31	3,187	220	300	250	869	81	1,200	600	600	160	760	733	127	0	860	M
May 07	1,806	1,477	0	39.24	3,283	216	300	250	869	81	1,200	600	600	160	760	733	0	0	733	M
May 08	2,103	1,237	0	41.70	3,340	213	300	250	869	81	1,200	600	600	160	760	733	0	0	733	M
May 09	2,099	1,110	0	43.90	3,209	209	300	250	869	81	1,200	600	600	160	760	733	0	0	733	M
May 10	2,096	1,110	0	46.10	3,206	206	300	250	869	81	1,200	600	600	160	760	733	0	0	733	M
May 11	2,092	1,110	0	48.30	3,202	202	300	250	869	81	1,200	600	600	160	760	733	0	0	733	M
May 12	2,089	1,110	0	50.50	3,199	199	300	250	669	81	1,000	550	550	160	710	733	0	0	733	
May 13	2,085	1,110	0	52.70	3,195	195	300	250	300		550	450	450	160	610	733	0	0	733	
May 14	2,032	1,110	0	54.91	3,142	192	300	250	50		300	389	389		389	733			733	
May 15	1,928	910	0	56.71	2,838	188	300	250			250	302	302		302	733			733	
May 16	1,863	300			2,163	185	300	250			250	215	215		215	733			733	
May 17	1,773	50			1,823	181	300	250			250	150	150		150	733			733	
May 18	1,683	0			1,683	178	300	250			250	150	150		150	733			733	
May 19	1,614	0			1,614	174	300	250			250	150	150		150	733			733	
May 20	1,611	0			1,611	171	300	250			250	150	150		150	733			733	
May 21	1,607	0			1,607	167	300	250			250	150	150		150	733			733	
May 22	1,604	0			1,604	164	300	250			250	150	150		150	733			733	
May 23	1,600	0			1,600	160	300	250			250	150	150		150	733			733	
May 24	1,597	0			1,597	157	300	250			250	150	150		150	733			733	
May 25	1,593	0			1,593	153	300	250			250	150	150		150	733			733	
May 26	1,590	0			1,590	150	300	250			250	150	150		150	733			733	
May 27	1,586	0			1,586	146	300	250			250	150	150		150	733			733	
May 28	1,583	0			1,583	143	300	250			250	150	150		150	733			733	
May 29	1,579	0			1,579	139	300	250			250	150	150		150	733			733	
May 30	1,576	0			1,576	136	300	250			250	150	150		150	733			733	
May 31	1,572	0			1,572	132	300	250			250	150	150		150	733			733	
	VAMP period																			
Avg (cfs):	2,278	922			3,200	248	300	250	516	81	847	730	730	163	893	750	163	0	913	
Suppl. Water (TAF)		56.71							31.72	4.98				10.00			10.01			

Target flow period

Period of desired flow stability

Appendix A – 1, Table 4

VAMP DAILY OPERATION PLAN, MARCH 26, 2003 (B) • HIGH

Target Flow Period: April 15 – May 15 • Flow Target: 3,200 cfs

San Joaquin River near Vernalis							Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus River below Goodwin					
Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. Flow	Exch Contr VAMP Suppl. Flow	VAMP Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol.	
(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		
					548	500	250			250	150	150		150	746			746		Apr 01
					544	500	250			250	150	150		150	746			746		Apr 02
					540	500	250			250	150	150		150	746			746		Apr 03
2,190				2,190	536	500	250			250	150	150		150	746			746		Apr 04
2,186				2,186	532	500	250			250	150	150		150	746			746		Apr 05
2,182				2,182	528	500	250			250	150	150		150	746			746		Apr 06
2,178				2,178	524	500	250			250	150	150		150	746			746		Apr 07
2,174				2,174	520	500	250			250	150	150		150	746			746		Apr 08
2,170				2,170	516	500	250			250	150	150		150	746			746		Apr 09
2,166				2,166	512	500	250			250	150	150		150	746			746		Apr 10
2,162				2,162	508	500	250	50		300	150	150		150	746			746		Apr 11
2,158				2,158	504	500	250	150	0	400	400	400		400	746			746		Apr 12
2,154	0			2,154	500	500	250	150	0	400	800	800	0	800	746	0	0	746		Apr 13
2,400	50			2,450	496	500	250	150	0	400	1,100	1,100	0	1,100	746	0	0	746		Apr 14
2,796	150	0	0.30	2,946	491	500	250	150	0	400	1,100	1,100	0	1,100	746	0	0	746		Apr 15
3,092	150	0	0.60	3,242	487	500	250	150	0	400	1,100	1,100	0	1,100	746	0	0	746		Apr 16
3,087	150	0	0.89	3,237	483	500	250	150	0	400	1,100	1,100	0	1,100	746	0	0	746		Apr 17
3,083	150	0	1.19	3,233	478	500	250	150	0	400	1,100	1,100	0	1,100	746	0	0	746		Apr 18
3,079	150	0	1.49	3,229	474	500	250	150	0	400	1,100	1,100	0	1,100	746	0	0	746		Apr 19
3,074	150	0	1.79	3,224	469	500	250	150	0	400	1,100	1,100	0	1,100	746	0	0	746		Apr 20
3,070	150	0	2.08	3,220	465	500	250	150	0	400	1,100	1,100	0	1,100	746	0	0	746		Apr 21
3,065	150	0	2.38	3,215	461	500	250	200	0	450	1,100	1,100	0	1,100	746	0	0	746		Apr 22
3,061	150	0	2.68	3,211	456	500	250	200	0	450	1,100	1,100	0	1,100	746	0	0	746		Apr 23
3,057	150	0	2.98	3,207	452	500	250	200	0	450	1,100	1,100	0	1,100	746	0	0	746		Apr 24
3,052	200	0	3.37	3,252	448	500	250	250	0	500	1,100	1,100	0	1,100	746	0	0	746		Apr 25
3,048	200	0	3.77	3,248	443	500	250	250	0	500	900	900	0	900	746	0	0	746		Apr 26
3,044	200	0	4.17	3,244	439	500	250	250	0	500	600	600	0	600	950	0	0	950	M	Apr 27
2,839	250	0	4.66	3,089	435	500	250	250	0	500	429	429	0	429	1,500	0	0	1,500	M, S	Apr 28
2,739	250	0	5.16	2,989	430	500	250	250	0	500	300	300	0	300	1,500	0	0	1,500	M, S	Apr 29
3,114	250	0	5.65	3,364	426	500	250	250	0	500	300	300	0	300	1,500	0	0	1,500	M, S	Apr 30
2,980	250	0	6.15	3,230	421	500	250	250	0	500	300	300	0	300	1,500	0	0	1,500	M, S	May 01
2,976	250	0	6.64	3,226	417	500	250	250	0	500	300	300	0	300	1,500	0	0	1,500	M, S	May 02
2,971	250	0	7.14	3,221	413	500	250	250	0	500	300	300	0	300	1,500	0	0	1,500	S	May 03
2,967	250	0	7.64	3,217	408	500	250	700	0	950	300	300	0	300	1,500	0	0	1,500	S	May 04
2,963	250	0	8.13	3,213	404	500	250	800	0	1,050	300	300	0	300	1,100	0	0	1,100	M	May 05
2,958	250	0	8.63	3,208	400	500	250	800	0	1,050	600	600	0	600	707	0	0	707	M	May 06
2,554	700	0	10.02	3,254	395	500	250	800	0	1,050	600	600	0	600	707	0	0	707	M	May 07
2,457	800	0	11.60	3,257	391	500	250	800	0	1,050	600	600	0	600	707	0	0	707	M	May 08
2,452	800	0	13.19	3,252	386	500	250	800	0	1,050	600	600	0	600	707	0	0	707	M	May 09
2,448	800	0	14.78	3,248	382	500	250	800	0	1,050	600	600	0	600	707	0	0	707	M	May 10
2,443	800	0	16.36	3,243	378	500	250	800	0	1,050	600	600	0	600	707	0	0	707	M	May 11
2,439	800	0	17.95	3,239	373	500	250	550	0	800	550	550	0	550	707	0	0	707		May 12
2,435	800	0	19.54	3,235	369	500	250	150		400	450	450	0	450	707	0	0	707		May 13
2,380	800	0	21.12	3,180	365	500	250			250	389	389		389	707			707		May 14
2,276	550	0	22.21	2,826	361	500	250			250	302	302		302	707			707		May 15
2,211	150			2,361	357	500	250			250	215	215		215	707			707		May 16
2,120	0			2,120	353	500	250			250	150	150		150	707			707		May 17
2,029	0			2,029	349	500	250			250	150	150		150	707			707		May 18
1,960	0			1,960	345	500	250			250	150	150		150	707			707		May 19
1,956	0			1,956	341	500	250			250	150	150		150	707			707		May 20
1,952	0			1,952	337	500	250			250	150	150		150	707			707		May 21
1,948	0			1,948	333	500	250			250	150	150		150	707			707		May 22
1,944	0			1,944	329	500	250			250	150	150		150	707			707		May 23
1,940	0			1,940	325	500	250			250	150	150		150	707			707		May 24
1,936	0			1,936	321	500	250			250	150	150		150	707			707		May 25
1,932	0			1,932	317	500	250			250	150	150		150	707			707		May 26
1,928	0			1,928	313	500	250			250	150	150		150	707			707		May 27
1,924	0			1,924	309	500	250			250	150	150		150	707			707		May 28
1,920	0			1,920	305	500	250			250	150	150		150	707			707		May 29
1,916	0			1,916	301	500	250			250	150	150		150	707			707		May 30
1,912	0			1,912	297	500	250			250	150	150		150	707			707		May 31
VAMP period																				
2,839	361			3,200	435	500	250	361	0	611	730	730	0	730	924	0	0	924		Avg (cfs):
	22.21							22.21	0.00				0.00			0.00				Suppl. Water (TAF)

Target flow period

Period of desired flow stability

Appendix A–1, Table 5

VAMP DAILY OPERATION PLAN, APRIL 4, 2003

Target Flow Period: April 15–May 15 • Flow Target: 3,200 cfs

bold numbers: observed real time

	San Joaquin River near Vernalis							Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus River below Goodwin					
	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. Flow	Exch Contr VAMP Suppl. Flow	VAMP Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	Existing Flow (re-shaped)	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol. S=Stan.
	(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		(cfs)	(cfs)	(cfs)	
Apr 01	**1,940**				**1,940**	**668**	**338**	**225**			**225**	150	**181**		**181**	**606**	**606**			**606**	
Apr 02	**2,000**				**2,000**	**627**	**311**	**229**			**229**	150	**182**		**182**	**604**	**604**			**604**	
Apr 03	**2,040**				**2,040**	**616**	**368**	**249**			**249**	150	**180**		**180**	**650**	**650**			**650**	
Apr 04	2,038				2,038	626	400	250			250	150	150		150	650	650			650	
Apr 05	2,075				2,075	612	400	250			250	150	150		150	650	650			650	
Apr 06	2,075				2,075	598	400	250			250	150	150		150	650	650			650	
Apr 07	2,062				2,062	584	400	250			250	150	150		150	650	650			650	
Apr 08	2,048				2,048	570	400	250			250	150	150		150	650	650			650	
Apr 09	2,034				2,034	556	400	250			250	150	150		150	650	650			650	
Apr 10	2,020				2,020	542	400	250			250	150	150		150	650	650			650	
Apr 11	2,006				2,006	528	400	250	100		350	150	150		150	650	650			650	
Apr 12	1,992				1,992	514	400	250	300	60	610	400	400		400	650	650			650	
Apr 13	1,978	0			1,978	500	400	250	300	60	610	800	800	0	800	763	500	150	0	650	
Apr 14	2,214	100			2,314	496	400	250	300	60	610	1,100	1,100	0	1,100	763	500	150	0	650	
Apr 15	2,450	510	0	1.01	2,960	491	400	250	300	60	610	1,100	1,100	0	1,100	763	500	150	0	650	
Apr 16	2,746	510	0	2.02	3,256	487	400	250	300	60	610	1,100	1,100	0	1,100	763	500	150	0	650	
Apr 17	2,741	510	0	3.03	3,251	483	400	250	300	60	610	1,100	1,100	0	1,100	763	500	150	0	650	
Apr 18	2,737	510	0	4.05	3,247	478	400	250	300	60	610	1,100	1,100	0	1,100	763	500	150	0	650	
Apr 19	2,733	510	0	5.06	3,243	474	400	250	300	60	610	1,100	1,100	0	1,100	763	500	150	0	650	
Apr 20	2,728	510	0	6.07	3,238	469	400	250	300	60	610	1,100	1,100	0	1,100	763	500	150	0	650	
Apr 21	2,724	510	0	7.08	3,234	465	400	250	300	60	610	1,100	1,100	0	1,100	763	500	150	0	650	
Apr 22	2,719	510	0	8.09	3,229	461	400	250	230	60	540	1,100	1,100	0	1,100	763	500	150	0	650	
Apr 23	2,715	510	0	9.10	3,225	456	400	250	130	70	450	1,100	900	0	900	763	500	400	0	900	
Apr 24	2,711	510	0	10.12	3,221	452	400	250	130	70	450	1,100	725	0	725	763	900	300	0	1,200	M
Apr 25	2,506	690	0	11.48	3,196	448	400	250	130	70	450	1,100	500	0	500	763	1,250	250	0	1,500	M, S
Apr 26	2,727	500	0	12.48	3,227	443	400	250	130	70	450	900	450	0	450	763	1,250	250	0	1,500	M, S
Apr 27	2,848	450	0	13.37	3,298	439	400	250	130	70	450	600	450	0	450	763	1,250	250	0	1,500	M, S
Apr 28	2,793	450	0	14.26	3,243	435	400	250	130	70	450	429	450	0	450	763	1,250	250	0	1,500	M, S
Apr 29	2,789	450	0	15.15	3,239	430	400	250	130	70	450	300	450	0	450	737	1,250	250	0	1,500	M, S
Apr 30	2,785	450	0	16.05	3,235	426	400	250	130	70	450	300	450	0	450	737	1,250	250	0	1,500	M, S
May 01	2,780	450	0	16.94	3,230	421	400	250	130	70	450	300	450	0	450	737	1,250	250	0	1,500	S
May 02	2,776	450	0	17.83	3,226	417	400	250	180	60	490	300	500	0	500	737	1,250	250	0	1,500	S
May 03	2,771	450	0	18.72	3,221	413	400	250	500	70	820	300	600	0	600	737	1,100	200	0	1,300	
May 04	2,817	450	0	19.62	3,267	408	400	250	880	70	1,200	300	600	0	600	737	813	192	0	1,005	M
May 05	2,763	440	0	20.49	3,203	404	400	250	880	70	1,200	300	600	0	600	737	550	50	0	600	M
May 06	2,471	762	0	22.00	3,233	400	400	250	880	70	1,200	600	600	0	600	737	550	50	0	600	M
May 07	2,204	1,000	0	23.98	3,204	395	400	250	880	70	1,200	600	600	0	600	737	550	50	0	600	M
May 08	2,200	1,000	0	25.97	3,200	391	400	250	880	70	1,200	600	600	0	600	737	550	50	0	600	M
May 09	2,195	1,000	0	27.95	3,195	386	400	250	880	70	1,200	600	600	0	600	737	550	50	0	600	M
May 10	2,191	1,000	0	29.93	3,191	382	400	250	880	70	1,200	600	600	0	600	737	550	50	0	600	M
May 11	2,186	1,000	0	31.92	3,186	378	400	250	880	70	1,200	600	600	0	600	737	550	50	0	600	M
May 12	2,182	1,000	0	33.90	3,182	373	400	250	480	70	800	550	600	0	600	737	550	50	0	600	
May 13	2,178	1,000	0	35.88	3,178	369	400	250	250	0	500	450	600	0	600	737	550	50	0	600	
May 14	2,173	1,000	0	37.87	3,173	365	400	250	100	0	350	389	389		389	737	737			737	
May 15	2,169	600	0	39.06	2,769	361	400	250			250	302	302		302	737	737			737	
May 16	2,141	250			2,391	357	400	250			250	215	215		215	737	737			737	
May 17	2,050	100			2,150	353	400	250			250	150	150		150	737	737			737	
May 18	1,959	0			1,959	349	400	250			250	150	150		150	737	737			737	
May 19	1,890	0			1,890	345	400	250			250	150	150		150	737	737			737	
May 20	1,886	0			1,886	341	400	250			250	150	150		150	737	737			737	
May 21	1,882	0			1,882	337	400	250			250	150	150		150	737	737			737	
May 22	1,878	0			1,878	333	400	250			250	150	150		150	737	737			737	
May 23	1,874	0			1,874	329	400	250			250	150	150		150	737	737			737	
May 24	1,870	0			1,870	325	400	250			250	150	150		150	737	737			737	
May 25	1,866	0			1,866	321	400	250			250	150	150		150	737	737			737	
May 26	1,862	0			1,862	317	400	250			250	150	150		150	737	737			737	
May 27	1,858	0			1,858	313	400	250			250	150	150		150	737	737			737	
May 28	1,854	0			1,854	309	400	250			250	150	150		150	737	737			737	
May 29	1,850	0			1,850	305	400	250			250	150	150		150	737	737			737	
May 30	1,846	0			1,846	301	400	250			250	150	150		150	737	737			737	
May 31	1,842	0			1,842	297	400	250			250	150	150		150	737	737			737	
	VAMP period																				
Avg (cfs):	2,565	635			3,200	435	400	250	406	66	723	730	730	0	730	750	750	163	0	913	
Suppl. Water (TAF)		39.06							24.99	4.07				0.00				10.00			

Target flow period

Period of desired flow stability

Appendix A – 1, Table 6

VAMP DAILY OPERATION PLAN, APRIL 9, 2003

Target Flow Period: April 15–May 15 • Flow Target: 3,200 cfs

bold numbers: observed real time

San Joaquin River near Vernalis							Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus River below Goodwin						
Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. Flow	Exch Contr VAMP Suppl. Flow	VAMP Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow (flat)	Existing Flow (re-shaped)	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol. S=Stan.	
(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		
1,940				**1,940**	**668**	**338**	**225**			**225**	150	**181**		**181**	650	**606**			**606**		Apr 01
2,000				**2,000**	**627**	**311**	**229**			**229**	150	**182**		**182**	650	**604**			**604**		Apr 02
2,040				**2,040**	**616**	**368**	**249**			**249**	150	**180**		**180**	650	**650**			**650**		Apr 03
2,020				**2,020**	**572**	**382**	**245**			**245**	150	**181**		**181**	650	**709**			**709**		Apr 04
2,070				**2,077**	**555**	**402**	**250**			**250**	150	**183**		**183**	650	**709**			**709**		Apr 05
2,010				**2,010**	**546**	**299**	**245**			**245**	150	**181**		**181**	650	**700**			**700**		Apr 06
2,050				**2,050**	**542**	**358**	**240**			**240**	150	**184**		**184**	650	**757**			**757**		Apr 07
1,990				1,990	510	313	250			250	150	150		150	650	800			800		Apr 08
2,028				2,028	498	300	250			250	150	150		150	650	800			800		Apr 09
2,000				2,000	486	300	250			250	150	150		150	650	800			800		Apr 10
1,998				1,998	474	300	250	100		350	150	150		150	650	800			800		Apr 11
1,986				1,986	462	300	250	320	80	650	425	425		425	650	800			800		Apr 12
1,974	0			1,974	450	300	250	320	80	650	700	700	70	770	763	500	150	0	650		Apr 13
2,237	100			2,337	446	300	250	320	80	650	906	1,000	200	1,200	763	500	150	0	650		Apr 14
2,200	620	0	1.23	2,820	442	300	250	320	80	650	906	1,000	200	1,200	763	500	150	0	650		Apr 15
2,496	750	0	2.72	3,246	438	300	250	320	80	650	906	1,000	200	1,200	763	500	150	0	650		Apr 16
2,492	750	0	4.20	3,242	433	300	250	320	80	650	906	1,000	200	1,200	763	500	150	0	650		Apr 17
2,488	750	0	5.69	3,238	429	300	250	320	80	650	906	1,000	200	1,200	763	500	150	0	650		Apr 18
2,483	750	0	7.18	3,233	425	300	250	320	80	650	906	1,000	200	1,200	763	500	150	0	650		Apr 19
2,479	750	0	8.67	3,229	421	300	250	320	80	650	906	1,000	200	1,200	763	500	150	0	650		Apr 20
2,475	750	0	10.16	3,225	417	300	250	320	80	650	906	1,000	200	1,200	763	500	150	0	650		Apr 21
2,471	750	0	11.64	3,221	413	300	250	230	80	560	906	1,000	200	1,200	763	500	150	0	650		Apr 22
2,467	750	0	13.13	3,217	408	300	250	150	80	480	906	780	270	1,050	763	500	400	0	900		Apr 23
2,463	750	0	14.62	3,213	404	300	250	150	80	480	906	580	250	830	763	900	300	0	1,200	M	Apr 24
2,238	980	0	16.56	3,218	400	300	250	150	80	480	768	430	120	550	763	1,250	250	0	1,500	M, S	Apr 25
2,434	780	0	18.11	3,214	396	300	250	150	80	480	580	430	110	540	763	1,250	250	0	1,500	M, S	Apr 26
2,630	600	0	19.30	3,230	392	300	250	150	80	480	425	430	110	540	763	1,250	250	0	1,500	M, S	Apr 27
2,626	590	0	20.47	3,216	388	300	250	150	80	480	425	430	110	540	763	1,250	250	0	1,500	M, S	Apr 28
2,622	590	0	21.64	3,212	383	300	250	150	80	480	425	430	110	540	737	1,250	250	0	1,500	M, S	Apr 29
2,618	590	0	22.81	3,208	379	300	250	150	80	480	425	430	110	540	737	1,250	250	0	1,500	M, S	Apr 30
2,613	590	0	23.98	3,203	375	300	250	200	80	530	425	430	110	540	737	1,250	250	0	1,500	S	May 01
2,609	590	0	25.15	3,199	371	300	250	350	100	700	425	430	110	540	737	1,250	250	0	1,500	S	May 02
2,605	590	0	26.32	3,195	367	300	250	660	100	1,010	425	430	160	590	737	1,100	135	0	1,235		May 03
2,601	640	0	27.59	3,241	363	300	250	960	80	1,290	425	430	160	590	737	813	122	0	935	M	May 04
2,447	745	0	29.07	3,192	358	300	250	960	80	1,290	425	430	280	710	737	550	50	0	600	M	May 05
2,156	1,042	0	31.13	3,198	354	300	250	960	80	1,290	562	570	140	710	737	550	50	0	600	M	May 06
1,888	1,370	0	33.85	3,258	350	300	250	960	80	1,290	562	570	140	710	737	550	50	0	600	M	May 07
2,024	1,230	0	36.29	3,254	346	300	250	960	80	1,290	562	570	140	710	737	550	50	0	600	M	May 08
2,020	1,230	0	38.73	3,250	342	300	250	960	80	1,290	562	570	140	710	737	550	50	0	600	M	May 09
2,016	1,230	0	41.17	3,246	338	300	250	960	80	1,290	562	570	140	710	737	550	50	0	600	M	May 10
2,012	1,230	0	43.61	3,242	333	300	250	960	80	1,290	562	570	140	710	737	550	50	0	600	M	May 11
2,008	1,230	0	46.05	3,238	329	300	250	550	80	880	528	530	160	690	737	550	50	0	600		May 12
2,003	1,230	0	48.49	3,233	325	300	250	250	0	500	459	460	160	620	737	550	185	0	735		May 13
1,959	1,250	0	50.97	3,209	321	300	250	100	0	350	417	417		417	737	737			737		May 14
1,885	975	0	52.90	3,860	317	300	250			250	357	357		357	737	737			737		May 15
2,025	250			2,275	313	300	250			250	298	298		298	737	737			737		May 16
1,961	100			2,061	309	300	250			250	150	150		150	737	737			737		May 17
1,898	0			1,898	305	300	250			250	150	150		150	737	737			737		May 18
1,746	0			1,746	301	300	250			250	150	150		150	737	737			737		May 19
1,742	0			1,742	297	300	250			250	150	150		150	737	737			737		May 20
1,738	0			1,738	293	300	250			250	150	150		150	737	737			737		May 21
1,734	0			1,734	289	300	250			250	150	150		150	737	737			737		May 22
1,730	0			1,730	285	300	250			250	150	150		150	737	737			737		May 23
1,726	0			1,726	281	300	250			250	150	150		150	737	737			737		May 24
1,722	0			1,722	277	300	250			250	150	150		150	737	737			737		May 25
1,718	0			1,718	273	300	250			250	150	150		150	737	737			737		May 26
1,714	0			1,714	269	300	250			250	150	150		150	737	737			737		May 27
1,710	0			1,710	265	300	250			250	150	150		150	737	737			737		May 28
1,706	0			1,706	261	300	250			250	150	150		150	737	737			737		May 29
1,702	0			1,702	257	300	250			250	150	150		150	737	737			737		May 30
1,698	0			1,698	253	300	250			250	150	150		150	737	737			737		May 31
VAMP period																					
2,340	860			3,200	388	300	250	454	81	785	652	652	163	814	750	750	163	0	913		Avg (cfs):
	52.90							27.91	5.00				10.00				10.00				Suppl. Water (TAF)

Target flow period

Period of desired flow stability

Appendix A–1, Table 7

VAMP DAILY OPERATION PLAN, APRIL 22, 2003

Target Flow Period: April 15–May 15 • Flow Target: 3,200 cfs

bold numbers: observed real time

	San Joaquin River near Vernalis							Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus River below Goodwin					
	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. Flow	Exch Contr VAMP Suppl. Flow	VAMP Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow (flat)	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)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	
Apr 01	**1,940**				**1,950**	**612**	**402**	**225**			**225**	150	**181**		**181**	650	**606**			**606**	
Apr 02	**2,010**				**2,010**	**568**	**377**	**229**			**229**	150	**182**		**182**	650	**604**			**604**	
Apr 03	**2,050**				**2,050**	**548**	**434**	**249**			**249**	150	**180**		**180**	650	**650**			**650**	
Apr 04	**2,030**				**2,030**	**510**	**451**	**245**			**245**	150	**181**		**181**	650	**709**			**709**	
Apr 05	**2,080**				**2,080**	**494**	**473**	**250**			**250**	150	**183**		**183**	650	**709**			**709**	
Apr 06	**2,020**				**2,020**	**484**	**371**	**245**			**245**	150	**181**		**181**	650	**700**			**700**	
Apr 07	**2,060**				**2,060**	**482**	**429**	**240**			**240**	150	**184**		**184**	650	**757**			**757**	
Apr 08	**1,980**				**1,980**	**463**	**365**	**234**			**234**	150	**150**		**182**	650	**800**			**801**	
Apr 09	**1,930**				**1,930**	**442**	**262**	**235**			**235**	150	**150**		**183**	650	**800**			**801**	
Apr 10	**1,880**				**1,880**	**410**	**194**	**239**			**239**	150	**150**		**182**	650	**800**			**802**	
Apr 11	**1,920**				**1,920**	**385**	**260**	**250**	104		**354**	150	**150**		**295**	650	**800**			**808**	
Apr 12	**2,000**				**2,000**	**329**	**371**	**250**	276	80	**606**	425	**425**		**452**	650	**800**			**805**	
Apr 13	**2,290**	0			**2,290**	**277**	**563**	**250**	307	80	**637**	700	**700**	138	**838**	763	**500**	232	0	**732**	
Apr 14	**2,494**	136			**2,630**	**290**	**690**	**250**	324	80	**654**	906	**1,000**	220	**1,220**	763	**500**	147	0	**647**	
Apr 15	**2,133**	726	0	1.44	**2,859**	**325**	**406**	**250**	308	80	**638**	906	**1,000**	240	**1,240**	763	**500**	149	0	**649**	
Apr 16	**2,266**	754	0	2.94	**3,020**	**323**	**226**	**250**	348	80	**678**	906	**1,000**	230	**1,230**	763	**500**	149	0	**649**	
Apr 17	**2,317**	793	0	4.51	**3,110**	**327**	**242**	**250**	343	80	**673**	906	**1,000**	230	**1,230**	763	**500**	149	0	**649**	
Apr 18	**2,423**	767	0	6.03	**3,190**	**374**	**350**	**250**	345	80	**675**	906	**1,000**	250	**1,250**	763	**500**	149	0	**649**	
Apr 19	**2,403**	807	0	7.63	**3,210**	**392**	**326**	**250**	340	80	**670**	906	**1,000**	250	**1,250**	763	**500**	149	0	**649**	
Apr 20	**2,558**	822	0	9.26	**3,380**	**378**	**434**	**250**	333	80	**663**	906	**1,000**	260	**1,260**	763	**500**	152	0	**652**	
Apr 21	**2,686**	824	0	10.90	**3,510**	**362**	**544**	**250**	321	80	**651**	906	**1,000**	250	**1,250**	763	500	152	0	**652**	
Apr 22	2,588	832	0	12.55	3,420	413	460	250	230	80	560	906	1,000	100	1,100	763	500	150	0	650	
Apr 23	2,412	815	0	14.16	3,227	408	300	250	150	80	480	906	780	170	950	763	500	400	0	900	
Apr 24	2,463	651	0	15.45	3,114	404	300	250	150	80	480	906	580	150	730	763	900	300	0	1,200	M
Apr 25	2,238	880	0	17.20	3,118	400	300	250	150	80	480	768	430	120	550	763	1,250	250	0	1,500	M,S
Apr 26	2,434	680	0	18.55	3,114	396	300	250	150	80	480	580	430	110	540	763	1,250	250	0	1,500	M,S
Apr 27	2,630	600	0	19.74	3,230	392	300	250	150	80	480	425	430	110	540	763	1,250	250	0	1,500	M,S
Apr 28	2,626	590	0	20.91	3,216	388	300	250	150	80	480	425	430	110	540	763	1,250	250	0	1,500	M,S
Apr 29	2,622	590	0	22.08	3,212	383	300	250	150	80	480	425	430	110	540	737	1,250	250	0	1,500	M,S
Apr 30	2,618	590	0	23.25	3,208	379	300	250	150	80	480	425	430	110	540	737	1,250	250	0	1,500	M,S
May 01	2,613	590	0	24.42	3,203	375	300	250	200	80	530	425	430	110	540	737	1,250	250	0	1,500	S
May 02	2,609	590	0	25.59	3,199	371	300	250	350	100	700	425	430	110	540	737	1,250	250	0	1,500	S
May 03	2,605	590	0	26.76	3,195	367	300	250	660	100	1,010	425	430	160	590	737	1,100	135	0	1,235	
May 04	2,601	640	0	28.03	3,241	363	300	250	960	80	1,290	425	430	160	590	737	813	122	0	935	M
May 05	2,447	745	0	29.51	3,192	358	300	250	960	80	1,290	425	430	280	710	737	550	50	0	600	M
May 06	2,156	1,042	0	31.57	3,198	354	300	250	960	80	1,290	562	570	140	710	737	550	50	0	600	M
May 07	1,888	1,370	0	34.29	3,258	350	300	250	960	80	1,290	562	570	140	710	737	550	50	0	600	M
May 08	2,024	1,230	0	36.73	3,254	346	300	250	960	80	1,290	562	570	140	710	737	550	50	0	600	M
May 09	2,020	1,230	0	39.17	3,250	342	300	250	960	80	1,290	562	570	140	710	737	550	50	0	600	M
May 10	2,016	1,230	0	41.61	3,246	338	300	250	960	80	1,290	562	570	140	710	737	550	50	0	600	M
May 11	2,012	1,230	0	44.05	3,242	333	300	250	960	80	1,290	562	570	140	710	737	550	50	0	600	M
May 12	2,008	1,230	0	46.49	3,238	329	300	250	550	80	880	528	530	160	690	737	550	50	0	600	
May 13	2,003	1,230	0	48.93	3,233	325	300	250	250	0	500	459	460	160	620	737	550	185	0	735	
May 14	1,959	1,250	0	51.41	3,209	321	300	250	100	0	350	417	417		417	737	737			737	
May 15	1,885	975	0	53.34	2,860	317	300	250			250	357	357		357	737	737			737	
May 16	2,025	250			2,275	313	300	250			250	298	298		298	737	737			737	
May 17	1,961	100			2,061	309	300	250			250	150	150		150	737	737			737	
May 18	1,898	0			1,898	305	300	250			250	150	150		150	737	737			737	
May 19	1,746	0			1,746	301	300	250			250	150	150		150	737	737			737	
May 20	1,742	0			1,742	297	300	250			250	150	150		150	737	737			737	
May 21	1,738	0			1,738	293	300	250			250	150	150		150	737	737			737	
May 22	1,734	0			1,734	289	300	250			250	150	150		150	737	737			737	
May 23	1,730	0			1,730	285	300	250			250	150	150		150	737	737			737	
May 24	1,726	0			1,726	281	300	250			250	150	150		150	737	737			737	
May 25	1,722	0			1,722	277	300	250			250	150	150		150	737	737			737	
May 26	1,718	0			1,718	273	300	250			250	150	150		150	737	737			737	
May 27	1,714	0			1,714	269	300	250			250	150	150		150	737	737			737	
May 28	1,710	0			1,710	265	300	250			250	150	150		150	737	737			737	
May 29	1,706	0			1,706	261	300	250			250	150	150		150	737	737			737	
May 30	1,702	0			1,702	257	300	250			250	150	150		150	737	737			737	
May 31	1,698	0			1,698	253	300	250			250	150	150		150	737	737			737	
	VAMP period																				
Avg (cfs):	2,331	868			3,199	360	319	250	455	81	787	652	652	166	817	750	750	165	0	916	
Suppl. Water (TAF)		53.34							28.00	5.00				10.19					10.16		

Target flow period

Period of desired flow stability

Appendix A–1, Table 8

VAMP DAILY OPERATION PLAN, APRIL 30, 2003

Target Flow Period: April 15–May 15 • Flow Target: 3,200 cfs

bold numbers: observed real time

San Joaquin River near Vernalis							Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus River below Goodwin						
Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. Flow	Exch Contr VAMP Suppl. Flow	VAMP Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow (flat)	Existing Flow (re-shaped)	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol. S=Stan.	
(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		
1,940				**1,950**	**612**	**402**	225			**225**	150	181		**181**	650	606			**606**		Apr 01
2,010				**2,010**	**568**	**377**	229			**229**	150	182		**182**	650	604			**604**		Apr 02
2,050				**2,050**	**548**	**434**	249			**249**	150	180		**180**	650	650			**650**		Apr 03
2,030				**2,030**	**510**	**451**	245			**245**	150	181		**181**	650	709			**709**		Apr 04
2,080				**2,080**	**494**	**473**	250			**250**	150	183		**182**	650	709			**709**		Apr 05
2,020				**2,020**	**484**	**371**	245			**245**	150	181		**181**	650	700			**700**		Apr 06
2,060				**2,060**	**482**	**429**	240			**240**	150	184		**184**	650	757			**757**		Apr 07
1,980				**1,980**	**463**	**365**	234			**234**	150	150		**182**	650	800			**801**		Apr 08
1,930				**1,930**	**442**	**262**	235			**235**	150	150		**183**	650	800			**801**		Apr 09
1,880				**1,880**	**410**	**194**	239			**239**	150	150		**182**	650	800			**802**		Apr 10
1,920				**1,920**	**385**	**260**	250	104		**354**	150	150		**303**	650	800			**808**		Apr 11
2,000				**2,000**	**329**	**371**	250	276	80	**606**	425	425		**472**	650	800			**805**		Apr 12
2,290	0			**2,290**	**277**	**563**	250	307	80	**637**	700	700	191	**891**	763	500	232	0	**732**		Apr 13
2,494	136			**2,630**	**290**	**690**	250	324	80	**654**	906	1,000	300	**1,300**	763	500	147	0	**647**		Apr 14
2,133	779	0	1.55	**2,859**	**325**	**406**	250	308	80	**638**	906	1,000	310	**1,310**	763	500	149	0	**649**		Apr 15
2,266	834	0	3.20	**3,020**	**323**	**226**	250	348	80	**678**	906	1,000	310	**1,310**	763	500	149	0	**649**		Apr 16
2,317	863	0	4.91	**3,110**	**327**	**242**	250	343	80	**673**	906	1,000	310	**1,310**	763	500	149	0	**649**		Apr 17
2,423	847	0	6.59	**3,190**	**374**	**350**	250	345	80	**675**	906	1,000	330	**1,330**	763	500	149	0	**649**		Apr 18
2,403	887	0	8.35	**3,210**	**392**	**326**	250	340	80	**670**	906	1,000	330	**1,330**	763	500	149	0	**649**		Apr 19
2,558	902	0	10.14	**3,380**	**378**	**434**	250	333	80	**663**	906	1,000	340	**1,340**	763	500	152	0	**652**		Apr 20
2,686	904	0	11.93	**3,510**	**362**	**544**	250	321	80	**651**	906	1,000	330	**1,330**	763	500	152	0	**652**		Apr 21
2,508	912	0	13.74	**3,420**	**348**	**380**	250	241	80	**571**	906	1,000	270	**1,270**	763	500	152	0	**652**		Apr 22
2,425	895	0	15.52	**3,320**	**325**	**313**	250	177	80	**507**	906	780	250	**1,030**	763	500	281	0	**781**		Apr 23
2,227	823	0	17.15	**3,050**	**311**	**129**	250	163	80	**493**	906	580	238	**818**	763	900	321	0	**1,221**	M	Apr 24
2,228	852	0	18.84	**3,080**	**288**	**373**	250	182	80	**512**	768	430	176	**606**	763	1,250	262	0	**1,512**	M,S	Apr 25
2,394	816	0	20.46	**3,210**	**313**	**353**	250	187	80	**517**	580	430	149	**579**	763	1,250	251	0	**1,501**	M,S	Apr 26
2,569	681	0	21.81	**3,250**	**316**	**351**	250	182	80	**512**	425	430	151	**581**	763	1,250	253	0	**1,503**	M,S	Apr 27
2,668	662	0	23.12	**3,330**	**308**	**425**	250	196	80	**526**	425	430	153	**583**	763	1,250	256	0	**1,506**	M,S	Apr 28
2,759	671	0	24.45	**3,430**	**320**	**513**	250	180	80	**510**	425	430	130	**560**	737	1,250	253	0	**1,503**	M,S	Apr 29
2,638	671	0	25.78	3,309	379	400	250	150	80	480	425	430	110	540	737	1,250	250	0	1,500	M,S	Apr 30
2,550	659	0	27.09	3,209	375	300	250	200	80	530	425	430	110	540	737	1,250	250	0	1,500	S	May 01
2,609	620	0	28.32	3,229	371	300	250	350	100	700	425	430	110	540	737	1,250	250	0	1,500	S	May 02
2,605	590	0	29.49	3,195	367	300	250	660	100	1,010	425	430	110	540	737	1,100	135	0	1,235		May 03
2,601	640	0	30.76	3,241	363	300	250	1,000	80	1,330	425	430	110	540	737	813	122	0	935	M	May 04
2,447	695	0	32.14	3,142	358	300	250	1,000	80	1,330	425	430	110	540	737	550	50	0	600	M	May 05
2,156	992	0	34.11	3,148	354	300	250	1,000	80	1,330	562	570	30	600	737	550	50	0	600	M	May 06
1,888	1,240	0	36.57	3,128	350	300	250	1,000	80	1,330	425	570	30	600	737	550	50	0	600	M	May 07
2,024	1,160	0	38.87	3,184	346	300	250	1,000	80	1,330	425	570	30	600	737	550	50	0	600	M	May 08
2,020	1,160	0	41.17	3,180	342	300	250	1,000	80	1,330	425	570	30	600	737	550	50	0	600	M	May 09
2,016	1,160	0	43.47	3,176	338	300	250	1,000	80	1,330	425	570	30	600	737	550	50	0	600	M	May 10
2,012	1,160	0	45.77	3,172	333	300	250	1,000	80	1,330	425	570	30	600	737	550	50	0	600	M	May 11
2,008	1,160	0	48.07	3,168	329	300	250	550	80	880	528	530	30	560	737	550	50	0	600		May 12
2,003	1,160	0	50.37	3,163	325	300	250	250	0	500	459	460	30	490	737	550	185	0	735		May 13
1,959	1,160	0	52.67	3,119	321	300	250	100	0	350	417	417		417	737	737			737		May 14
1,885	845	0	54.35	2,730	317	300	250			250	357	357		357	737	737			737		May 15
2,025	250			2,275	313	300	250			250	298	298		298	737	737			737		May 16
1,961	100			2,061	309	300	250			250	150	150		150	737	737			737		May 17
1,898	0			1,898	305	300	250			250	150	150		150	737	737			737		May 18
1,746	0			1,746	301	300	250			250	150	150		150	737	737			737		May 19
1,742	0			1,742	297	300	250			250	150	150		150	737	737			737		May 20
1,738	0			1,738	293	300	250			250	150	150		150	737	737			737		May 21
1,734	0			1,734	289	300	250			250	150	150		150	737	737			737		May 22
1,730	0			1,730	285	300	250			250	150	150		150	737	737			737		May 23
1,726	0			1,726	281	300	250			250	150	150		150	737	737			737		May 24
1,722	0			1,722	277	300	250			250	150	150		150	737	737			737		May 25
1,718	0			1,718	273	300	250			250	150	150		150	737	737			737		May 26
1,714	0			1,714	269	300	250			250	150	150		150	737	737			737		May 27
1,710	0			1,710	265	300	250			250	150	150		150	737	737			737		May 28
1,706	0			1,706	261	300	250			250	150	150		150	737	737			737		May 29
1,702	0			1,702	257	300	250			250	150	150		150	737	737			737		May 30
1,698	0			1,698	253	300	250			250	150	150		150	737	737			737		May 31
VAMP period																					
2,322	884			3,189	339	331	250	473	81	804	652	652	167	818	750	750	163	0	913		Avg (cfs):
	54.35							29.08	5.00				10.25				10.01				Suppl. Water (TAF)

Target flow period

Period of desired flow stability

Appendix A–2, Table 1

2003 VERNALIS ADAPTIVE MANAGEMENT PLAN (VAMP)

Final Accounting of Supplemental Water Contributions

Target Flow Period: April 15–May 15 • Target Flow: 3,200 cfs

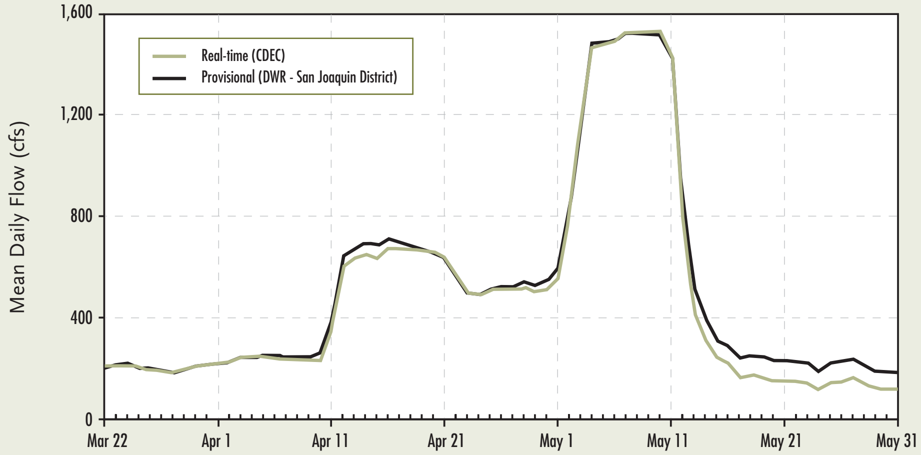
	Merced R. at Cressey (3 Day Travel Time to Vernalis)			Tuolumne R. below LaGrange Dam (2 Day Travel Time to Vernalis)			Stanislaus R. below Goodwin Dam (2 Day Travel Time to Vernalis)			SJRECWA (3 Day)	San Joaquin River at Vernalis		
	Existing Flow	Observed Flow	VAMP Suppl. Water	Existing Flow	Observed Flow	VAMP Suppl. Water	Existing Flow	Observed Flow	VAMP Suppl. Water	VAMP Suppl. Water	Existing Flow	Observed Flow	VAMP Suppl. Water
	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
Apr 01	228	228		181	181		606	606			1,950	1,950	
Apr 02	232	232		182	182		604	604			2,010	2,010	
Apr 03	253	253		180	180		650	650			2,050	2,050	
Apr 04	252	252		181	181		709	709			2,030	2,030	
Apr 05	259	259		182	182		709	709			2,080	2,080	
Apr 06	257	257		181	181		700	700			2,010	2,010	
Apr 07	253	253		184	184		757	757			2,050	2,050	
Apr 08	250	250		182	182		801	801			1,970	1,970	
Apr 09	254	254		183	183		801	801			1,920	1,920	
Apr 10	261	261		182	182		802	802			1,850	1,850	
Apr 11	250	386		303	303		808	808			1,880	1,880	
Apr 12	250	649	399	472	472		805	805		0	1,980	1,980	
Apr 13	250	681	431	700	891	191	500	732	232	0	2,260	2,260	
Apr 14	250	701	451	1,000	1,300	300	500	647	147	0	2,610	2,610	
Apr 15	250	688	438	1,000	1,310	310	500	649	149	0	2,017	2,839	822
Apr 16	250	719	469	1,000	1,310	310	500	649	149	0	2,132	3,010	878
Apr 17	250	702	452	1,000	1,310	310	500	649	149	0	2,190	3,100	910
Apr 18	250	693	443	1,000	1,330	330	500	649	149	0	2,283	3,180	897
Apr 19	250	678	428	1,000	1,330	330	500	649	149	0	2,272	3,200	928
Apr 20	250	658	408	1,000	1,340	340	500	652	152	0	2,439	3,370	931
Apr 21	250	637	387	1,000	1,330	330	500	652	152	0	2,578	3,500	922
Apr 22	250	559	309	1,000	1,270	270	500	652	152	0	2,490	3,410	920
Apr 23	250	502	252	780	1,030	250	500	781	281	0	2,420	3,310	890
Apr 24	250	495	245	580	818	238	900	1,221	321	0	2,241	3,050	809
Apr 25	250	519	269	430	602	172	1,250	1,512	262	0	2,230	3,070	840
Apr 26	250	527	277	430	574	144	1,250	1,501	251	0	2,389	3,200	811
Apr 27	250	527	277	430	573	143	1,250	1,503	253	0	2,561	3,240	679
Apr 28	250	547	297	430	575	145	1,250	1,506	256	0	2,656	3,320	664
Apr 29	250	536	286	430	551	121	1,250	1,503	253	0	2,747	3,420	673
Apr 30	250	549	299	430	522	92	1,250	1,502	252	0	2,642	3,320	678
May 01	250	598	348	430	524	94	1,250	1,502	252	0	2,609	3,280	671
May 02	250	846	596	430	525	95	1,250	1,506	256	0	2,630	3,260	630
May 03	250	1,190	940	430	525	95	1,100	1,268	168	0	2,685	3,330	645
May 04	250	1,490	1,240	430	524	94	813	950	137	0	2,790	3,489	699
May 05	250	1,490	1,240	430	524	94	550	598	48	0	2,600	3,459	859
May 06	250	1,500	1,250	570	589	19	550	600	50	0	2,149	3,320	1,171
May 07	250	1,530	1,280	570	585	15	550	604	54	0	1,828	3,210	1,382
May 08	250	1,520	1,270	570	583	13	550	600	50	0	1,941	3,250	1,309
May 09	250	1,520	1,270	570	574	4	550	607	57	0	1,981	3,300	1,319
May 10	250	1,520	1,270	570	577	7	550	603	53	0	1,947	3,290	1,343
May 11	250	1,420	1,170	570	579	9	550	603	53	0	2,059	3,390	1,331
May 12	250	847	597	530	542	12	550	603	53	0	2,070	3,400	1,330
May 13	250	524		460	488	28	550	691	141		1,898	3,230	1,332
May 14	250	407		407	407		741	741			1,645	2,880	1,235
May 15	250	315		353	353		733	733			1,884	2,650	766
May 16	254	292		306	306		751	751			2,216	2,490	
May 17	249	249		228	228		914	914			2,183	2,340	
May 18	257	257		185	185		1,004	1,004			2,225	2,290	
May 19	252	252		184	184		998	998			2,332	2,370	
May 20	235	235		348	348		1,004	1,004			2,250	2,250	
May 21	236	236		563	563		772	772			2,110	2,110	
May 22	233	233		565	565		599	599			2,120	2,120	
May 23	227	227		569	569		603	603			2,070	2,070	
May 24	196	196		567	567		606	606			2,060	2,060	
May 25	228	228		568	568		605	605			2,080	2,080	
May 26	230	230		568	568		604	604			2,150	2,150	
May 27	243	243		569	569		740	740			2,050	2,050	
May 28	215	215		566	566		976	976			1,950	1,950	
May 29	196	196		512	512		1,046	1,046			2,039	2,039	
May 30	188	188		323	323		1,051	1,051			2,160	2,160	
May 31	189	189		266	266		1,051	1,051			2,190	2,190	
Total Supplemental Water (acre-feet):			38,257			9,729			10,078	0			58,065
Target Flow Period Average											2,290	3,235	

Observed Flow Sources (best available data as of July 31, 2003):

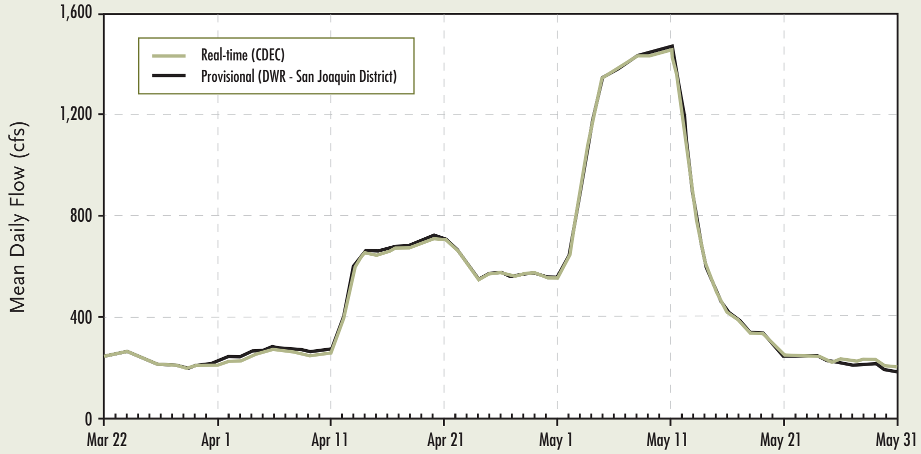
Merced River at Cressey (CA DWR B05155): California DWR, San Joaquin District • Tuolumne River below LaGrange Dam near LaGrange (USGS 11289650): USGS Stanislaus River below Goodwin Dam: USBR, Goodwin Reservoir Daily Operations Report – OID/SSJID/Tri-Dams • San Joaquin River near Vernalis (USGS 11303500): USGS

A–3. Comparison of "Real-Time" and Provisional Flows

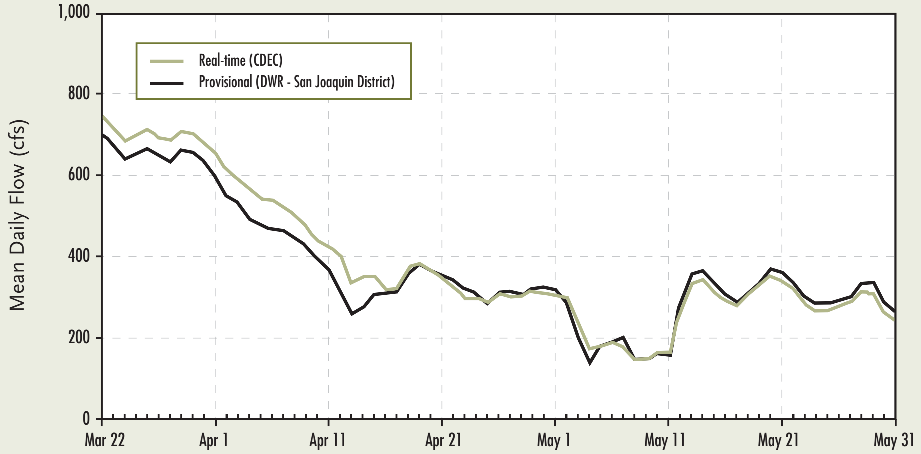
Merced River Near Cressey



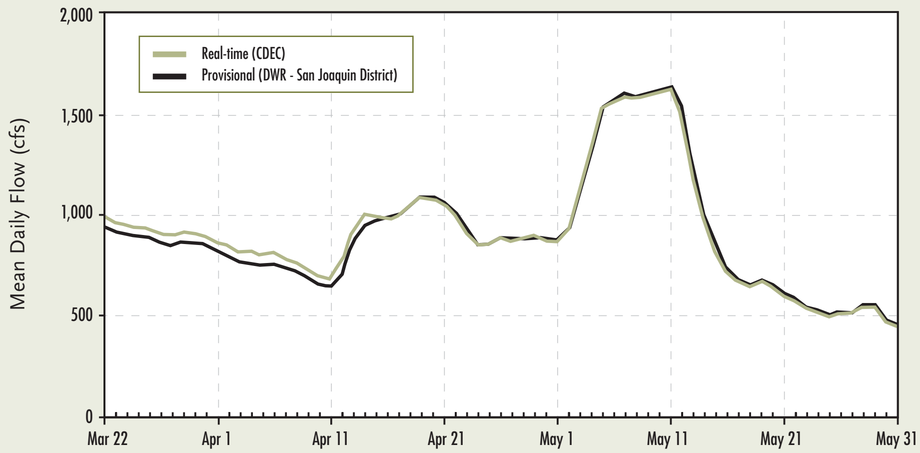
Merced River Near Stevinson



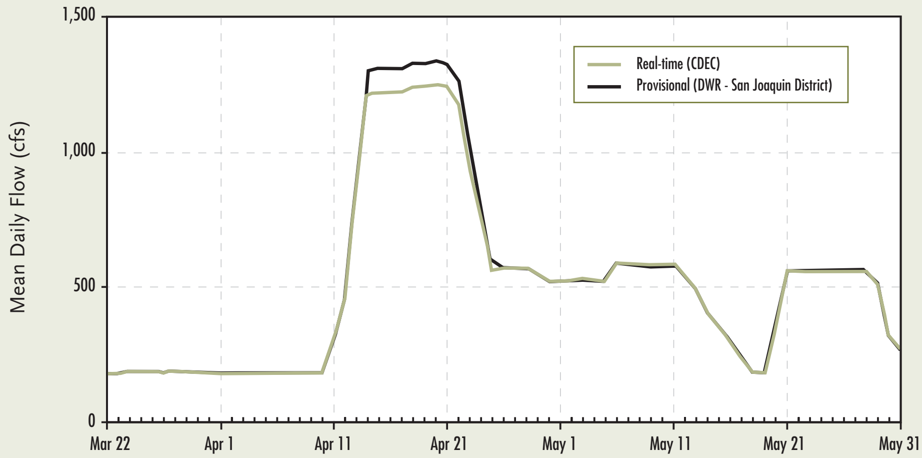
San Joaquin River Above Merced River



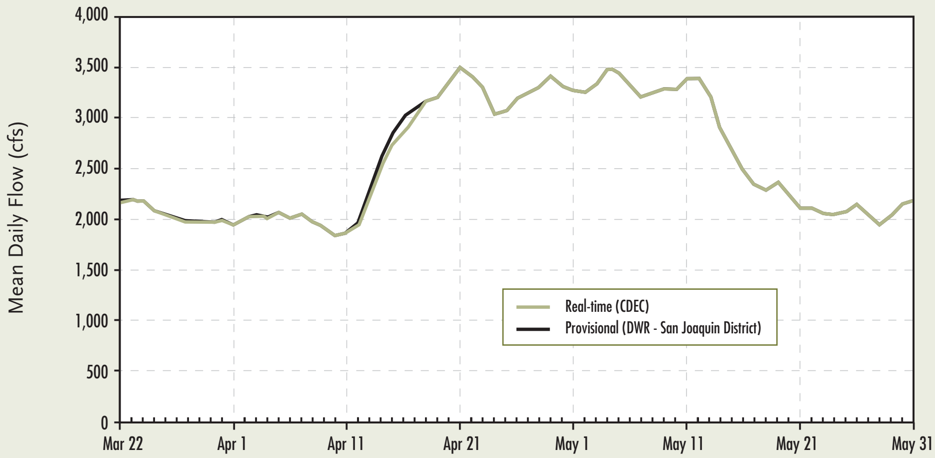
San Joaquin River near Newman



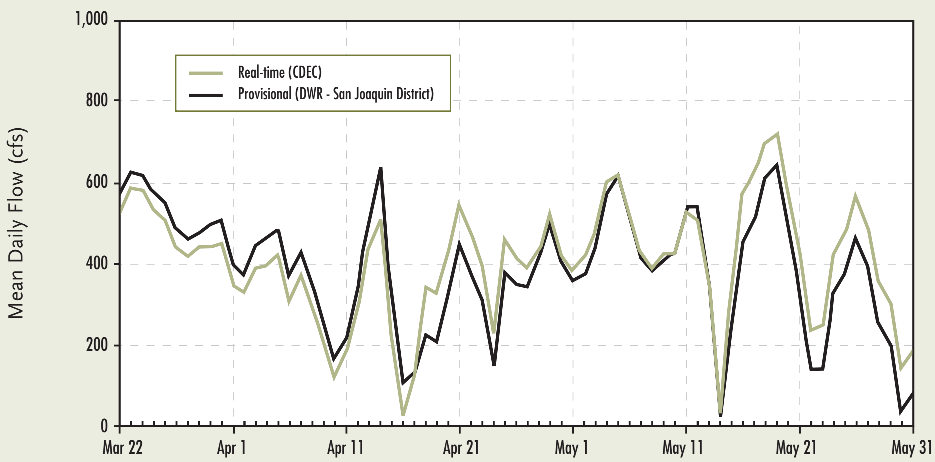
Tuolumne River below LaGrange Dam



San Joaquin River near Vernalis



Ungaged Flow in San Joaquin near Vernalis



Appendix A–4

FLOW IN SAN JOAQUIN RIVER AND OLD RIVER NEAR HORB

All values in cfs

Date	San Joaquin River near Vernalis (1)	Old River at Head (2)	San Joaquin River below Old River (3)	Through HORB Culverts (4)	Estimated HORB Seepage (5)
Mar 01	2,020	1,081	939		
Mar 02	2,050	1,032	1,018		
Mar 03	2,120	1,102	1,018		
Mar 04	2,130	1,005	1,125		
Mar 05	2,050	1,007	1,043		
Mar 06	2,070	974	1,096		
Mar 07	2,130	1,046	1,084		
Mar 08	2,210	938	1,272		
Mar 09	2,240	916	1,324		
Mar 10	2,260	945	1,315		
Mar 11	2,200	969	1,231		
Mar 12	2,200	1,016	1,184		
Mar 13	2,280	1,101	1,179		
Mar 14	2,270	1,070	1,200		
Mar 15	2,470	1,179	1,291		
Mar 16	2,620	1,224	1,396		
Mar 17	2,540	1,292	1,248		
Mar 18	2,500	1,302	1,198		
Mar 19	2,420	1,138	1,282		
Mar 20	2,320	1,095	1,225		
Mar 21	2,230	1,037	1,193		
Mar 22	2,180	1,011	1,169		
Mar 23	2,200	992	1,208		
Mar 24	2,180	1,032	1,148		
Mar 25	2,100	973	1,127		
Mar 26	2,060	1,020	1,040		
Mar 27	2,010	1,135	875		
Mar 28	1,980	1,039	941		
Mar 29	1,980	879	1,101		
Mar 30	1,970	953	1,017		
Mar 31	2,000	932	1,068		
Apr 01	1,950	1,017	933		
Apr 02	2,010	820	1,190		
Apr 03	2,050	846	1,204		
Apr 04	2,030	838	1,192		
Apr 05	2,080	862	1,218		
Apr 06	2,010	832	1,178		
Apr 07	2,050	709	1,341		
Apr 08	1,970	649	1,321		
Apr 09	1,920	507	1,413		
Apr 10	1,850	617	1,233		
Apr 11	1,880	368	1,512		
Apr 12	1,970	262	1,708		
Apr 13	2,260	379	1,881		
Apr 14	2,600	415	2,185	138	277
Apr 15	2,839	354	2,485	153	201
Apr 16	3,000	388	2,612	186	202
Apr 17	3,090	467	2,623	198	269
Apr 18	3,160	427	2,733	195	232
Apr 19	3,180	469	2,711	192	277
Apr 20	3,350	459	2,891	186	273
Apr 21	3,469	409	3,060	174	235
Apr 22	3,390	280	3,110	180	100
Apr 23	3,300	291	3,009	180	111
Apr 24	3,050	207	2,843	168	39
Apr 25	3,070	179	2,891	177	2
Apr 26	3,200	270	2,930	177	93
Apr 27	3,240	284	2,956	177	107
Apr 28	3,320	218	3,102	165	53
Apr 29	3,420	285	3,135	171	114
Apr 30	3,320	322	2,998	174	148

San Joaquin River near Vernalis (1)	Old River at Head (2)	San Joaquin River below Old River (3)	Through HORB Culverts (4)	Estimated HORB Seepage (5)	Date
3,280	258	3,022	168	90	May 01
3,260	189	3,071	168	21	May 02
3,330	192	3,138	162	30	May 03
3,489	326	3,163	168	158	May 04
3,459	341	3,118	177	164	May 05
3,320	354	2,966	168	186	May 06
3,210	325	2,885	159	166	May 07
3,240	388	2,852	156	232	May 08
3,290	360	2,930	171	189	May 09
3,270	334	2,936	171	163	May 10
3,370	305	3,065	171	134	May 11
3,360	316	3,044	171	145	May 12
3,190	359	2,831	171	188	May 13
2,829	434	2,395	162	272	May 14
2,600	389	2,211	159	230	May 15
2,430	372	2,058	153	219	May 16
2,270	385	1,885			May 17
2,210	373	1,837			May 18
2,290	661	1,629			May 19
2,160	462	1,698			May 20
2,020	432	1,588			May 21
2,010	500	1,510			May 22
1,960	603	1,357			May 23
1,940	721	1,219			May 24
1,950	756	1,194			May 25
2,020	675	1,345			May 26
1,900	613	1,287			May 27
1,810	663	1,147			May 28
1,890	822	1,068			May 29
2,000	945	1,055			May 30
2,020	906	1,114			May 31
2,000	881	1,119			Jun 01
1,980	858	1,122			Jun 02
1,920	957	963			Jun 03
1,840	1,048	792			Jun 04
1,870	999	871			Jun 05
1,920	1,025	895			Jun 06
2,070	1,067	1,003			Jun 07
2,150	1,026	1,124			Jun 08
2,200	1,086	1,114			Jun 09
2,130	956	1,174			Jun 10
2,080	742	1,338			Jun 11
1,990	554	1,436			Jun 12
1,980	678	1,302			Jun 13
2,010	650	1,360			Jun 14
2,150	620	1,530			Jun 15
2,200	663	1,537			Jun 16
2,150	683	1,467			Jun 17
2,120	738	1,382			Jun 18
2,030	622	1,408			Jun 19
1,970	635	1,335			Jun 20
1,960	545	1,415			Jun 21
2,000	473	1,527			Jun 22
2,020	515	1,505			Jun 23
2,020	501	1,519			Jun 24
1,990	507	1,483			Jun 25
1,980	529	1,451			Jun 26
2,039	599	1,440			Jun 27
2,050	604	1,446			Jun 28
2,090	649	1,441			Jun 29
2,100	652	1,448			Jun 30

VAMP target flow period highlighted

(1) USGS provisional data as of 11/6/2003
(2) DWR Acoustic Doppler Current Meter located 840 ft. downstream of HORB
(3) (1)–(2)
(4) Three times the measured flow in HORB Culvert #4
(5) (2)–(4)

APPENDIX B

Fall Water Transfer & Delivery Information

B–1. MERCED IRRIGATION DISTRICT

SJRA Fall 2003 Water Transfer · Daily Summary

	SCHEDULED			
	BASE FLOW – Merced River at Cressey	SJRA Transfer Water	TARGET FLOW – Merced River at Cressey	SJRA Transfer Water Cumulative Volume
	(cfs)	(cfs)	(cfs)	(acre-feet)
Oct 01	30	70	100	139
Oct 02	30	70	100	278
Oct 03	30	125	155	526
Oct 04	30	125	155	774
Oct 05	30	125	155	1,021
Oct 06	30	125	155	1,269
Oct 07	30	125	155	1,517
Oct 08	30	125	155	1,765
Oct 09	30	125	155	2,013
Oct 10	30	125	155	2,261
Oct 11	30	125	155	2,509
Oct 12	30	125	155	2,757
Oct 13	30	125	155	3,005
Oct 14	30	125	155	3,253
Oct 15	30	125	155	3,501
Oct 16	85	125	210	3,749
Oct 17	85	185	270	4,116
Oct 18	85	315	400	4,740
Oct 19	85	515	600	5,762
Oct 20	85	515	600	6,783
Oct 21	85	515	600	7,805
Oct 22	85	515	600	8,826
Oct 23	85	515	600	9,848
Oct 24	85	315	400	10,473
Oct 25	85	215	300	10,899
Oct 26	85	135	220	11,167
Oct 27	85	135	220	11,435
Oct 28	85	135	220	11,702
Oct 29	85	135	220	11,970
Oct 30	85	135	220	12,238
Oct 31	85	135	220	12,506

B–2. MERCED IRRIGATION DISTRICT

SJRA Fall 2002 Water Transfer · Daily Summary (FINAL)

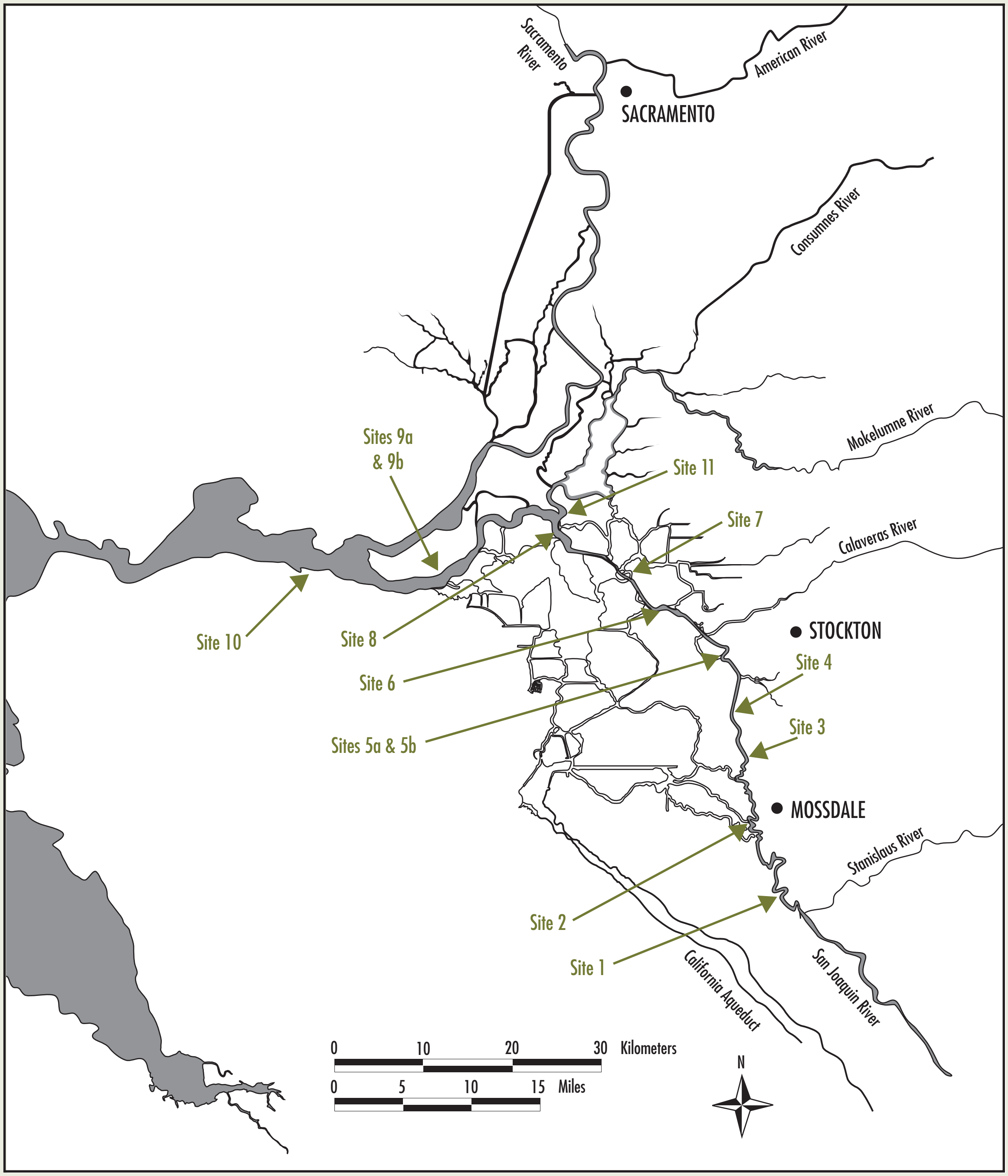
	SCHEDULED				OBSERVED		
	BASE FLOW – Merced River at Cressey	SJRA Transfer Water	SJRA Transfer Water Cumulative Volume	TARGET FLOW – Merced River at Cressey	FLOW – Merced River at Cressey	SJRA Transfer Water	SJRA Transfer Water Cumulative Volume
	(cfs)	(cfs)	(acre-feet)	(cfs)	(cfs)	(cfs)	(acre-feet)
Oct 01	30	0	0	30	93	0	0
Oct 02	30	0	0	30	104	0	0
Oct 03	30	0	0	30	108	0	0
Oct 04	30	0	0	30	100	0	0
Oct 05	30	0	0	30	99	0	0
Oct 06	30	0	0	30	100	0	0
Oct 07	30	0	0	30	119	0	0
Oct 08	30	0	0	30	101	0	0
Oct 09	30	0	0	30	102	0	0
Oct 10	30	0	0	30	108	0	0
Oct 11	30	0	0	30	122	0	0
Oct 12	30	0	0	30	124	0	0
Oct 13	30	0	0	30	138	0	0
Oct 14	30	0	0	30	146	0	0
Oct 15	30	220	436	250	312	220	436
Oct 16	85	350	1,131	435	481	350	1,131
Oct 17	85	625	2,370	710	702	617	2,354
Oct 18	85	625	3,610	710	747	625	3,594
Oct 19	85	625	4,850	710	787	625	4,834
Oct 20	85	625	6,089	710	810	625	6,073
Oct 21	85	625	7,329	710	815	625	7,313
Oct 22	85	625	8,569	710	760	625	8,553
Oct 23	85	625	9,808	710	745	625	9,792
Oct 24	85	390	10,582	475	543	390	10,566
Oct 25	85	240	11,058	325	420	240	11,042
Oct 26	85	120	11,296	205	335	120	11,280
Oct 27	85	120	11,534	205	303	120	11,518
Oct 28	85	120	11,772	205	296	120	11,756
Oct 29	85	120	12,010	205	280	120	11,994
Oct 30	85	120	12,248	205	258	120	12,232
Oct 31	85	120	12,486	205	224	120	12,470

APPENDIX C

Chinook Salmon Survival Investigations

C–1. WATER TEMPERATURE MONITORING LOCATIONS DURING THE VAMP 2003 EXPERIMENT

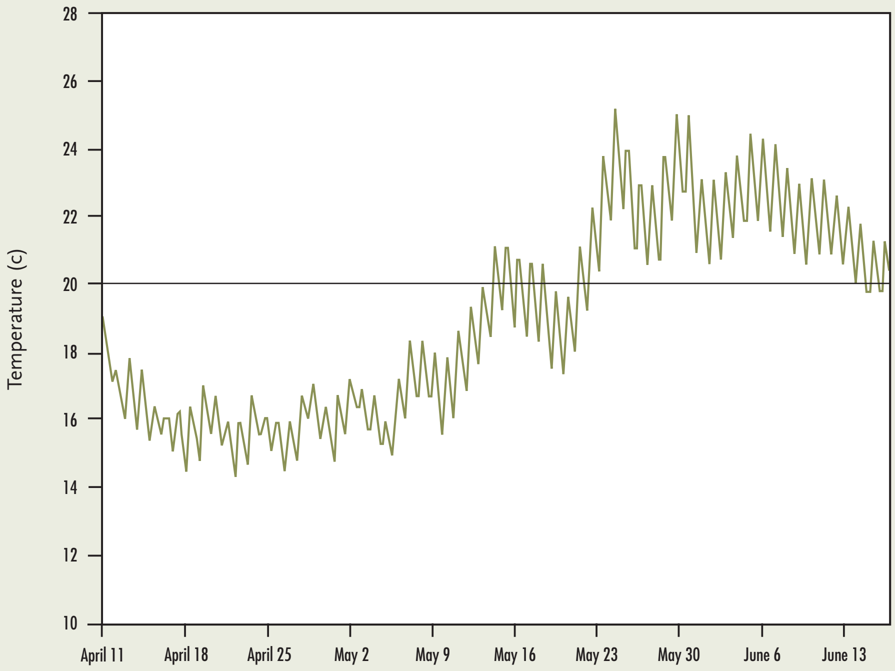
SACRAMENTO-SAN JOAQUIN ESTUARY



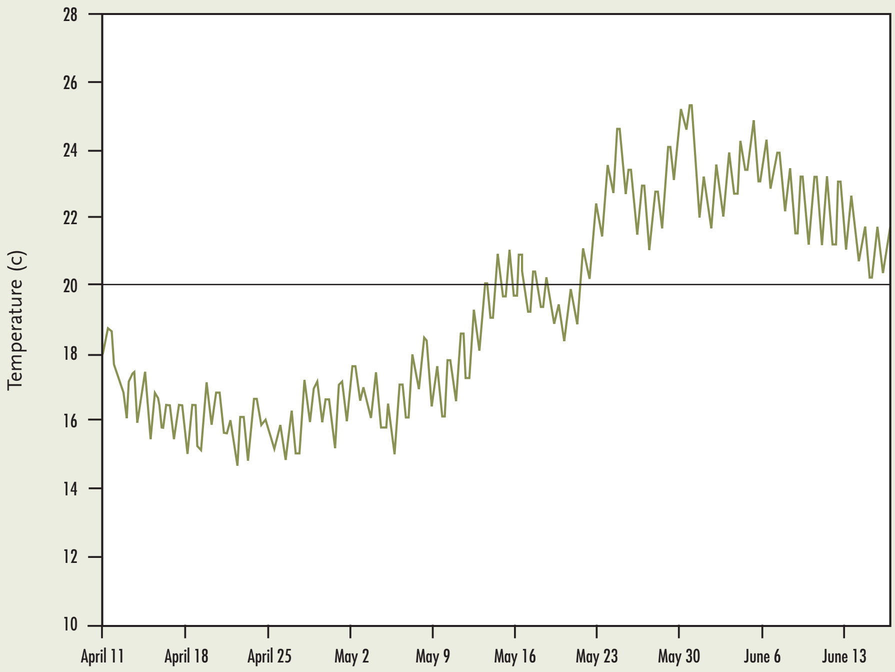
C–1. VAMP 2003 WATER TEMPERATURE MONITORING LOCATIONS

	Temperature Monitoring Location	Latitude	Longitude	Distance from Durham Ferry (mi)	Date Deployed	Date Retrieved	Notes
	Merced River Hatchery–1			n/a	March 21	April 23	In river April 21
	Merced River Hatchery–1			n/a	March 21	April 30	In river April 28
1	Durham Ferry	N 37 41.381	W 121 15.657	n/a	April 11	June 15	Logger was buried in silt when retrieved
2	Mossdale	N 37 47.180	W 121 18.425	11.2	April 11	June 15	3-1/2 feet below surface
3	Dos Reis	N 37 49.808	W 121 18.665	16.4	April 11	June 15	3 feet below surface
4	DWR Monitoring Station	N 37 51.869	W 121 19.376	19.4	April 11	June 15	3 feet below surface
5a	Confluence–Top	N 37 56.818	W 121 20.285	26.5	April 11	Logger Malfunction	3 feet below surface
5b	Confluence–Bottom	N 37 56.818	W 121 20.285	26.5	April 11		Located on bottom
6	Downstream of Channel Marker 30	N 37 59.776	W 121 25.569	33.3	April 11	June 15	3 feet below surface
7	1/2 mile Upstream of Channel Marker 13	N 38 01.940	W 121 28.769	37.3	April 11	June 15	3 feet below surface
8	Downstream of Channel Marker 36	N 38 04.522	W 121 34.413	44.7	April 11	June 15	3 feet below surface
9a	Jersey Point USGS Gauging Station–top	N 38 03.172	W121 41.637	56	April 11	Logger Lost	3 feet below surface
10	Chipps Island	N 38 03.084	W 121 55.463	71.5	April 11	June 15	4-1/2 feet below surface
11	Mokelumne River–Lighthouse Marina	N 38 06.334	W 121 34.213	40	April 11	June 15	Under pier in 3 feet of water

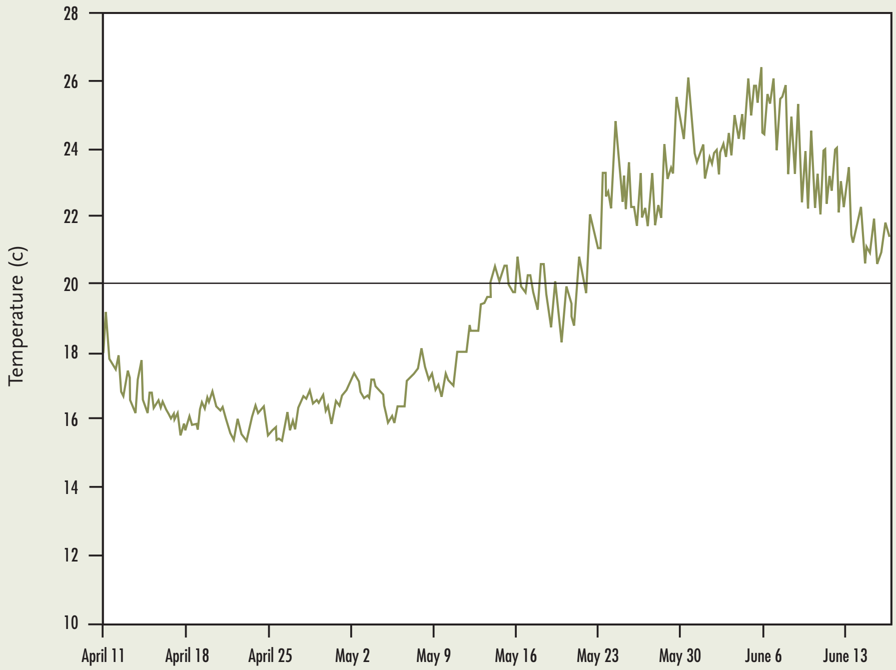
Site 1 • Durham Ferry



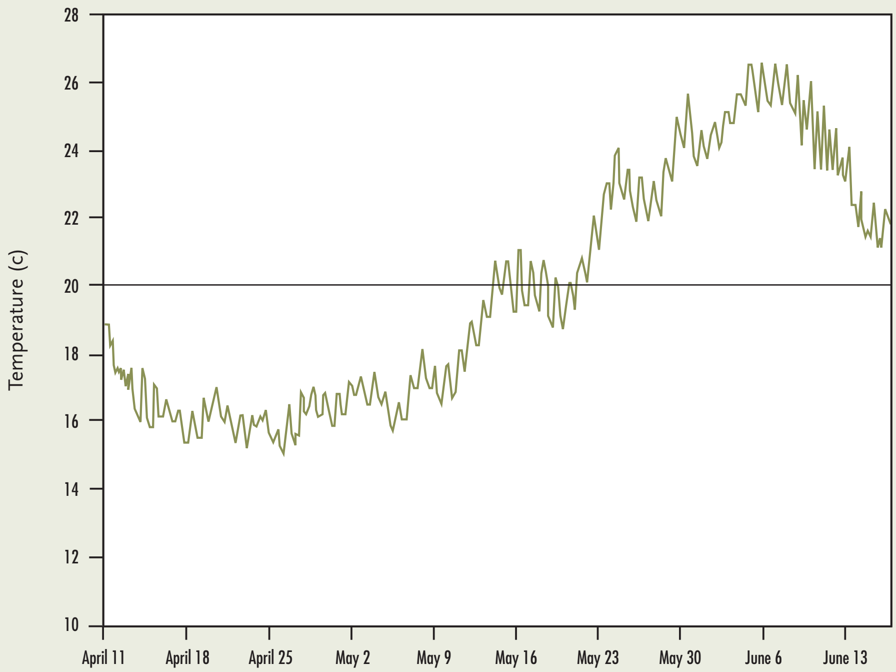
Site 2 • Mossdale



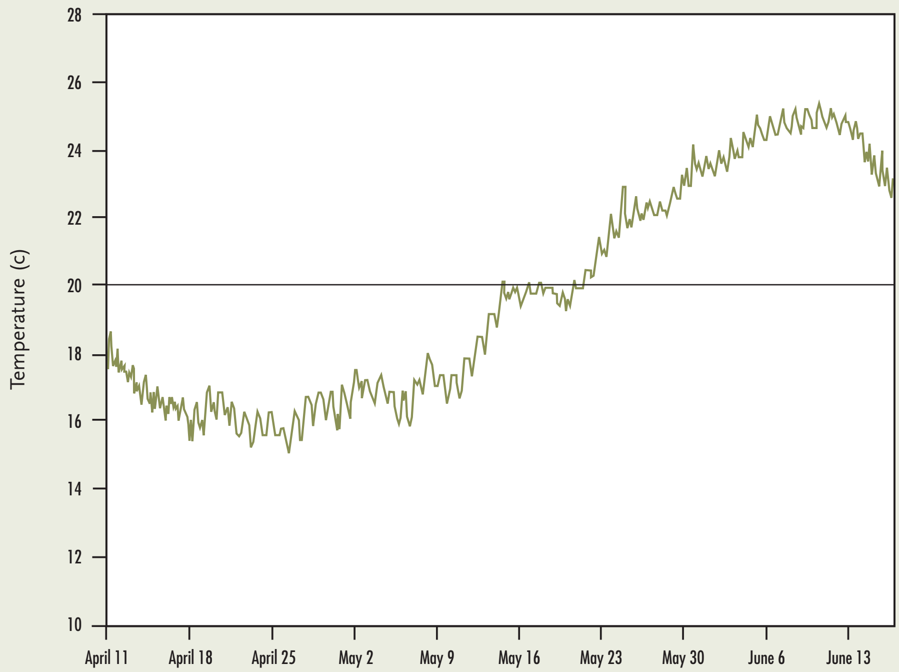
Site 3 • Dos Reis



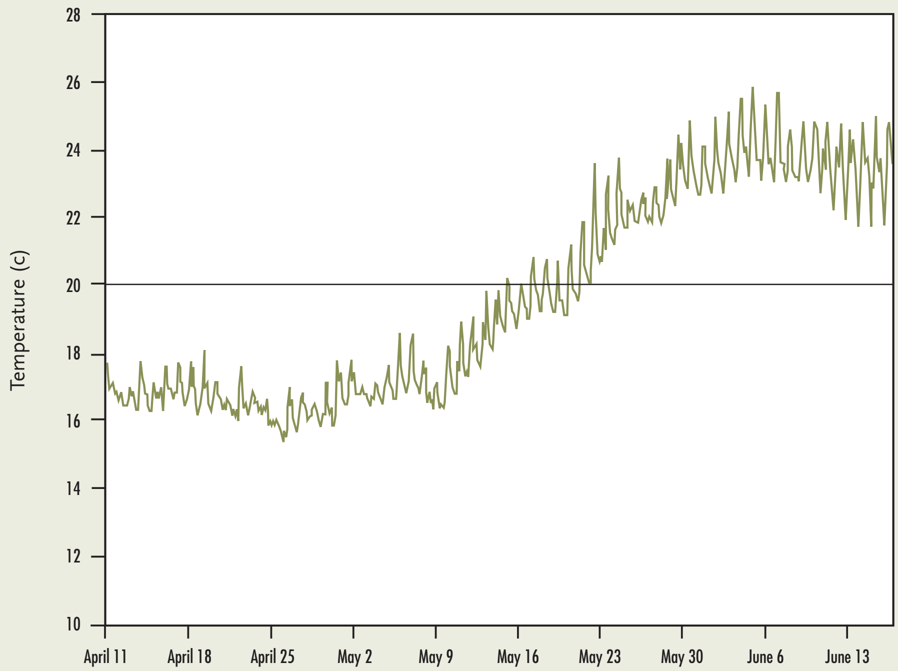
Site 4 • DWR Monitoring Station



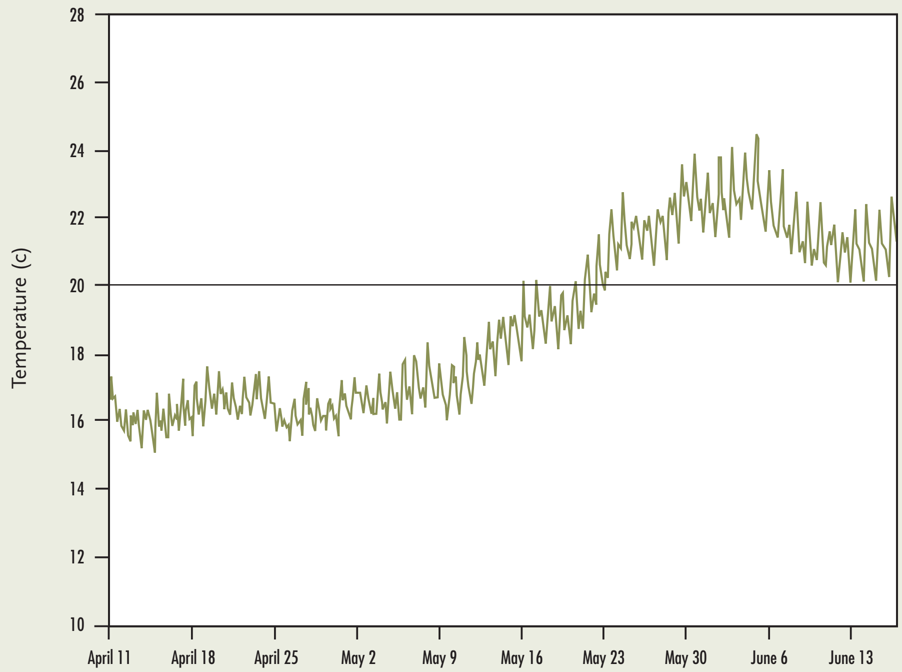
Site 5b • Confluence-Bottom



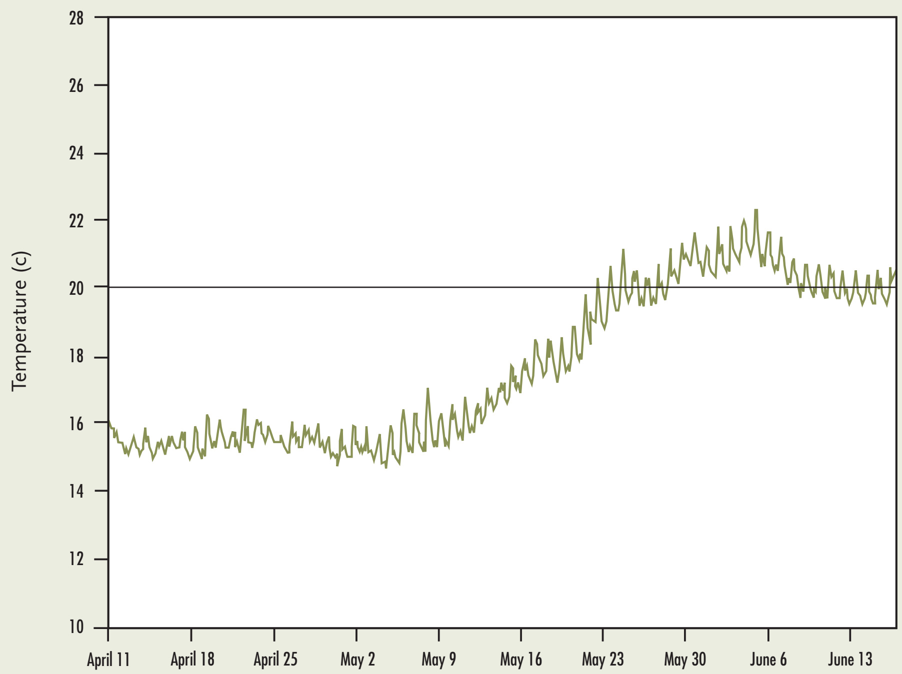
Site 6 • Downstream of Channel Marker 30



Site 7 • 1/2 Mile Upstream of Channel Marker 13

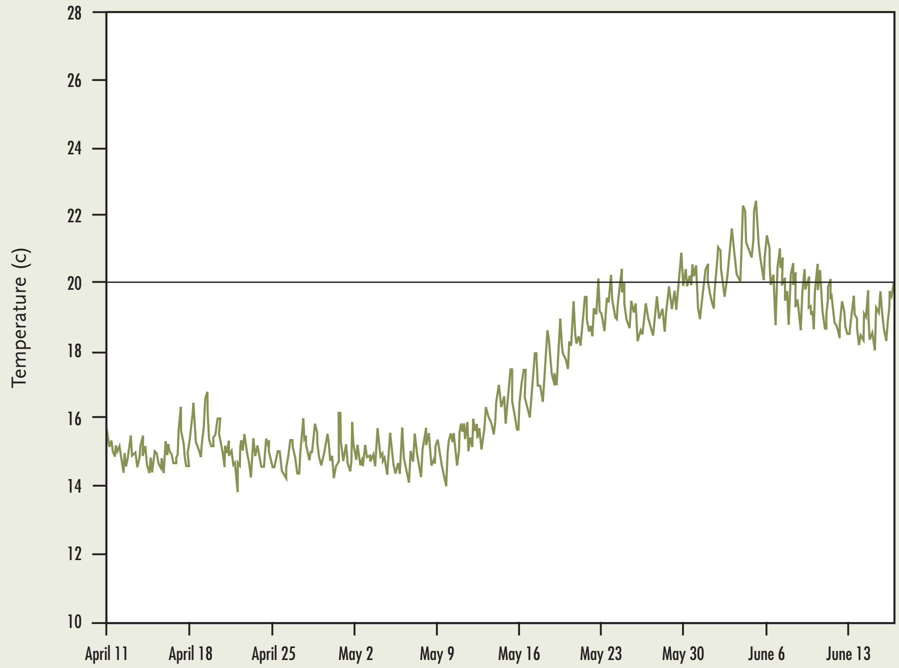


Site 8 • Downstream of Channel Marker 36



C–2. WATER TEMPERATURE MONITORING

Site 10 • Chipps Island



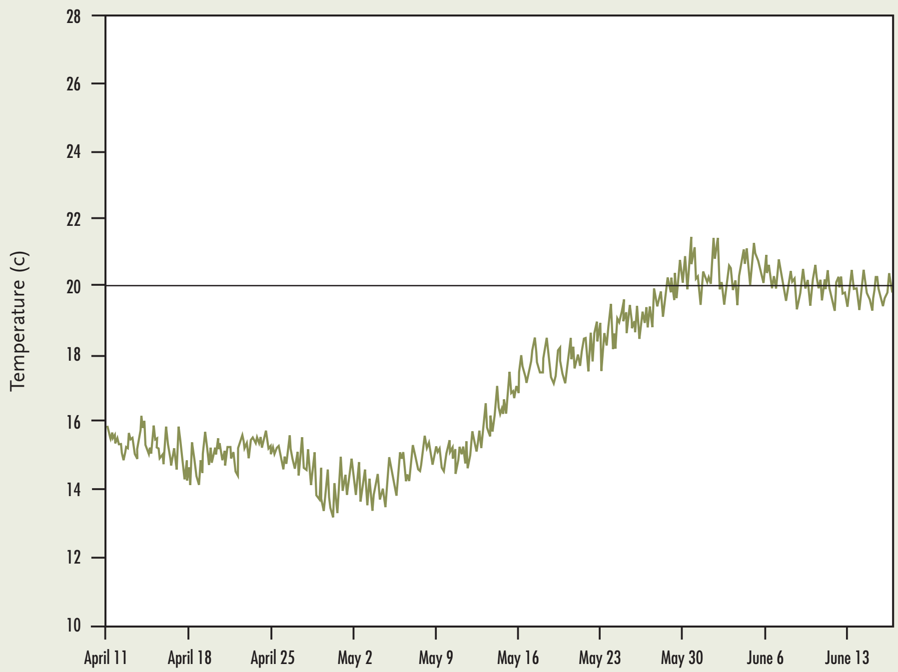
C–3. RESULTS OF NET PEN SAMPLING

a. Conducted After First Set Juvenile Chinook Salmon Releases, VAMP 2003

	Release Date	Release Location and Number	Coded-wire tag codes(s)	Number in sample	Mean fork length (and range in mm)	Mean weight (and range in g)	Mean scale loss (and range in %)
Samples at 00 Hours	21 Apr	Durham Ferry I[1]	06-02-82 06-02-83 06-27-42	50	85 (72-96)	6.6 (4.2-9.2)	9 (3-25)
	22 Apr	Mossdale I	06-27-43 06-27-48	25 25	86 (74-101) 88 (78-92)	6.9 (4.3-12.1) 7.0 (4.5-9.2)	3 (1-6) 3 (1-8)
	25 Apr	Jersey Point I	06-27-44	25	89 (77-98)	7.5 (4.9-9.9)	3 (2-6)
Samples at 48 Hours	21 Apr	Durham Ferry I[1,2]	06-02-82 06-02-83 06-27-42	265	86 (68-99)	6.7 (3.3-10.3)	11 (5-30)
	22 Apr	Mossdale I[2]	06-27-43 06-27-48	234 267	88 (72-104) 85 (65-99)	7.2 (3.7-12.0) 7.1 (3.0-10.7)	8 (4-15) 7 (3-15)
	25 Apr	Jersey Point I[2]	06-27-44	200	88 (69-103)	7.5 (2.7-11.3)	4 (2-10)

[1] *Coded-wire tag codes for Durham Ferry releases were combined at the hatchery, so reported values are for all three tag codes.*
[2] *Color, fin hemorrhaging, eye appearance, and gill color were assessed from the first 25 fish for Mossdale and Jersey Point releases at 48 hours. These characteristics were assessed using the first 50 fish from the first Durham Ferry release at 48 hours.*

Site 1 • Mokelumne River



Color (% normal)	Fin Hemorrhaging (% none)	Eye appearance (% normal)	Gill color (% normal)	Missing adipose fin clips (%)	Partial adipose fin clips (%)	Number of mortalities	Other deformities and comments
98	100	100	100	0	10	0	2 fish had ragged dorsal fins
100	100	100	100	4	8	0	
100	100	100	100	0	0	0	1 fish with stunted pectoral fin and partial operculum
100	100	100	96	0	0	0	1 fish with caudal fin rot
100	100	98	100	1.5	9.4	1	2 fish with caudal fin rot, 1 fish with left eye missing, 5 fish with ragged fins, 1 fish with partial operculum
100	100	96	96	1.7	10.7	1	
100	100	100	96	0.4	1.9	0	1 fish with a split dorsal fin, 2 fish with a partial operculum
100	100	100	96	0.0	0.5	7	26 additional fish were released on 4/27/03 without being measured

C–3. RESULTS OF NET PEN SAMPLING

b. Conducted After Second Set Juvenile Chinook Salmon Releases, VAMP 2003

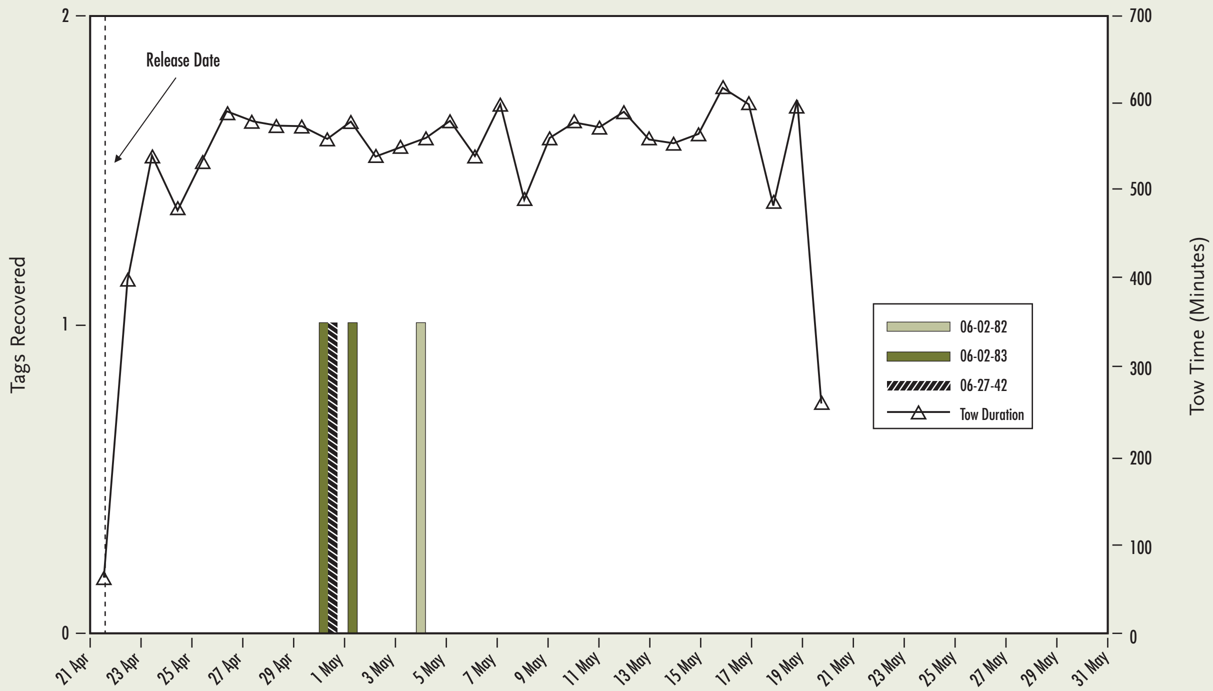
	Release Date	Release Location and Number	Coded-wire tag codes(s)	Number in sample	Mean fork length (and range in mm)	Mean weight (and range in g)	Mean scale loss (and range in %)
Samples at 00 Hours	28 Apr	Durham Ferry II[1]	06-27-45 06-27-46 06-27-47	50	87 (73-93)	6.9 (3.7-8.4)	14 (3-35)
	29 Apr	Mossdale II	06-27-49	25	86 (78-92)	7.0 (4.4-9.7)	12 (5-35)
			06-27-50	25	88 (78-92)	7.3 (4.8-8.7)	12 (3-25)
	2 May	Jersey Point II	06-27-51	25	88 (79-97)	7.3 (5.0-9.5)	19 (10-35)
Samples at 48 Hours	28 Apr	Durham Ferry II[1,2]	06-27-45 06-27-46 06-27-47	358	87 (73-100)	6.9 (3.6-10.4)	3 (1-5)
	29 Apr	Mossdale II[2]	06-27-49	33	89 (73-98)	7.5 (3.9-9.4)	10 (5-20)
			06-27-50	144	88 (70-102)	7.3 (3.8-10.4)	14 (5-30)
	2 May	Jersey Point II[2]	06-27-51	236	90 (71-102	7.8 (4.0-11.3)	4 (2-10)

[1] *Coded-wire tag codes for Durham Ferry releases were combined at the hatchery, so reported values are for all three tag codes.*
[2] *Color, fin hemorrhaging, eye appearance, and gill color were assessed from the first 25 fish for Mossdale and Jersey Point releases at 48 hours. These characteristics were assessed using the first 49 fish from the second Durham Ferry release at 48 hours.*

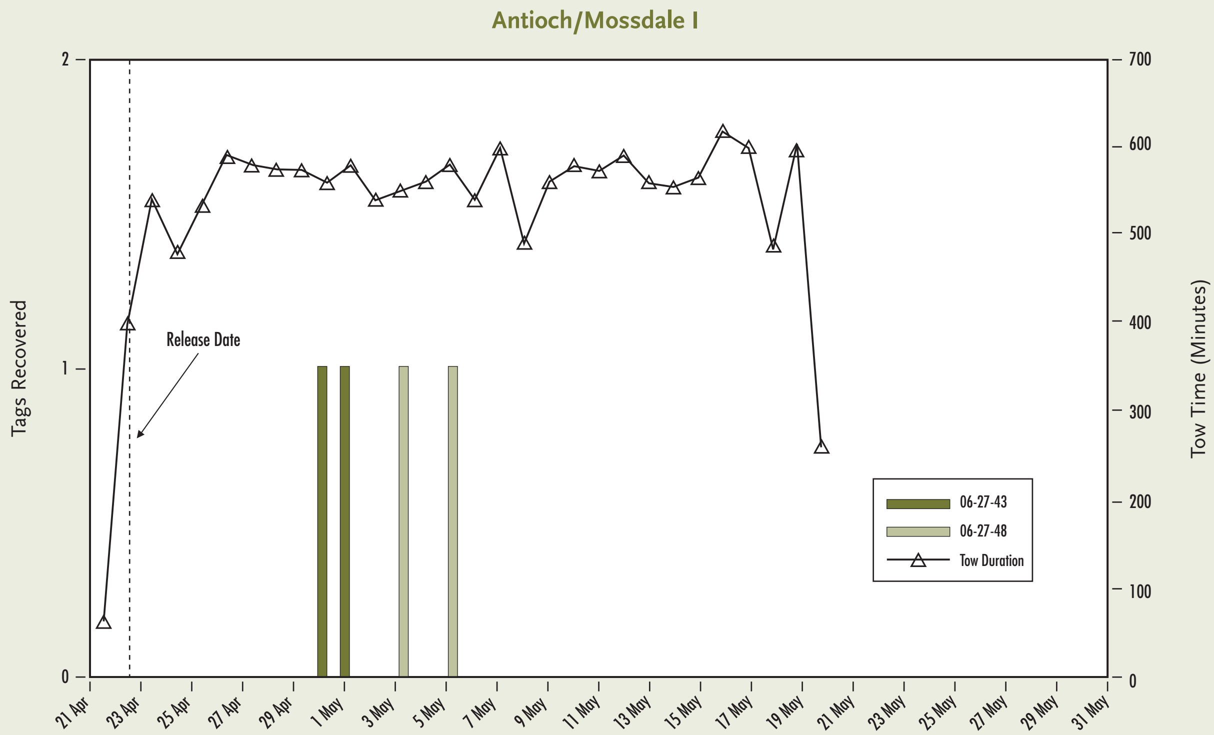
C–4. VAMP 2003 CODED-WIRE TAG RECOVERIES

The following graphs are of coded-wire tagged juvenile chinook salmon, from the two sets of VAMP 2003, releases recovered during trawling at Antioch. No coded-wire tagged juveniles were recovered at Antioch from the second Durham Ferry release (on April 28, 2003) or the second Mossdale release (on April 29, 2003).

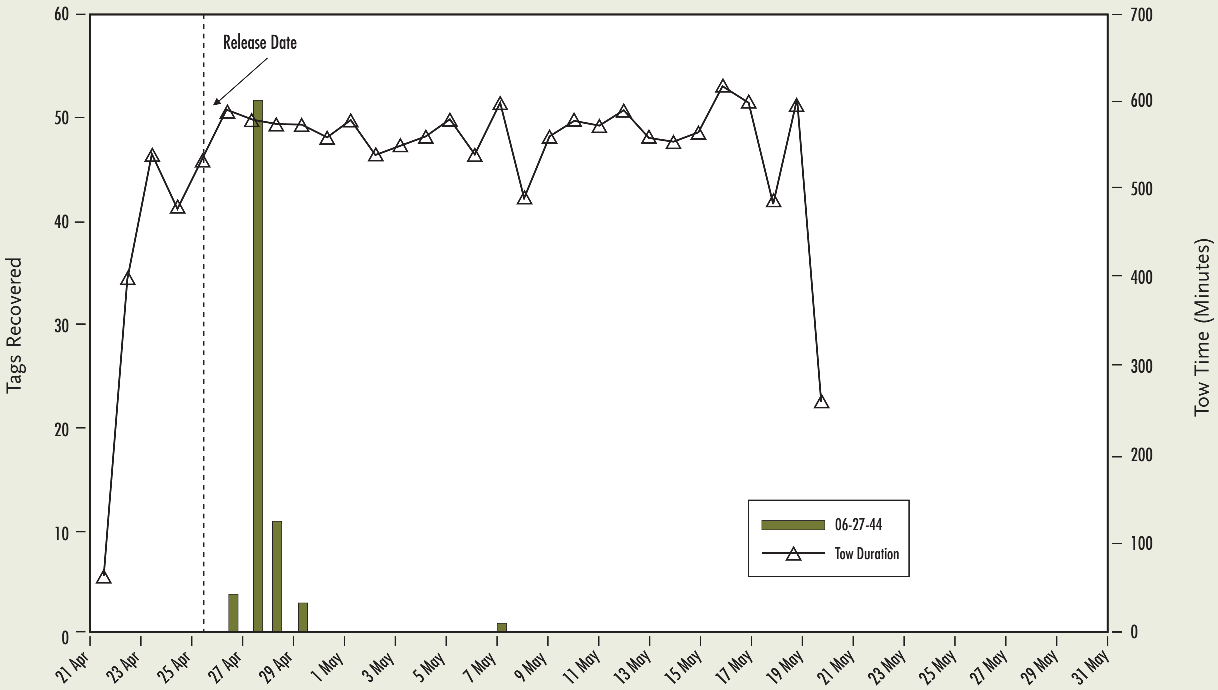
Antioch/Durham Ferry I



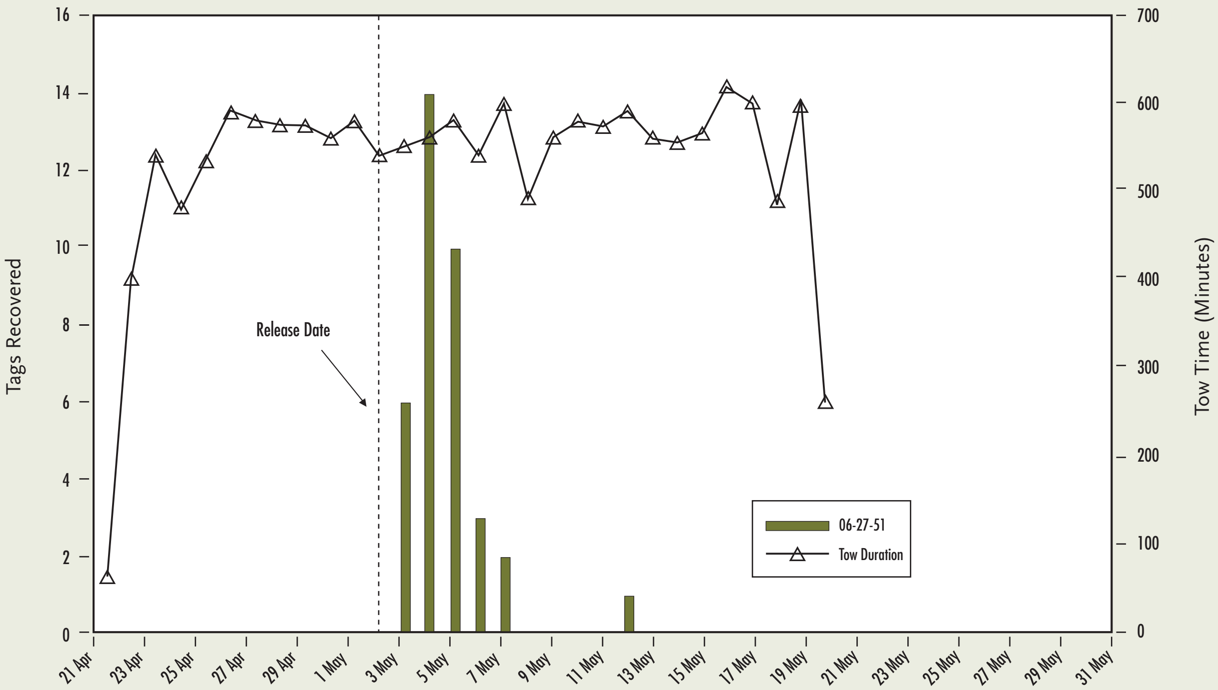
Color (% normal)	Fin Hemorrhaging (% none)	Eye appearance (% normal)	Gill color (% normal)	Missing adipose fin clips (%)	Partial adipose fin clips (%)	Number of mortalities	Other deformities and comments
100	100	98	98	2	2	0	
100	100	100	88	0	8	0	
100	100	96	100	4	0	0	left eye was missing
100	100	100	88	4	8	0	
100	100	100	98	0.0	1.7	2	
100	100	100	100	0	0	0	small holes in net pen may have allowed fish to escape
100	100	100	100	0.7	3.5	0	
100	100	100	100	0.8	3.4	0	



Antioch/Jersey Point I



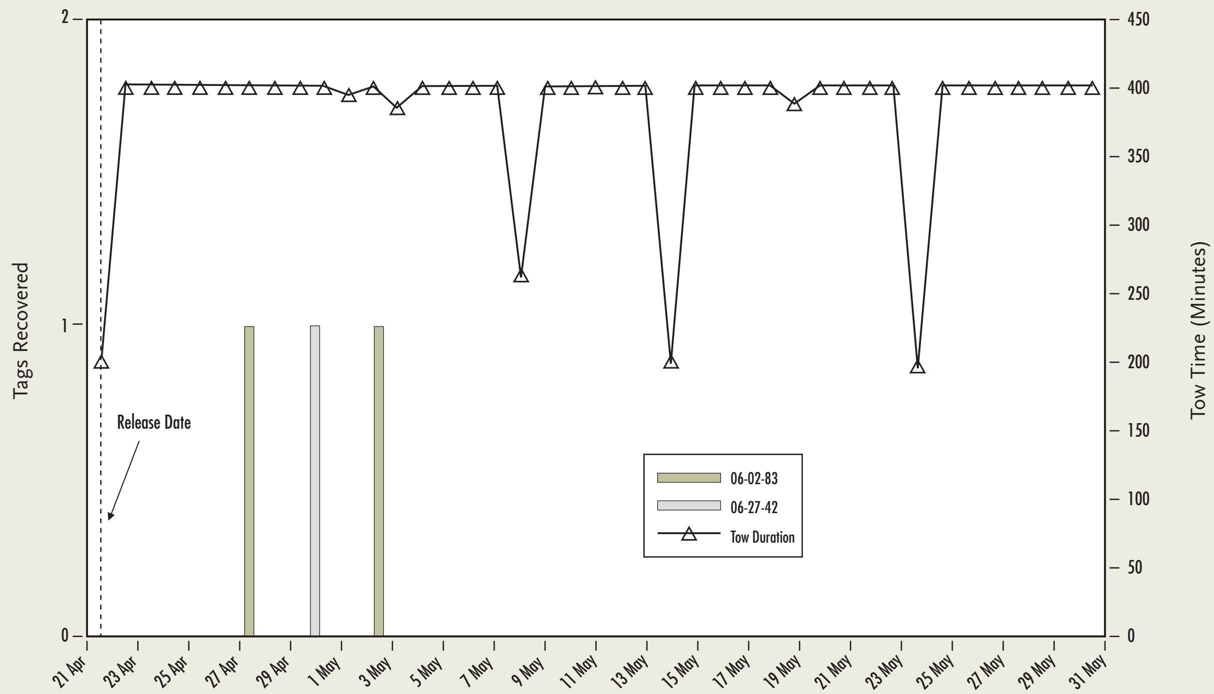
Antioch/Jersey Point II



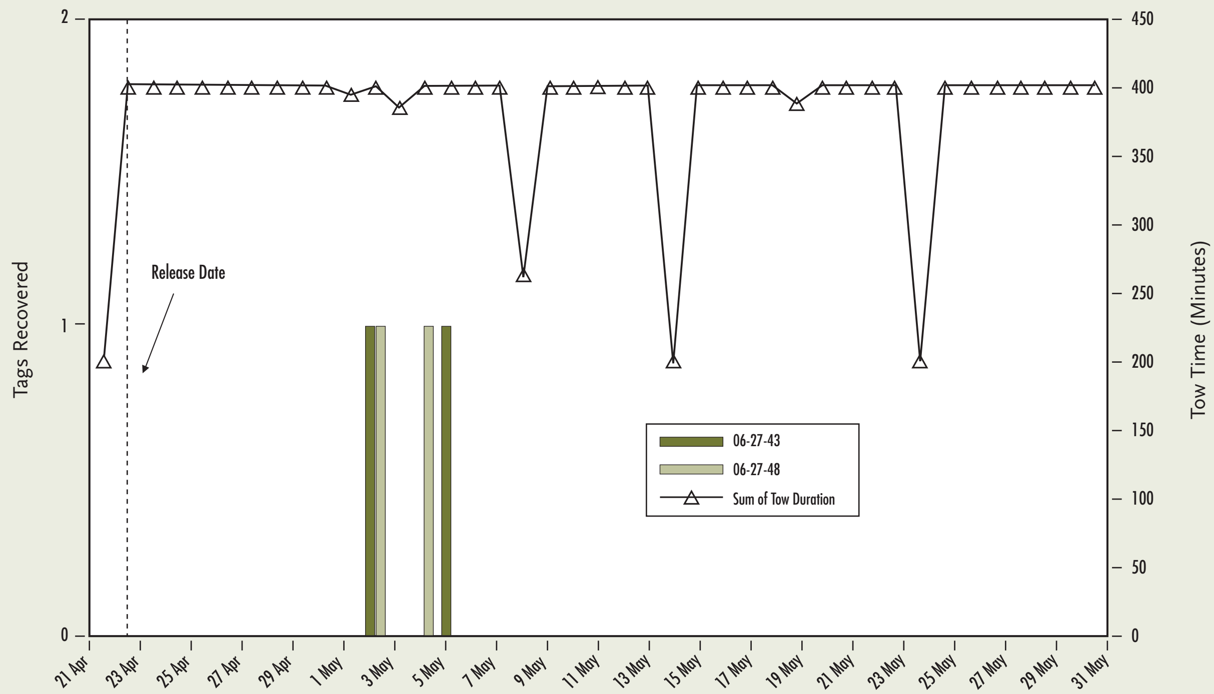
C–4. VAMP 2003 CODED-WIRE TAG RECOVERIES

The following graphs are of coded-wire tagged juvenile chinook salmon, from the two sets of VAMP 2003, releases recovered during trawling at Chipps Island. No coded-wire tagged juveniles were recovered at Chipps Island from the second Durham Ferry release (on April 28, 2003).

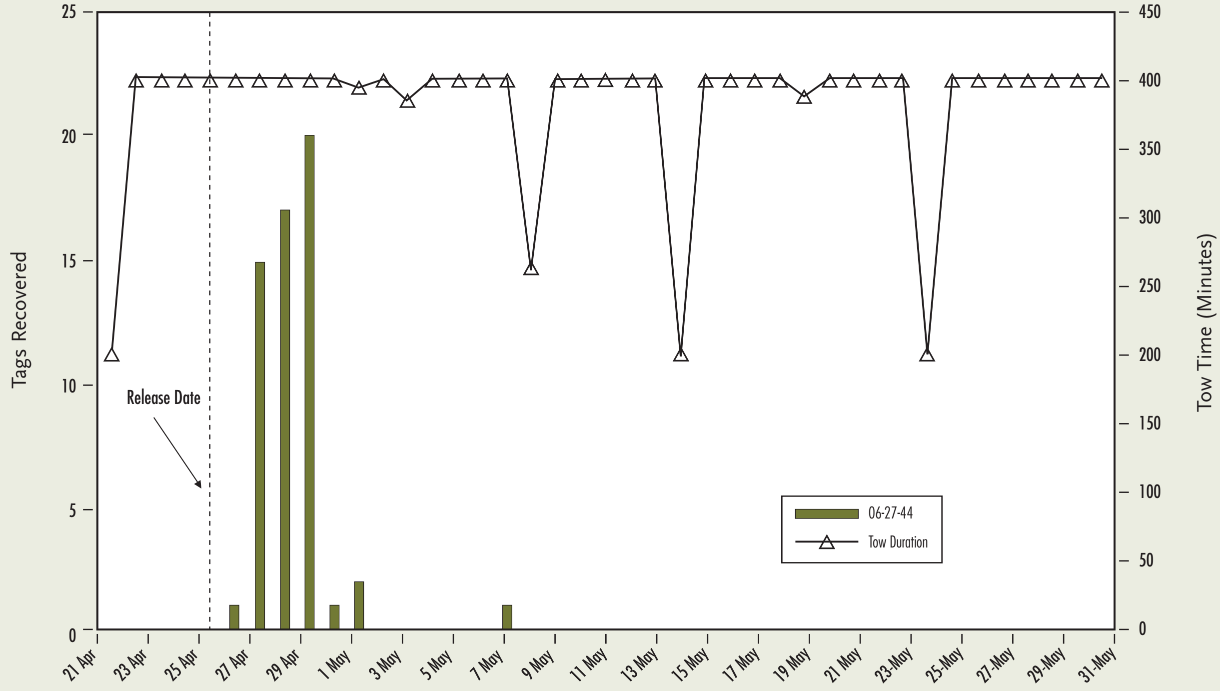
Chipps Island/Durham Ferry I



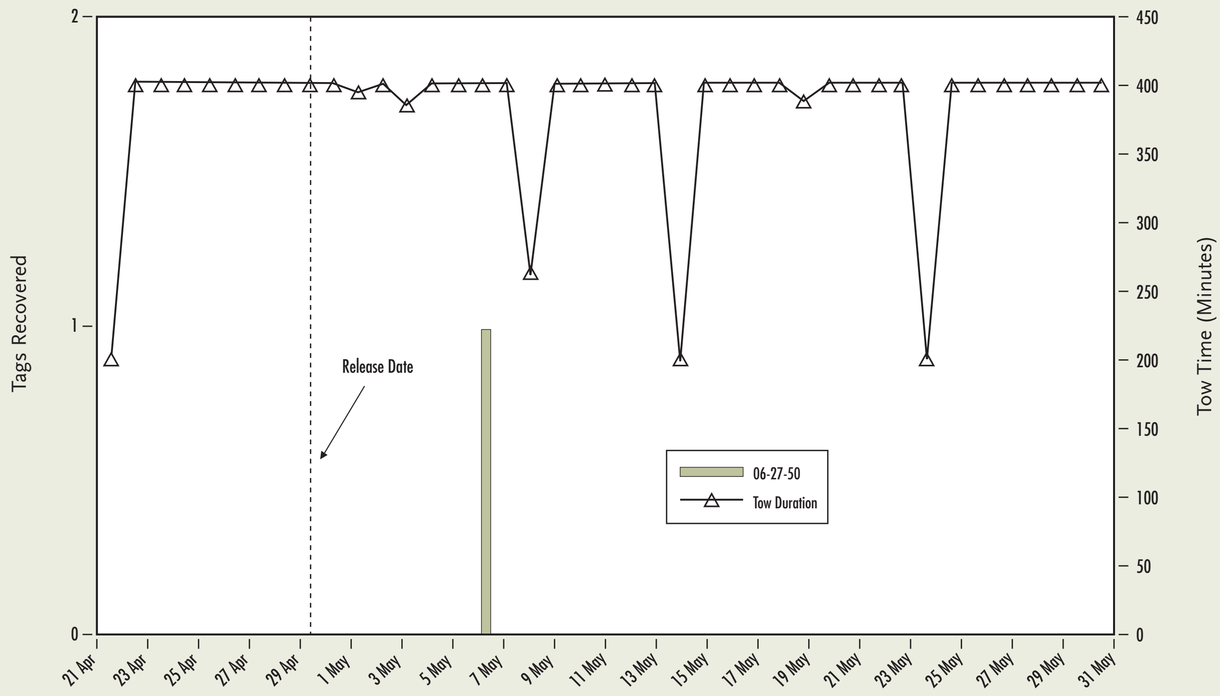
Chipps Island/Mossdale I

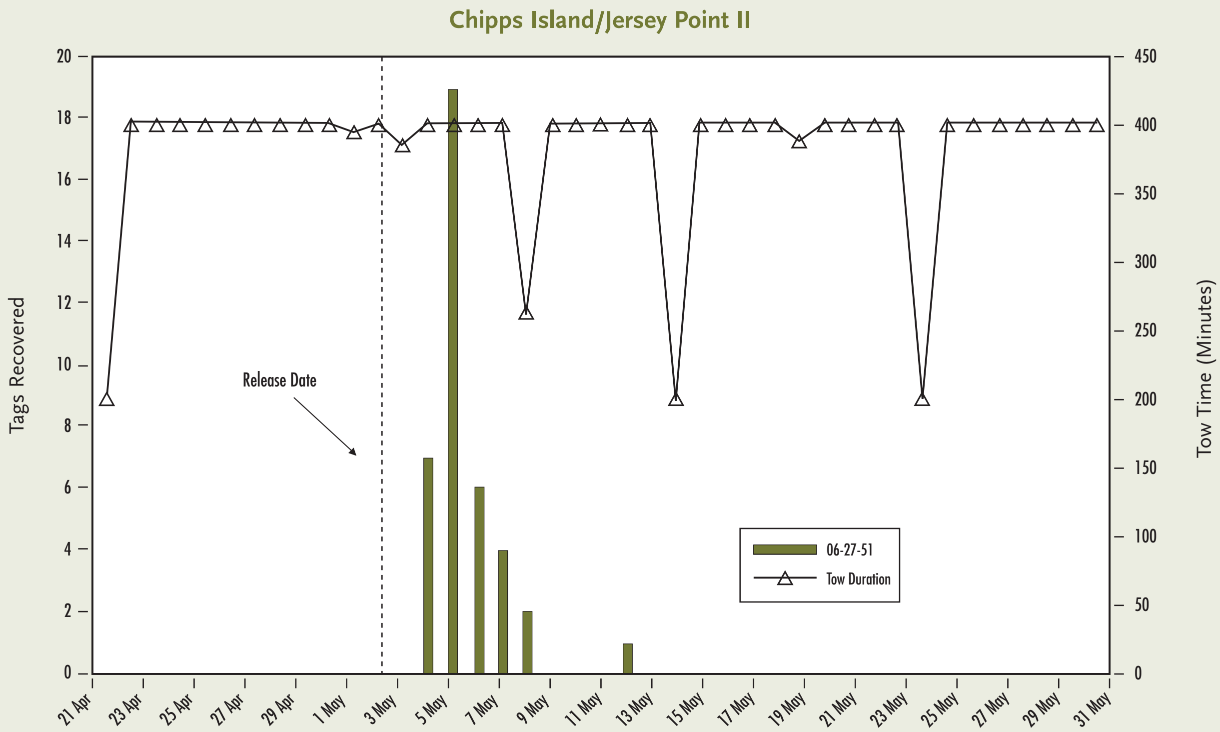


Chipps Island/Jersey Point I



Chipps Island/Mossdale II





Chipps Island/Jersey Point II
Tags Recovered
Tow Time (Minutes)
Release Date
06-27-51
Tow Duration
0
2
4
6
8
10
12
14
16
18
20
0
50
100
150
200
250
300
350
400
450
21 Apr
23 Apr
25 Apr
27 Apr
29 Apr
1 May
3 May
5 May
7 May
9 May
11 May
13 May
15 May
17 May
19 May
21 May
23 May
25 May
27 May
29 May
31 May

C–5. RECOVERY TIMING OF CWT RELEASED AS SAN JOAQUIN TRIBUTARY STUDIES IN 2003

	Tag code	Release Site/Release Stock	Release Date	Antioch			Chipps Island		
				First day recovered	Last day recovered	Days at large	First day recovered	Last day recovered	Days at large
Merced River	06-44-89	Merced River Fish Facility		4/24/03	4/27/03	14	4/25/03	4/25/03	12
	06-44-90	Merced River Fish Facility		4/26/03	4/26/03	13	4/23/03	4/23/03	10
	06-44-91	Merced River Fish Facility		4/26/03	5/04/03	21	—	—	—
	06-44-92	Merced River Fish Facility		—	—	—	4/29/03	4/29/03	16
		Total	4/13/03	4/24/03	5/04/03	21	4/23/03	4/29/03	16
	06-44-93	Hatfield State Park (lower Merced)		4/24/03	4/27/03	11	4/24/03	4/26/03	10
	06-44-94	Hatfield State Park (lower Merced)		4/25/03	5/03/03	17	4/26/03	4/26/03	10
	06-44-95	Hatfield State Park (lower Merced)		4/23/03	4/26/03	10	4/25/03	5/05/03	19
		Total	4/16/03	4/23/03	5/03/03	17	4/24/03	5/05/03	19
	06-44-96	Merced River Fish Facility		—	—	—	—	—	—
	06-44-97	Merced River Fish Facility		—	—	—	—	—	—
	06-44-98	Merced River Fish Facility		5/11/03	5/11/03	16	—	—	—
	06-44-99	Merced River Fish Facility		—	—	—	—	—	—
		Total	4/25/03	5/11/03	5/11/03	16	—	—	—
	06-45-64	Hatfield State Park (lower Merced)		—	—	—	—	—	—
	06-45-65	Hatfield State Park (lower Merced)		—	—	—	5/07/03	5/10/03	11
	06-45-66	Hatfield State Park (lower Merced)		5/12/03	5/12/03	13	—	—	—
		Total	4/29/03	5/12/03	5/12/03	13	5/07/03	5/10/03	11
	06-27-77	Merced River Fish Facility		—	—	—	5/20/03	5/20/03	16
	06-27-78	Merced River Fish Facility		—	—	—	—	—	—
	06-44-49	Merced River Fish Facility		5/18/03	5/18/03	14	5/17/03	5/17/03	13
	06-44-50	Merced River Fish Facility		—	—	—	5/15/03	5/18/03	14
		Total	5/04/03	5/18/03	5/18/03	14	5/15/03	5/20/03	16
	06-45-46	Hatfield State Park (lower Merced)		—	—	—	5/17/03	5/17/03	10
	06-45-47	Hatfield State Park (lower Merced)		5/15/03	5/17/03	10	—	—	—
	06-45-72	Hatfield State Park (lower Merced)		—	—	—	5/15/03	5/15/03	8
		Total	5/07/03	5/15/03	5/17/03	10	5/15/03	5/17/03	10
Stanislaus River	06-45-67	Knight's Ferry		5/17/03	5/17/03	22	—	—	—
	06-45-68	Knight's Ferry		—	—	—	5/11/03	5/11/03	16
	06-45-69	Knight's Ferry		5/04/03	5/04/03	9	—	—	—
		Total	4/25/03	5/04/03	5/17/03	22	5/11/03	5/11/03	16
	06-45-70	Two Rivers		5/05/03	5/05/03	8	—	—	—
	06-45-71	Two Rivers		5/07/03	5/12/03	15	—	—	—
		Total	4/27-4/28/03	5/05/03	5/12/03	15	—	—	—

APPENDIX D

Errata

ERRATA FOR THE YEAR 2002 ANNUAL TECHNICAL REPORT

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

1. Page 38: VAMP Chinook Salmon CWT Survival Indices, 2nd Sentence: Should be replaced with "Survival indices were calculated by dividing the number of CWT salmon recovered by the product of the effective number released (E) multiplied by the fraction of time (T) and channel Width (W) sampled as shown by the formula: SI = R/(E*T*W).

2. Page 54, Figure 5–14: Legend should read "Catch per Minute of all Unmarked Juvenile Chinook Salmon in the Mossdale Kodiak Trawl, March 15, 2002 through June 30, 2002."

3. Page 108–113, Appendix C: The title "Net Pen Sampling Results" should be deleted at the top of each page.

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Turlock Irrigation District
Oakdale Irrigation District
Merced Irrigation District
Friant Water Users Authority
City and County of San Francisco
South San Joaquin Irrigation District
San Joaquin River Exchange Contractors

2002 ANNUAL TECHNICAL REPORT

VIEW
REPORT

2002

SAN JOAQUIN RIVER GROUP AUTHORITY

Head of Old River Barrier

2002 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
STATE WATER RESOURCES CONTROL BOARD

In Compliance with D-1641

JANUARY 2003

TABLE OF CONTENTS

EXECUTIVE SUMMARY 3

CHAPTER 1

Introduction 6

Experimental Design Elements 6

CHAPTER 2

VAMP Hydrologic Planning and Implementation 8

VAMP Flow and SWP/CVP Exports 8

Hydrologic Planning 9

Implementation 12

Results of Operations 12

CHAPTER 3

Additional Water Supply Arrangements & Deliveries 17

Merced Irrigation District 17

Oakdale Irrigation District 17

CHAPTER 4

Head of Old River Barrier 18

Barrier Design, Installation and Operation 19

Fishery Monitoring at the Head of Old River Barrier 22

Results and Discussion 23

CHAPTER 5

Salmon Smolt Survival Investigations 30

Coded-Wire Tagging 30

CWT Releases 31

Water Temperature Monitoring 31

Post-Release-Live-Car Studies 34

CWT Recovery Efforts 35

VAMP Chinook Salmon CWT Survival Indices 38

Absolute Chinook Salmon Survival Estimates and Differential Combined Recovery Rates 39

Role of Flow and Exports on Absolute Survival and Recovery Rates 45

The Role of HORB on Survival 47

Ocean Recovery Information 50

San Joaquin River Salmon Protection 53

CHAPTER 6

Complimentary Studies Related to the Vamp 60

Survival Estimates for the Tributaries 60

Radio Tagging Studies in the Lower River 60

Striped Bass Predation Monitoring Program 62

Mokelumne River Juvenile Survival Studies 62

CHAPTER 7

Conclusions and Recommendations 66

LITERATURE CITED 68

CONTRIBUTING AUTHORS 69

SIGNATORIES TO THE SAN JOAQUIN RIVER AGREEMENT 70

USEFUL WEB PAGES 71

APPENDIX TABLE OF CONTENTS 72

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). Using a consensus-based approach, the SJRA united a large and diverse group of agricultural, urban, environmental and governmental interests.

The 2002 Annual Technical Report comprises the consolidated annual SJRA Operations Report and Vernalis Adaptive Management Plan (VAMP) Monitoring Report. The VAMP 2002 program represents the third 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 VAMP program. Specifically, this report includes the following information on the implementation of the SJRA: the hydrologic chronicle; management of the additional SJRA water; installation, operation, and monitoring of the Head of Old River Barrier (HORB); results of the juvenile Chinook salmon smolt survival investigations; discussion of complementary investigations; and, conclusions and recommendations. Condition 4.b of D-1641 directs the Department of Water Resources (DWR) and the U.S. Bureau of Reclamation (USBR) to send the Executive Director, SWRCB the results of the fishery monitoring studies on an annual basis and Condition 7 of D-1641 directs Merced, Modesto, Turlock, South San Joaquin and Oakdale irrigation districts to submit a report detailing district operations as a result of the SJRA. By letter dated September 8, 2000, the SWRCB approved combining these two reports into a single comprehensive report due the SWRCB on January 31, of each year.

The 2002 Annual Technical Report comprises the consolidated annual SJRA Operations Report and Vernalis Adaptive Management Plan (VAMP) Monitoring Report.

A key part of this landmark agreement is the VAMP. VAMP is designed to protect juvenile Chinook salmon migrating from the San Joaquin River through the Sacramento-San Joaquin Delta. VAMP is also a scientifically recognized 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 and the installation of the HORB.

VAMP employs an adaptive management strategy to use current knowledge of hydrology and environmental conditions to protect Chinook salmon smolt passage, while gathering information to allow more efficient protection in the future. In addition to providing improved protection for juvenile Chinook salmon emigrating from the San Joaquin River system, specific experimental objectives of VAMP 2002 included:

- Quantification of Chinook salmon smolt survival between Durham Ferry and Jersey Point using recapture locations at Antioch and Chipps Island, under conditions of a San Joaquin River flow at Vernalis of 3,200 cfs, with an installed HORB, and SWP/CVP export rate of 1,500 cfs; and
- Comparison of juvenile Chinook salmon survival between Durham Ferry and Mossdale for use in comparing results of VAMP 2002 with results from earlier survival studies where coded-wire tagged (CWT) salmon releases occurred at Mossdale.

The VAMP 2001 Annual Technical Report presented a series of conclusions and recommended modifications to the VAMP experimental design and/or program implementation. The 2001

See useful web pages

recommendations were used, in part, as the basis for developing the 2002 VAMP test program. For example, the 2001 report recommended weekly measurements of San Joaquin River flow at the Vernalis gage, continued hydrology investigations to estimate ungaged flows (accretions, depletions) to improve hydrologic predictions, and continued coordination among tributary operators to facilitate implementation of the VAMP test flow conditions. As part of the 2002 program, the VAMP Hydrology Group, working in cooperation with tributary operators and USGS, was able to improve our understanding of San Joaquin River hydrology, provide measurements of Vernalis flow, and provide effective coordination of releases from upstream tributaries.

Contained in the 2001 report were several recommendations including modification of the HORB trash screen design and routine maintenance, continued refinement of operational criteria for culverts, securing all necessary permits for construction of the barrier, measuring flows within each of the culverts, continuing monitoring to evaluate potential impacts of seepage, and improving the experimental design of fishery monitoring in the HORB investigations. These recommendations were addressed as part of the 2002 VAMP program. In addition, the Department of Water Resources (DWR) was successful in securing all of the necessary permits and approvals from the regulatory agencies for the installation of the HORB over the next five years. The landowner access permits for the HORB continue to be renewed annually.

The 2001 report recommended that, to the extent possible, VAMP survival testing be conducted at flow and export extremes to improve the ability of the program to detect differences in juvenile Chinook salmon survival among target flow and export conditions. Hydrologic conditions within the San Joaquin River watershed were not suitable for testing extreme target conditions as part of the VAMP 2002 program. These and other recommendations from the 2001 VAMP program were used to improve the overall experimental design and implementation of the 2002 VAMP investigations. Recommendations made based upon analysis of the VAMP 2002 program will also be used, in a similar way, by the VAMP Hydrology and Fishery Biology Groups in developing and implementing the experimental design for the 2003 VAMP studies.

Based on data gathered during the experimental mark-recapture studies that occurred over a 31-day period in April and May 2002, a set of conclusions and recommendations has been developed. These conclusions and recommendations provide guidance and a foundation for design and implementation of future VAMP operations. Key conclusions and recommendations derived from VAMP 2002 include:

To the extent possible, VAMP survival testing should be conducted at flow and export extremes to IMPROVE THE ABILITY of the program to detect differences in juvenile Chinook salmon survival.

- VAMP 2002 is the third year of full implementation of the program. Average Vernalis flow during the VAMP period was 3,300 cfs. SWP and CVP export rate averaged 1,430 cfs. The VAMP period was between April 15 and May 15, 2002.
- Relative recovery rates of CWT salmon released at Durham Ferry and Jersey Point using recaptures at Antioch and Chipps Island indicated that there was no statistical ($P>0.05$) difference between the two replicates conducted in 2002.
- The proportion of CWT salmon released and recaptured from the combined Durham Ferry and Mossdale groups relative to the proportion of CWT salmon released and recaptured from the Jersey Point (control) releases showed that the relative

proportions during 2002 (target flow 3,200 cfs and 1,500 cfs exports) were not significantly different (P>0.05) than the proportions from the VAMP 2000 study (target flow 5,700 cfs and 2,250 cfs exports) or VAMP 2001 study (target flow 4,450 cfs and 1,500 cfs exports).

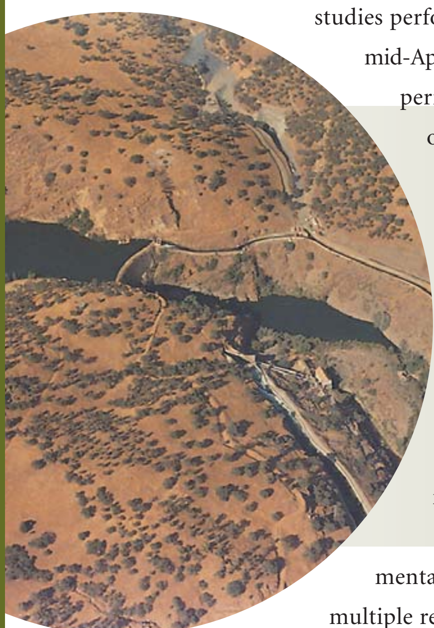
- Streamflow data at Vernalis were improved by weekly flow measurements and rating curve verification, however estimation of ungaged flow (accretions and depletions) requires further investigation for use in establishing annual VAMP target flows. Alternative methods of measuring flow at Vernalis and/or alternative measurement locations should also be investigated.
- The design of the HORB was unchanged for this year, however rock debris and on going construction activities during the final phases of construction after closure of the barrier proved to be a problem for fishery sampling. Recommendations were made to delay salmon releases at Durham Ferry and Mossdale in future years for a period of approximately 5 days after HORB closure to allow time for gravel and rock to flush from the culverts and to improve fishery sampling at the site. It is recommended that there be improved maintenance of the culverts to reduce debris accumulation.
- Accurate flow measurements in the San Joaquin River and the Old River near the HORB continue to limit the accuracy of the entrainments correlations. Flows are currently based on extrapolating from upstream measurements, some spot flow measurements in the Old River and San Joaquin River, as well as, estimates of flow through the culverts and seepage through the HORB.
- Construction of multiple barriers within the south delta during the spring has the potential to delay completion of the construction of HORB and release of the coded wire tagged salmon as part of the VAMP. This delay may contribute to exposure of juvenile Chinook salmon to elevated water temperatures. Due to the high risk of losing major salmon protection benefits and biasing experimental conditions, it is strongly recommended that construction of the HORB be completed on schedule to avoid delays in implementing survival investigations.
- It is also recommended that flow measurements be made to document flow through HORB culverts and the resultant flow within the San Joaquin River downstream of the confluence with Old River.
- The variability in conducting salmon smolt survival studies in the lower San Joaquin River and Delta makes it difficult to detect statistically significant differences in salmon survival between VAMP flow and export target conditions, which are relatively similar. It is strongly recommended that, when possible, target flow and export conditions be selected to conduct survival tests at VAMP flow and export extremes to improve the ability to detect potential differences in salmon smolt survival among test conditions.
- Approximately 77 percent of the unmarked salmon migrating past Mossdale between March 15 and June 30, 2002 migrated during the VAMP period (April 15 through May 15) and were, therefore protected by increased San Joaquin River flow, installation of the HORB and decreased export pumping.
- The selection and management of VAMP flow conditions should, if possible, minimize or avoid requiring upstream tributary flows that adversely affect habitat quality or survival of natural salmon produced within the tributaries. It is therefore recommended that upstream tributary and VAMP studies are coordinated as much as possible.
- Estimates of salmon survival rates under flow and export conditions tested in 2000, 2001, and 2002 have not been found to be significantly different. Survival tests at extreme target levels (e.g., 7,000 cfs flow and 1,500 cfs exports) are important to obtain. The VAMP program provides improved protection for juvenile salmon when compared to “without-VAMP” conditions. Further tests, over a wider range of flow and export conditions, are needed to evaluate the respective roles of San Joaquin River flow and SWP/CVP exports on juvenile Chinook salmon smolt survival. The report recommends that the VAMP experimental test program be continued.

CHAPTER 1 | INTRODUCTION

The Vernalis Adaptive Management Plan (VAMP) was implemented between April 15 and May 15, 2002 to protect juvenile Chinook salmon and evaluate the relationship between San Joaquin River flow and State (SWP) and federal (CVP) water project exports on survival of juvenile Chinook salmon migrating through the Sacramento–San Joaquin Delta. This represents the third official year of the VAMP experiment.

EXPERIMENTAL DESIGN ELEMENTS

The VAMP experimental design measures salmon smolt survival rates under six different combinations of flow and export rates. The experimental design includes two mark-recapture studies performed each year during the mid-April to mid-May outmigration period that provide estimates of salmon survival under each set of conditions. Chinook salmon survival indices under each of the experimental conditions are then calculated based on the numbers of marked salmon released and the number recaptured.



The VAMP 2002 experimental design included both multiple release locations (Durham Ferry, Mossdale, and Jersey Point), and multiple recapture locations (Antioch, Chipps Island, SWP and CVP salvage operations, and in the ocean fisheries Figure 1-1). Two sets of releases were made at Durham Ferry, Mossdale, and Jersey Point. The use of data from multiple release and recapture locations allows for a more thorough evaluation of juvenile Chinook salmon survival as compared to recapture data from only one sampling location and/or one series of releases. The VAMP coded-wire tag (CWT) releases (Durham Ferry, Mossdale, and Jersey Point) and recapture locations (Antioch and Chipps Island) will be consistent from one year to the next, providing a greater opportunity to assess salmon smolt survival over a range of Vernalis flows, SWP/CVP exports, and with and without the presence of the Head of Old River Barrier (HORB). Releases at Jersey Point serve as controls for recaptures at Antioch and Chipps Island, thereby allowing the calculation of survival estimates based on the ratio of survival indices from marked salmon recaptured from upstream (e.g., Durham Ferry and Mossdale) and downstream (control release at Jersey Point) releases. The use of ratio estimates as part of the VAMP study design substantially reduces the bias associated with differential gear collection efficiency within and among years, improves the precision associated with the individual survival estimates, and improves confidence in detecting differences in salmon smolt survival as a function of Vernalis flows and SWP/CVP exports.

A quality assurance/quality control program has been used as a routine part of VAMP tests, including the 2002 CWT tagging at the Merced River Fish Hatchery to provide information useful in quantifying CWT tag retention and improving tag efficiency. Modifications were also made during the 2002 program to improve releases at Durham Ferry through coordination with the local landowner to curtail operation of an agricultural diversion pump located immediately downstream of the release site, coincident with each of the two Durham Ferry releases. In addition, the 2002 VAMP program continued use of the net pen studies to determine the health and survival of test fish released as part of VAMP. Efforts also continued to improve the procedure used to statistically analyze VAMP survival and recovery information, however additional improvements remain to be made in the ability to measure flow passing through the HORB culverts and the resultant flow within the San Joaquin River downstream of the confluence with Old River. Measurements in the future of San Joaquin River flow downstream of the HORB will be used to evaluate the relationship between San Joaquin River flow and juvenile Chinook salmon survival.

Additional complimentary studies, including survival studies for juvenile Chinook salmon released into the Mokelumne River tributaries and radio tracking of salmon migrating downstream though Delta channels, were incorporated into the 2002 VAMP investigations.

FIGURE 1–1

Sacramento-San Joaquin Estuary

Location of VAMP 2002 Release Sites (Durham Ferry, Mossdale and Jersey Point), Recovery Locations (Antioch and Chipps Island), and Head of Old River Barrier Location Within the Sacramento-San Joaquin River Delta/Estuary.

CHAPTER 2 | VAMP HYDROLOGIC PLANNING AND IMPLEMENTATION

This section documents the planning and implementation undertaken by the Hydrology Group of the San Joaquin River Technical Committee (SJRTC) for the 2002 VAMP investigations. Implementation of VAMP is guided by the framework provided in the SJRA and anticipated hydrologic conditions within the watershed.

The Hydrology Group 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 2002, the agencies belonging to the Hydrology Group included: Merced Irrigation District (Merced), Turlock Irrigation District (TID), Modesto Irrigation District (MID), Oakdale Irrigation District (OID), South San Joaquin Irrigation District (SSJID), San Joaquin River Exchange Contractors (Exchange Contractors), 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 installation of the HORB and the planning of delta exports consistent with the VAMP.

VAMP FLOW AND SWP/CVP EXPORTS

The VAMP investigations are designed to collect data and information on the relationship between San Joaquin River flow and Delta exports (SWP and CVP pumping at the Tracy and Banks pumping plants) on the survival rates of juvenile Chinook salmon emigrating from the San Joaquin River system. The VAMP provides for a 31-day pulse flow (target flow) at the Vernalis gage during the months of April and May, along with a corresponding reduction in SWP/CVP exports, as shown in Table 2-1. The magnitude of the pulse flow is based on San Joaquin River flow that would occur during the pulse period absent the VAMP, referred to as the existing flow.

As part of the development of the VAMP experimental design, the VAMP Hydrology and Biology Groups jointly 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 VAMP Hydrology and Biology Groups 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 technical committees 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.

The ability to manage and regulate San Joaquin River flows was more difficult due to variation in unregulated flows, uncertainty 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 technical committees 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

TABLE 2–1

VAMP Vernalis Flow and Delta Export Targets

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
4,500 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 the extent possible	

joint Hydrology and Biology Groups agreed to a target range variation of plus or minus 7% of the Vernalis flow target as a guideline for evaluating the VAMP experimental conditions. It was recognized by the Hydrology and Biology Groups that these guidelines were not absolute conditions, but was to be used by the VAMP hydrology fisheries workgroups to evaluate experimental test conditions and the potential effect of flow and export variation in our ability to detect and assess variation in juvenile Chinook salmon survival rates among VAMP test conditions.

Under the SJRA, the following SJRGA agencies have agreed to provide the supplemental water, limited to a maximum of 110,000 acre-feet, needed to achieve the VAMP target flows shown in Table 2-1: Merced, OID, SSJID, Exchange Contractors, MID and TID.

The 2,000 cfs VAMP target flow shown in Table 2-1 does not represent a VAMP experiment data point but is used to define the supplemental water volume to be provided by the SJRGA agencies. 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 2000 cfs, the USBR, in accordance with the SJRA, shall act to purchase additional water from willing sellers to fulfill the requirements of existing biological opinions.

Based upon hydrologic conditions, the target flow in a given year could either be increased to the next highest value ("double-step") or the supplemental water requirement could be eliminated entirely. A numerical procedure has been established in the SJRA to determine the target flow. The SWRCB San Joaquin Valley Water Year Hydrologic Classification ("60-20-20" classification) is given a numerical indicator as shown in Table 2-2.

TABLE 2–2

San Joaquin Valley Water Year Hydrologic Year Classifications Used in VAMP

60-20-20 WATER YEAR CLASSIFICATION	VAMP NUMERICAL INDICATOR
Wet	5
Above Normal	4
Below Normal	3
Dry	2
Critical	1

"Double-step" flow years occur when the sum of last year's numerical indicator and the 90 percent exceedence forecast of the current year's numerical indicator is seven (7) or greater.

If the sum of the two previous years' numerical indicators and the 90 percent exceedence forecast of the current year's numerical indicator is four (4) or less, indicative of an extended dry period, no VAMP supplemental water will be provided. The USBR, however, has a continuing obligation to meet San Joaquin River flows pursuant to the March 6, 1995 Delta Smelt Biological Opinion.

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. Based on the targets outlined in Table 2-1, in a double-step year up to 157,000 acre-feet of supplemental water may be required. If the VAMP target flow requires more than 110,000 acre-feet of supplemental water, then additional water may be acquired on a willing seller basis.

HYDROLOGIC PLANNING

Hydrology Group Meetings

Beginning in February 2002, and continuing until early April, the Hydrology Group held five planning and coordination meetings (February 13, March 13, March 28, April 3 and April 10). At these meetings, forecasts of hydrologic and operational conditions on the San Joaquin River and its tributaries were discussed and refined.

Monthly Operation Forecasts

As part of the early planning efforts, monthly operation forecasts were developed by the Hydrology Group to estimate the existing flow at Vernalis. Inflows to the tributary reservoirs used in these forecasts were based on DWR Bulletin 120 runoff forecasts. The monthly operation forecasts used the 90 percent and 50 percent probability of exceedence runoff forecasts. The initial monthly operation forecast was prepared in early February and presented at the February 13 Hydrology Group meeting. The 90 percent exceedence forecast called for a VAMP target flow of 3,200 cfs with a need for about 30,000 acre-feet of supplemental water; the 50 percent exceedence forecast called for a VAMP target flow of 4,450 cfs with a need for about 76,000 acre-feet of supplemental water. Hydrologic projections and planning were subsequently refined as additional information became available in March and April.

Daily Operation Plan

Starting in mid-March, the Hydrology Group began development of a daily operation plan, updating it as hydrologic conditions and operational requirements changed. The daily operation plan calculated an estimated mean daily flow at Vernalis based on estimates 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 major tributaries. The following key assumptions were used in the development of the daily operation plan:

(1) The travel times for flows from the tributary control points and upper San Joaquin River to the Vernalis gauge are assumed as follows:

a. Merced River at Cressey to Vernalis	3 days
b. San Joaquin River above Merced River to Vernalis	2 days
c. Tuolumne River at LaGrange to Vernalis	2 days
d. Stanislaus River below Goodwin Dam to Vernalis	2 days

(2) Based upon a review of the historical flow record, the ungauged flow at Vernalis was assumed to be constant throughout the VAMP period and equal to the trending value entering the period. By definition, the ungauged flow is that unmeasured flow entering the system between Vernalis and the upstream measuring points and is calculated as follows:

Vernalis Ungauged =

VNS - GDWlag - LGNlag - CRSlag - USJRlag

where:

VNS = San Joaquin River near Vernalis

GDWlag = Stanislaus River below Goodwin Dam lagged 2 days

LGNlag = Tuolumne River below LaGrange Dam lagged 2 days

CRSlag = Merced River at Cressey lagged 3 days

USJRlag = San Joaquin River above Merced River lagged 2 days (USJR is not a gauged flow but is the calculated difference between the gauged flows at the San Joaquin River at Newman (NEW) and the Merced River near Stevinson (MST)).

A disagreement occurred between members of the Hydrology Group on how to compute the existing flow for the Stanislaus River. It was agreed that the existing flow would be the flow set by the New Melones Interim Operations Plan (IOP); however, there was disagreement on what level of exceedence forecast should be used when applying the IOP. The USBR uses a 90% exceedence forecast for developing water supply allocations. The U.S. Fish and Wildlife Service (USFWS) however, has suggested that since the IOP was developed based on a long-term planning model which used a set of known (perfect foresight) inflows, the 50% exceedence data set would best match what was used in the long-term modeling. At this time, the USBR and the USFWS are working to reach a common understanding on this issue.

By definition, the VAMP 31-day pulse flow period can occur anytime between April 1 and May 31. Until the VAMP flow period is specifically defined, it is assumed for the purposes of planning to be April 15 through May 15. Flexibility of the VAMP flow period exists so that it can coincide with the period of peak salmon out-migration. Other factors, including installation of HORB, availability of juvenile salmon at the hatchery, and manpower and equipment availability for salmon releases and recapture need to be considered in determining the timing of the VAMP period.

The 60-20-20 classification for water year 2001 was “dry”, giving it a VAMP numerical indicator of 2. There was no possibility of a dry period offramp (numerical indicator of previous two plus current year total of 4 or less) because the classification for water year 2000 was “above normal” with a numerical indicator of 4. In order to trigger the “double-step” criteria, the April 1 90 percent exceedence forecast for water year 2002 would need to be for a “wet” year, with a VAMP numerical indicator of 5. The early 90% exceedence forecasts (Jan., Feb. and Mar.) were indicating a “dry” or “critical” year, making it very unlikely that 2002 would be a “double-step” year; therefore, planning efforts concentrated on the “single step” criteria. In fact, the 90 percent exceedence forecast on April 1 for the San Joaquin Valley was for a “dry” year, resulting in the 2002 VAMP following the “single step” criteria.

The initial Daily Operation Plan was prepared on March 13, and was modified as hydrologic conditions and operational requirements changed. Table 2-3 summarizes the various iterations of and demonstrates the evolutionary nature of the daily operation plan. Copies of the daily operation plans are provided in Appendix A.

In early March DWR announced that the HORB would be completed by April 15, therefore the period of April 15 through May 15 was designated as the target flow period. Due to regulatory and operational constraints, Merced needs approximately 7 days of lead time to effect a flow change at Vernalis (48 hours regulatory notice on operation change and approximately 5 days travel time from New Exchequer Dam to Vernalis), therefore the target flow needed to be defined by April 8. Based on the available data the Hydrology Group set the target flow at 3,200 cfs at its meeting on April 8.

TABLE 2–3

Summary of 2002 VAMP Daily Operation Plans Prepared During Planning Phase

VAMP FORECAST DATE	PULSE PERIOD	ASSUMED UNGAUGED FLOW AT VERNALIS (CFS)	EXISTING FLOW (CFS)	VAMP TARGET FLOW (CFS)	SUPPLEMENTAL WATER NEEDED TO MEET TARGET FLOW (1,000 AF)
March 13	April 15–May 15	400	2,150	3,200	64.30
		800	3,130	3,200	4.12
March 22	April 15–May 15	400	2,450	3,200	46.16
		600	2,880	3,200	19.47
March 28	April 15–May 15	400	2,531	3,200	41.16
		600	3,525	4,450	56.91
April 08	April 15–May 15	400	2,842	3,200	22.04
April 09	April 15–May 15	400	2,742	3,200	28.19

TABLE 2–4

Summary of USGS Flow Measurements at the San Joaquin River Near Vernalis Gage

DATE	RIVER STAGE (FT)	MEASURED FLOW (CFS)	CDEC REPORTED REAL-TIME FLOW (CFS)	PERCENT DIFFERENCE	RATING SHIFT
March 5 at 9:30	9.61	1,990	1,940	+2.6%	No
March 27 at 8:26	9.82	2,120	2,120	0.0%	No
April 3 at 9:59	9.30	1,670	1,696	-1.5%	No
April 10 at 9:17	9.48	1,810	1,838	-1.5%	No
April 17 at 8:53	10.75	2,990	2,973	+0.6%	No
April 24 at 10:52	11.00	3,220	3,219	0.0%	No
May 1 at 9:26	11.20	3,340	3,426	-2.6%	No
May 8 at 9:00	11.18	3,340	3,408	-2.0%	No

Normally, the USGS measures the flow at Vernalis to check the current rating shift on a monthly basis. The real-time flows reported by the USGS and CDEC are dependent on the most current rating shift, therefore a new measurement and 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 March 27 and May 8. The results of these measurements are summarized in Table 2-4. As can be seen in Table 2-4, the Vernalis gage site was relatively stable and no rating shifts were applied during the target flow period.

IMPLEMENTATION

Operation Conference Calls

During implementation of the VAMP pulse flow, conference calls were conducted on a regular basis to discuss the status of the pulse flow and to make changes to the operation plan if needed. The calls were held at 6:30 a.m. so that potential operational changes could be implemented on that day. The conference calls were held every Monday, Wednesday and Friday, starting on April 12 and ending on May 10.

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 2-5. The CDEC real-time data has not been reviewed for accuracy or adjusted for rating shifts; 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 were continuously monitored. Similarly, the computed ungaged flow at Vernalis and the flow in the San Joaquin River upstream of the Merced River were continuously updated. The monitoring was necessary to verify that supplemental water deliveries were adhering to tributary allocations contained in the SJRA to the extent possible, as well as to determine if changes in hydrologic conditions would require changes to the operation plan.

TABLE 2–5

Real-time Flow Data and Sources

MEASUREMENT LOCATION	REAL-TIME DATA SOURCE
San Joaquin River near Vernalis	USGS
Stanislaus River below Goodwin Dam	USBR Goodwin Dam daily operation report
Tuolumne River below LaGrange Dam (LGN)	USGS
Merced River at Cressey (CRS)	CDEC
Merced River near Stevinson (MST)	CDEC
San Joaquin River at Newman (NEW)	USGS

The daily operation plan was updated throughout the VAMP flow period. A summary of the updated daily operation plans is provided in Table 2-6. Copies of the updated daily operation plans are provided in Appendix A.

RESULTS OF OPERATIONS

The final accounting for the VAMP operation is accomplished using provisional mean daily flow data available from USGS and DWR. The provisional data 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 to illustrate the differences between the real-time and the provisional data.

The mean daily flow at the Vernalis gage averaged 3,300 cfs during the VAMP test flow period, with a maximum of 3,610 cfs and a minimum of 2,840 cfs. The average flow for the test flow

TABLE 2–6

Summary of 2002 VAMP Daily Operation Plans Prepared During Implementation Phase

VAMP FORECAST DATE	VAMP PERIOD	ASSUMED UNGAUGED FLOW AT VERNALIS (CFS)	EXISTING FLOW (CFS)	VAMP TARGET FLOW (CFS)	SUPPLEMENTAL WATER NEEDED TO MEET TARGET FLOW (1,000 AF)
April 16	April 15–May 15	300	2,645	3,200	34.10
April 19	April 15–May 15	300	2,623	3,200	35.49
April 25	April 15–May 15	300	2,636	3,200	34.68
May 09	April 15–May 15	450	2,747	3,200	27.88

FIGURE 2–1

2002 VAMP–San Joaquin River Near Vernalis–With and Without VAMP

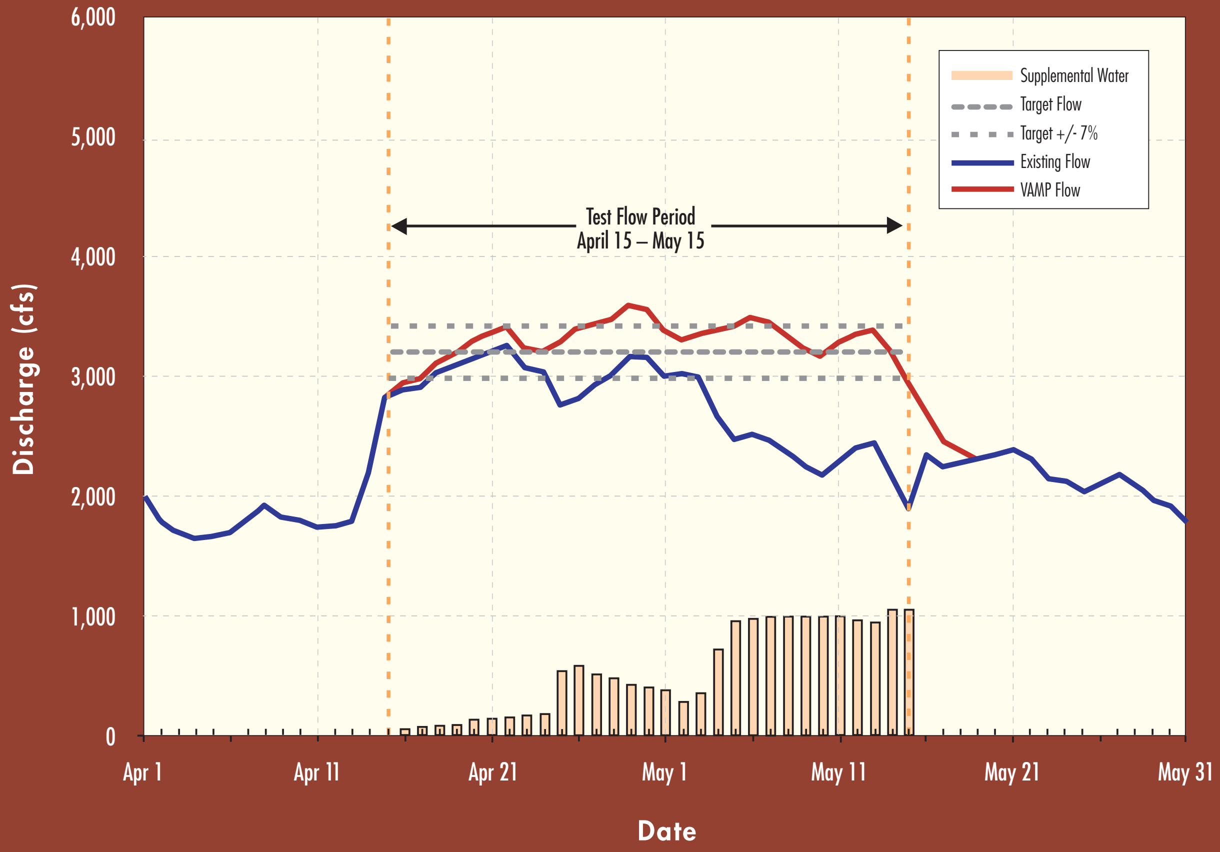


FIGURE 2–2

2002 VAMP–San Joaquin River Near Vernalis With Lagged Contributions From Primary Sources

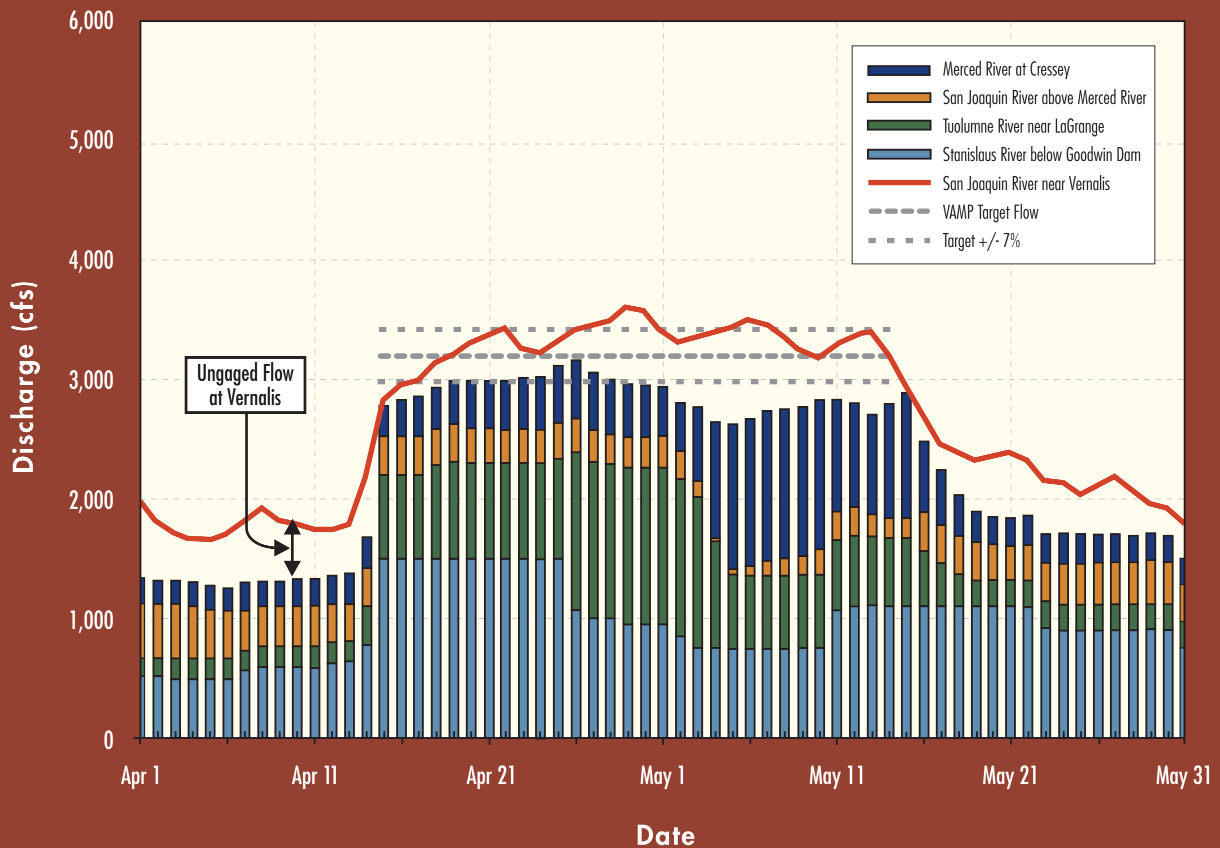


FIGURE 2–3

2002 VAMP–Ungaged Flow at Vernalis During Test Flow Period

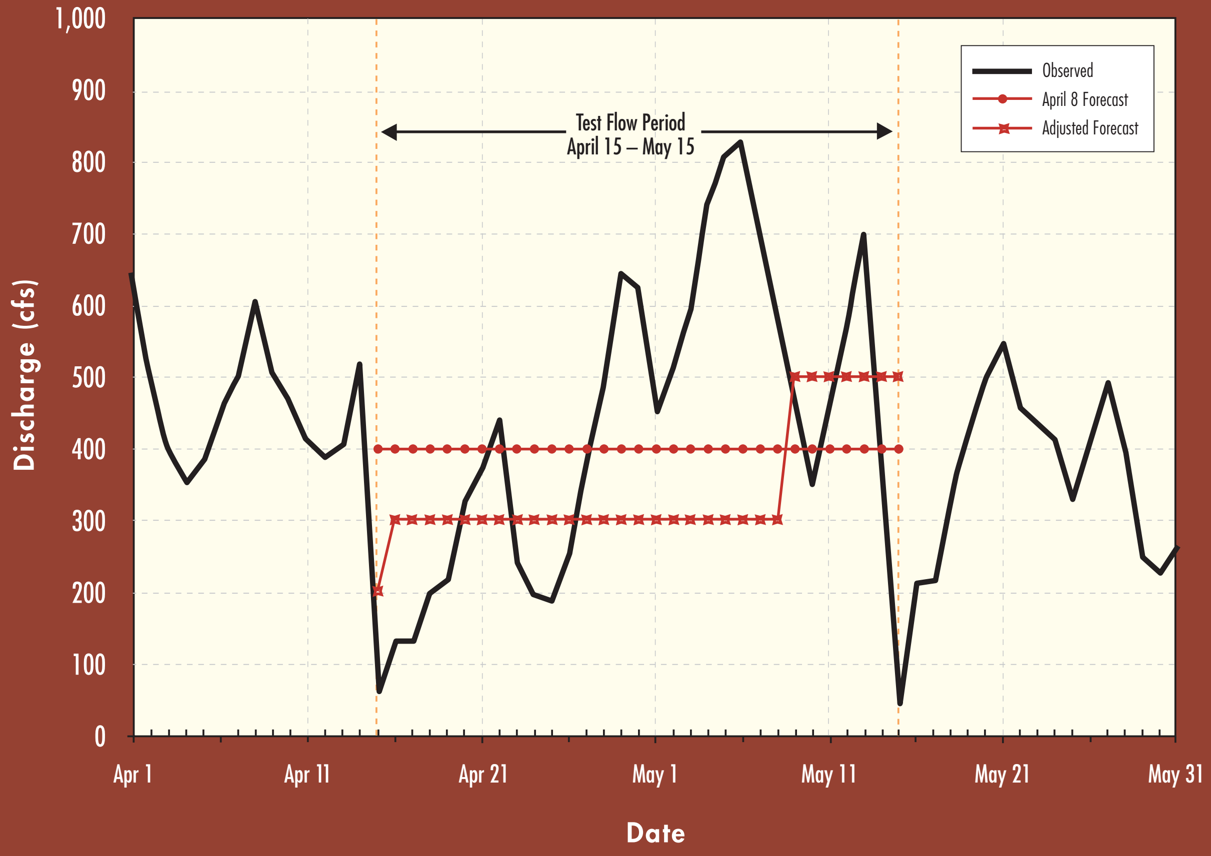


FIGURE 2–4

2002 VAMP–Federal and State Exports [Source: USBR Delta Operations Report]

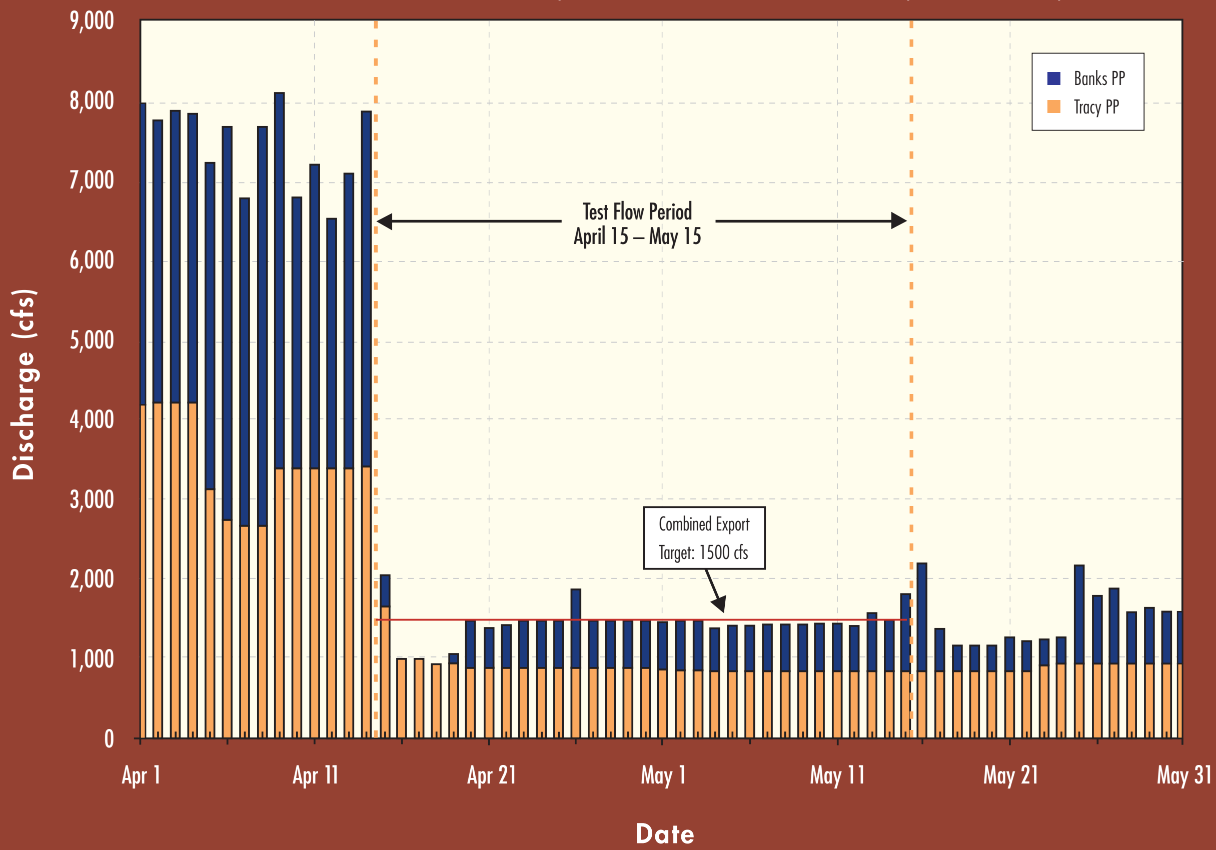


FIGURE 2–5

2002 VAMP–SJRA Storage Impacts–Lake McClure (Merced River), October 2001 through December 2002

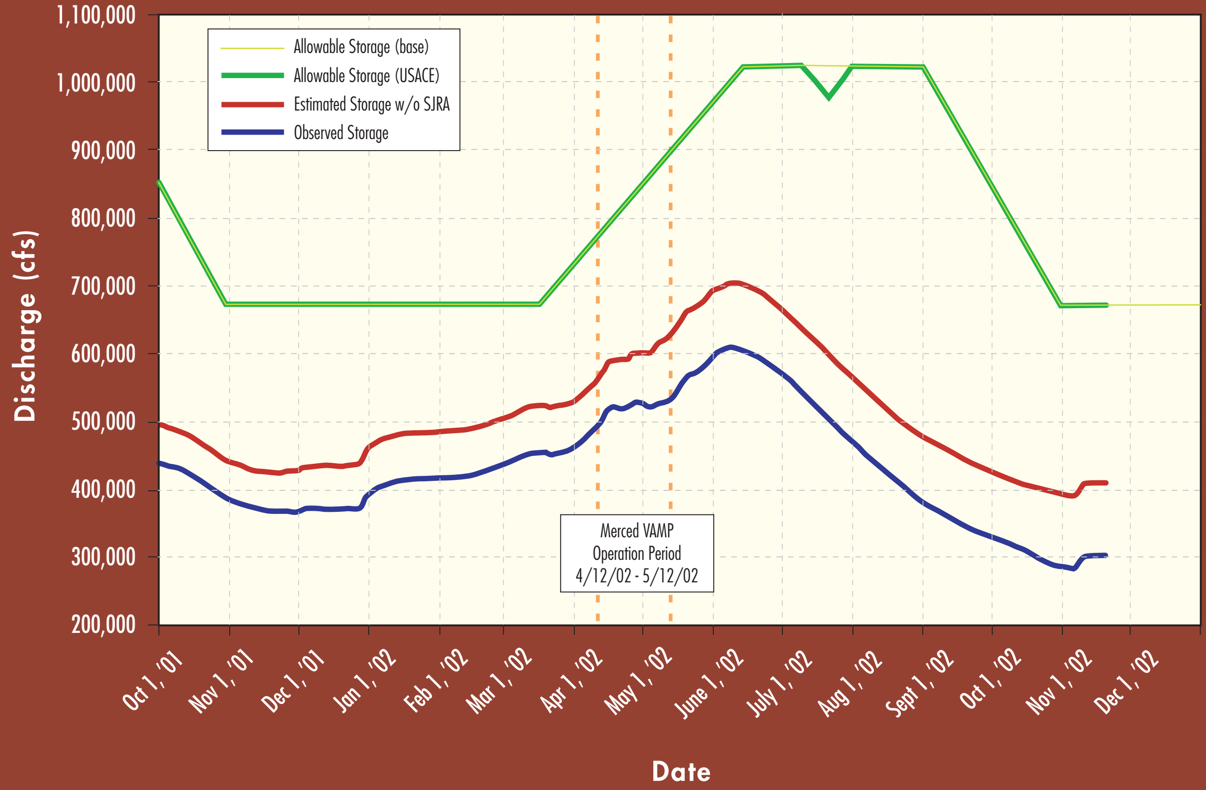
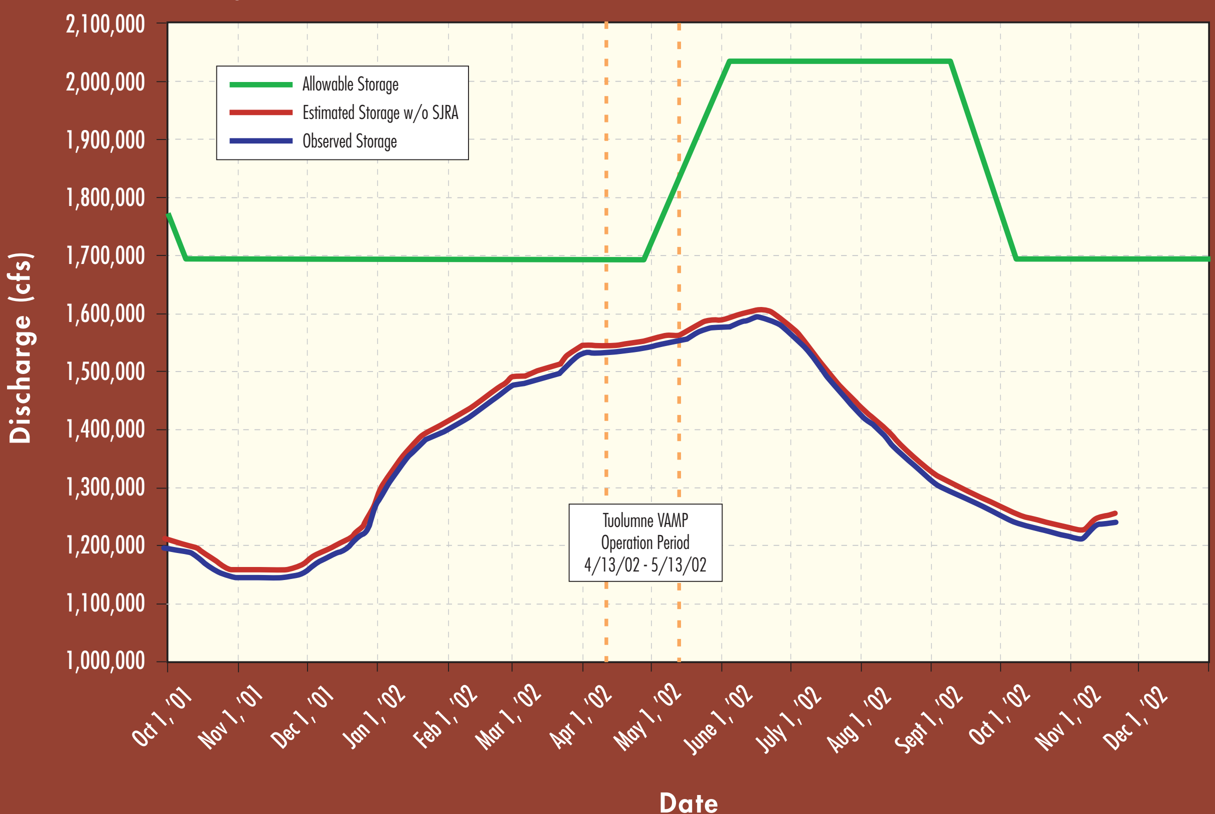


FIGURE 2–6

SJRA Storage Impacts–New Don Pedro Reservoir (Tuolumne River), October 2001 through December 2002



period absent the VAMP supplemental water (existing flow) was estimated to be 2,760 cfs. The VAMP operation resulted in a 20 percent increase in flow at Vernalis during the target flow period. Figure 2-1 shows the flow at Vernalis with and without the VAMP pulse flow. Figure 2-2 shows the sources of the flow at Vernalis. A total of 33,430 acre-feet of supplemental water was provided during the VAMP test flow period. A daily summary of VAMP operations, along with supporting data, is provided in Appendix A.

In planning for the VAMP operation the ungaged flow at Vernalis is the most difficult factor to forecast for the test flow period. The Daily Operation Plan is developed assuming a steady ungaged flow during the test flow period, but in reality there will be day to day fluctuations due to a number of unpredictable factors including weather, pre-existing conditions, irrigation operations, as well as mathematical uncertainties introduced by using mean daily flows and assumed travel times rounded to the nearest day. During the implementation phase of the VAMP operation, the forecast ungaged flow will not necessarily be adjusted as a result of the day to day fluctuations, but will be adjusted if the general trend appears to be deviating from the existing forecast. This is all illustrated in Figure 2-3, which shows in hindsight the observed ungaged flow along with that forecast prior to the test flow period on April 8 and the adjusted forecast that was modified on an ongoing basis in an attempt to account for deviation from the existing forecast.

The combined CVP and SWP export rate averaged 1,430 cfs during the 31-day period, about 5 percent below the target of 1,500 cfs. The daily SWP and CVP exports during the VAMP test period are shown in Figure 2-4.

SJRG member agencies have entered into the Division Agreement, which allocates responsibility of the members for providing VAMP supplemental water. The distribution of supplemental water for the 2002 VAMP operation, compared to the distribution called for under the Division Agreement, is summarized in Table 2-7.

Hydrologic Impacts

The VAMP supplemental water contributions, with the exception of that provided by the Exchange Contractors and OID/SSJID, are supplied from reservoir storage: Lake McClure on the Merced River and New Don Pedro Reservoir on the Tuolumne River. 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.

As noted in the 2001 Annual Technical Report, the storage impact in Lake McClure on the Merced River following the 2001 VAMP operation was 55,650 acre-feet. As per the SJRA, Merced provided 12,500 acre-feet of supplemental water in the Fall of 2001 (see Chapter 3), resulting in a total SJRA storage impact on Lake McClure at the end of 2001 of 68,150 acre-feet. There were no opportunities to make up for any of this impact during the winter, therefore the entire impact of 68,150 acre-feet carried over into the 2002 VAMP operation period. With the 25,840 acre-feet of supplemental water provided by Merced for the 2002 VAMP operation along with 1,270 acre-feet of operational ramp-down water, the current impact of the SJRA on Lake McClure storage is 95,260 acre-feet. Figure 2-5 shows Lake McClure storage for water year 2002 with and without the SJRA.

As noted in the 2001 Annual Technical Report, the storage impact in New Don Pedro Reservoir on the Tuolumne River following the 2001 VAMP operation was 14,060 acre-feet. There were no opportunities to make up for any of this impact during the winter, therefore the entire impact of 14,060 acre-feet carried over into the 2002 VAMP operation period. No supplemental water was provided from New Don Pedro Reservoir for the 2002 VAMP; therefore the current storage impact due to the SJRA remains at 14,060 acre-feet. Figure 2-6 shows New Don Pedro Reservoir storage for water year 2002 with and without the SJRA.

In the 2001 Annual Technical Report, a cumulative storage impact to New Melones of 54,210 acre-feet was identified. This statement was not correct. The water provided by OID/SSJID for both the VAMP pulse flow and the "additional" water is made available from their diversion entitlements. Thus, there are no storage impacts in New Melones due to either VAMP or the "additional" water purchase.

TABLE 2–7

2002 VAMP–Distribution of Supplemental Water

AGENCY	DIVISION AGREEMENT DISTRIBUTION (ACRE–FEET)	SUPPLEMENTAL WATER PROVIDED (ACRE–FEET)	DEVIATION FROM DIVISION AGREEMENT (ACRE–FEET)
Merced I.D.	25,000	25,840	+840
Oakdale I.D./ South San Joaquin I.D.	8,430	7,590	–840
Exchange Contractors	0	0	0
Modesto I.D./ Turlock I.D.	0	0	0

CHAPTER 3 | ADDITIONAL WATER SUPPLY ARRANGEMENTS & DELIVERIES

MERCED IRRIGATION DISTRICT

The SJRA includes a provision (Paragraph 8.4) stating that "Merced Irrigation District (Merced) 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." This water is referred to as the Fall SJRA Transfer Water. The daily schedule for the Fall SJRA Transfer Water is to be developed by Department of Fish and Game (DFG), United States Fish and Wildlife Services (USFWS) and Merced ID.

The schedule for the 2002 Fall SJRA Transfer was finalized on October 3, 2002, with the transfer commencing on October 15, 2002. The schedule is provided in Appendix B, Table B-1. As with the VAMP operation, the final accounting for the Fall Transfer will be done using provisional flow data.

The 2001 Fall SJRA Transfer was in progress at the time of publication of the 2001 Annual Technical Report and therefore only preliminary data was provided in the 2001 report. The final data for the 2001 Fall SJRA Transfer are included in Appendix B, Table B-2, of this report.

The schedule for the 2002 Fall SJRA Transfer was finalized on October 3, 2002, with the TRANSFER COMMENCING on October 15, 2002.

OAKDALE IRRIGATION DISTRICT

Pursuant to Paragraph 8.5 of the SJRA, "Oakdale Irrigation District (OID) shall sell 15,000 acre-feet of water to the USBR in every year of (the) Agreement...In addition to the 15,000 acre-feet, Oakdale will sell the difference between the water made available to VAMP under the SJRGA agreement and 11,000 acre-feet." This water is referred to as the Difference water.

OID provided 3,795 acre-feet of supplemental water for the year 2002 VAMP, resulting in 7,205 acre-feet of Difference water. Therefore, pursuant to Paragraph 8.5 of the Agreement, OID sold a total of 22,205 acre-feet of water to the USBR in 2002.

Release of the OID additional water by the USBR began on October 20, 2002 and is scheduled to be completed by February 28, 2003. The preliminary daily schedule as of October 30, 2002 for the release of the OID additional water is provided in Appendix B, Table B-3.

CHAPTER 4 | HEAD OF OLD RIVER BARRIER

BARRIER DESIGN, INSTALLATION AND OPERATION

In early April 2002, DWR installed and operated the temporary HORB. The spring HORB is a component of the south delta Temporary Barriers Project (TBP). The TBP mitigates for low water levels in the south delta and improves water circulation and quality for agricultural purposes. The HORB, as currently configured, is now fully permitted though 2005.

The spring HORB was first constructed in 1992. Since then, the barrier has been installed in 1994, 1996, 1997 (w/two culverts), 2000, 2001, and 2002. In 2000-2002 the barrier was installed with six culverts. The HORB was not installed in 1993, 1995 and 1998 due to high San Joaquin River flows. The HORB was not installed in 1999 due to landowner access problems. The HORB, a key component of VAMP, is intended to increase San Joaquin River Chinook salmon smolt survival by preventing them from entering Old River.

The HORB was originally designed to withstand a San Joaquin River flow of about 3,000 cfs. Through the years, the design and installation of the HORB has been revised on several occasions to accommodate different needs. Beginning in 2001, the barrier design included two versions. A "low-flow" barrier when San Joaquin River target flows are below 7,000 cfs would be built to a height of 10 feet mean sea level (MSL). A "high-flow" barrier for target flow of 7,000 cfs would be built to a height of 11 feet MSL and additional material would be placed to raise the abutments to 13 feet MSL. Both barrier versions are equipped with six 48-inch diameter operable culverts and an overflow weir back-filled with clay. In 2002, the low-flow version was installed.

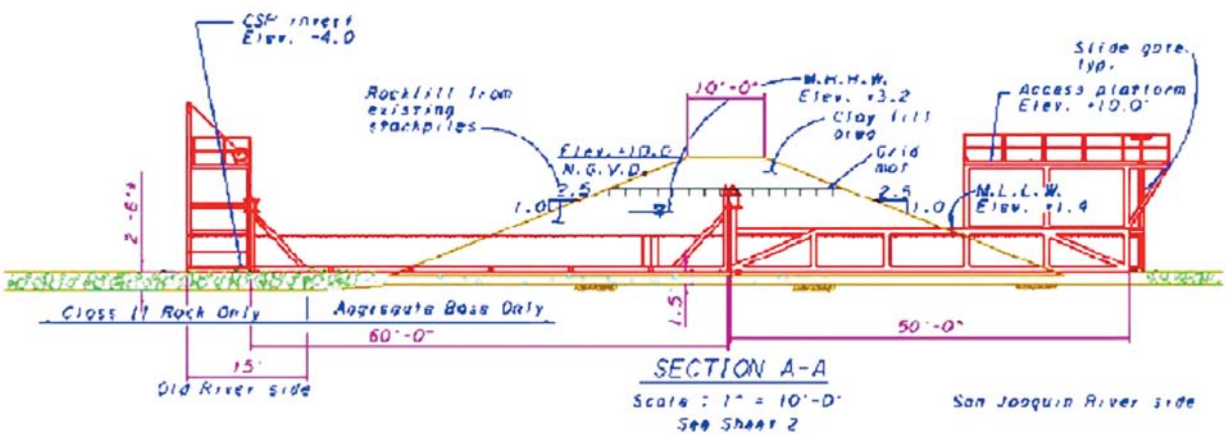
The dimensions of the 2002 HORB (Figure 4-1) were similar to the 2000 and 2001 HORB. The base width of the HORB in 2002 was 100 feet and the crest elevation was 10 feet MSL. The top of HORB was constructed with a 75-foot wide notch, protected with concrete grid mats and back-filled with clay. The HORB was designed to safely operate with flows corresponding to stages up to 8.5 feet MSL.

To help mitigate anticipated low water levels in the south delta (downstream of the HORB) caused by the operation of the HORB, two open culverts were installed in the barrier in 1997, and six operable culverts were installed beginning in 2000. Operation of the culverts is controlled by a slide gate control structure located on the upstream side of HORB. DWR relied on daily modeling and field data collection to monitor water levels at three locations within the south Delta to determine when and how long to operate the culverts. Generally, the model forecasts would tend to forecast low-low water levels lower than actual levels observed in the field. Consequently, DWR would make decisions regarding the culvert operations that would take this into consideration. It is expected that refinements to the model over time will provide modeling results that correspond more closely with field measurements.

The downstream outlet of each culvert was designed so fyke nets could be attached to evaluate fish passage. DFG staff conducted a fishery-monitoring program as part of the 2002 HORB operations.

FIGURE 4–1

Head of Old River Barrier (HORB)



Permitting and Construction

The various permit conditions that are placed on the Temporary Barriers Program, by the USFWS, National Marine Fisheries Service (NMFS), and DFG, require that the earliest in-water construction activities that can be conducted on the Head of Old River (HOR), Middle River (MR), and Old River at Tracy (ORT) barriers, during the Spring barrier installation period, are limited to no earlier than April 7. In addition, construction of the northern abutment and boat ramps of the Grant Line Canal (GLC) barrier and construction of out-of-water portions of the HOR, MR, and ORT barriers may not be started any earlier than April 1. Full closure of the GLC barrier is not required but construction of the north abutment and boat ramps must be completed to the extent that full barrier closure and operation can be readily achieved in a reasonable time frame, if and when directed by DWR. The permit conditions also require that all the above work be completed by April 15th, a total of 15 working days. Following is a brief summary of the various permit conditions:

USFWS Biological Opinion

1) The spring HORB barrier installation may begin on April 1 but in-water work shall not occur until April 7, except for construction necessary to place the scour pad and the pad for the culverts (item No. 8, page 6);

2) DWR may begin construction of the Middle River barrier on April 1 but in-water work shall not occur until after April 7 (item No. 1, page 4);

3) DWR may begin construction of the Old River at Tracy barrier on April 1 but in-water work shall not commence before April 7 (item No. 2, page 4);

4) DWR may begin construction of the northern abutment and the boat ramp of the GLC barrier on April 1 provided that the HOR barrier is being constructed concurrently (item No. 3, page 5).

NMFS Biological Opinion

1) the spring HORB installation shall begin on April 1 (item 8, page 8);

2) the MR barrier construction may begin on April 7 (item 1, page6);

3) the ORT barrier construction may begin on April 1 (item2, page 6);

4) the northern abutment and boat ramp of the GLC barrier may begin construction on April 1 provided that the HORB is being constructed concurrently (item 3, page 7).

DFG 1601–HORB

HORB Spring Installation–All work in or near the stream zone will be confined to the period beginning no earlier than April.

DFG 1601–Agricultural Barriers

MR–All work in or near the stream zone will be confined to the period beginning no earlier than March 1.

ORT–All work in or near the stream zone will be confined to the period beginning no earlier than April 1.

GLC–All work in or near the stream zone will be confined to the period beginning no earlier than April 1.

The downstream outlet of each culvert was designed so fyke nets could be attached to evaluate fish passage. DFG staff conducted a fishery-monitoring program as part of the 2002 HORB operations.

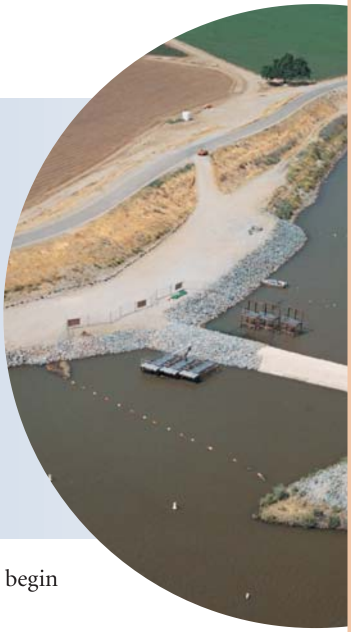


TABLE 4–1

Flow in Old River Downstream of the Head of Old River Barrier–2002

DATE	MEAN DAILY FLOW (CFS)	DAILY MAX FLOW (CFS)	DAILY MIN FLOW (CFS)	DATE	MEAN DAILY FLOW (CFS)	DAILY MAX FLOW (CFS)	DAILY MIN FLOW (CFS)
April 1	870	1567	419	May 02	278	763	-113
April 2	898	1590	287	May 03	328	717	-164
April 3	889	1418	101	May 04	291	828	-169
April 4	858	1409	96	May 05	234	745	-76
April 5	758	1315	-26	May 06	364	750	-123
April 6	727	1111	-13	May 07	327	772	-33
April 7	616	1047	93	May 08	274	794	-197
April 8	596	1100	276	May 09	362	691	-11
April 9	543	1211	138	May 10	366	644	-83
April 10	471	1157	13	May 11	258	679	-73
April 11	577	1136	147	May 12	356	844	-36
April 12	519	1016	45	May 13	568	888	324
April 13	347	1015	-128	May 14	525	811	220
April 14	487	1372	-486	May 15	458	674	169
April 15	680	1821	77	May 16	417	661	0
April 16	538	832	49	May 17	371	648	115
April 17	541	822	225	May 18	388	575	142
April 18	412	838	-158	May 19	232	548	-161
April 19	259	687	-194	May 20	218	537	-33
April 20	229	577	-140	May 21	294	540	-11
April 21	232	851	-201	May 22	325	585	35
April 22	160	751	-233	May 23	331	607	-55
April 23	169	495	-226	May 24	409	1651	-239
April 24	205	559	-259	May 25	683	1612	-33
April 25	249	538	-148	May 26	923	1870	305
April 26	328	626	20	May 27	854	1752	-12
April 27	238	494	-66	May 28	713	1582	-129
April 28	180	595	-243	May 29	471	1334	23
April 29	241	638	-73	May 30	413	858	0
April 30	187	534	-225	May 31	492	889	68
May 01	200	766	-127				

In addition to the above conditions, water users of the South Delta Water Agency (SDWA) and the fisheries agencies impose separate mitigation requirements on DWR for installation and operation of the HORB by itself. As a result, DWR's contractor must sequentially close and start operation of the MR and ORT barriers, and complete as much construction of north abutment and boat ramps on the GLC barrier as possible, before they can close and operate the HORB.

From the contractors point of view there are really two milestones that must be completed in sequence. First and foremost is to obtain closure and operation of the barriers in accordance with the conditions imposed by the project permits/biological opinions and mitigation requirements. The second is to satisfy DWR's contract specifications. The first milestone can be achieved within the required 15 working days but it is unlikely that the contractor can complete the entire amount of work required to satisfy DWR's contract specifications within the same time period.

Therefore, the contractor's construction activities consist of placing enough materials to make sure they obtain closure and operation by April 15th, then following closure they continue placing barrier material above the water line until barrier construction is completed in accordance with DWR's contract specifications. The contractor then conducts site cleanup and demobilizes from the site. This is why work usually continues beyond the April 15 deadline.

Barrier Operations and Monitoring Plan

A barrier operations and monitoring plan was developed based on forecasting and monitoring of tidal conditions. DWR determined the number of culverts to be opened at the HORB so that water levels at Old River near Tracy Road Bridge, Middle River near

Howard Road and Grant Line Canal near Tracy Road Bridge would remain above 0.0 feet MSL. Based on modeling results and/or field monitoring of water levels in the south delta, all six culvert slide gates remained open from April 15 to May 24, 2002 when the HORB was breached.

The average daily flow through the culverts varied in response to tidal and San Joaquin River flow conditions. The characteristics of the flow through the culverts are complicated in that the flow rate is influenced by many variables, including the culvert inlet geometry, slope, size, culvert roughness, and approach and tail water conditions. An approximation of the combined net flow through the culverts, including any seepage through the barrier, was accomplished by measuring the flow in Old River just downstream of the HORB using Acoustic Doppler technology. A fixed Acoustic Doppler Current Meter was operated approximately 840 feet downstream of the HORB which recorded velocity measurements every 15 minutes during the period the HORB was operated (April 15 through May 24, 2002). The flow in Old River was then calculated using the known cross-sectional area of the channel as a function of the stage elevation at that location.

The mean daily flow measured in Old River during the operation of the HORB ranged from 160 to 568 cubic feet per second as shown in Table 4-1. These figures ignore the first and the last day of operation which is skewed by flows occurring before and after the HORB was closed or breached. On May 24, the barrier was breached, which accounts for the maximum flow of 1,651 cfs shown in Table 4-1. The negative flows listed indicate the channel below the HORB was filling on a flood tide; however, this does not mean that flows through the culverts were negative. As long at the river stages on the upstream side of the barrier remain higher than the downstream side, flows through the culverts will always be positive.

Barrier Emergency Response Plan

In addition to the operation and monitoring plan, DWR has also prepared an "Emergency Operations Plan for the Spring HORB". The plan provided that if the daily measured or forecasted flow at Vernalis exceeded a flow that would correspond to stage at the HORB of 10.0 feet MSL, and the stage was likely to exceed 11.0 feet MSL (the height of the barrier under the "high-flow" target), the barrier would be removed. Operation of the HORB was uneventful this year. Vernalis flows and stages at the barrier were not high enough in 2002 to warrant action under the emergency operations plan.

Seepage Monitoring

A seepage-monitoring program was initiated in April 2000 and continued this year, to evaluate the effects of HORB operations on seepage and groundwater on Upper Roberts Island.

Three seepage monitoring well sites were chosen in 2000 on Upper Roberts Island. Each site had two shallow wells, positioned 10 feet and 100 feet from the toe of the levee to monitor the seepage gradient to and from the San Joaquin River. In addition, a deeper well was drilled at Site 1 (near the Head of Old River) to determine vertical gradients.

In addition to the groundwater monitoring wells, a temporary gage was installed in April 2000 to record water surface elevations in the San Joaquin River, about 1,500 feet downstream of the HORB. Installation of a permanent tide gage was completed in early 2002. The water surface elevations in the San Joaquin River are compared to groundwater levels on Upper Roberts Island to determine how groundwater levels change relative to changing water level conditions in the river.

In November 2002, DWR completed a "Reclamation District 544 Seepage Monitoring Study". This is an ongoing study to document the seepage monitoring results from Upper Robert Island. (Copies of the report are available from DWR). Based on the 2000 and 2001 data, it is apparent that the San Joaquin River stage influences groundwater levels on Upper Roberts Island. When stage increases in the river, groundwater levels will rise toward the land surface, but not as rapidly as the river stage rises. However, over the monitoring period, river stage did not reach levels sufficient to raise groundwater levels to the point where seepage into crop root zones might occur.

Given the results of the seepage monitoring since April 2000, DWR expects that if a VAMP target flow of 7,000 was implemented, stages near the HORB would rise to about 7 1/2 to 8 feet MSL. This would translate to groundwater levels in the monitoring well closest to the levee of about 6 1/2 to 7 feet MSL. Because the ground surface elevation is 13 feet MSL near site 1, DWR concludes that seepage should not impact the root zone of crops that could be planted in this area.

The monitoring program will be continued in order to gather more data, particularly during high flow periods in the spring.

FISHERY MONITORING AT THE HEAD OF OLD RIVER BARRIER

During the VAMP 2002 test period, all six culverts in the HORB were operational. The six culverts are installed to maintain water quality and water levels in the south delta downstream of the HORB. Since the culverts are not screened, juvenile Chinook salmon and other fish species that pass near the culverts are vulnerable to entrainment. A fishery monitoring program was designed and implemented by the DFG to evaluate and quantify fish entrainment at the HORB. The specific objectives of the 2002 fishery investigations were:

- Determine the total number of juvenile Chinook salmon and other fish species entrained through the culverts at the HORB (Entrainment Monitoring).
- Determine the percentage of coded-wire tagged (CWT) salmon released at Mossdale and Durham Ferry entrained into Old River (Entrainment Monitoring).
- Determine tidal and diel effects on juvenile Chinook salmon entrainment (Entrainment Special Study).

Results of these fishery investigations are intended, in part, to provide information on the design and operation of a future permanent operable barrier at the head of Old River.

Materials and Methods

As part of the VAMP 2002 studies, a total of 148,502 CWT salmon smolts were released at Durham Ferry and Mossdale on April 18 and 19, respectively. Another 147,842 were released at the same locations on April 25 and 26. Salmon from the VAMP releases were used in the Entrainment Monitoring studies. For the Entrainment Special Study, eight uniquely color-marked groups of juvenile Chinook salmon (approximately 3,000 fish per group) were marked with photonic fluorescent microspheres at the Merced River Hatchery. The salmon were transported to the HORB and placed in live cages where they were held at least 10 hours before release. Each color-marked group was released approximately one mile upstream of the HORB, in the middle of the San Joaquin River. The color-marked releases coincided with the two VAMP salmon releases. On the night of April 19, one group was released on the ebb tide and one group on the flood tide. The following day, a group was released on the subsequent ebb and flood tides. The process was repeated on April 25.

Fish entrained into the culverts were caught with fyke nets. The nets have a 48 inch cylindrical mouth tapering down to a 1-foot square cod-end, are made of 1/4 inch braided mesh, and five of the nets are 60 feet long and one is 40 feet long. A live-box (15.5 x 19.5 x 36 inches), constructed of perforated aluminum sheet metal, was attached to the cod-end of each net. Each live-box has an aluminum baffle designed to reduce water velocities within the live-box and improve survival of captured fish. The fyke nets were attached to the culvert flanges on April 17. The nets were attached to the culverts by closing the culvert slide gates on the upstream side of the barrier, raising the flanges that slide over the culvert outfalls, and then strapping the nets over the flange. The 40 foot net was attached to culvert number 1 and the 60 foot nets were used on the remaining culverts. The culverts were numbered 1 through 6 with number 1 located next to the shoreline and number 6 located near mid-channel (Figure 4-2). On April 18, the flanges, with the attached fyke nets, were lowered down to the culvert outfalls and the live-boxes were attached to the cod-end of the nets to commence sampling.

The fyke nets were checked on every tide change until May 1. From May 1 through May 11, the nets were checked twice a day; in the morning and the evening. On May 12, the nets were removed. The nets were checked by closing the culvert slide gate, for a period of 30 to 45 minutes, which enabled the live-boxes to be pulled onto a boat so that the fish could be removed and placed into buckets. Once all the nets had been checked and reset, the collected fish were processed. The fish were speciated and counted. Fork lengths (mm) were recorded for up to 50 salmon per live-box. Salmon were checked for a clipped adipose fin and for the presence of a color mark on the dorsal, anal, or caudal fin. Salmon that had a clipped adipose fin were saved for CWT processing. The color and location of the dyed fin was noted for each color-marked salmon. During each net check, culvert

FIGURE 4–2

Culvert Numbers for HORB 2002

number, date, time, water temperature, tidal stage, and diel period was recorded. Except for the CWT smolts, all processed fish were released downstream of the fyke nets into Old River.

Entrainment Monitoring

Loss indices for the CWT salmon released as part of the VAMP survival studies at Durham Ferry and Mossdale were calculated based on data collected from April 18 to May 11. The loss index represents the percentage of CWT salmon entrained into the HORB culverts. As in previous years, the loss index is calculated using the equation:

$$I = (TC/TR)(TT/ST)$$

Where:

TC = Total number of CWT salmon collected in culvert fyke nets
TR = Total number of CWT released
TT = Total time (hours) during the test period
ST = Total time (hours) sampled at HORB during the test period

However, this year, for the nine occasions when a culvert was not monitored and/or the sample was lost, the total catch for the missing culvert was estimated by using the average of the other culverts for that sample period. Consequently, all sampling time is accounted for and TT/ST = 1, and the loss index is equal to TC/TR.

Catch-Per-Unit-Effort (CPUE) for salmon was calculated as the number of fish collected per hour. The percentage of color-marked salmon recovered in the fyke nets compared to the total number released was used as an index of entrainment vulnerability at the HORB.

RESULTS AND DISCUSSION

Results

The HORB was closed on April 15; however, construction on the barrier continued for another week. Due to the large gravel pad in front of the culverts and/or the ongoing construction and the water currents, gravel was swept through the culverts into the nets during the first three days of sampling. Nine samples were lost or not taken because it required considerable time and effort to retrieve the rock filled net from the bottom of the river. Several of the lost samples occurred during a critical time when the CWT and color-marked salmon were approaching the barrier.

The DFG monitored the HORB culverts for 25 days and collected 381 samples. The nets sampled 3,379 hours out of a possible 3,429 hours. Almost 18,000 fish were collected representing at least 28 species and 14 families of fish. No delta smelt, one juvenile steelhead, and 30 adult splittail were entrained. The most abundant species was Chinook salmon, followed by white catfish

TABLE 4–2

The raw abundance and composition of fishes entrained at the HORB in 2002. Chinook salmon catch is divided into CWT VAMP and nonVAMP released salmon, unmarked salmon, and color-marked salmon.

Cyprinidae	1
Red Shiner	1
Black Bullhead	1
Centrarchidae	1
Steelhead	**1**
American Shad	1
Prickly Sculpin	2
Sacramento Pikeminnow	2
Petromyzontidae	3
White Crappie	4
Tule Perch	4
Shimofuri Goby	5
Warmouth	9
Green Sunfish	10
Largemouth Bass	12
Golden Shiner	14
Sacramento Sucker	15
Black Crappie	19
Redear Sunfish	26
Brown Bullhead	26
Striped Bass	27
Bigscale Logperch	27
Splittail	**30**
Goldfish	37
Inland Silverside	88
Bluegill	118
Common Carp	199
Channel Catfish	560
Threadfin Shad	1,219
White Catfish	6,925
Total Chinook Salmon	**8,467**
CWT VAMP Salmon	4,145
CWT NonVAMP Salmon	1,213
Unmarked Salmon	2,748
Color-Marked Salmon	361
Total	**17,854**

FIGURE 4–3

The total daily catch of salmon smolts entrained at the HORB in 2002. The total catch is divided into nonVAMP, VAMP, and unmarked salmon.

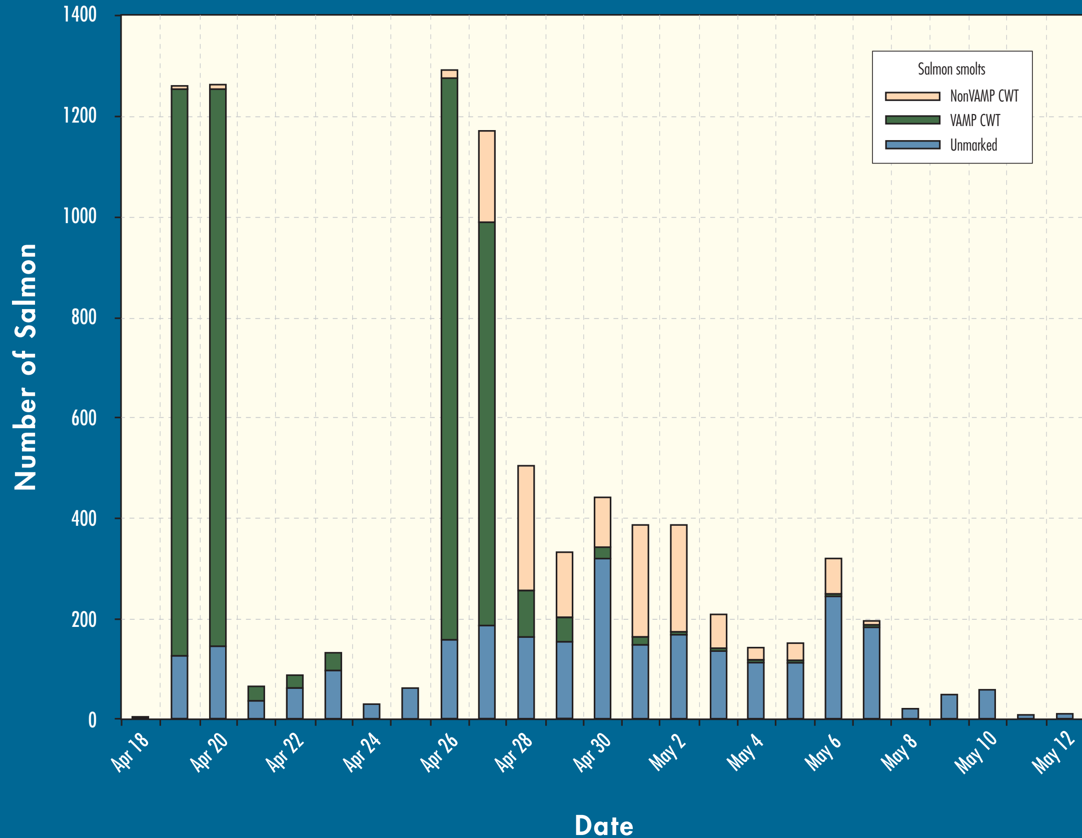


FIGURE 4–4

The number of CWT salmon caught by sampling period during the first VAMP releases in 2002. River stage for Old River is indicated by the line.

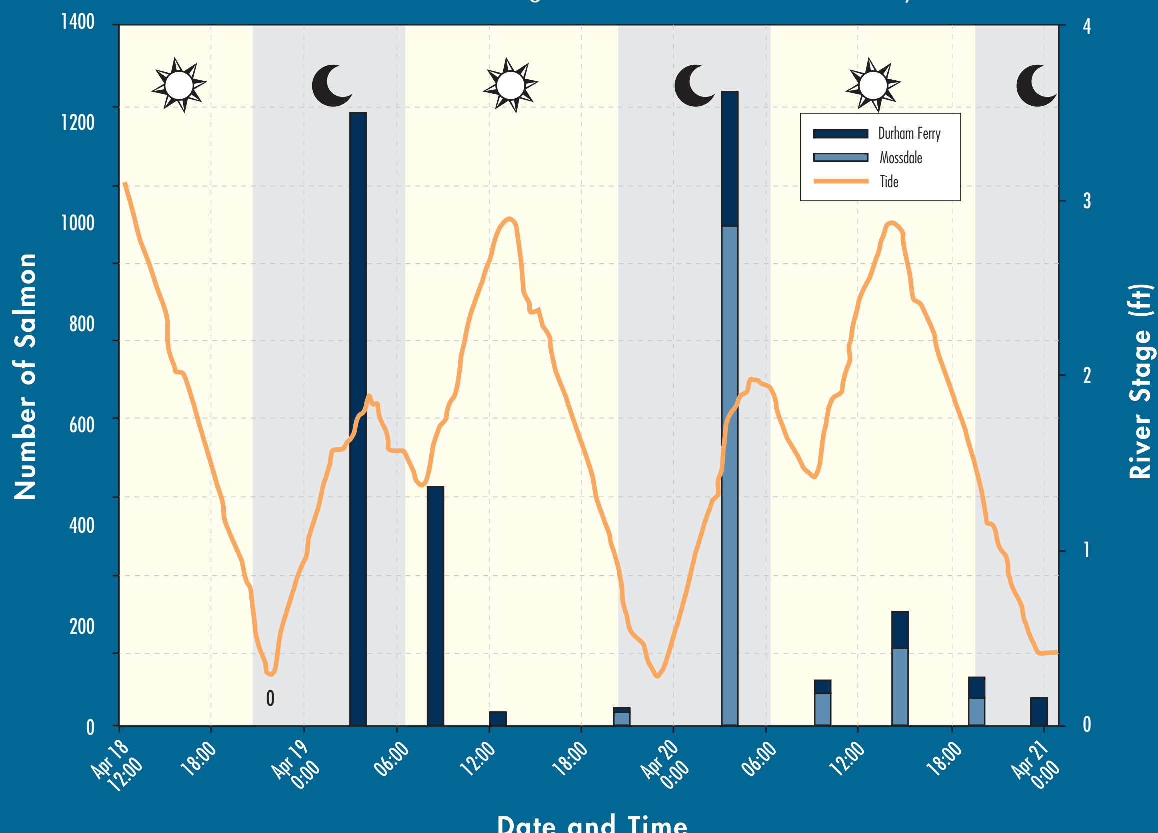


FIGURE 4–5

The number of CWT salmon caught by sampling period during the second VAMP releases in 2002. River stage for Old River is indicated by the line.

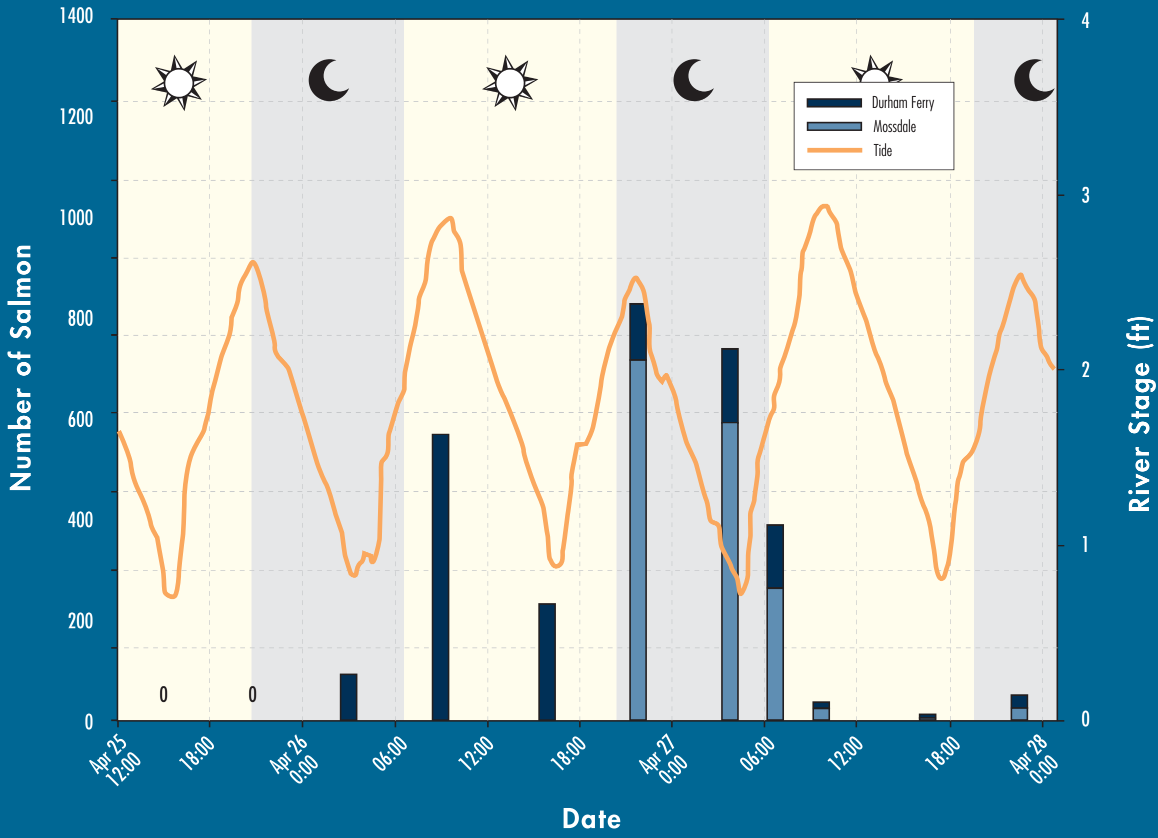
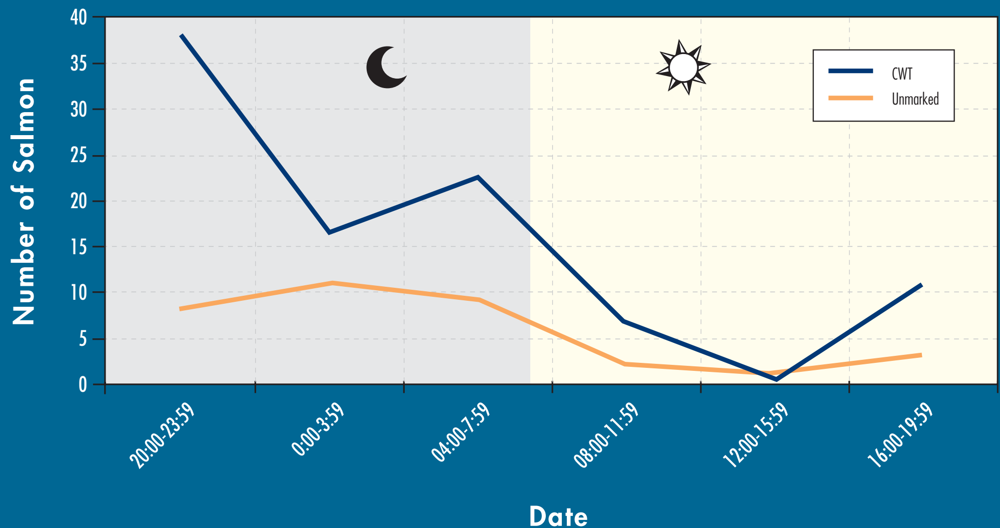


FIGURE 4–6

The average number of CWT and unmarked salmon caught over 24 hours, grouped into 4 hour time blocks.



(*Ictalurus catus*) (Table 4-2). CWT salmon dominated the catch in April and white catfish dominated the catch in May. Of the 8,493 salmon caught; 5,358 had a CWT; 2,748 were unmarked; and 361 had a color mark.

This year the number of CWT salmon increased 323 % over last year's CWT salmon entrainment (1,268 salmon). Salmon smolts were caught throughout the monitoring period although most of the VAMP released salmon were caught within a couple days of their release (Figure 4-3). During the first VAMP salmon release, it appears most of the Durham Ferry CWT salmon were entrained on the night of April 18 and the Mossdale released salmon were entrained on the night of April 19 (Figure 4-4). During the second VAMP release, the Durham Ferry salmon were entrained at a lower rate and few were caught on the night of April 25 (Figure 4-5). In contrast, the Mossdale salmon were entrained at a high rate on the night of April 26. The loss indices for the first Durham Ferry and Mossdale salmon releases were 1.6% and 1.7%, respectively. The loss indices for the second Durham Ferry and Mossdale releases were 1.0% and 2.3%, respectively. The overall loss index for the VAMP released salmon was 1.5%. This year's overall loss index is higher than the previous two years' indices of 0.5% and 0.8%.

TABLE 4–3

The percentage of color-marked salmon entrained for various diel and tidal stages. Due to some salmon escaping from their live-cages, the number of salmon released was estimated for the second releases.

NUMBER OF FISH RELEASED	DIEL	TIDE	FISH ENTRAINED	PERCENT RECOVERED
First Releases (19 & 20 April)				
3,032	Night	Flood	159	5.2%
3,009	Night	Ebb	46	1.5%
3,281	Day	Flood	15	0.5%
3,008	Day	Ebb	62	2.1%
Second Releases (25 & 26 April)				
2,990	Night	Flood	71	2.4%
3,000	Night	Ebb	10	0.3%
3,000	Day	Flood	39	1.3%
3,000	Day	Ebb	5	0.2%

Entrainment of the VAMP released salmon peaked during the late evening to midnight time block, and bottomed out in the afternoon at less than one fish per hour (Figure 4-6). The unmarked smolts had a steady rate of entrainment through the night and a relatively low rate during the day. For the entire monitoring duration, the average CPUE for the VAMP smolts per culvert was 1.6 ± 4.0. The highest CPUEs occurred soon after the VAMP releases, with a maximum CPUE of 32.5 on April 19. The average unmarked smolt CPUE (0.9 ± 1.3) was much lower than the VAMP CPUE. The highest unmarked CPUEs occurred in late April and early May, with a maximum CPUE of 7.5 on April 30.

To address tidal and diel effects, color-marked smolts were released on various tidal and diel period combinations. The first releases went well; however, some problems were encountered during the second release when an unknown number of smolts escaped from the holding pens before their intended release. The color-marked salmon were entrained within 5 hours at the HORB (Figure 4-7). Entrainment rates were higher for the first releases (2.3%) than the second releases (1.0%), but the overall entrainment rate (1.7%) was similar to the entrainment of the CWT smolts (Table 4-3). More smolts were caught at night than during the day, and more smolts were entrained during the flood than the ebb tide.

Salmon entrainment through the middle culvert was high this year (Figure 4-8). The remaining culverts entrained a similar amount of salmon, although the outside culverts (numbers 1 and 6) had a slightly lower overall entrainment rate. Culvert number 4 entrained 39% of the smolts during the day. On the day-ebb tides, culverts numbers 4 and 5 combined entrained almost 75% of the smolts (Table 4-4).

A current velocity meter (Swoffer Instruments, Inc., model 2100) was used on three occasions to estimate flows through each of the culverts. Velocity measurements were made near a low slack tide, a high slack tide, and on the ebb that was close to high slack. Due to the staff shortage and time constraints, only the ebb flow estimates occurred while we were monitoring the fyke nets. The other two readings took place after the fyke nets were removed at the end of the monitoring period. Results from the limited data gathered suggest culverts 2 through 6 had similar flows, and that culvert 1 averaged a little over 10 cfs less than the others (Table 4-4). Flows through the culverts were twice as high during low tide than high tide.

FIGURE 4–7

The total number of unmarked, color marked, and VAMP salmon caught by culvert. The total catch per culvert was adjusted for missing samples.

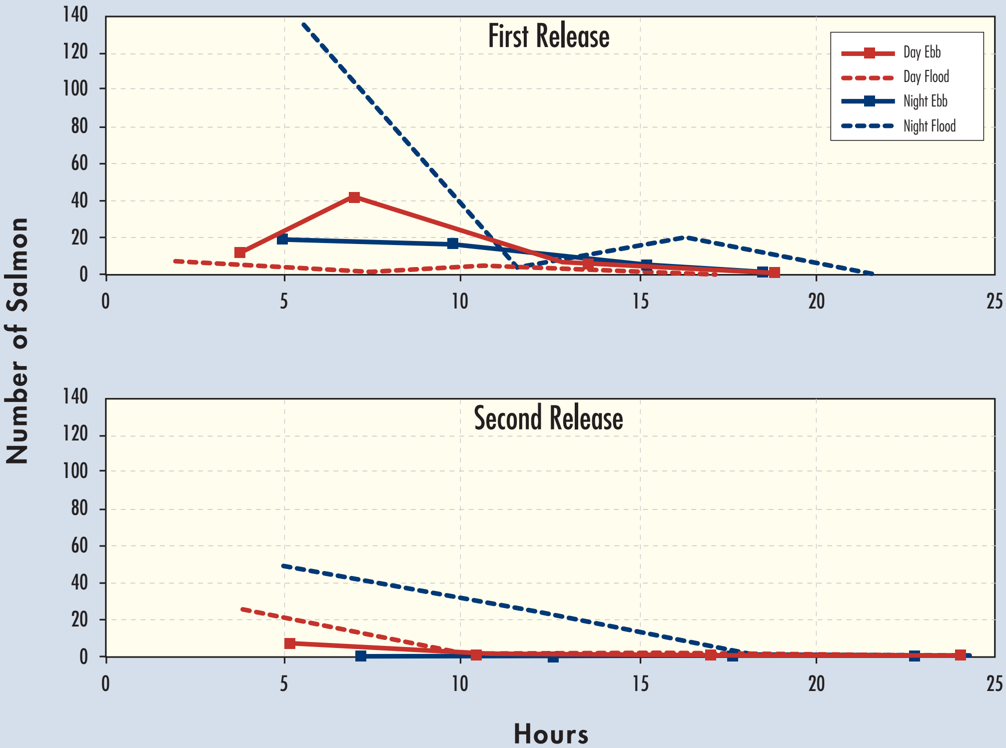


FIGURE 4–8

The total number of unmarked, color marked,and VAMP salmon caught by culvert. The total catch per culvert was adjusted for missing samples.

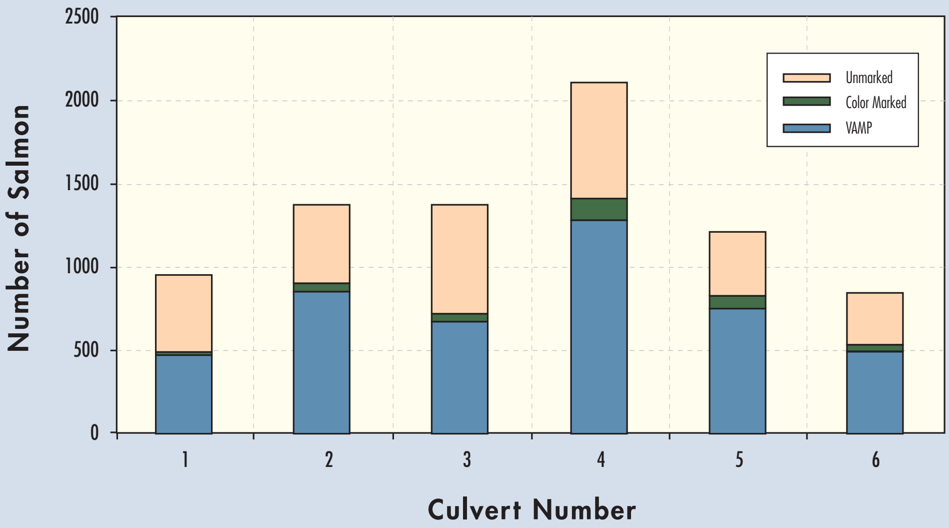


TABLE 4–4

The percentage of the VAMP salmon entrained, by culvert, for various diel and tidal stage combinations (top); and the average flow per culvert taken on three separate occasions (bottom).

ENTRAINMENT (PERCENT)								
DAY/ NIGHT	TIDE	Culvert Number						TOTAL
		1	2	3	4	5	6	
Day	Flood	8	18	13	38	11	12	100
Day	Ebb	7	3	6	46	28	9	100
Night	Flood	8	20	16	24	19	13	100
Night	Ebb	17	21	15	28	12	6	100
Wtd. Avg.		10	19	15	29	17	11	100
WATER FLOW (CFS)								
DATE	TIDE	Culvert Number						AVERAGE
		1	2	3	4	5	6	
May 16	High Slack	34	42	46	43	42	44	42
May 15	Ebb	48	55	57	53	63	58	56
May 07	Low Slack	70	92	88	92	91	90	87

Discussion

Despite a staff shortage and some sampling difficulties, the DFG successfully monitored fish entrainment at the HORB. Although the culvert monitoring duration increased 38% over 2001, the amount of fish entrained tripled. The increased catch was due primarily to Chinook salmon, white catfish and threadfin shad (*Dorosoma petensense*) which together comprised 93% of the total entrainment. The higher salmon entrainment this year could be due, in part, to less accumulation of debris in front of the culverts; the lower VAMP flows on the San Joaquin River which results in a higher proportion of the river flowing through the culverts; other environmental factors; and factors related to the barrier configuration and operation which may affect the hydraulics surrounding the barrier.

Similarly, the loss indices for the VAMP salmon were higher this year than in previous years. The loss indices within the two 2002 VAMP salmon releases varied. The loss indices for the first VAMP salmon release at Durham Ferry and Mossdale were similar. The loss indices for the second VAMP release were considerably different. The second Durham Ferry salmon release had a low loss index (1.0%) whereas the second Mossdale release, the following day, had a relatively high loss index (2.3%). The low loss index of the second Durham Ferry release was due to the low entrainment of salmon on the night of their release. In contrast, most of the entrained Mossdale salmon were caught the night of their release and they had a relatively high loss index. Typically, VAMP salmon entrainment is highest the night of their release.

The difference in the second VAMP loss indices could be due to slightly different salmon migration routes down the San Joaquin River, differential mortality, temporary debris obstruction of the culverts, and a combination of other environmental and behavioral factors. The majority of the Durham Ferry salmon could have migrated down the center or far side of the channel and avoided the HORB, and the Mossdale fish could have migrated closer to the HORB and were entrained. However, the Mossdale Kodiak Trawl (MKT) results indicate a similar catch trend between releases that was observed at the HORB. The MKT samples for fish in the middle of the San Joaquin River, just upstream of the HORB. The MKT only caught 250 VAMP salmon from the second Durham Ferry release compared to 573 salmon from the first release. The MKT caught more Mossdale VAMP salmon from the second release (41) compared to the first release (24). The MKT data suggests the lower loss indices at the HORB could be reflective of fewer salmon migrating pass the barrier. It is possible the second Durham Ferry released salmon experienced a high rate of mortality before reaching the HORB. The potential source of mortality affecting the second release group is unknown.

In contrast with the loss indices at the HORB, survival estimates from Chipps Island and Antioch (Chapter 5) suggest the second VAMP salmon release at Durham Ferry had a slightly higher survival than the release at Mossdale. The apparently higher numbers of Mossdale salmon at the HORB did not translate to higher survival through the Delta. In fact, few salmon from the second Durham Ferry and Mossdale releases were recovered at Chipps Island and Antioch indicating overall VAMP salmon survival was poor.

More CWT salmon were caught at night than during the day, and more were caught on the flood than the ebb tide. Both the VAMP salmon and unmarked salmon entrainment was relatively low in the afternoon. The larger catch of VAMP salmon at night could be confounded by their daytime release upstream of the barrier. Due to the timing of the VAMP release and the distance of the release sites from the HORB, most of these fish probably reached the barrier at night.

Tidal stage may effect entrainment. The river stage gage near the HORB on Old River indicated a relatively low tide near dusk during the first VAMP releases. The low tide creates a large head difference between water levels upstream and downstream of the barrier. The amount of water passing through the culverts depends on this head difference. Although the head difference at the HORB was shrinking on the ensuing flood tide after dusk, the CWT salmon approaching the barrier were still experiencing a large head difference. Over the next seven hours, on both nights (the ensuing high tide was still relatively low), entrainment of VAMP salmon was high. During the second VAMP release, the high tides occurred at dusk which resulted in less head difference as the smolts were approaching the barrier. This may have affected the number of smolts entrained at the barrier. Even with this smaller head difference, more smolts were still entrained at night than during the day.

Results from the Entrainment Special Study are similar to last year's Entrainment Special Study results. More color-marked salmon were entrained on a flood tide than on an ebb tide, and more were entrained at night than during the day. Marked salmon were entrained at the highest rate during a night-flood, although a large number of color-marked salmon were entrained on the day-ebb during the first release. As with the VAMP released salmon, more salmon were entrained during the first release than the second release. However, the lower entrainment index for the second release was confounded by some color-marked salmon escaping their live-cages.

Results from the 2002 Entrainment Monitoring Study and the Entrainment Special Study suggest salmon are more vulnerable to entrainment at night and on the flood tide. Even the unmarked salmon entrainment is higher at night than during the day. However, the VAMP salmon releases are not timed to address tidal-diel effects and their daytime releases may confound the diel results. The tidal effects on entrainment are still unclear. Water velocities through the culverts are greatest near a low slack tide which should result in the highest entrainment. This was not always the case. Some of the highest catches occurred during the flood. The changing hydraulics surrounding the barrier as the tide changes effects flows near the culverts which could affect entrainment. Also salmon smolt behavior and relative abundance near the barrier probably plays an important role in entrainment vulnerability.

Overall, the highest salmon entrainment occurred in culvert number 4 and the lowest in culvert numbers 1and 6. In contrast, in 2001, culvert number 6 entrained the most fish and entrainment in each culvert decreased as the culverts got closer to shore. This year, culvert number 4 entrained the most fish, and culvert numbers 1 and 6 entrained the fewest. However, since the remaining culverts had similar flows, the reason for the high entrainment in culvert number 4 and the low entrainment in culvert number 6 is still unclear. The reason for the difference in culvert entrainment this year from last year is also unclear. Lower flows on the San Joaquin River and slight differences in culvert angles could affect the flow through the culvert and thus, entrainment.

Unfortunately, the first VAMP release occurred while the HORB was under construction. A lot of time was wasted and several samples lost due to gravel accumulation in the nets. Future VAMP salmon studies should schedule their salmon releases after the completion of the barrier, typically 5 days after the HORB is "closed". To better address diel affects, VAMP should schedule one of the Mossdale releases for night. A night release, instead of the usual day release, could shed some light on entrainment at the HORB. A more systematic monitoring of flows through the culverts during future VAMP salmon releases would help us understand salmon entrainment as related to tide. Future studies should also assess juvenile Chinook salmon mortality associated with the barrier.

CHAPTER 5 | SALMON SMOLT SURVIVAL INVESTIGATIONS

One of the primary objectives of the VAMP program is to identify the respective roles of San Joaquin River flow, and SWP and CVP export rates with the HORB in place on the survival of juvenile Chinook salmon emigrating from San Joaquin River tributaries. This section describes the methods used in conducting the VAMP 2002 Chinook salmon smolt survival investigations, and presents results of the calculated survival indices and absolute survival estimates for juvenile Chinook salmon during the VAMP 2002 test period. Additional data and information related to the salmon survival investigations are presented in Appendix C.

CODED-WIRE TAGGING

Merced River Hatchery Chinook salmon smolts, released as part of VAMP 2002, were coded-wire tagged (CWT) between March and early April. After the salmon were tagged, they were held in the hatchery for up to 21 days before being released. A sub-sample of the salmon were measured for length and checked for retention of the CWTs a day or two prior to release. The sub-sample was typically comprised of 100 to 300 salmon collected from the top, middle, and bottom of the release group's raceway. Each tag code within a release group was held separately at the hatchery with the exception of the two Durham Ferry releases where each release was made up of four tag codes that were held together in one section of the raceway.

Although tag retention is usually quite high, as a double check on the tag detector, all salmon from the sub-sample that had no tag detected were sacrificed. These sacrificed salmon were dissected to determine whether they contained an un-magnetized tag. A separate sub-sample of 25 salmon was sacrificed from each release group; the tags were removed and read to detect any incorrect tag codes in the raceways. Table 5-1 summarizes results of the CWT retention rate and the estimate of the effective numbers of salmon released to calculate survival indices. Tag retention rates were determined to be similar to last year, with an overall loss rate of 9.5% among all VAMP groups. The tag retention loss rates varied from 0.5% to 15%. It is recommended that this loss rate be reduced for future VAMP studies.

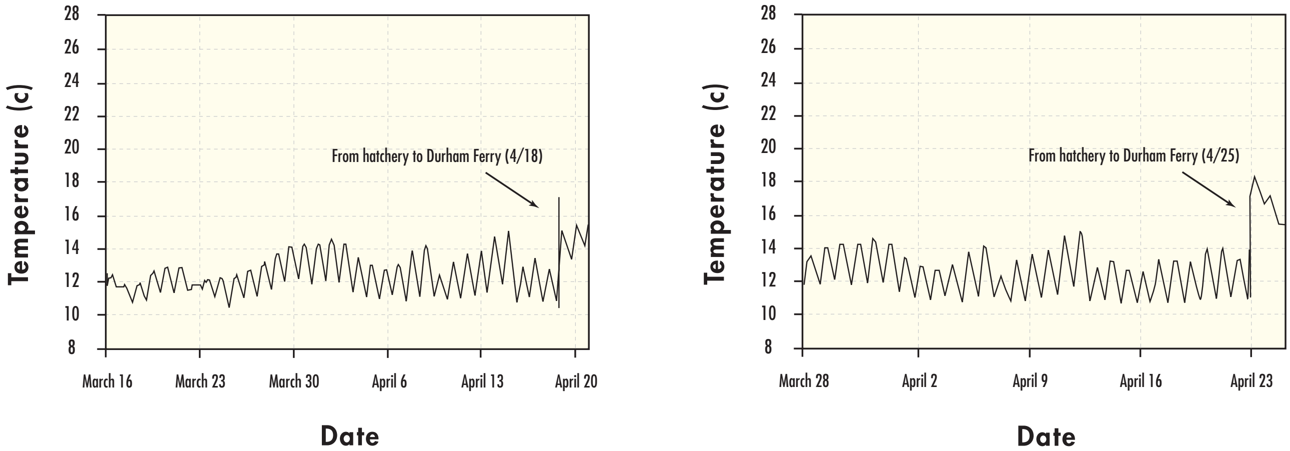
TABLE 5–1

Coded Wire Tag Retention Rates and Effective Release Numbers for Juvenile Salmon Released for VAMP 2002.

RELEASE DATE	TAG CODE	RELEASE SITE	AVERAGE FL(mm)	NUMBER TAGGED	TOTAL LOSS	TAG RETENTION	NUMBER RELEASED	EFFECTIVE RELEASE
April 18	06-44-71	Durham Ferry	83	25,251	123	95.19%	25,128	23,919
April 18	06-44-72	Durham Ferry	83	26,576	129	95.19%	26,447	25,175
April 18	06-44-73	Durham Ferry	83	25,201	123	95.19%	25,078	23,872
April 18	06-44-74	Durham Ferry	83	26,124	127	95.19%	25,997	24,747
April 19	06-44-57	Mossdale	84	25,864	227	99.52%	25,637	25,514
April 19	06-44-58	Mossdale	82	26,301	251	97.01%	26,050	25,271
April 22	06-44-59	Jersey Point	85	25,793	262	97.14%	25,531	24,801
April 22	06-44-60	Jersey Point	83	25,339	269	96.24%	25,070	24,127
April 25	06-44-70	Durham Ferry	80	25,969	138	95.54%	25,831	24,679
April 25	06-44-75	Durham Ferry	80	25,947	138	95.54%	25,809	24,658
April 25	06-44-76	Durham Ferry	80	26,078	139	95.54%	25,939	24,782
April 25	06-44-77	Durham Ferry	80	25,654	136	95.54%	25,518	24,380
April 26	06-44-78	Mossdale	79	26,357	281	94.03%	26,076	24,519
April 26	06-44-79	Mossdale	81	25,977	261	96.52%	25,716	24,821
April 30	06-44-80	Jersey Point	82	25,328	295	96.00%	25,033	24,032
April 30	06-44-81	Jersey Point	82	25,483	289	90.82%	25,194	22,881

FIGURE 5–1

Results of Water Temperature Monitoring at the Merced River Fish Hatchery.



CWT RELEASES

Two sets of CWT salmon releases were made as part of the 2002 VAMP experiment. The first set occurred at 1215 hours on April 18 at Durham Ferry, at 1535 hours on April 19 at Mossdale and at 1010 hours on April 22 at Jersey Point. The second set of releases was made at Durham Ferry at 1050 hours on April 25, Mossdale at 1620 hours on April 26, and Jersey Point at 1535 hours on April 30.

Approximately 100,000 salmon, in four distinct tag lots of about 25,000 fish, were released at Durham Ferry, while approximately 50,000 fish, in two tag lots, were used at each Mossdale and Jersey Point release (Table 5-1). Prior to VAMP 2000, each release was made such that all tag lots were trucked from the hatchery mixed and released as a single group. However, during VAMP 2000, 2001 and 2002, a new transport trailer with three tanks allowed each separate CWT lot to be transported to its release site in a separate tank and distinctly released. As mentioned earlier, the four tag lots comprising each of the groups released at Durham Ferry were already mixed at the hatchery and were therefore transported in a large single tank release truck. This year both Durham Ferry releases were made from the more desirable location alongside the river, instead of from the top of the levee. The nearby agricultural diversion was turned off from the time of the releases until several hours after the release to allow the tagged salmon time to disperse from the release site.

Releases at Jersey Point were made at the beginning of the flood tide to increase dispersion of the tagged fish before they passed Antioch and Chipps Island. Releases at Mossdale and Durham Ferry were not made on any specific tidal condition.

The water temperature both in the hatchery truck and in the receiving waters was measured at the release site immediately prior to release. These, as well as additional release and recovery data, are provided in Table 5-2.

WATER TEMPERATURE MONITORING

Water temperature was monitored during the VAMP 2002 study using individual computerized temperature recorders (e.g., Onset Stowaway Temperature Monitoring/Data Loggers). The water temperature was 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). Water temperature was recorded at 24-minute intervals throughout the period of the VAMP 2002 investigations. Water temperature was also recorded within the hatchery raceways at the Merced River Hatchery coincident with the period when juvenile Chinook salmon were being tagged.

Results of water temperature monitoring within the Merced River Hatchery showed that juvenile Chinook salmon were reared in and acclimated to water temperatures of approximately 11-14 C (52- 57F) prior to release into the lower San Joaquin River Figure 5-1. Results of water temperature monitoring at Durham Ferry, Mossdale, and Jersey Point following the first and second sets of VAMP 2002 releases are compared in Figures 5-2, 5-3, and 5-4. Results of water temperature monitoring showed that water temperatures at the release locations and throughout the lower San Joaquin River and delta (Appendix C-2) were higher than those at the hatchery. Water temperatures measured within the lower San Joaquin River and delta were not expected to result in mortality or adverse effects to emigrating juvenile Chinook salmon released as part of the VAMP 2002 investigations.

TABLE 5–2

Release and Recovery Information for Coded Wire Tag Groups Released for VAMP 2002.

TAG CODE	RELEASE SITE	DATE	TRUCK TEMP F°	RIVER TEMP F°	NUMBER RELEASED	AVG. SIZE (mm)	NUMBER RECOVERED AT ANTIOCH	PERCENT SAMPLED AT ANTIOCH	SURVIVAL INDEX AT ANTIOCH	GROUP INDEX AT ANTIOCH
06-44-71	Durham Ferry		54.5	59	23,919	83	11	0.391	0.085	
06-44-72	Durham Ferry		54.5	59	25,175	83	20	0.391	0.146	
06-44-73	Durham Ferry		54.5	59	23,872	83	12	0.391	0.093	
06-44-74	Durham Ferry		54.5	59	24,747	83	20	0.391	0.149	
Total		April 18			97,713		63	0.391		0.119
06-44-57	Mossdale		55.4	57.2	25,514	84	13	0.388	0.095	
06-44-58	Mossdale		55.4	51.8	25,271	82	29	0.388	0.213	
Total		April 19			50,785		42	0.388		0.153
06-44-59	Jersey Point		59	64.4	24,801	85	101	0.387	0.758	
06-44-60	Jersey Point		59	64.4	24,127	83	89	0.386	0.688	
Total		April 22			48,928		190	0.386		0.724
06-44-70	Durham Ferry		60.8	62.6	24,679	80	6	0.399	0.044	
06-44-75	Durham Ferry		60.8	62.6	24,658	80	2	0.384	0.015	
06-44-76	Durham Ferry		60.8	62.6	24,782	80	4	0.382	0.030	
06-44-77	Durham Ferry		60.8	62.6	24,380	80	6	0.392	0.045	
Total		April 25			98,499		18	0.398		0.033
06-44-78	Mossdale		55.4	63.5	24,519	79	3	0.399	0.022	
06-44-79	Mossdale		55.4	63.5	24,821	81	4	0.400	0.029	
Total		April 26			49,340		7	0.400		0.026
06-44-80	Jersey Point		52.7	63.5	24,032	82	43	0.399	0.323	
06-44-81	Jersey Point		52.7	63.5	22,881	82	32	0.398	0.253	
Total		April 30			46,913		75	0.398		0.289

FIGURE 5–2

Water Temperature Monitoring Results at Durham Ferry.

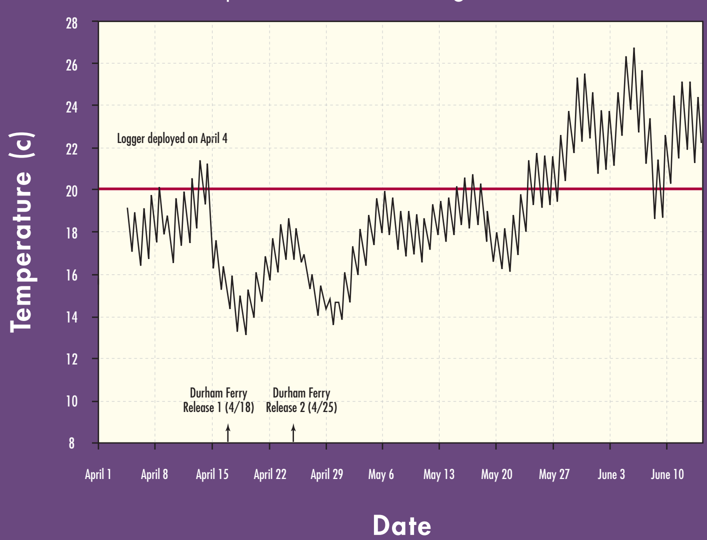
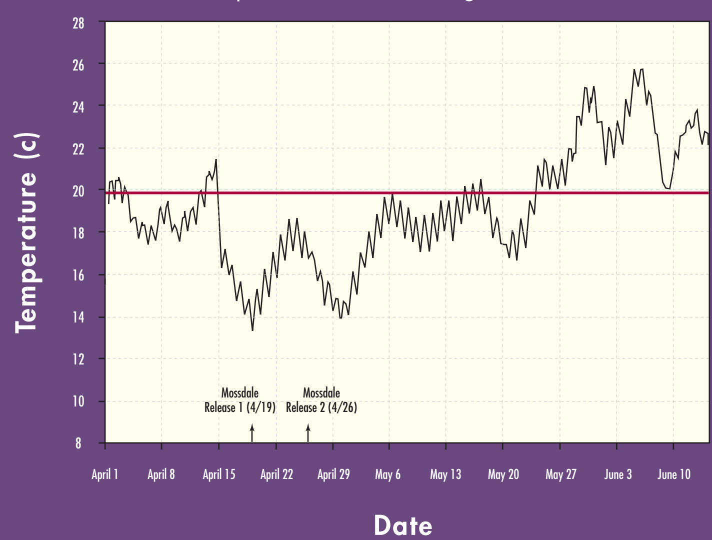


FIGURE 5–3

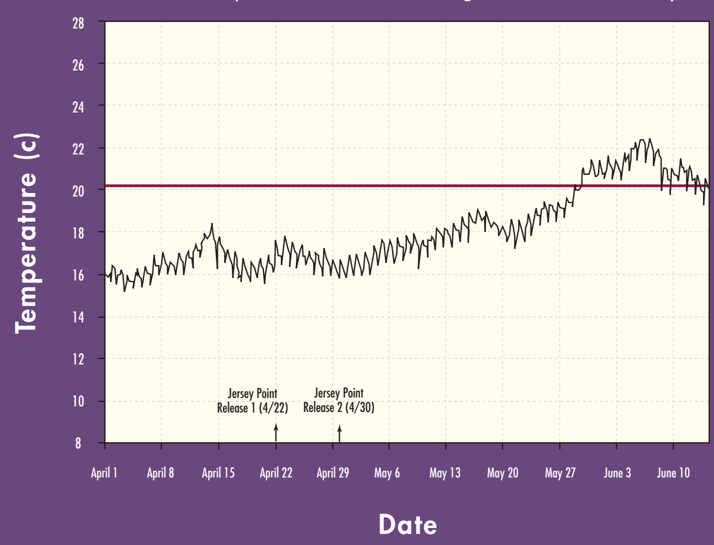
Water Temperature Monitoring Results at Mossdale.



NUMBER RECOVERED AT CHIPPS	PERCENT SAMPLED AT CHIPPS	SURVIVAL INDEX AT CHIPPS	GROUP INDEX AT CHIPPS	EXPANDED SALVAGE CVP	EXPANDED SALVAGE SWP	ABSOLUTE SURVIVAL ANTIOCH	ABSOLUTE SURVIVAL CHIPPS ISLAND	ABSOLUTE DF-MD SURVIVAL ANTIOCH	ABSOLUTE DF-MD SURVIVAL CHIPPS
4	0.277	0.078		12	12				
9	0.264	0.176		60	36				
4	0.273	0.080		0	27				
4	0.278	0.076		24	36				
21	0.265		0.105			0.16	0.13	0.77	0.86
6	0.272	0.112		24	90				
7	0.273	0.132		72	48				
13	0.273		0.122			0.21	0.15		
46	0.273	0.882		0	12				
37	0.266	0.132		24	12				
83	0.266		0.830						
3	0.273	0.058		36	6				
5	0.259	0.102		0	24				
3	0.275	0.057		24	25				
4	0.266	0.080		24	36				
15	0.257		0.077			0.11	0.16	1.2	1.5
2	0.273	0.039		12	93				
3	0.260	0.060		0	24				
5	0.260		0.051			0.09	0.11		
18	0.265	0.367		0	0				
28	0.270	0.589		0	0				
46	0.265		0.480						

FIGURE 5–4

Water Temperature Monitoring Results at Jersey Point.



POST-RELEASE-LIVE-CAR STUDIES

Survival and Condition

The post-release survival and condition of marked salmon was evaluated as part of the VAMP program using sub-samples of marked salmon from each release group. Approximately 200 salmon from each tag code were held at the respective release site in net pens for 48 hours after release and were evaluated for overall short-term mortality which might be associated with the handling, transport and release process. In addition to the 200 salmon held for 48 hours, 25 salmon from each tag code were evaluated for condition immediately after release. Another 25 salmon were held and evaluated using the same condition parameters after the 48-hour holding period. The remaining salmon were measured, weighed and sacrificed for further coded wire tag verification if necessary. Due to the mixed tag codes in the Durham Ferry releases two net pens with approximately 200 fish each were held in order to maintain consistency with the other net pen studies. To assess overall condition, fork length in millimeters, weight in grams, and six other characteristics as described in Table 5-3 were examined. Obvious abnormalities or deformities were also noted.

Results of the evaluations of marked fish in the net pens, both immediately after release and 48 hours later, showed few abnormalities in the condition assessed characteristics, and are shown in Appendix C-3. Scale loss ranged from 1-40% and averaged 5.7%. All fish examined were noted to have normal coloration, no fin hemorrhaging, normal eye characteristics and normal gill color. Of the 1,433 salmon assessed, four (0.3%) were found to have a poor or incomplete fin clip. A total of three fish had some type of deformity, two of which had eroded pectoral fins (not uncommon for hatchery raised fish) and one that had a partial operculum. The percentage of salmon deformed within the sample group (0.2%) was within the normal range for hatchery-raised fish.

Out of 2301 fish examined as part of this year' VAMP net pen experiments, no mortalities were observed.

Tag Quality Control

The subset of 25 salmon from each tag group (a total of 25 from each of the Durham Ferry net pens) evaluated for condition as described above were sacrificed to verify purity of tag codes. The additional 200+ fish from each release that were held were archived in a freezer. Though rare, on few occasions in the past, salmon from different release groups have been mixed at some point prior to release. While performing quality control checks on the April 18 Durham Ferry releases, one errant tag code was discovered. A total of 201 tags were read to verify tag code purity. After reading all tags, it was determined that the apparent error was likely the result of tags being lost and found, and not reported as lost, in the lab. All remaining fish will be held for a period to allow tag processing for further evaluation if necessary.

Physiology

Physiological studies were conducted on samples of the juvenile salmon used in the VAMP study by the California-Nevada Fish Health Center (Nichols and Foot 2002). These results are summarized below.

Physiological tests were conducted on a subset of the smolts released at Durham Ferry, Mossdale and Jersey Point at the hatchery before transport to the release site and after they had been

TABLE 5–3
Smolt Condition Characteristics

	NORMAL	ABNORMAL
Eyes	Normally shaped	Bulging
Color	High contrast dark dorsal surface and light sides	Low contrast dorsal surface and sides, coppery color
Fin Hemorrhaging	No blood or red at base of fins	Blood at base of fins
Percent Scale Loss	Lower relative numbers better based on 0-100% scale loss	Higher relative numbers worse based on 0-100% scale loss
Gill Color	Dark beet red to cherry red gill filaments	Light red to gray gill filaments
Vigor	Active swimming (prior to anesthesia)	Lethargic or motionless (prior to anesthesia)

held in the live cars for approximately 24 hours. At the hatchery, 144 fish were examined for virus, systemic bacteria, gill ATPase activity, blood hematocrit value, plasma total protein concentration, plasma chloride concentration, external and internal signs of disease, and other abnormalities. From live cars, a total of 216 fish were assessed for gill ATPase activity, plasma total protein concentration, plasma chloride concentration, internal and external abnormalities, and *Tetracapsula bryosalmonae* (*Tb*) prevalence of infection. No bacterial or viral pathogens were detected in any of the fish examined. Overall 93 of 201 (46%) of fish examined were infected with the kidney parasite *Tb*, the myxosporean causing Proliferative Kidney Disease (PKD). Infection rates ranged from 29% to 70% among individual release groups with 99% of infected fish in the early stage of PKD (Clifton-Hadley et. al. 1987). This stage was characterized by the initial invasion of the kidney blood sinuses by the parasite and minor inflammatory changes. No evidence of anemia was seen in the blood hematocrit values from any of the live car groups but the disease may progress even after the fish enter salt water (Hedrick and Aronstien 1987) and PKD related anemia could arise weeks after release.

Gill Na+/K+-ATPase activity levels were similar among and between hatchery and live car groups. There was no significant change in the 1-6 days between hatchery and 24-hour post-release samples. All sample groups demonstrated elevated gill ATPase activity consistent with salmon in an advanced stage of smoltification.

Plasma total protein concentrations of some individual fish were slightly elevated, although no protein values were outside of normal ranges for juvenile Chinook. Elevated plasma protein values would not necessarily indicate reduced survival for the affected fish. Possible reasons for this site effect include variations in time since last feeding (mild starvation), differences in transport, or site-specific water quality.

Results of the evaluations of marked fish in the net pens, both immediately after release and 48 hours later, showed ***FEW*** *abnormalities in the condition assessed characteristics.*

Plasma chloride values further supported the "stress event" observed in the hatchery total protein values. All live car groups had depressed plasma chloride values relative to baseline hatchery values (p<0.001, t-test) indicating they were under stress probably due to sampling. Hatchery fish were dip-netted directly from the raceway and quickly euthanized, while capture from the live car took longer. Even with this added stress of sampling, plasma chloride values of live car groups remained within the normal range for juvenile salmonids.

In summary, all 6 release groups were in good health and at a similar state of smolt development when sampled at the hatchery and 24-hours post-release. No biologically significant differences were observed in pathogen infections, gill Na+/K+-ATPase activities, or blood chemistry values. Early infections of *Tb* were common, with clinical signs of Proliferative Kidney Disease (PKD) in only 1% of fish examined. Short-term survival of all groups was not likely to be impacted by their health. Health problems resulting from PKD (e.g. anemia) could have arisen several weeks post-release but are not discussed in this part of the report.

CWT RECOVERY EFFORTS

CWT salmon were recaptured at Antioch and Chipps Island, at CVP and SWP fish salvage facilities and during sampling at upper Old River near the barrier (See Figure 1-1) CWT salmon released upstream of, and at, Mossdale were also recovered in DFG Kodiak trawls at Mossdale but are not discussed in this part of the report. Juvenile Chinook salmon with an adipose fin clip (which identifies CWT salmon) caught at any of these sampling locations were sacrificed, labeled, and frozen pending CWT processing. Coded-wire tag processing was done by USFWS (Stockton) for fish recovered at Chipps Island, Antioch, and SWP/CVP salvage facilities. DFG Bay Delta Branch and Region IV assisted in processing the fish captured at the HORB fyke nets.

Coded wire tag processing entails dissecting each tagged fish to obtain the half (0.5 millimeter) or full (1 millimeter) cylindrical tag from the snout. Tags are then placed under a dissecting microscope and the numbers are read and recorded in a database. Tags were read twice, with any discrepancies resolved by a third reader. All tags are archived for future reference. It should be noted that many tags recovered at Chipps Island, Antioch, SWP/CVP salvage, and other locations are from coded wire tag releases not affiliated with VAMP. Since it is unknown until after reading the tag, which tags are from the VAMP study, all tags recovered are read.

SWP/CVP Salvage Recapture Sampling

Sampling at the CVP and SWP fish salvage facilities was conducted approximately every two hours. The number of marked salmon collected (raw salvage) was “expanded” based on the number of minutes sampled during each two hour time period. The estimated expanded total number of CWT salmon, from each release group, was obtained by adding together the expanded number of each tag group for all time periods. Only the CWT salmon recovered in the raw salvage collections were sacrificed for tag decoding. Expanded salvage is only a portion of the direct loss experienced by juvenile salmon at the facilities as it does not include losses prior to, and associated with, pre-screen predation, screening, handling and trucking.

Expanded CVP and SWP salvage estimates of marked salmon released as part of the VAMP 2002 studies are shown in Table 5-2. Salvage numbers at both the CVP and SWP were higher in 2002 than in 2001 but continued to be lower than salvage numbers in years without the HORB installed. It is likely that the smolts migrated to the CVP and SWP via Turner or Columbia Cuts, river junctions off the San Joaquin River downstream of the head of Old River.

Antioch Recapture Sampling

Fishery sampling was conducted in the vicinity of Antioch on the lower San Joaquin River using a Kodiak trawl. The Kodiak trawl has a graded stretch mesh, from 2-inch mesh at the mouth to 1/2-inch mesh at the cod-end. Its overall length is 65 feet, and the mouth opening is six feet deep and 25 feet wide. The net was towed between two skiffs, sampling in an upstream direction. Trawls were performed parallel to the left bank, mid-channel, and right bank to sample CWT salmon emigrating from the San Joaquin River. Each sample was approximately 20 minutes in duration.

All fish collected were transferred immediately from the Kodiak trawl to buckets filled with river water, where the fish were held during processing. Data collected during each trawl included fish identification, measuring the fork length of fish collected, tow start time, duration and location in the channel. Mortality and damage to fish collected was documented to comply with the Endangered Species Act permit requirements.

Juvenile Chinook salmon with an adipose fin clip were retained for later CWT processing while unmarked salmon, steelhead, delta smelt, splittail, and other fish were released at a location downstream of the sampling site immediately after identification, enumeration and measurement.

Sampling at Antioch was initiated April 4 and continued through May 15. Each day between 5:00 a.m. and 9:00 p.m., anywhere from 8 to 31, 20-minute tows were conducted. All told, 1,088 Kodiak trawl samples were collected, representing a total sampling duration of 21,582 minutes. During the sampling, a total of 6,134 unmarked juvenile Chinook salmon and 1,822 salmon with an adipose fin clip (CWT) were collected. In addition, 963 Delta smelt, 195 splittail, and 50 unmarked steelhead, and 52 adipose-clipped steelhead were caught in the sampling.

Chipps Island Recapture Sampling

As part of VAMP recovery efforts at Chipps Island, trawling shifts were conducted twice daily between April 4 and May 28, once daily from May 29 to June 8, and once daily Monday through Friday from June 9 through the end of the month. The first shift was begun just before dawn, while the second shift ended at or after sunset in order to incorporate the crepuscular periods of Chinook movement. It is hypothesized, based on an analysis of salmon smolts caught during twenty-four hour sampling at Jersey Point in 1997, that a greater number of salmon would be caught around dawn and dusk. Both targeting this crepuscular period and doubling the total trawl effort at Chipps Island were intended to increase the numbers of CWT salmon recaptured and reduce the variability in VAMP survival indices. This second shift has been conducted during the spring releases since 1998.

The trawl at Chipps Island was towed at the surface using a net with a mouth opening 10 feet deep by 30 feet wide, with a total net length of 82 feet. Aluminum hydrofoils were used on the top bridles and steel depressors along with a weighted lead line were used on the bottom bridles to keep the mouth of the net open. The net was variable mesh net starting with 4-inch mesh at the mouth and ending with a 1/4 inch cod end.


CALIFORNIA

To sample across the channel, trawling at Chipps Island was conducted in three distinct lanes, one each in the north, south and middle of the channel. Each lane was generally sampled at least three times per shift, with one lane sampled a fourth time during each shift. This lane was chosen at random or selected by the boat operator based on flow conditions.

Coded wire tagged salmon released as part of the VAMP program were recovered at Chipps Island between April 24 and May 19. A total of 182 VAMP CWT salmon were recovered at Chipps Island. During the April 24 and May 19 VAMP recovery period, a total of 6,463 unmarked salmon, 1164 CWT salmon from other non-VAMP experiments, 165 delta smelt, 360 Sacramento splittail, 15 clipped steelhead, and 15 non-clipped steelhead, were also collected at Chipps Island.

Although the survival indices indicated that the first groups released survived at a higher rate than the second group, comparisons using the absolute estimates of survival moderated this ***DIFFERENCE****.*

VAMP CHINOOK SALMON CWT SURVIVAL INDICES

Survival indices were calculated for marked salmon released at Durham Ferry, Mossdale, and Jersey Point and recovered at Antioch and Chipps Island. Survival indices were calculated by dividing the number of CWT salmon recovered (R) by the effective number released (E) and multiplying the fraction of time (T) and channel width (W) sampled as shown by the formula (R/E)*T*W. The fraction of the channel width sampled at Chipps Island (0.00769) was the net width (30 feet) divided by an estimate of the channel width (3,900 feet). The fraction of the channel width sampled at Antioch (0.01388) was also based on the net width (25 feet) and an estimate of the channel width (1,800 feet). The fraction of time sampled, at both locations, was calculated based on the number of minutes sampled, between the first and last day of catching each particular tag code or group, divided by the total number of minutes in the time period. The percent of time sampled for the VAMP 2002 release groups at Chipps Island was about 27 percent, while at Antioch it averaged 39 percent.

Survival indices were calculated for each separate tag code to provide a sense of the variability associated with the overall group survival index. To generate the group survival index, the recovery numbers and release numbers are combined for the tag codes within a release group. This results in a slightly different index than would be generated by taking the mean of the survival indices of the individual tag codes within a group.

The individual and group survival indices to Antioch and Chipps Island of the CWT salmon released as part of VAMP 2002 are shown in Table 5-2. As in past years, survival indices from the release locations to Antioch were sometimes lower than to Chipps Island. It is expected that indices to Antioch would be greater than to Chipps Island since Antioch is closer to the release locations and the percent of time sampled is greater and the channel width is narrower at Antioch. It may be the inherent variability associated with catching the marked fish that sometimes causes more to be caught at Chipps Island.

The first and second Durham Ferry releases had survival indices to Antioch of 0.12 and 0.03, respectively. Survival indices to Chipps Island were 0.11 for the first group and 0.08 for the second. While differences between the two groups at Chipps Island did not appear meaningful, those at Antioch did. The individual tag code survival indices at Antioch for the two groups did not overlap and thus there appeared to be a difference in survival between the first and second Durham Ferry groups.

The two Mossdale releases showed similar differences between the first and second releases. The first and second releases had survival indices to Antioch of 0.15 and 0.03 and 0.12 and 0.05 to

Chipps Island, respectively. Again none of the individual tag code survival indices overlapped between groups indicating a real difference between the two groups at both recovery locations.

Similarly, the two Jersey Point groups also appeared to survive at different rates; with the first group surviving at a higher rate than the second. The first group released on April 22 had a survival index to Antioch of 0.72. The second group released on April 30 had an index to Antioch of 0.29. Chipps Island recoveries demonstrated the same apparent difference between groups with the first group having an index of 0.83 and the second group having an index of 0.48.

Why survival was lower for the second groups (releases at Durham Ferry, Mossdale, and Jersey Point), relative to the first groups is unknown. Flow and export conditions were similar for both sets of releases. Water temperatures increased for the releases in the second group, but increases were small and all temperatures at release were below 65 degrees (Table 5-3).

ABSOLUTE CHINOOK SALMON SURVIVAL ESTIMATES AND DIFFERENTIAL COMBINED RECOVERY RATES

More important than the differences in survival indices between sets of releases is the comparison of absolute survival estimates, where the survival indices of the upstream release groups are divided by the survival indices of the downstream groups (recovered at the same location). It is most useful for comparisons between groups, recovery locations and years.

In 2002, we have also used the differential combined recovery rates as an estimate of survival. The combined recovery rate for each release group was obtained by summing the recoveries from Antioch and Chipps Island and dividing by the number released. The differential combined recovery rate was the combined recovery rate of an upstream group relative to the downstream group and is another way to estimate survival between release locations. The differential recovery rate is similar to calculating absolute survival estimates, but does not expand each estimate by the fraction of the time and space sampled. The differential recovery rates and the absolute survival estimates should be similar as 1) the fraction of the time sampled is similar between groups within a recovery location and 2) the fraction of space sampled at each recovery location is a constant. Neither would change the relative differences between groups. However, combining the recovery numbers from Antioch and Chipps Island may result in differences using the two methods in estimating survival.

Variance and standard errors were also calculated for the differential combined recovery rates based on the Delta method provided by Dr. Ken Newman (pers. comm). The differential recovery rates plus or minus two standard errors are roughly equivalent to the 95% confidence intervals. Plus or minus one standard error equates to roughly the 68% confidence intervals. (Ken Newman, personal communication). It is not clear how similar variances, standard errors or confidence intervals could be generated using the absolute survival estimates.

In comparing survival between reaches and replicates the confidence intervals were used to determine if estimates were significantly different. If the 95% confidence intervals overlapped they were not considered statistically different. Differences observed using the lower level of confidence 68% are noted.

The use of absolute survival estimates and differential combined recovery rates are more powerful for use in comparing survival rates, since the use of ratios between upstream and downstream groups theoretically standardizes for differences in catch efficiency between recovery locations and/or years. Both types of estimates of survival have been calculated for VAMP 2002. An additional estimate of absolute survival will be possible from recoveries in the ocean fishery, 2 to 4 years following release.

Although the survival indices indicated that the first groups released survived at a higher rate than the second group, comparisons using the absolute estimates of survival moderated this difference (Table 5-2). Absolute survival between Durham Ferry and Mossdale and Jersey Point was still somewhat higher for the first releases using the Antioch recovery information. Absolute survival for the two sets of releases was similar using the Chipps Island recovery information, but it is uncertain if these differences are significant.

Results using the differential combined recovery rates also indicated the first groups appeared to survive at a higher rate than the second groups, with the first Durham Ferry and Mossdale groups relative to Jersey Point being higher than the second groups (Table 5-4). Estimates of 95% confidence intervals (plus and minus 2 standard errors) indicated differences were not significant at the $p<0.05$ level. The first Mossdale to Jersey Point estimate was greater than the second using the lower level of confidence (68%) (Table 5-4 and Figure 5-5).

One surprise was that the second group released at Durham Ferry appeared to survive at a higher rate than the second group released at Mossdale. This result was shown using both absolute

TABLE 5–4

2002 Smolt Survival Differential Recovery Rates

	REC. AT ANTIOCH	REC. AT CL	# RELEASED	A+C	A+C/R	S DF TO MD	S MD TO JP	S DF TO JP	S DF/MD-JP
Durham Ferry (DF) 1	11	4	23,920	15	0.00062				
	20	9	25,176	29	0.00115				
	12	4	23,872	16	0.00067				
	20	4	24,747	24	0.00096				
Total	63	21	97,715	84	0.00085	0.793			
Mossdale (MD) 1	13	6	25,515	19	0.00074			0.154	
	29	7	25,272	36	0.00142				
Total	42	13	50,787	55	0.00108		0.194		
Jersey Point (JP) 1	101	46	24,802	147	0.00592				
	89	37	24,128	126	0.00522				
Total	190	83	48,930	273	0.00557				
Durham Ferry (DF) 2	6	3	24,680	9	0.00036				
	2	5	24,659	7	0.00028				
	4	3	24,783	7	0.00028				
	6	4	24,381	10	0.00041				
Total	18	15	98,503	33	0.00033	1.377			
Mossdale (MD) 2	3	2	24,519	5	0.00020			0.129	
	4	3	24,820	7	0.00028				
Total	7	5	9,339	12	0.00024		0.094		
Jersey Point (JP) 2	43	18	24,032	61	0.00253				
	32	28	22,880	60	0.00262				
Total	75	46	46,912	121	0.00257				
Combined									
DF (1&2)	81	36	196,218	117	0.00059	0.891			
MD (1&2)	49	18	100,126	67	0.00066		0.162		
JP (1&2)	265	129	95,842	394	0.00411			0.145	
DF/MD (1&2)	130	54	296,344	184	0.00062				0.151

S – Differential Recovery Rate • 1SE – One Standard Error • 2SE – Two Standard Errors

S-2SE	S+2SE	S-1SE	S+1SE
0.518	1.069	0.656	0.931
0.115	0.192	0.134	0.173
0.136	0.251	0.165	0.222
0.448	2.305	0.913	1.841
0.078	0.180	0.104	0.155
0.037	0.151	0.065	0.122
0.618	1.164	0.754	1.027
0.119	0.205	0.141	0.184
0.114	0.175	0.129	0.160
0.124	0.177	0.137	0.164

survival estimates and differential combined recovery rates of the Durham Ferry/Jersey Point groups relative to the Mossdale/Jersey Point groups (Tables 5-2 and 5-4). However, the difference in recovery rates was not significant at either the 68 percent or 95 percent confidence level. Durham Ferry is 11 miles further upstream than Mossdale and is expected to include additional mortality.

Both differential recovery rate estimates of survival between Durham Ferry and Mossdale were not significantly different from each other using either confidence levels (Table 5-4). Thus the differential recovery rates of the two groups were combined and survival between Durham Ferry and Mossdale was estimated at 0.89. These data appear to show that there is substantial variability within recovery rate estimates and that survival was relatively high between the two locations.

In 2000 it did appear that survival was less for groups released at Durham Ferry relative to those released at Mossdale using the absolute survival estimates generated from information at Antioch. This difference led to the recommendation of making releases at both Durham Ferry and Mossdale in future years. When looking at the 2000 data using combined differential recovery rates, the variability was such it was not clear that survival was greater for the Mossdale group. The recovery rate of the first Mossdale group relative to the first Jersey Point group was not significantly different (at the $p<0.05$ level) from the first Durham Ferry group relative to the first Jersey Point group. The same was true for the second set of releases. The first Mossdale/Jersey recovery rate was significantly greater than the second Durham Ferry/Jersey Point group at both levels of significance (Figure 5-6).

In 2001 and 2002 differential recovery rates indicated that survival between Durham Ferry and Jersey Point and Mossdale and Jersey Point was not statistically different ($p<0.05$), thus we can infer survival between Durham Ferry and Mossdale was high in these years. Surprisingly, the survival was higher in 2001 for the first Durham Ferry group relative to the Jersey Point group than the first Mossdale group relative to the Jersey Point group using the lower level of significance (Figure 5-7). It is uncertain how the Durham Ferry groups could survive at a higher rate than the Mossdale groups, but it probably is possible. Continuation of releasing groups at both sites, will allow detection of mortality between Durham Ferry and Mossdale if it does occur and become significant in the future. If survival between locations is shown not to be statistically significant then groups can be combined.

FIGURE 5–5

Differential Recovery Rates of CWT Smolts Released at Mossdale and Jersey Point (MD-JP) and Durham Ferry and Jersey Point (DF-JP) for the First (1) and Second (2) Groups in 2002. The Estimate and Plus and Minus 1 and 2 Standard Error(s) is Provided.

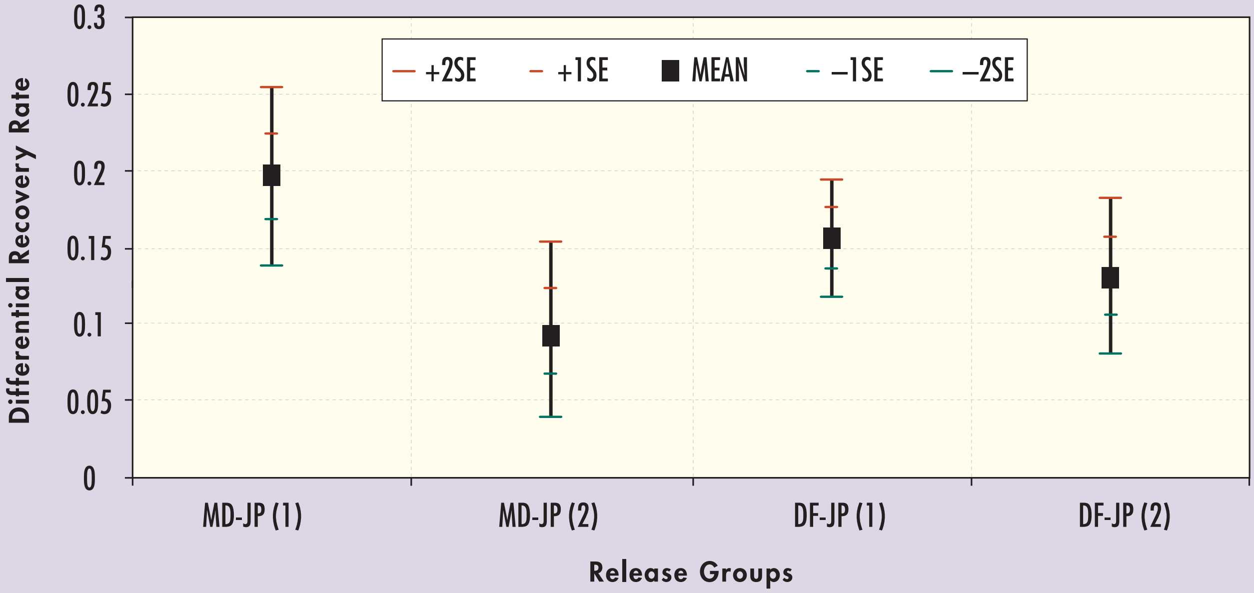
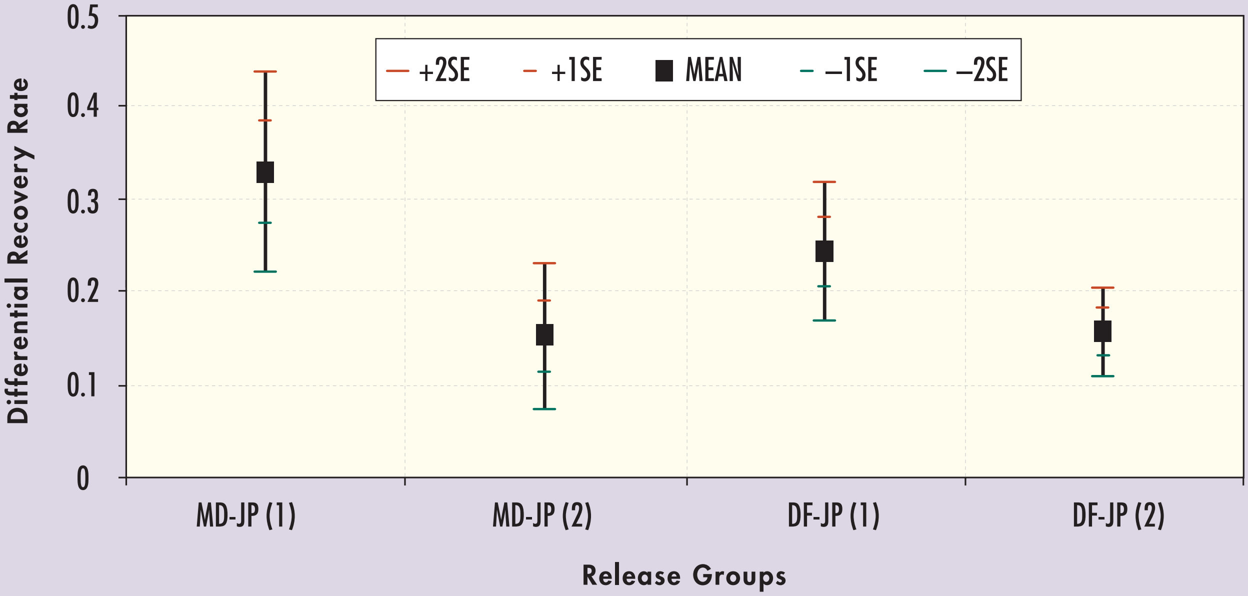


FIGURE 5–6

Differential Recovery Rates of CWT Smolts Released at Mossdale and Jersey Point (MD-JP) and Durham Ferry and Jersey Point (DF-JP) for the First (1) and Second (2) groups in 2000. The Estimate and Plus and Minus 1 and 2 Standard Error(s) is Provided.



In 2002, absolute survival for the Durham Ferry and Mossdale groups relative to the Jersey Point groups ranged between 0.09 and 0.21 and averaged 0.14. Differential recovery rates ranged between 0.09 and 0.19. As mentioned earlier, the combined recovery rates relative to the Jersey Point groups was not significantly different between the Durham Ferry and Mossdale groups using the 95% confidence levels. Thus it may be appropriate to combine these recovery rate estimates. Similarly, if replicates are not statistically different, they could be combined. The confidence intervals around each differential recovery rate provide a means to assess whether groups should be combined.

Differential recovery rates of the first and second Durham Ferry groups relative to the Jersey Point releases were not statistically different. Similarly, differential recovery rates for the first and second Mossdale groups relative to the Jersey Point groups were also not significantly different. (Note the two replicates from Mossdale to Jersey Point were significantly different using a 68% confidence interval.) In addition, the differential recovery rates of the Durham Ferry/Jersey Point estimates were not significantly different than the Mossdale/Jersey Point estimates, thus combined estimates were generated (Table 5-4). The combined Durham Ferry/Mossdale to Jersey Point estimate of survival using the combined differential recovery rates was 0.15 - not much different than the average absolute estimate of survival (0.14).

Similar estimates of differential recovery rates with the 95% confidence intervals were calculated for past VAMP years (2000 and 2001)(Tables 5-5 and 5-6). (Note there was an error in the 2001 Annual Report in reporting these estimates. - They have been recalculated and included in this report.) Differential recovery rate replicates in those years were also not significantly different from each other at the 95 percent confidence level. Thus they were combined into one estimate of recovery rate for the Durham Ferry/Mossdale groups relative to the Jersey Point groups. Some replicates were significantly different at a lower significance level (~68%). For instance, the Mossdale to Jersey Point and Durham Ferry to Jersey Point replicates in 2000 were significantly different at this lower level of significance. In addition, the combined Durham Ferry/Jersey Point estimates were significantly lower than the Mossdale/Jersey Point estimates in 2001 at this lower level of confidence

TRANSIT TIME

Data on transit times for marked salmon from the release to recapture sites during VAMP 2002 is summarized in graphic form in Appendix C-4. CWT salmon released April 18 at Durham Ferry took between 7 and 19 days to arrive at Antioch and 8 to 22 days to arrive at Chipps Island. The April 19th release at Mossdale release took between 6 and 11 days to arrive at Antioch and 7 and

FIGURE 5–7

Differential Recovery Rates of CWT smolts released at Mossdale and Jersey Point (MD-JP) and Durham Ferry and Jersey Point (DF-JP) for the first (1) and second (2) groups in 2001. The estimate and plus and minus 1 and 2 standard error(s) is provided.

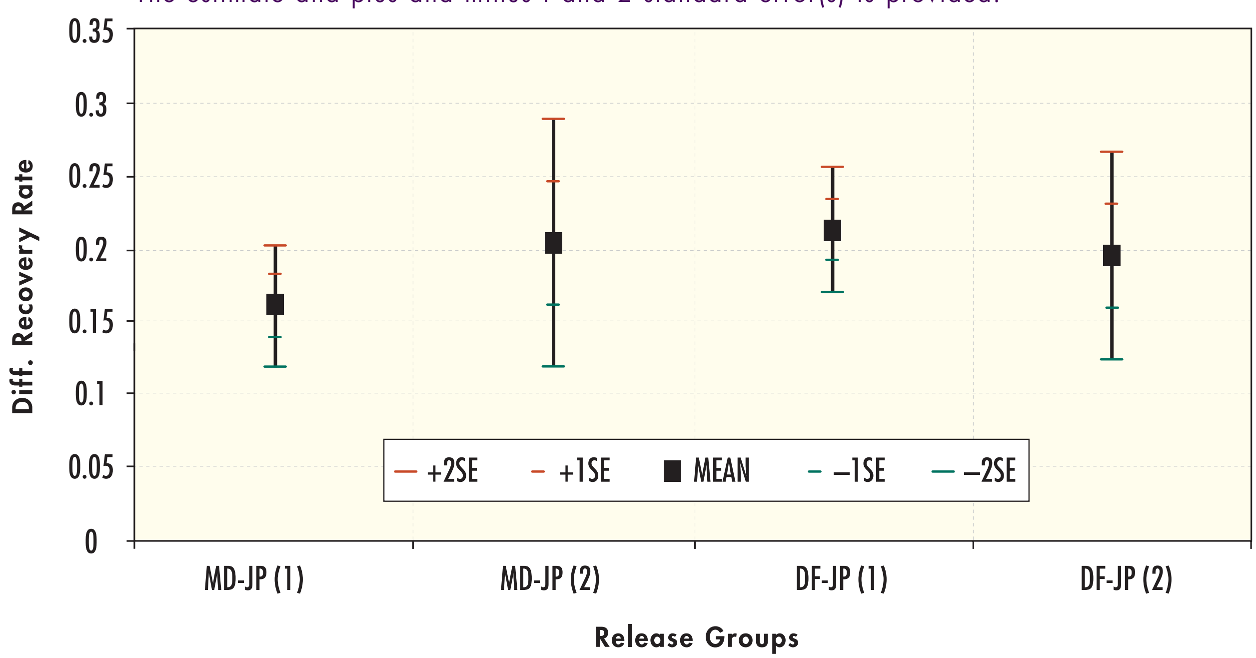


TABLE 5–5

2000 Smolt Survival Differential Recovery Rates

	REC. AT ANTIOCH	REC. AT CL	# RELEASED	A+C	A+C/R	S DF TO MD	S MD TO JP	S DF TO JP	S DF/MD-JP
Durham Ferry (DF) 1	6	7	23,629	13	0.00055				
	10	10	24,177	20	0.00082				
	11	11	24,457	22	0.00089				
Total	27	28	72,263	55	0.00076	0.733			
Mossdale (MD) 1	14	9	23,465	23	0.00098				
	16	9	22,784	25	0.00109				
Total	30	18	46,249	48	0.00103		0.328		
Jersey Point (JP) 1	50	24	25,527	74	0.00289				
	47	41	25,824	88	0.00340				
Total	97	65	51,351	162	0.00315			0.241	
Durham Ferry (DF) 2	8	7	23,698	15	0.00063				
	15	5	26,805	20	0.00074				
	8	10	23,889	18	0.00075				
Total	31	22	74,392	53	0.00071	1.036			
Mossdale (MD) 2	9	7	23,288	16	0.00068		0.150		
Jersey Point (JP) 2	76	48	25,572	124	0.00484				
	76	30	24,661	106	0.00429				
Total	152	78	50,233	230	0.00457			0.155	
Combined									
DF (1&2)	58	50	146,655	108	0.00073	1.066			
MD (1&2)	39	25	69,537	48	0.00069		0.178		
JP (1&2)	249	143	101,584	392	0.00385			0.190	
DF/MD (1&2)	97	75	216,192	156	0.00072				0.186

S – Differential Recovery Rate • 1SE – One Standard Error • 2SE – Two Standard Errors

S-2SE	S+2SE	S-1SE	S+1SE
0.443	1.022	0.588	0.878
0.220	0.437	0.274	0.383
0.166	0.316	0.203	0.278
0.445	1.628	0.741	1.332
0.072	0.227	0.111	0.188
0.108	0.202	0.131	0.179
0.814	1.319	0.940	1.193
0.114	0.243	0.146	0.211
0.149	0.232	0.170	0.211
0.149	0.224	0.168	0.205

17 days to reach Chipps Island. Jersey Point release groups were recovered between 2 and 14 days after release at Antioch and between 2 and 21 days at Chipps Island. The April 25 Durham Ferry release group arrived at Antioch between 7 and 18 days and between 7 and 15 days at Chipps Island. The April 26 release group at Mossdale was recovered at Antioch between 7 and 14 days and between 9 and 19 days at Chipps Island. The second Jersey Point release group was recovered between 1 and 14 days after release at Antioch and 1 and 19 days after release at Chipps Island. The transit time from release location to Antioch and Chipps Island of both sets of releases was similar. It is interesting that the Jersey Point groups were recovered over as long or longer period than those released upstream.

Transit times appeared slower in 2002, than in 2001. In 2001, recovery dates were as early as 4 days after releases were made at Durham Ferry and Mossdale. River flows were lower in 2002 than in 2001 (approximately 3,300 cfs versus 4,200 cfs, respectively), which may have increased travel time in 2002. The number of individual recoveries by tag code and the number of minutes towed per day for both Antioch and Chipps Island recoveries are shown in Appendix C-4.

ROLE OF FLOW AND EXPORTS ON ABSOLUTE SURVIVAL AND RECOVERY RATES

Historically, April–June, San Joaquin River flow and flow relative to exports was correlated to adult escapement in the San Joaquin basin 2 1/2 years later (Figures 5-8 and 5-9). Both relationships are statistically significant ($p<0.01$) with the flow/exports variable accounting for slightly more of the variability than the relationship with flow alone (r^2= 0.44 vs. r^2 = 0.58, respectively). These relationships appeared to indicate that adult escapement in the San Joaquin basin was affected by the amount of flow in the San Joaquin River and exports from the CVP and SWP during the spring months when the juveniles migrated through the river and Delta to the ocean. VAMP was designed to further define the mechanisms behind this relationship using smolt survival through the Delta and testing lower San Joaquin River flows with the presence of the HORB.

Survival of juvenile Chinook salmon emigrating from the San Joaquin River system has been evaluated within the framework established by the VAMP experimental design since the spring of 2000. Similar and complementary studies in the south delta were conducted prior to the official implementation of VAMP.

TABLE 5–6

2001 Smolt Survival Differential Recovery Rates

	REC. AT ANTIOCH	REC. AT CL	# RELEASED	A+C	A+C/R	S DF TO MD	S MD TO JP	S DF TO JP	S DF/MD-JP
Durham Ferry (DF) 1	28	14	23,354	42	0.00179				
	30	22	22,837	52	0.00227				
	18	17	22,491	35	0.00155				
Total	76	53	68,682	129	0.00187	1.325			
Mossdale (MD) 1	18	17	23,000	35	0.00152				
	15	14	22,177	29	0.00130				
Total	33	31	45,177	64	0.00141		0.159		
Jersey Point (JP) 1	156	50	24,443	206	0.00842				
	173	61	24,992	234	0.00936				
Total	329	111	49,435	440	0.00890			0.211	
Durham Ferry (DF) 2	8	2	24,025	10	0.00041				
	11	5	24,029	16	0.00066				
	10	2	24,177	12	0.00049				
Total	29	9	72,231	38	0.00052	0.958			
Mossdale (MD) 2	8	4	23,878	12	0.00050				
	11	4	25,308	15	0.00059				
Total	19	8	49,186	27	0.00054		0.201		
Jersey Point (JP) 2	43	17	25,909	60	0.00231				
	53	27	25,465	80	0.00314				
Total	96	44	51,374	140	0.00272			0.193	
Combined									
DF (1&2)	105	62	140,913	167	0.00118	1.228			
MD (1&2)	52	39	94,363	91	0.00096		0.167		
JP (1&2)	425	155	100,809	580	0.00575			0.205	
DF/MD (1&2)	157	101	235,276	258	0.00109				0.190

S – Differential Recovery Rate • 1SE – One Standard Error • 2SE – Two Standard Errors

S-2SE	S+2SE	S-1SE	S+1SE
0.920	1.730	1.123	1.528
0.116	0.201	0.137	0.180
0.168	0.253	0.189	0.232
0.476	1.440	0.717	1.199
0.116	0.286	0.159	0.243
0.122	0.263	0.157	0.228
0.908	1.549	1.068	1.388
0.129	0.205	0.148	0.186
0.169	0.242	0.187	0.224
0.162	0.219	0.176	0.204

The differential relative recovery rates of all releases each year were combined as they were not significantly different from each other at the 95 percent confidence level. These combined estimates and their 95 percent confidence intervals for the three years of VAMP releases (2000 - 2002) are shown in relation to the log of the average San Joaquin River flow at Vernalis on Figure 5-10. The average river flow was from the two-10 day periods after release. Data obtained in 1994 and 1997 are added but do not have comparable confidence intervals at this time. The relative recovery rates with the confidence intervals are also shown in comparison to average Vernalis flow/combined exports for the 10 days after release (Figure 5-11). The relationship of relative recovery rate to San Joaquin River flow is improved by incorporating exports. Relationships without the 1994 and 1997 are similar (Figures 5-10 and 5-11). While recovery rates do appear to increase as flows and flows relative to exports increase ($p<0.05$) data points that have confidence intervals around them are not significantly different from each other.

Given the relatively high variability inherent in conducting salmon smolt survival studies within the lower San Joaquin River and Delta, and modeling conducting by Ken Newman (November, 2001) the lack of statistically significant differences between relative recovery rates from similar flow-export conditions was not unexpected. Results of these analysis underscore the importance of collecting salmon smolt survival data under the most extreme flow-export conditions identified as VAMP targets. Flows of 7,000 cfs and exports of 1,500 cfs would provide the highest flow/export ratio (4.7) to test and increase our chances of detecting significant differences in recovery rates between VAMP targets.

THE ROLE OF HORB ON SURVIVAL

The relationship to date between absolute survival between Mossdale and Jersey Point and San Joaquin River flow at Vernalis and exports with and without the barrier in upper Old River is shown in Figure 5-12. Differential recovery rates are not reported since without barrier releases do not have comparable estimates. Replicates of survival estimates within a year measured with the HORB have not been combined as the differential recovery rates were in Figure 5-11. Thus while comparisons can be made between regression lines, variance around each data point is not yet available. Two regression lines have been developed based on survival data with and without the HORB. Statistically neither regression line is significant, although prior to adding the data from 1999, the without barrier relationship was significant. The

FIGURE 5–8

Flow at Vernalis (Mean April 15-June 15) Between 1951-1998 Versus San Joaquin Basin Escapement (2 ½ Years Later).

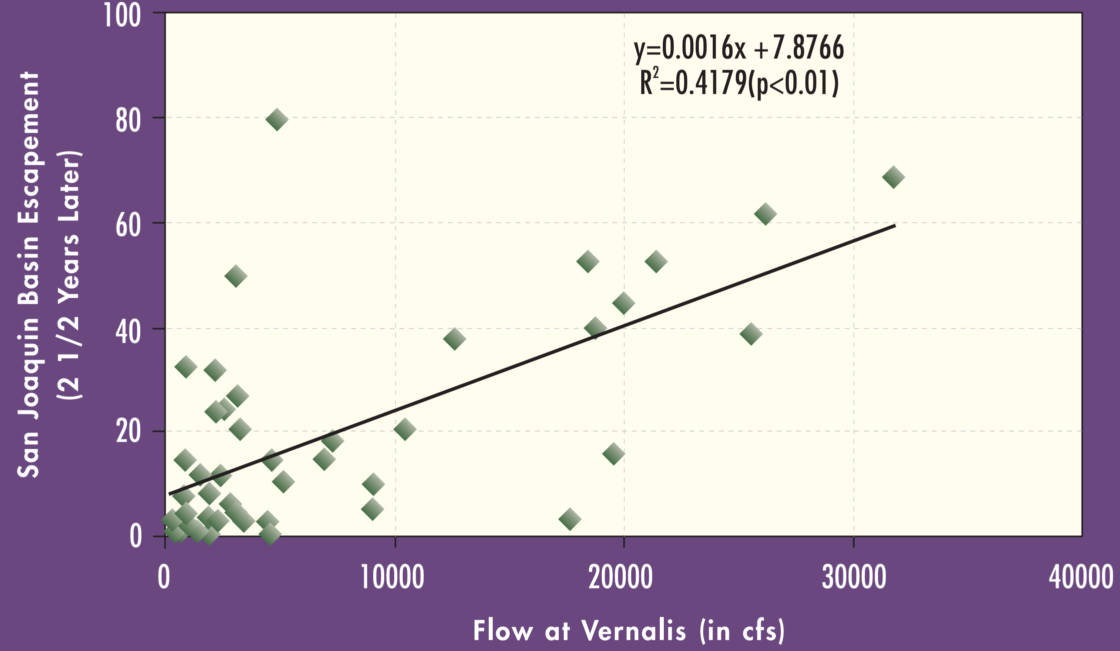


FIGURE 5–9

Mean Spring Flows/Delta Exports (Mean April 15-June 15) Between 1951-1998 and San Joaquin Basin Escapement (2 ½ Years Later).

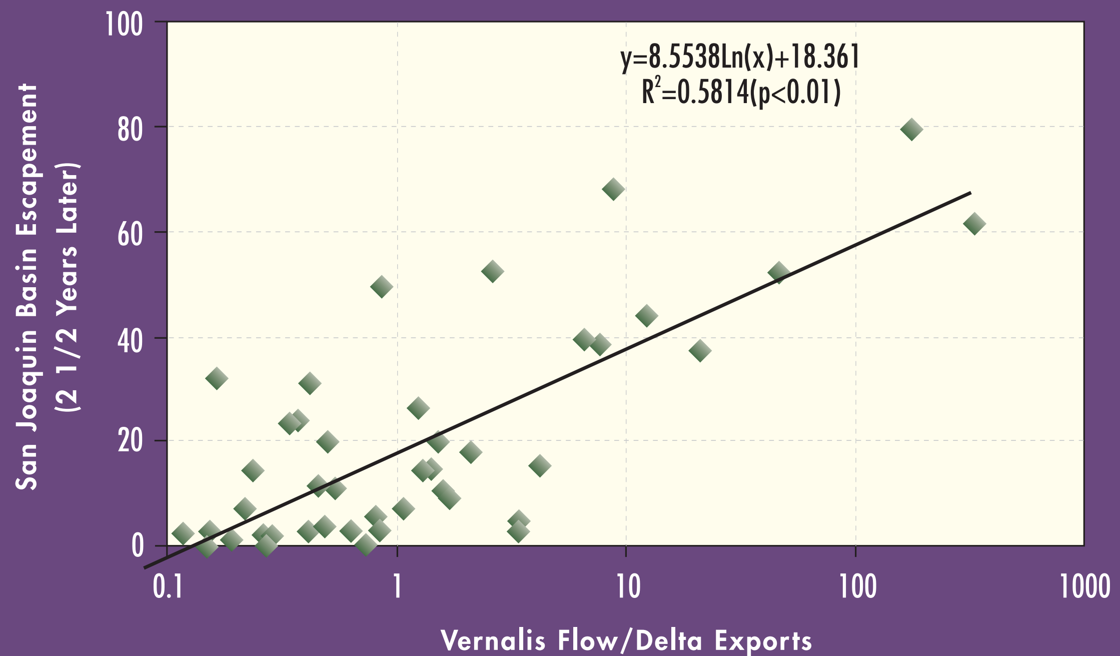


FIGURE 5–10

Survival (Plus and Minus 1 and 2 SE) From Durham Ferry/Mossdale to Jersey Point With HORB in Place Versus Flow at Vernalis, 2000-2002. 2000-2002 Vernalis Flows Were Averaged for Both 10 day Periods After Release. 1994 and 1997 Data are Added but do not Have SE. The Equation Without the 1994 and 1997 Data Added is Similar at $y=0.0621\ln(x) - 0.3445$ ($R^2=0.6371$).

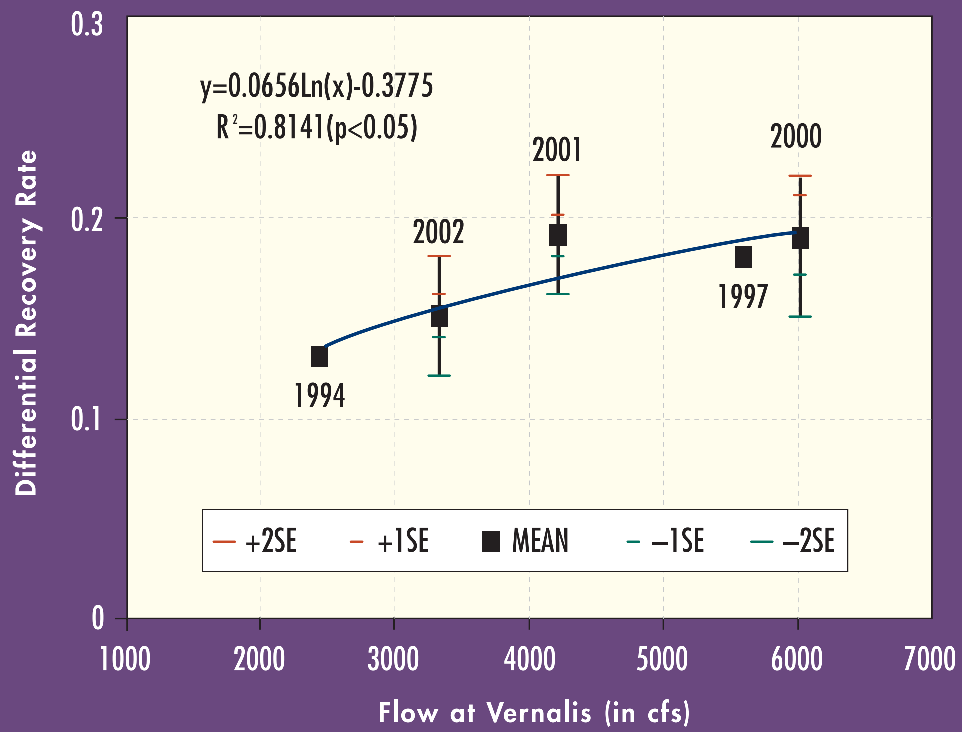
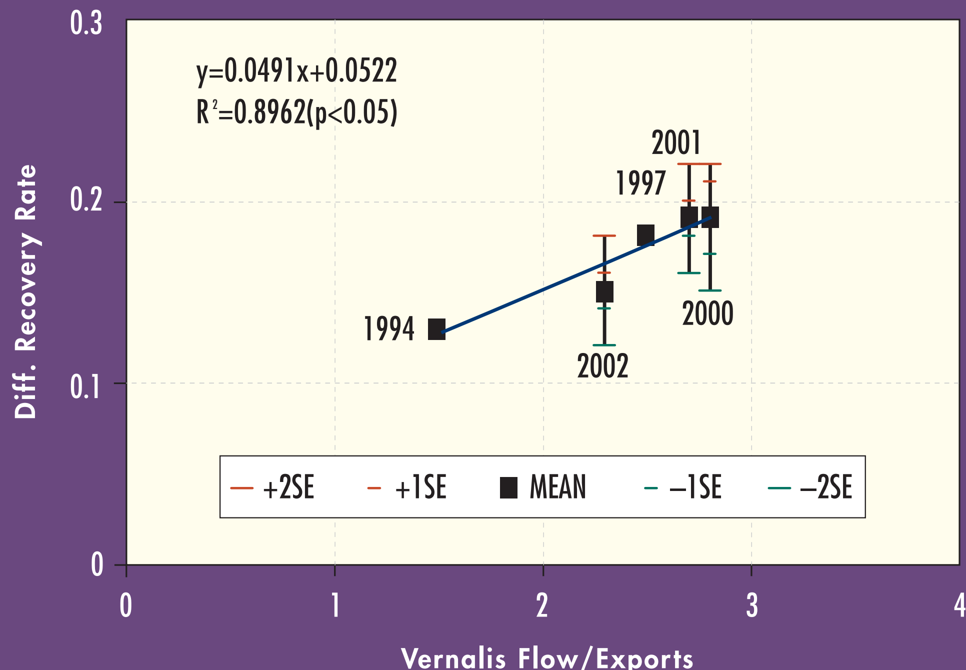


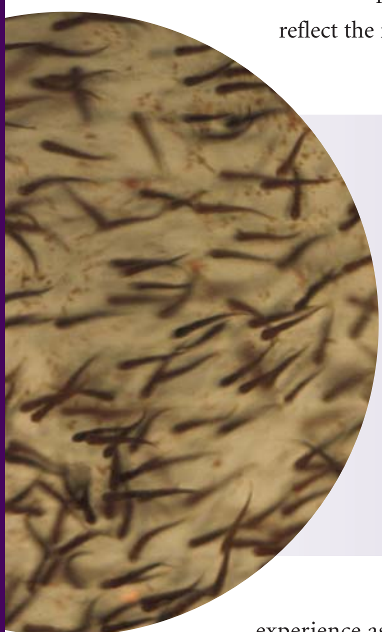
FIGURE 5–11

Survival (Plus and Minus 1 and 2 SE) From Durham Ferry/Mossdale to Jersey Point With HORB in Place, Versus Inflow at Vernalis/exports, Average of Both 10 day Periods After Release, 2000-2002. 1994 and 1997 Data are Added but do not Have SE. The Equation Without 1994 and 1997 is $y=0.0857x - 0.0462$, $R^2=0.9643$.



barrier appears to generally increase survival at any one flow/export level, although the survival was high in 1999 without a barrier. We have hypothesized that data collected in 1999, could be biased high as sampling was interrupted during collection of the downstream control group (Brandes, 2000).

Figure 5-12 shows the relationship between absolute salmon smolt survival and San Joaquin River flow at Vernalis relative to exports with the HORB. A better estimate of flow would be the net flow on the San Joaquin River downstream of upper Old River because of the different permeability of the HORB (culvert operations) over the years. The estimated flow in the San Joaquin River downstream of upper Old River would better reflect the river flow the juvenile salmon



In the five years of measuring survival with the barrier in place, the flow/export ratio has only varied from 1.5 (1994) to 2.9. These are very small differences in TARGET CONDITIONS of which to measure survival.

experience as they migrate down the San Joaquin River. This estimate has been calculated in past years by subtracting the estimated mean daily flow in upper Old River 840 feet downstream of the barrier from the USGS gaged mean daily flow at Vernalis.

It appears as exports increase relative to flow, survival (differential recovery rates) decreases. Although the relationship is significant the individual recovery rates are not significantly different from one another. One source of variability that could be reduced is the variable permeability of the HORB within and among years. During the five years the barrier has been installed (and comparable survival studies conducted) the design and permeability has changed. In 1994, the HORB was installed without culverts, while in 1997 the barrier had two open culverts that diverted approximately 300 cfs into upper Old River. In 2000, the HORB had six gated culverts, with two open during the Mossdale and first Durham Ferry release and four open during the second Durham Ferry release. In 2001 and 2002, six culverts were installed and operated throughout the VAMP test period. It is estimated that approximately 400 cfs of San Joaquin River flow moved through the culverts in 2001 and 2002 (Simon Kwan, personal communication). The amount of water flowing through the culverts is based on the head differential between the San Joaquin River and Old River. This changes as flow/stage on the river changes and as the tide changes, even if all 6 culverts remain open for the remaining 9 years of the study. The varying designs and changes in the culvert operations of the barrier add variability to the survival measurements, making it more difficult to detect significant differences between closely related flow/export ratios.

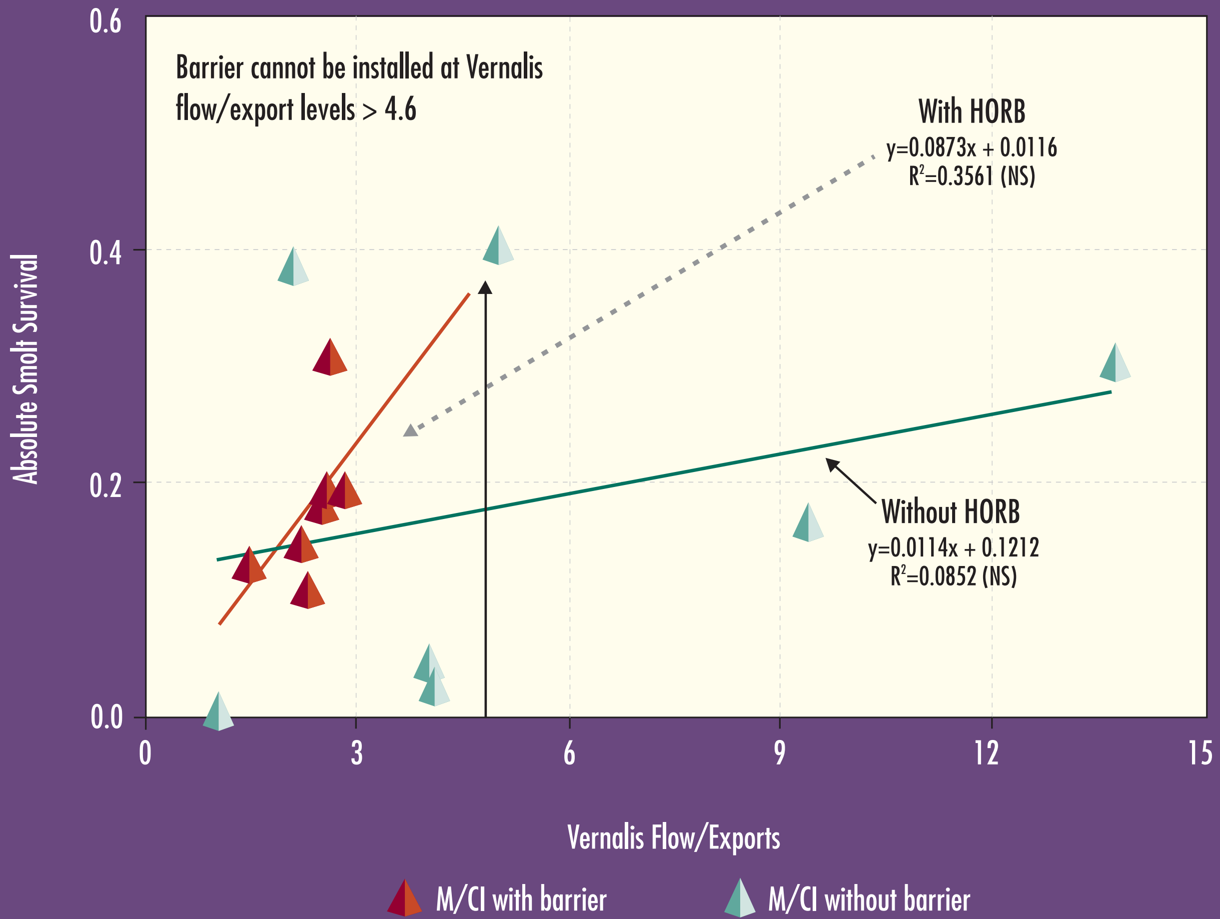
In the five years of measuring survival with the barrier in place, the flow/export ratio has only varied from 1.5 (1994) to 2.9. These are very small differences in target conditions of which to measure survival. The ratios in the relationship between flow/export and adult escapement vary from 0.1 to 1000.

OCEAN RECOVERY INFORMATION FROM RECENT YEARS

Ocean recovery data of CWT salmon groups can contribute to a more complete understanding and evaluation of salmon smolt survival studies. These data can provide another independent estimate of the ratio of survival of a test release group relative to a control release group, or "absolute survival", and can be compared with estimates based on juvenile salmon recoveries at Chipps Island and Antioch. Past recoveries at Jersey Point (1997-1999) can not be compared since the Jersey Point trawling site was located upstream of the Jersey Point release site and a ratio between the upstream and downstream sites can not be generated. Recovery from trawling at Antioch began in 2000. The ocean harvest data may be particularly reliable due to the number of tag recoveries and the extended recovery period.

FIGURE 5–12

Estimates of Survival Versus Vernalis Flow/Exports With and Without a HORB.



Adult 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 2001. The ocean CWT recovery data accumulate over a 1-4 year period following the year a study release is made as nearly all of a given year class of salmon have either been harvested or spawned by age 5. Consequently, these data are essentially complete for releases made through 1996 and 1997 and partially available for CWT releases made from 1998-2000. Once the data for these and later releases are available they will be used to compare the three independent estimates of survival (using Antioch, Chipps Island, and ocean recoveries): based on VAMP releases starting in 2000.

Survival estimates based on ocean recoveries for salmon produced at the Merced River Hatchery, and released as part of south delta survival evaluations from 1996-2000 were compared to survival estimates based on Chipps Island and Antioch recoveries (Table 5-7). Releases over that period were made at several locations: Dos Reis (on the San Joaquin River downstream of the upper Old River junction), Mossdale, Durham Ferry, and Jersey Point. Ocean absolute survival ratios were very similar to those at Chipps Island for the releases made in 1996, and 1999, and 2000 and at Antioch for the Mossdale and second Durham Ferry releases in 2000. Although ocean absolute survival ratios were higher than those to Chipps Island for releases in 1997 and 1998 and to Antioch for the first Durham Ferry release in 2000, they were generally similar (in the mid-range of survival).

Results of this comparative analysis of survival estimates for Chinook salmon produced in the Merced River Hatchery show (1) there is generally good agreement between survival estimates based on juvenile CWT salmon recoveries in Chipps Island and Antioch trawling and adult recoveries from the ocean fishery, (2) survival estimates using Chipps Island or Antioch recoveries were lower in some years than estimates based on ocean recoveries, and (3) additional comparisons need to be made, as more data becomes available from VAMP releases for recoveries at Antioch,

TABLE 5–7

Survival Indices Based on Chipps Island, Antioch and Ocean Recoveries of Merced Hatchery Salmon Released as Part of South Delta Studies Between 1996 and 2000.

RELEASE YEAR	SAN JOAQUIN RIVER *(Merced River Origin)* TAG NO.	RELEASE NUMBER	RELEASE SITE	RELEASE DATE	CHIPPS IS. RECOVS.	ANTIOCH RECOVS.
			Juvenile Salmon CWT Releases			
1996	H61110412	25,633	DOS REIS	MAY 01 '96	2	
	H61110413	28,192	DOS REIS	MAY 01 '96	3	
	H61110414	18,533	DOS REIS	MAY 01 '96	1	
	H61110415	36,037	DOS REIS	MAY 01 '96	5	
	H61110501	53,337	JERSEY PT	MAY 03 '96	39	
	Effective Release	107,961	DOS REIS		11	
	Effective Release	51,737	JERSEY PT		39	
1997	H62545	50,695	DOS REIS	APR 29 '97	9	
	H62546	55,315	DOS REIS	APR 29 '97	7	
	H62547	51,588	JERSEY PT	MAY 02 '97	27	
	Effective Release	106,010	DOS REIS		16	
	Effective Release	51,588	JERSEY PT		27	
	H62548	46,728	DOS REIS	MAY 08 '97	5	
	H62549	47,254	JERSEY PT	MAY 12 '97	18	
1998	61110809	26,465	MOSSDALE	APR 16 '98	25	
	61110810	25,264	MOSSDALE	APR 16 '98	31	
	61110811	25,926	MOSSDALE	APR 16 '98	32	
	61110806	26,215	DOS REIS	APR 17 '98	33	
	61110807	26,366	DOS REIS	APR 17 '98	23	
	61110808	24,792	DOS REIS	APR 17 '98	34	
	61110812	24,598	JERSEY PT	APR 20 '98	87	
	61110813	25,673	JERSEY PT	APR 20 '98	100	
	Effective Release	77,655	MOSSDALE		88	
	Effective Release	77,373	DOS REIS		90	
	Effective Release	50,271	JERSEY PT		187	
1999	064606	25,005	MOSSDALE	APR 20 '99	2	
	062642	24,715	MOSSDALE	APR 19 '99	8	
	062643	24,725	MOSSDALE	APR 19 '99	15	
	062644	25,433	MOSSDALE	APR 19 '99	13	
	062645	25,014	DOS REIS	APR 19 '99	20	
	062646	24,841	DOS REIS	APR 19 '99	19	
	0601110815	24,927	JERSEY PT	APR 21 '99	34	
	062647	24,193	JERSEY PT	APR 21 '99	25	
	Effective Release	99,878	MOSSDALE		38	
	Effective Release	49,855	DOS REIS		39	
	Effective Release	49,120	JERSEY PT		59	
2000	06-45-63	24,457	DURHAM FERRY	APR 17 '00	11	11
	06-04-01	23,529	DURHAM FERRY	APR 17 '00	7	6
	06-04-02	24,177	DURHAM FERRY	APR 17 '00	10	10
	06-44-01	23,465	MOSSDALE	APR 18 '00	9	14
	06-04-02	22,784	MOSSDALE	APR 18 '00	9	16
	06-44-03	25,527	JERSEY PT	APR 20 '00	24	50
	06-04-04	25,824	JERSEY PT	APR 20 '00	41	47
	Effective Release	72,163	DURHAM FERRY		28	27
	Effective Release	46,249	MOSSDALE		18	30
	Effective Release	51,351	JERSEY PT		65	97
	601060914	23,698	DURHAM FERRY	APR 28 '00	7	8
	601060915	26,805	DURHAM FERRY	APR 28 '00	5	15
	0601110814	23,889	DURHAM FERRY	APR 28 '00	10	8
	0601061001	25,572	JERSEY PT	May 1 '00	48	76
	0601061002	24,661	JERSEY PT	May 1 '00	30	76
	Effective Release	74,392	DURHAM FERRY		22	31
	Effective Release	50,233	JERSEY PT		78	152

NOTE: Ocean recoveries are based on data through 2001

EXPANDED ADULT OCEAN RECOVS. (AGE 1+ TO 4+) TOTAL	CHIPPS ISLAND	ANTIOCH	OCEAN CATCH
	Juvenile Salmon CWT Survival Estimates		
3			
37			
8			
10			
187			
58	0.14		0.15
187			
183			
167			
351			
350	0.29		0.49
351			
91	0.28		0.48
191			
61			
40			
58			
47			
35			
61			
110			
90			
159	0.30		0.51
143	0.31		0.46
200			
57			
101			
119			
112			
138			
191			
244			
302			
389	0.32		0.35
329	0.65		0.59
546			
10			
10			
20			
10			
9			
50			
24			
40	0.31	0.20	0.38
19	0.31	0.34	0.29
74			
4			
4			
0			
14			
32			
8	0.19	0.14	0.12
46			

Chipps Island, and the ocean fishery. Information on survival of juvenile salmon and the contribution to the adult salmon population will be valuable in evaluating the biological benefits of changes in flow and export rates under VAMP.

SAN JOAQUIN RIVER SALMON PROTECTION

One of the VAMP objectives is to provide improved conditions and increased 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 hoped that these actions to improve conditions for the juveniles would translate to greater adult escapement in future years, especially during low flows, when escapement 2 1/2 years later has been extremely low in the San Joaquin basin (Figure 5-13).

To determine if VAMP in 2002 was successful in protecting juvenile salmon emigrating from the San Joaquin River tributaries, estimates of survival were compared with VAMP and in the absence of VAMP. Catches of unmarked salmon at Mossdale and in salvage at the CVP and SWP facilities were also compared prior to and during the VAMP period.

Unmarked Salmon Recovered at Mossdale

In assessing VAMP's objective to provide increased protection for the natural production of juvenile salmon migrating from the San Joaquin River tributaries, an estimate of survival was calculated with VAMP and in the absence of VAMP. The equation of survival to flow/exports was used to estimate survival under both conditions (Figure 5-11). With VAMP the flow/export ratio during the VAMP period was 2.3. This flow/export ratio generated a survival of 0.15. Without the export curtailments and flow augmentation due to VAMP the flow/export rate was estimated to be 0.35 (given the barrier was still in without the VAMP flow and exports). At this level of flow/export rate survival was estimated to have been 0.08. The export curtailments and increase in flows from VAMP essentially doubled survival from 0.08 to 0.15.

The original time period for VAMP (April 15 to May 15) was chosen based on historical data that indicated a high percentage of the juvenile salmon emigrating from the San Joaquin tributaries was passing into the delta at Mossdale during that time period. The average catch per minute per day of unmarked juvenile salmon caught in Kodiak trawling at Mossdale between March 15 and June 30, 2002 is shown in Figure 5-14. Unmarked salmon do not have an adipose clip and could be fish from the Merced River Hatchery or juveniles from natural spawning. An assessment of the percent of catch per unit effort over time indicated that the

FIGURE 5–13

Natural and Hatchery Escapement Returning to the San Joaquin Basin Between 1953 and 2001.

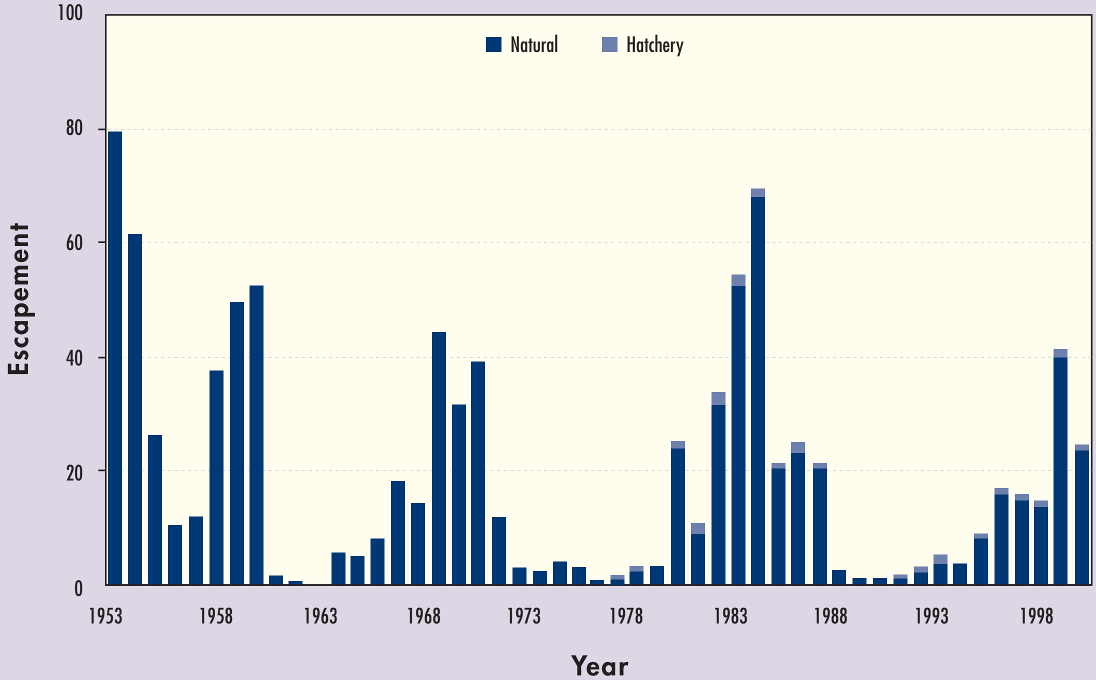


FIGURE 5–14

Catch Per Cubic Meter of all Unmarked Juvenile Chinook Salmon in the Mossdale Kodiak Trawl, March 15, 2002 Through June 30, 2002.

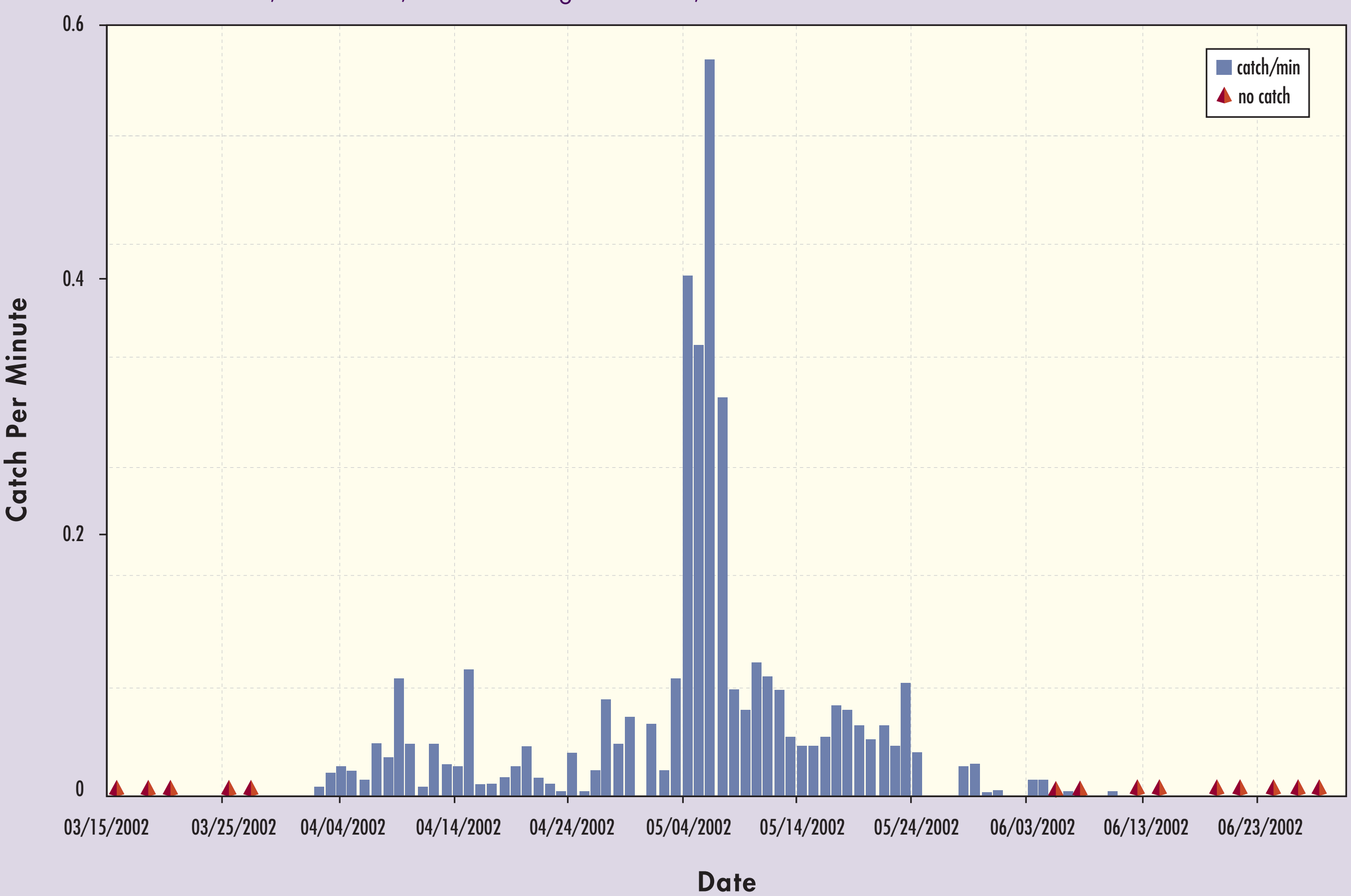
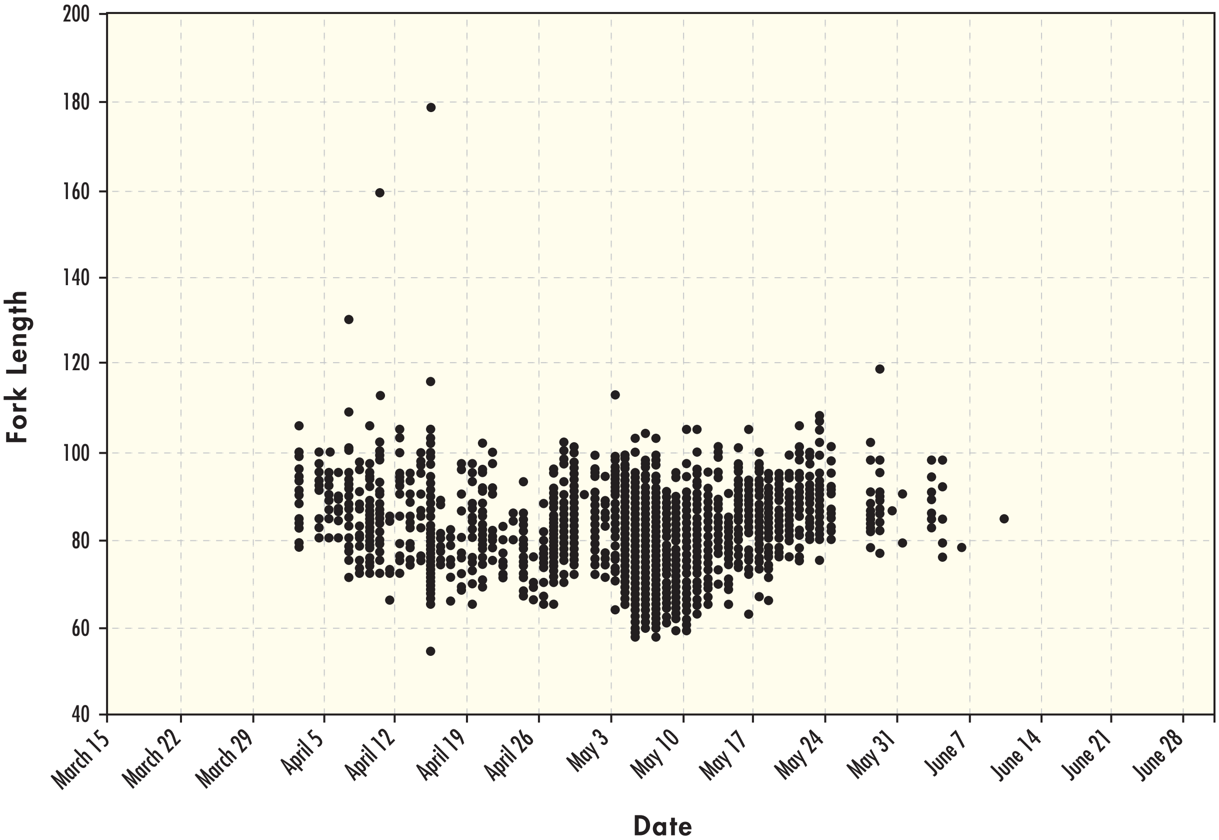


FIGURE 5–15

Individual Fork Lengths for Unmarked Juvenille Chinook in the Mossdale Kodiak Trawl, March 15, 2002 Through June 30, 2002.



majority of juvenile salmon (77%) migrated past Mossdale during the VAMP period. Delaying removal of the HORB until May 24, continuing export curtailments and ramping exports into early June protected an even greater percent of the population (91%). Reducing flows may stimulate movement of the juvenile salmon out of the system. Continuing the export curtailments and keeping the barrier in place for a week after the VAMP period provided some protection to these later out-migrants. These additional protection measures after VAMP appear to have been beneficial to protecting a greater proportion of the population of unmarked juvenile salmon emigrating from the San Joaquin basin.

Each unique size in millimeters of the juvenile salmon caught in the trawl at Mossdale between March 15 and June 30 is shown in Figure 5-15. In early April there were large juvenile salmon observed in the catch. These may be yearlings that have over-summered in the San Joaquin tributaries. Additional protection in early April may be warranted for this component of the population.

Salmon Salvage and Losses at Delta Export Pumps

Fish salvage operations at the CVP and SWP export facilities capture unmarked salmon for transport by tanker truck and release downstream in the western Sacramento-San Joaquin delta. The untagged salmon are either naturally produced or hatchery salmon, 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 CWT recovery data at the facilities to provide some general indications.

The salvage at the facilities is based on expansions from subsamples taken throughout the day. Approximately 4-5 salmon are estimated to be lost per salvaged salmon in the SWP Clifton Court Forebay based on high predation rates. The CVP pumps divert directly from the Old River channel and the loss estimates range from about 50-80% of the number salvaged, or about 6- 8 times less per salvaged salmon than for the SWP. The loss estimates do not include any indirect mortality in the delta due to water export operations or additional mortality associated with trucking and handling. Salvage density of salmon is the number of salvaged fish per acre-foot of water pumped.

The number 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 and density of juvenile salmon salvaged and lost. Density may be the best indicator of when the most juvenile salmon were moving through the salvage system.

FIGURE 5–16

2002 SWP Salmon Salvage and Loss.

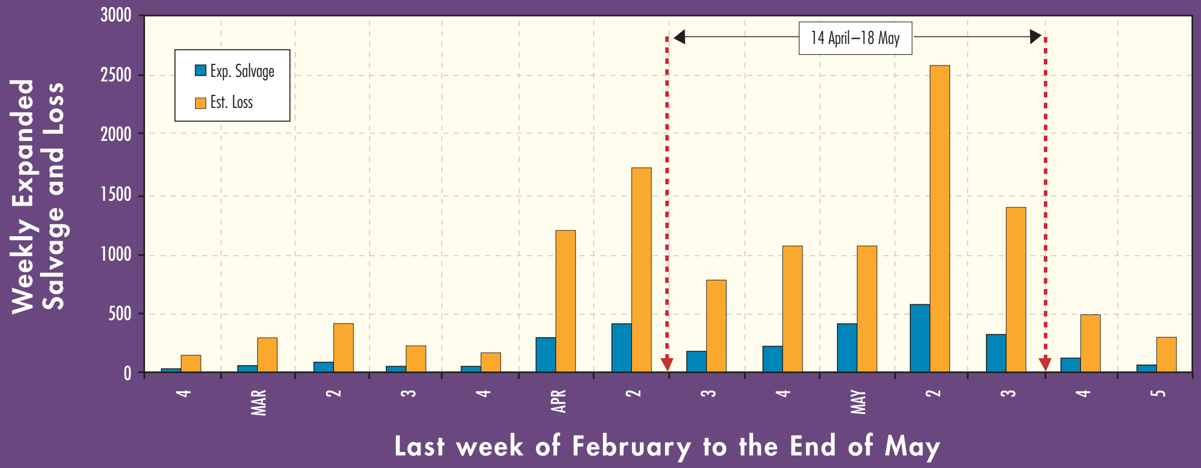


FIGURE 5–17

2002 CVP Salmon Salvage and Loss.

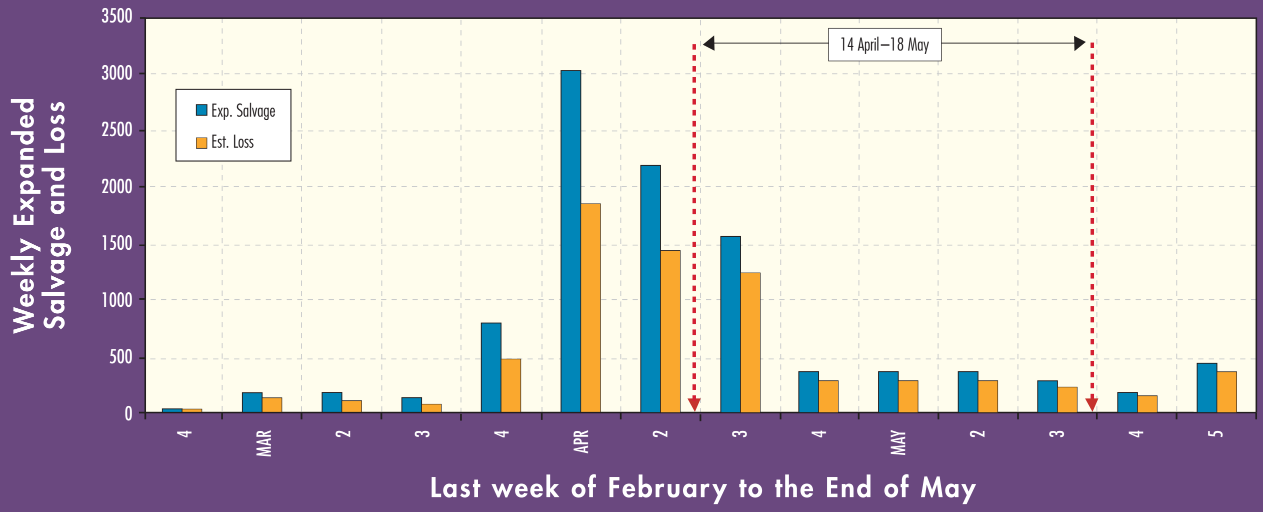
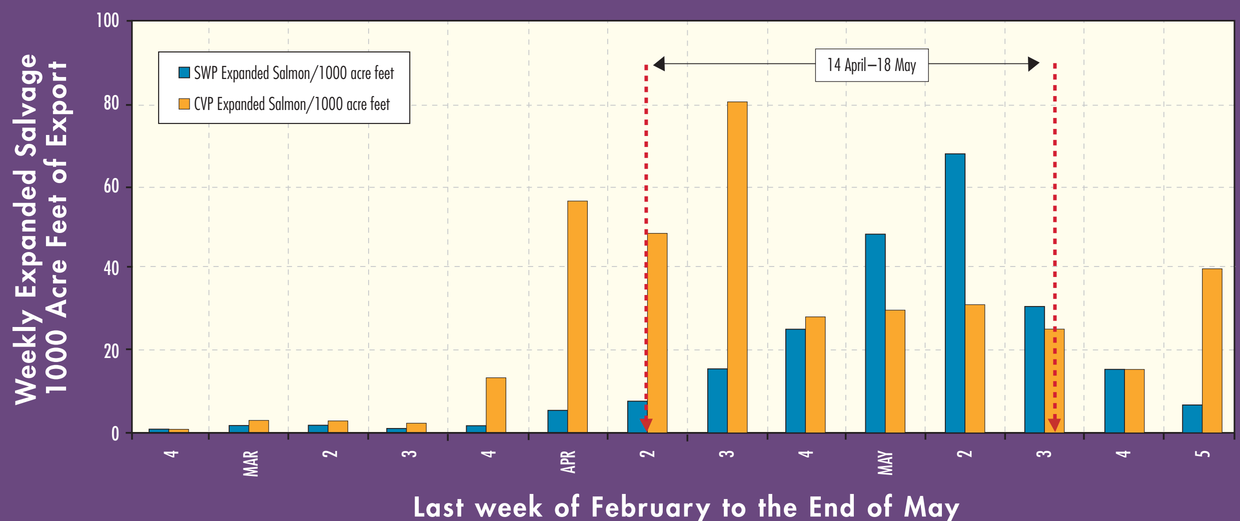


FIGURE 5–18

2002 SWP & CVP Expanded Salmon Salvage Density.



A review of the weekly salvage data around the 2002 VAMP period indicates that the highest salvage and losses occurred during the second week of May at the SWP and in the second week prior to the VAMP period at the CVP (Figures 5-16 and 5-17). Salmon density was highest in the first week of the VAMP period at the CVP facility, which also had high densities in the two preceding weeks, and in the fourth week of the VAMP period at the SWP facility (Figure 5-18). The salvage, loss and density information indicates that the salmon protection measures of VAMP may have been beneficial if they were implemented in the first half of April, similar to 2000 and 2001. Reducing exports during this earlier period of time would not only provide better conditions for juvenile salmon emigrating from the San Joaquin River basin, but from the Sacramento River basin as well.

It is recommended that these **CONDITIONS** *be tested as soon as possible to determine if VAMP should continue or if the study design needs to be changed.*

Juvenile spring-, winter-, and fall- run Chinook salmon migrate through the Delta in early April from the Sacramento River basin. Compared to the previous two years, salvage, losses, and density were several times lower in 2002, indicating that overall juvenile abundance was much less this year at the fish facilities.

The size distribution of unmarked salmon during April and May in the Mossdale trawl (Figure 5-15) and at the salvage facilities (Figure 5-19): Source E. Chappell, DWR) were generally similar in 2002, as was observed in 2001.

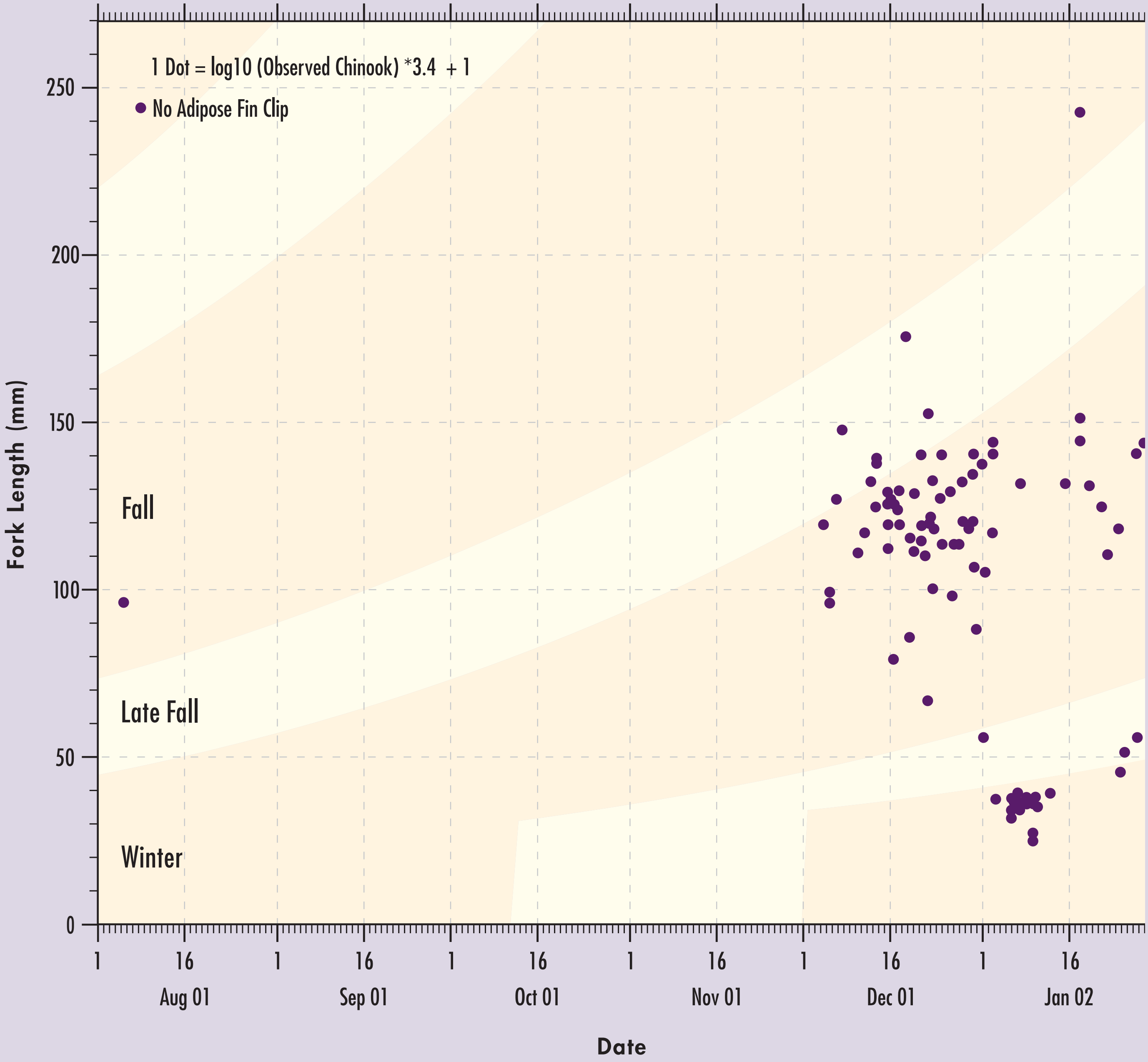
Results of these analysis showed that the VAMP 2002 test period coincided with much of the peak period of salmon smolt emigration. Reductions in SWP and CVP exports and increased San Joaquin River flow provided improved conditions for salmon survival, although starting the VAMP period two weeks earlier may have had substantial benefits. Additional VAMP studies are required, however, to improve quantification of biological benefits over a broader range of environmental conditions.

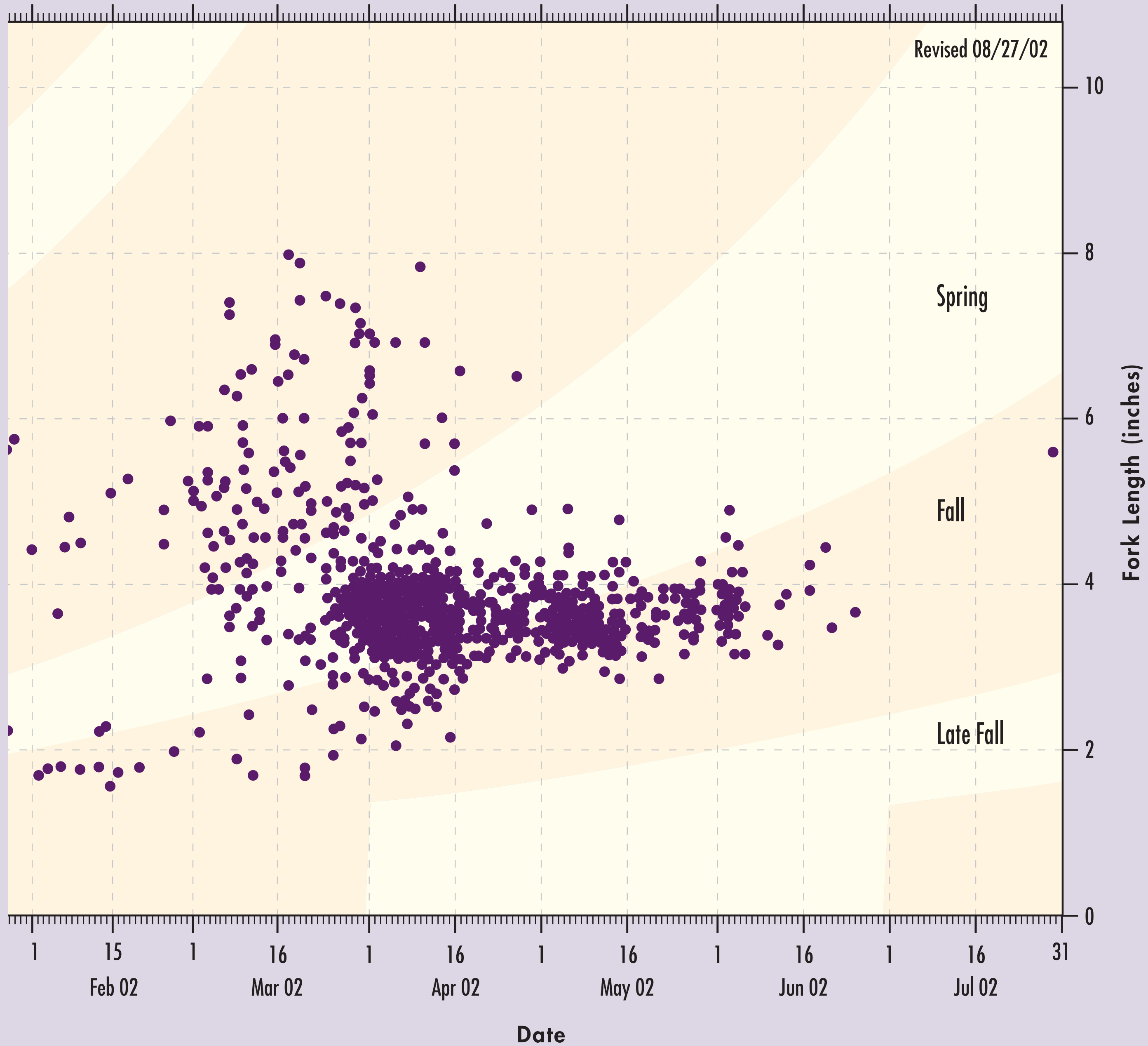
Summary and Recommendations

The variability in survival (recovery rates) at any one flow or flow/export with the HORB makes any preliminary conclusions uncertain based on VAMP results to date. Measuring survival within the narrow ranges of flow and export targets within the VAMP design further limits our ability to detect significant differences between targets. Future studies should prioritize, to the extent possible, flows of 7000 cfs and exports of 1500 cfs to achieve the highest target ratio (4.7) within the VAMP design to better enable us to determine the role of flow and export on salmon smolt survival. It is recommended that these conditions be tested as soon as possible to determine if VAMP should continue or if the study design needs to be changed. It is uncertain how such a condition can be prescribed independently of the hydrology within the existing San Joaquin River Agreement, but the idea should be explored by the VAMP Management Team. Also continued assessment of past data is recommended such that other methodologies or criteria for determining statistical differences between groups may be developed.

FIGURE 5–19

Observed Chinook Salvage at the SWP & CVP Delta Fish Facilities 8/01/01 through 7/31/02.




Revised 08/27/02
Spring
Fall
Late Fall
Fork Length (inches)
0
2
4
6
8
10
1
15
1
16
1
16
1
16
1
16
1
16
31
Feb 02
Mar 02
Apr 02
May 02
Jun 02
Jul 02
Date

CHAPTER 6 | COMPLIMENTARY STUDIES RELATED TO THE VAMP

During the 2002 VAMP period several studies were performed that were considered to be complimentary and are summarized below for the reader. The studies included (1) Survival Estimates for CWT Releases Made in the San Joaquin Tributaries; (2) Radio-Tagged Juvenile Chinook Salmon Release Studies; (3) Striped Bass Predation Monitoring; and (4) the Mokelumne River Juvenile Chinook Salmon Survival Study.

SURVIVAL ESTIMATES FOR CWT RELEASES MADE IN THE SAN JOAQUIN TRIBUTARIES

CWT salmon releases were made in the San Joaquin River tributaries between March 31 and May 4 as part of independent (complimentary) fishery investigations. Releases were made in the upper Merced River (Merced River Fish Facility) and lower Merced River (Hatfield State Park), upper Tuolumne River (La Grange) and on the mainstem San Joaquin River just downstream of the confluence with the Tuolumne River (Old Fisherman's Club). Groups of CWT salmon were also released in the upper (Knights Ferry) and lower (Two Rivers) Stanislaus River.

Group survival indices for salmon released in the tributaries and recovered at Antioch ranged between 0.002 and 0.04 (Appendix C-5). Group survival indices ranged between 0.005 and 0.05 to Chipps Island (Appendix C-5). These indices were much lower than in 2001, where indices ranged from 0.03 to 0.20. These indices include both the survival upstream as well as through the delta. Vernalis flows were lower in 2002 (3,300 cfs vs. 4,200 cfs). The tributary flows were also likely lower.

Comparison of survival indices of the upstream groups relative to the downstream groups provides an index of survival through the tributaries. The survival estimates through the tributaries are provided in Appendix C-5. Survival through the Merced River ranged between 0.0 and 0.11. Again, survival through the tributaries was greater in 2001, with estimates through the Merced River ranging between 0.17 and 0.52. Survival through the Tuolumne Rivers was higher, with upstream release recoveries at Antioch greater than the downstream releases. Using Chipps Island recovery information survival ranged from 0.47 to 0.84 in 2002. In 2001 survival through the Tuolumne River was 0.20. Recoveries from the upstream groups were higher than the downstream group at both Antioch and Chipps Island for releases made on the Stanislaus River in 2002. No recoveries were made from either the upstream or downstream groups on the Stanislaus in 2001.

Survival through the Merced appeared low in 2002, while it appeared higher on the Tuolumne and Stanislaus Rivers in 2002 than in 2001. Recovery numbers from these groups are small and the inherent variability associated with the probability of capture may be the reason estimates are greater than 1.0.

Information on the transit time between release and recovery of the CWT groups released in the San Joaquin River mainstem and tributaries at both Antioch and Chipps Island is summarized in Appendix C-6. As observed for VAMP releases, recovery times were generally similar between Antioch and Chipps Island for the various groups released upstream in the mainstem San Joaquin and tributaries.

RADIO TAGGING STUDIES IN THE LOWER SAN JOAQUIN RIVER

(Contributed by Dave Vogel, Natural Resource Scientists, Inc.)

During April 2002, Natural Resource Scientists, Inc. released and monitored radio-tagged juvenile Chinook salmon in the lower San Joaquin River. Field data collection for this project was designed to acquire information on specific behavior (movements) as juvenile Chinook salmon migrated through delta channels just prior to and during VAMP implementation. The study expanded upon the techniques NRS developed in prior studies on juvenile salmon using radio telemetry, including recent studies at the Delta Cross Channel, north Delta, and south Delta.

Juvenile Chinook salmon with surgically-implanted miniature (1 gram) radio transmitters were released in the San Joaquin River near Fourteen-Mile Slough (downstream of Stockton). Twelve to 14 radio-tagged salmon were released on each of the following dates: April 2, April 10 (pre-VAMP), and April 16, and April 23 (during VAMP). The radio-tagged fish were tracked for 3-4 days after release using mobile receivers on two inboard jet boats. Individual fish movements, migration rates, and behavior in response to tidal cycles and flow splits in Delta channels were important parameters assessed from field observations. In particular, the project was intended to evaluate what occurs during the telemetered salmon migration past the flow splits at Turner Cut, Columbia Cut, and lower Middle and

FIGURE 6–1

Locations of Radio-Tagged Juvenile Salmon Released on April 2, 2002.

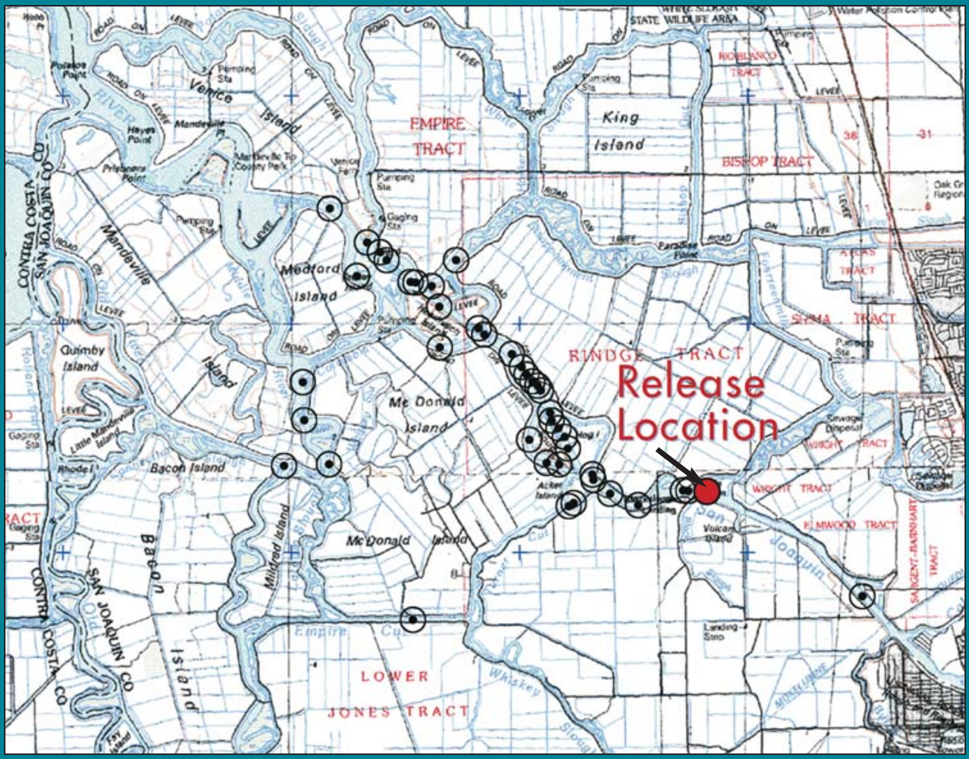
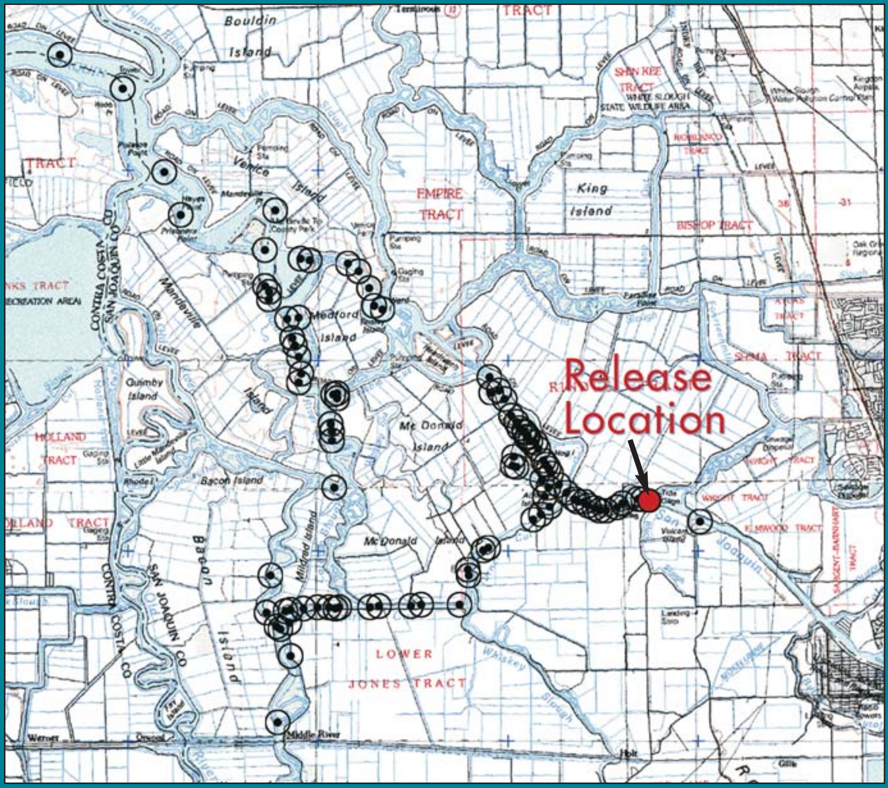


FIGURE 6–2

Locations of Radio-Tagged Juvenile Salmon Released on April 10, 2002.



Old rivers. Each time a radio-tagged fish was located, the exact position (via GPS), time, and any relevant biological and behavioral observations were recorded. Figures 6-1, 6-2, 6-3, and 6-4 show preliminary data on locations of radio-tagged juvenile Chinook salmon released and tracked in the Delta during the four weeks of experiments.

A report on this project will be completed after receipt of DWR tidal flow data measured in the San Joaquin River near Rough and Ready Island.

STRIPED BASS PREDATION MONITORING PROGRAM

(Contributed by Heather McIntire, California Department of Fish and Game)

In early March, EPA (Bruce Herbold) suggested USFWS and DFG coordinate the Striped Bass Predation Monitoring Program with the VAMP smolt release at Mossdale and Durham Ferry. The Striped Bass Predation Monitoring Program is a requirement of DFG's Striped Bass Management Program's ESA Conservation Plan. Based on previous scheduling, DFG collected striped bass at the HORB on April 3, 16, and 25. Salmon releases at Mossdale occurred on the April 19 and 26. Because the smolt release schedules were not confirmed until the day before releases, DFG was unable to coordinate a boat operator and crew to sample immediately during the releases.

DFG sampled striped bass by gillnet and hook and line. Three days of sampling yielded 2 striped bass, 176 catfish, 1 bluegill and 1 black crappie. The stomachs of both striped bass were flushed by gastric lavage and one was sacrificed after lavage to confirm the stomach was empty. Neither fish had any remains in the stomach.

Fishing upstream of the Mossdale bridge on April 16 and 25, yielded a total of 5 striped bass which had empty stomachs based on gastric lavage and dissection. Three of these 5 fish were sacrificed to confirm stomach contents.

MOKELUMNE RIVER JUVENILE CHINOOK SALMON SURVIVAL STUDIES

The East Bay Municipal Utility District (EBMUD) conducted a series of juvenile Chinook salmon survival studies in the lower Mokelumne River during spring 2002 that complement VAMP investigations. Juvenile Chinook salmon from the Mokelumne River Fish Hatchery were coded-wire tagged (CWT) for use in these tests. The experimental design included release of CWT salmon into the north fork Mokelumne River (approximately 52,000-54,000 CWT salmon in each release group), the south fork Mokelumne River at New Hope Landing (approximately 103,000 CWT salmon in each release), and a downstream control release at Jersey Point (approximately 51,000–52,000 CWT salmon in each release). Releases were made prior to the 2002 VAMP test period (releases were made on April 4 into the north fork and south fork of the Mokelumne River and April 11 at Jersey Point) and during the VAMP test period (releases were made April 18 into the north fork and south fork Mokelumne River and April 23 at Jersey Point). CWT Chinook salmon were subsequently recovered in fishery sampling at Antioch and Chipps Island, in addition to recoveries in SWP and CVP salvage operations. Hydrologic conditions prior to and during the VAMP test period, including San Joaquin River flows and SWP and CVP export rates, are discussed in Section 2.

CWT CHINOOK salmon were subsequently recovered in fishery sampling at Antioch and Chipps Island, in addition to recoveries in SWP and CVP salvage operations.

FIGURE 6–3

Locations of Radio-Tagged Juvenile Salmon Released on April 16, 2002.

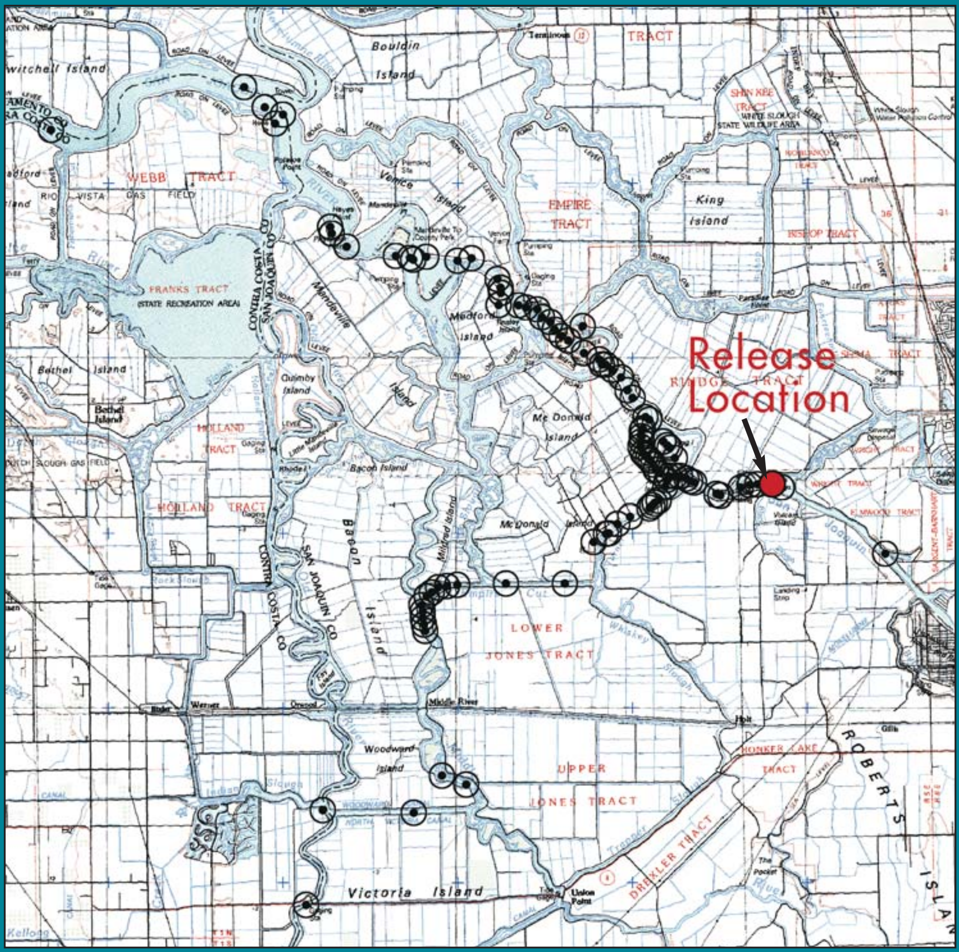
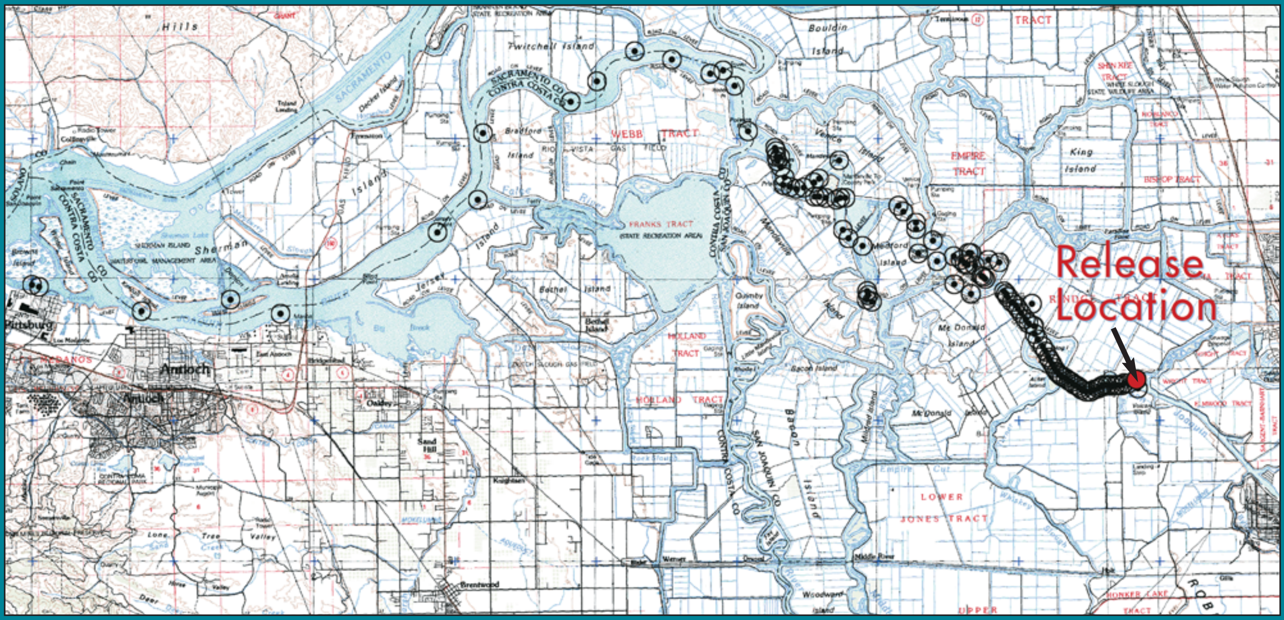


FIGURE 6–4

Locations of Radio-Tagged Juvenile Salmon Released on April 23, 2002.



As part of the Chinook salmon survival studies, EBMUD monitored water temperatures within the Mokelumne River Fish Hatchery, north fork Mokelumne River, south fork Mokelumne River at New Hope Landing, and Jersey Point. Results of water temperature monitoring within the Mokelumne River Hatchery showed that water temperatures typically ranged from approximately 11-13 C (52-55 F) within the raceways prior to release of the CWT Chinook salmon. Water temperatures within the north fork Mokelumne River ranged from approximately 16-19 C (61-66 F) which were similar to water temperatures observed in the south fork Mokelumne River during both the first and second sets of releases. Water temperature observed during the period of these salmon survival studies was within the range considered to be suitable for juvenile emigrating Chinook salmon.

Results of recaptures of CWT Chinook salmon at Chipps Island released prior to the VAMP test period showed that the absolute estimate of survival (based upon the ratio of survival indices calculated for each north and south fork Mokelumne River release group and adjusted for sampling effort, and the downstream Jersey Point control) of juvenile salmon released in the south fork Mokelumne River (survival rate equals 0.10) was greater than the survival rate for fish released into the north fork Mokelumne River (survival rate equals 0.03). In contrast, survival rates for Chinook salmon released during the pre-VAMP period and recaptured at Antioch showed higher survival from the north fork Mokelumne river (survival rate equals 0.27) than observed for salmon from the south fork Mokelumne River (survival rate 0.15). Factors contributing to the contradictory survival results for the pre-VAMP period between recaptures at Antioch and Chipps Island could not be determined from results of the 2002 tests.

For those CWT juvenile Chinook salmon released during the VAMP period and recaptured at Chipps Island, absolute survival rates were comparable between the north fork (survival rate equals 0.11) and south fork Mokelumne River (survival rate equals 0.12). Survival rates during the VAMP period for recaptures at Antioch were similar to results based on recaptures at Chipps Island.

Results of these complimentary survival studies provide insight into the survival of juvenile Chinook salmon emigrating from the lower Mokelumne River through the Delta and the potential effects of changes in San Joaquin River flow and SWP/CVP export rates may have on juvenile Chinook salmon survival.

Results of these complimentary survival studies provide insight into the survival of juvenile Chinook salmon emigrating from the lower MOKELUMNE RIVER...

CHAPTER 7 | CONCLUSIONS AND RECOMMENDATIONS

The 2002 VAMP experimental investigation of juvenile Chinook salmon survival, implemented during spring 2002, represents the third year under the SWRCB D-1641. The Vernalis target flow was 3200 cfs, with SWP and CVP export flow of 1500 cfs. The HORB was successfully installed and maintained throughout the VAMP test period. Estimates of juvenile Chinook salmon smolt survival were calculated based upon releases of CWT juvenile salmon produced in the Merced River Hatchery and released at Durham Ferry, Mossdale, and Jersey Point.

Marked salmon were subsequently recaptured in sampling at the HORB, SWP and CVP export facility salvage, and through intensive fishery sampling at Antioch and Chipps Island. Based upon the data and experience gained during the VAMP 2002 investigations, conclusions and recommendations have been developed, as summarized in Table 7-1. The conclusions and recommendations include both technical and policy/management issues that will affect the design and implementation of VAMP 2003 operations and investigations.

TABLE 7–1

Summary of VAMP 2002 Conclusions and Recommendations

CONCLUSIONS	RECOMMENDATIONS
Real-time flow data at Vernalis were improved by weekly flow measurements. 2002 funding provided by CALFED grant.	Continue weekly flow measurements. Investigate alternative flow measurement methods and/or locations. Obtain additional funding for USGS weekly Vernalis gage verification.
Estimation of ungaged flows (accretions, depletions) at Vernalis was improved.	Continue hydrology investigation to improve predictions of ungaged flows.
Disagreement over forecasting New Melones releases impacted planning for tributary flows and related operations.	Hydrology and/or management committee should resolve forecasting issues prior to 2003 VAMP and a set of written procedures for operational planning within each tributary should be established.
Coordination with upstream tributary operations was successful.	Continue coordination among tributary operators.
Maintenance frequency of the HORB was increased.	Continue frequent maintenance of HORB culverts.
HORB construction continued after barrier closure causing debris (rock) problems for fishery sampling after closure of HORB.	Delay CWT releases for five days after HORB closure to allow time for gravel to be flushed from the culverts.
Operation of the HORB was successful in maintaining south delta water levels.	Continue to refine operational criteria for culverts.
Closure of HORB is dependent on completion of other barriers. Construction of multiple barriers in south delta channels may delay HORB closure.	Schedule construction to avoid delay in HORB installation and closure.
An estimate of the flow through HORB culverts needs to be taken so that a continuous record of flow through the culverts can be reported.	Take flow measurements within each culvert and/or install water stage recorders upstream and downstream of the barrier.
HORB did not cause seepage impacts on upper Roberts Island.	Continue seepage monitoring.

CONCLUSIONS CONTINUED	RECOMMENDATIONS CONTINUED
The use of fyke nets was successful in collecting entrained fish at the culverts.	Continue monitoring culverts using fyke nets to document fish entrainment.
A larger number of CWT salmon than expected were collected at HORB.	Increase effort and budget for CWT processing.
The index of salmon entrainment at HORB was substantially higher in 2002 compared to 2001.	Continue barrier monitoring and analysis of factors affecting entrainment.
2002 studies were successful in determining salmon entrainment at HORB culverts, but did not estimate mortality associated with HORB.	Evaluate methods to estimate mortality associated with HORB
CWT loss rate remained similar to 2001 at a rate of about 9.5 percent with a range between 0.5 and 15.0 percent.	Continue CWT quality control to improve retention rates.
The release at Durham Ferry was improved by having the diversion pump at the site curtail operation.	Continue to curtail diversion pump operations during releases – coordinate release schedule with landowner.
Water temperatures were suitable during both sets of releases.	Avoid seasonal delays in barrier installation and survival testing to allow releases when most suitable water temperatures.
Results of net pen studies showed high survival of test fish.	Continue net pen studies and fish health inspections.
Physiological studies provided useful information on fish health and condition and indicated all test fish were healthy.	Re-evaluate physiological tests and modify protocol prior to 2003 VAMP to document fish health and condition within hatchery and at time of release.
Using current statistical methods, differences in survival rates among flows and export rates tested in 2000, 2001, and 2002 were not found to be statistically significant.	Continue to evaluate alternative statistical methods to assess differences in survival rates between release locations, flows, and export conditions.
Differences in survival from Durham Ferry in 2002 were not significantly different from 2000 or 2001. It appears greater differences in flow and export rate may be needed to detect differences in survival.	Conduct survival testing at VAMP flow and export extremes when water is available to do so. Recommend testing at 7,000 cfs flow and 1,500 cfs exports to determine survival under higher flow:export ratio.
San Joaquin River flow downstream of HORB is important to evaluating salmon survival.	Measure the flow in the San Joaquin River downstream of head of Old River.
Complimentary studies to evaluate mechanisms affecting survival of fish from tributaries and across the Delta were conducted .	Encourage an expansion of complementary studies to provide additional information on factors and mechanisms affecting salmon survival.
Relatively few CWT salmon from VAMP releases were recovered at the SWP and CVP salvage facilities.	Continue salvage monitoring to document direct losses at SWP/CVP export facilities.
Estimates of salmon survival rates under flow and export conditions tested in 2000, 2001, and 2002 have not been found to be significantly different. The VAMP program provides improved protection for juvenile salmon when compared to “pre-VAMP” conditions.	Continue VAMP test program. Further tests, over a wider range of flow and export conditions, are needed to evaluate the respective roles of San Joaquin River flow and SWP/CVP exports on juvenile Chinook salmon smolt survival.

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U.S. FISH AND WILDLIFE SERVICE

CALIFORNIA DEPARTMENT OF WATER RESOURCES

CALIFORNIA DEPARTMENT OF FISH AND GAME

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Page 3	**SWRCB Decision 1641**	www.waterrights.ca.gov/hearings/Decisions.htm
Page 4	**VAMP 2001 Annual Technical Report**	www.sjrg.org/technicalreport/2001_tech_report.htm
Page 8	**VAMP Experimental Design**	www.sjrg.org/agreement.htm
Page 12	**Operation Monitoring, CDEC Hourly**	http://cdec.water.ca.gov/cgi-progs/queryGroup?s=fw1
	Operation Monitoring, CDEC Daily	http://cdec.water.ca.gov/cgi-progs/queryDgroups?s=fw2
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Page 18	**Temporary Barrier Program**	http://sdelta.water.ca.gov
Page 21	**Reclamation District 544 Seepage Monitoring Study**	http://sdelta.water.ca.gov/web_pg/pub_doc.htm
Page 29	**HORB on Old River Tidal Stage**	http://cdec.water.ca.gov
Page 55	**USFWS Stockton**	http://www.delta.dfg.ca.gov/usfws/monitoring_main/monitoring_main.html
	Pacific States Marine Fisheries Commission Regional Mark Information System	http://www.rmis.org
	DFG - Bay Delta	http://www.delta.dfg.ca.gov/data/salvage/

APPENDIX TABLE OF CONTENTS

APPENDIX A

Hydrology and Operation Plans .73
- A-1 Daily Operation Plans .74
- A-2 Accounting of Supplemental Water Contributions .86
- A-3 Comparison of "Real-time" and Provisional Flows .87

APPENDIX B

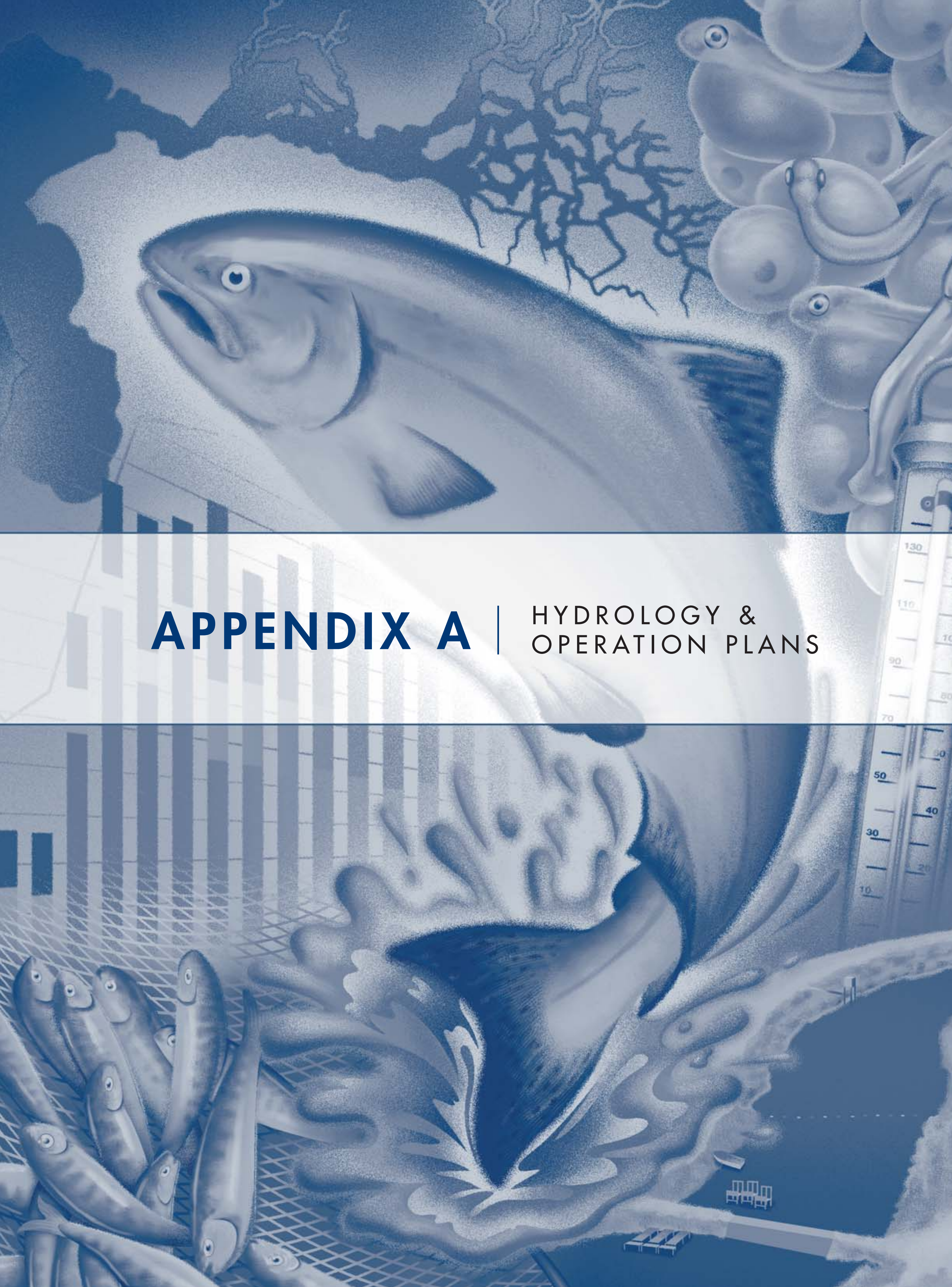
Fall Water Transfer and Delivery Information .90
- B-1 Merced I.D. 2002 Fall SJRA Water Transfer Preliminary Schedule .91
- B-2 Merced I.D. 2001 Fall Water Transfer Daily Flow, Final .92
- B-3 Oakdale I.D Daily Schedule of Additional Water, Preliminary .94

APPENDIX C

Chinook Salmon Survival Investigations .96
- C-1 Water Temperature Monitoring Locations .97
- C-2 Water Temperature Monitoring Data .99
- C-3 Net Pen Sampling Results Immediately and 48 Hours After Release .106
- C-4 Net Pen Sampling Results .108
- C-5 Coded Wire Tag Release and Recovery Data .114
- C-6 Coded Wire Tag TIming of Recovery Data .116

APPENDIX D

Errata .118
- Errata for the 2001 Annual Technical Report .119



APPENDIX A | HYDROLOGY & OPERATION PLANS

DAILY OPERATION PLAN, MARCH 13, 2002

Pulse Period: April 15–May 15 • Flow Target: 3,200cfs

Ungaged Flow at Vernalis = 400cfs • (A) Dry~90% Exceedence

	San Joaquin River near Vernalis							Merced River at Cressey			Exchange Contractors	Tuolumne River at LaGrange				Stanislaus River below Goodwin				
	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	VAMP Suppl. Flow	VAMP Flow (3-day lag)	VAMP Suppl. Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol.
	(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	
	[calc]	[calc]		[calc]	[calc]					[calc]					[calc]				[calc]	
Apr 01						290	400	250		250		150	150		150	637			637	
Apr 02						286	400	250		250		150	150		150	637			637	
Apr 03						283	400	250		250		150	150		150	637			637	
Apr 04	1,723				1,723	280	400	250		250		150	150		150	637			637	
Apr 05	1,720				1,720	276	400	250		250		150	150		150	637			637	
Apr 06	1,717				1,717	273	400	250		250		150	150		150	637			637	
Apr 07	1,713				1,713	270	400	250		250		150	150		150	637			637	
Apr 08	1,710				1,710	267	400	250		250		150	150		150	637			637	
Apr 09	1,707				1,707	263	400	250		250		150	150		150	637			637	
Apr 10	1,704				1,704	260	400	250		250		150	150		150	637			637	
Apr 11	1,700				1,700	257	400	250	250	500		150	150		150	637			637	
Apr 12	1,697				1,697	253	400	250	750	1,000		150	150		150	637			637	
Apr 13	1,694	0			1,694	250	400	250	800	1,050		650	650	0	650	637	225	0	862	
Apr 14	1,690	250			1,940	247	400	250	800	1,050		650	650	0	650	637	225	0	862	
Apr 15	2,187	975	0	1.93	3,162	243	400	250	800	1,050		650	650	0	650	637	225	0	862	
Apr 16	2,184	1,025	0	3.97	3,209	240	400	250	805	1,055		650	650	0	650	637	225	0	862	
Apr 17	2,180	1,025	0	6.00	3,205	237	400	250	810	1,060		650	650	0	650	637	225	0	862	
Apr 18	2,177	1,025	0	8.03	3,202	234	400	250	810	1,060		650	650	0	650	637	225	0	862	
Apr 19	2,174	1,030	0	10.08	3,204	230	400	250	815	1,065		650	650	0	650	637	225	0	862	
Apr 20	2,171	1,035	0	12.13	3,206	227	400	250	815	1,065		650	650	0	650	637	225	0	862	
Apr 21	2,167	1,035	0	14.18	3,202	224	400	250	820	1,070		650	650	0	650	637	225	0	862	
Apr 22	2,164	1,040	0	16.24	3,204	220	400	250	590	840		650	650	0	650	637	225	0	862	
Apr 23	2,161	1,040	0	18.31	3,201	217	400	250	190	440		650	650	240	890	637	225	0	862	
Apr 24	2,157	1,045	0	20.38	3,202	214	400	250	190	440		650	650	650	1,300	637	225	0	862	
Apr 25	2,154	1,055	0	22.47	3,209	210	400	250	195	445		650	650	650	1,300	637	225	0	862	
Apr 26	2,151	1,065	0	24.59	3,216	207	400	250	200	450		650	650	650	1,300	637	225	0	862	
Apr 27	2,147	1,065	0	26.70	3,212	204	400	250	200	450		650	650	650	1,300	637	225	0	862	
Apr 28	2,144	1,070	0	28.82	3,214	201	400	250	200	450		650	650	650	1,300	637	225	0	862	
Apr 29	2,141	1,075	0	30.95	3,216	197	400	250	200	450		650	650	650	1,300	637	225	0	862	
Apr 30	2,138	1,075	0	33.08	3,213	194	400	250	600	850		650	650	650	1,300	637	225	0	862	
May 01	2,134	1,075	0	35.22	3,209	191	400	250	860	1,110		650	650	250	900	677	185	0	862	
May 02	2,131	1,075	0	37.35	3,206	187	400	250	860	1,110		650	650	0	650	677	185	0	862	
May 03	2,168	1,035	0	39.40	3,203	184	400	250	860	1,110		650	650	0	650	677	185	0	862	
May 04	2,164	1,045	0	41.47	3,209	181	400	250	865	1,115		650	650	0	650	677	185	0	862	
May 05	2,161	1,045	0	43.55	3,206	177	400	250	870	1,120		650	650	0	650	677	185	0	862	
May 06	2,158	1,045	0	45.62	3,203	174	400	250	875	1,125		650	650	0	650	677	185	0	862	
May 07	2,154	1,050	0	47.70	3,204	171	400	250	875	1,125		650	650	0	650	677	185	0	862	
May 08	2,151	1,055	0	49.80	3,206	168	400	250	880	1,130		650	650	0	650	677	185	0	862	
May 09	2,148	1,060	0	51.90	3,208	164	400	250	880	1,130		650	650	0	650	677	185	0	862	
May 10	2,145	1,060	0	54.00	3,205	161	400	250	880	1,130		650	650	0	650	677	185	0	862	
May 11	2,141	1,065	0	56.11	3,206	158	400	250	880	1,130		650	650	0	650	677	185	0	862	
May 12	2,138	1,065	0	58.22	3,203	154	400	250	750	1,000		650	650	0	650	677	185	0	862	
May 13	2,135	1,065	0	60.34	3,200	151	400	250	250	500		650	650	0	650	677	185	0	862	
May 14	2,131	1,065	0	62.45	3,196	148	400	250		250		400	400		400	677			677	
May 15	2,128	935	0	64.30	3,063	144	400	250		250		250	250		250	677			677	
May 16	1,875	250			2,125	141	400	250		250		175	175		175	677			677	
May 17	1,721	0			1,721	138	400	250		250		175	175		175	677			677	
May 18	1,643	0			1,643	135	400	250		250		175	175		175	677			677	
May 19	1,640	0			1,640	131	400	250		250		175	175		175	677			677	
May 20	1,637	0			1,637	128	400	250		250		175	175		175	677			677	
May 21	1,633	0			1,633	125	400	250		250		175	175		175	677			677	
May 22	1,630	0			1,630	121	400	250		250		175	175		175	677			677	
May 23	1,627	0			1,627	118	400	250		250		175	175		175	677			677	
May 24	1,623	0			1,623	115	400	250		250		175	175		175	677			677	
May 25	1,620	0			1,620	111	400	250		250		175	175		175	677			677	
May 26	1,617	0			1,617	108	400	250		250		175	175		175	677			677	
May 27	1,613	0			1,613	105	400	250		250		175	175		175	677			677	
May 28	1,610	0			1,610	102	400	250		250		175	175		175	677			677	
May 29	1,607	0			1,607	98	400	250		250		175	175		175	677			677	
May 30	1,604	0			1,604	95	400	250		250		175	175		175	677			677	
May 31	1,600	0			1,600	92	400	250		250		140	140		140	677			677	
	VAMP period																			
Mean (cfs):	2,154	1,046			3,200	201	400	250	675	925		650	650	163	813	654	208	0	862	
Suppl. Water (TAF)		64.30							41.50		0.00			10.00			12.80	0.00		

Pulse flow period

Period of desired flow stability

DAILY OPERATION PLAN, MARCH 13, 2002

Pulse Period: April 15–May 15 • Flow Target: 3,200cfs

Ungaged Flow at Vernalis = 800cfs • (B) AVG~50% Exceedence

San Joaquin River near Vernalis							Merced River at Cressey			Exchange Contractors	Tuolumne River at LaGrange				Stanislaus River below Goodwin					
Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	VAMP Suppl. Flow	VAMP Flow (3-day lag)	VAMP Suppl. Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol.	
(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		
[calc]	[calc]		[calc]	[calc]					[calc]					[calc]				[calc]		
					548	800	250		250		150	150		150	685			685		Apr 01
					544	800	250		250		150	150		150	685			685		Apr 02
					540	800	250		250		150	150		150	685			685		Apr 03
2,429				2,429	536	800	250		250		150	150		150	685			685		Apr 04
2,425				2,425	532	800	250		250		150	150		150	685			685		Apr 05
2,421				2,421	528	800	250		250		150	150		150	685			685		Apr 06
2,417				2,417	524	800	250		250		150	150		150	685			685		Apr 07
2,413				2,413	520	800	250		250		150	150		150	685			685		Apr 08
2,409				2,409	516	800	250		250		150	150		150	685			685		Apr 09
2,405				2,405	512	800	250		250		150	150		150	685			685		Apr 10
2,401				2,401	508	800	250		250		150	150		150	685			685		Apr 11
2,397				2,397	504	800	250	250	500		150	150		150	685			685		Apr 12
2,393	0			2,393	500	800	250	300	550		845	680	0	680	685		0	685		Apr 13
2,389	0			2,389	496	800	250	300	550		845	680	0	680	685	0	0	685		Apr 14
2,915	250	0	0.50	3,165	491	800	250	300	550		845	680	0	680	685	0	0	685		Apr 15
2,911	300	0	1.09	3,211	487	800	250	300	550		845	680	0	680	685	0	0	685		Apr 16
2,906	300	0	1.69	3,206	483	800	250	300	550		845	680	0	680	685	0	0	685		Apr 17
2,902	300	0	2.28	3,202	478	800	250	60	310		845	680	0	680	685	0	0	685		Apr 18
2,898	300	0	2.88	3,198	474	800	250	60	310		845	680	0	680	955	0	0	955		Apr 19
2,893	300	0	3.47	3,193	469	800	250	60	310		845	680	0	680	955	0	0	955		Apr 20
3,159	60	0	3.59	3,219	465	800	250	50	300		845	680	0	680	955	0	0	955		Apr 21
3,154	60	0	3.71	3,214	461	800	250	50	300		845	680	0	680	955	0	0	955		Apr 22
3,150	60	0	3.83	3,210	456	800	250	45	295		845	680	0	680	955	0	0	955		Apr 23
3,146	50	0	3.93	3,196	452	800	250	0	250		845	690	0	690	955	0	0	955		Apr 24
3,141	50	0	4.03	3,191	448	800	250	0	250		845	1,300	0	1,300	415	0	0	415		Apr 25
3,147	45	0	4.12	3,192	443	800	250	0	250		845	1,300	0	1,300	415	0	0	415		Apr 26
3,213	0	0	4.12	3,213	439	800	250	0	250		845	1,300	0	1,300	415	0	0	415		Apr 27
3,208	0	0	4.12	3,208	435	800	250	0	250		845	1,300	0	1,300	415	0	0	415		Apr 28
3,204	0	0	4.12	3,204	430	800	250	0	250		845	1,300	0	1,300	415	0	0	415		Apr 29
3,200	0	0	4.12	3,200	426	800	250	0	250		845	1,300	0	1,300	415	0	0	415		Apr 30
3,195	0	0	4.12	3,195	421	800	250	0	250		845	800	0	800	954	0	0	954		May 01
3,191	0	0	4.12	3,191	417	800	250	0	250		845	800	0	800	954	0	0	954		May 02
3,225	0	0	4.12	3,225	413	800	250	0	250		845	800	0	800	954	0	0	954		May 03
3,221	0	0	4.12	3,221	408	800	250	0	250		845	800	0	800	954	0	0	954		May 04
3,217	0	0	4.12	3,217	404	800	250	0	250		845	800	0	800	954	0	0	954		May 05
3,212	0	0	4.12	3,212	400	800	250	0	250		845	800	0	800	954	0	0	954		May 06
3,208	0	0	4.12	3,208	395	800	250	0	250		845	800	0	800	954	0	0	954		May 07
3,204	0	0	4.12	3,204	391	800	250	0	250		845	800	0	800	954	0	0	954		May 08
3,199	0	0	4.12	3,199	386	800	250	0	250		845	800	0	800	954	0	0	954		May 09
3,195	0	0	4.12	3,195	382	800	250	0	250		845	800	0	800	954	0	0	954		May 10
3,190	0	0	4.12	3,190	378	800	250	0	250		845	800	0	800	954	0	0	954		May 11
3,186	0	0	4.12	3,186	373	800	250	0	250		845	800	0	800	954	0	0	954		May 12
3,182	0	0	4.12	3,182	369	800	250		250		845	800	0	800	954	0	0	954		May 13
3,177	0	0	4.12	3,177	365	800	250		250		500	450		450	954			954		May 14
3,173	0	0	4.12	3,173	361	800	250		250		350	300		300	954			954		May 15
2,819	0			2,819	357	800	250		250		250	175		175	954			954		May 16
2,665	0			2,665	353	800	250		250		175	175		175	954			954		May 17
2,536	0			2,536	349	800	250		250		175	175		175	954			954		May 18
2,532	0			2,532	345	800	250		250		175	175		175	954			954		May 19
2,528	0			2,528	341	800	250		250		175	175		175	954			954		May 20
2,524	0			2,524	337	800	250		250		175	175		175	954			954		May 21
2,520	0			2,520	333	800	250		250		175	175		175	954			954		May 22
2,516	0			2,516	329	800	250		250		175	175		175	954			954		May 23
2,512	0			2,512	325	800	250		250		175	175		175	954			954		May 24
2,508	0			2,508	321	800	250		250		175	175		175	954			954		May 25
2,504	0			2,504	317	800	250		250		175	175		175	954			954		May 26
2,500	0			2,500	313	800	250		250		175	175		175	954			954		May 27
2,496	0			2,496	309	800	250		250		175	175		175	954			954		May 28
2,492	0			2,492	305	800	250		250		175	175		175	954			954		May 29
2,488	0			2,488	301	800	250		250		175	175		175	954			954		May 30
2,484	0			2,484	297	800	250		250		140	140		140	954			954		May 31
									VAMP period											
3,133	67			3,200	435	800	250	67	317		845	851	0	851	798	0	0	798		Mean (cfs):
	4.12							4.12		0.00			0.00			0.00	0.00			Suppl. Water (TAF)

Pulse flow period

Period of desired flow stability

DAILY OPERATION PLAN, MARCH 22, 2002

Pulse Period: April 15–May 15 • Flow Target: 3,200cfs

Ungaged Flow at Vernalis = 400 cfs • (A) Low

	San Joaquin River near Vernalis							Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus River below Goodwin				
	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. Flow	Exch Contr VAMP Suppl. Flow	VAMP Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol. S=Stan.
	(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	
	[calc]	[calc]		[calc]	[calc]						[calc]				[calc]				[calc]	
Apr 01						290	400	250			250	150	150		150	637			637	
Apr 02						286	400	250			250	150	150		150	637			637	
Apr 03						283	400	250			250	150	150		150	637			637	
Apr 04	1,723				1,723	280	400	250			250	150	150		150	637			637	
Apr 05	1,720				1,720	276	400	250			250	150	150		150	637			637	
Apr 06	1,717				1,717	273	400	250			250	150	150		150	637			637	
Apr 07	1,713				1,713	270	400	250			250	150	150		150	637			637	
Apr 08	1,710				1,710	267	400	250			250	150	150		150	637			637	
Apr 09	1,707				1,707	263	400	250			250	150	150		150	637			637	
Apr 10	1,704				1,704	260	400	250			250	150	150		150	637			637	
Apr 11	1,700				1,700	257	400	250	50		300	150	150		150	637			637	
Apr 12	1,697				1,697	253	400	250	238	82	570	150	150		150	637			637	
Apr 13	1,694	0			1,694	250	400	250	248	82	580	945	945	0	945	637	393	0	1,030	
Apr 14	1,690	50			1,740	247	400	250	248	82	580	945	945	0	945	637	393	0	1,030	
Apr 15	2,482	713	0	1.41	3,195	243	400	250	258	82	590	945	945	0	945	637	393	0	1,030	
Apr 16	2,479	723	0	2.85	3,202	240	400	250	258	82	590	945	945	0	945	637	393	0	1,030	
Apr 17	2,475	723	0	4.28	3,198	237	400	250	268	82	600	945	945	0	945	637	393	0	1,030	
Apr 18	2,472	733	0	5.74	3,205	234	400	250	268	82	600	945	945	0	945	637	393	0	1,030	
Apr 19	2,469	733	0	7.19	3,202	230	400	250	268	82	600	945	945	0	945	637	393	0	1,030	
Apr 20	2,466	743	0	8.66	3,209	227	400	250	269	81	600	945	945	0	945	637	393	0	1,030	
Apr 21	2,462	743	0	10.14	3,205	224	400	250	269	81	600	945	945	0	945	637	393	0	1,030	
Apr 22	2,459	743	0	11.61	3,202	220	400	250	269	81	600	945	945	0	945	637	383	0	1,020	
Apr 23	2,456	743	0	13.08	3,199	217	400	250	269	81	600	945	945	0	945	637	383	0	1,020	
Apr 24	2,452	733	0	14.54	3,185	214	400	250	269	81	600	945	945	355	1,300	637	63	0	700	T
Apr 25	2,449	733	0	15.99	3,182	210	400	250	269	81	600	945	945	355	1,300	637	63	0	700	T
Apr 26	2,446	768	0	17.52	3,214	207	400	250	269	81	600	945	945	355	1,300	637	63	0	700	T, S
Apr 27	2,442	768	0	19.04	3,210	204	400	250	269	81	600	945	945	355	1,300	637	63	0	700	T, S
Apr 28	2,439	768	0	20.56	3,207	201	400	250	269	81	600	945	945	355	1,300	637	63	0	700	T, S
Apr 29	2,436	768	0	22.09	3,204	197	400	250	279	81	610	945	945	355	1,300	637	63	0	700	T, S
Apr 30	2,433	768	0	23.61	3,201	194	400	250	279	81	610	945	945	355	1,300	637	63	0	700	T, S
May 01	2,429	768	0	25.13	3,197	191	400	250	379	81	710	945	945	355	1,300	677	23	0	700	T, S
May 02	2,426	778	0	26.68	3,204	187	400	250	639	81	970	945	945	265	1,210	677	23	0	700	S
May 03	2,463	738	0	28.14	3,201	184	400	250	649	81	980	945	945	0	945	677	23	0	700	S
May 04	2,459	748	0	29.62	3,207	181	400	250	669	81	1,000	945	945	0	945	677	23	0	700	M
May 05	2,456	743	0	31.10	3,199	177	400	250	669	81	1,000	945	945	0	945	677	23	0	700	M
May 06	2,453	753	0	32.59	3,206	174	400	250	669	81	1,000	945	945	0	945	677	23	0	700	M
May 07	2,449	773	0	34.12	3,222	171	400	250	669	81	1,000	945	945	0	945	677	23	0	700	M
May 08	2,446	773	0	35.66	3,219	168	400	250	669	81	1,000	945	945	0	945	677	23	0	700	M
May 09	2,443	773	0	37.19	3,216	164	400	250	669	81	1,000	945	945	0	945	677	23	0	700	M
May 10	2,440	773	0	38.72	3,213	161	400	250	669	81	1,000	945	945	0	945	677	23	0	700	M
May 11	2,436	773	0	40.26	3,209	158	400	250	669	81	1,000	945	945	0	945	677	23	0	700	M
May 12	2,433	773	0	41.79	3,206	154	400	250	554	81	885	945	945	0	945	677	23	0	700	
May 13	2,430	773	0	43.32	3,203	151	400	250	200		450	945	945	0	945	677	23	0	700	
May 14	2,426	773	0	44.86	3,199	148	400	250			250	500	500		500	677			677	
May 15	2,423	658	0	46.16	3,081	144	400	250			250	350	350		350	677			677	
May 16	1,975	200			2,175	141	400	250			250	250	250		250	677			677	
May 17	1,821	0			1,821	138	400	250			250	175	175		175	677			677	
May 18	1,718	0			1,718	135	400	250			250	175	175		175	677			677	
May 19	1,640	0			1,640	131	400	250			250	175	175		175	677			677	
May 20	1,637	0			1,637	128	400	250			250	175	175		175	677			677	
May 21	1,633	0			1,633	125	400	250			250	175	175		175	677			677	
May 22	1,630	0			1,630	121	400	250			250	175	175		175	677			677	
May 23	1,627	0			1,627	118	400	250			250	175	175		175	677			677	
May 24	1,623	0			1,623	115	400	250			250	175	175		175	677			677	
May 25	1,620	0			1,620	111	400	250			250	175	175		175	677			677	
May 26	1,617	0			1,617	108	400	250			250	175	175		175	677			677	
May 27	1,613	0			1,613	105	400	250			250	175	175		175	677			677	
May 28	1,610	0			1,610	102	400	250			250	175	175		175	677			677	
May 29	1,607	0			1,607	98	400	250			250	175	175		175	677			677	
May 30	1,604	0			1,604	95	400	250			250	175	175		175	677			677	
May 31	1,600	0			1,600	92	400	250			250	140	140		140	677			677	
	VAMP period																			
Mean (cfs):	2,449	751			3,200	201	400	250	407	81	738	945	945	100	1,045	654	163	0	816	
Suppl. Water (TAF)	46.16							25.00	5.00				6.16			10.00	0.00			

Pulse flow period

Period of desired flow stability

DAILY OPERATION PLAN, MARCH 22, 2002

Pulse Period: April 15–May 15 • Flow Target: 3,200cfs

Ungaged Flow at Vernalis = 600cfs • (B) High

San Joaquin River near Vernalis							Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus River below Goodwin					
Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. Flow	Exch Contr VAMP Suppl. Flow	VAMP Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol.	
(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		
[calc]	[calc]		[calc]	[calc]						[calc]				[calc]				[calc]		
					548	600	250			250	150	150		150	637			637		Apr 01
					544	600	250			250	150	150		150	637			637		Apr 02
					540	600	250			250	150	150		150	637			637		Apr 03
2,181				2,181	536	600	250			250	150	150		150	637			637		Apr 04
2,177				2,177	532	600	250			250	150	150		150	637			637		Apr 05
2,173				2,173	528	600	250			250	150	150		150	637			637		Apr 06
2,169				2,169	524	600	250			250	150	150		150	637			637		Apr 07
2,165				2,165	520	600	250			250	150	150		150	637			637		Apr 08
2,161				2,161	516	600	250			250	150	150		150	637			637		Apr 09
2,157				2,157	512	600	250			250	150	150		150	637			637		Apr 10
2,153				2,153	508	600	250	50		300	150	150		150	637			637		Apr 11
2,149				2,149	504	600	250	305	0	555	150	150		150	637			637		Apr 12
2,145	0			2,145	500	600	250	400	0	650	945	830	0	830	637		0	637		Apr 13
2,141	50			2,191	496	600	250	400	0	650	945	830	0	830	637	0	0	637		Apr 14
2,817	305	0	0.60	3,122	491	600	250	400	0	650	945	830	0	830	637	0	0	637		Apr 15
2,813	400	0	1.40	3,213	487	600	250	400	0	650	945	830	0	830	637	0	0	637		Apr 16
2,808	400	0	2.19	3,208	483	600	250	410	0	660	945	830	0	830	637	0	0	637		Apr 17
2,804	400	0	2.99	3,204	478	600	250	410	0	660	945	830	0	830	637	0	0	637		Apr 18
2,800	400	0	3.78	3,200	474	600	250	420	0	670	945	830	0	830	637	0	0	637		Apr 19
2,795	410	0	4.59	3,205	469	600	250	420	0	670	945	830	0	830	637	0	0	637		Apr 20
2,791	410	0	5.40	3,201	465	600	250	420	0	670	945	830	0	830	637	0	0	637		Apr 21
2,786	420	0	6.24	3,206	461	600	250	250	0	500	945	830	0	830	637	0	0	637		Apr 22
2,782	420	0	7.07	3,202	456	600	250	0	0	250	945	1,000	0	1,000	637	0	0	637		Apr 23
2,778	420	0	7.90	3,198	452	600	250	0	0	250	945	1,280	0	1,280	637	0	0	637	T	Apr 24
2,943	250	0	8.40	3,193	448	600	250	0	0	250	945	1,280	0	1,280	637	0	0	637	T	Apr 25
3,219	0	0	8.40	3,219	443	600	250	0	0	250	945	1,280	0	1,280	637	0	0	637	T, S	Apr 26
3,215	0	0	8.40	3,215	439	600	250	0	0	250	945	1,280	0	1,280	637	0	0	637	T, S	Apr 27
3,210	0	0	8.40	3,210	435	600	250	0	0	250	945	1,280	0	1,280	637	0	0	637	T, S	Apr 28
3,206	0	0	8.40	3,206	430	600	250	0	0	250	945	1,280	0	1,280	637	0	0	637	T, S	Apr 29
3,202	0	0	8.40	3,202	426	600	250	190	0	440	945	1,280	0	1,280	637	0	0	637	T, S	Apr 30
3,197	0	0	8.40	3,197	421	600	250	430	0	680	945	1,075	0	1,075	677	0	0	677	T, S	May 01
3,193	0	0	8.40	3,193	417	600	250	430	0	680	945	830	0	830	677	0	0	677	S	May 02
3,023	190	0	8.78	3,213	413	600	250	440	0	690	945	830	0	830	677	0	0	677	S	May 03
2,774	430	0	9.63	3,204	408	600	250	455	0	705	945	830	0	830	677	0	0	677	M	May 04
2,770	430	0	10.48	3,200	404	600	250	455	0	705	945	830	0	830	677	0	0	677	M	May 05
2,765	440	0	11.36	3,205	400	600	250	455	0	705	945	830	0	830	677	0	0	677	M	May 06
2,761	455	0	12.26	3,216	395	600	250	455	0	705	945	830	0	830	677	0	0	677	M	May 07
2,757	455	0	13.16	3,212	391	600	250	455	0	705	945	830	0	830	677	0	0	677	M	May 08
2,752	455	0	14.06	3,207	386	600	250	455	0	705	945	830	0	830	677	0	0	677	M	May 09
2,748	455	0	14.97	3,203	382	600	250	455	0	705	945	830	0	830	677	0	0	677	M	May 10
2,743	455	0	15.87	3,198	378	600	250	455	0	705	945	830	0	830	677	0	0	677	M	May 11
2,739	455	0	16.77	3,194	373	600	250	450	0	700	945	830	0	830	677	0	0	677		May 12
2,735	455	0	17.67	3,190	369	600	250	100		350	945	830	0	830	677	0	0	677		May 13
2,730	455	0	18.58	3,185	365	600	250			250	500	500		500	677			677		May 14
2,726	450	0	19.47	3,176	361	600	250			250	350	350		350	677			677		May 15
2,392	100			2,492	357	600	250			250	250	250		250	677			677		May 16
2,238	0			2,238	353	600	250			250	175	175		175	677			677		May 17
2,134	0			2,134	349	600	250			250	175	175		175	677			677		May 18
2,055	0			2,055	345	600	250			250	175	175		175	677			677		May 19
2,051	0			2,051	341	600	250			250	175	175		175	677			677		May 20
2,047	0			2,047	337	600	250			250	175	175		175	677			677		May 21
2,043	0			2,043	333	600	250			250	175	175		175	677			677		May 22
2,039	0			2,039	329	600	250			250	175	175		175	677			677		May 23
2,035	0			2,035	325	600	250			250	175	175		175	677			677		May 24
2,031	0			2,031	321	600	250			250	175	175		175	677			677		May 25
2,027	0			2,027	317	600	250			250	175	175		175	677			677		May 26
2,023	0			2,023	313	600	250			250	175	175		175	677			677		May 27
2,019	0			2,019	309	600	250			250	175	175		175	677			677		May 28
2,015	0			2,015	305	600	250			250	175	175		175	677			677		May 29
2,011	0			2,011	301	600	250			250	175	175		175	677			677		May 30
2,007	0			2,007	297	600	250			250	140	140		140	677			677		May 31
VAMP period																				
2,883	317			3,200	435	600	250	317	0	567	945	945	0	945	654	0	0	654		Mean (cfs):
	19.47							19.47	0.00				0.00			0.00	0.00			Suppl. Water (TAF)

Pulse flow period

Period of desired flow stability

DAILY OPERATION PLAN, MARCH 28, 2002

Pulse Period: April 15–May 15 • Flow Target: 3,200cfs

Ungaged Flow at Vernalis = 400cfs • (A) Low

	San Joaquin River near Vernalis							Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus River below Goodwin				
	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. Flow	Exch Contr VAMP Suppl. Flow	VAMP Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol. S=Stan.
	(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	
	[calc]	[calc]		[calc]	[calc]						[calc]				[calc]				[calc]	
Apr 01						290	400	250			250	150	150		150	637			637	
Apr 02						286	400	250			250	150	150		150	637			637	
Apr 03						283	400	250			250	150	150		150	637			637	
Apr 04	1,723				1,723	280	400	250			250	150	150		150	637			637	
Apr 05	1,720				1,720	276	400	250			250	150	150		150	637			637	
Apr 06	1,717				1,717	273	400	250			250	150	150		150	637			637	
Apr 07	1,713				1,713	270	400	250			250	150	150		150	637			637	
Apr 08	1,710				1,710	267	400	250			250	150	150		150	637			637	
Apr 09	1,707				1,707	263	400	250			250	150	150		150	637			637	
Apr 10	1,704				1,704	260	400	250			250	150	150		150	637			637	
Apr 11	1,700				1,700	257	400	250			250	150	150		150	637			637	
Apr 12	1,697				1,697	253	400	250	165	85	500	150	150		150	637			637	
Apr 13	1,694	0			1,694	250	400	250	190	85	525	945	760	0	760	800	480	0	1,280	
Apr 14	1,690	0			1,690	247	400	250	190	85	525	945	760	0	760	800	480	0	1,280	
Apr 15	2,460	730	0	1.45	3,190	243	400	250	190	85	525	945	760	0	760	800	480	0	1,280	
Apr 16	2,457	755	0	2.95	3,212	240	400	250	190	85	525	945	760	0	760	800	480	0	1,280	
Apr 17	2,453	755	0	4.44	3,208	237	400	250	200	85	535	945	760	0	760	800	480	0	1,280	
Apr 18	2,450	755	0	5.94	3,205	234	400	250	200	85	535	945	760	0	760	800	480	0	1,280	
Apr 19	2,447	755	0	7.44	3,202	230	400	250	200	85	535	945	760	0	760	800	480	0	1,280	
Apr 20	2,444	765	0	8.96	3,209	227	400	250	210	80	540	945	760	0	760	800	480	0	1,280	
Apr 21	2,440	765	0	10.47	3,205	224	400	250	210	80	540	945	760	0	760	800	480	0	1,280	
Apr 22	2,437	765	0	11.99	3,202	220	400	250	260	80	590	945	760	0	760	800	480	0	1,280	
Apr 23	2,434	770	0	13.52	3,204	217	400	250	260	80	590	945	970	10	980	790	240	0	1,030	
Apr 24	2,430	770	0	15.04	3,200	214	400	250	260	80	590	945	1,230	70	1,300	700	0	0	700	T
Apr 25	2,627	590	0	16.21	3,217	210	400	250	270	80	600	945	1,230	70	1,300	700	0	0	700	T
Apr 26	2,794	410	0	17.03	3,204	207	400	250	270	80	600	945	1,230	70	1,300	700	0	0	700	T, S
Apr 27	2,790	410	0	17.84	3,200	204	400	250	280	80	610	945	1,230	70	1,300	700	0	0	700	T, S
Apr 28	2,787	420	0	18.67	3,207	201	400	250	280	80	610	945	1,230	70	1,300	700	0	0	700	T, S
Apr 29	2,784	420	0	19.51	3,204	197	400	250	280	80	610	945	1,230	70	1,300	700	0	0	700	T, S
Apr 30	2,781	430	0	20.36	3,211	194	400	250	280	80	610	945	1,230	70	1,300	700	0	0	700	T, S
May 01	2,777	430	0	21.21	3,207	191	400	250	590	80	920	945	1,230	70	1,300	700	0	0	700	T, S
May 02	2,774	430	0	22.07	3,204	187	400	250	690	80	1,020	945	985	15	1,000	700	0	0	700	S
May 03	2,771	430	0	22.92	3,201	184	400	250	690	80	1,020	945	900	0	900	700	0	0	700	S
May 04	2,522	685	0	24.28	3,207	181	400	250	710	80	1,040	945	900	0	900	700	0	0	700	M
May 05	2,434	770	0	25.80	3,204	177	400	250	710	80	1,040	945	900	0	900	700	0	0	700	M
May 06	2,431	770	0	27.33	3,201	174	400	250	710	80	1,040	945	900	0	900	700	0	0	700	M
May 07	2,427	790	0	28.90	3,217	171	400	250	710	80	1,040	945	900	0	900	700	0	0	700	M
May 08	2,424	790	0	30.47	3,214	168	400	250	710	80	1,040	945	900	0	900	700	0	0	700	M
May 09	2,421	790	0	32.03	3,211	164	400	250	710	80	1,040	945	900	0	900	700	0	0	700	M
May 10	2,418	790	0	33.60	3,208	161	400	250	710	80	1,040	945	900	0	900	700	0	0	700	M
May 11	2,414	790	0	35.17	3,204	158	400	250	710	80	1,040	945	900	0	900	700	0	0	700	M
May 12	2,411	790	0	36.73	3,201	154	400	250	570	80	900	945	900	0	900	700	0	0	700	
May 13	2,408	790	0	38.30	3,198	151	400	250	200		450	945	900	0	900	700	0	0	700	
May 14	2,404	790	0	39.87	3,194	148	400	250			250	500	500		500	677			677	
May 15	2,401	650	0	41.16	3,051	144	400	250			250	350	350		350	677			677	
May 16	1,975	200			2,175	141	400	250			250	250	250		250	677			677	
May 17	1,821	0			1,821	138	400	250			250	175	175		175	677			677	
May 18	1,718	0			1,718	135	400	250			250	175	175		175	677			677	
May 19	1,640	0			1,640	131	400	250			250	175	175		175	677			677	
May 20	1,637	0			1,637	128	400	250			250	175	175		175	677			677	
May 21	1,633	0			1,633	125	400	250			250	175	175		175	677			677	
May 22	1,630	0			1,630	121	400	250			250	175	175		175	677			677	
May 23	1,627	0			1,627	118	400	250			250	175	175		175	677			677	
May 24	1,623	0			1,623	115	400	250			250	175	175		175	677			677	
May 25	1,620	0			1,620	111	400	250			250	175	175		175	677			677	
May 26	1,617	0			1,617	108	400	250			250	175	175		175	677			677	
May 27	1,613	0			1,613	105	400	250			250	175	175		175	677			677	
May 28	1,610	0			1,610	102	400	250			250	175	175		175	677			677	
May 29	1,607	0			1,607	98	400	250			250	175	175		175	677			677	
May 30	1,604	0			1,604	95	400	250			250	175	175		175	677			677	
May 31	1,600	0			1,600	92	400	250			250	140	140		140	677			677	
	VAMP period																			
Mean (cfs):	2,531	669			3,200	201	400	250	407	81	738	945	945	19	964	735	163	0	898	
Suppl. Water (TAF)		41.16							25.00	5.00				1.16			10.00	0.00		

Pulse flow period

Period of desired flow stability

DAILY OPERATION PLAN, MARCH 28, 2002

Pulse Period: April 15–May 15 • Flow Target: 4,450cfs

Ungaged Flow at Vernalis=600cfs • (B) High

San Joaquin River near Vernalis							Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus River below Goodwin					
Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. Flow	Exch Contr VAMP Suppl. Flow	VAMP Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol.	
(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		
[calc]	[calc]		[calc]	[calc]						[calc]				[calc]				[calc]		
					548	600	250			250	150	150		150	685			685		Apr 01
					544	600	250			250	150	150		150	685			685		Apr 02
					540	600	250			250	150	150		150	685			685		Apr 03
2,229				2,229	536	600	250			250	150	150		150	685			685		Apr 04
2,225				2,225	532	600	250			250	150	150		150	685			685		Apr 05
2,221				2,221	528	600	250			250	150	150		150	685			685		Apr 06
2,217				2,217	524	600	250			250	150	150		150	685			685		Apr 07
2,213				2,213	520	600	250			250	150	150		150	685			685		Apr 08
2,209				2,209	516	600	250			250	150	150		150	685			685		Apr 09
2,205				2,205	512	600	250			250	150	150		150	685			685		Apr 10
2,201				2,201	508	600	250	150		400	150	150		150	685			685		Apr 11
2,197				2,197	504	600	250	465	85	800	150	150		150	685			685		Apr 12
2,193	0			2,193	500	600	250	570	85	905	945	945	15	960	1,295	205	0	1,500		Apr 13
2,189	150			2,339	496	600	250	570	85	905	945	945	15	960	1,295	205	0	1,500		Apr 14
3,590	770	0	1.53	4,360	491	600	250	570	85	905	945	945	15	960	1,295	205	0	1,500		Apr 15
3,586	875	0	3.26	4,461	487	600	250	580	85	915	945	945	15	960	1,295	205	0	1,500		Apr 16
3,581	875	0	5.00	4,456	483	600	250	580	85	915	945	945	15	960	1,295	205	0	1,500		Apr 17
3,577	875	0	6.73	4,452	478	600	250	600	85	935	945	945	15	960	1,295	205	0	1,500		Apr 18
3,573	885	0	8.49	4,458	474	600	250	600	85	935	945	945	15	960	1,295	205	0	1,500		Apr 19
3,568	885	0	10.24	4,453	469	600	250	600	80	930	945	945	15	960	1,295	205	0	1,500		Apr 20
3,564	905	0	12.04	4,469	465	600	250	420	80	750	945	945	15	960	1,295	205	0	1,500		Apr 21
3,559	905	0	13.83	4,464	461	600	250	270	80	600	945	945	200	1,145	1,295	205	0	1,500		Apr 22
3,555	900	0	15.62	4,455	456	600	250	270	80	600	945	945	355	1,300	1,295	205	0	1,500		Apr 23
3,551	905	0	17.41	4,456	452	600	250	330	80	660	945	945	355	1,300	1,295	205	0	1,500		Apr 24
3,546	910	0	19.22	4,456	448	600	250	360	80	690	945	945	355	1,300	1,295	150	0	1,445		Apr 25
3,542	910	0	21.02	4,452	443	600	250	360	80	690	945	945	355	1,300	1,295	135	0	1,430	T, S	Apr 26
3,538	915	0	22.84	4,453	439	600	250	360	80	690	945	945	355	1,300	1,295	135	0	1,430	T, S	Apr 27
3,533	930	0	24.68	4,463	435	600	250	360	80	690	945	945	355	1,300	1,295	135	0	1,430	T, S	Apr 28
3,529	930	0	26.53	4,459	430	600	250	370	80	700	945	945	355	1,300	1,295	135	0	1,430	T, S	Apr 29
3,525	930	0	28.37	4,455	426	600	250	370	80	700	945	945	355	1,300	1,295	135	0	1,430	T, S	Apr 30
3,520	930	0	30.22	4,450	421	600	250	375	80	705	945	945	355	1,300	1,295	135	0	1,430	T, S	May 01
3,516	940	0	32.08	4,456	417	600	250	540	80	870	945	945	355	1,300	1,295	135	0	1,430	S	May 02
3,511	940	0	33.95	4,451	413	600	250	640	80	970	945	945	200	1,145	1,295	135	0	1,430	S	May 03
3,507	945	0	35.82	4,452	408	600	250	670	80	1,000	945	945	100	1,045	1,295	135	0	1,430	M	May 04
3,503	955	0	37.72	4,458	404	600	250	670	80	1,000	945	945	95	1,040	1,295	135	0	1,430	M	May 05
3,498	955	0	39.61	4,453	400	600	250	670	80	1,000	945	945	95	1,040	1,295	135	0	1,430	M	May 06
3,494	980	0	41.55	4,474	395	600	250	670	80	1,000	945	945	95	1,040	1,295	135	0	1,430	M	May 07
3,490	980	0	43.50	4,470	391	600	250	670	80	1,000	945	945	95	1,040	1,295	135	0	1,430	M	May 08
3,485	980	0	45.44	4,465	386	600	250	670	80	1,000	945	945	95	1,040	1,295	135	0	1,430	M	May 09
3,481	980	0	47.39	4,461	382	600	250	670	80	1,000	945	945	95	1,040	1,295	135	0	1,430	M	May 10
3,476	980	0	49.33	4,456	378	600	250	670	80	1,000	945	945	95	1,040	1,295	135	0	1,430	M	May 11
3,472	980	0	51.27	4,452	373	600	250	570	80	900	945	945	95	1,040	1,295	135	0	1,430		May 12
3,468	980	0	53.22	4,448	369	600	250	200		450	945	945	95	1,040	1,295	135	0	1,430		May 13
3,463	980	0	55.16	4,443	365	600	250			250	500	500		500	723			723		May 14
3,459	880	0	56.91	4,339	361	600	250			250	350	350		350	723			723		May 15
2,438	200			2,638	357	600	250			250	250	250		250	723			723		May 16
2,284	0			2,284	353	600	250			250	175	175		175	723			723		May 17
2,180	0			2,180	349	600	250			250	175	175		175	723			723		May 18
2,101	0			2,101	345	600	250			250	175	175		175	723			723		May 19
2,097	0			2,097	341	600	250			250	175	175		175	723			723		May 20
2,093	0			2,093	337	600	250			250	175	175		175	723			723		May 21
2,089	0			2,089	333	600	250			250	175	175		175	723			723		May 22
2,085	0			2,085	329	600	250			250	175	175		175	723			723		May 23
2,081	0			2,081	325	600	250			250	175	175		175	723			723		May 24
2,077	0			2,077	321	600	250			250	175	175		175	723			723		May 25
2,073	0			2,073	317	600	250			250	175	175		175	723			723		May 26
2,069	0			2,069	313	600	250			250	175	175		175	723			723		May 27
2,065	0			2,065	309	600	250			250	175	175		175	723			723		May 28
2,061	0			2,061	305	600	250			250	175	175		175	723			723		May 29
2,057	0			2,057	301	600	250			250	175	175		175	723			723		May 30
2,053	0			2,053	297	600	250			250	140	140		140	723			723		May 31
VAMP period																				
3,525	925			4,450	435	600	250	519	81	850	945	945	163	1,108	1,295	163	0	1,458		Mean (cfs):
	56.91							31.91	5.00				10.00			10.00	0.00			Suppl. Water (TAF)

Pulse flow period

Period of desired flow stability

DAILY OPERATION PLAN, APRIL 8, 2002

Pulse Period: April 15–May 15 • Flow Target: 3,200cfs

Ungaged Flow at Vernalis = 400cfs

	San Joaquin River near Vernalis							Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus River below Goodwin				
	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	MelD VAMP Suppl. Flow	Exch Contr VAMP Suppl. Flow	VAMP Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol. S=Stan.
	(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	
	[calc]	[calc]		[calc]	[calc]						[calc]				[calc]				[calc]	
Apr 01					1,990	428	651	199			199	150	169		169	505			505	
Apr 02					1,810	422	476	189			189	150	171		171	504			504	
Apr 03					1,710	407	400	171			171	150	170		170	501			501	
Apr 04	1,660				1,660	390	364	173			173	150	172		172	504			504	
Apr 05	1,670				1,670	373	403	204			204	150	171		171	574			574	
Apr 06	1,710				1,710	324	473	213			213	150	172		172	603			603	
Apr 07	1,820				1,820	317	529	224			224	150	173		173	603			603	
Apr 08	1,923				1,923	314	620	250			250	150	150		150	637			637	
Apr 09	1,856				1,856	311	550	250			250	150	150		150	637			637	
Apr 10	1,825				1,825	309	500	250			250	150	150		150	637			637	
Apr 11	1,828				1,828	306	480	250			250	150	150		150	637			637	
Apr 12	1,806				1,806	303	460	250	0	0	250	150	150		150	637	363		1,000	
Apr 13	1,783	0			1,783	300	440	250	0	0	250	945	780	0	780	1,500	0	0	1,500	
Apr 14	1,760	363			2,123	297	420	250	0	0	250	945	780	0	780	1,500	0	0	1,500	
Apr 15	3,230	0	0	0.00	3,230	293	400	250	0	0	250	945	780	0	780	1,500	0	0	1,500	
Apr 16	3,227	0	0	0.00	3,227	290	400	250	0	0	250	945	780	0	780	1,500	0	0	1,500	
Apr 17	3,223	0	0	0.00	3,223	286	400	250	0	0	250	945	780	0	780	1,500	0	0	1,500	
Apr 18	3,220	0	0	0.00	3,220	283	400	250	0	0	250	945	780	0	780	1,500	0	0	1,500	
Apr 19	3,216	0	0	0.00	3,216	279	400	250	0	0	250	945	780	0	780	1,500	0	0	1,500	
Apr 20	3,213	0	0	0.00	3,213	276	400	250	0	0	250	945	780	0	780	1,500	0	0	1,500	
Apr 21	3,209	0	0	0.00	3,209	272	400	250	0	0	250	945	780	0	780	1,500	0	0	1,500	
Apr 22	3,206	0	0	0.00	3,206	269	400	250	240	0	490	945	780	0	780	1,500	0	0	1,500	
Apr 23	3,202	0	0	0.00	3,202	265	400	250	270	0	520	945	780	0	780	1,270	0	0	1,270	M
Apr 24	3,199	0	0	0.00	3,199	262	400	250	270	0	520	945	1,300	0	1,300	735	0	0	735	M,T
Apr 25	2,965	240	0	0.48	3,205	258	400	250	270	0	520	945	1,300	0	1,300	735	0	0	735	M,T
Apr 26	2,947	270	0	1.01	3,217	255	400	250	270	0	520	945	1,300	0	1,300	735	0	0	735	M,T,S
Apr 27	2,943	270	0	1.55	3,213	251	400	250	270	0	520	945	1,300	0	1,300	735	0	0	735	M,T,S
Apr 28	2,940	270	0	2.08	3,210	248	400	250	270	0	520	945	1,300	0	1,300	735	0	0	735	M,T,S
Apr 29	2,936	270	0	2.62	3,206	244	400	250	270	0	520	945	1,300	0	1,300	735	0	0	735	M,T,S
Apr 30	2,933	270	0	3.15	3,203	241	400	250	270	0	520	945	1,300	0	1,300	735	0	0	735	M,T,S
May 01	2,929	270	0	3.69	3,199	237	400	250	670	0	920	945	1,300	0	1,300	735	0	0	735	T,S
May 02	2,926	270	0	4.22	3,196	234	400	250	730	0	980	945	910	0	910	735	0	0	735	S
May 03	2,922	270	0	4.76	3,192	230	400	250	730	0	980	945	855	0	855	735	0	0	735	S
May 04	2,529	670	0	6.09	3,199	227	400	250	750	0	1,000	945	855	0	855	735	0	0	735	M
May 05	2,470	730	0	7.54	3,200	223	400	250	750	0	1,000	945	855	0	855	735	0	0	735	M
May 06	2,467	730	0	8.99	3,197	220	400	250	750	0	1,000	945	855	0	855	735	0	0	735	M
May 07	2,463	750	0	10.47	3,213	216	400	250	750	0	1,000	945	855	0	855	735	0	0	735	M
May 08	2,460	750	0	11.96	3,210	213	400	250	750	0	1,000	945	855	0	855	735	0	0	735	M
May 09	2,456	750	0	13.45	3,206	209	400	250	750	0	1,000	945	855	0	855	735	0	0	735	M
May 10	2,453	750	0	14.94	3,203	206	400	250	750	0	1,000	945	855	0	855	735	0	0	735	M
May 11	2,449	750	0	16.42	3,199	202	400	250	750	0	1,000	945	855	0	855	735	0	0	735	M
May 12	2,446	750	0	17.91	3,196	199	400	250	580	0	830	945	855	0	855	735	0	0	735	
May 13	2,442	750	0	19.40	3,192	195	400	250	170		420	945	855	0	855	735	0	0	735	
May 14	2,439	750	0	20.89	3,189	191	400	250			250	500	500		500	677			677	
May 15	2,435	580	0	22.04	3,015	187	400	250			250	350	350		350	677			677	
May 16	2,018	170			2,188	183	400	250			250	250	250		250	677			677	
May 17	1,864	0			1,864	179	400	250			250	175	175		175	677			677	
May 18	1,760	0			1,760	175	400	250			250	175	175		175	677			677	
May 19	1,681	0			1,681	171	400	250			250	175	175		175	677			677	
May 20	1,677	0			1,677	167	400	250			250	175	175		175	677			677	
May 21	1,673	0			1,673	163	400	250			250	175	175		175	677			677	
May 22	1,669	0			1,669	159	400	250			250	175	175		175	677			677	
May 23	1,665	0			1,665	155	400	250			250	175	175		175	677			677	
May 24	1,661	0			1,661	151	400	250			250	175	175		175	677			677	
May 25	1,657	0			1,657	147	400	250			250	175	175		175	677			677	
May 26	1,653	0			1,653	143	400	250			250	175	175		175	677			677	
May 27	1,649	0			1,649	139	400	250			250	175	175		175	677			677	
May 28	1,645	0			1,645	135	400	250			250	175	175		175	677			677	
May 29	1,641	0			1,641	131	400	250			250	175	175		175	677			677	
May 30	1,637	0			1,637	127	400	250			250	175	175		175	677			677	
May 31	1,633	0			1,633	123	400	250			250	140	140		140	677			677	
	VAMP period																			
Mean (cfs):	2,842	358			3,200	248	400	250	358	0	608	945	945	0	945	999	0	0	999	
Suppl. Water (TAF)		22.04							22.04	0.00				0.00			0.00	0.00		

Pulse flow period

Period of desired flow stability

DAILY OPERATION PLAN, APRIL 9, 2002

Pulse Period: April 15–May 15 • Flow Target: 3,200cfs

Ungaged Flow at Vernalis = 400cfs

San Joaquin River near Vernalis							Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus River below Goodwin					
Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. Flow	Exch Contr VAMP Suppl. Flow	VAMP Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol. S=Stan.	
(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		
[calc]	[calc]		[calc]	[calc]						[calc]				[calc]				[calc]		
				1,990	428	651	199			199	150	169		169	505			505		Apr 01
				1,810	422	476	189			189	150	171		171	504			504		Apr 02
				1,710	407	400	171			171	150	170		170	501			501		Apr 03
1,660				1,660	390	364	173			173	150	172		172	504			504		Apr 04
1,670				1,670	373	403	204			204	150	171		171	574			574		Apr 05
1,710				1,710	324	473	213			213	150	172		172	603			603		Apr 06
1,820				1,820	317	529	224			224	150	173		173	603			603		Apr 07
1,940				1,940	315	637	226			226	150	175		175	604			604		Apr 08
1,856				1,856	311	550	250			250	150	150		150	637			637		Apr 09
1,818				1,818	309	500	250			250	150	150		150	637			637		Apr 10
1,804				1,804	306	480	250			250	150	150		150	637			637		Apr 11
1,806				1,806	303	460	250	0	0	250	150	150	165	315	637	363		1,000		Apr 12
1,783	0			1,783	300	440	250	70	0	320	845	700	0	700	1,500	0	0	1,500		Apr 13
1,760	528			2,288	297	420	250	70	0	320	845	700	0	700	1,500	0	0	1,500		Apr 14
3,150	0	0	0.00	3,150	293	400	250	70	0	320	845	700	0	700	1,500	0	0	1,500		Apr 15
3,147	70	0	0.14	3,217	290	400	250	70	0	320	845	700	0	700	1,500	0	0	1,500		Apr 16
3,143	70	0	0.28	3,213	286	400	250	70	0	320	845	700	0	700	1,500	0	0	1,500		Apr 17
3,140	70	0	0.42	3,210	283	400	250	70	0	320	845	700	0	700	1,500	0	0	1,500		Apr 18
3,136	70	0	0.56	3,206	279	400	250	80	0	330	845	700	0	700	1,500	0	0	1,500		Apr 19
3,133	70	0	0.69	3,203	276	400	250	80	0	330	845	700	0	700	1,500	0	0	1,500		Apr 20
3,129	70	0	0.83	3,199	272	400	250	80	0	330	845	700	0	700	1,500	0	0	1,500		Apr 21
3,126	80	0	0.99	3,206	269	400	250	200	0	450	845	700	0	700	1,500	0	0	1,500		Apr 22
3,122	80	0	1.15	3,202	265	400	250	220	0	470	845	795	0	795	1,180	100	0	1,280	M	Apr 23
3,119	80	0	1.31	3,199	262	400	250	220	0	470	845	1,250	0	1,250	720	130	0	850	M,T	Apr 24
2,890	300	0	1.90	3,190	258	400	250	220	0	470	845	1,250	0	1,250	720	130	0	850	M,T	Apr 25
2,882	350	0	2.60	3,232	255	400	250	220	0	470	845	1,250	0	1,250	720	130	0	850	M,T	Apr 26
2,878	350	0	3.29	3,228	251	400	250	220	0	470	845	1,250	0	1,250	720	130	0	850	M,T	Apr 27
2,875	350	0	3.99	3,225	248	400	250	220	0	470	845	1,250	0	1,250	720	130	0	850	M,T	Apr 28
2,871	350	0	4.68	3,221	244	400	250	220	0	470	845	1,250	0	1,250	720	130	0	850	M,T	Apr 29
2,868	350	0	5.38	3,218	241	400	250	425	0	675	845	1,250	0	1,250	720	130	0	850	M,T	Apr 30
2,864	350	0	6.07	3,214	237	400	250	780	0	1,030	845	1,150	0	1,150	750	0	0	750	T,S	May 01
2,861	350	0	6.76	3,211	234	400	250	880	0	1,130	845	800	0	800	750	0	0	750	S	May 02
2,787	425	0	7.61	3,212	230	400	250	880	0	1,130	845	700	0	700	750	0	0	750	S	May 03
2,434	780	0	9.15	3,214	227	400	250	880	0	1,130	845	700	0	700	750	0	0	750	M,S	May 04
2,330	880	0	10.90	3,210	223	400	250	880	0	1,130	845	700	0	700	750	0	0	750	M,S	May 05
2,327	880	0	12.64	3,207	220	400	250	880	0	1,130	845	700	0	700	750	0	0	750	M,S	May 06
2,323	880	0	14.39	3,203	216	400	250	880	0	1,130	845	700	0	700	750	0	0	750	M,S	May 07
2,320	880	0	16.14	3,200	213	400	250	780	0	1,030	845	700	0	700	750	0	0	750	M,S	May 08
2,316	880	0	17.88	3,196	209	400	250	780	0	1,030	845	700	0	700	750	120	0	870	M	May 09
2,313	880	0	19.63	3,193	206	400	250	780	0	1,030	845	700	0	700	750	120	0	870	M	May 10
2,309	900	0	21.41	3,209	202	400	250	780	0	1,030	845	700	0	700	750	120	0	870	M	May 11
2,306	900	0	23.20	3,206	199	400	250	600	0	850	845	700	0	700	750	120	0	870		May 12
2,302	900	0	24.98	3,202	195	400	250	200		450	845	700	0	700	750	120	0	870		May 13
2,299	900	0	26.77	3,199	191	400	250			250	500	500		500	677			677		May 14
2,295	720	0	28.20	3,015	187	400	250			250	350	350		350	677			677		May 15
2,018	200			2,218	183	400	250			250	250	250		250	677			677		May 16
1,864	0			1,864	179	400	250			250	175	175		175	677			677		May 17
1,760	0			1,760	175	400	250			250	175	175		175	677			677		May 18
1,681	0			1,681	171	400	250			250	175	175		175	677			677		May 19
1,677	0			1,677	167	400	250			250	175	175		175	677			677		May 20
1,673	0			1,673	163	400	250			250	175	175		175	677			677		May 21
1,669	0			1,669	159	400	250			250	175	175		175	677			677		May 22
1,665	0			1,665	155	400	250			250	175	175		175	677			677		May 23
1,661	0			1,661	151	400	250			250	175	175		175	677			677		May 24
1,657	0			1,657	147	400	250			250	175	175		175	677			677		May 25
1,653	0			1,653	143	400	250			250	175	175		175	677			677		May 26
1,649	0			1,649	139	400	250			250	175	175		175	677			677		May 27
1,645	0			1,645	135	400	250			250	175	175		175	677			677		May 28
1,641	0			1,641	131	400	250			250	175	175		175	677			677		May 29
1,637	0			1,637	127	400	250			250	175	175		175	677			677		May 30
1,633	0			1,633	123	400	250			250	140	140		140	677			677		May 31
VAMP period																				
2,742	459			3,200	248	400	250	407	0	657	845	845	0	845	999	52	0	1,051		Mean (cfs):
	28.19							25.00	0.00				0.00			3.19	0.00			Suppl. Water (TAF)

Pulse flow period

Period of desired flow stability

DAILY OPERATION PLAN, APRIL 16, 2002

Pulse Period: April 15–May 15 • Flow Target: 3,200cfs

Ungaged Flow at Vernalis = 300cfs

	San Joaquin River near Vernalis							Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus River below Goodwin				
	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. Flow	Exch Contr VAMP Suppl. Flow	VAMP Flow (3-day lag)	FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol. S=Stan.
	(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	
	[calc]	[calc]		[calc]	[calc]						[calc]				[calc]				[calc]	
Apr 01					1,990	428	651	199			199	169	169		169	505			505	
Apr 02					1,810	422	476	189			189	171	171		171	504			504	
Apr 03					1,710	407	400	171			171	170	170		170	501			501	
Apr 04	1,660				1,660	390	364	173			173	172	172		172	504			504	
Apr 05	1,670				1,670	373	403	204			204	171	171		171	574			574	
Apr 06	1,710				1,710	324	473	213			213	172	172		172	603			603	
Apr 07	1,820				1,820	317	529	224			224	173	173		173	603			603	
Apr 08	1,940				1,940	315	637	226			226	175	175		175	604			604	
Apr 09	1,820				1,820	322	514	232			232	174	174		174	602			602	
Apr 10	1,810				1,810	296	492	242			242	170	170		170	644			644	
Apr 11	1,760				1,760	295	436	241			241	170	170		170	654			654	
Apr 12	1,760				1,760	301	418	242	0	0	242	325	322		322	637		152	789	
Apr 13	1,800	0			1,800	300	439	250	59	0	309	845	704	0	704	1,505	0	0	1,505	
Apr 14	2,068	0	152		2,220	276	567	250	68	0	318	845	708	0	708	1,504	0	0	1,504	
Apr 15	2,860	0	0	0.00	2,860	286	109	250	76	0	326	845	709	0	709	1,504	0	0	1,504	
Apr 16	3,038	59	0	0.12	3,097	290	300	250	70	0	320	845	800	0	800	1,500	0	0	1,500	
Apr 17	3,049	68	0	0.25	3,117	286	300	250	70	0	320	845	800	0	800	1,500	0	0	1,500	
Apr 18	3,140	76	0	0.40	3,216	283	300	250	70	0	320	845	800	0	800	1,500	0	0	1,500	
Apr 19	3,136	70	0	0.54	3,206	279	300	250	80	0	330	845	800	0	800	1,500	0	0	1,500	
Apr 20	3,133	70	0	0.68	3,203	276	300	250	80	0	330	845	800	0	800	1,500	0	0	1,500	
Apr 21	3,129	70	0	0.82	3,199	272	300	250	80	0	330	845	800	0	800	1,500	0	0	1,500	
Apr 22	3,126	80	0	0.98	3,206	269	300	250	150	0	400	845	850	0	850	1,500	0	0	1,500	
Apr 23	3,122	80	0	1.14	3,202	265	300	250	150	0	400	845	850	0	850	1,180	250	0	1,430	M
Apr 24	3,169	80	0	1.30	3,249	262	300	250	150	0	400	845	1,200	0	1,200	720	350	0	1,070	M,T
Apr 25	2,845	400	0	2.09	3,245	258	300	250	150	0	400	845	1,250	0	1,250	720	320	0	1,040	M,T
Apr 26	2,732	500	0	3.08	3,232	255	300	250	150	0	400	845	1,250	0	1,250	720	320	0	1,040	M,T
Apr 27	2,778	470	0	4.01	3,248	251	300	250	150	0	400	845	1,250	0	1,250	720	320	0	1,040	M,T
Apr 28	2,775	470	0	4.94	3,245	248	300	250	150	0	400	845	1,250	0	1,250	720	320	0	1,040	M,T
Apr 29	2,771	470	0	5.88	3,241	244	300	250	150	0	400	845	1,250	0	1,250	720	320	0	1,040	M,T
Apr 30	2,768	470	0	6.81	3,238	241	300	250	400	0	650	845	1,250	0	1,250	720	320	0	1,040	M,T
May 01	2,764	470	0	7.74	3,234	237	300	250	770	0	1,020	845	1,250	0	1,250	750	50	0	800	T,S
May 02	2,761	470	0	8.67	3,231	234	300	250	910	0	1,160	845	890	0	890	750	50	0	800	S
May 03	2,787	450	0	9.57	3,237	230	300	250	910	0	1,160	845	720	0	720	750	50	0	800	S
May 04	2,424	820	0	11.19	3,244	227	300	250	930	0	1,180	845	720	0	720	750	50	0	800	M,S
May 05	2,250	960	0	13.10	3,210	223	300	250	930	0	1,180	845	720	0	720	750	50	0	800	M,S
May 06	2,247	960	0	15.00	3,207	220	300	250	930	0	1,180	845	720	0	720	750	50	0	800	M,S
May 07	2,243	980	0	16.94	3,223	216	300	250	930	0	1,180	845	720	0	720	750	50	0	800	M,S
May 08	2,240	980	0	18.89	3,220	213	300	250	860	0	1,110	845	720	0	720	750	50	0	800	M,S
May 09	2,236	980	0	20.83	3,216	209	300	250	860	0	1,110	845	550	0	550	750	330	0	1,080	M
May 10	2,233	980	0	22.78	3,213	206	300	250	860	0	1,110	845	550	0	550	750	330	0	1,080	M
May 11	2,059	1,190	0	25.14	3,249	202	300	250	860	0	1,110	845	550	0	550	750	330	0	1,080	M
May 12	2,056	1,190	0	27.50	3,246	199	300	250	600	0	850	845	550	0	550	750	330	0	1,080	
May 13	2,052	1,190	0	29.86	3,242	195	300	250	200		450	845	550	0	550	750	330	0	1,080	
May 14	2,049	1,190	0	32.22	3,239	191	300	250			250	500	350		350	677			677	
May 15	2,045	930	0	34.06	2,975	187	300	250			250	350	250		250	677			677	
May 16	1,768	200			1,968	183	300	250			250	250	175		175	677			677	
May 17	1,664	0			1,664	179	300	250			250	175	175		175	677			677	
May 18	1,585	0			1,585	175	300	250			250	175	175		175	677			677	
May 19	1,581	0			1,581	171	300	250			250	175	175		175	677			677	
May 20	1,577	0			1,577	167	300	250			250	175	175		175	677			677	
May 21	1,573	0			1,573	163	300	250			250	175	175		175	677			677	
May 22	1,569	0			1,569	159	300	250			250	175	175		175	677			677	
May 23	1,565	0			1,565	155	300	250			250	175	175		175	677			677	
May 24	1,561	0			1,561	151	300	250			250	175	175		175	677			677	
May 25	1,557	0			1,557	147	300	250			250	175	175		175	677			677	
May 26	1,553	0			1,553	143	300	250			250	175	175		175	677			677	
May 27	1,549	0			1,549	139	300	250			250	175	175		175	677			677	
May 28	1,545	0			1,545	135	300	250			250	175	175		175	677			677	
May 29	1,541	0			1,541	131	300	250			250	175	175		175	677			677	
May 30	1,537	0			1,537	127	300	250			250	175	175		175	677			677	
May 31	1,533	0			1,533	123	300	250			250	140	140		140	677			677	
	VAMP period																			
Mean (cfs):	2,645	554			3,199	247	294	250	407	0	656	845	856	0	856	999	147	0	1,147	
Suppl. Water (TAF)		34.06							25.00	0.00				0.00			9.06	0.00		

Pulse flow period

Period of desired flow stability

DAILY OPERATION PLAN, APRIL 19, 2002

Pulse Period: April 15–May 15 • Flow Target: 3,200cfs

Ungaged Flow at Vernalis = 300cfs

San Joaquin River near Vernalis							Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus River below Goodwin					
Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. Flow	Exch Contr VAMP Suppl. Flow	VAMP Flow (3-day lag)	FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol. S=Stan.	
(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		
[calc]	[calc]		[calc]	[calc]						[calc]				[calc]				[calc]		
				1,990	428	651	199			199	169	169		169	505			505		Apr 01
				1,810	422	476	189			189	171	171		171	504			504		Apr 02
				1,710	407	400	171			171	170	170		170	501			501		Apr 03
1,660				1,660	390	364	173			173	172	172		172	504			504		Apr 04
1,670				1,670	373	403	204			204	171	171		171	574			574		Apr 05
1,710				1,710	324	473	213			213	172	172		172	603			603		Apr 06
1,810				1,820	317	519	224			224	173	173		173	603			603		Apr 07
1,930				1,930	315	627	226			226	175	175		175	604			604		Apr 08
1,820				1,820	322	514	232			232	174	174		174	602			602		Apr 09
1,800				1,800	296	482	242			242	170	170		170	644			644		Apr 10
1,750				1,750	295	426	241			241	170	170		170	654			654		Apr 11
1,750				1,750	301	408	242	0	0	242	325	322		322	637		152	789		Apr 12
1,790	0			1,790	300	429	250	59	0	309	845	704	0	704	1,505	0	0	1,505		Apr 13
2,048	0	152		2,200	276	547	250	68	0	318	845	708	0	708	1,504	0	0	1,504		Apr 14
2,839	0	0	0.00	2,839	286	88	250	76	0	326	845	709	0	709	1,504	0	0	1,504		Apr 15
2,901	59	0	0.12	2,960	274	163	250	78	0	328	845	782	0	782	1,503	0	0	1,503		Apr 16
2,922	68	0	0.25	2,990	285	173	250	117	0	367	845	806	0	806	1,508	0	0	1,508		Apr 17
3,054	76	0	0.40	3,130	253	245	250	118	0	368	845	804	0	804	1,503	0	0	1,503		Apr 18
3,149	78	0	0.56	3,227	279	300	250	80	0	330	845	800	0	800	1,500	0	0	1,500		Apr 19
3,110	117	0	0.79	3,227	276	300	250	80	0	330	845	800	0	800	1,500	0	0	1,500		Apr 20
3,129	118	0	1.02	3,247	272	300	250	80	0	330	845	800	0	800	1,500	0	0	1,500		Apr 21
3,126	80	0	1.18	3,206	269	300	250	120	0	370	845	800	0	800	1,500	0	0	1,500		Apr 22
3,122	80	0	1.34	3,202	265	300	250	150	0	400	845	800	0	800	1,180	320	0	1,500	M	Apr 23
3,119	80	0	1.50	3,199	262	300	250	150	0	400	845	1,300	0	1,300	720	290	0	1,010	M,T	Apr 24
2,795	440	0	2.37	3,235	258	300	250	150	0	400	845	1,300	0	1,300	720	280	0	1,000	M,T	Apr 25
2,832	440	0	3.24	3,272	255	300	250	150	0	400	845	1,300	0	1,300	720	280	0	1,000	M,T	Apr 26
2,828	430	0	4.10	3,258	251	300	250	150	0	400	845	1,300	0	1,300	720	280	0	1,000	M,T	Apr 27
2,825	430	0	4.95	3,255	248	300	250	150	0	400	845	1,300	0	1,300	720	280	0	1,000	M,T	Apr 28
2,821	430	0	5.80	3,251	244	300	250	150	0	400	845	1,300	0	1,300	720	280	0	1,000	M,T	Apr 29
2,818	430	0	6.66	3,248	241	300	250	375	0	625	845	1,300	0	1,300	720	280	0	1,000	T	Apr 30
2,814	430	0	7.51	3,244	237	300	250	780	0	1,030	845	1,300	0	1,300	750	0	0	750	T,S	May 01
2,811	430	0	8.36	3,241	234	300	250	1,025	60	1,335	845	885	0	885	750	0	0	750	M,S	May 02
2,837	375	0	9.11	3,212	230	300	250	1,050	35	1,335	845	600	0	600	750	0	0	750	M,S	May 03
2,419	780	0	10.65	3,199	227	300	250	1,050	35	1,335	845	600	0	600	750	0	0	750	M,S	May 04
2,130	1,085	0	12.81	3,215	223	300	250	1,050	35	1,335	845	600	0	600	750	0	0	750	M,S	May 05
2,127	1,085	0	14.96	3,212	220	300	250	1,050	35	1,335	845	600	0	600	750	0	0	750	M,S	May 06
2,123	1,085	0	17.11	3,208	216	300	250	1,050	35	1,335	845	600	0	600	750	0	0	750	M,S	May 07
2,120	1,085	0	19.26	3,205	213	300	250	650	0	900	845	600	0	600	750	0	0	750	S	May 08
2,116	1,085	0	21.41	3,201	209	300	250	650	0	900	845	575	0	575	750	550	0	1,300		May 09
2,113	1,085	0	23.57	3,198	206	300	250	650	0	900	845	575	0	575	750	550	0	1,300		May 10
2,084	1,200	0	25.95	3,284	202	300	250	650	0	900	845	550	0	550	750	550	0	1,300		May 11
2,081	1,200	0	28.33	3,281	199	300	250	650	0	900	845	550	0	550	750	550	0	1,300		May 12
2,052	1,200	0	30.71	3,252	195	300	250	200		450	845	550	0	550	750	550	0	1,300		May 13
2,049	1,200	0	33.09	3,249	191	300	250			250	500	450		450	677			677		May 14
2,045	1,200	0	35.47	3,245	187	300	250			250	350	350		350	677			677		May 15
1,868	200			2,068	183	300	250			250	250	250		250	677			677		May 16
1,764	0			1,764	179	300	250			250	175	175		175	677			677		May 17
1,660	0			1,660	175	300	250			250	175	175		175	677			677		May 18
1,581	0			1,581	171	300	250			250	175	175		175	677			677		May 19
1,577	0			1,577	167	300	250			250	175	175		175	677			677		May 20
1,573	0			1,573	163	300	250			250	175	175		175	677			677		May 21
1,569	0			1,569	159	300	250			250	175	175		175	677			677		May 22
1,565	0			1,565	155	300	250			250	175	175		175	677			677		May 23
1,561	0			1,561	151	300	250			250	175	175		175	677			677		May 24
1,557	0			1,557	147	300	250			250	175	175		175	677			677		May 25
1,553	0			1,553	143	300	250			250	175	175		175	677			677		May 26
1,549	0			1,549	139	300	250			250	175	175		175	677			677		May 27
1,545	0			1,545	135	300	250			250	175	175		175	677			677		May 28
1,541	0			1,541	131	300	250			250	175	175		175	677			677		May 29
1,537	0			1,537	127	300	250			250	175	175		175	677			677		May 30
1,533	0			1,533	123	300	250			250	140	140		140	677			677		May 31
VAMP period																				
2,623	577			3,200	245	283	250	407	8	664	845	845	0	845	1,000	163	0	1,162		Mean (cfs):
	35.47							25.00	0.47				0.00			10.00	0.00			Suppl. Water (TAF)

Pulse flow period

Period of desired flow stability

DAILY OPERATION PLAN, APRIL 25, 2002

Pulse Period: April 15–May 15 • Flow Target: 3,200cfs

Ungaged Flow at Vernalis = 300cfs

	San Joaquin River near Vernalis							Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus River below Goodwin				
	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. Flow	Exch Contr VAMP Suppl. Flow	VAMP Flow (3-day lag)	FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol. S=Stan.
	(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	
	[calc]	[calc]		[calc]	[calc]						[calc]				[calc]				[calc]	
Apr 01					1,990	428	651	199			199	169	169		169	505			505	
Apr 02					1,810	422	476	189			189	171	171		171	504			504	
Apr 03					1,710	407	400	171			171	170	170		170	501			501	
Apr 04	1,660				1,660	390	364	173			173	172	172		172	504			504	
Apr 05	1,670				1,670	373	403	204			204	171	171		171	574			574	
Apr 06	1,710				1,710	324	473	213			213	172	172		172	603			603	
Apr 07	1,810				1,820	317	519	224			224	173	173		173	603			603	
Apr 08	1,930				1,930	315	627	226			226	175	175		175	604			604	
Apr 09	1,820				1,820	322	514	232			232	174	174		174	602			602	
Apr 10	1,800				1,800	296	482	242			242	170	170		170	644			644	
Apr 11	1,750				1,750	295	426	241			241	170	170		170	654			654	
Apr 12	1,750				1,750	301	408	242	0	0	242	325	322		322	637		152	789	
Apr 13	1,790	0			1,790	300	429	250	59	0	309	845	704	0	704	1,505	0	0	1,505	
Apr 14	2,048	0	152		2,200	279	547	250	68	0	318	845	708	0	708	1,504	0	0	1,504	
Apr 15	2,839	0	0	0.00	2,839	292	88	250	76	0	326	845	709	0	709	1,504	0	0	1,504	
Apr 16	2,901	59	0	0.12	2,960	282	160	250	78	0	328	845	782	0	782	1,503	0	0	1,503	
Apr 17	2,922	68	0	0.25	2,990	295	167	250	117	0	367	845	806	0	806	1,508	0	0	1,508	
Apr 18	3,054	76	0	0.40	3,130	263	237	250	118	0	368	845	804	0	804	1,503	0	0	1,503	
Apr 19	3,121	78	0	0.56	3,199	265	262	250	124	0	374	845	807	0	807	1,502	0	0	1,502	
Apr 20	3,193	117	0	0.79	3,310	248	373	250	136	0	386	845	810	0	810	1,504	0	0	1,504	
Apr 21	3,252	118	0	1.02	3,370	261	428	250	141	0	391	845	810	0	810	1,503	0	0	1,503	
Apr 22	3,306	124	0	1.27	3,430	263	494	250	165	0	415	845	811	0	811	1,502	0	0	1,502	
Apr 23	3,114	136	0	1.54	3,250	291	290	250	171	0	421	845	838	0	838	1,180	324	0	1,504	M
Apr 24	3,079	141	0	1.82	3,220	276	253	250	167	0	417	845	1,310	0	1,310	720	360	0	1,080	M,T
Apr 25	2,859	489	0	2.79	3,348	258	300	250	150	0	400	845	1,300	0	1,300	720	280	0	1,000	M,T
Apr 26	2,856	531	0	3.84	3,387	255	300	250	150	0	400	845	1,300	0	1,300	720	280	0	1,000	M,T
Apr 27	2,828	447	0	4.73	3,275	251	300	250	150	0	400	845	1,300	0	1,300	720	230	0	950	M,T
Apr 28	2,825	430	0	5.58	3,255	248	300	250	150	0	400	845	1,300	0	1,300	720	230	0	950	M,T
Apr 29	2,821	380	0	6.34	3,201	244	300	250	150	0	400	845	1,300	0	1,300	720	230	0	950	M,T
Apr 30	2,818	380	0	7.09	3,198	241	300	250	350	0	600	845	1,300	0	1,300	720	230	0	950	T
May 01	2,814	380	0	7.84	3,194	237	300	250	780	0	1,030	845	1,300	0	1,300	750	0	0	750	T,S
May 02	2,811	380	0	8.60	3,191	234	300	250	1,050	0	1,300	845	895	0	895	750	0	0	750	M,S
May 03	2,837	350	0	9.29	3,187	230	300	250	1,050	0	1,300	845	600	0	600	750	0	0	750	M,S
May 04	2,429	780	0	10.84	3,209	227	300	250	1,050	0	1,300	845	600	0	600	750	0	0	750	M,S
May 05	2,130	1,050	0	12.92	3,180	223	300	250	1,050	0	1,300	845	600	0	600	750	0	0	750	M,S
May 06	2,127	1,050	0	15.00	3,177	220	300	250	1,050	0	1,300	845	600	0	600	750	0	0	750	M,S
May 07	2,123	1,050	0	17.09	3,173	216	300	250	1,050	0	1,300	845	600	0	600	750	0	0	750	M,S
May 08	2,120	1,050	0	19.17	3,170	213	300	250	600	0	850	845	600	0	600	750	0	0	750	S
May 09	2,116	1,050	0	21.25	3,166	209	300	250	600	0	850	845	575	0	575	750	540	0	1,290	
May 10	2,113	1,050	0	23.33	3,163	206	300	250	600	0	850	845	575	0	575	750	540	0	1,290	
May 11	2,084	1,140	0	25.59	3,224	202	300	250	600	0	850	845	550	0	550	750	540	0	1,290	
May 12	2,081	1,140	0	27.86	3,221	199	300	250	600	0	850	845	550	0	550	750	540	0	1,290	
May 13	2,052	1,140	0	30.12	3,192	195	300	250	200		450	845	550	0	550	750	540	0	1,290	
May 14	2,049	1,140	0	32.38	3,189	191	300	250			250	500	450		450	677			677	
May 15	2,045	1,140	0	34.64	3,185	187	300	250			250	350	350		350	677			677	
May 16	1,868	200			2,068	183	300	250			250	250	250		250	677			677	
May 17	1,764	0			1,764	179	300	250			250	175	175		175	677			677	
May 18	1,660	0			1,660	175	300	250			250	175	175		175	677			677	
May 19	1,581	0			1,581	171	300	250			250	175	175		175	677			677	
May 20	1,577	0			1,577	167	300	250			250	175	175		175	677			677	
May 21	1,573	0			1,573	163	300	250			250	175	175		175	677			677	
May 22	1,569	0			1,569	159	300	250			250	175	175		175	677			677	
May 23	1,565	0			1,565	155	300	250			250	175	175		175	677			677	
May 24	1,561	0			1,561	151	300	250			250	175	175		175	677			677	
May 25	1,557	0			1,557	147	300	250			250	175	175		175	677			677	
May 26	1,553	0			1,553	143	300	250			250	175	175		175	677			677	
May 27	1,549	0			1,549	139	300	250			250	175	175		175	677			677	
May 28	1,545	0			1,545	135	300	250			250	175	175		175	677			677	
May 29	1,541	0			1,541	131	300	250			250	175	175		175	677			677	
May 30	1,537	0			1,537	127	300	250			250	175	175		175	677			677	
May 31	1,533	0			1,533	123	300	250			250	140	140		140	677			677	
	VAMP period																			
Mean (cfs):	2,636	563			3,199	246	292	250	406	0	656	845	848	0	848	1,000	157	0	1,157	
Suppl. Water (TAF)		34.64							24.99	0.00				0.00			9.65	0.00		

Pulse flow period

Period of desired flow stability

DAILY OPERATION PLAN, MAY 9, 2002

Pulse Period: April 15–May 15 • Flow Target: 3,200cfs

Ungaged Flow at Vernalis = 450cfs

San Joaquin River near Vernalis							Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus River below Goodwin					
Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. Flow	Exch Contr VAMP Suppl. Flow	VAMP Flow (3-day lag)	FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol. S=Stan.	
(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		
[calc]	[calc]		[calc]	[calc]						[calc]				[calc]				[calc]		
				1,990	428	651	199			199	169	169		169	505			505		Apr 01
				1,810	422	476	189			189	171	171		171	504			504		Apr 02
				1,710	407	400	171			171	170	170		170	501			501		Apr 03
1,660				1,660	390	364	173			173	172	172		172	504			504		Apr 04
1,670				1,670	373	403	204			204	171	171		171	574			574		Apr 05
1,710				1,710	324	473	213			213	172	172		172	603			603		Apr 06
1,810				1,820	317	519	224			224	173	173		173	603			603		Apr 07
1,930				1,930	315	627	226			226	175	175		175	604			604		Apr 08
1,820				1,820	322	514	232			232	174	174		174	602			602		Apr 09
1,800				1,800	296	482	242			242	170	170		170	644			644		Apr 10
1,750				1,750	295	426	241			241	170	170		170	654			654		Apr 11
1,750				1,750	301	408	242	0	0	242	325	322		322	637		152	789		Apr 12
1,790	0			1,790	300	429	250	59	0	309	845	704	0	704	1,505	0	0	1,505		Apr 13
2,048	0	152		2,200	279	547	250	68	0	318	845	708	0	708	1,504	0	0	1,504		Apr 14
2,839	0	0	0.00	2,839	292	88	250	76	0	326	845	709	0	709	1,504	0	0	1,504		Apr 15
2,901	59	0	0.12	2,960	282	160	250	78	0	328	845	782	0	782	1,503	0	0	1,503		Apr 16
2,922	68	0	0.25	2,990	295	167	250	117	0	367	845	806	0	806	1,508	0	0	1,508		Apr 17
3,054	76	0	0.40	3,130	263	237	250	118	0	368	845	804	0	804	1,503	0	0	1,503		Apr 18
3,121	78	0	0.56	3,199	265	262	250	124	0	374	845	807	0	807	1,502	0	0	1,502		Apr 19
3,193	117	0	0.79	3,310	248	373	250	136	0	386	845	810	0	810	1,504	0	0	1,504		Apr 20
3,252	118	0	1.02	3,370	261	428	250	141	0	391	845	810	0	810	1,503	0	0	1,503		Apr 21
3,306	124	0	1.27	3,430	263	494	250	165	0	415	845	811	0	811	1,502	0	0	1,502		Apr 22
3,114	136	0	1.54	3,250	291	290	250	171	0	421	845	838	0	838	1,180	324	0	1,504	M	Apr 23
3,079	141	0	1.82	3,220	276	253	250	167	0	417	845	1,310	0	1,310	720	360	0	1,080	M,T	Apr 24
2,811	489	0	2.79	3,300	253	252	250	157	0	407	845	1,310	0	1,310	720	285	0	1,005	M,T	Apr 25
2,879	531	0	3.84	3,410	237	323	250	169	0	419	845	1,290	0	1,290	720	285	0	1,005	M,T	Apr 26
2,997	452	0	4.74	3,449	244	464	250	168	0	418	845	1,310	0	1,310	720	234	0	954	M,T	Apr 27
3,047	442	0	5.62	3,489	252	550	250	164	0	414	845	1,310	0	1,310	720	231	0	951	M,T	Apr 28
3,207	403	0	6.41	3,610	266	683	250	173	0	423	845	1,310	0	1,310	720	231	0	951	M,T	Apr 29
3,171	399	0	7.21	3,570	231	639	250	412	0	662	845	1,310	0	1,310	720	139	0	859	T	Apr 30
2,995	395	0	7.99	3,390	158	449	250	798	0	1,048	845	1,260	0	1,260	756	0	0	756	T,S	May 01
2,998	312	0	8.61	3,310	33	487	250	1,074	0	1,324	845	897	0	897	754	0	0	754	M,S	May 02
2,948	412	0	9.43	3,360	36	524	250	1,116	0	1,366	845	612	0	612	753	0	0	753	M,S	May 03
2,592	798	0	11.01	3,390	64	658	250	1,120	0	1,370	845	599	0	599	752	0	0	752	M,S	May 04
2,346	1,074	0	13.14	3,420	113	695	250	1,102	0	1,352	845	594	0	594	752	0	0	752	M,S	May 05
2,373	1,116	0	15.35	3,489	121	708	250	1,078	0	1,328	845	598	0	598	754	0	0	754	M,S	May 06
2,330	1,120	0	17.57	3,450	128	621	250	1,076	0	1,326	845	600	0	600	759	0	0	759	M,S	May 07
2,248	1,102	0	19.76	3,350	174	525	250	722	0	972	845	599	0	599	759	0	0	759	S	May 08
2,237	1,078	0	21.90	3,315	120	500	250	600	0	850	845	575	0	575	750	350	0	1,100		May 09
2,282	1,076	0	24.03	3,358	120	500	250	600	0	850	845	575	0	575	750	350	0	1,100		May 10
2,195	1,072	0	26.16	3,267	120	500	250	600	0	850	845	550	0	550	750	350	0	1,100		May 11
2,195	950	0	28.04	3,145	120	500	250	600	0	850	845	550	0	550	750	350	0	1,100		May 12
2,170	950	0	29.93	3,120	120	500	250	200		450	845	550	0	550	750	350	0	1,100		May 13
2,170	950	0	31.81	3,120	120	500	250			250	500	450		450	677			677		May 14
2,170	950	0	33.70	3,120	120	500	250			250	350	350		350	677			677		May 15
1,997	200			2,197	120	500	250			250	250	250		250	677			677		May 16
1,897	0			1,897	120	500	250			250	175	175		175	677			677		May 17
1,797	0			1,797	120	500	250			250	175	175		175	677			677		May 18
1,722	0			1,722	120	500	250			250	175	175		175	677			677		May 19
1,722	0			1,722	120	500	250			250	175	175		175	677			677		May 20
1,722	0			1,722	120	500	250			250	175	175		175	677			677		May 21
1,722	0			1,722	120	500	250			250	175	175		175	677			677		May 22
1,722	0			1,722	120	500	250			250	175	175		175	677			677		May 23
1,722	0			1,722	120	500	250			250	175	175		175	677			677		May 24
1,722	0			1,722	120	500	250			250	175	175		175	677			677		May 25
1,722	0			1,722	120	500	250			250	175	175		175	677			677		May 26
1,722	0			1,722	120	500	250			250	175	175		175	677			677		May 27
1,722	0			1,722	120	500	250			250	175	175		175	677			677		May 28
1,722	0			1,722	120	500	250			250	175	175		175	677			677		May 29
1,722	0			1,722	120	500	250			250	175	175		175	677			677		May 30
1,722	0			1,722	120	500	250			250	140	140		140	677			677		May 31
VAMP period																				
2,747	548			3,295	201	446	250	424	0	674	845	848	0	848	1,002	124	0	1,125		Mean (cfs):
	33.70							26.08	0.00				0.00			7.61	0.00			Suppl. Water (TAF)

Pulse flow period

Period of desired flow stability

2002 VERNALIS ADAPTIVE MANAGEMENT PLAN (VAMP)

ACCOUNTING OF SUPPLEMENTAL WATER CONTRIBUTIONS

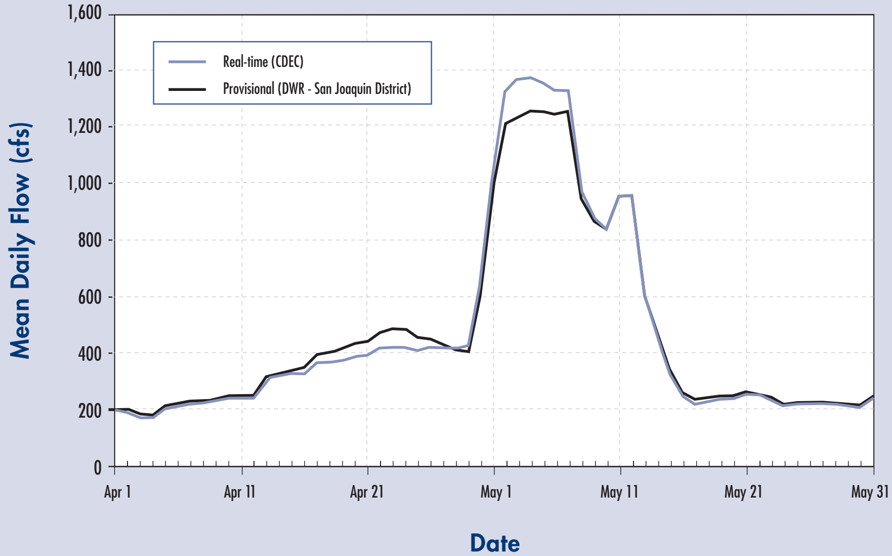
Hydrology Subgroup of the San Joaquin River Technical Committee

Pulse Flow Period: April 15–May 15

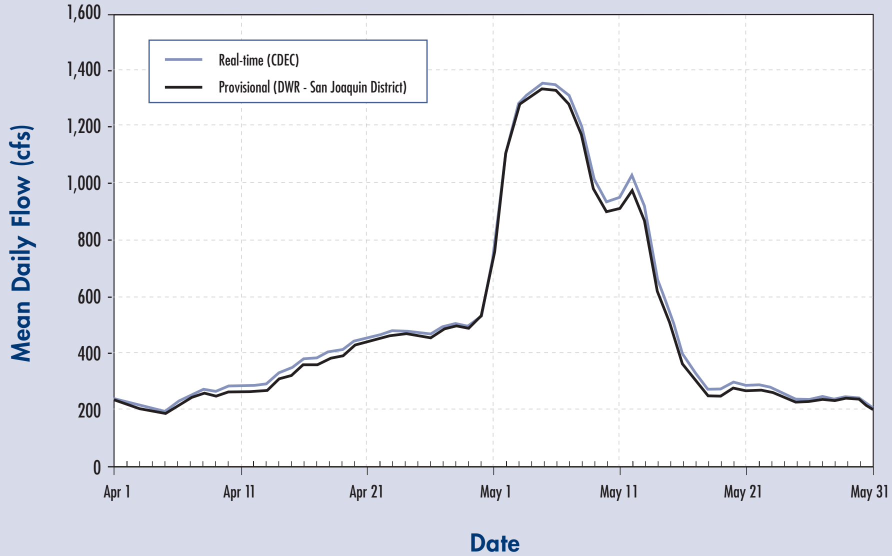
	Merced R. at Cressey (3 Day Travel Time to Vernalis)			Tuolumne R. below LaGrange Dam (2 Day Travel Time to Vernalis)			Stanislaus R. below Goodwin Dam (2 Day Travel Time to Vernalis)			SJRECWA (3 Day)	San Joaquin River at Vernalis		
	Existing Flow	Observed Flow	VAMP Suppl. Water	Existing Flow	Observed Flow	VAMP Suppl. Water	Existing Flow	Observed Flow	VAMP Suppl. Water	VAMP Suppl. Water	Existing Flow	Observed Flow	VAMP Suppl. Water
	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
Apr 01	197	197		169	169		505	505			1,990	1,990	
Apr 02	197	197		171	171		504	504			1,810	1,810	
Apr 03	182	182		170	170		501	501			1,710	1,710	
Apr 04	180	180		172	172		504	504			1,660	1,660	
Apr 05	210	210		171	171		574	574			1,670	1,670	
Apr 06	219	219		172	172		603	603			1,710	1,710	
Apr 07	229	229		173	173		603	603			1,810	1,810	
Apr 08	229	229		175	175		604	604			1,930	1,930	
Apr 09	235	235		174	174		602	602			1,820	1,820	
Apr 10	245	245		170	170		644	644			1,800	1,800	
Apr 11	246	246		170	170		654	654			1,750	1,750	
Apr 12	248	248	0	322	322		789	789		0	1,750	1,750	
Apr 13	250	314	64	704	704	0	1,505	1,505	0	0	1,790	1,790	
Apr 14	250	328	78	708	708	0	1,504	1,504	0	0	2,200	2,200	
Apr 15	250	340	90	709	709	0	1,504	1,504	0	0	2,839	2,839	0
Apr 16	250	347	97	782	782	0	1,503	1,503	0	0	2,896	2,960	64
Apr 17	250	393	143	807	807	0	1,508	1,508	0	0	2,912	2,990	78
Apr 18	250	401	151	804	804	0	1,503	1,503	0	0	3,040	3,130	90
Apr 19	250	411	161	807	807	0	1,502	1,502	0	0	3,103	3,200	97
Apr 20	250	429	179	810	810	0	1,504	1,504	0	0	3,167	3,310	143
Apr 21	250	439	189	810	810	0	1,503	1,503	0	0	3,219	3,370	151
Apr 22	250	472	222	811	811	0	1,502	1,502	0	0	3,269	3,430	161
Apr 23	250	482	232	838	838	0	1,180	1,504	324	0	3,071	3,250	179
Apr 24	250	481	231	1,310	1,310	0	720	1,080	360	0	3,031	3,220	189
Apr 25	250	453	203	1,310	1,310	0	720	1,005	285	0	2,754	3,300	546
Apr 26	250	447	197	1,290	1,290	0	720	1,005	285	0	2,818	3,410	592
Apr 27	250	427	177	1,310	1,310	0	720	954	234	0	2,933	3,449	516
Apr 28	250	406	156	1,310	1,310	0	720	951	231	0	3,001	3,489	488
Apr 29	250	400	150	1,310	1,310	0	720	951	231	0	3,179	3,610	431
Apr 30	250	612	362	1,310	1,310	0	720	859	139	0	3,162	3,570	408
May 01	250	976	726	1,260	1,260	0	756	756	0	0	3,003	3,390	387
May 02	250	1,210	960	897	897	0	754	754	0	0	3,021	3,310	289
May 03	250	1,230	980	620	620	0	753	753	0	0	2,998	3,360	362
May 04	250	1,250	1,000	607	607	0	752	752	0	0	2,664	3,390	726
May 05	250	1,250	1,000	603	603	0	752	752	0	0	2,470	3,430	960
May 06	250	1,240	990	607	607	0	754	754	0	0	2,520	3,500	980
May 07	250	1,250	1,000	608	608	0	759	759	0	0	2,459	3,459	1,000
May 08	250	937	687	607	607	0	759	759	0	0	2,360	3,360	1,000
May 09	250	862	612	584	584	0	750	1,066	316	0	2,250	3,240	990
May 10	250	833	583	591	591	0	750	1,101	351	0	2,170	3,170	1,000
May 11	250	954	704	567	567	0	750	1,113	363	0	2,287	3,290	1,003
May 12	250	956	706	566	566	0	750	1,101	351	0	2,397	3,360	963
May 13	250	595		553	553	0	750	1,106	356		2,454	3,400	946
May 14	250	463		456	456		1,107	1,107			2,155	3,210	1,055
May 15	250	335		358	358		1,105	1,105			1,868	2,930	1,062
May 16	254	254		265	265		1,105	1,105			2,345	2,690	
May 17	229	229		218	218		1,099	1,099			2,237	2,450	
May 18	234	234		219	219		1,104	1,104			2,275	2,360	
May 19	240	240		217	217		1,103	1,103			2,310	2,310	
May 20	243	243		224	224		1,095	1,095			2,340	2,340	
May 21	255	255		222	222		921	921			2,380	2,380	
May 22	248	248		218	218		899	899			2,310	2,310	
May 23	235	235		217	217		901	901			2,140	2,140	
May 24	212	212		216	216		903	903			2,120	2,120	
May 25	217	217		216	216		903	903			2,030	2,030	
May 26	217	217		217	217		901	901			2,100	2,100	
May 27	218	218		216	216		905	905			2,180	2,180	
May 28	214	214		217	217		903	903			2,080	2,080	
May 29	211	211		217	217		754	754			1,950	1,950	
May 30	209	209		223	223		581	581			1,910	1,910	
May 31	241	241		181	181		504	504			1,760	1,760	
Total Supplemental Water (TAF):			25.84			0.00			7.59	0.00			33.43
Pulse Period Average:											2,757	3,301	

Observed Flow Sources:
Merced River at Cressey (CA DWR B05155): DWR San Joaquin District, provisional data received July 2, 2002. • Tuolumne River below LaGrange Dam near LaGrange (USGS 11289650): USGS, provisional data dated July 1, 2002. • Stanislaus River below Goodwin Dam: Goodwin Reservoir Daily Operations report, OID/SSJID/Tri-Dams (published by USBR CVO) • San Joaquin River near Vernalis (USGS 11303500): USGS, provisional data dated July 1, 2002.

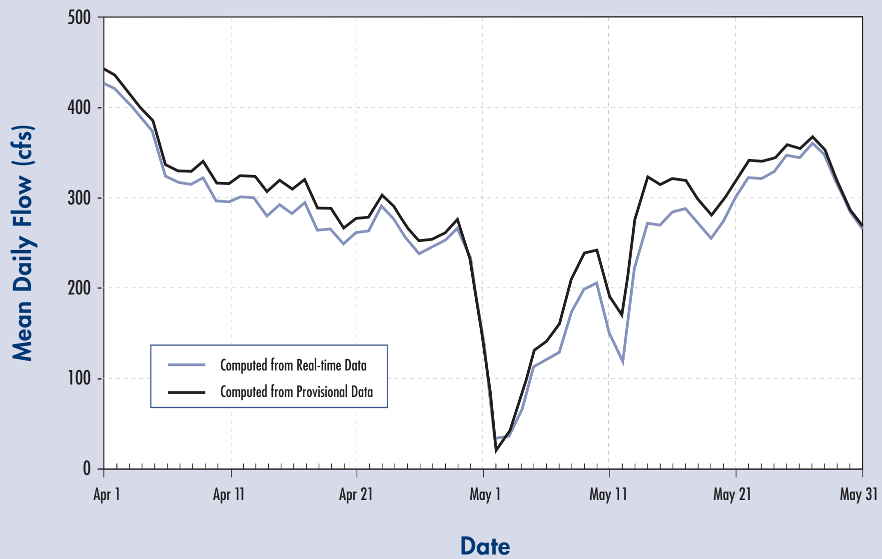
Merced River Near Cressey



Merced River Near Stevinson

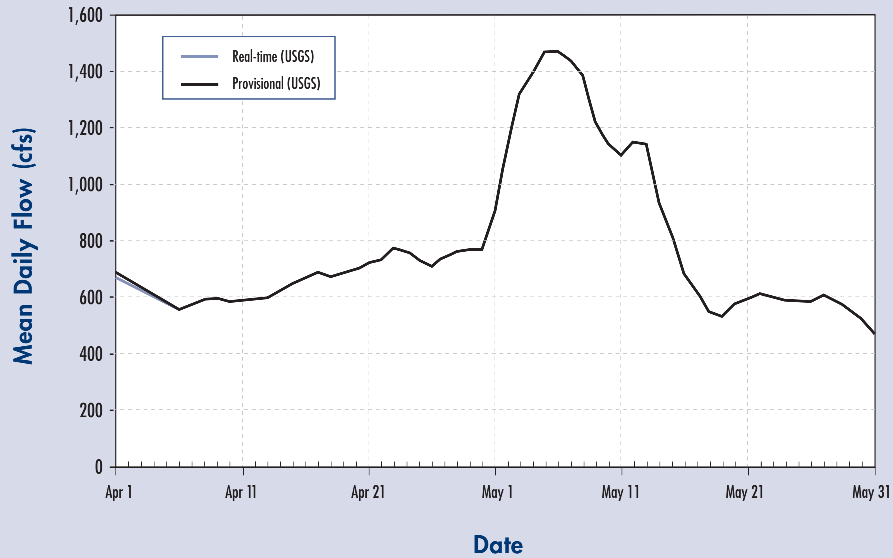


San Joaquin River Above Merced River



COMPARISON OF "REAL-TIME" AND PROVISIONAL FLOWS

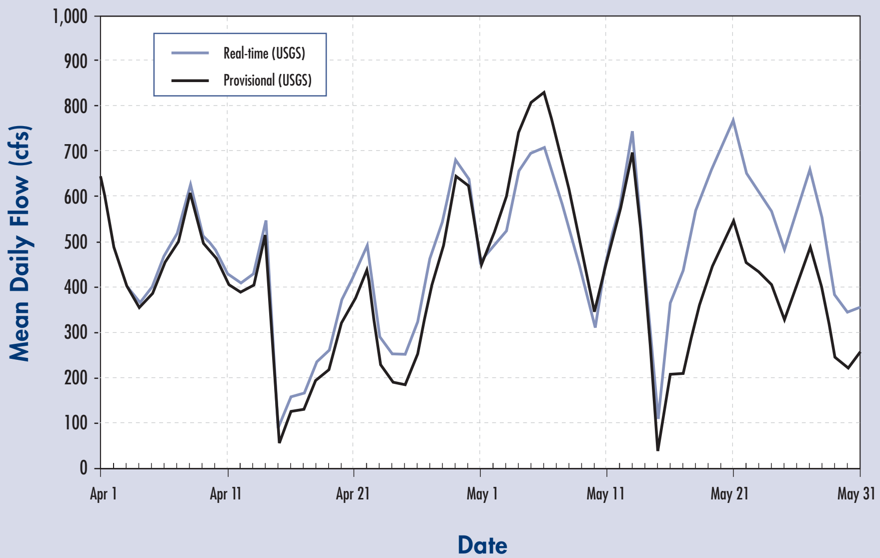
San Joaquin River near Newman



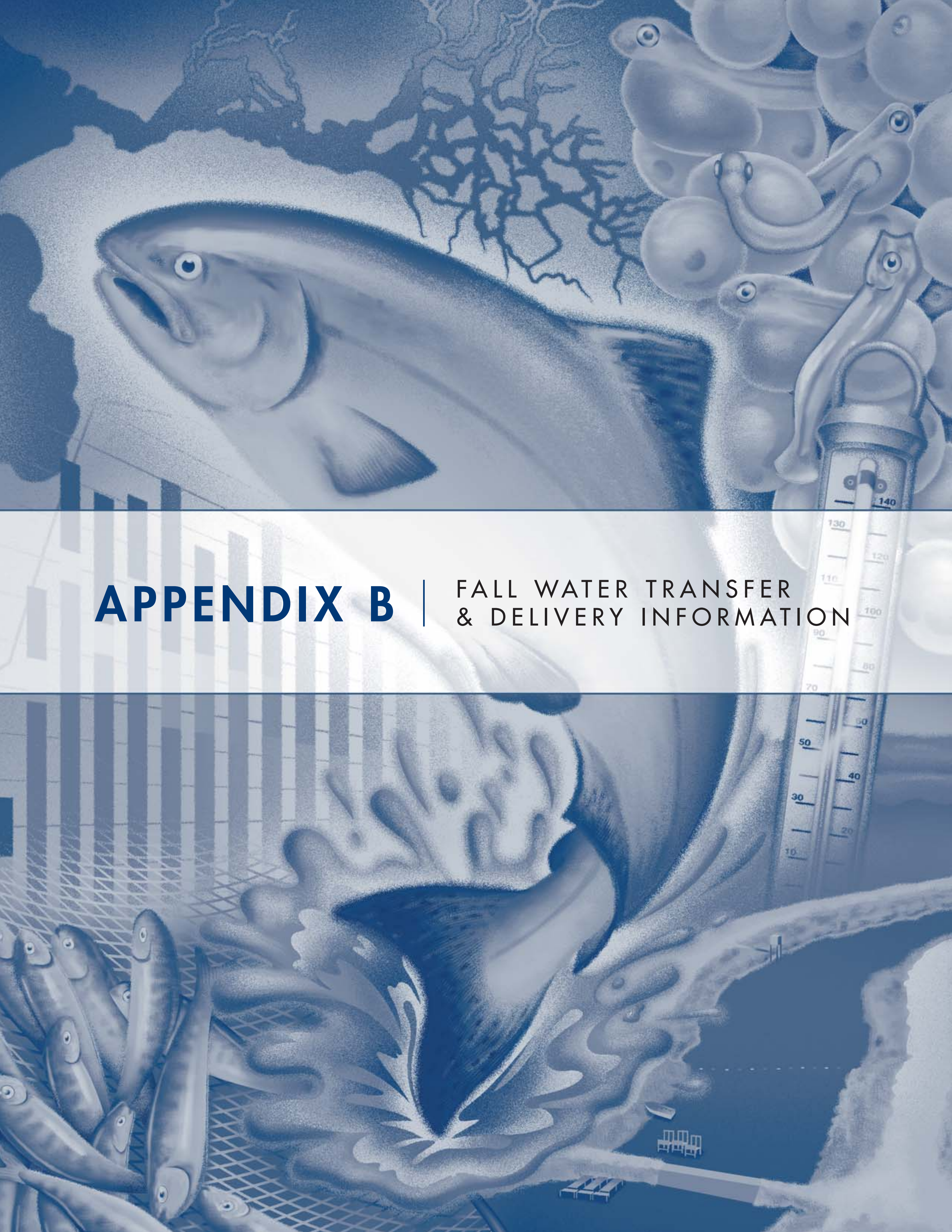
Tuolumne River below LaGrange Dam

San Joaquin River near Vernalis

Ungaged Flow at Vernalis



APPENDIX B | FALL WATER TRANSFER & DELIVERY INFORMATION



MERCED IRRIGATION DISTRICT (PRELIMINARY)

2002 Fall SJRA Water Transfer • Daily Flow Schedule

	SJRA Transfer Water			
	Merced River at Cressey Base Flow	Flow	Cumulative Volume	Merced River at Cressey Target Flow
	(cfs)	(cfs)	(acre-feet)	(cfs)
Oct 01	30	0	0	30
Oct 02	30	0	0	30
Oct 03	30	0	0	30
Oct 04	30	0	0	30
Oct 05	30	0	0	30
Oct 06	30	0	0	30
Oct 07	30	0	0	30
Oct 08	30	0	0	30
Oct 09	30	0	0	30
Oct 10	30	0	0	30
Oct 11	30	0	0	30
Oct 12	30	0	0	30
Oct 13	30	0	0	30
Oct 14	30	0	0	30
Oct 15	30	220	436	250
Oct 16	85	350	1,131	435
Oct 17	85	625	2,370	710
Oct 18	85	625	3,610	710
Oct 19	85	625	4,850	710
Oct 20	85	625	6,089	710
Oct 21	85	625	7,329	710
Oct 22	85	625	8,569	710
Oct 23	85	625	9,808	710
Oct 24	85	390	10,582	475
Oct 25	85	240	11,058	325
Oct 26	85	120	11,296	205
Oct 27	85	120	11,534	205
Oct 28	85	120	11,772	205
Oct 29	85	120	12,010	205
Oct 30	85	120	12,248	205
Oct 31	85	120	12,486	205

MERCED IRRIGATION DISTRICT (FINAL)

2001 Fall Water Transfer • Daily Flow Summary

			SJRA Transfer Water			EWA Transfer Water					
	Merced River Base Flow for SJRA Transfer Water (cfs)	Merced River at Cressey Observed Mean Daily Flow (cfs)	SJRA Transfer Water (cfs)		SJRA Transfer Water Cumulative Volume (ac-ft)	Observed Livingston Spill (cfs)	Livingston Spill Applied to Transfer (cfs)	Merced River Below Livingston Spill - for Transfer (cfs)	Total EWA Transfer Water Flow (cfs)		EWA Transfer Balance (ac-ft)
		DWR Provisional	Scheduled	Observed					Scheduled	Observed	
Oct 01	30	111	0	0	0	0	0	111	0	0	0
Oct 02	30	112	0	0	0	0	0	112	0	0	0
Oct 03	30	105	0	0	0	0	0	105	0	0	0
Oct 04	30	105	0	0	0	0	0	105	0	0	0
Oct 05	30	102	0	0	0	1	0	102	0	0	0
Oct 06	30	86	0	0	0	13	0	86	0	0	0
Oct 07	30	111	0	0	0	4	0	111	0	0	0
Oct 08	30	111	0	0	0	1	0	111	0	0	0
Oct 09	30	115	0	0	0	0	0	115	0	0	0
Oct 10	30	114	0	0	0	0	0	114	0	0	0
Oct 11	30	113	0	0	0	0	0	113	0	0	0
Oct 12	30	114	0	0	0	1	0	114	0	0	0
Oct 13	30	116	0	0	0	0	0	116	0	0	0
Oct 14	30	116	0	0	0	0	0	116	0	0	0
Oct 15	30	119	0	0	0	1	0	119	0	0	0
Oct 16	85	173	0	0	0	4	0	173	85	85	169
Oct 17	85	422	0	0	0	8	0	422	335	335	833
Oct 18	85	598	0	0	0	4	0	598	510	510	1,845
Oct 19	85	684	0	0	0	3	0	684	600	599	3,033
Oct 20	85	699	0	0	0	4	0	699	610	610	4,243
Oct 21	85	732	0	0	0	0	0	732	635	635	5,503
Oct 22	85	747	0	0	0	0	0	747	635	635	6,763
Oct 23	85	738	0	0	0	0	0	738	635	635	8,023
Oct 24	85	744	0	0	0	0	0	744	635	635	9,283
Oct 25	85	738	0	0	0	0	0	738	635	635	10,543
Oct 26	85	726	0	0	0	8	0	726	635	635	11,803
Oct 27	85	716	0	0	0	0	0	716	635	631	13,055
Oct 28	85	724	0	0	0	4	0	724	635	635	14,315
Oct 29	85	737	0	0	0	11	0	737	635	635	15,575
Oct 30	85	733	0	0	0	17	0	733	635	635	16,835
Oct 31	85	735	0	0	0	46	0	735	635	635	18,095
Nov 01	220	516	0	0	0	86	86	602	380	380	18,849
Nov 02	220	466	0	0	0	111	111	577	355	355	19,553
Nov 03	220	448	0	0	0	106	106	554	315	315	20,178
Nov 04	220	429	0	0	0	91	91	520	305	300	20,773
Nov 05	220	430	0	0	0	90	90	520	305	300	21,368
Nov 06	220	430	0	0	0	96	96	526	305	305	21,973
Nov 07	220	435	0	0	0	95	95	530	305	305	22,578
Nov 08	220	442	0	0	0	101	101	543	305	305	23,183
Nov 09	220	438	0	0	0	105	105	543	305	305	23,788
Nov 10	220	444	0	0	0	107	107	551	305	305	24,393
Nov 11	220	422	0	0	0	106	106	528	305	305	24,998
Nov 12	220	394	140	140	278	67	0	394	0	0	24,998
Nov 13	220	409	140	140	555	51	0	409	0	0	24,998
Nov 14	220	397	140	140	833	14	0	397	0	0	24,998
Nov 15	220	397	140	140	1,111	4	0	397	0	0	24,998

MERCED IRRIGATION DISTRICT (FINAL)

2001 Fall Water Transfer • Daily Flow Summary

		SJRA Transfer Water			EWA Transfer Water						
Merced River Base Flow for SJRA Transfer Water (cfs)	Merced River at Cressey Observed Mean Daily Flow (cfs)	SJRA Transfer Water (cfs)		SJRA Transfer Water Cumulative Volume (ac-ft)	Observed Livingston Spill (cfs)	Livingston Spill Applied to Transfer (cfs)	Merced River Below Livingston Spill - for Transfer (cfs)	Total EWA Transfer Water Flow (cfs)		EWA Transfer Balance (ac-ft)	
	DWR Provisional	Scheduled	Observed					Scheduled	Observed		
220	397	140	140	1,388	0	0	397	0	0	24,998	Nov 16
220	402	140	140	1,666	0	0	402	0	0	24,998	Nov 17
220	401	140	140	1,944	0	0	401	0	0	24,998	Nov 18
220	402	140	140	2,221	0	0	402	0	0	24,998	Nov 19
220	412	140	140	2,499	0	0	412	0	0	24,998	Nov 20
220	410	140	140	2,777	0	0	410	0	0	24,998	Nov 21
220	411	140	140	3,055	0	0	411	0	0	24,998	Nov 22
220	408	140	140	3,332	0	0	408	0	0	24,998	Nov 23
220	423	140	140	3,610	0	0	423	0	0	24,998	Nov 24
220	431	140	140	3,888	1	0	431	0	0	24,998	Nov 25
220	419	140	140	4,165	2	0	419	0	0	24,998	Nov 26
220	416	120	120	4,403	0	0	416	0	0	24,998	Nov 27
220	420	120	120	4,641	0	0	420	0	0	24,998	Nov 28
220	424	120	120	4,879	0	0	424	0	0	24,998	Nov 29
220	428	120	120	5,117	0	0	428	0	0	24,998	Nov 30
220	435	120	120	5,355	0	0	435	0	0	24,998	Dec 01
220	426	120	120	5,593	0	0	426	0	0	24,998	Dec 02
220	448	120	120	5,831	3	0	448	0	0	24,998	Dec 03
220	422	120	120	6,069	2	0	422	0	0	24,998	Dec 04
220	416	120	120	6,307	1	0	416	0	0	24,998	Dec 05
220	414	120	120	6,545		0	414	0	0	24,998	Dec 06
220	409	120	120	6,783		0	409	0	0	24,998	Dec 07
220	410	120	120	7,021		0	410	0	0	24,998	Dec 08
220	404	120	120	7,260		0	404	0	0	24,998	Dec 09
220	401	120	120	7,498		0	401	0	0	24,998	Dec 10
220	415	120	120	7,736		0	415	0	0	24,998	Dec 11
220	407	120	120	7,974		0	407	0	0	24,998	Dec 12
220	396	120	120	8,212		0	396	0	0	24,998	Dec 13
220	405	120	120	8,450		0	405	0	0	24,998	Dec 14
220	398	120	120	8,688		0	398	0	0	24,998	Dec 15
220	393	120	120	8,926		0	393	0	0	24,998	Dec 16
220	394	120	120	9,164		0	394	0	0	24,998	Dec 17
220	395	120	120	9,402		0	395	0	0	24,998	Dec 18
220	393	120	120	9,640		0	393	0	0	24,998	Dec 19
220	401	120	120	9,878		0	401	0	0	24,998	Dec 20
220	429	120	120	10,116		0	429	0	0	24,998	Dec 21
220	425	120	120	10,354		0	425	0	0	24,998	Dec 22
220	415	120	120	10,592		0	415	0	0	24,998	Dec 23
220	406	120	120	10,830		0	406	0	0	24,998	Dec 24
220	406	120	120	11,068		0	406	0	0	24,998	Dec 25
220	403	120	120	11,306		0	403	0	0	24,998	Dec 26
220	400	120	120	11,544		0	400	0	0	24,998	Dec 27
220	403	120	120	11,782		0	403	0	0	24,998	Dec 28
220	996	120	120	12,020		0	996	0	0	24,998	Dec 29
220	1,400	120	120	12,258		0	1,400	0	0	24,998	Dec 30
220	1,030	120	120	12,496		0	1,030	0	0	24,998	Dec 31

OAKDALE IRRIGATION DISTRICT (PRELIMINARY)

Daily Schedule of Additional Water Release
Additional Water Available: 22,205 acre-feet

Subject to change

		Scheduled		
	DFG Base Fish Flow (cfs)	Total Fish Release (cfs)	Flow (cfs)	Cumulative Volume (ac-ft)
			Oakdale ID Additional Water	
Oct 19 '02	200	200	0	0
Oct 20 '02	200	350	150	298
Oct 21 '02	200	600	400	1,091
Oct 22 '02	200	700	500	2,083
Oct 23 '02	200	700	500	3,074
Oct 24 '02	200	700	500	4,066
Oct 25 '02	200	700	500	5,058
Oct 26 '02	200	700	500	6,050
Oct 27 '02	200	700	500	7,041
Oct 28 '02	200	450	250	7,537
Oct 29 '02	200	250	50	7,636
Oct 30 '02	200	250	50	7,736
Oct 31 '02	200	250	50	7,835
Nov 01 '02	200	250	50	7,934
Nov 02 '02	200	250	50	8,033
Nov 03 '02	200	250	50	8,132
Nov 04 '02	200	250	50	8,231
Nov 05 '02	200	250	50	8,331
Nov 06 '02	200	250	50	8,430
Nov 07 '02	200	275	75	8,579
Nov 08 '02	200	300	100	8,777
Nov 09 '02	200	300	100	8,975
Nov 10 '02	200	300	100	9,174
Nov 11 '02	200	300	100	9,372
Nov 12 '02	200	300	100	9,570
Nov 13 '02	200	300	100	9,769
Nov 14 '02	200	300	100	9,967
Nov 15 '02	200	300	100	10,165
Nov 16 '02	200	300	100	10,364
Nov 17 '02	200	300	100	10,562
Nov 18 '02	200	300	100	10,760
Nov 19 '02	200	300	100	10,959
Nov 20 '02	200	300	100	11,157
Nov 21 '02	200	300	100	11,355
Nov 22 '02	200	300	100	11,554
Nov 23 '02	200	300	100	11,752
Nov 24 '02	200	300	100	11,950
Nov 25 '02	200	300	100	12,149
Nov 26 '02	200	300	100	12,347
Nov 27 '02	200	300	100	12,545
Nov 28 '02	200	300	100	12,744
Nov 29 '02	200	300	100	12,942
Nov 30 '02	200	300	100	13,140
Dec 01 '02	200	275	75	13,289
Dec 02 '02	200	275	75	13,438

OAKDALE IRRIGATION

Daily Schedule of
Additional Water Available:

	DFG Base Fish Flow (cfs)	Total Fish Release (cfs)
Dec 03 '02	200	275
Dec 04 '02	200	275
Dec 05 '02	200	275
Dec 06 '02	200	275
Dec 07 '02	200	275
Dec 08 '02	200	275
Dec 09 '02	200	275
Dec 10 '02	200	275
Dec 11 '02	200	275
Dec 12 '02	200	275
Dec 13 '02	200	275
Dec 14 '02	200	275
Dec 15 '02	200	275
Dec 16 '02	200	275
Dec 17 '02	200	275
Dec 18 '02	200	275
Dec 19 '02	200	275
Dec 20 '02	200	275
Dec 21 '02	200	275
Dec 22 '02	200	275
Dec 23 '02	200	275
Dec 24 '02	200	275
Dec 25 '02	200	275
Dec 26 '02	200	275
Dec 27 '02	200	275
Dec 28 '02	200	275
Dec 29 '02	200	275
Dec 30 '02	200	275
Dec 31 '02	200	275
Jan 01 '03	175	225
Jan 02 '03	175	225
Jan 03 '03	175	225
Jan 04 '03	175	225
Jan 05 '03	175	225
Jan 06 '03	175	225
Jan 07 '03	175	225
Jan 08 '03	175	225
Jan 09 '03	175	225
Jan 10 '03	175	225
Jan 11 '03	175	225
Jan 12 '03	175	225
Jan 13 '03	175	225
Jan 14 '03	175	225
Jan 15 '03	175	225
Jan 16 '03	175	225

DISTRICT (PRELIMINARY)

Additional Water Release
22,205 acre-feet

Subject to change

Scheduled Flow (cfs)	Scheduled Cumulative Volume (ac-ft)	
Oakdale ID Additional Water		
75	13,587	Dec 03 '02
75	13,736	Dec 04 '02
75	13,884	Dec 05 '02
75	14,033	Dec 06 '02
75	14,182	Dec 07 '02
75	14,331	Dec 08 '02
75	14,479	Dec 09 '02
75	14,628	Dec 10 '02
75	14,777	Dec 11 '02
75	14,926	Dec 12 '02
75	15,074	Dec 13 '02
75	15,223	Dec 14 '02
75	15,372	Dec 15 '02
75	15,521	Dec 16 '02
75	15,669	Dec 17 '02
75	15,818	Dec 18 '02
75	15,967	Dec 19 '02
75	16,116	Dec 20 '02
75	16,264	Dec 21 '02
75	16,413	Dec 22 '02
75	16,562	Dec 23 '02
75	16,711	Dec 24 '02
75	16,859	Dec 25 '02
75	17,008	Dec 26 '02
75	17,157	Dec 27 '02
75	17,306	Dec 28 '02
75	17,455	Dec 29 '02
75	17,603	Dec 30 '02
75	17,752	Dec 31 '02
50	17,851	Jan 01 '03
50	17,950	Jan 02 '03
50	18,050	Jan 03 '03
50	18,149	Jan 04 '03
50	18,248	Jan 05 '03
50	18,347	Jan 06 '03
50	18,446	Jan 07 '03
50	18,545	Jan 08 '03
50	18,645	Jan 09 '03
50	18,744	Jan 10 '03
50	18,843	Jan 11 '03
50	18,942	Jan 12 '03
50	19,041	Jan 13 '03
50	19,140	Jan 14 '03
50	19,240	Jan 15 '03
50	19,339	Jan 16 '03

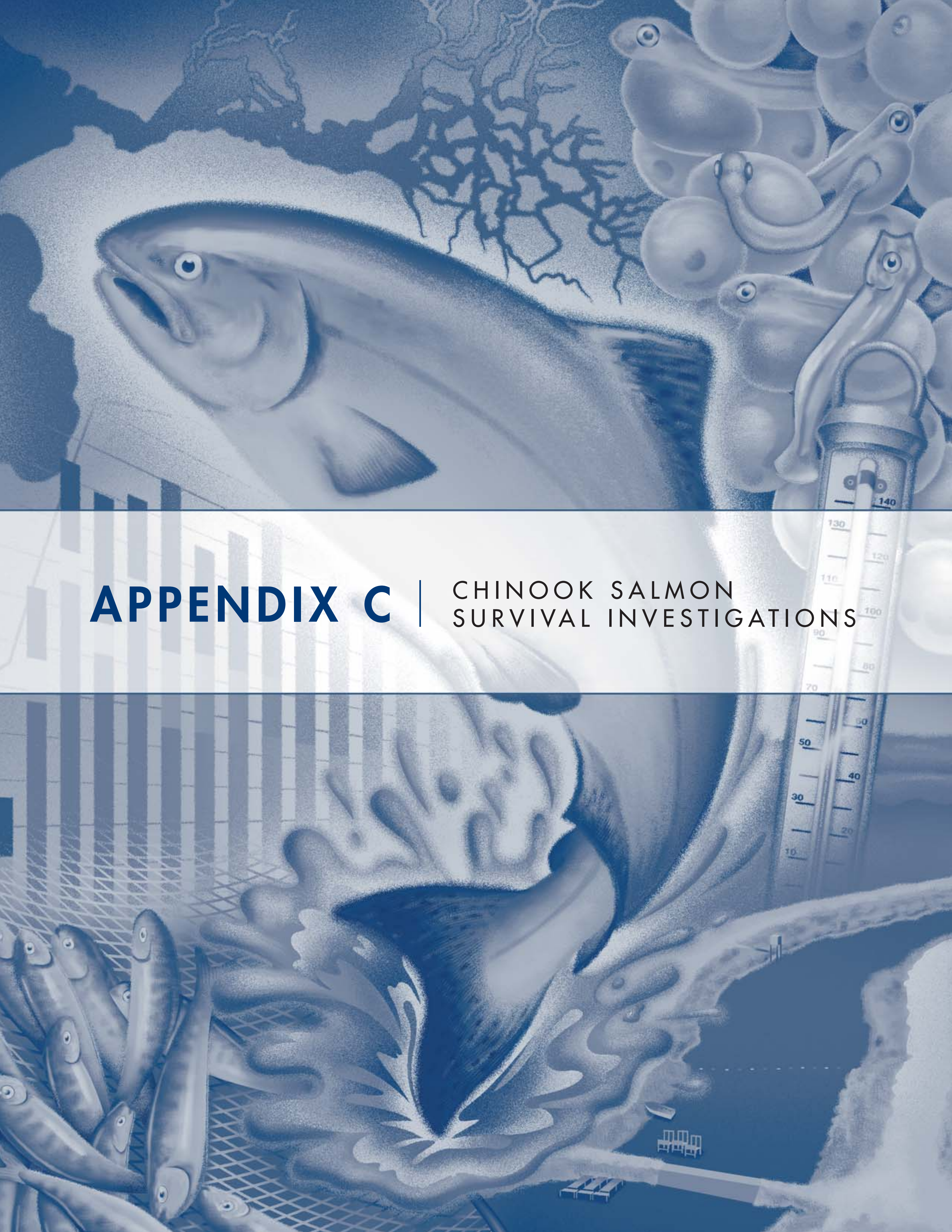
OAKDALE IRRIGATION DISTRICT (PRELIMINARY)

Daily Schedule of Additional Water Release
Additional Water Available: 22,205 acre-feet

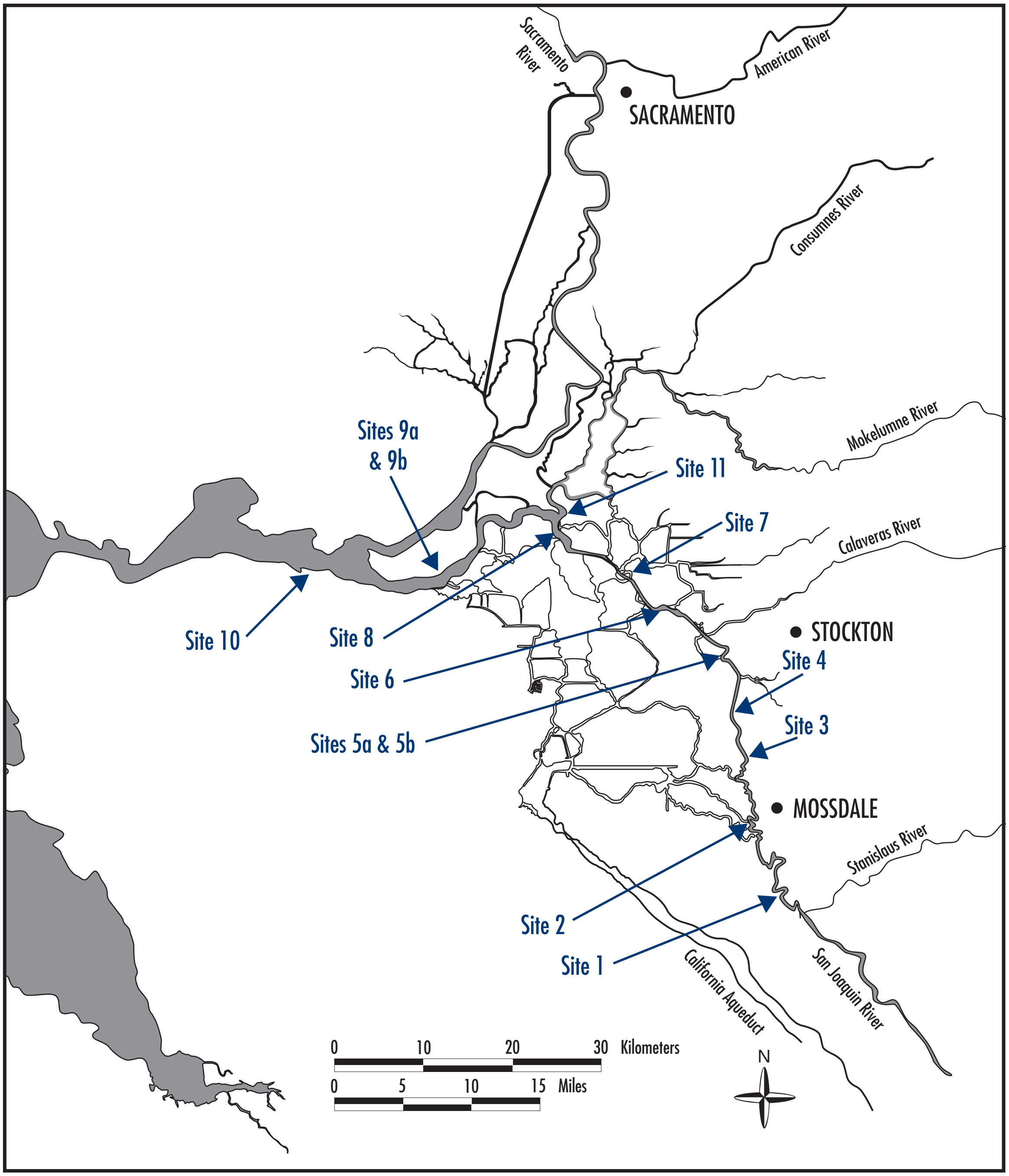
Subject to change

DFG Base Fish Flow (cfs)	Total Fish Release (cfs)	Scheduled Flow (cfs)	Scheduled Cumulative Volume (ac-ft)	
		Oakdale ID Additional Water		
175	225	50	19,438	Jan 17 '03
175	225	50	19,537	Jan 18 '03
175	225	50	19,636	Jan 19 '03
175	225	50	19,736	Jan 20 '03
175	225	50	19,835	Jan 21 '03
175	225	50	19,934	Jan 22 '03
175	225	50	20,033	Jan 23 '03
175	225	50	20,132	Jan 24 '03
175	225	50	20,231	Jan 25 '03
175	225	50	20,331	Jan 26 '03
175	225	50	20,430	Jan 27 '03
175	225	50	20,529	Jan 28 '03
175	225	50	20,628	Jan 29 '03
175	225	50	20,727	Jan 30 '03
175	200	25	20,777	Jan 31 '03
150	200	50	20,876	Feb 01 '03
150	175	25	20,926	Feb 02 '03
150	175	25	20,975	Feb 03 '03
150	175	25	21,025	Feb 04 '03
150	175	25	21,074	Feb 05 '03
150	175	25	21,124	Feb 06 '03
150	175	25	21,174	Feb 07 '03
150	175	25	21,223	Feb 08 '03
150	175	25	21,273	Feb 09 '03
150	175	25	21,322	Feb 10 '03
150	175	25	21,372	Feb 11 '03
150	175	25	21,421	Feb 12 '03
150	175	25	21,471	Feb 13 '03
150	175	25	21,521	Feb 14 '03
150	175	25	21,570	Feb 15 '03
150	175	25	21,620	Feb 16 '03
150	175	25	21,669	Feb 17 '03
150	175	25	21,719	Feb 18 '03
150	175	25	21,769	Feb 19 '03
150	175	25	21,818	Feb 20 '03
150	175	25	21,868	Feb 21 '03
150	175	25	21,917	Feb 22 '03
150	175	25	21,967	Feb 23 '03
150	175	25	22,017	Feb 24 '03
150	175	25	22,066	Feb 25 '03
150	175	25	22,116	Feb 26 '03
150	175	25	22,165	Feb 27 '03
150	175	25	22,215	Feb 28 '03

APPENDIX C | CHINOOK SALMON SURVIVAL INVESTIGATIONS



SACRAMENTO-SAN JOAQUIN ESTUARY

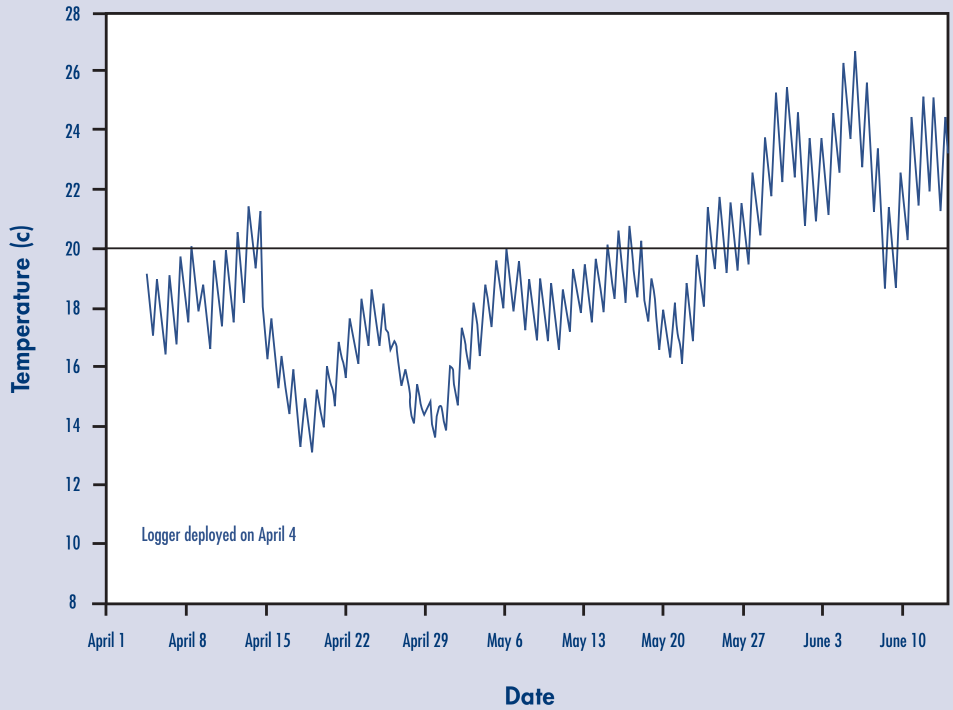


Water Temperature Monitoring Locations During the VAMP 2002 Experiment

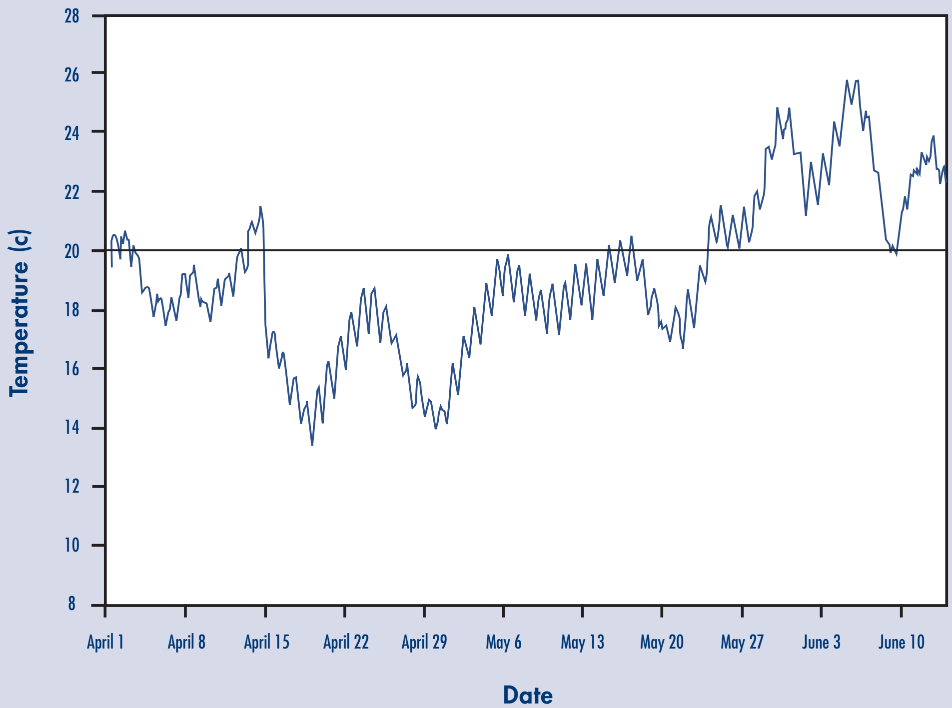
VAMP 2002 WATER TEMPERATURE MONITORING LOCATIONS

Site no.	Temperature Monitoring Location	Latitude	Longitude	Distance from Durham Ferry (mi)	Date Deployed	Date Retrieved	Notes
	Merced River Hatchery–1			n/a	March 15	April 26	In river April 18
	Merced River Hatchery–2			n/a	March 15	April 30	In river April 25
1	Durham Ferry	N 37 41.381	W 121 15.657	n/a	April 4	June 15	In 3 feet of water
2	Mossdale	N 37 47.180	W 121 18.425	11.2	April 1	June 15	In 3 feet of water
3	Dos Reis	N 37 49.808	W 121 18.665	16.4	April 1	June 15	In 3 feet of water
4	DWR Monitoring Station	N 37 51.869	W 121 19.376	19.4	April 1	June 15	In 3 feet of water
5a	Confluence–Top	N 37 56.818	W 121 20.285	26.5	April 1	June 15	2 feet below surface
5b	Confluence–Bottom	N 37 56.818	W 121 20.285	26.5	April 1	June 15	On river bottom
6	Downstream of Channel Marker 30	N 37 59.776	W 121 25.569	33.3	April 1	June 15	In 3 feet of water
7	1/2 mile Upstream of Channel Marker 13	N 38 01.940	W 121 28.769	37.3	April 1	June 15	In 3 feet of water
8	Downstream of Channel Marker 36	N 38 04.522	W 121 34.413	44.7	April 1	June 15	In 3 feet of water
9a	Jersey Point USGS Gauging Station–top	N 38 03.172	W121 41.637	56	April 1	June 15	2 feet below surface
9b	Jersey Point USGS Gauging Station–bottom	N 38 03.172	W121 41.637	56	April 1		Logger lost
10	Chipps Island	N 38 03.084	W 121 55.463	71.5	April 1	June 15	In 3 feet of water
11	Mokelumne River	N 38 06.334	W 121 34.213	40	April 1	June 15	In 3 feet of water

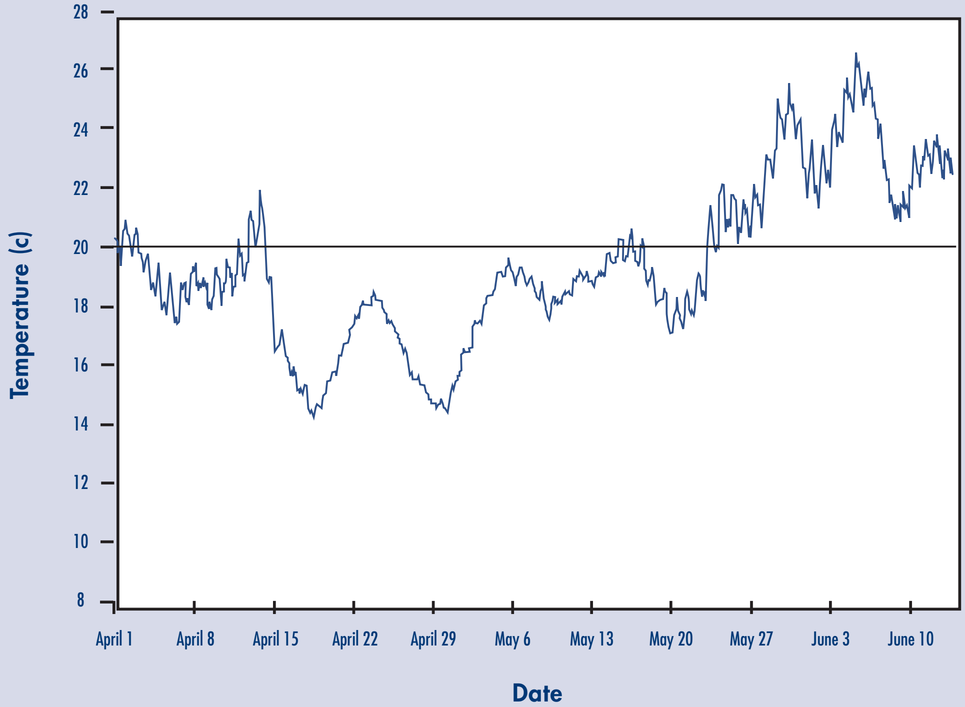
Site 1 • Durham Ferry



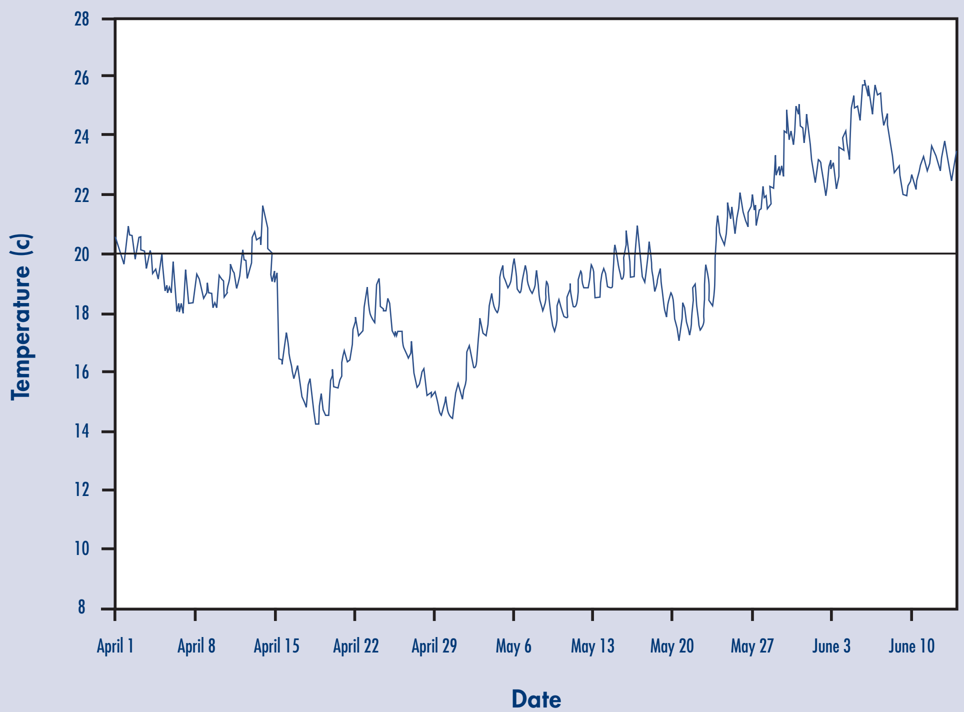
Site 2 • Mossdale



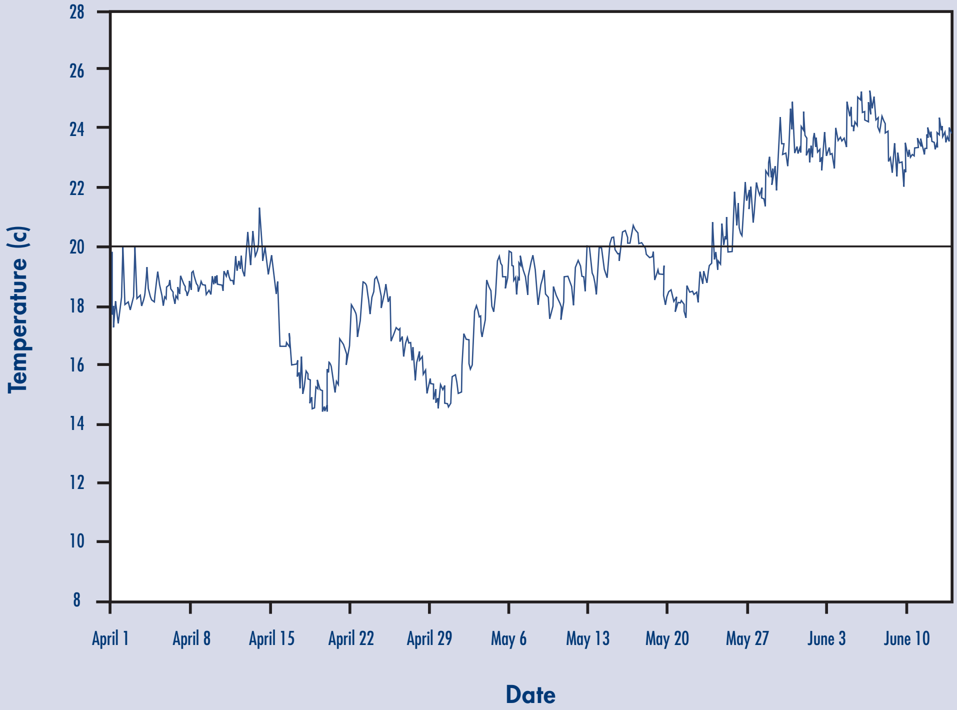
Site 3 • Dos Reis



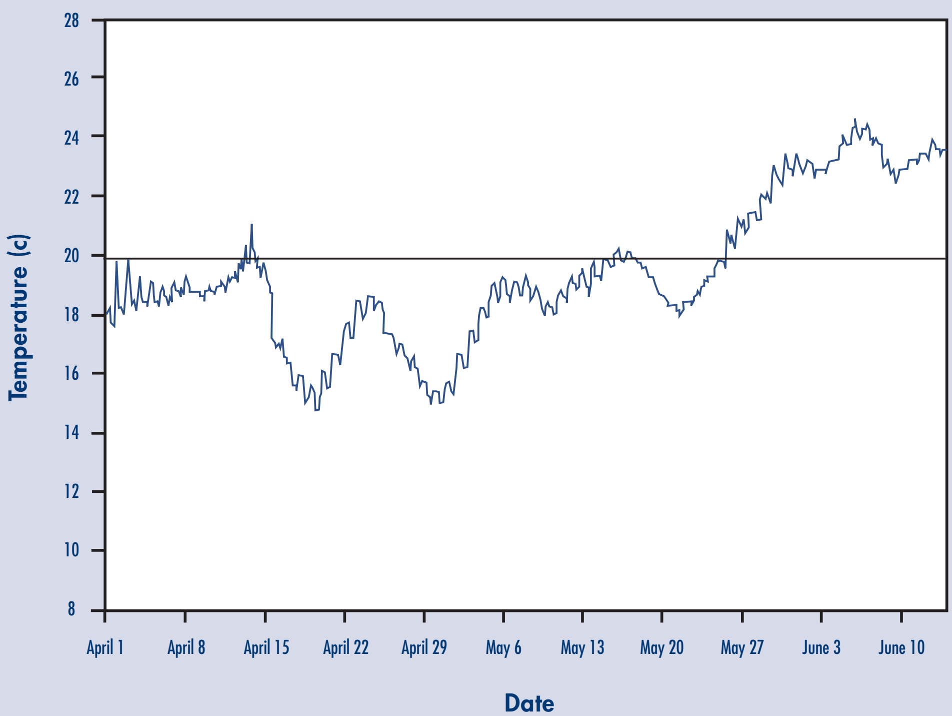
Site 4 • DWR Monitoring Station



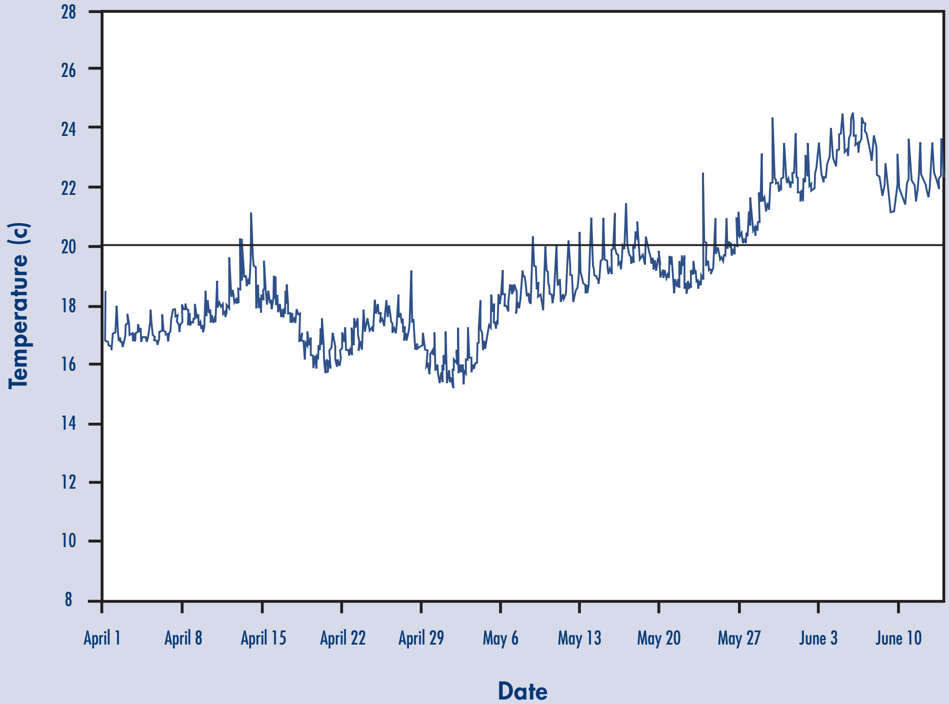
Site 5a • Confluence-Top



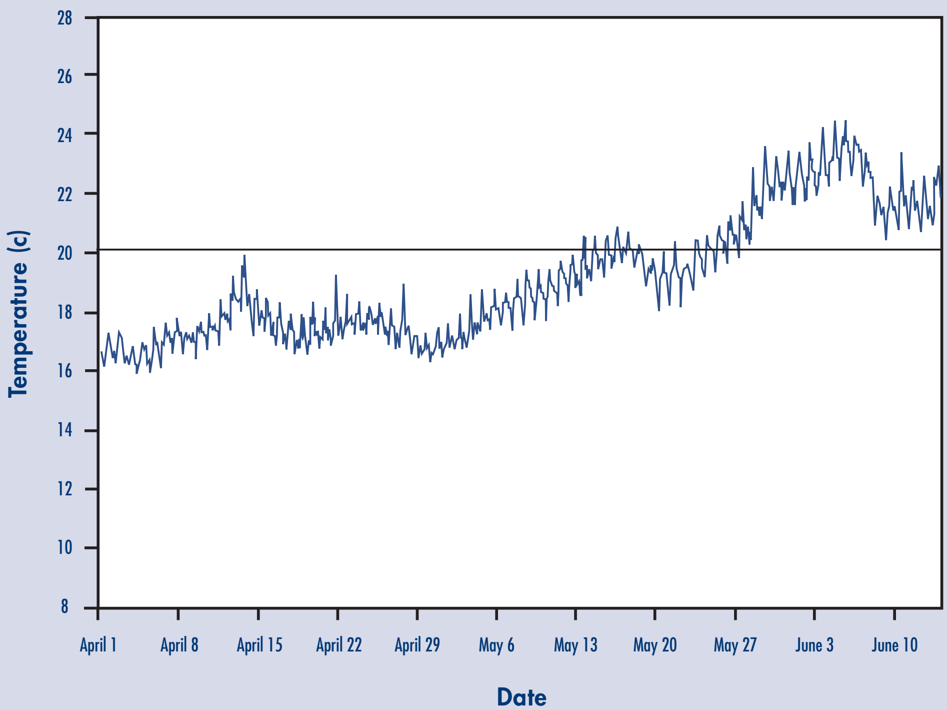
Site 5b • Confluence-Bottom



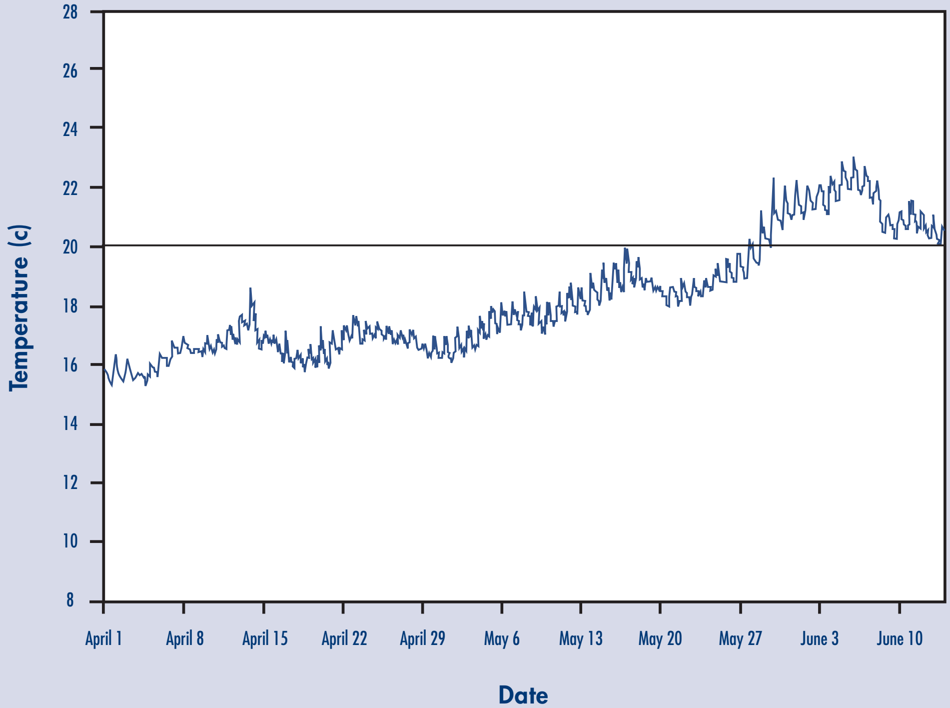
Site 6 • Downstream of Channel Marker 30



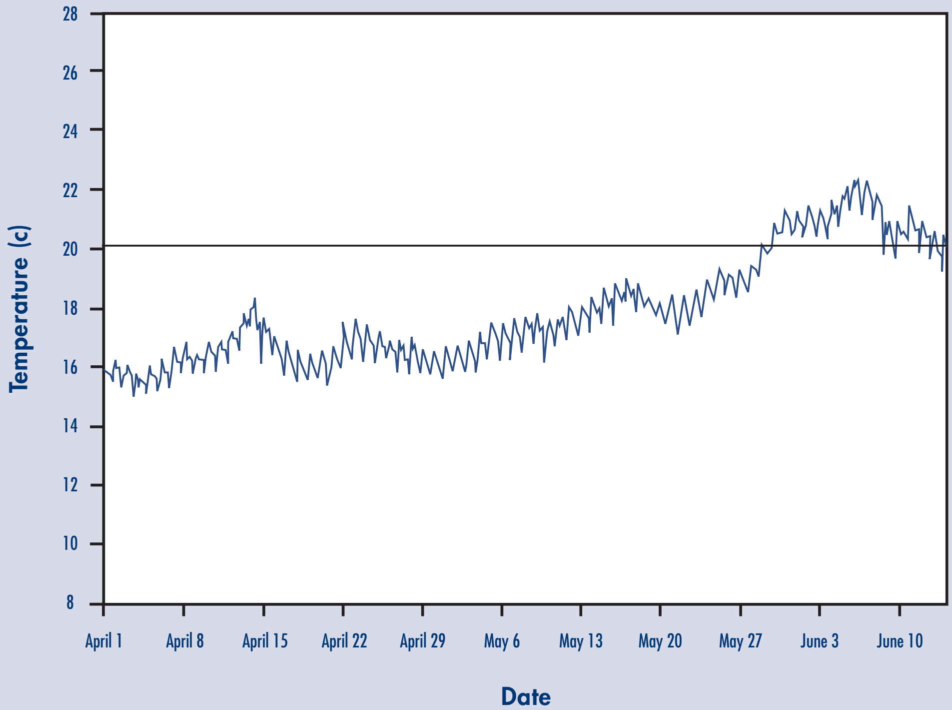
Site 7 • 1/2 Mile Upstream of Channel Marker 13



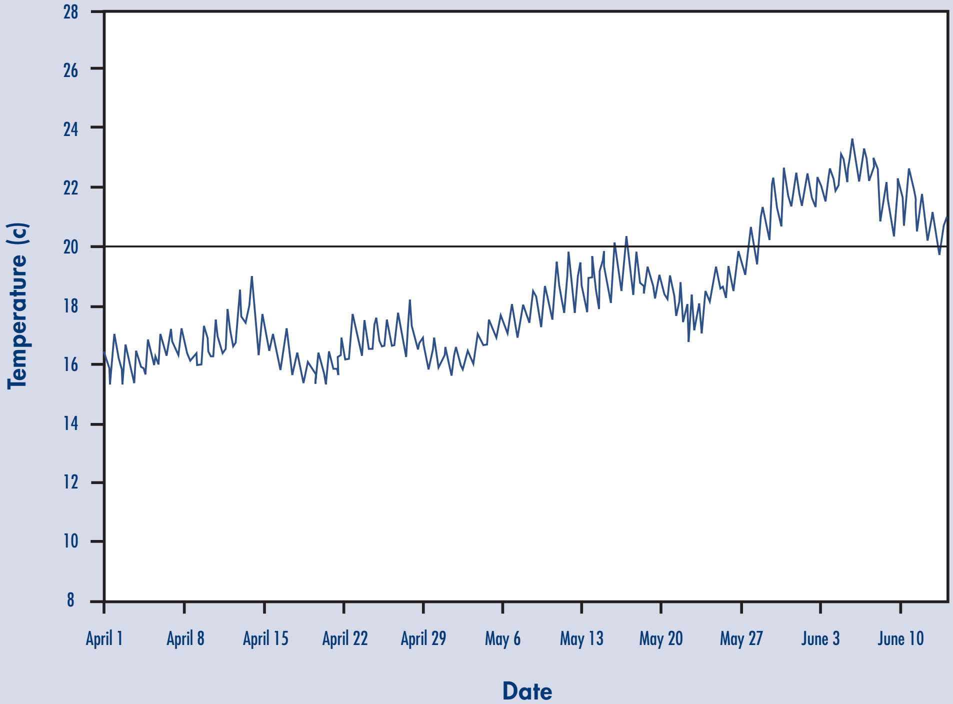
Site 8 • Downstream of Channel Marker 36



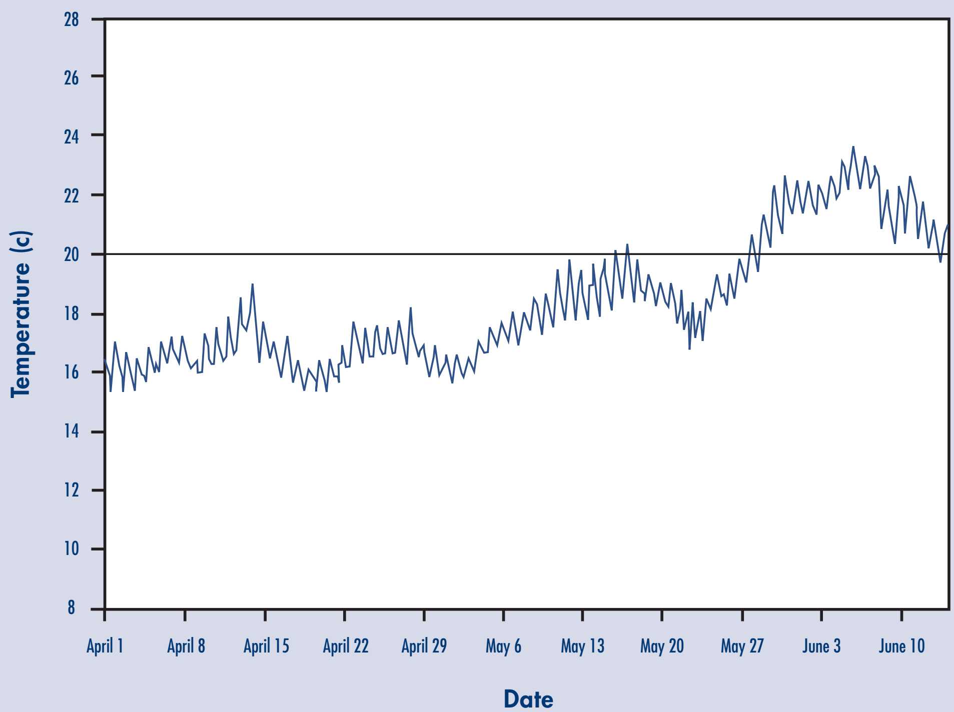
Site 9a • Jersey Point–Top



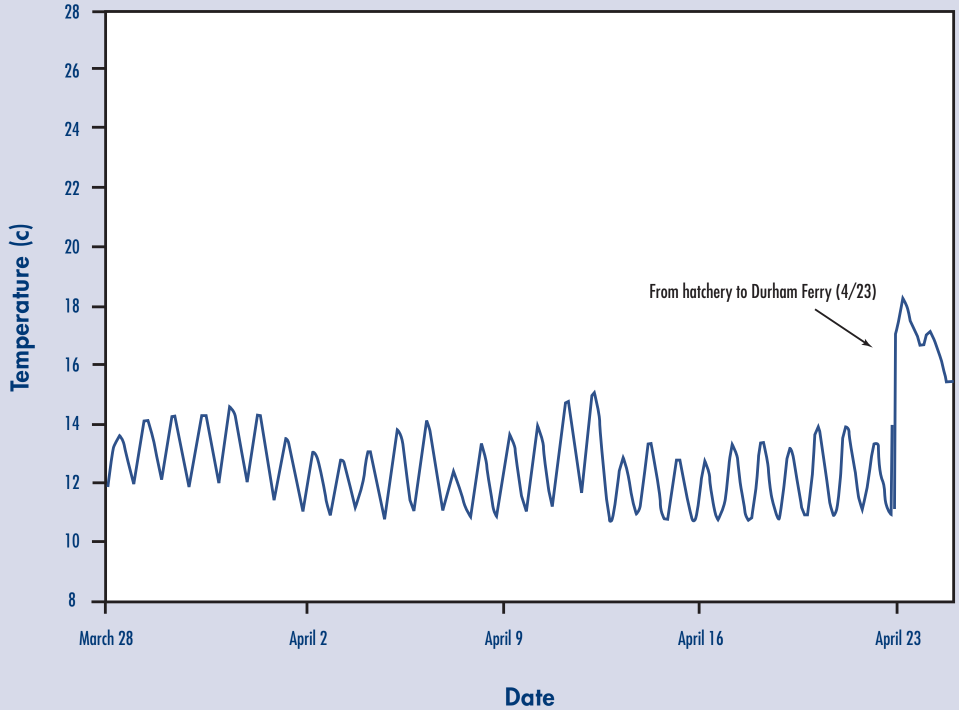
Site 10 • Chipps Island



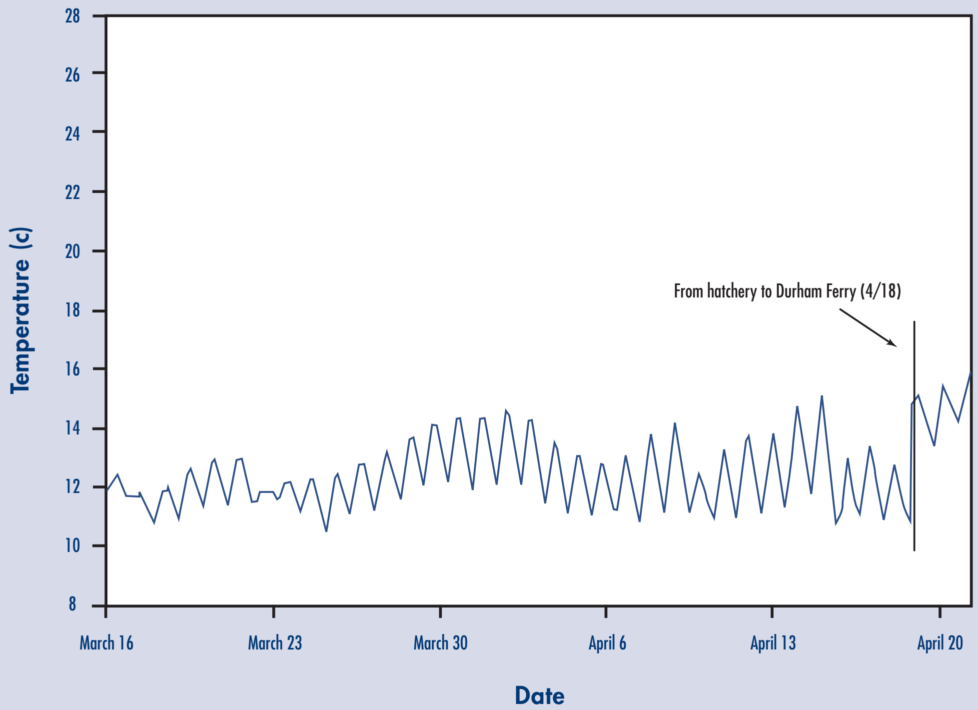
Site 11 • Mokelumne River



Merced River Fish Hatchery – 1



Merced River Fish Hatchery – 2



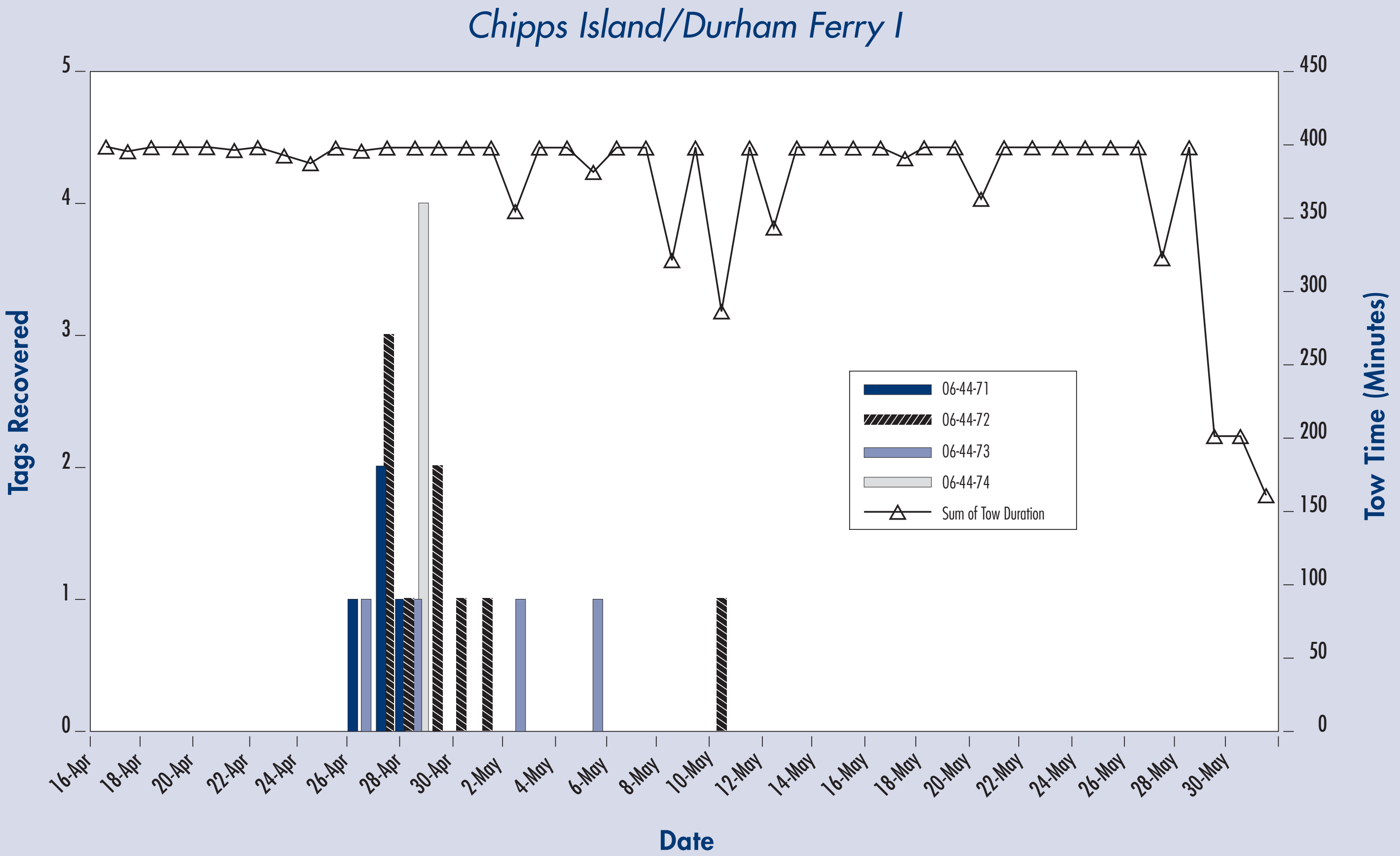
RESULTS OF NET PEN SAMPLING CONDUCTED IMMEDIATELY AFTER RELEASE, VAMP 2002

Release location, release date, tag code, number in sample	Mean fork length (and range in millimeters)	Mean weight (and range in grams)	Mean scale loss (and range in percent)	Color	Fin hemorrhaging	Eyes	Gill color	Ad clips, comments and mortalities
Durham Ferry I Pen #1	80.96(64-87)	5.82(2.7-7)	3.8(1-11)	Normal	None	Normal	Normal	0.04 (1 deformed pectoral fin)
Durham Ferry I Pen #2	82.00(74-90)	6.1 (4.4-7.7)	3.6(2-7)	Normal	None	Normal	Normal	
Mossdale I Pen #2	84.5(77-92)	6.7(4.9-8.9)	4.9(1-15)	Normal	None	Normal	Normal	0.04 (1 poor ad clip)
Mossdale I Pen #3	81.9(68-90)	5.9(3.5-8)	3.4(1-15)	Normal	None	Normal	Normal	0.04 (1 deformed pectoral fin)
Jersey Point I Pen #2	85.0(70-95)	6.7(3.6-9.4)	3.6(1-7)	Normal	None	Normal	Normal	0.08 (2 half ad clips) 0.04 (1 deformed pectoral fin)
Jersey Point I Pen #3	82.0(61-92)	6.1(2.4-8.2)	3.3(1-5)	Normal	None	Normal	Normal	0.04 (1 half ad clip) 0.04 (1 deformed pectoral fin)
Group I	82.76(61-95)	6.24(2.4-9.4)	3.77(1-15)					
Durham Ferry II Pen #1	80.1(72-89)	5.8(4.1-8.1)	5.9(2-20)	Normal	None	Normal	Normal	0.04 (1 half adipose fin clip)
Durham Ferry II Pen #2	79.24(67-93)	5.24(3.1-8.4)	12.32(1-25)	Normal	None	Normal	Normal	0.04 (1 caudal fin damage)
Mossdale II Pen #1	82.4(75-104)	6.1(4.4-12.4)	7.3(3-15)	Normal	None	Normal	Normal	0.08 (2 caudal fins damage)
Mossdale II Pen #2	80.2(70-90)	5.43(3.7-7.7)	8.08(2-25)	Normal	None	Normal	Normal	0.04 (caudal/ dorsal clip?) 0.08 (2 no adipose fin clips)
Jersey Point II Pen #2	85.2(77-96)	6.77(4.8-10)	2.44(1-5)	Normal	None	Normal	Normal	
Jersey Point II Pen #3	83.8(75-90)	6.62(4.3-9)	2.32(1-6)	Normal	None	Normal	Normal	0.08 (2 half adipose fin clips) 0.08 (2 deformed pectoral fins)
Group II	81.83(67-104)	5.99(3.1-12.4)	6.39(1-25)					

RESULTS OF NET PEN SAMPLING CONDUCTED 48 HOURS AFTER RELEASE, VAMP 2002

Release location, release date, tag code, number in sample	Mean fork length (and range in millimeters)	Mean weight (and range in grams)	Mean scale loss (and range in percent)	Color	Fin hemorrhaging	Eyes	Gill color	Ad clips, comments and mortalities
Durham Ferry I Pen #1	83(69-102)	6.0(3.2-11.5)	4(2-7)	Normal	None	Normal	Normal	
Durham Ferry I Pen #2	84.4(76-90)	6.2(4.5-7.7)	2.9(1.0-5.0)	Normal	None	Normal	Normal	
Mossdale I Pen #2	82.92(75-91)	6.0(4.3-7.8)	3.7(1-12)	Normal	None	Normal	Normal	
Mossdale I Pen #3	82.4(66-92)	5.8(4-8.2)	2.9(1-7)	Normal	None	Normal	Normal	0.04(scoliosis-spine)
Jersey Point I Pen #2	85.5(76-94)	6.6(4.3-8.1)	12.8(1-40)	Normal	None	Normal	Normal	0.08(half adipose clip)
Jersey Point I Pen #3	83.6(72-95)	5.9(3.8-9.1)	9.1(4.0-15.0)	Normal	None	Normal	Normal	0.04(hemmoraged eye)
Group II	83.6(66-102)	6.1(3.2-11.5)	6(1-40)					
Durham Ferry II Pen #1	80(71-94)	5.4(3.7-8.8)	12.3(2.0-30.0)	Normal	None	Normal	Normal	
Durham Ferry II Pen #2	80.64(71-93)	5.3(3.6-9.3)	6.5(1-21)	Normal	None	Normal	Normal	
Mossdale II Pen#1	80.6(70-89)	5.4(3.6-7.4)	5.2(2.0-10.0)	Normal	None	Normal	Normal	0.04(hemmoraged eye) 0.04(no adipose fin clip)
Mossdale II Pen#2	79.9(67-88)	5.3(3.2-7.0)	6.5(2.0-12.0)	Normal	None	Normal	Normal	
Jersey Point II Pen #2	82.0(71-94)	5.8(3.7-9.2)	4.3(1.0-10.0)	Normal	None	Normal	Normal	0.20(half adipose fin clip) 0.04(deformed pectoral fin)
Jersey Point II Pen #3	82.9(75-93)	6.3(4.4-8.6)	4.9(2.0-9.0)	Normal	None	Normal	Normal	0.16(half adipose fin clip) 0.04(no adipose fin clip)
Group II	80.48(67-82.9)	5.5(9.3-7.9)	6.6(1.0-30.0)					

Note: averages are for first 25 fish worked up in each pen.


Chipps Island/Durham Ferry I
Tags Recovered
Tow Time (Minutes)
Date
06-44-71
06-44-72
06-44-73
06-44-74
Sum of Tow Duration
16-Apr
18-Apr
20-Apr
22-Apr
24-Apr
26-Apr
28-Apr
30-Apr
2-May
4-May
6-May
8-May
10-May
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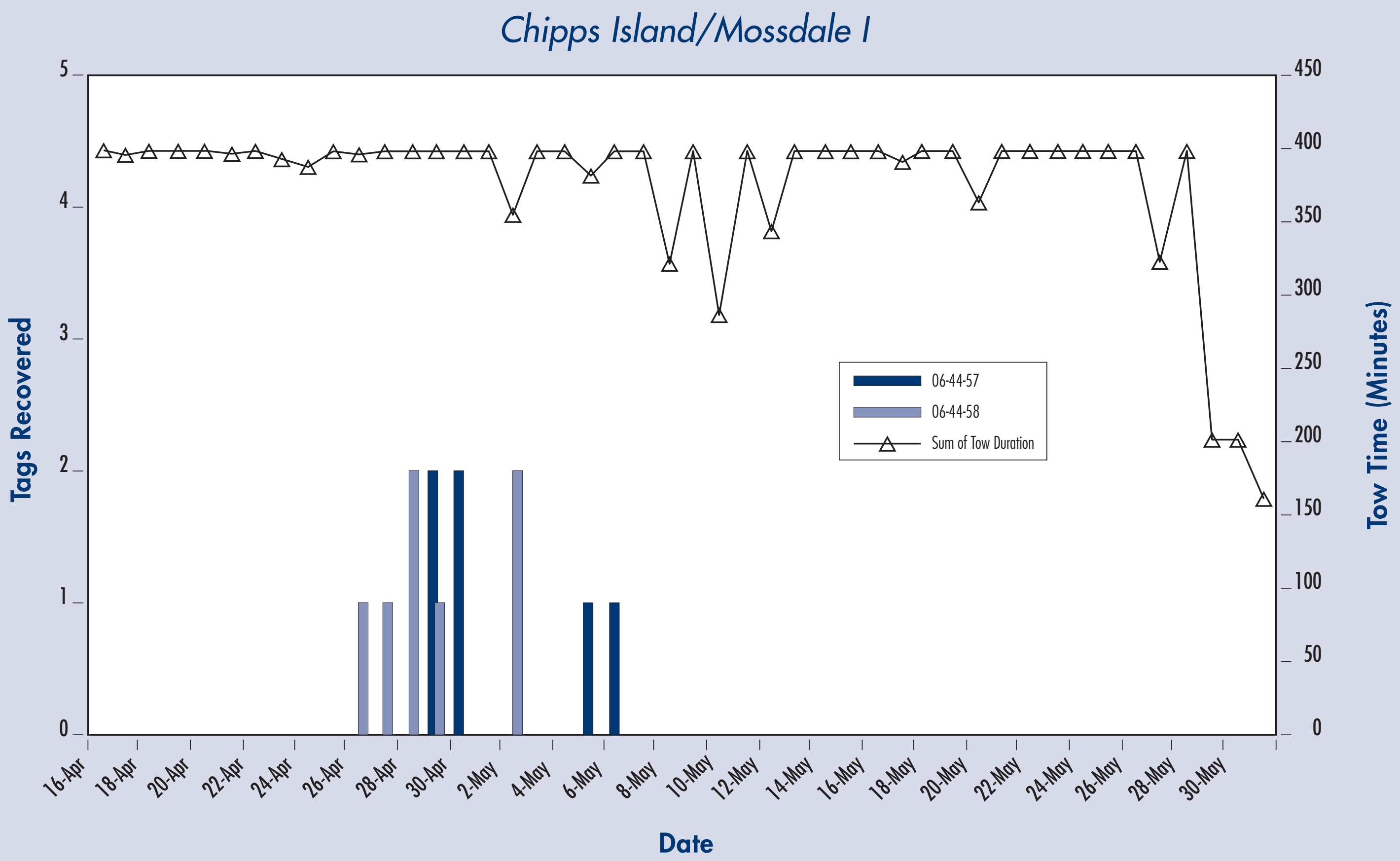
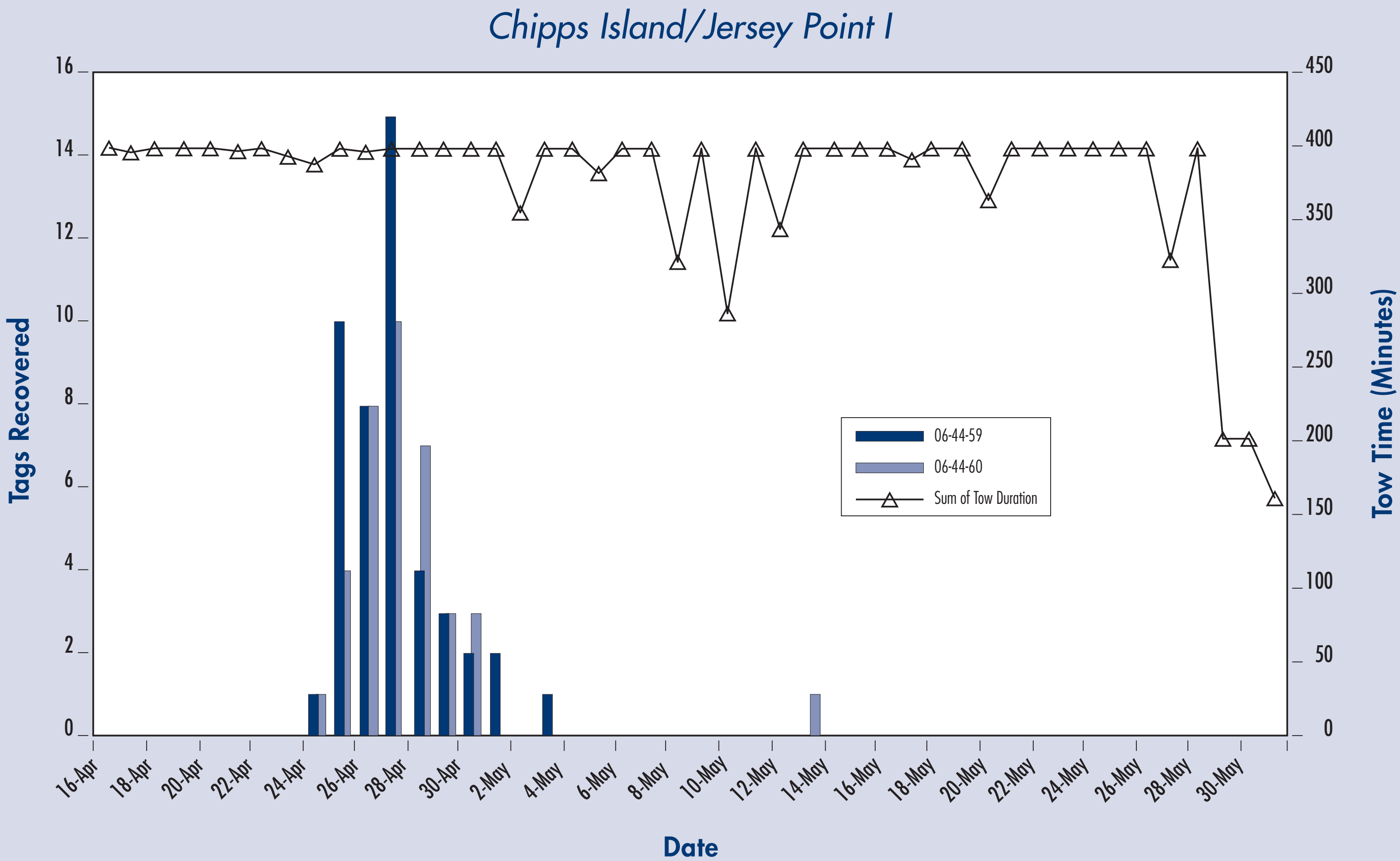
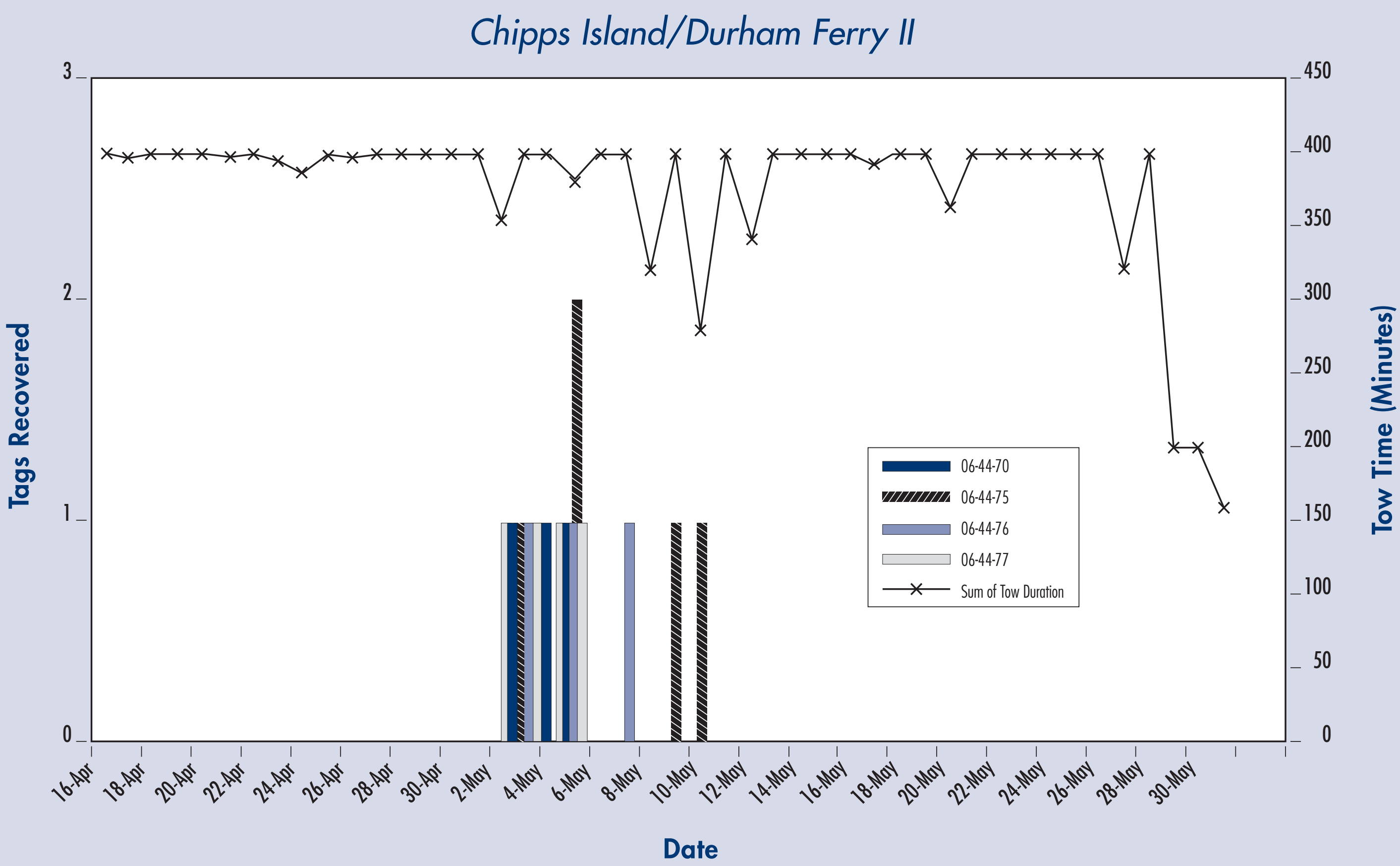
30-May

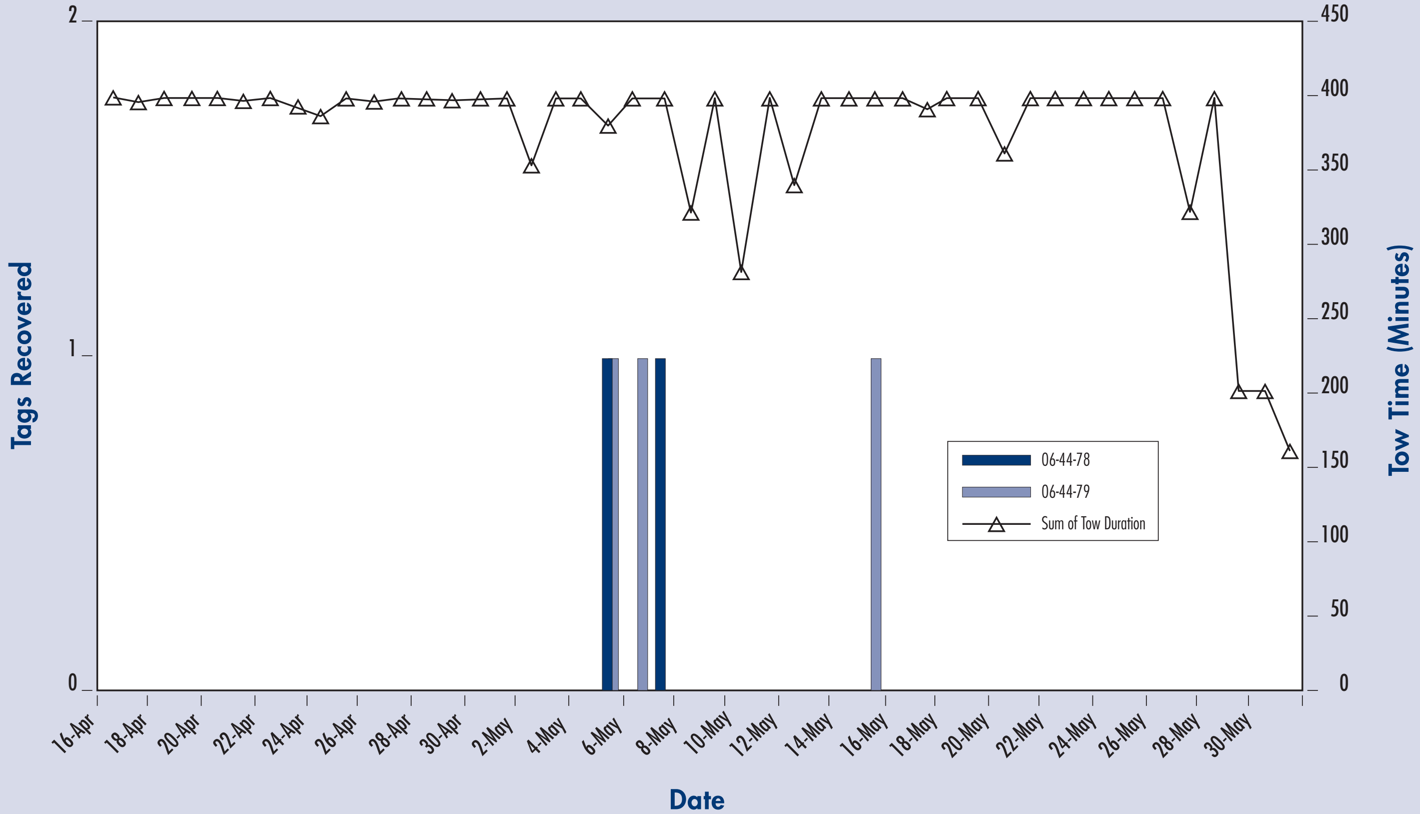

Chipps Island/Mossdale I
Tags Recovered
Tow Time (Minutes)
Date
06-44-57
06-44-58
Sum of Tow Duration
16-Apr
18-Apr
20-Apr
22-Apr
24-Apr
26-Apr
28-Apr
30-Apr
2-May
4-May
6-May
8-May
10-May
12-May
14-May
16-May
18-May
20-May
22-May
24-May
26-May
28-May
30-May

NET PEN SAMPLING RESULTS

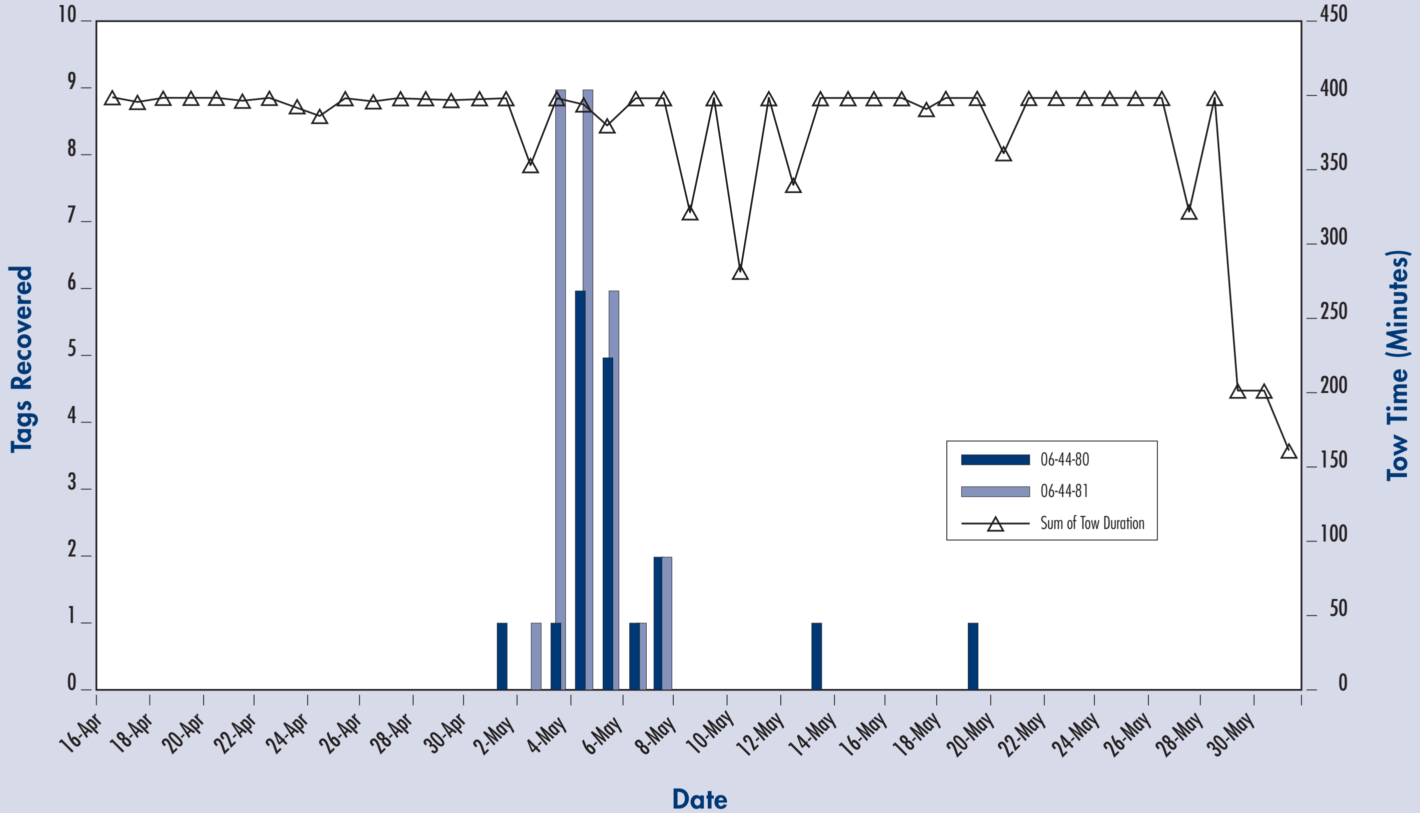




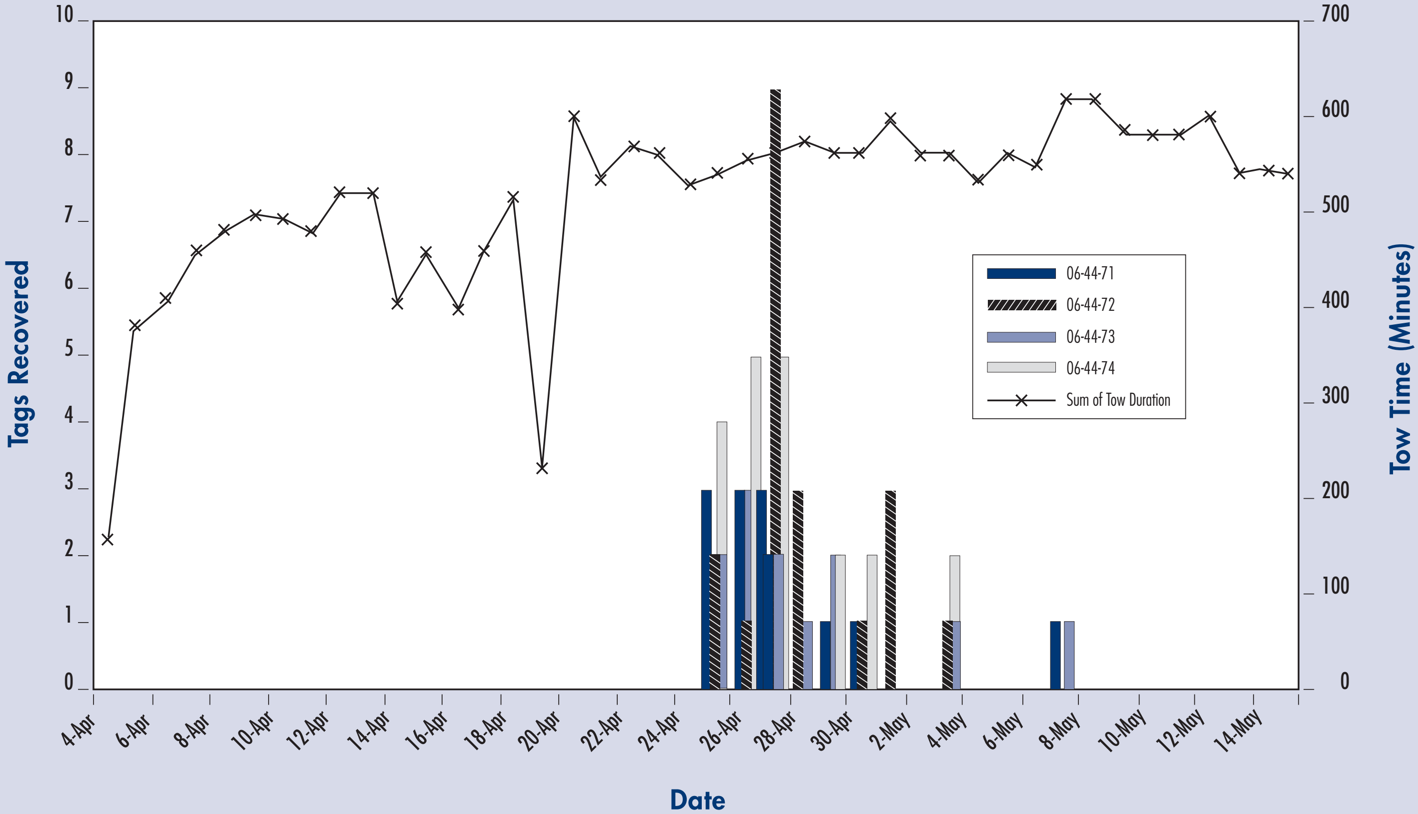
Chipps Island/Mossdale II



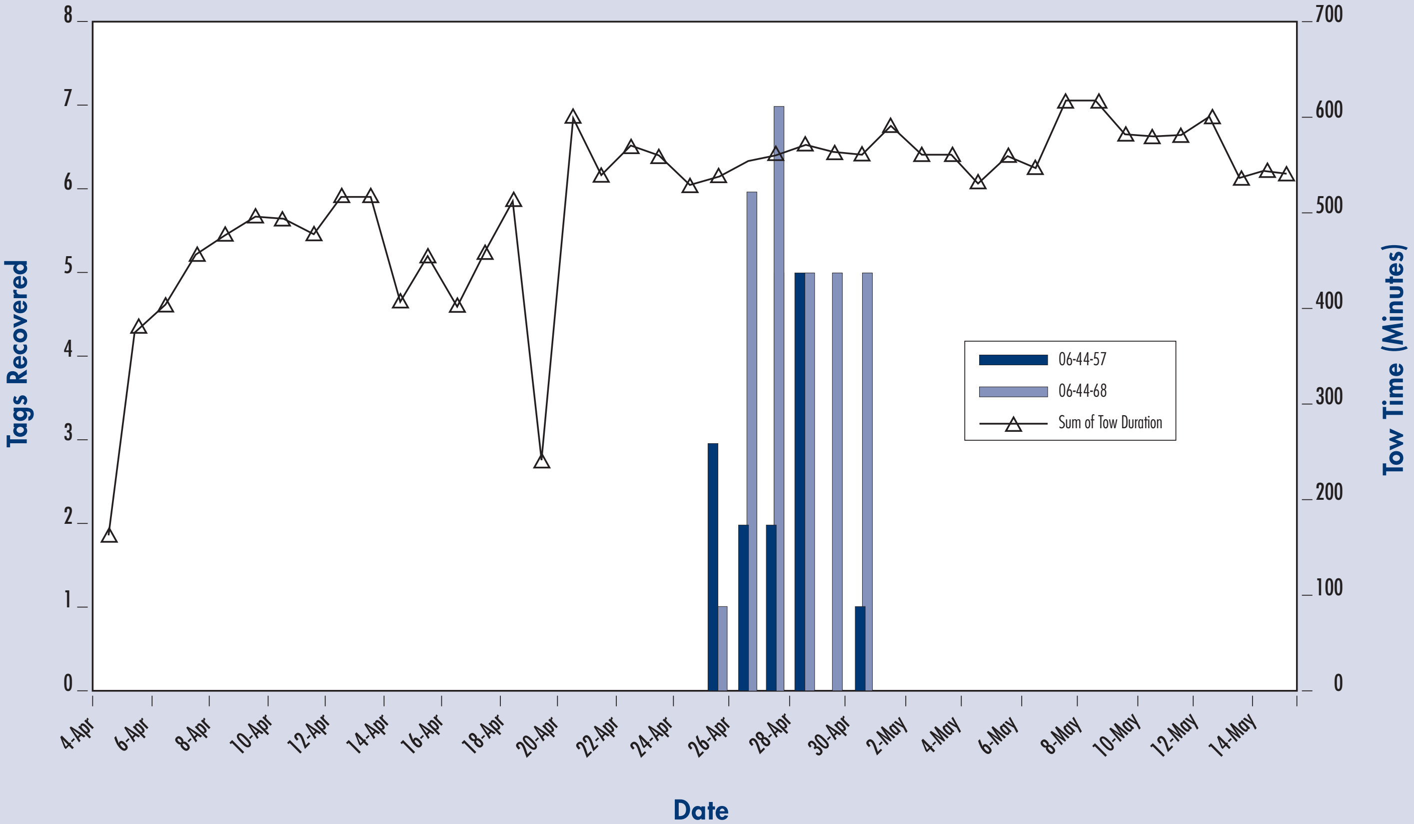
Chipps Island/Jersey Point II



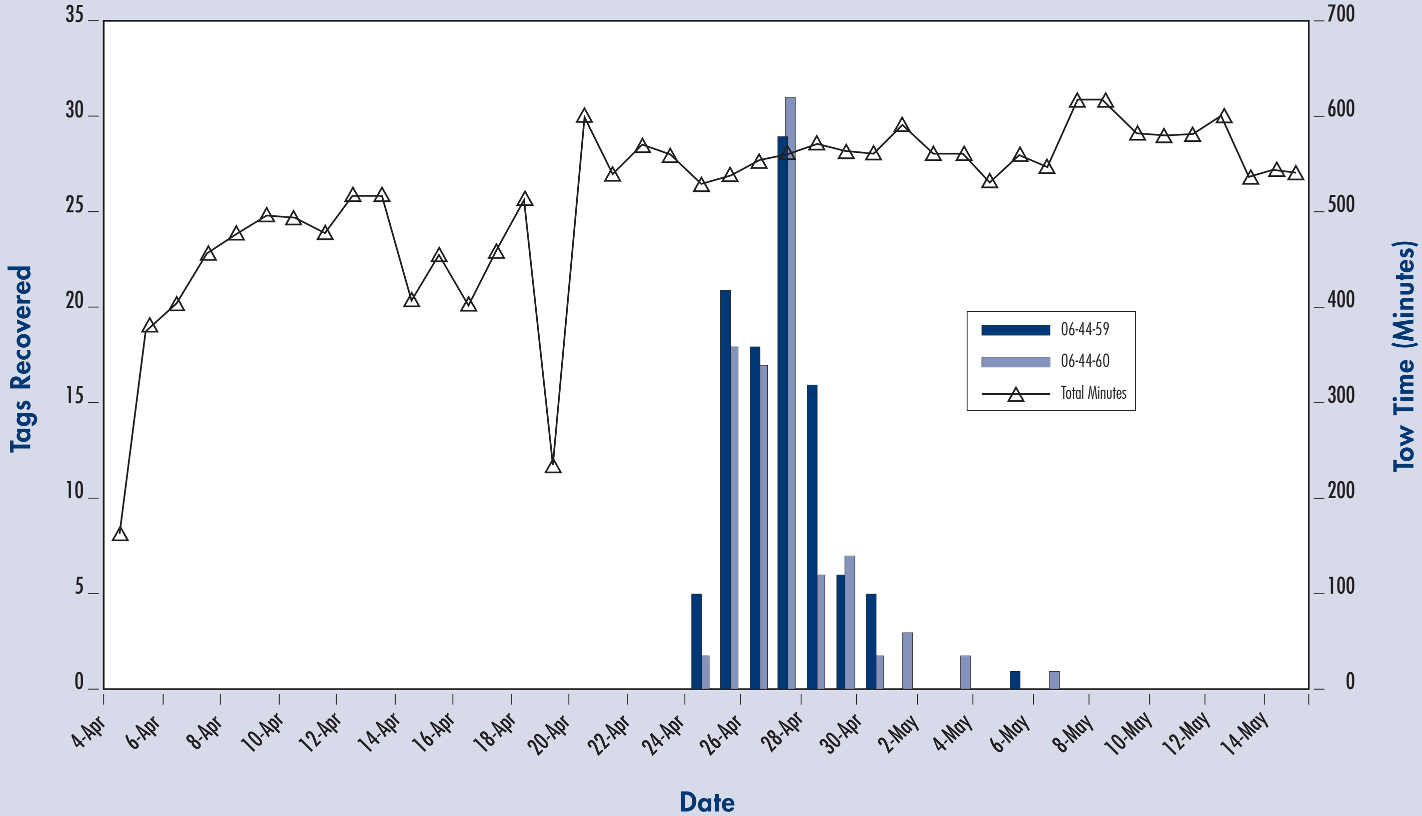
Antioch/Durham Ferry I



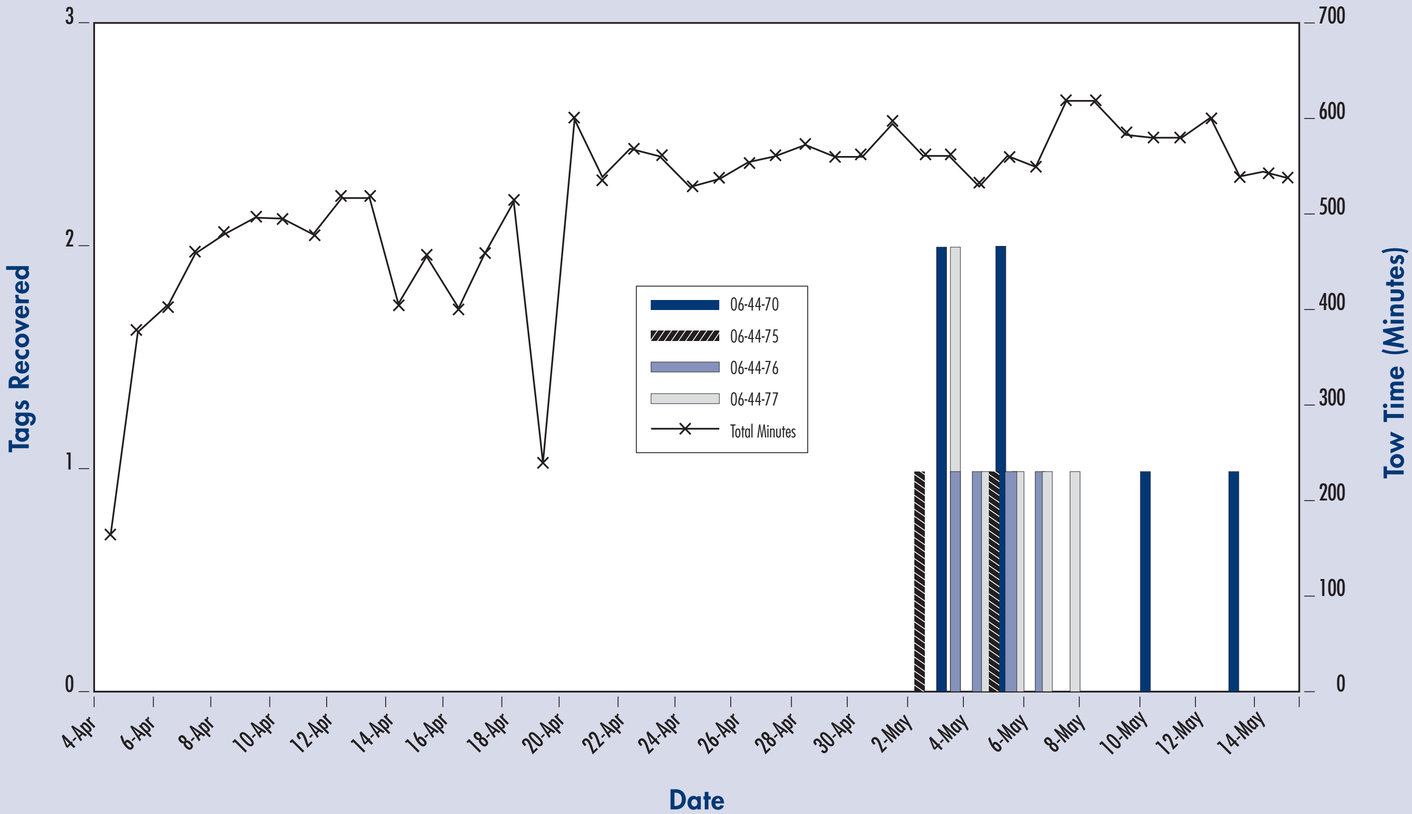
Antioch/Mossdale I



Antioch/Jersey Point I

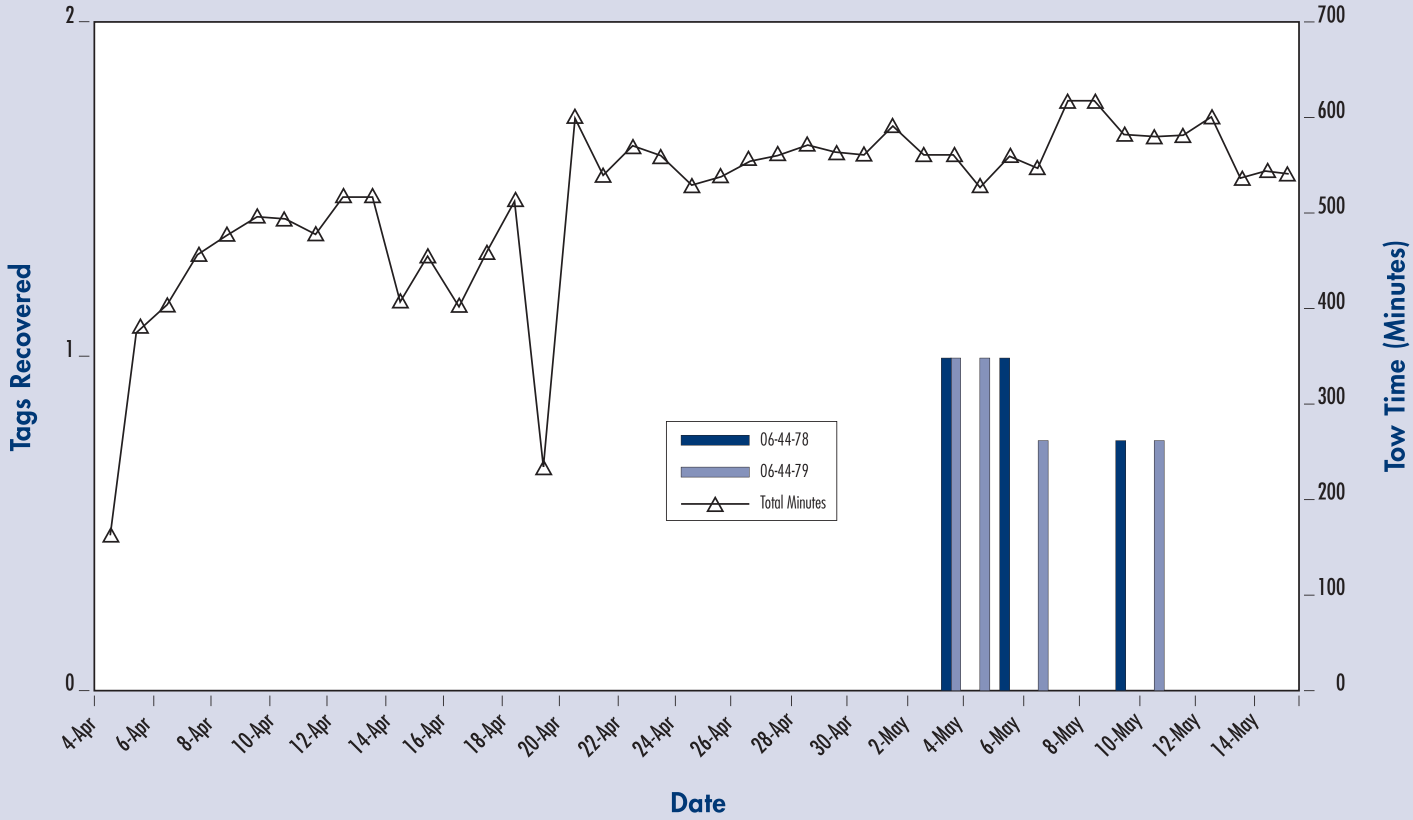


Antioch/Durham Ferry II

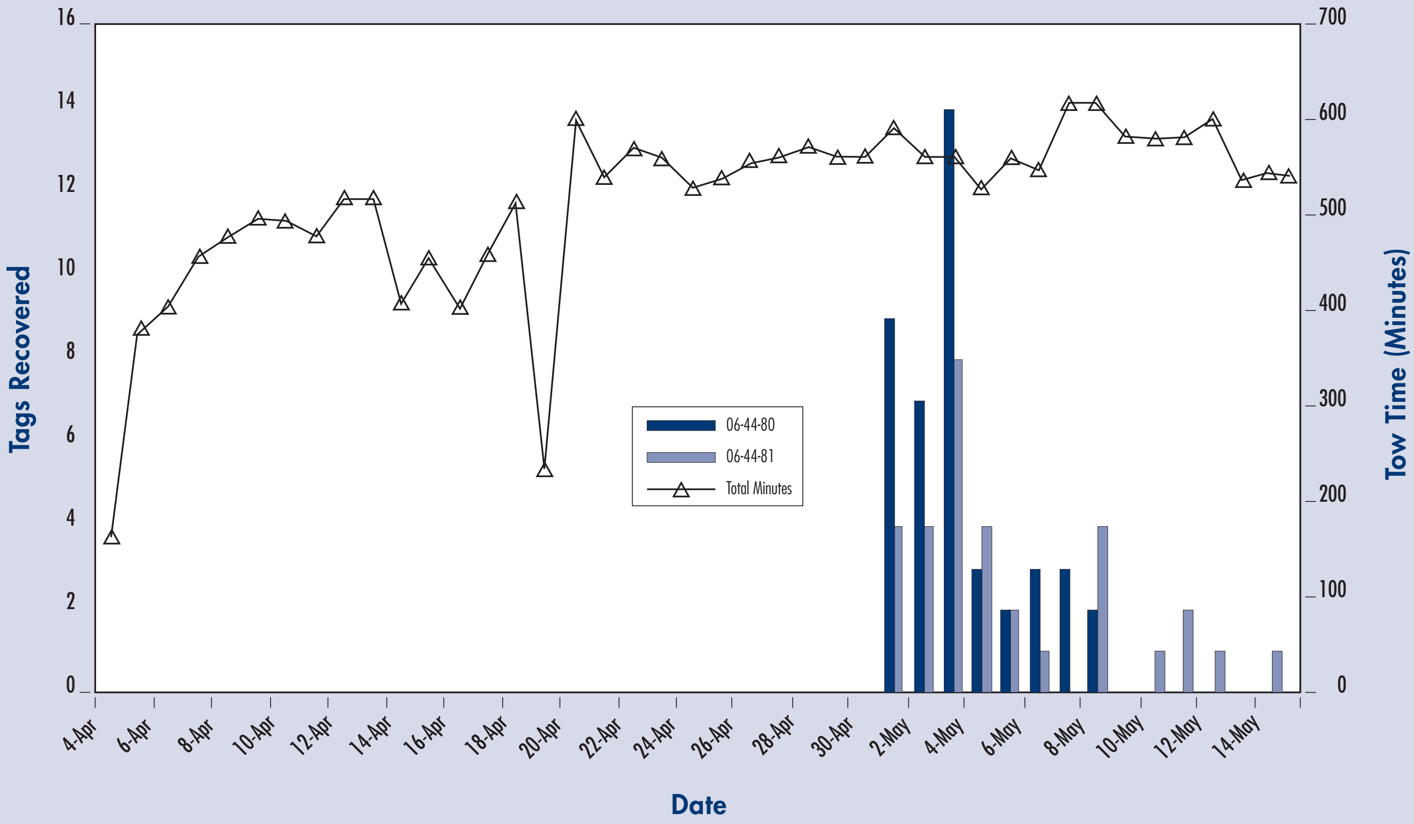


NET PEN SAMPLING RESULTS

Antioch/Mossdale II



Antioch/Jersey Point II



Release and Recovery Information for Coded Wire Tagged Smolts Released in the San Joaquin River and Tributaries in the Spring of 2002.

Tag Code	Release Site/Stock	Date	Truck Temp (F)	River Temp (F)	Number Released	Average Size (mm)
Merced River						
06-44-63	Upper Merced @ MRFF		N/P	N/P	23188	74
06-44-64	Upper Merced @ MRFF		N/P	N/P	23915	74
06-44-65	Upper Merced @ MRFF		N/P	N/P	23775	74
06-44-66	Upper Merced @ MRFF		N/P	N/P	23185	74
	Total	Mar 31			94063	
06-44-51	Hatfield State Park (MRFF)		53.6	62.6	24380	77
06-44-52	Hatfield State Park (MRFF)		53.6	62.6	24228	77
06-45-48	Hatfield State Park (MRFF)		53.6	62.6	24890	77
	Total	Apr 03			73498	
06-44-82	Upper Merced @ MRFF		N/P	N/P	22522	71
06-44-83	Upper Merced @ MRFF		N/P	N/P	23086	71
06-44-84	Upper Merced @ MRFF		N/P	N/P	23140	71
06-44-85	Upper Merced @ MRFF		N/P	N/P	22183	71
	Total	Apr 21			90931	
06-44-86	Hatfield State Park (MRFF)		53.6	60.8	23349	73
06-44-87	Hatfield State Park (MRFF)		53.6	60.8	23363	73
06-44-88	Hatfield State Park (MRFF)		53.6	60.8	23639	73
	Total	Apr 26			70351	
Tuolumne River						
06-44-06	La Grange (MRFF)		57.2	53.6	24976	86
06-44-67	La Grange (MRFF)		57.2	53.6	24813	86
06-44-68	La Grange (MRFF)		57.2	53.6	25220	86
	Total	Apr 24			75009	
San Joaquin River						
06-44-61	Old Fisherman's Club (MRFF)	Apr 26	55.4	62	25701	85
06-44-69	Old Fisherman's Club (MRFF)	Apr 29	55.4	60.8	23870	86
Stanislaus River						
06-44-46	Knight's Ferry (MRFF)		56.3	53.6	23745	82
06-44-47	Knight's Ferry (MRFF)		53.6	52.7	24236	83
	Total	May 01			47981	
06-44-48	Two Rivers (MRFF)	May 04	59	64.4	24646	84

Antioch				Chipps Island				Salvage		Tributary Survival	
Number Recovered	Percent Sampled	Survival Index	Group Index	Number Recovered	Percent Sampled	Survival Index	Group Index	Expanded CVP	Expanded SWP	Antioch	Chipps Island
1	0.316	0.010		1	0.278	0.020		12	6		
0	--	--		0	--	--		0	0		
0	--	--		0	--	--		0	0		
0	--	--		0	--	--		0	0		
1	0.316		0.002	1	0.278		0.005			0.05	0.11
10	0.345	0.086		2	0.272	0.039		480	47		
1	0.389	0.008		1	0.222	0.024		492	34		
3	0.361	0.024		3	0.180	0.087		528	55		
14	0.345		0.040	6	0.238		0.045				
0	--	--		0	--	--		0	0		
1	0.375	0.008		0	--	--		0	0		
0	--	--		0	--	--		0	0		
0	--	--		0	--	--		0	0		
1	0.375		0.002	0	--		--			0.08	0
2	0.410	0.015		2	0.250	0.045		12	6		
5	0.405	0.038		0	--	--		0	12		
2	0.404	0.015		1	0.278	0.020		0	0		
9	0.402		0.023	3	0.250		0.022				
3	0.423	0.020		1	0.264	0.020		12	12		
5	0.392	0.037		7	0.261	0.141		0	12		
3	0.378	0.023		0	--	--		12	18		
11	0.399		0.026	8	0.261		0.053				
1	0.389	0.007		6	0.273	0.111		0	6	3.7	0.47
2	0.408	0.015		3	0.260	0.063		12	15	1.7	0.84
1	0.403	0.008		2	0.257	0.043		12	0	1.04	2.09
5	0.397	0.037		2	0.194	0.055		0	6		
6	0.397		0.023	4	0.236		0.046				
3	0.398	0.022		1	0.236	0.022		0	0		

Timing of Recovery at Antioch and Chipps Island for Coded Wire Tagged Smolts Released in San Joaquin River and Tributaries in the Spring of 2002.

Tag Code	Release Site/Stock	Date	Truck Temp (F)	River Temp (F)	Number Released	Average Size (mm)
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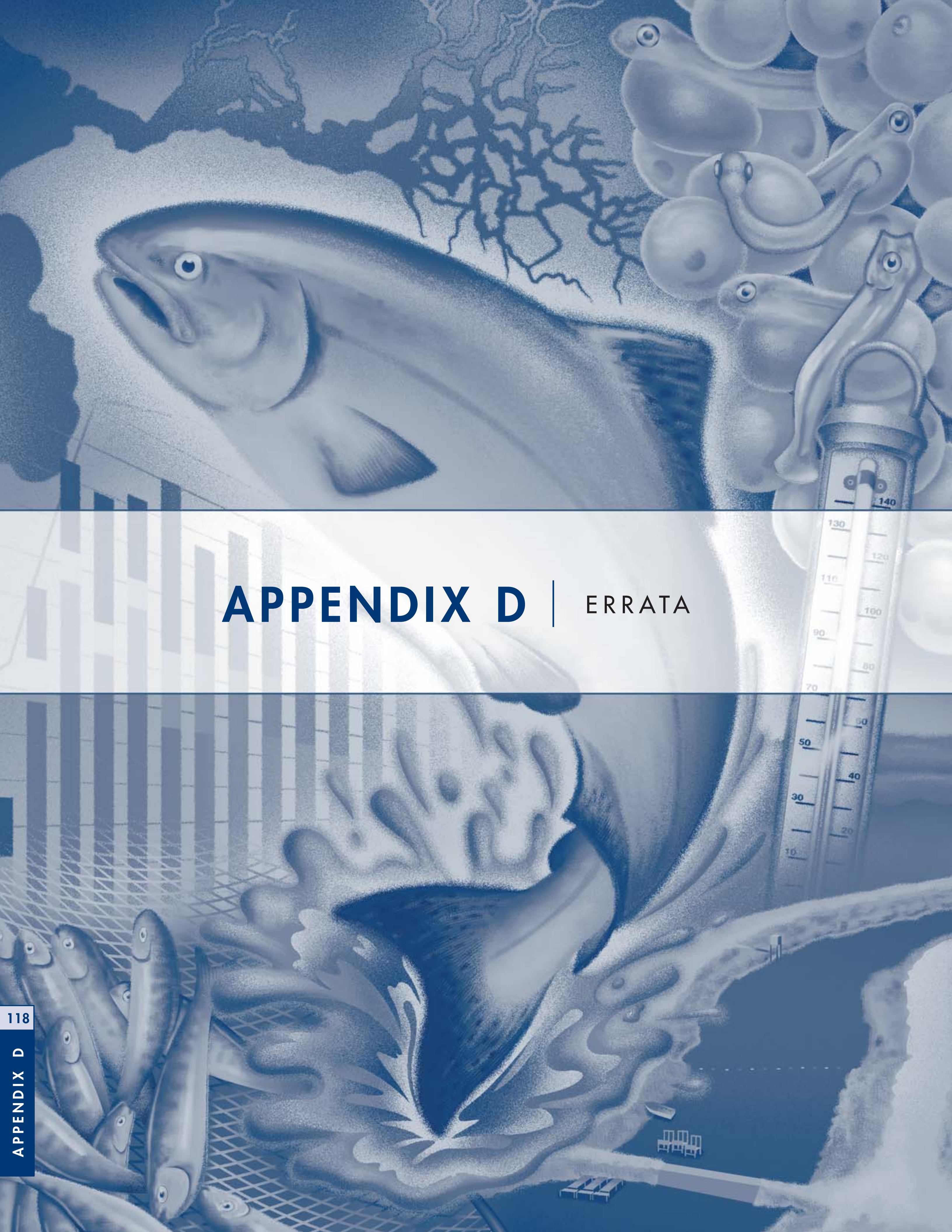
06-44-66	Upper Merced @ MRFF		N/P	N/P	23185	74
	Total	Mar 31			94063	
06-44-51	Hatfield State Park (MRFF)		53.6	62.6	24380	77
06-44-52	Hatfield State Park (MRFF)		53.6	62.6	24228	77
06-45-48	Hatfield State Park (MRFF)		53.6	62.6	24890	77
	Total	Apr 03			73498	
06-44-82	Upper Merced @ MRFF		N/P	N/P	22522	71
06-44-83	Upper Merced @ MRFF		N/P	N/P	23086	71
06-44-84	Upper Merced @ MRFF		N/P	N/P	23140	71
06-44-85	Upper Merced @ MRFF		N/P	N/P	22183	71
	Total	Apr 21			90931	
06-44-86	Hatfield State Park (MRFF)		53.6	60.8	23349	73
06-44-87	Hatfield State Park (MRFF)		53.6	60.8	23363	73
06-44-88	Hatfield State Park (MRFF)		53.6	60.8	23639	73
	Total	Apr 26			70351	
Tuolumne River						
06-44-06	La Grange (MRFF)		57.2	53.6	24976	86
06-44-67	La Grange (MRFF)		57.2	53.6	24813	86
06-44-68	La Grange (MRFF)		57.2	53.6	25220	86
	Total	Apr 24			75009	
San Joaquin River						
06-44-61	Old Fisherman's Club (MRFF)	Apr 26	55.4	62	25701	85
06-44-69	Old Fisherman's Club (MRFF)	Apr 29	55.4	60.8	23870	86
Stanislaus River						
06-44-46	Knight's Ferry (MRFF)		56.3	53.6	23745	82
06-44-47	Knight's Ferry (MRFF)		53.6	52.7	24236	83
	Total	May 01			47981	
06-44-48	Two Rivers (MRFF)	May 04	59	64.4	24646	84

Antioch						Chipps Island						
First Day Recovered	Last Day Recovered	Number Recovered	Minutes Fished	Survival Index	Group Index	First Day Recovered	Last Day Recovered	Number Recovered	Minutes Fished	Percent Sampled	Survival Index	Group Index
Apr 15	Apr 15	1	455	0.010		Apr 11	Apr 11	1	400	0.278	0.020	
--	--	0	--	--		--	--	0	--	--	--	
--	--	0	--	--		--	--	0	--	--	--	
--	--	0	--	--		--	--	0	--	--	--	
Apr 15	Apr 15	1	455		0.002	Apr 11	Apr 11	1	400	0.278		0.005
Apr 10	Apr 27	10	8937	0.086		Apr 07	Apr 11	2	1960	0.272	0.039	
Apr 27	Apr 27	1	560	0.008		Apr 12	Apr 12	1	320	0.222	0.024	
Apr 12	Apr 12	3	520	0.024		Apr 12	Apr 14	3	777	0.180	0.087	
Apr 10	Apr 27	14	8937		0.040	Apr 07	Apr 14	6	2737	0.238		0.045
--	--	0	--	--	--	--		0	--	--	--	
May 13	May 13	1	540	0.008	--	--		0	--	--	--	
--	--	0	--	--		--	--	0	--	--	--	
--	--	0	--	--		--	--	0	--	--	--	
May 13	May 13	1	540		0.002	--	--	0	--	--		--
May 06	May 12	2	4136	0.015		May 09	May 11	2	1080	0.250	0.045	
May 07	May 14	5	4671	0.038		--	--	0	--	--	--	
May 09	May 11	2	1746	0.015		May 09	May 09	1	400	0.278	0.020	
May 06	May 14	9	5221		0.023	May 09	May 11	3	1080	0.250		0.022
May 07	May 09	3	1826	0.020		May 05	May 05	1	380	0.264	0.020	
May 03	May 07	5	2820	0.037		May 3	May 11	7	3379	0.261	0.141	
May 03	May 04	3	1090	0.023		--	--	0	--	--	--	
May 03	May 09	11	4026		0.026	May 03	May 11	8	3379	0.261		0.053
May 05	May 05	1	560	0.007		May 03	May 05	6	1179	0.273	0.111	
May 05	May 08	2	2350	0.015		May 05	May 08	3	1500	0.260	0.063	
May 11	May 11	1	580	0.008		May 11	May 12	2	740	0.257	0.043	
May 9	May 14	5	3431	0.037		May 10	May 10	2	280	0.194	0.055	
May 9	May 14	6	3431		0.023	May 10	May 12	4	1020	0.236		0.046
May 11	May 13	3	1720	0.022		May 12	May 12	1	340	0.236	0.022	



APPENDIX D | ERRATA

ERRATA FOR THE YEAR 2001 ANNUAL TECHNICAL REPORT
ON IMPLEMENTATION AND MONITORING OF THE SAN JOAQUIN RIVER AGREEMENT AND THE VERNALIS ADAPTIVE MANAGEMENT PLAN

Table 5 – 6:

Estimates of Survival Between Durham Ferry and Mossdale (S DF to MD) and Between Mossdale and Jersey Point (S MD to JP), and Survival minus (S – 2se) and Plus (S + 2se) two Standard errors. The corrected values have been highlighted in the table below.

	REC. AT ANTIOCH	REC. AT CI	# RELEASED	A+C	A+C/R	S DF TO MD	S MD TO JP	S–2SE	S+2SE
Durham 1	28	14	23,354	42	0.001798407				
	30	22	22,837	52	0.002277007				
	18	17	22,491	35	0.001556178				
	76	53	68,682	129	0.001878221	1.33		0.92	1.73
MD 1	18	17	23,000	35	0.001521739				
	15	14	22,177	29	0.001307661				
	33	31	45,177	64	0.00141665		0.16	0.12	0.20
JP 1	156	50	24,443	206	0.008427771				
	173	61	24,992	234	0.009362996				
	329	111	49,435	440	0.008900577				
Durham 2	8	2	24,025	10	0.000416233				
	11	5	24,029	16	0.000665862				
	10	2	24,177	12	0.000496339				
	29	8	72,231	38		0.96		0.48	1.44
MD 2	8	4	23,878	12	0.000502555				
	11	4	25,308	15	0.000592698				
	19	8	49,186	27	0.000548937		0.20	0.12	0.29
JP 2	43	17	25,909	60	0.002315798				
	53	27	25,465	80	0.003141567				
	96	44	51,374	140	0.002725114				

In Appendix C-5, the Expanded salvage/SWP was reported incorrectly in the 2001 Report. The tag code for the group released on April 28 in the San Joaquin River at Old Fisherman's Club was also reported incorrectly. The correct tag codes with changes are provided below.

TAGCODE	RELEASE SITE/STOCK	DATE	EXPANDED SWP
Merced River			
06-44-15	Merced River Fish Facility		0
06-44-16	Merced River Fish Facility		6
06-44-17	Merced River Fish Facility		6
06-44-18	Merced River Fish Facility		0
	Total	Apr. 21	
06-44-33	Old Fisherman's Club	Apr. 28	0

SAN JOAQUIN RIVER GROUP AUTHORITY

P.O. Box 4060, Modesto, CA 95352 • (209)526-7405 • FAX (209)526-7315

Modesto Irrigation District
Turlock Irrigation District
Oakdale Irrigation District
Merced Irrigation District
Friant Water Users Authority
City and County of San Francisco
South San Joaquin Irrigation District
San Joaquin River Exchange Contractors

2002 ANNUAL TECHNICAL REPORT

VIEW
REPORT

SAN JOAQUIN RIVER GROUP AUTHORITY

2002

Head of Old River Barrier

2002 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
STATE WATER RESOURCES CONTROL BOARD

In Compliance with D-1641

JANUARY 2003

TABLE OF CONTENTS

EXECUTIVE SUMMARY 3

CHAPTER 1

Introduction 6

Experimental Design Elements 6

CHAPTER 2

VAMP Hydrologic Planning and Implementation 8

VAMP Flow and SWP/CVP Exports 8

Hydrologic Planning 9

Implementation 12

Results of Operations 12

CHAPTER 3

Additional Water Supply Arrangements & Deliveries 17

Merced Irrigation District 17

Oakdale Irrigation District 17

CHAPTER 4

Head of Old River Barrier 18

Barrier Design, Installation and Operation 19

Fishery Monitoring at the Head of Old River Barrier 22

Results and Discussion 23

CHAPTER 5

Salmon Smolt Survival Investigations 30

Coded-Wire Tagging 30

CWT Releases 31

Water Temperature Monitoring 31

Post-Release-Live-Car Studies 34

CWT Recovery Efforts 35

VAMP Chinook Salmon CWT Survival Indices 38

Absolute Chinook Salmon Survival Estimates and Differential Combined Recovery Rates 39

Role of Flow and Exports on Absolute Survival and Recovery Rates 45

The Role of HORB on Survival 47

Ocean Recovery Information 50

San Joaquin River Salmon Protection 53

CHAPTER 6

Complimentary Studies Related to the Vamp 60

Survival Estimates for the Tributaries 60

Radio Tagging Studies in the Lower River 60

Striped Bass Predation Monitoring Program 62

Mokelumne River Juvenile Survival Studies 62

CHAPTER 7

Conclusions and Recommendations 66

LITERATURE CITED 68

CONTRIBUTING AUTHORS 69

SIGNATORIES TO THE SAN JOAQUIN RIVER AGREEMENT 70

USEFUL WEB PAGES 71

APPENDIX TABLE OF CONTENTS 72

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). Using a consensus-based approach, the SJRA united a large and diverse group of agricultural, urban, environmental and governmental interests.

The 2002 Annual Technical Report comprises the consolidated annual SJRA Operations Report and Vernalis Adaptive Management Plan (VAMP) Monitoring Report. The VAMP 2002 program represents the third 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 VAMP program. Specifically, this report includes the following information on the implementation of the SJRA: the hydrologic chronicle; management of the additional SJRA water; installation, operation, and monitoring of the Head of Old River Barrier (HORB); results of the juvenile Chinook salmon smolt survival investigations; discussion of complementary investigations; and, conclusions and recommendations. Condition 4.b of D-1641 directs the Department of Water Resources (DWR) and the U.S. Bureau of Reclamation (USBR) to send the Executive Director, SWRCB the results of the fishery monitoring studies on an annual basis and Condition 7 of D-1641 directs Merced, Modesto, Turlock, South San Joaquin and Oakdale irrigation districts to submit a report detailing district operations as a result of the SJRA. By letter dated September 8, 2000, the SWRCB approved combining these two reports into a single comprehensive report due the SWRCB on January 31, of each year.

*The 2002 Annual Technical Report comprises the consolidated annual SJRA Operations Report and Vernalis Adaptive Management Plan **(VAMP)** Monitoring Report.*

A key part of this landmark agreement is the VAMP. VAMP is designed to protect juvenile Chinook salmon migrating from the San Joaquin River through the Sacramento-San Joaquin Delta. VAMP is also a scientifically recognized 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 and the installation of the HORB.

VAMP employs an adaptive management strategy to use current knowledge of hydrology and environmental conditions to protect Chinook salmon smolt passage, while gathering information to allow more efficient protection in the future. In addition to providing improved protection for juvenile Chinook salmon emigrating from the San Joaquin River system, specific experimental objectives of VAMP 2002 included:

- Quantification of Chinook salmon smolt survival between Durham Ferry and Jersey Point using recapture locations at Antioch and Chipps Island, under conditions of a San Joaquin River flow at Vernalis of 3,200 cfs, with an installed HORB, and SWP/CVP export rate of 1,500 cfs; and
- Comparison of juvenile Chinook salmon survival between Durham Ferry and Mossdale for use in comparing results of VAMP 2002 with results from earlier survival studies where coded-wire tagged (CWT) salmon releases occurred at Mossdale.

The VAMP 2001 Annual Technical Report presented a series of conclusions and recommended modifications to the VAMP experimental design and/or program implementation. The 2001

See useful web pages

recommendations were used, in part, as the basis for developing the 2002 VAMP test program. For example, the 2001 report recommended weekly measurements of San Joaquin River flow at the Vernalis gage, continued hydrology investigations to estimate ungaged flows (accretions, depletions) to improve hydrologic predictions, and continued coordination among tributary operators to facilitate implementation of the VAMP test flow conditions. As part of the 2002 program, the VAMP Hydrology Group, working in cooperation with tributary operators and USGS, was able to improve our understanding of San Joaquin River hydrology, provide measurements of Vernalis flow, and provide effective coordination of releases from upstream tributaries.

*To the extent possible, **VAMP** survival testing should be conducted at flow and export extremes to IMPROVE THE ABILITY of the program to detect differences in juvenile Chinook salmon survival.*

Contained in the 2001 report were several recommendations including modification of the HORB trash screen design and routine maintenance, continued refinement of operational criteria for culverts, securing all necessary permits for construction of the barrier, measuring flows within each of the culverts, continuing monitoring to evaluate potential impacts of seepage, and improving the experimental design of fishery monitoring in the HORB investigations. These recommendations were addressed as part of the 2002 VAMP program. In addition, the Department of Water Resources (DWR) was successful in securing all of the necessary permits and approvals from the regulatory agencies for the installation of the HORB over the next five years. The landowner access permits for the HORB continue to be renewed annually.

The 2001 report recommended that, to the extent possible, VAMP survival testing be conducted at flow and export extremes to improve the ability of the program to detect differences in juvenile Chinook salmon survival among target flow and export conditions. Hydrologic conditions within the San Joaquin River watershed were not suitable for testing extreme target conditions as part of the VAMP 2002 program. These and other recommendations from the 2001 VAMP program were used to improve the overall experimental design and implementation of the 2002 VAMP investigations. Recommendations made based upon analysis of the VAMP 2002 program will also be used, in a similar way, by the VAMP Hydrology and Fishery Biology Groups in developing and implementing the experimental design for the 2003 VAMP studies.

Based on data gathered during the experimental mark-recapture studies that occurred over a 31-day period in April and May 2002, a set of conclusions and recommendations has been developed. These conclusions and recommendations provide guidance and a foundation for design and implementation of future VAMP operations. Key conclusions and recommendations derived from VAMP 2002 include:

- VAMP 2002 is the third year of full implementation of the program. Average Vernalis flow during the VAMP period was 3,300 cfs. SWP and CVP export rate averaged 1,430 cfs. The VAMP period was between April 15 and May 15, 2002.
- Relative recovery rates of CWT salmon released at Durham Ferry and Jersey Point using recaptures at Antioch and Chipps Island indicated that there was no statistical (P>0.05) difference between the two replicates conducted in 2002.
- The proportion of CWT salmon released and recaptured from the combined Durham Ferry and Mossdale groups relative to the proportion of CWT salmon released and recaptured from the Jersey Point (control) releases showed that the relative

proportions during 2002 (target flow 3,200 cfs and 1,500 cfs exports) were not significantly different (P>0.05) than the proportions from the VAMP 2000 study (target flow 5,700 cfs and 2,250 cfs exports) or VAMP 2001 study (target flow 4,450 cfs and 1,500 cfs exports).

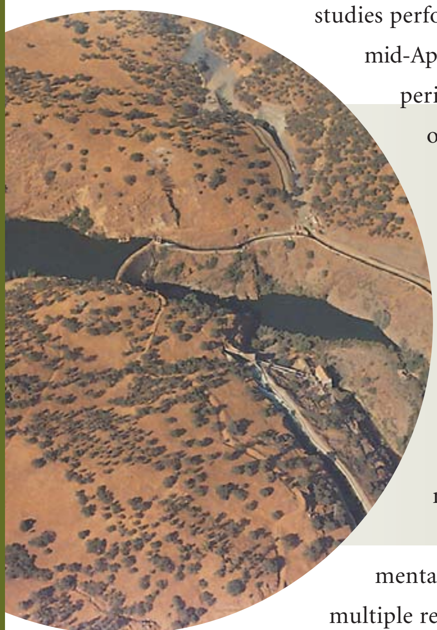
- Streamflow data at Vernalis were improved by weekly flow measurements and rating curve verification, however estimation of ungaged flow (accretions and depletions) requires further investigation for use in establishing annual VAMP target flows. Alternative methods of measuring flow at Vernalis and/or alternative measurement locations should also be investigated.
- The design of the HORB was unchanged for this year, however rock debris and on going construction activities during the final phases of construction after closure of the barrier proved to be a problem for fishery sampling. Recommendations were made to delay salmon releases at Durham Ferry and Mossdale in future years for a period of approximately 5 days after HORB closure to allow time for gravel and rock to flush from the culverts and to improve fishery sampling at the site. It is recommended that there be improved maintenance of the culverts to reduce debris accumulation.
- Accurate flow measurements in the San Joaquin River and the Old River near the HORB continue to limit the accuracy of the entrainments correlations. Flows are currently based on extrapolating from upstream measurements, some spot flow measurements in the Old River and San Joaquin River, as well as, estimates of flow through the culverts and seepage through the HORB.
- Construction of multiple barriers within the south delta during the spring has the potential to delay completion of the construction of HORB and release of the coded wire tagged salmon as part of the VAMP. This delay may contribute to exposure of juvenile Chinook salmon to elevated water temperatures. Due to the high risk of losing major salmon protection benefits and biasing experimental conditions, it is strongly recommended that construction of the HORB be completed on schedule to avoid delays in implementing survival investigations.
- It is also recommended that flow measurements be made to document flow through HORB culverts and the resultant flow within the San Joaquin River downstream of the confluence with Old River.
- The variability in conducting salmon smolt survival studies in the lower San Joaquin River and Delta makes it difficult to detect statistically significant differences in salmon survival between VAMP flow and export target conditions, which are relatively similar. It is strongly recommended that, when possible, target flow and export conditions be selected to conduct survival tests at VAMP flow and export extremes to improve the ability to detect potential differences in salmon smolt survival among test conditions.
- Approximately 77 percent of the unmarked salmon migrating past Mossdale between March 15 and June 30, 2002 migrated during the VAMP period (April 15 through May 15) and were, therefore protected by increased San Joaquin River flow, installation of the HORB and decreased export pumping.
- The selection and management of VAMP flow conditions should, if possible, minimize or avoid requiring upstream tributary flows that adversely affect habitat quality or survival of natural salmon produced within the tributaries. It is therefore recommended that upstream tributary and VAMP studies are coordinated as much as possible.
- Estimates of salmon survival rates under flow and export conditions tested in 2000, 2001, and 2002 have not been found to be significantly different. Survival tests at extreme target levels (e.g., 7,000 cfs flow and 1,500 cfs exports) are important to obtain. The VAMP program provides improved protection for juvenile salmon when compared to “without-VAMP” conditions. Further tests, over a wider range of flow and export conditions, are needed to evaluate the respective roles of San Joaquin River flow and SWP/CVP exports on juvenile Chinook salmon smolt survival. The report recommends that the VAMP experimental test program be continued.

CHAPTER 1 | INTRODUCTION

The Vernalis Adaptive Management Plan (VAMP) was implemented between April 15 and May 15, 2002 to protect juvenile Chinook salmon and evaluate the relationship between San Joaquin River flow and State (SWP) and federal (CVP) water project exports on survival of juvenile Chinook salmon migrating through the Sacramento–San Joaquin Delta. This represents the third official year of the VAMP experiment.

EXPERIMENTAL DESIGN ELEMENTS

The VAMP experimental design measures salmon smolt survival rates under six different combinations of flow and export rates. The experimental design includes two mark-recapture studies performed each year during the mid-April to mid-May outmigration period that provide estimates of salmon survival under each set of conditions. Chinook salmon survival indices under each of the experimental conditions are then calculated based on the numbers of marked salmon released and the number recaptured.



The VAMP 2002 experimental design included both multiple release locations (Durham Ferry, Mossdale, and Jersey Point), and multiple recapture locations (Antioch, Chipps Island, SWP and CVP salvage operations, and in the ocean fisheries Figure 1-1). Two sets of releases were made at Durham Ferry, Mossdale, and Jersey Point. The use of data from multiple release and recapture locations allows for a more thorough evaluation of juvenile Chinook salmon survival as compared to recapture data from only one sampling location and/or one series of releases. The VAMP coded-wire tag (CWT) releases (Durham Ferry, Mossdale, and Jersey Point) and recapture locations (Antioch and Chipps Island) will be consistent from one year to the next, providing a greater opportunity to assess salmon smolt survival over a range of Vernalis flows, SWP/CVP exports, and with and without the presence of the Head of Old River Barrier (HORB). Releases at Jersey Point serve as controls for recaptures at Antioch and Chipps Island, thereby allowing the calculation of survival estimates based on the ratio of survival indices from marked salmon recaptured from upstream (e.g., Durham Ferry and Mossdale) and downstream (control release at Jersey Point) releases. The use of ratio estimates as part of the VAMP study design substantially reduces the bias associated with differential gear collection efficiency within and among years, improves the precision associated with the individual survival estimates, and improves confidence in detecting differences in salmon smolt survival as a function of Vernalis flows and SWP/CVP exports.

A quality assurance/quality control program has been used as a routine part of VAMP tests, including the 2002 CWT tagging at the Merced River Fish Hatchery to provide information useful in quantifying CWT tag retention and improving tag efficiency. Modifications were also made during the 2002 program to improve releases at Durham Ferry through coordination with the local landowner to curtail operation of an agricultural diversion pump located immediately downstream of the release site, coincident with each of the two Durham Ferry releases. In addition, the 2002 VAMP program continued use of the net pen studies to determine the health and survival of test fish released as part of VAMP. Efforts also continued to improve the procedure used to statistically analyze VAMP survival and recovery information, however additional improvements remain to be made in the ability to measure flow passing through the HORB culverts and the resultant flow within the San Joaquin River downstream of the confluence with Old River. Measurements in the future of San Joaquin River flow downstream of the HORB will be used to evaluate the relationship between San Joaquin River flow and juvenile Chinook salmon survival.

Additional complimentary studies, including survival studies for juvenile Chinook salmon released into the Mokelumne River tributaries and radio tracking of salmon migrating downstream though Delta channels, were incorporated into the 2002 VAMP investigations.

FIGURE 1–1

Sacramento-San Joaquin Estuary

Location of VAMP 2002 Release Sites (Durham Ferry, Mossdale and Jersey Point), Recovery Locations (Antioch and Chipps Island), and Head of Old River Barrier Location Within the Sacramento-San Joaquin River Delta/Estuary.

CHAPTER 2 | VAMP HYDROLOGIC PLANNING AND IMPLEMENTATION

This section documents the planning and implementation undertaken by the Hydrology Group of the San Joaquin River Technical Committee (SJRTC) for the 2002 VAMP investigations. Implementation of VAMP is guided by the framework provided in the SJRA and anticipated hydrologic conditions within the watershed.

The Hydrology Group 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 2002, the agencies belonging to the Hydrology Group included: Merced Irrigation District (Merced), Turlock Irrigation District (TID), Modesto Irrigation District (MID), Oakdale Irrigation District (OID), South San Joaquin Irrigation District (SSJID), San Joaquin River Exchange Contractors (Exchange Contractors), 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 installation of the HORB and the planning of delta exports consistent with the VAMP.

VAMP FLOW AND SWP/CVP EXPORTS

The VAMP investigations are designed to collect data and information on the relationship between San Joaquin River flow and Delta exports (SWP and CVP pumping at the Tracy and Banks pumping plants) on the survival rates of juvenile Chinook salmon emigrating from the San Joaquin River system. The VAMP provides for a 31-day pulse flow (target flow) at the Vernalis gage during the months of April and May, along with a corresponding reduction in SWP/CVP exports, as shown in Table 2-1. The magnitude of the pulse flow is based on San Joaquin River flow that would occur during the pulse period absent the VAMP, referred to as the existing flow.

As part of the development of the VAMP experimental design, the VAMP Hydrology and Biology Groups jointly 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 VAMP Hydrology and Biology Groups 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 technical committees 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.

The ability to manage and regulate San Joaquin River flows was more difficult due to variation in unregulated flows, uncertainty 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 technical committees 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

TABLE 2–1
VAMP Vernalis Flow and Delta Export Targets

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
4,500 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 the extent possible	

joint Hydrology and Biology Groups agreed to a target range variation of plus or minus 7% of the Vernalis flow target as a guideline for evaluating the VAMP experimental conditions. It was recognized by the Hydrology and Biology Groups that these guidelines were not absolute conditions, but was to be used by the VAMP hydrology fisheries workgroups to evaluate experimental test conditions and the potential effect of flow and export variation in our ability to detect and assess variation in juvenile Chinook salmon survival rates among VAMP test conditions.

Under the SJRA, the following SJRGA agencies have agreed to provide the supplemental water, limited to a maximum of 110,000 acre-feet, needed to achieve the VAMP target flows shown in Table 2-1: Merced, OID, SSJID, Exchange Contractors, MID and TID.

The 2,000 cfs VAMP target flow shown in Table 2-1 does not represent a VAMP experiment data point but is used to define the supplemental water volume to be provided by the SJRGA agencies. 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 2000 cfs, the USBR, in accordance with the SJRA, shall act to purchase additional water from willing sellers to fulfill the requirements of existing biological opinions.

Based upon hydrologic conditions, the target flow in a given year could either be increased to the next highest value (“double-step”) or the supplemental water requirement could be eliminated entirely. A numerical procedure has been established in the SJRA to determine the target flow. The SWRCB San Joaquin Valley Water Year Hydrologic Classification (“60-20-20” classification) is given a numerical indicator as shown in Table 2-2.

TABLE 2–2

San Joaquin Valley Water Year Hydrologic Year Classifications Used in VAMP

60-20-20 WATER YEAR CLASSIFICATION	VAMP NUMERICAL INDICATOR
Wet	5
Above Normal	4
Below Normal	3
Dry	2
Critical	1

“Double-step” flow years occur when the sum of last year’s numerical indicator and the 90 percent exceedence forecast of the current year's numerical indicator is seven (7) or greater.

If the sum of the two previous years’ numerical indicators and the 90 percent exceedence forecast of the current year's numerical indicator is four (4) or less, indicative of an extended dry period, no VAMP supplemental water will be provided. The USBR, however, has a continuing obligation to meet San Joaquin River flows pursuant to the March 6, 1995 Delta Smelt Biological Opinion.

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. Based on the targets outlined in Table 2-1, in a double-step year up to 157,000 acre-feet of supplemental water may be required. If the VAMP target flow requires more than 110,000 acre-feet of supplemental water, then additional water may be acquired on a willing seller basis.

HYDROLOGIC PLANNING

Hydrology Group Meetings

Beginning in February 2002, and continuing until early April, the Hydrology Group held five planning and coordination meetings (February 13, March 13, March 28, April 3 and April 10). At these meetings, forecasts of hydrologic and operational conditions on the San Joaquin River and its tributaries were discussed and refined.

Monthly Operation Forecasts

As part of the early planning efforts, monthly operation forecasts were developed by the Hydrology Group to estimate the existing flow at Vernalis. Inflows to the tributary reservoirs used in these forecasts were based on DWR Bulletin 120 runoff forecasts. The monthly operation forecasts used the 90 percent and 50 percent probability of exceedence runoff forecasts. The initial monthly operation forecast was prepared in early February and presented at the February 13 Hydrology Group meeting. The 90 percent exceedence forecast called for a VAMP target flow of 3,200 cfs with a need for about 30,000 acre-feet of supplemental water; the 50 percent exceedence forecast called for a VAMP target flow of 4,450 cfs with a need for about 76,000 acre-feet of supplemental water. Hydrologic projections and planning were subsequently refined as additional information became available in March and April.

Daily Operation Plan

Starting in mid-March, the Hydrology Group began development of a daily operation plan, updating it as hydrologic conditions and operational requirements changed. The daily operation plan calculated an estimated mean daily flow at Vernalis based on estimates 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 major tributaries. The following key assumptions were used in the development of the daily operation plan:

(1) The travel times for flows from the tributary control points and upper San Joaquin River to the Vernalis gauge are assumed as follows:

a. Merced River at Cressey to Vernalis	3 days
b. San Joaquin River above Merced River to Vernalis	2 days
c. Tuolumne River at LaGrange to Vernalis	2 days
d. Stanislaus River below Goodwin Dam to Vernalis	2 days

(2) Based upon a review of the historical flow record, the ungauged flow at Vernalis was assumed to be constant throughout the VAMP period and equal to the trending value entering the period. By definition, the ungauged flow is that unmeasured flow entering the system between Vernalis and the upstream measuring points and is calculated as follows:

Vernalis Ungauged =

VNS - GDWlag - LGNlag - CRSlag - USJRlag
where:

VNS = San Joaquin River near Vernalis

GDWlag = Stanislaus River below Goodwin Dam lagged 2 days

LGNlag = Tuolumne River below LaGrange Dam lagged 2 days

CRSlag = Merced River at Cressey lagged 3 days

USJRlag = San Joaquin River above Merced River lagged 2 days (USJR is not a gauged flow but is the calculated difference between the gauged flows at the San Joaquin River at Newman (NEW) and the Merced River near Stevinson (MST)).

A disagreement occurred between members of the Hydrology Group on how to compute the existing flow for the Stanislaus River. It was agreed that the existing flow would be the flow set by the New Melones Interim Operations Plan (IOP); however, there was disagreement on what level of exceedence forecast should be used when applying the IOP. The USBR uses a 90% exceedence forecast for developing water supply allocations. The U.S. Fish and Wildlife Service (USFWS) however, has suggested that since the IOP was developed based on a long-term planning model which used a set of known (perfect foresight) inflows, the 50% exceedence data set would best match what was used in the long-term modeling. At this time, the USBR and the USFWS are working to reach a common understanding on this issue.

By definition, the VAMP 31-day pulse flow period can occur anytime between April 1 and May 31. Until the VAMP flow period is specifically defined, it is assumed for the purposes of planning to be April 15 through May 15. Flexibility of the VAMP flow period exists so that it can coincide with the period of peak salmon out-migration. Other factors, including installation of HORB, availability of juvenile salmon at the hatchery, and manpower and equipment availability for salmon releases and recapture need to be considered in determining the timing of the VAMP period.

The 60-20-20 classification for water year 2001 was "dry", giving it a VAMP numerical indicator of 2. There was no possibility of a dry period offramp (numerical indicator of previous two plus current year total of 4 or less) because the classification for water year 2000 was "above normal" with a numerical indicator of 4. In order to trigger the "double-step" criteria, the April 1 90 percent exceedence forecast for water year 2002 would need to be for a "wet" year, with a VAMP numerical indicator of 5. The early 90% exceedence forecasts (Jan., Feb. and Mar.) were indicating a "dry" or "critical" year, making it very unlikely that 2002 would be a "double-step" year; therefore, planning efforts concentrated on the "single step" criteria. In fact, the 90 percent exceedence forecast on April 1 for the San Joaquin Valley was for a "dry" year, resulting in the 2002 VAMP following the "single step" criteria.

The initial Daily Operation Plan was prepared on March 13, and was modified as hydrologic conditions and operational requirements changed. Table 2-3 summarizes the various iterations of and demonstrates the evolutionary nature of the daily operation plan. Copies of the daily operation plans are provided in Appendix A.

In early March DWR announced that the HORB would be completed by April 15, therefore the period of April 15 through May 15 was designated as the target flow period. Due to regulatory and operational constraints, Merced needs approximately 7 days of lead time to effect a flow change at Vernalis (48 hours regulatory notice on operation change and approximately 5 days travel time from New Exchequer Dam to Vernalis), therefore the target flow needed to be defined by April 8. Based on the available data the Hydrology Group set the target flow at 3,200 cfs at its meeting on April 8.

TABLE 2–3

Summary of 2002 VAMP Daily Operation Plans Prepared During Planning Phase

VAMP FORECAST DATE	PULSE PERIOD	ASSUMED UNGAUGED FLOW AT VERNALIS (CFS)	EXISTING FLOW (CFS)	VAMP TARGET FLOW (CFS)	SUPPLEMENTAL WATER NEEDED TO MEET TARGET FLOW (1,000 AF)
March 13	April 15–May 15	400	2,150	3,200	64.30
		800	3,130	3,200	4.12
March 22	April 15–May 15	400	2,450	3,200	46.16
		600	2,880	3,200	19.47
March 28	April 15–May 15	400	2,531	3,200	41.16
		600	3,525	4,450	56.91
April 08	April 15–May 15	400	2,842	3,200	22.04
April 09	April 15–May 15	400	2,742	3,200	28.19

TABLE 2–4

Summary of USGS Flow Measurements at the San Joaquin River Near Vernalis Gage

DATE	RIVER STAGE (FT)	MEASURED FLOW (CFS)	CDEC REPORTED REAL-TIME FLOW (CFS)	PERCENT DIFFERENCE	RATING SHIFT
March 5 at 9:30	9.61	1,990	1,940	+2.6%	No
March 27 at 8:26	9.82	2,120	2,120	0.0%	No
April 3 at 9:59	9.30	1,670	1,696	-1.5%	No
April 10 at 9:17	9.48	1,810	1,838	-1.5%	No
April 17 at 8:53	10.75	2,990	2,973	+0.6%	No
April 24 at 10:52	11.00	3,220	3,219	0.0%	No
May 1 at 9:26	11.20	3,340	3,426	-2.6%	No
May 8 at 9:00	11.18	3,340	3,408	-2.0%	No

Normally, the USGS measures the flow at Vernalis to check the current rating shift on a monthly basis. The real-time flows reported by the USGS and CDEC are dependent on the most current rating shift, therefore a new measurement and 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 March 27 and May 8. The results of these measurements are summarized in Table 2-4. As can be seen in Table 2-4, the Vernalis gage site was relatively stable and no rating shifts were applied during the target flow period.

IMPLEMENTATION

Operation Conference Calls

During implementation of the VAMP pulse flow, conference calls were conducted on a regular basis to discuss the status of the pulse flow and to make changes to the operation plan if needed. The calls were held at 6:30 a.m. so that potential operational changes could be implemented on that day. The conference calls were held every Monday, Wednesday and Friday, starting on April 12 and ending on May 10.

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 2-5. The CDEC real-time data has not been reviewed for accuracy or adjusted for rating shifts; 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 were continuously monitored. Similarly, the computed ungaged flow at Vernalis and the flow in the San Joaquin River upstream of the Merced River were continuously updated. The monitoring was necessary to verify that supplemental water deliveries were adhering to tributary allocations contained in the SJRA to the extent possible, as well as to determine if changes in hydrologic conditions would require changes to the operation plan.

TABLE 2–5
Real-time Flow Data and Sources

MEASUREMENT LOCATION	REAL-TIME DATA SOURCE
San Joaquin River near Vernalis	USGS
Stanislaus River below Goodwin Dam	USBR Goodwin Dam daily operation report
Tuolumne River below LaGrange Dam (LGN)	USGS
Merced River at Cressey (CRS)	CDEC
Merced River near Stevinson (MST)	CDEC
San Joaquin River at Newman (NEW)	USGS

The daily operation plan was updated throughout the VAMP flow period. A summary of the updated daily operation plans is provided in Table 2-6. Copies of the updated daily operation plans are provided in Appendix A.

RESULTS OF OPERATIONS

The final accounting for the VAMP operation is accomplished using provisional mean daily flow data available from USGS and DWR. The provisional data 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 to illustrate the differences between the real-time and the provisional data.

The mean daily flow at the Vernalis gage averaged 3,300 cfs during the VAMP test flow period, with a maximum of 3,610 cfs and a minimum of 2,840 cfs. The average flow for the test flow

TABLE 2–6
Summary of 2002 VAMP Daily Operation Plans Prepared During Implementation Phase

VAMP FORECAST DATE	VAMP PERIOD	ASSUMED UNGAUGED FLOW AT VERNALIS (CFS)	EXISTING FLOW (CFS)	VAMP TARGET FLOW (CFS)	SUPPLEMENTAL WATER NEEDED TO MEET TARGET FLOW (1,000 AF)
April 16	April 15–May 15	300	2,645	3,200	34.10
April 19	April 15–May 15	300	2,623	3,200	35.49
April 25	April 15–May 15	300	2,636	3,200	34.68
May 09	April 15–May 15	450	2,747	3,200	27.88

FIGURE 2–1

2002 VAMP–San Joaquin River Near Vernalis–With and Without VAMP

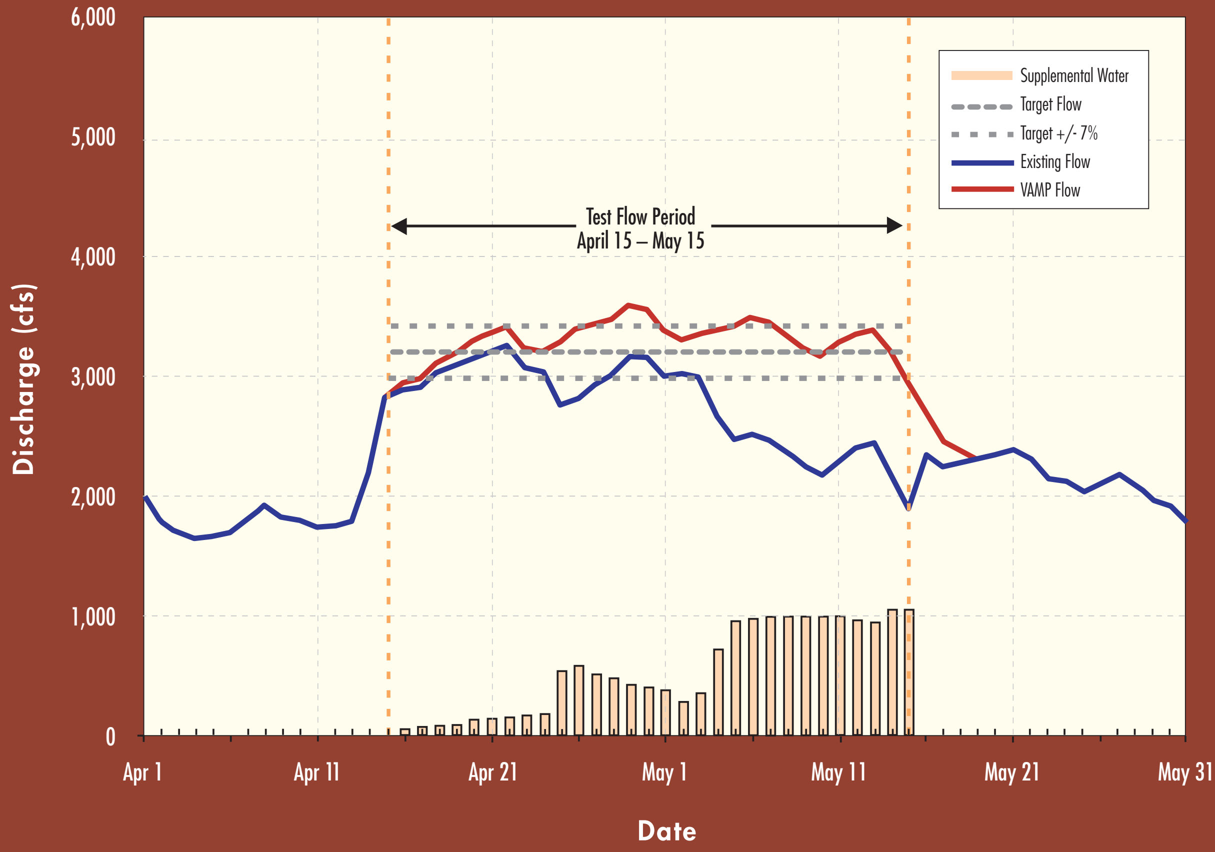


FIGURE 2–2

2002 VAMP–San Joaquin River Near Vernalis With Lagged Contributions From Primary Sources

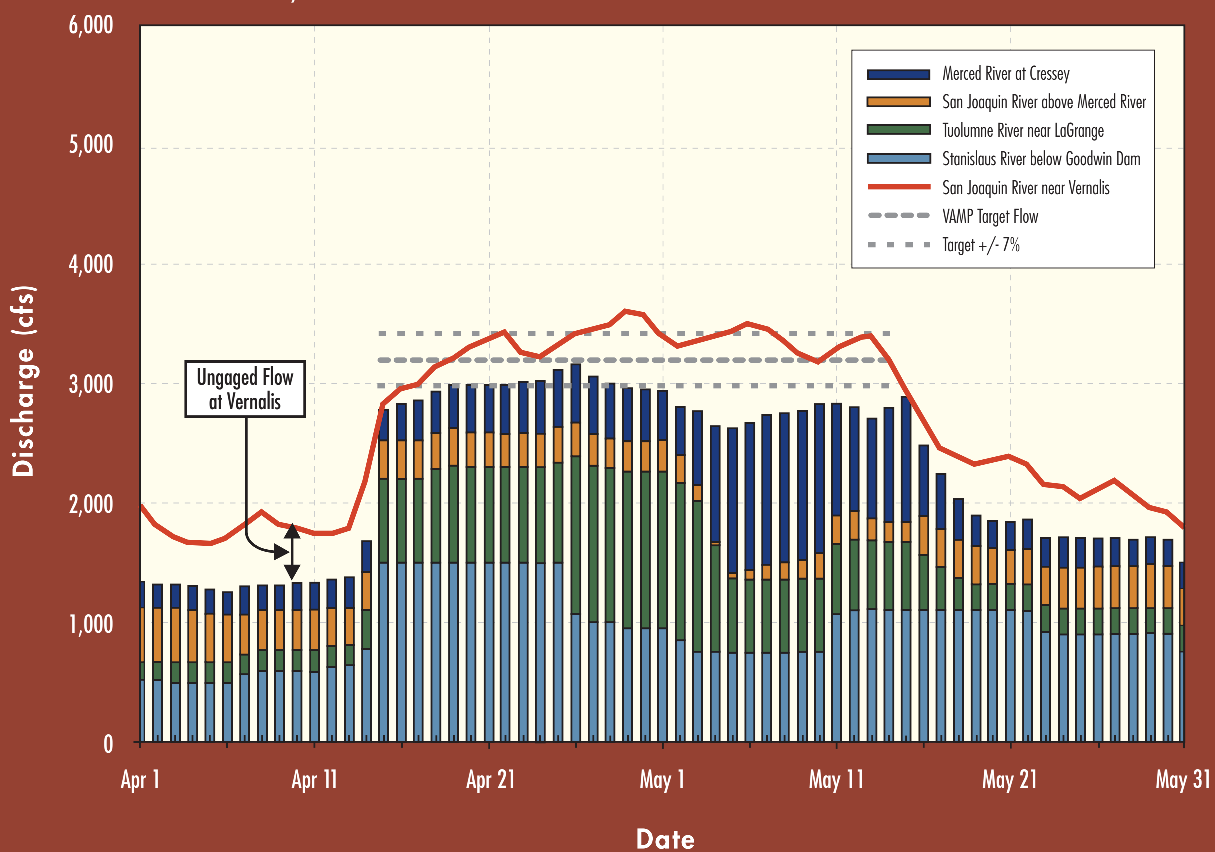


FIGURE 2–3

2002 VAMP–Ungaged Flow at Vernalis During Test Flow Period

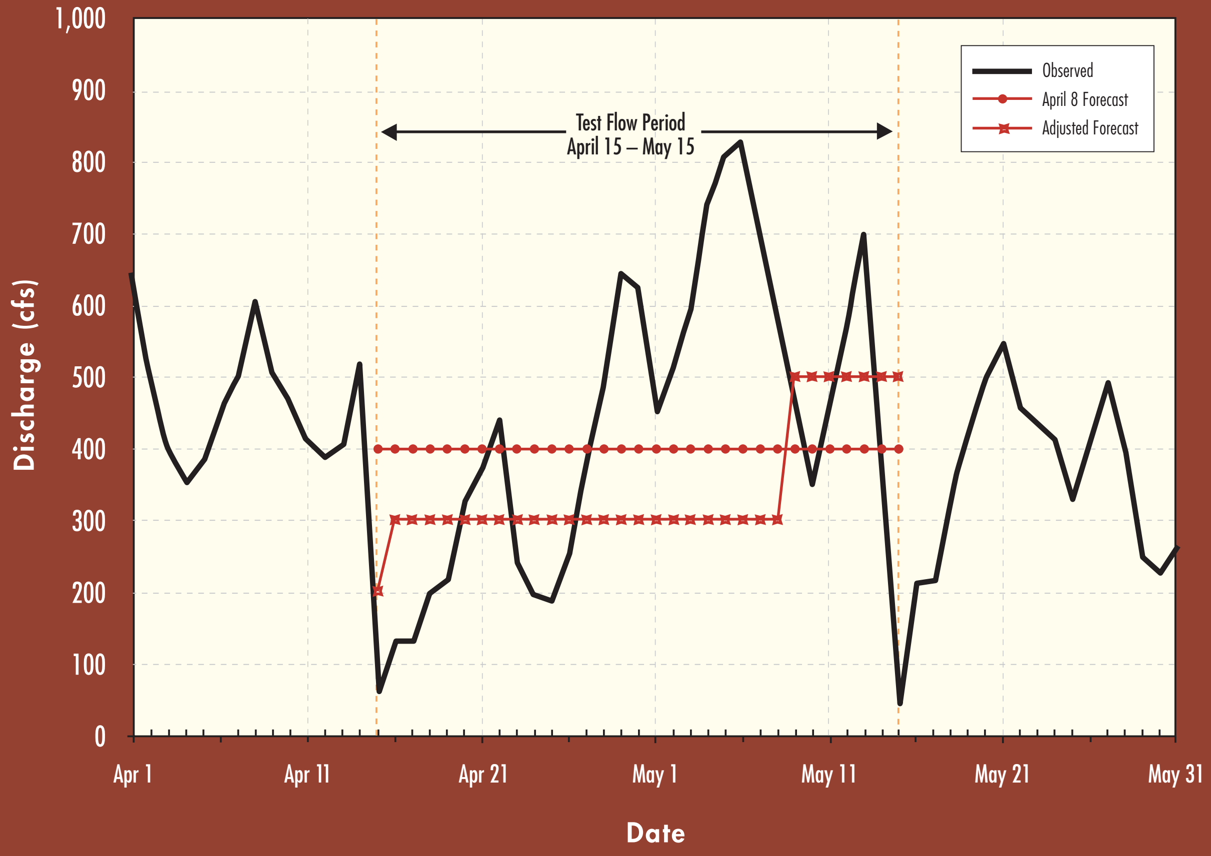


FIGURE 2–4

2002 VAMP–Federal and State Exports [Source: USBR Delta Operations Report]

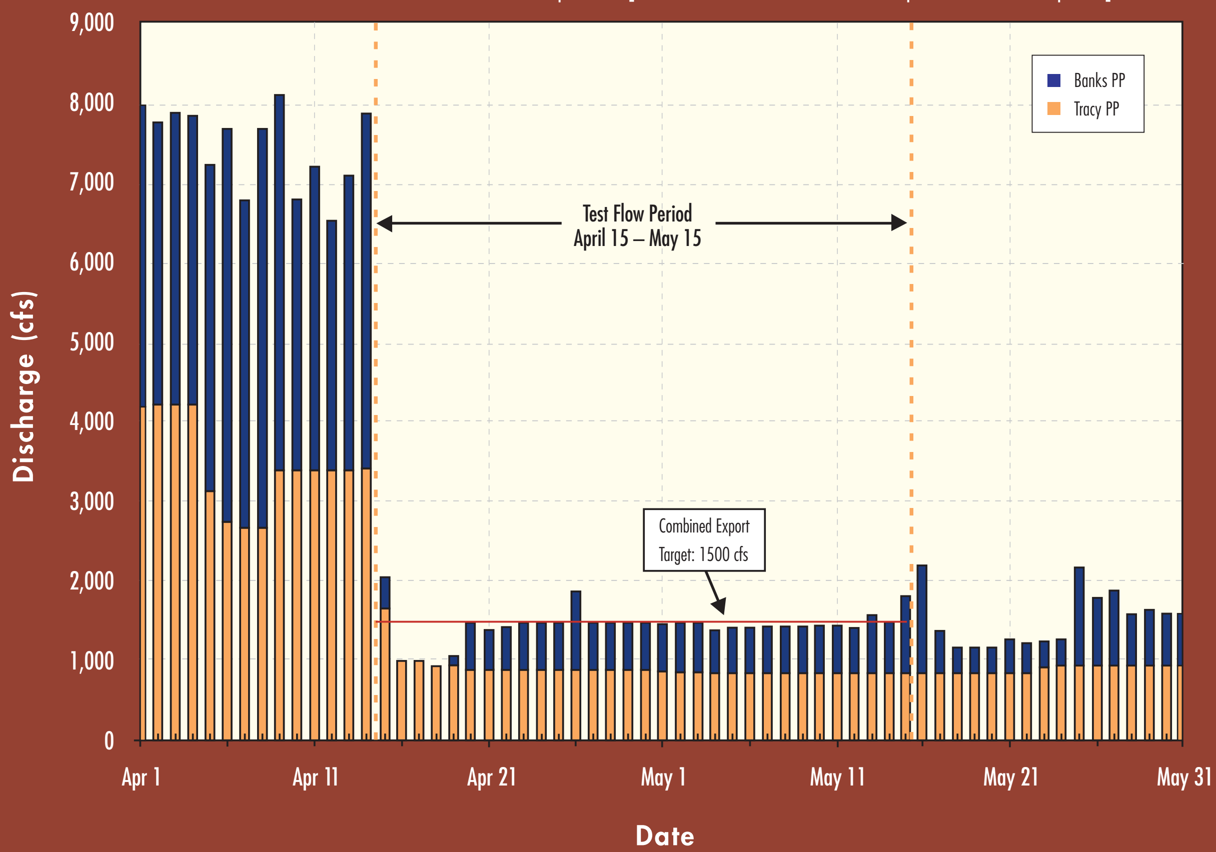


FIGURE 2–5

2002 VAMP–SJRA Storage Impacts–Lake McClure (Merced River), October 2001 through December 2002

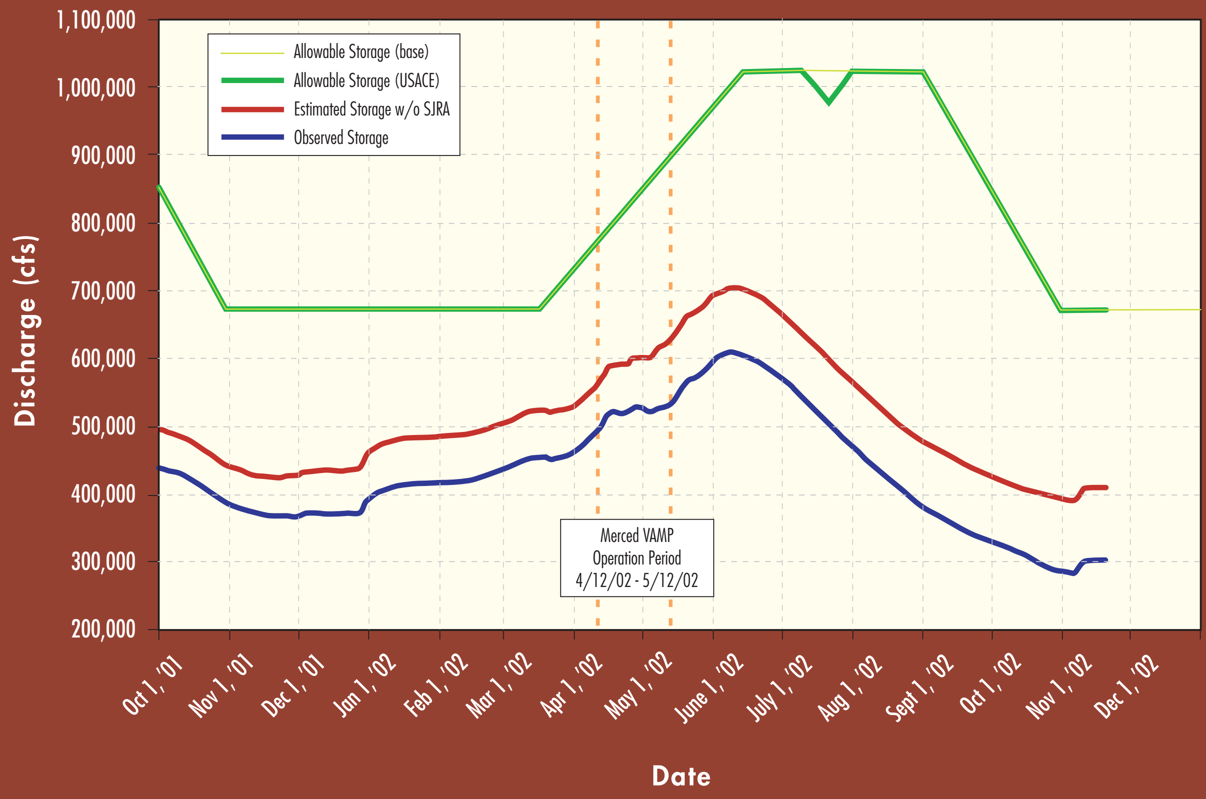
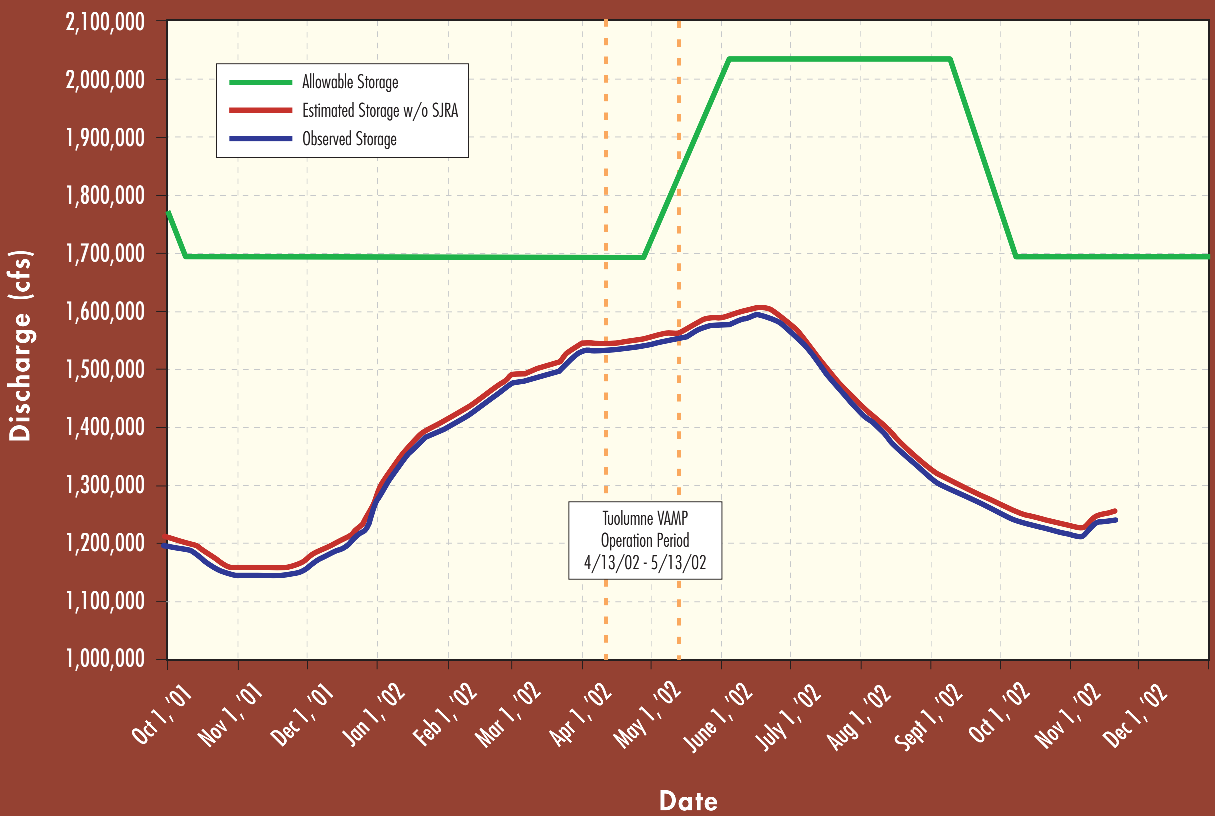


FIGURE 2–6

SJRA Storage Impacts–New Don Pedro Reservoir (Tuolumne River), October 2001 through December 2002



period absent the VAMP supplemental water (existing flow) was estimated to be 2,760 cfs. The VAMP operation resulted in a 20 percent increase in flow at Vernalis during the target flow period. Figure 2-1 shows the flow at Vernalis with and without the VAMP pulse flow. Figure 2-2 shows the sources of the flow at Vernalis. A total of 33,430 acre-feet of supplemental water was provided during the VAMP test flow period. A daily summary of VAMP operations, along with supporting data, is provided in Appendix A.

In planning for the VAMP operation the ungaged flow at Vernalis is the most difficult factor to forecast for the test flow period. The Daily Operation Plan is developed assuming a steady ungaged flow during the test flow period, but in reality there will be day to day fluctuations due to a number of unpredictable factors including weather, pre-existing conditions, irrigation operations, as well as mathematical uncertainties introduced by using mean daily flows and assumed travel times rounded to the nearest day. During the implementation phase of the VAMP operation, the forecast ungaged flow will not necessarily be adjusted as a result of the day to day fluctuations, but will be adjusted if the general trend appears to be deviating from the existing forecast. This is all illustrated in Figure 2-3, which shows in hindsight the observed ungaged flow along with that forecast prior to the test flow period on April 8 and the adjusted forecast that was modified on an ongoing basis in an attempt to account for deviation from the existing forecast.

The combined CVP and SWP export rate averaged 1,430 cfs during the 31-day period, about 5 percent below the target of 1,500 cfs. The daily SWP and CVP exports during the VAMP test period are shown in Figure 2-4.

SJRG member agencies have entered into the Division Agreement, which allocates responsibility of the members for providing VAMP supplemental water. The distribution of supplemental water for the 2002 VAMP operation, compared to the distribution called for under the Division Agreement, is summarized in Table 2-7.

Hydrologic Impacts

The VAMP supplemental water contributions, with the exception of that provided by the Exchange Contractors and OID/SSJID, are supplied from reservoir storage: Lake McClure on the Merced River and New Don Pedro Reservoir on the Tuolumne River. 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.

As noted in the 2001 Annual Technical Report, the storage impact in Lake McClure on the Merced River following the 2001 VAMP operation was 55,650 acre-feet. As per the SJRA, Merced provided 12,500 acre-feet of supplemental water in the Fall of 2001 (see Chapter 3), resulting in a total SJRA storage impact on Lake McClure at the end of 2001 of 68,150 acre-feet. There were no opportunities to make up for any of this impact during the winter, therefore the entire impact of 68,150 acre-feet carried over into the 2002 VAMP operation period. With the 25,840 acre-feet of supplemental water provided by Merced for the 2002 VAMP operation along with 1,270 acre-feet of operational ramp-down water, the current impact of the SJRA on Lake McClure storage is 95,260 acre-feet. Figure 2-5 shows Lake McClure storage for water year 2002 with and without the SJRA.

As noted in the 2001 Annual Technical Report, the storage impact in New Don Pedro Reservoir on the Tuolumne River following the 2001 VAMP operation was 14,060 acre-feet. There were no opportunities to make up for any of this impact during the winter, therefore the entire impact of 14,060 acre-feet carried over into the 2002 VAMP operation period. No supplemental water was provided from New Don Pedro Reservoir for the 2002 VAMP; therefore the current storage impact due to the SJRA remains at 14,060 acre-feet. Figure 2-6 shows New Don Pedro Reservoir storage for water year 2002 with and without the SJRA.

In the 2001 Annual Technical Report, a cumulative storage impact to New Melones of 54,210 acre-feet was identified. This statement was not correct. The water provided by OID/SSJID for both the VAMP pulse flow and the "additional" water is made available from their diversion entitlements. Thus, there are no storage impacts in New Melones due to either VAMP or the "additional" water purchase.

TABLE 2–7
2002 VAMP–Distribution of Supplemental Water

AGENCY	DIVISION AGREEMENT DISTRIBUTION (ACRE–FEET)	SUPPLEMENTAL WATER PROVIDED (ACRE–FEET)	DEVIATION FROM DIVISION AGREEMENT (ACRE–FEET)
Merced I.D.	25,000	25,840	+840
Oakdale I.D./ South San Joaquin I.D.	8,430	7,590	–840
Exchange Contractors	0	0	0
Modesto I.D./ Turlock I.D.	0	0	0

CHAPTER 3 | ADDITIONAL WATER SUPPLY ARRANGEMENTS & DELIVERIES

MERCED IRRIGATION DISTRICT

The SJRA includes a provision (Paragraph 8.4) stating that "Merced Irrigation District (Merced) 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." This water is referred to as the Fall SJRA Transfer Water. The daily schedule for the Fall SJRA Transfer Water is to be developed by Department of Fish and Game (DFG), United States Fish and Wildlife Services (USFWS) and Merced ID.

The schedule for the 2002 Fall SJRA Transfer was finalized on October 3, 2002, with the transfer commencing on October 15, 2002. The schedule is provided in Appendix B, Table B-1. As with the VAMP operation, the final accounting for the Fall Transfer will be done using provisional flow data.

The 2001 Fall SJRA Transfer was in progress at the time of publication of the 2001 Annual Technical Report and therefore only preliminary data was provided in the 2001 report. The final data for the 2001 Fall SJRA Transfer are included in Appendix B, Table B-2, of this report.

The schedule for the 2002 Fall SJRA Transfer was finalized on October 3, 2002, with the TRANSFER COMMENCING on October 15, 2002.

OAKDALE IRRIGATION DISTRICT

Pursuant to Paragraph 8.5 of the SJRA, "Oakdale Irrigation District (OID) shall sell 15,000 acre-feet of water to the USBR in every year of (the) Agreement...In addition to the 15,000 acre-feet, Oakdale will sell the difference between the water made available to VAMP under the SJRGA agreement and 11,000 acre-feet." This water is referred to as the Difference water.

OID provided 3,795 acre-feet of supplemental water for the year 2002 VAMP, resulting in 7,205 acre-feet of Difference water. Therefore, pursuant to Paragraph 8.5 of the Agreement, OID sold a total of 22,205 acre-feet of water to the USBR in 2002.

Release of the OID additional water by the USBR began on October 20, 2002 and is scheduled to be completed by February 28, 2003. The preliminary daily schedule as of October 30, 2002 for the release of the OID additional water is provided in Appendix B, Table B-3.

BARRIER DESIGN, INSTALLATION AND OPERATION

In early April 2002, DWR installed and operated the temporary HORB. The spring HORB is a component of the south delta Temporary Barriers Project (TBP). The TBP mitigates for low water levels in the south delta and improves water circulation and quality for agricultural purposes. The HORB, as currently configured, is now fully permitted though 2005.

The spring HORB was first constructed in 1992. Since then, the barrier has been installed in 1994, 1996, 1997 (w/two culverts), 2000, 2001, and 2002. In 2000-2002 the barrier was installed with six culverts. The HORB was not installed in 1993, 1995 and 1998 due to high San Joaquin River flows. The HORB was not installed in 1999 due to landowner access problems. The HORB, a key component of VAMP, is intended to increase San Joaquin River Chinook salmon smolt survival by preventing them from entering Old River.

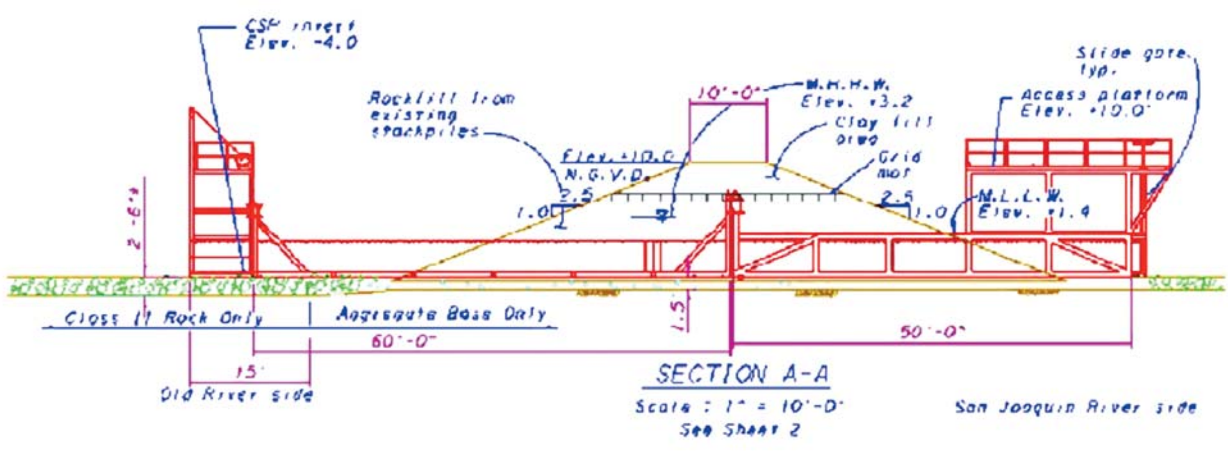
The HORB was originally designed to withstand a San Joaquin River flow of about 3,000 cfs. Through the years, the design and installation of the HORB has been revised on several occasions to accommodate different needs. Beginning in 2001, the barrier design included two versions. A "low-flow" barrier when San Joaquin River target flows are below 7,000 cfs would be built to a height of 10 feet mean sea level (MSL). A "high-flow" barrier for target flow of 7,000 cfs would be built to a height of 11 feet MSL and additional material would be placed to raise the abutments to 13 feet MSL. Both barrier versions are equipped with six 48-inch diameter operable culverts and an overflow weir back-filled with clay. In 2002, the low-flow version was installed.

The dimensions of the 2002 HORB (Figure 4-1) were similar to the 2000 and 2001 HORB. The base width of the HORB in 2002 was 100 feet and the crest elevation was 10 feet MSL. The top of HORB was constructed with a 75-foot wide notch, protected with concrete grid mats and back-filled with clay. The HORB was designed to safely operate with flows corresponding to stages up to 8.5 feet MSL.

To help mitigate anticipated low water levels in the south delta (downstream of the HORB) caused by the operation of the HORB, two open culverts were installed in the barrier in 1997, and six operable culverts were installed beginning in 2000. Operation of the culverts is controlled by a slide gate control structure located on the upstream side of HORB. DWR relied on daily modeling and field data collection to monitor water levels at three locations within the south Delta to determine when and how long to operate the culverts. Generally, the model forecasts would tend to forecast low-low water levels lower than actual levels observed in the field. Consequently, DWR would make decisions regarding the culvert operations that would take this into consideration. It is expected that refinements to the model over time will provide modeling results that correspond more closely with field measurements.

The downstream outlet of each culvert was designed so fyke nets could be attached to evaluate fish passage. DFG staff conducted a fishery-monitoring program as part of the 2002 HORB operations.

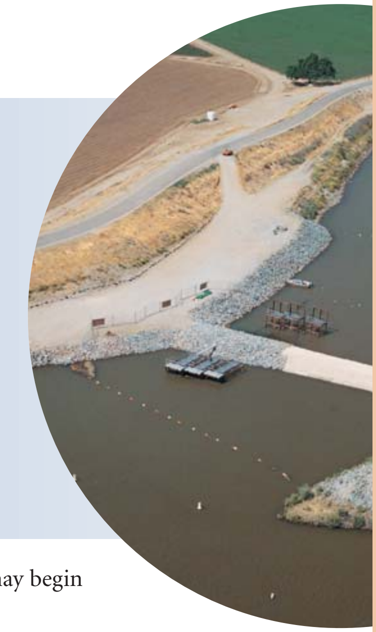
FIGURE 4–1
Head of Old River Barrier (HORB)



Permitting and Construction

The various permit conditions that are placed on the Temporary Barriers Program, by the USFWS, National Marine Fisheries Service (NMFS), and DFG, require that the earliest in-water construction activities that can be conducted on the Head of Old River (HOR), Middle River (MR), and Old River at Tracy (ORT) barriers, during the Spring barrier installation period, are limited to no earlier than April 7. In addition, construction of the northern abutment and boat ramps of the Grant Line Canal (GLC) barrier and construction of out-of-water portions of the HOR, MR, and ORT barriers may not be started any earlier than April 1. Full closure of the GLC barrier is not required but construction of the north abutment and boat ramps must be completed to the extent that full barrier closure and operation can be readily achieved in a reasonable time frame, if and when directed by DWR. The permit conditions also require that all the above work be completed by April 15th, a total of 15 working days. Following is a brief summary of the various permit conditions:

The downstream outlet of each culvert was designed so fyke nets could be attached to evaluate fish passage. DFG staff conducted a fishery-monitoring program as part of the 2002 HORB operations.



USFWS Biological Opinion

1) The spring HORB barrier installation may begin on April 1 but in-water work shall not occur until April 7, except for construction necessary to place the scour pad and the pad for the culverts (item No. 8, page 6);

2) DWR may begin construction of the Middle River barrier on April 1 but in-water work shall not occur until after April 7 (item No. 1, page 4);

3) DWR may begin construction of the Old River at Tracy barrier on April 1 but in-water work shall not commence before April 7 (item No. 2, page 4);

4) DWR may begin construction of the northern abutment and the boat ramp of the GLC barrier on April 1 provided that the HOR barrier is being constructed concurrently (item No. 3, page 5).

NMFS Biological Opinion

1) the spring HORB installation shall begin on April 1 (item 8, page 8);

2) the MR barrier construction may begin on April 7 (item 1, page6);

3) the ORT barrier construction may begin on April 1 (item2, page 6);

4) the northern abutment and boat ramp of the GLC barrier may begin construction on April 1 provided that the HORB is being constructed concurrently (item 3, page 7).

DFG 1601–HORB

HORB Spring Installation–All work in or near the stream zone will be confined to the period beginning no earlier than April.

DFG 1601–Agricultural Barriers

MR–All work in or near the stream zone will be confined to the period beginning no earlier than March 1.

ORT–All work in or near the stream zone will be confined to the period beginning no earlier than April 1.

GLC–All work in or near the stream zone will be confined to the period beginning no earlier than April 1.

TABLE 4–1

Flow in Old River Downstream of the Head of Old River Barrier–2002

DATE	MEAN DAILY FLOW (CFS)	DAILY MAX FLOW (CFS)	DAILY MIN FLOW (CFS)	DATE	MEAN DAILY FLOW (CFS)	DAILY MAX FLOW (CFS)	DAILY MIN FLOW (CFS)
April 1	870	1567	419	May 02	278	763	-113
April 2	898	1590	287	May 03	328	717	-164
April 3	889	1418	101	May 04	291	828	-169
April 4	858	1409	96	May 05	234	745	-76
April 5	758	1315	-26	May 06	364	750	-123
April 6	727	1111	-13	May 07	327	772	-33
April 7	616	1047	93	May 08	274	794	-197
April 8	596	1100	276	May 09	362	691	-11
April 9	543	1211	138	May 10	366	644	-83
April 10	471	1157	13	May 11	258	679	-73
April 11	577	1136	147	May 12	356	844	-36
April 12	519	1016	45	May 13	568	888	324
April 13	347	1015	-128	May 14	525	811	220
April 14	487	1372	-486	May 15	458	674	169
April 15	680	1821	77	May 16	417	661	0
April 16	538	832	49	May 17	371	648	115
April 17	541	822	225	May 18	388	575	142
April 18	412	838	-158	May 19	232	548	-161
April 19	259	687	-194	May 20	218	537	-33
April 20	229	577	-140	May 21	294	540	-11
April 21	232	851	-201	May 22	325	585	35
April 22	160	751	-233	May 23	331	607	-55
April 23	169	495	-226	May 24	409	1651	-239
April 24	205	559	-259	May 25	683	1612	-33
April 25	249	538	-148	May 26	923	1870	305
April 26	328	626	20	May 27	854	1752	-12
April 27	238	494	-66	May 28	713	1582	-129
April 28	180	595	-243	May 29	471	1334	23
April 29	241	638	-73	May 30	413	858	0
April 30	187	534	-225	May 31	492	889	68
May 01	200	766	-127				

In addition to the above conditions, water users of the South Delta Water Agency (SDWA) and the fisheries agencies impose separate mitigation requirements on DWR for installation and operation of the HORB by itself. As a result, DWR's contractor must sequentially close and start operation of the MR and ORT barriers, and complete as much construction of north abutment and boat ramps on the GLC barrier as possible, before they can close and operate the HORB.

From the contractors point of view there are really two milestones that must be completed in sequence. First and foremost is to obtain closure and operation of the barriers in accordance with the conditions imposed by the project permits/biological opinions and mitigation requirements. The second is to satisfy DWR's contract specifications. The first milestone can be achieved within the required 15 working days but it is unlikely that the contractor can complete the entire amount of work required to satisfy DWR's contract specifications within the same time period.

Therefore, the contractor's construction activities consist of placing enough materials to make sure they obtain closure and operation by April 15th, then following closure they continue placing barrier material above the water line until barrier construction is completed in accordance with DWR's contract specifications. The contractor then conducts site cleanup and demobilizes from the site. This is why work usually continues beyond the April 15 deadline.

Barrier Operations and Monitoring Plan

A barrier operations and monitoring plan was developed based on forecasting and monitoring of tidal conditions. DWR determined the number of culverts to be opened at the HORB so that water levels at Old River near Tracy Road Bridge, Middle River near

Howard Road and Grant Line Canal near Tracy Road Bridge would remain above 0.0 feet MSL. Based on modeling results and/or field monitoring of water levels in the south delta, all six culvert slide gates remained open from April 15 to May 24, 2002 when the HORB was breached.

The average daily flow through the culverts varied in response to tidal and San Joaquin River flow conditions. The characteristics of the flow through the culverts are complicated in that the flow rate is influenced by many variables, including the culvert inlet geometry, slope, size, culvert roughness, and approach and tail water conditions. An approximation of the combined net flow through the culverts, including any seepage through the barrier, was accomplished by measuring the flow in Old River just downstream of the HORB using Acoustic Doppler technology. A fixed Acoustic Doppler Current Meter was operated approximately 840 feet downstream of the HORB which recorded velocity measurements every 15 minutes during the period the HORB was operated (April 15 through May 24, 2002). The flow in Old River was then calculated using the known cross-sectional area of the channel as a function of the stage elevation at that location.

The mean daily flow measured in Old River during the operation of the HORB ranged from 160 to 568 cubic feet per second as shown in Table 4-1. These figures ignore the first and the last day of operation which is skewed by flows occurring before and after the HORB was closed or breached. On May 24, the barrier was breached, which accounts for the maximum flow of 1,651 cfs shown in Table 4-1. The negative flows listed indicate the channel below the HORB was filling on a flood tide; however, this does not mean that flows through the culverts were negative. As long at the river stages on the upstream side of the barrier remain higher than the downstream side, flows through the culverts will always be positive.

Barrier Emergency Response Plan

In addition to the operation and monitoring plan, DWR has also prepared an "Emergency Operations Plan for the Spring HORB". The plan provided that if the daily measured or forecasted flow at Vernalis exceeded a flow that would correspond to stage at the HORB of 10.0 feet MSL, and the stage was likely to exceed 11.0 feet MSL (the height of the barrier under the "high-flow" target), the barrier would be removed. Operation of the HORB was uneventful this year. Vernalis flows and stages at the barrier were not high enough in 2002 to warrant action under the emergency operations plan.

Seepage Monitoring

A seepage-monitoring program was initiated in April 2000 and continued this year, to evaluate the effects of HORB operations on seepage and groundwater on Upper Roberts Island.

Three seepage monitoring well sites were chosen in 2000 on Upper Roberts Island. Each site had two shallow wells, positioned 10 feet and 100 feet from the toe of the levee to monitor the seepage gradient to and from the San Joaquin River. In addition, a deeper well was drilled at Site 1 (near the Head of Old River) to determine vertical gradients.

In addition to the groundwater monitoring wells, a temporary gage was installed in April 2000 to record water surface elevations in the San Joaquin River, about 1,500 feet downstream of the HORB. Installation of a permanent tide gage was completed in early 2002. The water surface elevations in the San Joaquin River are compared to groundwater levels on Upper Roberts Island to determine how groundwater levels change relative to changing water level conditions in the river.

In November 2002, DWR completed a "Reclamation District 544 Seepage Monitoring Study". This is an ongoing study to document the seepage monitoring results from Upper Robert Island. (Copies of the report are available from DWR). Based on the 2000 and 2001 data, it is apparent that the San Joaquin River stage influences groundwater levels on Upper Roberts Island. When stage increases in the river, groundwater levels will rise toward the land surface, but not as rapidly as the river stage rises. However, over the monitoring period, river stage did not reach levels sufficient to raise groundwater levels to the point where seepage into crop root zones might occur.

Given the results of the seepage monitoring since April 2000, DWR expects that if a VAMP target flow of 7,000 was implemented, stages near the HORB would rise to about 7 1/2 to 8 feet MSL. This would translate to groundwater levels in the monitoring well closest to the levee of about 6 1/2 to 7 feet MSL. Because the ground surface elevation is 13 feet MSL near site 1, DWR concludes that seepage should not impact the root zone of crops that could be planted in this area.

The monitoring program will be continued in order to gather more data, particularly during high flow periods in the spring.

FISHERY MONITORING AT THE HEAD OF OLD RIVER BARRIER

During the VAMP 2002 test period, all six culverts in the HORB were operational. The six culverts are installed to maintain water quality and water levels in the south delta downstream of the HORB. Since the culverts are not screened, juvenile Chinook salmon and other fish species that pass near the culverts are vulnerable to entrainment. A fishery monitoring program was designed and implemented by the DFG to evaluate and quantify fish entrainment at the HORB. The specific objectives of the 2002 fishery investigations were:

- Determine the total number of juvenile Chinook salmon and other fish species entrained through the culverts at the HORB (Entrainment Monitoring).
- Determine the percentage of coded-wire tagged (CWT) salmon released at Mossdale and Durham Ferry entrained into Old River (Entrainment Monitoring).
- Determine tidal and diel effects on juvenile Chinook salmon entrainment (Entrainment Special Study).

Results of these fishery investigations are intended, in part, to provide information on the design and operation of a future permanent operable barrier at the head of Old River.

Materials and Methods

As part of the VAMP 2002 studies, a total of 148,502 CWT salmon smolts were released at Durham Ferry and Mossdale on April 18 and 19, respectively. Another 147,842 were released at the same locations on April 25 and 26. Salmon from the VAMP releases were used in the Entrainment Monitoring studies. For the Entrainment Special Study, eight uniquely color-marked groups of juvenile Chinook salmon (approximately 3,000 fish per group) were marked with photonic fluorescent microspheres at the Merced River Hatchery. The salmon were transported to the HORB and placed in live cages where they were held at least 10 hours before release. Each color-marked group was released approximately one mile upstream of the HORB, in the middle of the San Joaquin River. The color-marked releases coincided with the two VAMP salmon releases. On the night of April 19, one group was released on the ebb tide and one group on the flood tide. The following day, a group was released on the subsequent ebb and flood tides. The process was repeated on April 25.

Fish entrained into the culverts were caught with fyke nets. The nets have a 48 inch cylindrical mouth tapering down to a 1-foot square cod-end, are made of 1/4 inch braided mesh, and five of the nets are 60 feet long and one is 40 feet long. A live-box (15.5 x 19.5 x 36 inches), constructed of perforated aluminum sheet metal, was attached to the cod-end of each net. Each live-box has an aluminum baffle designed to reduce water velocities within the live-box and improve survival of captured fish. The fyke nets were attached to the culvert flanges on April 17. The nets were attached to the culverts by closing the culvert slide gates on the upstream side of the barrier, raising the flanges that slide over the culvert outfalls, and then strapping the nets over the flange. The 40 foot net was attached to culvert number 1 and the 60 foot nets were used on the remaining culverts. The culverts were numbered 1 through 6 with number 1 located next to the shoreline and number 6 located near mid-channel (Figure 4-2). On April 18, the flanges, with the attached fyke nets, were lowered down to the culvert outfalls and the live-boxes were attached to the cod-end of the nets to commence sampling.

The fyke nets were checked on every tide change until May 1. From May 1 through May 11, the nets were checked twice a day; in the morning and the evening. On May 12, the nets were removed. The nets were checked by closing the culvert slide gate, for a period of 30 to 45 minutes, which enabled the live-boxes to be pulled onto a boat so that the fish could be removed and placed into buckets. Once all the nets had been checked and reset, the collected fish were processed. The fish were speciated and counted. Fork lengths (mm) were recorded for up to 50 salmon per live-box. Salmon were checked for a clipped adipose fin and for the presence of a color mark on the dorsal, anal, or caudal fin. Salmon that had a clipped adipose fin were saved for CWT processing. The color and location of the dyed fin was noted for each color-marked salmon. During each net check, culvert

FIGURE 4–2
Culvert Numbers for HORB 2002

number, date, time, water temperature, tidal stage, and diel period was recorded. Except for the CWT smolts, all processed fish were released downstream of the fyke nets into Old River.

Entrainment Monitoring

Loss indices for the CWT salmon released as part of the VAMP survival studies at Durham Ferry and Mossdale were calculated based on data collected from April 18 to May 11. The loss index represents the percentage of CWT salmon entrained into the HORB culverts. As in previous years, the loss index is calculated using the equation:

$$I = (TC/TR)(TT/ST)$$

Where:

TC = Total number of CWT salmon collected in culvert fyke nets

TR = Total number of CWT released

TT = Total time (hours) during the test period

ST = Total time (hours) sampled at HORB during the test period

However, this year, for the nine occasions when a culvert was not monitored and/or the sample was lost, the total catch for the missing culvert was estimated by using the average of the other culverts for that sample period. Consequently, all sampling time is accounted for and TT/ST = 1, and the loss index is equal to TC/TR.

Catch-Per-Unit-Effort (CPUE) for salmon was calculated as the number of fish collected per hour. The percentage of color-marked salmon recovered in the fyke nets compared to the total number released was used as an index of entrainment vulnerability at the HORB.

RESULTS AND DISCUSSION

Results

The HORB was closed on April 15; however, construction on the barrier continued for another week. Due to the large gravel pad in front of the culverts and/or the ongoing construction and the water currents, gravel was swept through the culverts into the nets during the first three days of sampling. Nine samples were lost or not taken because it required considerable time and effort to retrieve the rock filled net from the bottom of the river. Several of the lost samples occurred during a critical time when the CWT and color-marked salmon were approaching the barrier.

The DFG monitored the HORB culverts for 25 days and collected 381 samples. The nets sampled 3,379 hours out of a possible 3,429 hours. Almost 18,000 fish were collected representing at least 28 species and 14 families of fish. No delta smelt, one juvenile steelhead, and 30 adult splittail were entrained. The most abundant species was Chinook salmon, followed by white catfish

TABLE 4–2

The raw abundance and composition of fishes entrained at the HORB in 2002. Chinook salmon catch is divided into CWT VAMP and nonVAMP released salmon, unmarked salmon, and color-marked salmon.

Cyprinidae	1
Red Shiner	1
Black Bullhead	1
Centrarchidae	1
Steelhead	**1**
American Shad	1
Prickly Sculpin	2
Sacramento Pikeminnow	2
Petromyzontidae	3
White Crappie	4
Tule Perch	4
Shimofuri Goby	5
Warmouth	9
Green Sunfish	10
Largemouth Bass	12
Golden Shiner	14
Sacramento Sucker	15
Black Crappie	19
Redear Sunfish	26
Brown Bullhead	26
Striped Bass	27
Bigscale Logperch	27
Splittail	**30**
Goldfish	37
Inland Silverside	88
Bluegill	118
Common Carp	199
Channel Catfish	560
Threadfin Shad	1,219
White Catfish	6,925
Total Chinook Salmon	**8,467**
CWT VAMP Salmon	4,145
CWT NonVAMP Salmon	1,213
Unmarked Salmon	2,748
Color-Marked Salmon	361
Total	**17,854**

FIGURE 4–3

The total daily catch of salmon smolts entrained at the HORB in 2002. The total catch is divided into nonVAMP, VAMP, and unmarked salmon.

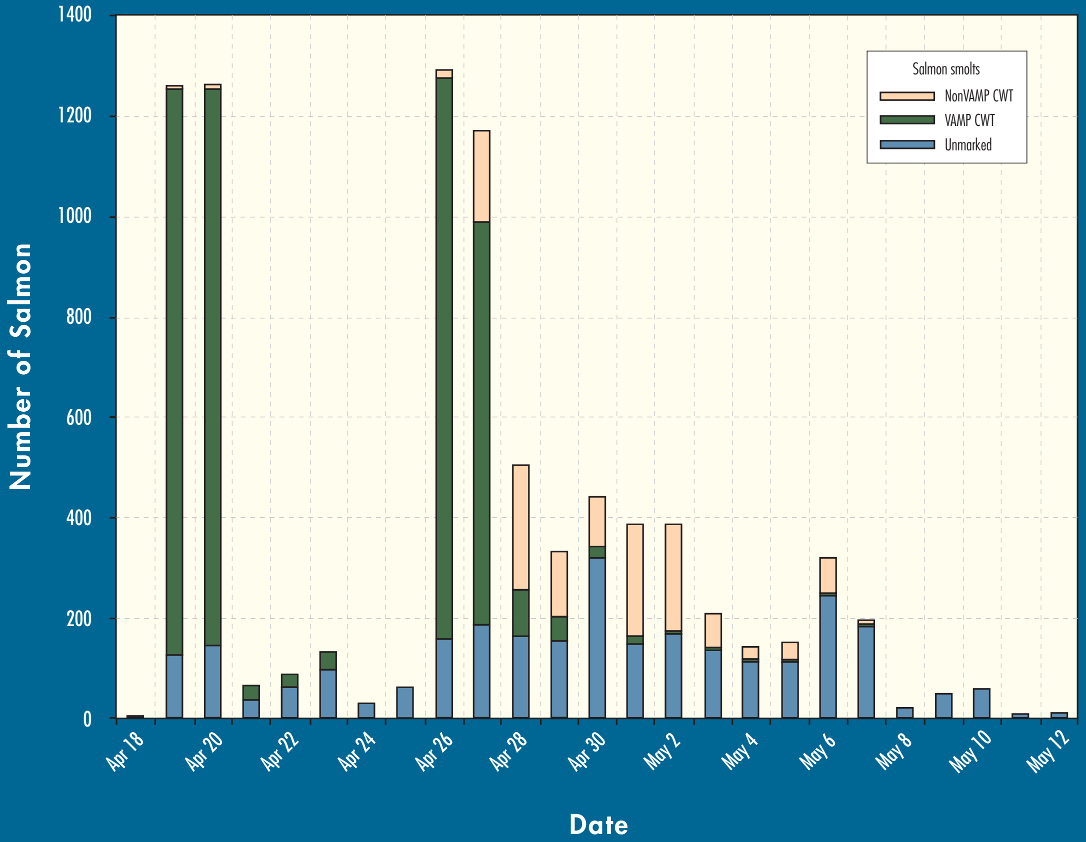


FIGURE 4–4

The number of CWT salmon caught by sampling period during the first VAMP releases in 2002. River stage for Old River is indicated by the line.

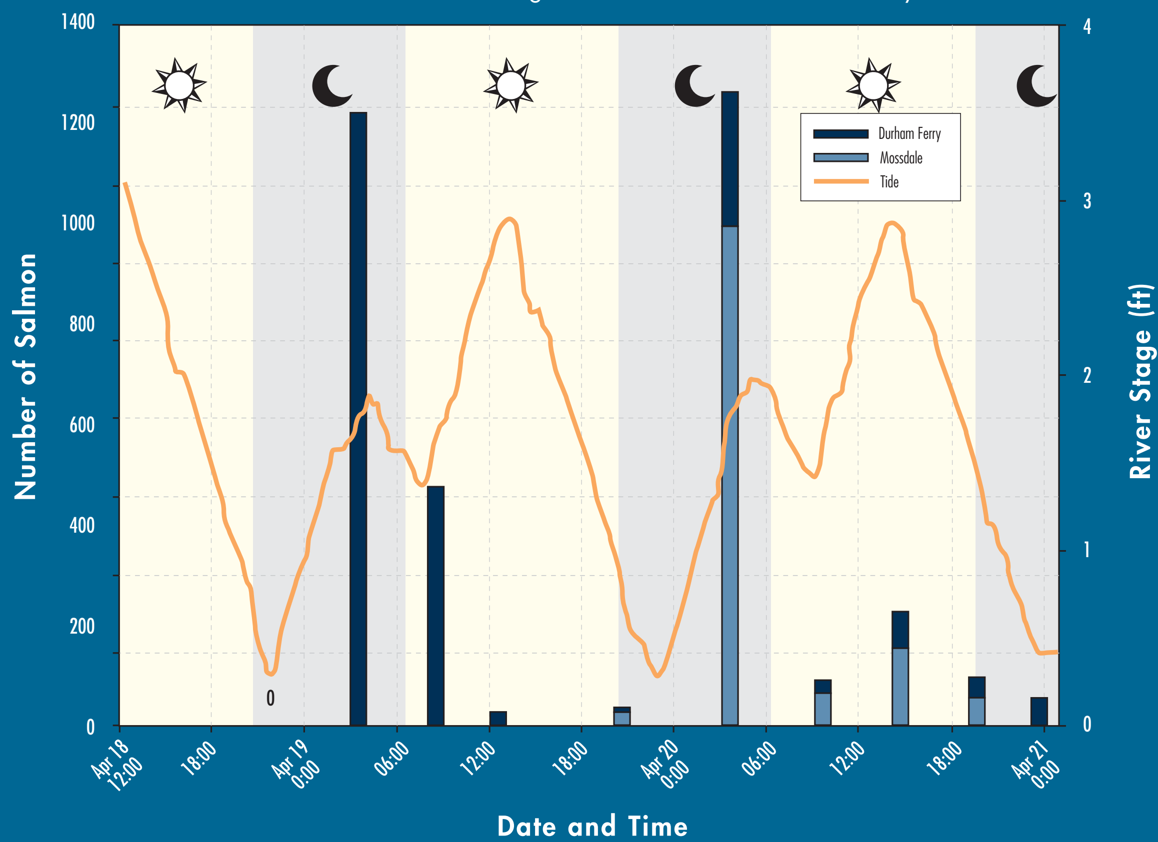


FIGURE 4–5

The number of CWT salmon caught by sampling period during the second VAMP releases in 2002. River stage for Old River is indicated by the line.

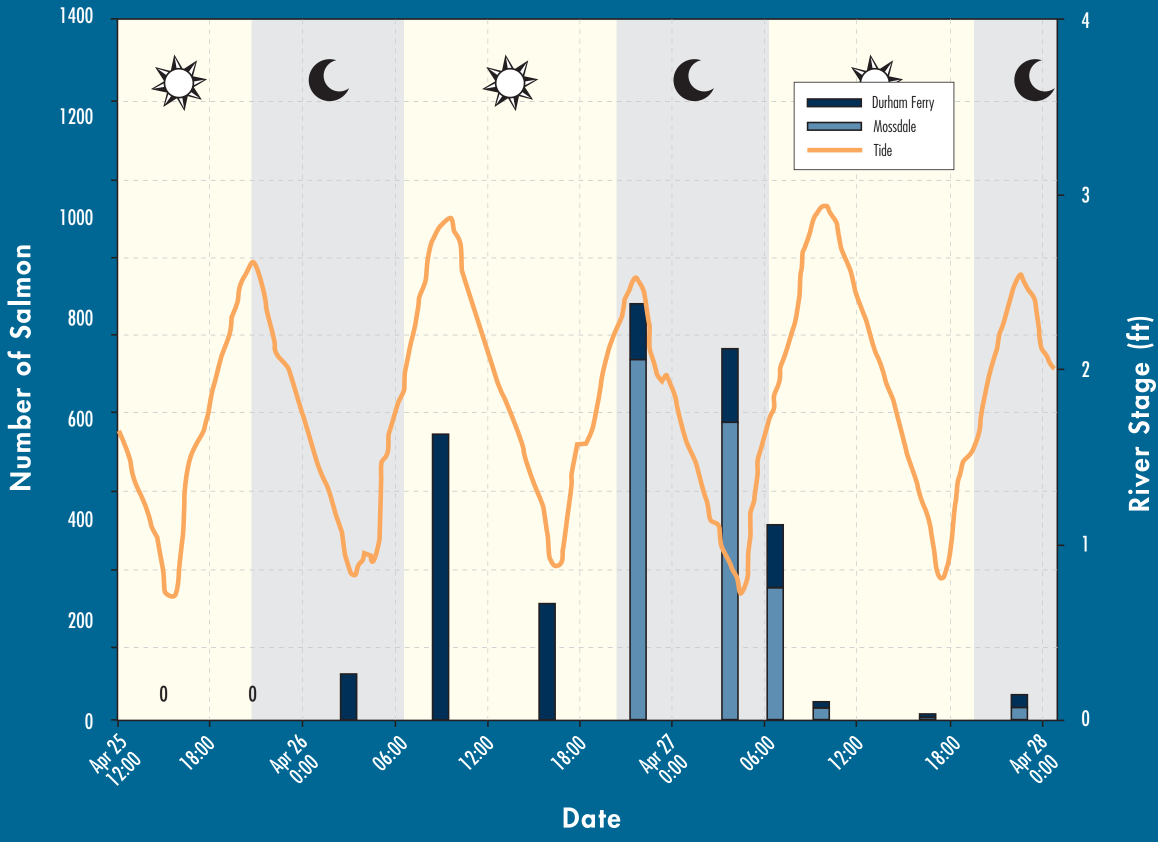
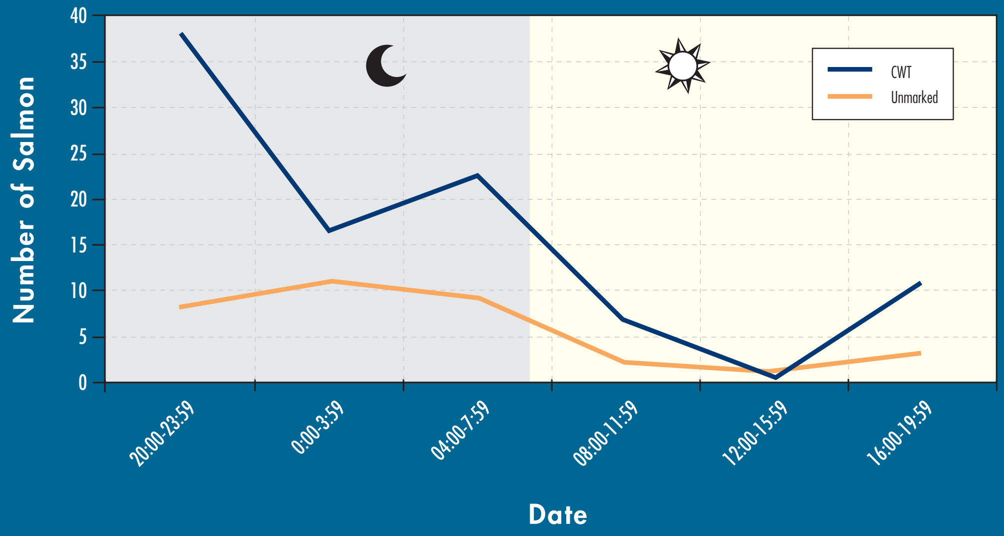


FIGURE 4–6

The average number of CWT and unmarked salmon caught over 24 hours, grouped into 4 hour time blocks.



(*Ictalurus catus*) (Table 4-2). CWT salmon dominated the catch in April and white catfish dominated the catch in May. Of the 8,493 salmon caught; 5,358 had a CWT; 2,748 were unmarked; and 361 had a color mark.

This year the number of CWT salmon increased 323 % over last year's CWT salmon entrainment (1,268 salmon). Salmon smolts were caught throughout the monitoring period although most of the VAMP released salmon were caught within a couple days of their release (Figure 4-3). During the first VAMP salmon release, it appears most of the Durham Ferry CWT salmon were entrained on the night of April 18 and the Mossdale released salmon were entrained on the night of April 19 (Figure 4-4). During the second VAMP release, the Durham Ferry salmon were entrained at a lower rate and few were caught on the night of April 25 (Figure 4-5). In contrast, the Mossdale salmon were entrained at a high rate on the night of April 26. The loss indices for the first Durham Ferry and Mossdale salmon releases were 1.6% and 1.7%, respectively. The loss indices for the second Durham Ferry and Mossdale releases were 1.0% and 2.3%, respectively. The overall loss index for the VAMP released salmon was 1.5%. This year's overall loss index is higher than the previous two years' indices of 0.5% and 0.8%.

TABLE 4–3

The percentage of color-marked salmon entrained for various diel and tidal stages. Due to some salmon escaping from their live-cages, the number of salmon released was estimated for the second releases.

NUMBER OF FISH RELEASED	DIEL	TIDE	FISH ENTRAINED	PERCENT RECOVERED
First Releases (19 & 20 April)				
3,032	Night	Flood	159	5.2%
3,009	Night	Ebb	46	1.5%
3,281	Day	Flood	15	0.5%
3,008	Day	Ebb	62	2.1%
Second Releases (25 & 26 April)				
2,990	Night	Flood	71	2.4%
3,000	Night	Ebb	10	0.3%
3,000	Day	Flood	39	1.3%
3,000	Day	Ebb	5	0.2%

Entrainment of the VAMP released salmon peaked during the late evening to midnight time block, and bottomed out in the afternoon at less than one fish per hour (Figure 4-6). The unmarked smolts had a steady rate of entrainment through the night and a relatively low rate during the day. For the entire monitoring duration, the average CPUE for the VAMP smolts per culvert was 1.6 ± 4.0. The highest CPUEs occurred soon after the VAMP releases, with a maximum CPUE of 32.5 on April 19. The average unmarked smolt CPUE (0.9 ± 1.3) was much lower than the VAMP CPUE. The highest unmarked CPUEs occurred in late April and early May, with a maximum CPUE of 7.5 on April 30.

To address tidal and diel effects, color-marked smolts were released on various tidal and diel period combinations. The first releases went well; however, some problems were encountered during the second release when an unknown number of smolts escaped from the holding pens before their intended release. The color-marked salmon were entrained within 5 hours at the HORB (Figure 4-7). Entrainment rates were higher for the first releases (2.3%) than the second releases (1.0%), but the overall entrainment rate (1.7%) was similar to the entrainment of the CWT smolts (Table 4-3). More smolts were caught at night than during the day, and more smolts were entrained during the flood than the ebb tide.

Salmon entrainment through the middle culvert was high this year (Figure 4-8). The remaining culverts entrained a similar amount of salmon, although the outside culverts (numbers 1 and 6) had a slightly lower overall entrainment rate. Culvert number 4 entrained 39% of the smolts during the day. On the day-ebb tides, culverts numbers 4 and 5 combined entrained almost 75% of the smolts (Table 4-4).

A current velocity meter (Swoffer Instruments, Inc., model 2100) was used on three occasions to estimate flows through each of the culverts. Velocity measurements were made near a low slack tide, a high slack tide, and on the ebb that was close to high slack. Due to the staff shortage and time constraints, only the ebb flow estimates occurred while we were monitoring the fyke nets. The other two readings took place after the fyke nets were removed at the end of the monitoring period. Results from the limited data gathered suggest culverts 2 through 6 had similar flows, and that culvert 1 averaged a little over 10 cfs less than the others (Table 4-4). Flows through the culverts were twice as high during low tide than high tide.

FIGURE 4–7

The total number of unmarked, color marked, and VAMP salmon caught by culvert. The total catch per culvert was adjusted for missing samples.

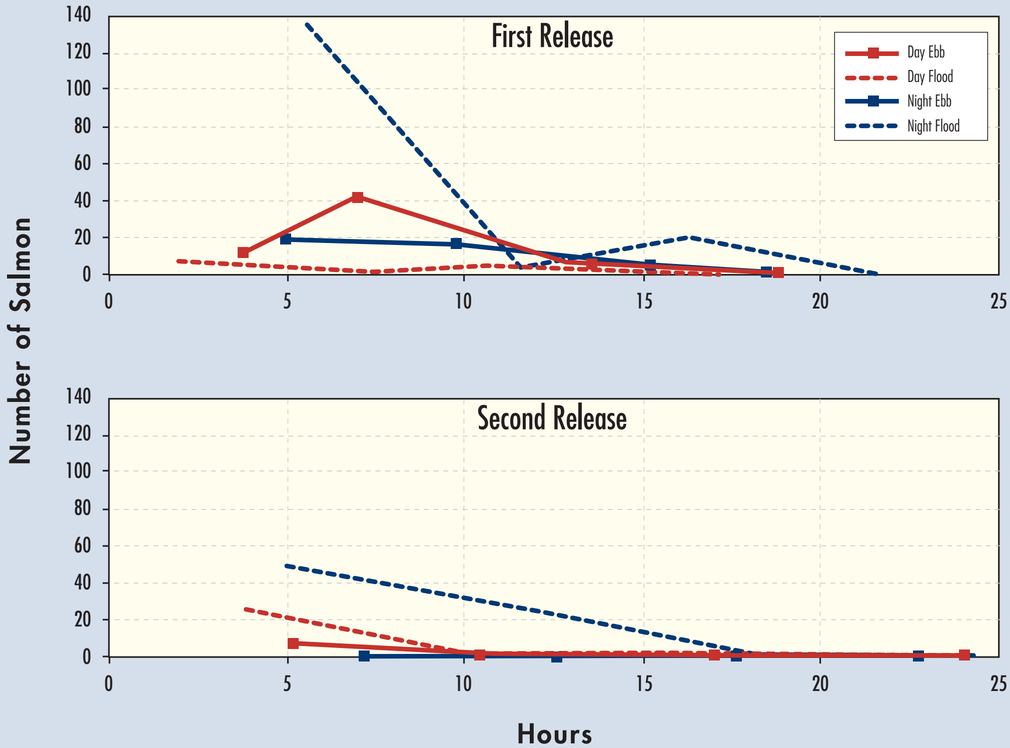


FIGURE 4–8

The total number of unmarked, color marked,and VAMP salmon caught by culvert. The total catch per culvert was adjusted for missing samples.

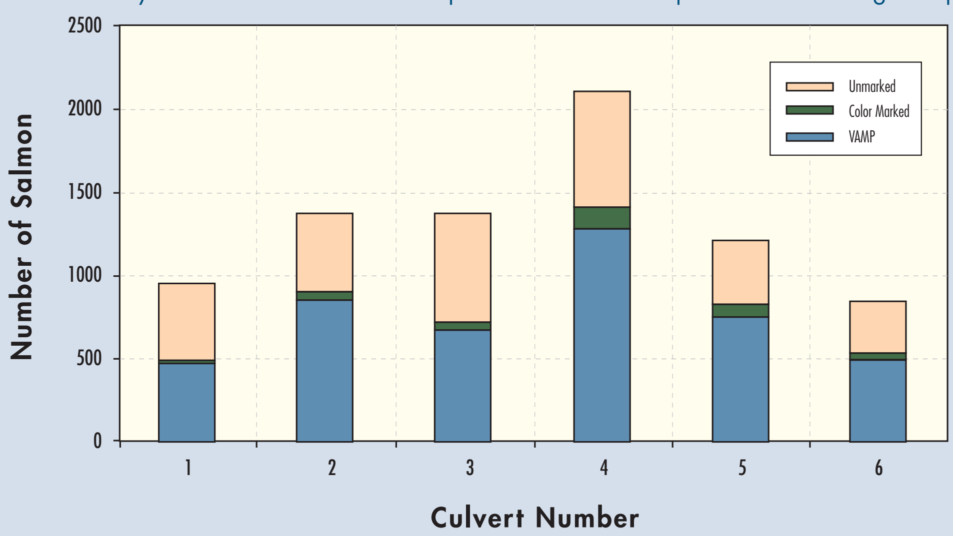


TABLE 4–4

The percentage of the VAMP salmon entrained, by culvert, for various diel and tidal stage combinations (top); and the average flow per culvert taken on three separate occasions (bottom).

ENTRAINMENT (PERCENT)								
DAY/ NIGHT	TIDE	Culvert Number						TOTAL
		1	2	3	4	5	6	
Day	Flood	8	18	13	38	11	12	100
Day	Ebb	7	3	6	46	28	9	100
Night	Flood	8	20	16	24	19	13	100
Night	Ebb	17	21	15	28	12	6	100
Wtd. Avg.		10	19	15	29	17	11	100
WATER FLOW (CFS)								
DATE	TIDE	Culvert Number						AVERAGE
		1	2	3	4	5	6	
May 16	High Slack	34	42	46	43	42	44	42
May 15	Ebb	48	55	57	53	63	58	56
May 07	Low Slack	70	92	88	92	91	90	87

Discussion

Despite a staff shortage and some sampling difficulties, the DFG successfully monitored fish entrainment at the HORB. Although the culvert monitoring duration increased 38% over 2001, the amount of fish entrained tripled. The increased catch was due primarily to Chinook salmon, white catfish and threadfin shad (*Dorosoma petensense*) which together comprised 93% of the total entrainment. The higher salmon entrainment this year could be due, in part, to less accumulation of debris in front of the culverts; the lower VAMP flows on the San Joaquin River which results in a higher proportion of the river flowing through the culverts; other environmental factors; and factors related to the barrier configuration and operation which may affect the hydraulics surrounding the barrier.

Similarly, the loss indices for the VAMP salmon were higher this year than in previous years. The loss indices within the two 2002 VAMP salmon releases varied. The loss indices for the first VAMP salmon release at Durham Ferry and Mossdale were similar. The loss indices for the second VAMP release were considerably different. The second Durham Ferry salmon release had a low loss index (1.0%) whereas the second Mossdale release, the following day, had a relatively high loss index (2.3%). The low loss index of the second Durham Ferry release was due to the low entrainment of salmon on the night of their release. In contrast, most of the entrained Mossdale salmon were caught the night of their release and they had a relatively high loss index. Typically, VAMP salmon entrainment is highest the night of their release.

The difference in the second VAMP loss indices could be due to slightly different salmon migration routes down the San Joaquin River, differential mortality, temporary debris obstruction of the culverts, and a combination of other environmental and behavioral factors. The majority of the Durham Ferry salmon could have migrated down the center or far side of the channel and avoided the HORB, and the Mossdale fish could have migrated closer to the HORB and were entrained. However, the Mossdale Kodiak Trawl (MKT) results indicate a similar catch trend between releases that was observed at the HORB. The MKT samples for fish in the middle of the San Joaquin River, just upstream of the HORB. The MKT only caught 250 VAMP salmon from the second Durham Ferry release compared to 573 salmon from the first release. The MKT caught more Mossdale VAMP salmon from the second release (41) compared to the first release (24). The MKT data suggests the lower loss indices at the HORB could be reflective of fewer salmon migrating pass the barrier. It is possible the second Durham Ferry released salmon experienced a high rate of mortality before reaching the HORB. The potential source of mortality affecting the second release group is unknown.

In contrast with the loss indices at the HORB, survival estimates from Chipps Island and Antioch (Chapter 5) suggest the second VAMP salmon release at Durham Ferry had a slightly higher survival than the release at Mossdale. The apparently higher numbers of Mossdale salmon at the HORB did not translate to higher survival through the Delta. In fact, few salmon from the second Durham Ferry and Mossdale releases were recovered at Chipps Island and Antioch indicating overall VAMP salmon survival was poor.

More CWT salmon were caught at night than during the day, and more were caught on the flood than the ebb tide. Both the VAMP salmon and unmarked salmon entrainment was relatively low in the afternoon. The larger catch of VAMP salmon at night could be confounded by their daytime release upstream of the barrier. Due to the timing of the VAMP release and the distance of the release sites from the HORB, most of these fish probably reached the barrier at night.

Tidal stage may effect entrainment. The river stage gage near the HORB on Old River indicated a relatively low tide near dusk during the first VAMP releases. The low tide creates a large head difference between water levels upstream and downstream of the barrier. The amount of water passing through the culverts depends on this head difference. Although the head difference at the HORB was shrinking on the ensuing flood tide after dusk, the CWT salmon approaching the barrier were still experiencing a large head difference. Over the next seven hours, on both nights (the ensuing high tide was still relatively low), entrainment of VAMP salmon was high. During the second VAMP release, the high tides occurred at dusk which resulted in less head difference as the smolts were approaching the barrier. This may have affected the number of smolts entrained at the barrier. Even with this smaller head difference, more smolts were still entrained at night than during the day.

Results from the Entrainment Special Study are similar to last year's Entrainment Special Study results. More color-marked salmon were entrained on a flood tide than on an ebb tide, and more were entrained at night than during the day. Marked salmon were entrained at the highest rate during a night-flood, although a large number of color-marked salmon were entrained on the day-ebb during the first release. As with the VAMP released salmon, more salmon were entrained during the first release than the second release. However, the lower entrainment index for the second release was confounded by some color-marked salmon escaping their live-cages.

Results from the 2002 Entrainment Monitoring Study and the Entrainment Special Study suggest salmon are more vulnerable to entrainment at night and on the flood tide. Even the unmarked salmon entrainment is higher at night than during the day. However, the VAMP salmon releases are not timed to address tidal-diel effects and their daytime releases may confound the diel results. The tidal effects on entrainment are still unclear. Water velocities through the culverts are greatest near a low slack tide which should result in the highest entrainment. This was not always the case. Some of the highest catches occurred during the flood. The changing hydraulics surrounding the barrier as the tide changes effects flows near the culverts which could affect entrainment. Also salmon smolt behavior and relative abundance near the barrier probably plays an important role in entrainment vulnerability.

Overall, the highest salmon entrainment occurred in culvert number 4 and the lowest in culvert numbers 1and 6. In contrast, in 2001, culvert number 6 entrained the most fish and entrainment in each culvert decreased as the culverts got closer to shore. This year, culvert number 4 entrained the most fish, and culvert numbers 1 and 6 entrained the fewest. However, since the remaining culverts had similar flows, the reason for the high entrainment in culvert number 4 and the low entrainment in culvert number 6 is still unclear. The reason for the difference in culvert entrainment this year from last year is also unclear. Lower flows on the San Joaquin River and slight differences in culvert angles could affect the flow through the culvert and thus, entrainment.

Unfortunately, the first VAMP release occurred while the HORB was under construction. A lot of time was wasted and several samples lost due to gravel accumulation in the nets. Future VAMP salmon studies should schedule their salmon releases after the completion of the barrier, typically 5 days after the HORB is "closed". To better address diel affects, VAMP should schedule one of the Mossdale releases for night. A night release, instead of the usual day release, could shed some light on entrainment at the HORB. A more systematic monitoring of flows through the culverts during future VAMP salmon releases would help us understand salmon entrainment as related to tide. Future studies should also assess juvenile Chinook salmon mortality associated with the barrier.

CHAPTER 5 | SALMON SMOLT SURVIVAL INVESTIGATIONS

One of the primary objectives of the VAMP program is to identify the respective roles of San Joaquin River flow, and SWP and CVP export rates with the HORB in place on the survival of juvenile Chinook salmon emigrating from San Joaquin River tributaries. This section describes the methods used in conducting the VAMP 2002 Chinook salmon smolt survival investigations, and presents results of the calculated survival indices and absolute survival estimates for juvenile Chinook salmon during the VAMP 2002 test period. Additional data and information related to the salmon survival investigations are presented in Appendix C.

CODED-WIRE TAGGING

Merced River Hatchery Chinook salmon smolts, released as part of VAMP 2002, were coded-wire tagged (CWT) between March and early April. After the salmon were tagged, they were held in the hatchery for up to 21 days before being released. A sub-sample of the salmon were measured for length and checked for retention of the CWTs a day or two prior to release. The sub-sample was typically comprised of 100 to 300 salmon collected from the top, middle, and bottom of the release group's raceway. Each tag code within a release group was held separately at the hatchery with the exception of the two Durham Ferry releases where each release was made up of four tag codes that were held together in one section of the raceway.

Although tag retention is usually quite high, as a double check on the tag detector, all salmon from the sub-sample that had no tag detected were sacrificed. These sacrificed salmon were dissected to determine whether they contained an un-magnetized tag. A separate sub-sample of 25 salmon was sacrificed from each release group; the tags were removed and read to detect any incorrect tag codes in the raceways. Table 5-1 summarizes results of the CWT retention rate and the estimate of the effective numbers of salmon released to calculate survival indices. Tag retention rates were determined to be similar to last year, with an overall loss rate of 9.5% among all VAMP groups. The tag retention loss rates varied from 0.5% to 15%. It is recommended that this loss rate be reduced for future VAMP studies.

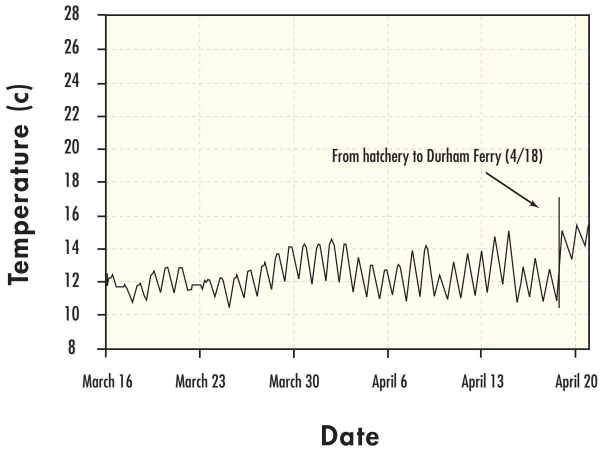
TABLE 5–1

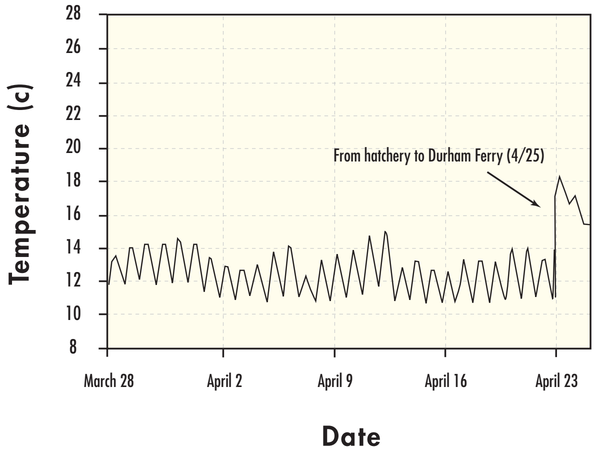
Coded Wire Tag Retention Rates and Effective Release Numbers for Juvenile Salmon Released for VAMP 2002.

RELEASE DATE	TAG CODE	RELEASE SITE	AVERAGE FL (mm)	NUMBER TAGGED	TOTAL LOSS	TAG RETENTION	NUMBER RELEASED	EFFECTIVE RELEASE
April 18	06-44-71	Durham Ferry	83	25,251	123	95.19%	25,128	23,919
April 18	06-44-72	Durham Ferry	83	26,576	129	95.19%	26,447	25,175
April 18	06-44-73	Durham Ferry	83	25,201	123	95.19%	25,078	23,872
April 18	06-44-74	Durham Ferry	83	26,124	127	95.19%	25,997	24,747
April 19	06-44-57	Mossdale	84	25,864	227	99.52%	25,637	25,514
April 19	06-44-58	Mossdale	82	26,301	251	97.01%	26,050	25,271
April 22	06-44-59	Jersey Point	85	25,793	262	97.14%	25,531	24,801
April 22	06-44-60	Jersey Point	83	25,339	269	96.24%	25,070	24,127
April 25	06-44-70	Durham Ferry	80	25,969	138	95.54%	25,831	24,679
April 25	06-44-75	Durham Ferry	80	25,947	138	95.54%	25,809	24,658
April 25	06-44-76	Durham Ferry	80	26,078	139	95.54%	25,939	24,782
April 25	06-44-77	Durham Ferry	80	25,654	136	95.54%	25,518	24,380
April 26	06-44-78	Mossdale	79	26,357	281	94.03%	26,076	24,519
April 26	06-44-79	Mossdale	81	25,977	261	96.52%	25,716	24,821
April 30	06-44-80	Jersey Point	82	25,328	295	96.00%	25,033	24,032
April 30	06-44-81	Jersey Point	82	25,483	289	90.82%	25,194	22,881

FIGURE 5–1

Results of Water Temperature Monitoring at the Merced River Fish Hatchery.





CWT RELEASES

Two sets of CWT salmon releases were made as part of the 2002 VAMP experiment. The first set occurred at 1215 hours on April 18 at Durham Ferry, at 1535 hours on April 19 at Mossdale and at 1010 hours on April 22 at Jersey Point. The second set of releases was made at Durham Ferry at 1050 hours on April 25, Mossdale at 1620 hours on April 26, and Jersey Point at 1535 hours on April 30.

Approximately 100,000 salmon, in four distinct tag lots of about 25,000 fish, were released at Durham Ferry, while approximately 50,000 fish, in two tag lots, were used at each Mossdale and Jersey Point release (Table 5-1). Prior to VAMP 2000, each release was made such that all tag lots were trucked from the hatchery mixed and released as a single group. However, during VAMP 2000, 2001 and 2002, a new transport trailer with three tanks allowed each separate CWT lot to be transported to its release site in a separate tank and distinctly released. As mentioned earlier, the four tag lots comprising each of the groups released at Durham Ferry were already mixed at the hatchery and were therefore transported in a large single tank release truck. This year both Durham Ferry releases were made from the more desirable location alongside the river, instead of from the top of the levee. The nearby agricultural diversion was turned off from the time of the releases until several hours after the release to allow the tagged salmon time to disperse from the release site.

Releases at Jersey Point were made at the beginning of the flood tide to increase dispersion of the tagged fish before they passed Antioch and Chipps Island. Releases at Mossdale and Durham Ferry were not made on any specific tidal condition.

The water temperature both in the hatchery truck and in the receiving waters was measured at the release site immediately prior to release. These, as well as additional release and recovery data, are provided in Table 5-2.

WATER TEMPERATURE MONITORING

Water temperature was monitored during the VAMP 2002 study using individual computerized temperature recorders (e.g., Onset Stowaway Temperature Monitoring/Data Loggers). The water temperature was 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). Water temperature was recorded at 24-minute intervals throughout the period of the VAMP 2002 investigations. Water temperature was also recorded within the hatchery raceways at the Merced River Hatchery coincident with the period when juvenile Chinook salmon were being tagged.

Results of water temperature monitoring within the Merced River Hatchery showed that juvenile Chinook salmon were reared in and acclimated to water temperatures of approximately 11-14 C (52- 57F) prior to release into the lower San Joaquin River Figure 5-1. Results of water temperature monitoring at Durham Ferry, Mossdale, and Jersey Point following the first and second sets of VAMP 2002 releases are compared in Figures 5-2, 5-3, and 5-4. Results of water temperature monitoring showed that water temperatures at the release locations and throughout the lower San Joaquin River and delta (Appendix C-2) were higher than those at the hatchery. Water temperatures measured within the lower San Joaquin River and delta were not expected to result in mortality or adverse effects to emigrating juvenile Chinook salmon released as part of the VAMP 2002 investigations.

TABLE 5–2

Release and Recovery Information for Coded Wire Tag Groups Released for VAMP 2002.

TAG CODE	RELEASE SITE	DATE	TRUCK TEMP F°	RIVER TEMP F°	NUMBER RELEASED	AVG. SIZE (mm)	NUMBER RECOVERED AT ANTIOCH	PERCENT SAMPLED AT ANTIOCH	SURVIVAL INDEX AT ANTIOCH	GROUP INDEX AT ANTIOCH
06-44-71	Durham Ferry		54.5	59	23,919	83	11	0.391	0.085	
06-44-72	Durham Ferry		54.5	59	25,175	83	20	0.391	0.146	
06-44-73	Durham Ferry		54.5	59	23,872	83	12	0.391	0.093	
06-44-74	Durham Ferry		54.5	59	24,747	83	20	0.391	0.149	
Total		April 18			97,713		63	0.391		0.119
06-44-57	Mossdale		55.4	57.2	25,514	84	13	0.388	0.095	
06-44-58	Mossdale		55.4	51.8	25,271	82	29	0.388	0.213	
Total		April 19			50,785		42	0.388		0.153
06-44-59	Jersey Point		59	64.4	24,801	85	101	0.387	0.758	
06-44-60	Jersey Point		59	64.4	24,127	83	89	0.386	0.688	
Total		April 22			48,928		190	0.386		0.724
06-44-70	Durham Ferry		60.8	62.6	24,679	80	6	0.399	0.044	
06-44-75	Durham Ferry		60.8	62.6	24,658	80	2	0.384	0.015	
06-44-76	Durham Ferry		60.8	62.6	24,782	80	4	0.382	0.030	
06-44-77	Durham Ferry		60.8	62.6	24,380	80	6	0.392	0.045	
Total		April 25			98,499		18	0.398		0.033
06-44-78	Mossdale		55.4	63.5	24,519	79	3	0.399	0.022	
06-44-79	Mossdale		55.4	63.5	24,821	81	4	0.400	0.029	
Total		April 26			49,340		7	0.400		0.026
06-44-80	Jersey Point		52.7	63.5	24,032	82	43	0.399	0.323	
06-44-81	Jersey Point		52.7	63.5	22,881	82	32	0.398	0.253	
Total		April 30			46,913		75	0.398		0.289

FIGURE 5–2

Water Temperature Monitoring Results at Durham Ferry.

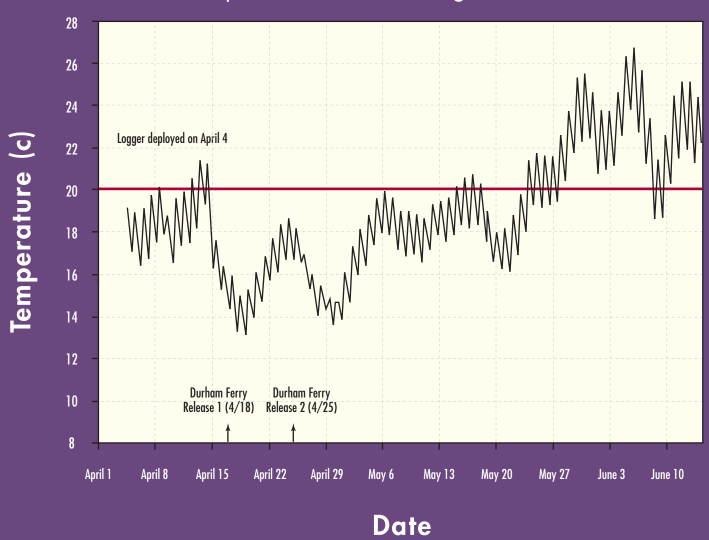
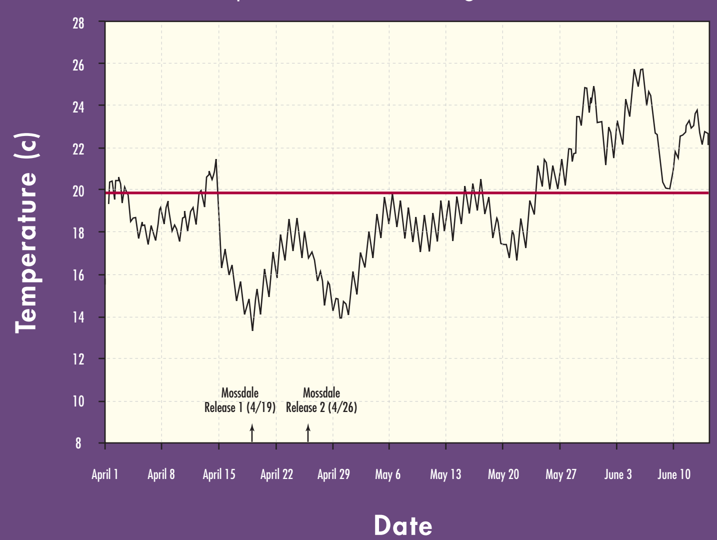


FIGURE 5–3

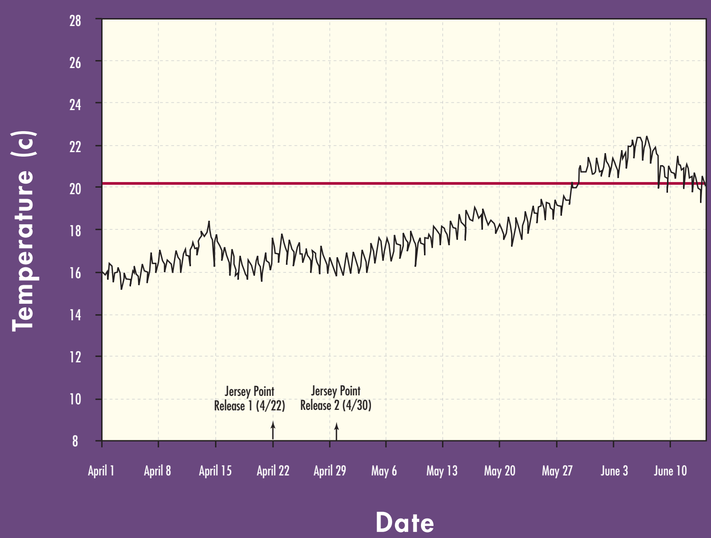
Water Temperature Monitoring Results at Mossdale.



NUMBER RECOVERED AT CHIPPS	PERCENT SAMPLED AT CHIPPS	SURVIVAL INDEX AT CHIPPS	GROUP INDEX AT CHIPPS	EXPANDED SALVAGE CVP	EXPANDED SALVAGE SWP	ABSOLUTE SURVIVAL ANTIOCH	ABSOLUTE SURVIVAL CHIPPS ISLAND	ABSOLUTE DF-MD SURVIVAL ANTIOCH	ABSOLUTE DF-MD SURVIVAL CHIPPS
4	0.277	0.078		12	12				
9	0.264	0.176		60	36				
4	0.273	0.080		0	27				
4	0.278	0.076		24	36				
21	0.265		0.105			0.16	0.13	0.77	0.86
6	0.272	0.112		24	90				
7	0.273	0.132		72	48				
13	0.273		0.122			0.21	0.15		
46	0.273	0.882		0	12				
37	0.266	0.132		24	12				
83	0.266		0.830						
3	0.273	0.058		36	6				
5	0.259	0.102		0	24				
3	0.275	0.057		24	25				
4	0.266	0.080		24	36				
15	0.257		0.077			0.11	0.16	1.2	1.5
2	0.273	0.039		12	93				
3	0.260	0.060		0	24				
5	0.260		0.051			0.09	0.11		
18	0.265	0.367		0	0				
28	0.270	0.589		0	0				
46	0.265		0.480						

FIGURE 5–4

Water Temperature Monitoring Results at Jersey Point.



POST-RELEASE-LIVE-CAR STUDIES

Survival and Condition

The post-release survival and condition of marked salmon was evaluated as part of the VAMP program using sub-samples of marked salmon from each release group. Approximately 200 salmon from each tag code were held at the respective release site in net pens for 48 hours after release and were evaluated for overall short-term mortality which might be associated with the handling, transport and release process. In addition to the 200 salmon held for 48 hours, 25 salmon from each tag code were evaluated for condition immediately after release. Another 25 salmon were held and evaluated using the same condition parameters after the 48-hour holding period. The remaining salmon were measured, weighed and sacrificed for further coded wire tag verification if necessary. Due to the mixed tag codes in the Durham Ferry releases two net pens with approximately 200 fish each were held in order to maintain consistency with the other net pen studies. To assess overall condition, fork length in millimeters, weight in grams, and six other characteristics as described in Table 5-3 were examined. Obvious abnormalities or deformities were also noted.

Results of the evaluations of marked fish in the net pens, both immediately after release and 48 hours later, showed few abnormalities in the condition assessed characteristics, and are shown in Appendix C-3. Scale loss ranged from 1-40% and averaged 5.7%. All fish examined were noted to have normal coloration, no fin hemorrhaging, normal eye characteristics and normal gill color. Of the 1,433 salmon assessed, four (0.3%) were found to have a poor or incomplete fin clip. A total of three fish had some type of deformity, two of which had eroded pectoral fins (not uncommon for hatchery raised fish) and one that had a partial operculum. The percentage of salmon deformed within the sample group (0.2%) was within the normal range for hatchery-raised fish.

Out of 2301 fish examined as part of this year' VAMP net pen experiments, no mortalities were observed.

Tag Quality Control

The subset of 25 salmon from each tag group (a total of 25 from each of the Durham Ferry net pens) evaluated for condition as described above were sacrificed to verify purity of tag codes. The additional 200+ fish from each release that were held were archived in a freezer. Though rare, on few occasions in the past, salmon from different release groups have been mixed at some point prior to release. While performing quality control checks on the April 18 Durham Ferry releases, one errant tag code was discovered. A total of 201 tags were read to verify tag code purity. After reading all tags, it was determined that the apparent error was likely the result of tags being lost and found, and not reported as lost, in the lab. All remaining fish will be held for a period to allow tag processing for further evaluation if necessary.

Physiology

Physiological studies were conducted on samples of the juvenile salmon used in the VAMP study by the California-Nevada Fish Health Center (Nichols and Foot 2002). These results are summarized below.

Physiological tests were conducted on a subset of the smolts released at Durham Ferry, Mossdale and Jersey Point at the hatchery before transport to the release site and after they had been

TABLE 5–3
Smolt Condition Characteristics

	NORMAL	ABNORMAL
Eyes	Normally shaped	Bulging
Color	High contrast dark dorsal surface and light sides	Low contrast dorsal surface and sides, coppery color
Fin Hemorrhaging	No blood or red at base of fins	Blood at base of fins
Percent Scale Loss	Lower relative numbers better based on 0-100% scale loss	Higher relative numbers worse based on 0-100% scale loss
Gill Color	Dark beet red to cherry red gill filaments	Light red to gray gill filaments
Vigor	Active swimming (prior to anesthesia)	Lethargic or motionless (prior to anesthesia)

held in the live cars for approximately 24 hours. At the hatchery, 144 fish were examined for virus, systemic bacteria, gill ATPase activity, blood hematocrit value, plasma total protein concentration, plasma chloride concentration, external and internal signs of disease, and other abnormalities. From live cars, a total of 216 fish were assessed for gill ATPase activity, plasma total protein concentration, plasma chloride concentration, internal and external abnormalities, and *Tetracapsula bryosalmonae* (*Tb*) prevalence of infection. No bacterial or viral pathogens were detected in any of the fish examined. Overall 93 of 201 (46%) of fish examined were infected with the kidney parasite *Tb*, the myxosporean causing Proliferative Kidney Disease (PKD). Infection rates ranged from 29% to 70% among individual release groups with 99% of infected fish in the early stage of PKD (Clifton-Hadley et. al. 1987). This stage was characterized by the initial invasion of the kidney blood sinuses by the parasite and minor inflammatory changes. No evidence of anemia was seen in the blood hematocrit values from any of the live car groups but the disease may progress even after the fish enter salt water (Hedrick and Aronstien 1987) and PKD related anemia could arise weeks after release.

Gill Na+/K+-ATPase activity levels were similar among and between hatchery and live car groups. There was no significant change in the 1-6 days between hatchery and 24-hour post-release samples. All sample groups demonstrated elevated gill ATPase activity consistent with salmon in an advanced stage of smoltification.

Plasma total protein concentrations of some individual fish were slightly elevated, although no protein values were outside of normal ranges for juvenile Chinook. Elevated plasma protein values would not necessarily indicate reduced survival for the affected fish. Possible reasons for this site effect include variations in time since last feeding (mild starvation), differences in transport, or site-specific water quality.

Results of the evaluations of marked fish in the net pens, both immediately after release and 48 hours later, showed ***FEW*** *abnormalities in the condition assessed characteristics.*

Plasma chloride values further supported the "stress event" observed in the hatchery total protein values. All live car groups had depressed plasma chloride values relative to baseline hatchery values ($p<0.001$, t-test) indicating they were under stress probably due to sampling. Hatchery fish were dip-netted directly from the raceway and quickly euthanized, while capture from the live car took longer. Even with this added stress of sampling, plasma chloride values of live car groups remained within the normal range for juvenile salmonids.

In summary, all 6 release groups were in good health and at a similar state of smolt development when sampled at the hatchery and 24-hours post-release. No biologically significant differences were observed in pathogen infections, gill Na+/K+-ATPase activities, or blood chemistry values. Early infections of *Tb* were common, with clinical signs of Proliferative Kidney Disease (PKD) in only 1% of fish examined. Short-term survival of all groups was not likely to be impacted by their health. Health problems resulting from PKD (e.g. anemia) could have arisen several weeks post-release but are not discussed in this part of the report.

CWT RECOVERY EFFORTS

CWT salmon were recaptured at Antioch and Chipps Island, at CVP and SWP fish salvage facilities and during sampling at upper Old River near the barrier (See Figure 1-1) CWT salmon released upstream of, and at, Mossdale were also recovered in DFG Kodiak trawls at Mossdale but are not discussed in this part of the report. Juvenile Chinook salmon with an adipose fin clip (which identifies CWT salmon) caught at any of these sampling locations were sacrificed, labeled, and frozen pending CWT processing. Coded-wire tag processing was done by USFWS (Stockton) for fish recovered at Chipps Island, Antioch, and SWP/CVP salvage facilities. DFG Bay Delta Branch and Region IV assisted in processing the fish captured at the HORB fyke nets.

Coded wire tag processing entails dissecting each tagged fish to obtain the half (0.5 millimeter) or full (1 millimeter) cylindrical tag from the snout. Tags are then placed under a dissecting microscope and the numbers are read and recorded in a database. Tags were read twice, with any discrepancies resolved by a third reader. All tags are archived for future reference. It should be noted that many tags recovered at Chipps Island, Antioch, SWP/CVP salvage, and other locations are from coded wire tag releases not affiliated with VAMP. Since it is unknown until after reading the tag, which tags are from the VAMP study, all tags recovered are read.

SWP/CVP Salvage Recapture Sampling

Sampling at the CVP and SWP fish salvage facilities was conducted approximately every two hours. The number of marked salmon collected (raw salvage) was "expanded" based on the number of minutes sampled during each two hour time period. The estimated expanded total number of CWT salmon, from each release group, was obtained by adding together the expanded number of each tag group for all time periods. Only the CWT salmon recovered in the raw salvage collections were sacrificed for tag decoding. Expanded salvage is only a portion of the direct loss experienced by juvenile salmon at the facilities as it does not include losses prior to, and associated with, pre-screen predation, screening, handling and trucking.

Expanded CVP and SWP salvage estimates of marked salmon released as part of the VAMP 2002 studies are shown in Table 5-2. Salvage numbers at both the CVP and SWP were higher in 2002 than in 2001 but continued to be lower than salvage numbers in years without the HORB installed. It is likely that the smolts migrated to the CVP and SWP via Turner or Columbia Cuts, river junctions off the San Joaquin River downstream of the head of Old River.

Antioch Recapture Sampling

Fishery sampling was conducted in the vicinity of Antioch on the lower San Joaquin River using a Kodiak trawl. The Kodiak trawl has a graded stretch mesh, from 2-inch mesh at the mouth to 1/2-inch mesh at the cod-end. Its overall length is 65 feet, and the mouth opening is six feet deep and 25 feet wide. The net was towed between two skiffs, sampling in an upstream direction. Trawls were performed parallel to the left bank, mid-channel, and right bank to sample CWT salmon emigrating from the San Joaquin River. Each sample was approximately 20 minutes in duration.

All fish collected were transferred immediately from the Kodiak trawl to buckets filled with river water, where the fish were held during processing. Data collected during each trawl included fish identification, measuring the fork length of fish collected, tow start time, duration and location in the channel. Mortality and damage to fish collected was documented to comply with the Endangered Species Act permit requirements.

Juvenile Chinook salmon with an adipose fin clip were retained for later CWT processing while unmarked salmon, steelhead, delta smelt, splittail, and other fish were released at a location downstream of the sampling site immediately after identification, enumeration and measurement.

Sampling at Antioch was initiated April 4 and continued through May 15. Each day between 5:00 a.m. and 9:00 p.m., anywhere from 8 to 31, 20-minute tows were conducted. All told, 1,088 Kodiak trawl samples were collected, representing a total sampling duration of 21,582 minutes. During the sampling, a total of 6,134 unmarked juvenile Chinook salmon and 1,822 salmon with an adipose fin clip (CWT) were collected. In addition, 963 Delta smelt, 195 splittail, and 50 unmarked steelhead, and 52 adipose-clipped steelhead were caught in the sampling.

Chipps Island Recapture Sampling

As part of VAMP recovery efforts at Chipps Island, trawling shifts were conducted twice daily between April 4 and May 28, once daily from May 29 to June 8, and once daily Monday through Friday from June 9 through the end of the month. The first shift was begun just before dawn, while the second shift ended at or after sunset in order to incorporate the crepuscular periods of Chinook movement. It is hypothesized, based on an analysis of salmon smolts caught during twenty-four hour sampling at Jersey Point in 1997, that a greater number of salmon would be caught around dawn and dusk. Both targeting this crepuscular period and doubling the total trawl effort at Chipps Island were intended to increase the numbers of CWT salmon recaptured and reduce the variability in VAMP survival indices. This second shift has been conducted during the spring releases since 1998.

The trawl at Chipps Island was towed at the surface using a net with a mouth opening 10 feet deep by 30 feet wide, with a total net length of 82 feet. Aluminum hydrofoils were used on the top bridles and steel depressors along with a weighted lead line were used on the bottom bridles to keep the mouth of the net open. The net was variable mesh net starting with 4-inch mesh at the mouth and ending with a 1/4 inch cod end.


CALIFORNIA

To sample across the channel, trawling at Chipps Island was conducted in three distinct lanes, one each in the north, south and middle of the channel. Each lane was generally sampled at least three times per shift, with one lane sampled a fourth time during each shift. This lane was chosen at random or selected by the boat operator based on flow conditions.

Coded wire tagged salmon released as part of the VAMP program were recovered at Chipps Island between April 24 and May 19. A total of 182 VAMP CWT salmon were recovered at Chipps Island. During the April 24 and May 19 VAMP recovery period, a total of 6,463 unmarked salmon, 1164 CWT salmon from other non-VAMP experiments, 165 delta smelt, 360 Sacramento splittail, 15 clipped steelhead, and 15 non-clipped steelhead, were also collected at Chipps Island.

the total number of minutes in the time period. The percent of time sampled for the VAMP 2002 release groups at Chipps Island was about 27 percent, while at Antioch it averaged 39 percent.

Survival indices were calculated for each separate tag code to provide a sense of the variability associated with the overall group survival index. To generate the group survival index, the recovery numbers and release numbers are combined for the tag codes within a release group. This results in a slightly different index than would be generated by taking the mean of the survival indices of the individual tag codes within a group.

The individual and group survival indices to Antioch and Chipps Island of the CWT salmon released as part of VAMP 2002 are shown in Table 5-2. As in past years, survival indices from the release locations to Antioch were sometimes lower than to Chipps Island. It is expected that indices to Antioch would be greater than to Chipps Island since Antioch is closer to the release locations and the percent of time sampled is greater and the channel width is narrower at Antioch. It may be the inherent variability associated with catching the marked fish that sometimes causes more to be caught at Chipps Island.

*Although the survival indices indicated that the first groups released survived at a higher rate than the second group, comparisons using the absolute estimates of survival moderated this **DIFFERENCE**.*

VAMP CHINOOK SALMON CWT SURVIVAL INDICES

Survival indices were calculated for marked salmon released at Durham Ferry, Mossdale, and Jersey Point and recovered at Antioch and Chipps Island. Survival indices were calculated by dividing the number of CWT salmon recovered (R) by the effective number released (E) and multiplying the fraction of time (T) and channel width (W) sampled as shown by the formula (R/E)*T*W. The fraction of the channel width sampled at Chipps Island (0.00769) was the net width (30 feet) divided by an estimate of the channel width (3,900 feet). The fraction of the channel width sampled at Antioch (0.01388) was also based on the net width (25 feet) and an estimate of the channel width (1,800 feet). The fraction of time sampled, at both locations, was calculated based on the number of minutes sampled, between the first and last day of catching each particular tag code or group, divided by

The first and second Durham Ferry releases had survival indices to Antioch of 0.12 and 0.03, respectively. Survival indices to Chipps Island were 0.11 for the first group and 0.08 for the second. While differences between the two groups at Chipps Island did not appear meaningful, those at Antioch did. The individual tag code survival indices at Antioch for the two groups did not overlap and thus there appeared to be a difference in survival between the first and second Durham Ferry groups.

The two Mossdale releases showed similar differences between the first and second releases. The first and second releases had survival indices to Antioch of 0.15 and 0.03 and 0.12 and 0.05 to

Chipps Island, respectively. Again none of the individual tag code survival indices overlapped between groups indicating a real difference between the two groups at both recovery locations.

Similarly, the two Jersey Point groups also appeared to survive at different rates; with the first group surviving at a higher rate than the second. The first group released on April 22 had a survival index to Antioch of 0.72. The second group released on April 30 had an index to Antioch of 0.29. Chipps Island recoveries demonstrated the same apparent difference between groups with the first group having an index of 0.83 and the second group having an index of 0.48.

Why survival was lower for the second groups (releases at Durham Ferry, Mossdale, and Jersey Point), relative to the first groups is unknown. Flow and export conditions were similar for both sets of releases. Water temperatures increased for the releases in the second group, but increases were small and all temperatures at release were below 65 degrees (Table 5-3).

ABSOLUTE CHINOOK SALMON SURVIVAL ESTIMATES AND DIFFERENTIAL COMBINED RECOVERY RATES

More important than the differences in survival indices between sets of releases is the comparison of absolute survival estimates, where the survival indices of the upstream release groups are divided by the survival indices of the downstream groups (recovered at the same location). It is most useful for comparisons between groups, recovery locations and years.

In 2002, we have also used the differential combined recovery rates as an estimate of survival. The combined recovery rate for each release group was obtained by summing the recoveries from Antioch and Chipps Island and dividing by the number released. The differential combined recovery rate was the combined recovery rate of an upstream group relative to the downstream group and is another way to estimate survival between release locations. The differential recovery rate is similar to calculating absolute survival estimates, but does not expand each estimate by the fraction of the time and space sampled. The differential recovery rates and the absolute survival estimates should be similar as 1) the fraction of the time sampled is similar between groups within a recovery location and 2) the fraction of space sampled at each recovery location is a constant. Neither would change the relative differences between groups. However, combining the recovery numbers from Antioch and Chipps Island may result in differences using the two methods in estimating survival.

Variance and standard errors were also calculated for the differential combined recovery rates based on the Delta method provided by Dr. Ken Newman (pers. comm). The differential recovery rates plus or minus two standard errors are roughly equivalent to the 95% confidence intervals. Plus or minus one standard error equates to roughly the 68% confidence intervals. (Ken Newman, personal communication). It is not clear how similar variances, standard errors or confidence intervals could be generated using the absolute survival estimates.

In comparing survival between reaches and replicates the confidence intervals were used to determine if estimates were significantly different. If the 95% confidence intervals overlapped they were not considered statistically different. Differences observed using the lower level of confidence 68% are noted.

The use of absolute survival estimates and differential combined recovery rates are more powerful for use in comparing survival rates, since the use of ratios between upstream and downstream groups theoretically standardizes for differences in catch efficiency between recovery locations and/or years. Both types of estimates of survival have been calculated for VAMP 2002. An additional estimate of absolute survival will be possible from recoveries in the ocean fishery, 2 to 4 years following release.

Although the survival indices indicated that the first groups released survived at a higher rate than the second group, comparisons using the absolute estimates of survival moderated this difference (Table 5-2). Absolute survival between Durham Ferry and Mossdale and Jersey Point was still somewhat higher for the first releases using the Antioch recovery information. Absolute survival for the two sets of releases was similar using the Chipps Island recovery information, but it is uncertain if these differences are significant.

Results using the differential combined recovery rates also indicated the first groups appeared to survive at a higher rate than the second groups, with the first Durham Ferry and Mossdale groups relative to Jersey Point being higher than the second groups (Table 5-4). Estimates of 95% confidence intervals (plus and minus 2 standard errors) indicated differences were not significant at the $p<0.05$ level. The first Mossdale to Jersey Point estimate was greater than the second using the lower level of confidence (68%) (Table 5-4 and Figure 5-5).

One surprise was that the second group released at Durham Ferry appeared to survive at a higher rate than the second group released at Mossdale. This result was shown using both absolute

TABLE 5–4

2002 Smolt Survival Differential Recovery Rates

	REC. AT ANTIOCH	REC. AT CL	# RELEASED	A+C	A+C/R	S DF TO MD	S MD TO JP	S DF TO JP	S DF/MD-JP
Durham Ferry (DF) 1	11	4	23,920	15	0.00062				
	20	9	25,176	29	0.00115				
	12	4	23,872	16	0.00067				
	20	4	24,747	24	0.00096				
Total	63	21	97,715	84	0.00085	0.793			
Mossdale (MD) 1	13	6	25,515	19	0.00074			0.154	
	29	7	25,272	36	0.00142				
Total	42	13	50,787	55	0.00108		0.194		
Jersey Point (JP) 1	101	46	24,802	147	0.00592				
	89	37	24,128	126	0.00522				
Total	190	83	48,930	273	0.00557				
Durham Ferry (DF) 2	6	3	24,680	9	0.00036				
	2	5	24,659	7	0.00028				
	4	3	24,783	7	0.00028				
	6	4	24,381	10	0.00041				
Total	18	15	98,503	33	0.00033	1.377			
Mossdale (MD) 2	3	2	24,519	5	0.00020			0.129	
	4	3	24,820	7	0.00028				
Total	7	5	9,339	12	0.00024		0.094		
Jersey Point (JP) 2	43	18	24,032	61	0.00253				
	32	28	22,880	60	0.00262				
Total	75	46	46,912	121	0.00257				
Combined									
DF (1&2)	81	36	196,218	117	0.00059	0.891			
MD (1&2)	49	18	100,126	67	0.00066		0.162		
JP (1&2)	265	129	95,842	394	0.00411			0.145	
DF/MD (1&2)	130	54	296,344	184	0.00062				0.151

S – Differential Recovery Rate • 1SE – One Standard Error • 2SE – Two Standard Errors

S-2SE	S+2SE	S-1SE	S+1SE
0.518	1.069	0.656	0.931
0.115	0.192	0.134	0.173
0.136	0.251	0.165	0.222
0.448	2.305	0.913	1.841
0.078	0.180	0.104	0.155
0.037	0.151	0.065	0.122
0.618	1.164	0.754	1.027
0.119	0.205	0.141	0.184
0.114	0.175	0.129	0.160
0.124	0.177	0.137	0.164

survival estimates and differential combined recovery rates of the Durham Ferry/Jersey Point groups relative to the Mossdale/Jersey Point groups (Tables 5-2 and 5-4). However, the difference in recovery rates was not significant at either the 68 percent or 95 percent confidence level. Durham Ferry is 11 miles further upstream than Mossdale and is expected to include additional mortality.

Both differential recovery rate estimates of survival between Durham Ferry and Mossdale were not significantly different from each other using either confidence levels (Table 5-4). Thus the differential recovery rates of the two groups were combined and survival between Durham Ferry and Mossdale was estimated at 0.89. These data appear to show that there is substantial variability within recovery rate estimates and that survival was relatively high between the two locations.

In 2000 it did appear that survival was less for groups released at Durham Ferry relative to those released at Mossdale using the absolute survival estimates generated from information at Antioch. This difference led to the recommendation of making releases at both Durham Ferry and Mossdale in future years. When looking at the 2000 data using combined differential recovery rates, the variability was such it was not clear that survival was greater for the Mossdale group. The recovery rate of the first Mossdale group relative to the first Jersey Point group was not significantly different (at the $p<0.05$ level) from the first Durham Ferry group relative to the first Jersey Point group. The same was true for the second set of releases. The first Mossdale/Jersey recovery rate was significantly greater than the second Durham Ferry/Jersey Point group at both levels of significance (Figure 5-6).

In 2001 and 2002 differential recovery rates indicated that survival between Durham Ferry and Jersey Point and Mossdale and Jersey Point was not statistically different ($p<0.05$), thus we can infer survival between Durham Ferry and Mossdale was high in these years. Surprisingly, the survival was higher in 2001 for the first Durham Ferry group relative to the Jersey Point group than the first Mossdale group relative to the Jersey Point group using the lower level of significance (Figure 5-7). It is uncertain how the Durham Ferry groups could survive at a higher rate than the Mossdale groups, but it probably is possible. Continuation of releasing groups at both sites, will allow detection of mortality between Durham Ferry and Mossdale if it does occur and become significant in the future. If survival between locations is shown not to be statistically significant then groups can be combined.

FIGURE 5–5

Differential Recovery Rates of CWT Smolts Released at Mossdale and Jersey Point (MD-JP) and Durham Ferry and Jersey Point (DF-JP) for the First (1) and Second (2) Groups in 2002. The Estimate and Plus and Minus 1 and 2 Standard Error(s) is Provided.

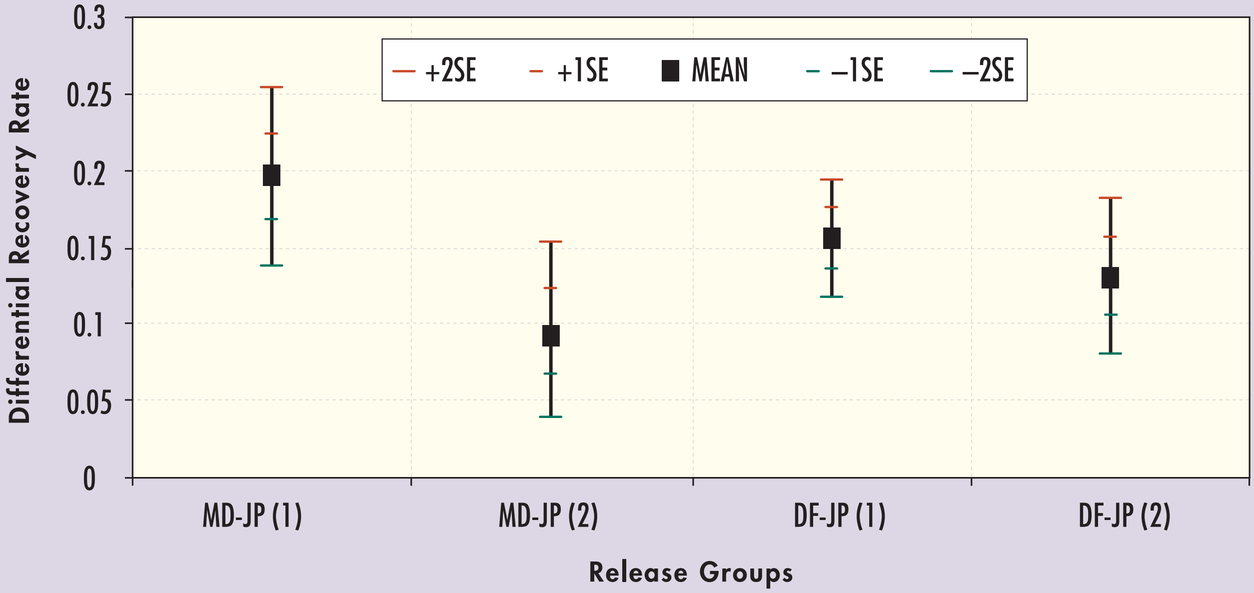
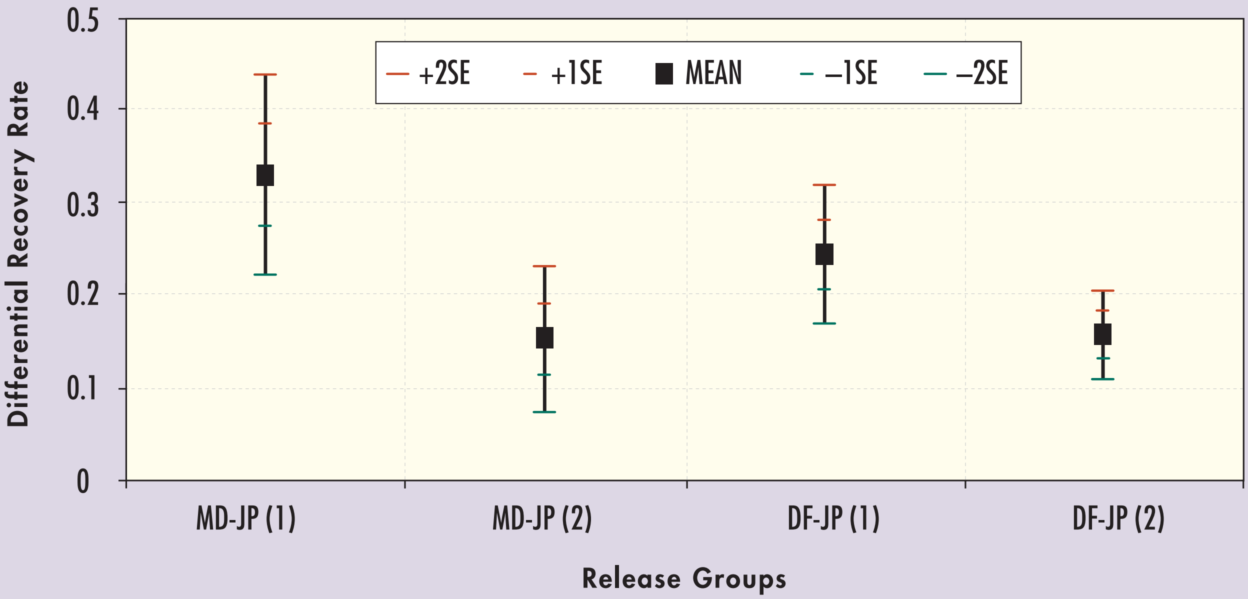


FIGURE 5–6

Differential Recovery Rates of CWT Smolts Released at Mossdale and Jersey Point (MD-JP) and Durham Ferry and Jersey Point (DF-JP) for the First (1) and Second (2) groups in 2000. The Estimate and Plus and Minus 1 and 2 Standard Error(s) is Provided.



In 2002, absolute survival for the Durham Ferry and Mossdale groups relative to the Jersey Point groups ranged between 0.09 and 0.21 and averaged 0.14. Differential recovery rates ranged between 0.09 and 0.19. As mentioned earlier, the combined recovery rates relative to the Jersey Point groups was not significantly different between the Durham Ferry and Mossdale groups using the 95% confidence levels. Thus it may be appropriate to combine these recovery rate estimates. Similarly, if replicates are not statistically different, they could be combined. The confidence intervals around each differential recovery rate provide a means to assess whether groups should be combined.

Differential recovery rates of the first and second Durham Ferry groups relative to the Jersey Point releases were not statistically different. Similarly, differential recovery rates for the first and second Mossdale groups relative to the Jersey Point groups were also not significantly different. (Note the two replicates from Mossdale to Jersey Point were significantly different using a 68% confidence interval.) In addition, the differential recovery rates of the Durham Ferry/Jersey Point estimates were not significantly different than the Mossdale/Jersey Point estimates, thus combined estimates were generated (Table 5-4). The combined Durham Ferry/Mossdale to Jersey Point estimate of survival using the combined differential recovery rates was 0.15 - not much different than the average absolute estimate of survival (0.14).

Similar estimates of differential recovery rates with the 95% confidence intervals were calculated for past VAMP years (2000 and 2001)(Tables 5-5 and 5-6). (Note there was an error in the 2001 Annual Report in reporting these estimates. - They have been recalculated and included in this report.) Differential recovery rate replicates in those years were also not significantly different from each other at the 95 percent confidence level. Thus they were combined into one estimate of recovery rate for the Durham Ferry/Mossdale groups relative to the Jersey Point groups. Some replicates were significantly different at a lower significance level (~68%). For instance, the Mossdale to Jersey Point and Durham Ferry to Jersey Point replicates in 2000 were significantly different at this lower level of significance. In addition, the combined Durham Ferry/Jersey Point estimates were significantly lower than the Mossdale/Jersey Point estimates in 2001 at this lower level of confidence

TRANSIT TIME

Data on transit times for marked salmon from the release to recapture sites during VAMP 2002 is summarized in graphic form in Appendix C-4. CWT salmon released April 18 at Durham Ferry took between 7 and 19 days to arrive at Antioch and 8 to 22 days to arrive at Chipps Island. The April 19th release at Mossdale release took between 6 and 11 days to arrive at Antioch and 7 and

FIGURE 5–7

Differential Recovery Rates of CWT smolts released at Mossdale and Jersey Point (MD-JP) and Durham Ferry and Jersey Point (DF-JP) for the first (1) and second (2) groups in 2001. The estimate and plus and minus 1 and 2 standard error(s) is provided.

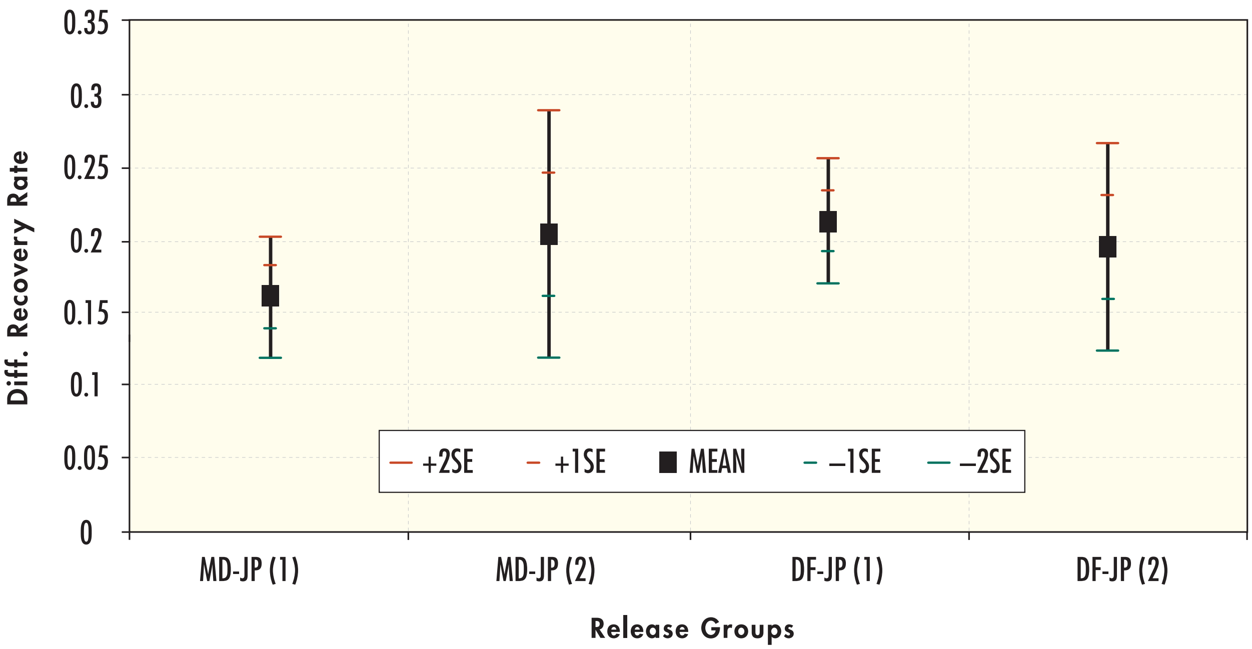


TABLE 5–5

2000 Smolt Survival Differential Recovery Rates

	REC. AT ANTIOCH	REC. AT CL	# RELEASED	A+C	A+C/R	S DF TO MD	S MD TO JP	S DF TO JP	S DF/MD-JP
Durham Ferry (DF) 1	6	7	23,629	13	0.00055				
	10	10	24,177	20	0.00082				
	11	11	24,457	22	0.00089				
Total	27	28	72,263	55	0.00076	0.733			
Mossdale (MD) 1	14	9	23,465	23	0.00098				
	16	9	22,784	25	0.00109				
Total	30	18	46,249	48	0.00103		0.328		
Jersey Point (JP) 1	50	24	25,527	74	0.00289				
	47	41	25,824	88	0.00340				
Total	97	65	51,351	162	0.00315			0.241	
Durham Ferry (DF) 2	8	7	23,698	15	0.00063				
	15	5	26,805	20	0.00074				
	8	10	23,889	18	0.00075				
Total	31	22	74,392	53	0.00071	1.036			
Mossdale (MD) 2	9	7	23,288	16	0.00068		0.150		
Jersey Point (JP) 2	76	48	25,572	124	0.00484				
	76	30	24,661	106	0.00429				
Total	152	78	50,233	230	0.00457			0.155	
Combined									
DF (1&2)	58	50	146,655	108	0.00073	1.066			
MD (1&2)	39	25	69,537	48	0.00069		0.178		
JP (1&2)	249	143	101,584	392	0.00385			0.190	
DF/MD (1&2)	97	75	216,192	156	0.00072				0.186

S – Differential Recovery Rate • 1SE – One Standard Error • 2SE – Two Standard Errors

S-2SE	S+2SE	S-1SE	S+1SE
0.443	1.022	0.588	0.878
0.220	0.437	0.274	0.383
0.166	0.316	0.203	0.278
0.445	1.628	0.741	1.332
0.072	0.227	0.111	0.188
0.108	0.202	0.131	0.179
0.814	1.319	0.940	1.193
0.114	0.243	0.146	0.211
0.149	0.232	0.170	0.211
0.149	0.224	0.168	0.205

17 days to reach Chipps Island. Jersey Point release groups were recovered between 2 and 14 days after release at Antioch and between 2 and 21 days at Chipps Island. The April 25 Durham Ferry release group arrived at Antioch between 7 and 18 days and between 7 and 15 days at Chipps Island. The April 26 release group at Mossdale was recovered at Antioch between 7 and 14 days and between 9 and 19 days at Chipps Island. The second Jersey Point release group was recovered between 1 and 14 days after release at Antioch and 1 and 19 days after release at Chipps Island. The transit time from release location to Antioch and Chipps Island of both sets of releases was similar. It is interesting that the Jersey Point groups were recovered over as long or longer period than those released upstream.

Transit times appeared slower in 2002, than in 2001. In 2001, recovery dates were as early as 4 days after releases were made at Durham Ferry and Mossdale. River flows were lower in 2002 than in 2001 (approximately 3,300 cfs versus 4,200 cfs, respectively), which may have increased travel time in 2002. The number of individual recoveries by tag code and the number of minutes towed per day for both Antioch and Chipps Island recoveries are shown in Appendix C-4.

ROLE OF FLOW AND EXPORTS ON ABSOLUTE SURVIVAL AND RECOVERY RATES

Historically, April–June, San Joaquin River flow and flow relative to exports was correlated to adult escapement in the San Joaquin basin 2 1/2 years later (Figures 5-8 and 5-9). Both relationships are statistically significant ($p<0.01$) with the flow/exports variable accounting for slightly more of the variability than the relationship with flow alone ($r^2= 0.44$ vs. $r^2 = 0.58$, respectively). These relationships appeared to indicate that adult escapement in the San Joaquin basin was affected by the amount of flow in the San Joaquin River and exports from the CVP and SWP during the spring months when the juveniles migrated through the river and Delta to the ocean. VAMP was designed to further define the mechanisms behind this relationship using smolt survival through the Delta and testing lower San Joaquin River flows with the presence of the HORB.

Survival of juvenile Chinook salmon emigrating from the San Joaquin River system has been evaluated within the framework established by the VAMP experimental design since the spring of 2000. Similar and complementary studies in the south delta were conducted prior to the official implementation of VAMP.

TABLE 5–6

2001 Smolt Survival Differential Recovery Rates

	REC. AT ANTIOCH	REC. AT CL	# RELEASED	A+C	A+C/R	S DF TO MD	S MD TO JP	S DF TO JP	S DF/MD-JP
Durham Ferry (DF) 1	28	14	23,354	42	0.00179				
	30	22	22,837	52	0.00227				
	18	17	22,491	35	0.00155				
Total	76	53	68,682	129	0.00187	1.325			
Mossdale (MD) 1	18	17	23,000	35	0.00152				
	15	14	22,177	29	0.00130				
Total	33	31	45,177	64	0.00141		0.159		
Jersey Point (JP) 1	156	50	24,443	206	0.00842				
	173	61	24,992	234	0.00936				
Total	329	111	49,435	440	0.00890			0.211	
Durham Ferry (DF) 2	8	2	24,025	10	0.00041				
	11	5	24,029	16	0.00066				
	10	2	24,177	12	0.00049				
Total	29	9	72,231	38	0.00052	0.958			
Mossdale (MD) 2	8	4	23,878	12	0.00050				
	11	4	25,308	15	0.00059				
Total	19	8	49,186	27	0.00054		0.201		
Jersey Point (JP) 2	43	17	25,909	60	0.00231				
	53	27	25,465	80	0.00314				
Total	96	44	51,374	140	0.00272			0.193	
Combined									
DF (1&2)	105	62	140,913	167	0.00118	1.228			
MD (1&2)	52	39	94,363	91	0.00096		0.167		
JP (1&2)	425	155	100,809	580	0.00575			0.205	
DF/MD (1&2)	157	101	235,276	258	0.00109				0.190

S – Differential Recovery Rate • 1SE – One Standard Error • 2SE – Two Standard Errors

S-2SE	S+2SE	S-1SE	S+1SE
0.920	1.730	1.123	1.528
0.116	0.201	0.137	0.180
0.168	0.253	0.189	0.232
0.476	1.440	0.717	1.199
0.116	0.286	0.159	0.243
0.122	0.263	0.157	0.228
0.908	1.549	1.068	1.388
0.129	0.205	0.148	0.186
0.169	0.242	0.187	0.224
0.162	0.219	0.176	0.204

The differential relative recovery rates of all releases each year were combined as they were not significantly different from each other at the 95 percent confidence level. These combined estimates and their 95 percent confidence intervals for the three years of VAMP releases (2000 - 2002) are shown in relation to the log of the average San Joaquin River flow at Vernalis on Figure 5-10. The average river flow was from the two-10 day periods after release. Data obtained in 1994 and 1997 are added but do not have comparable confidence intervals at this time. The relative recovery rates with the confidence intervals are also shown in comparison to average Vernalis flow/combined exports for the 10 days after release (Figure 5-11). The relationship of relative recovery rate to San Joaquin River flow is improved by incorporating exports. Relationships without the 1994 and 1997 are similar (Figures 5-10 and 5-11). While recovery rates do appear to increase as flows and flows relative to exports increase ($p<0.05$) data points that have confidence intervals around them are not significantly different from each other.

Given the relatively high variability inherent in conducting salmon smolt survival studies within the lower San Joaquin River and Delta, and modeling conducting by Ken Newman (November, 2001) the lack of statistically significant differences between relative recovery rates from similar flow-export conditions was not unexpected. Results of these analysis underscore the importance of collecting salmon smolt survival data under the most extreme flow-export conditions identified as VAMP targets. Flows of 7,000 cfs and exports of 1,500 cfs would provide the highest flow/export ratio (4.7) to test and increase our chances of detecting significant differences in recovery rates between VAMP targets.

THE ROLE OF HORB ON SURVIVAL

The relationship to date between absolute survival between Mossdale and Jersey Point and San Joaquin River flow at Vernalis and exports with and without the barrier in upper Old River is shown in Figure 5-12. Differential recovery rates are not reported since without barrier releases do not have comparable estimates. Replicates of survival estimates within a year measured with the HORB have not been combined as the differential recovery rates were in Figure 5-11. Thus while comparisons can be made between regression lines, variance around each data point is not yet available. Two regression lines have been developed based on survival data with and without the HORB. Statistically neither regression line is significant, although prior to adding the data from 1999, the without barrier relationship was significant. The

FIGURE 5–8

Flow at Vernalis (Mean April 15-June 15) Between 1951-1998 Versus San Joaquin Basin Escapement (2 ½ Years Later).

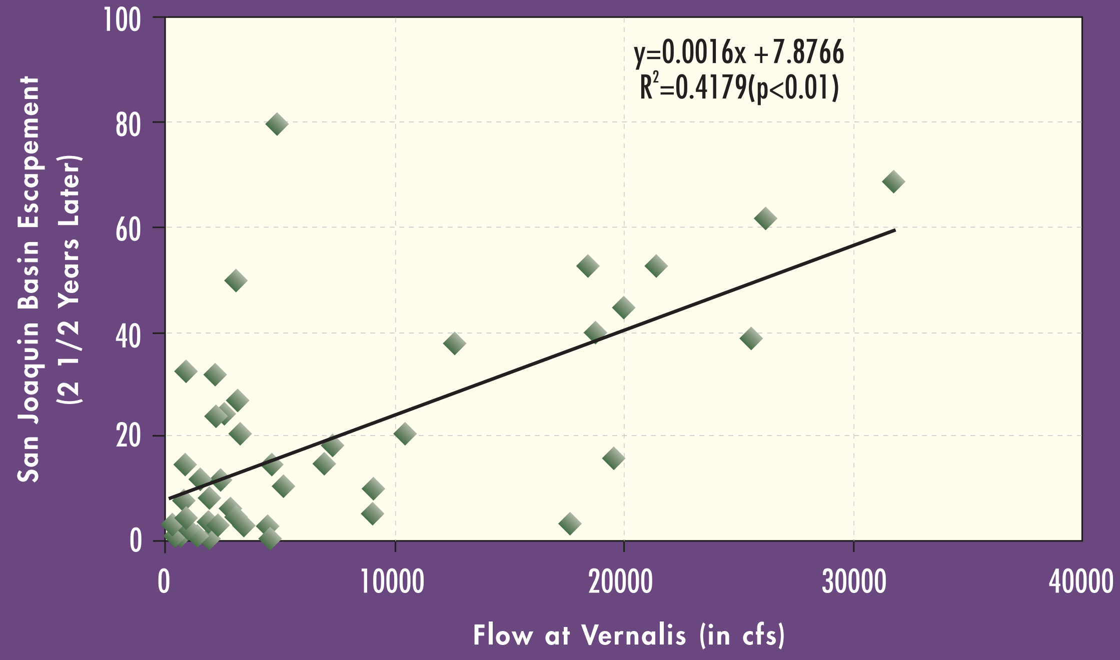


FIGURE 5–9

Mean Spring Flows/Delta Exports (Mean April 15-June 15) Between 1951-1998 and San Joaquin Basin Escapement (2 ½ Years Later).

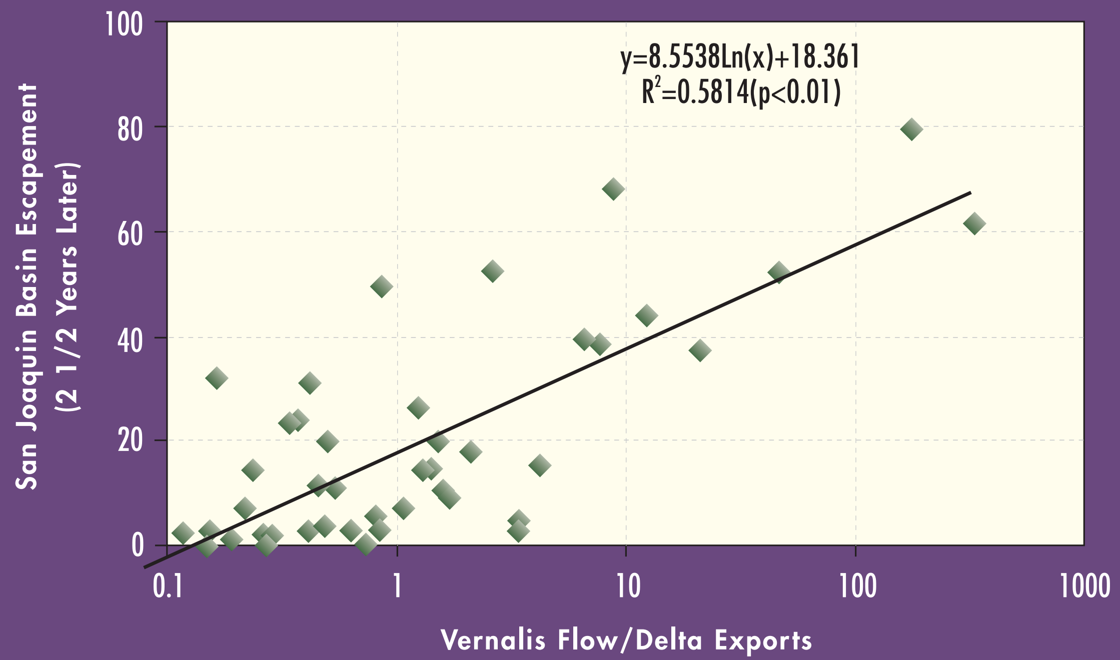


FIGURE 5–10

Survival (Plus and Minus 1 and 2 SE) From Durham Ferry/Mossdale to Jersey Point With HORB in Place Versus Flow at Vernalis, 2000-2002. 2000-2002 Vernalis Flows Were Averaged for Both 10 day Periods After Release. 1994 and 1997 Data are Added but do not Have SE. The Equation Without the 1994 and 1997 Data Added is Similar at $y=0.0621\ln(x) - 0.3445$ ($R^2=0.6371$).

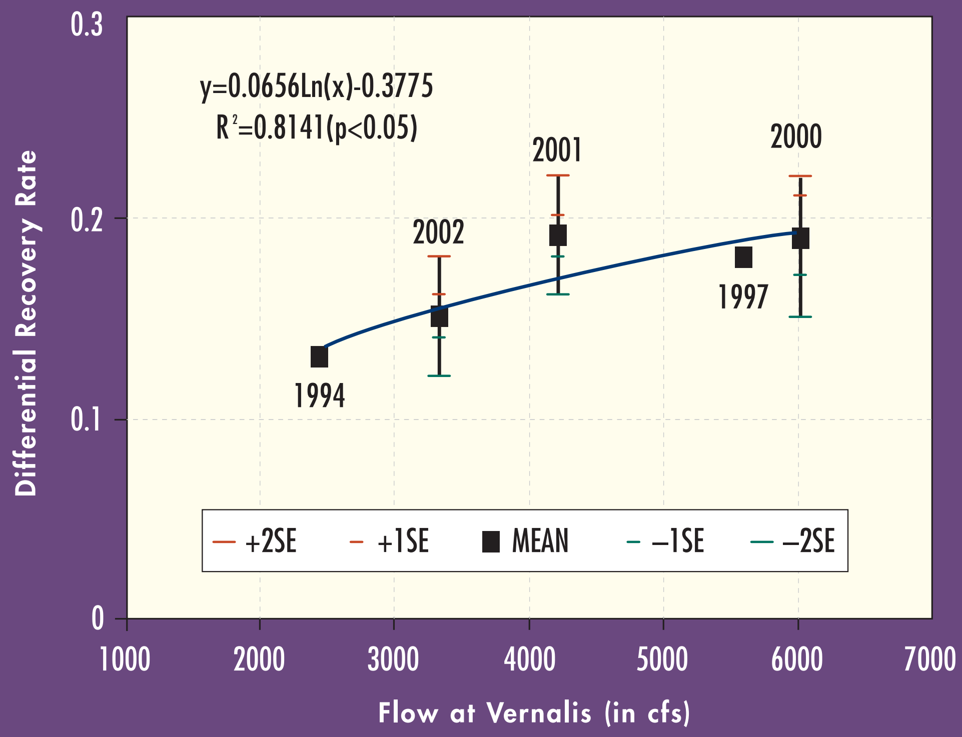
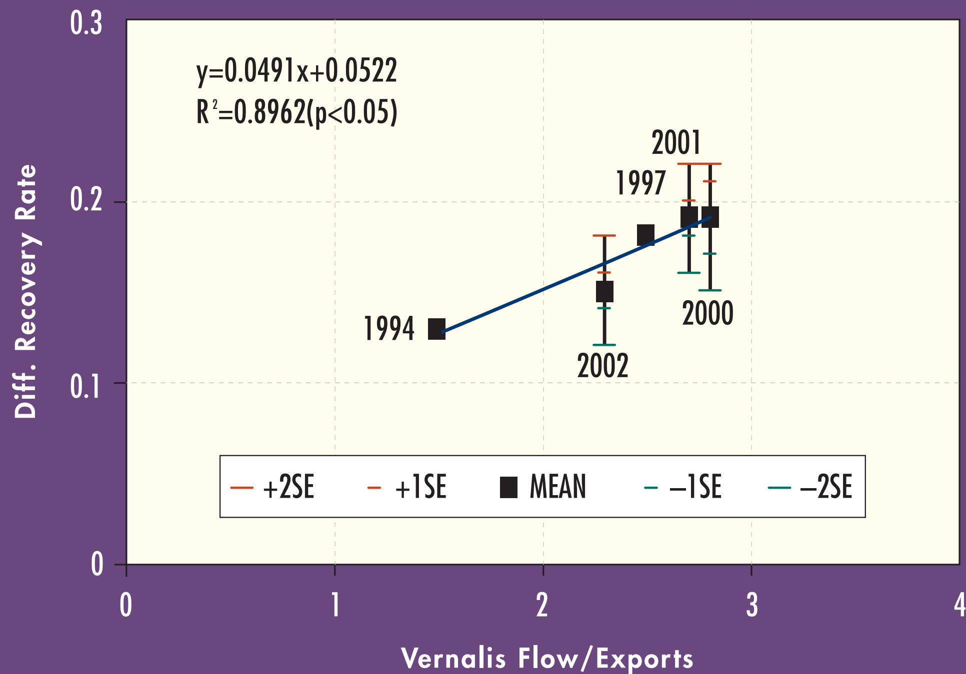


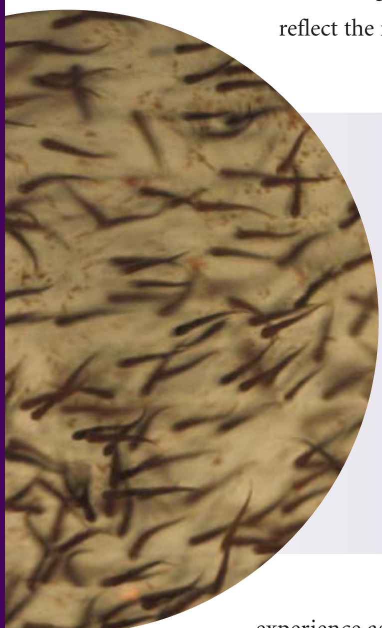
FIGURE 5–11

Survival (Plus and Minus 1 and 2 SE) From Durham Ferry/Mossdale to Jersey Point With HORB in Place, Versus Inflow at Vernalis/exports, Average of Both 10 day Periods After Release, 2000-2002. 1994 and 1997 Data are Added but do not Have SE. The Equation Without 1994 and 1997 is $y=0.0857x - 0.0462$, $R^2=0.9643$.



barrier appears to generally increase survival at any one flow/export level, although the survival was high in 1999 without a barrier. We have hypothesized that data collected in 1999, could be biased high as sampling was interrupted during collection of the downstream control group (Brandes, 2000).

Figure 5-12 shows the relationship between absolute salmon smolt survival and San Joaquin River flow at Vernalis relative to exports with the HORB. A better estimate of flow would be the net flow on the San Joaquin River downstream of upper Old River because of the different permeability of the HORB (culvert operations) over the years. The estimated flow in the San Joaquin River downstream of upper Old River would better reflect the river flow the juvenile salmon experience as they migrate down the San Joaquin River. This estimate has been calculated in past years by subtracting the estimated mean daily flow in upper Old River 840 feet downstream of the barrier from the USGS gaged mean daily flow at Vernalis.



In the five years of measuring survival with the barrier in place, the flow/export ratio has only varied from 1.5 (1994) to 2.9. These are very small differences in TARGET CONDITIONS of which to measure survival.

It appears as exports increase relative to flow, survival (differential recovery rates) decreases. Although the relationship is significant the individual recovery rates are not significantly different from one another. One source of variability that could be reduced is the variable permeability of the HORB within and among years. During the five years the barrier has been installed (and comparable survival studies conducted) the design and permeability has changed. In 1994, the HORB was installed without culverts, while in 1997 the barrier had two open culverts that diverted approximately 300 cfs into upper Old River. In 2000, the HORB had six gated culverts, with two open during the Mossdale and first Durham Ferry release and four open during the second Durham Ferry release. In 2001 and 2002, six culverts were installed and operated throughout the VAMP test period. It is estimated that approximately 400 cfs of San Joaquin River flow moved through the culverts in 2001 and 2002 (Simon Kwan, personal communication). The amount of water flowing through the culverts is based on the head differential between the San Joaquin River and Old River. This changes as flow/stage on the river changes and as the tide changes, even if all 6 culverts remain open for the remaining 9 years of the study. The varying designs and changes in the culvert operations of the barrier add variability to the survival measurements, making it more difficult to detect significant differences between closely related flow/export ratios.

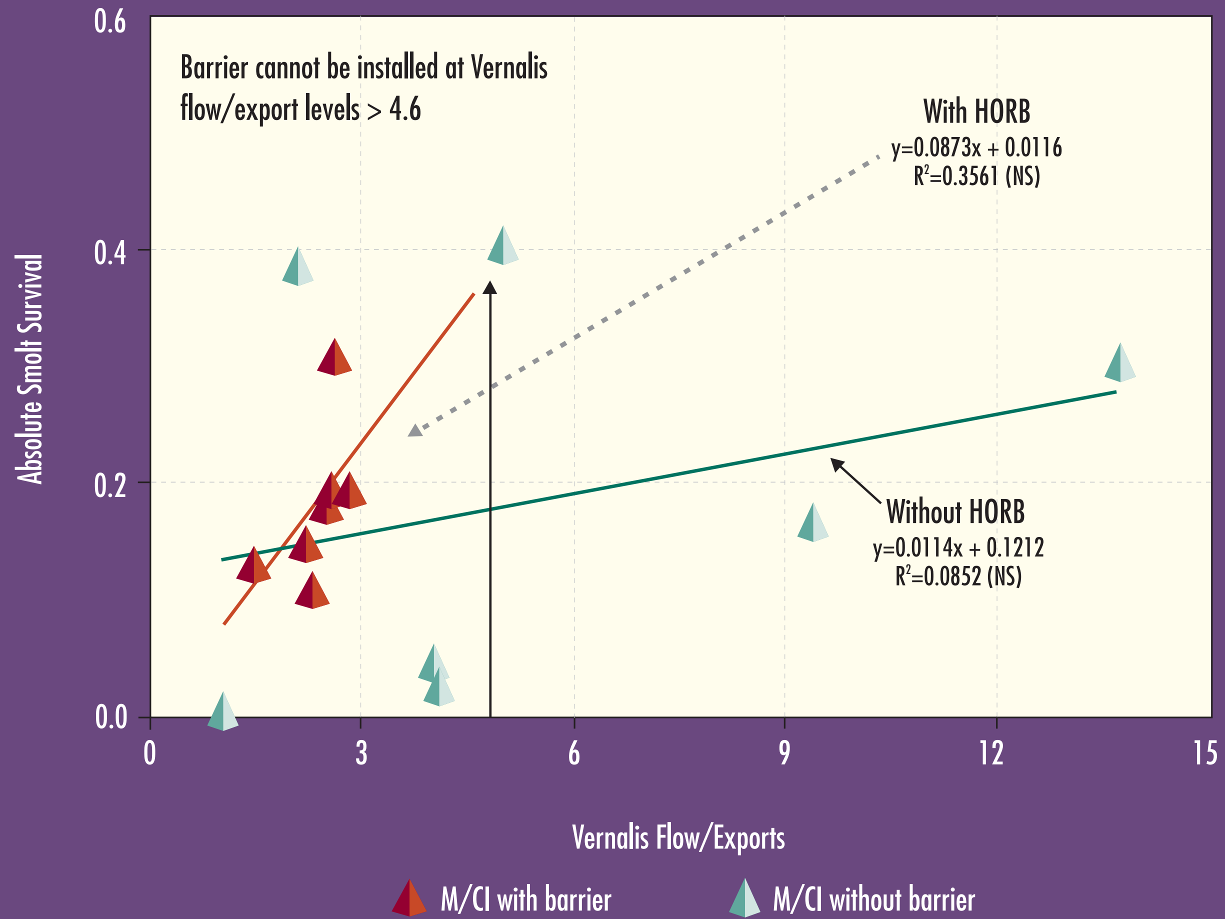
In the five years of measuring survival with the barrier in place, the flow/export ratio has only varied from 1.5 (1994) to 2.9. These are very small differences in target conditions of which to measure survival. The ratios in the relationship between flow/export and adult escapement vary from 0.1 to 1000.

OCEAN RECOVERY INFORMATION FROM RECENT YEARS

Ocean recovery data of CWT salmon groups can contribute to a more complete understanding and evaluation of salmon smolt survival studies. These data can provide another independent estimate of the ratio of survival of a test release group relative to a control release group, or "absolute survival", and can be compared with estimates based on juvenile salmon recoveries at Chipps Island and Antioch. Past recoveries at Jersey Point (1997-1999) can not be compared since the Jersey Point trawling site was located upstream of the Jersey Point release site and a ratio between the upstream and downstream sites can not be generated. Recovery from trawling at Antioch began in 2000. The ocean harvest data may be particularly reliable due to the number of tag recoveries and the extended recovery period.

FIGURE 5–12

Estimates of Survival Versus Vernalis Flow/Exports With and Without a HORB.



Adult 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 2001. The ocean CWT recovery data accumulate over a 1-4 year period following the year a study release is made as nearly all of a given year class of salmon have either been harvested or spawned by age 5. Consequently, these data are essentially complete for releases made through 1996 and 1997 and partially available for CWT releases made from 1998-2000. Once the data for these and later releases are available they will be used to compare the three independent estimates of survival (using Antioch, Chipps Island, and ocean recoveries): based on VAMP releases starting in 2000.

Survival estimates based on ocean recoveries for salmon produced at the Merced River Hatchery, and released as part of south delta survival evaluations from 1996-2000 were compared to survival estimates based on Chipps Island and Antioch recoveries (Table 5-7). Releases over that period were made at several locations: Dos Reis (on the San Joaquin River downstream of the upper Old River junction), Mossdale, Durham Ferry, and Jersey Point. Ocean absolute survival ratios were very similar to those at Chipps Island for the releases made in 1996, and 1999, and 2000 and at Antioch for the Mossdale and second Durham Ferry releases in 2000. Although ocean absolute survival ratios were higher than those to Chipps Island for releases in 1997 and 1998 and to Antioch for the first Durham Ferry release in 2000, they were generally similar (in the mid-range of survival).

Results of this comparative analysis of survival estimates for Chinook salmon produced in the Merced River Hatchery show (1) there is generally good agreement between survival estimates based on juvenile CWT salmon recoveries in Chipps Island and Antioch trawling and adult recoveries from the ocean fishery, (2) survival estimates using Chipps Island or Antioch recoveries were lower in some years than estimates based on ocean recoveries, and (3) additional comparisons need to be made, as more data becomes available from VAMP releases for recoveries at Antioch,

TABLE 5–7

Survival Indices Based on Chipps Island, Antioch and Ocean Recoveries of Merced Hatchery Salmon Released as Part of South Delta Studies Between 1996 and 2000.

RELEASE YEAR	SAN JOAQUIN RIVER *(Merced River Origin)* TAG NO.	RELEASE NUMBER	RELEASE SITE	RELEASE DATE	CHIPPS IS. RECOVS.	ANTIOCH RECOVS.
			Juvenile Salmon CWT Releases			
1996	H61110412	25,633	DOS REIS	MAY 01 '96	2	
	H61110413	28,192	DOS REIS	MAY 01 '96	3	
	H61110414	18,533	DOS REIS	MAY 01 '96	1	
	H61110415	36,037	DOS REIS	MAY 01 '96	5	
	H61110501	53,337	JERSEY PT	MAY 03 '96	39	
	Effective Release	107,961	DOS REIS		11	
	Effective Release	51,737	JERSEY PT		39	
1997	H62545	50,695	DOS REIS	APR 29 '97	9	
	H62546	55,315	DOS REIS	APR 29 '97	7	
	H62547	51,588	JERSEY PT	MAY 02 '97	27	
	Effective Release	106,010	DOS REIS		16	
	Effective Release	51,588	JERSEY PT		27	
	H62548	46,728	DOS REIS	MAY 08 '97	5	
	H62549	47,254	JERSEY PT	MAY 12 '97	18	
1998	61110809	26,465	MOSSDALE	APR 16 '98	25	
	61110810	25,264	MOSSDALE	APR 16 '98	31	
	61110811	25,926	MOSSDALE	APR 16 '98	32	
	61110806	26,215	DOS REIS	APR 17 '98	33	
	61110807	26,366	DOS REIS	APR 17 '98	23	
	61110808	24,792	DOS REIS	APR 17 '98	34	
	61110812	24,598	JERSEY PT	APR 20 '98	87	
	61110813	25,673	JERSEY PT	APR 20 '98	100	
	Effective Release	77,655	MOSSDALE		88	
	Effective Release	77,373	DOS REIS		90	
	Effective Release	50,271	JERSEY PT		187	
1999	064606	25,005	MOSSDALE	APR 20 '99	2	
	062642	24,715	MOSSDALE	APR 19 '99	8	
	062643	24,725	MOSSDALE	APR 19 '99	15	
	062644	25,433	MOSSDALE	APR 19 '99	13	
	062645	25,014	DOS REIS	APR 19 '99	20	
	062646	24,841	DOS REIS	APR 19 '99	19	
	0601110815	24,927	JERSEY PT	APR 21 '99	34	
	062647	24,193	JERSEY PT	APR 21 '99	25	
	Effective Release	99,878	MOSSDALE		38	
	Effective Release	49,855	DOS REIS		39	
	Effective Release	49,120	JERSEY PT		59	
2000	06-45-63	24,457	DURHAM FERRY	APR 17 '00	11	11
	06-04-01	23,529	DURHAM FERRY	APR 17 '00	7	6
	06-04-02	24,177	DURHAM FERRY	APR 17 '00	10	10
	06-44-01	23,465	MOSSDALE	APR 18 '00	9	14
	06-04-02	22,784	MOSSDALE	APR 18 '00	9	16
	06-44-03	25,527	JERSEY PT	APR 20 '00	24	50
	06-04-04	25,824	JERSEY PT	APR 20 '00	41	47
	Effective Release	72,163	DURHAM FERRY		28	27
	Effective Release	46,249	MOSSDALE		18	30
	Effective Release	51,351	JERSEY PT		65	97
	601060914	23,698	DURHAM FERRY	APR 28 '00	7	8
	601060915	26,805	DURHAM FERRY	APR 28 '00	5	15
	0601110814	23,889	DURHAM FERRY	APR 28 '00	10	8
	0601061001	25,572	JERSEY PT	May 1 '00	48	76
	0601061002	24,661	JERSEY PT	May 1 '00	30	76
	Effective Release	74,392	DURHAM FERRY		22	31
	Effective Release	50,233	JERSEY PT		78	152

NOTE: Ocean recoveries are based on data through 2001

EXPANDED ADULT OCEAN RECOVS. (AGE 1+ TO 4+) TOTAL	CHIPPS ISLAND	ANTIOCH	OCEAN CATCH
	Juvenile Salmon CWT Survival Estimates		
3			
37			
8			
10			
187			
58	0.14		0.15
187			
183			
167			
351			
350	0.29		0.49
351			
91	0.28		0.48
191			
61			
40			
58			
47			
35			
61			
110			
90			
159	0.30		0.51
143	0.31		0.46
200			
57			
101			
119			
112			
138			
191			
244			
302			
389	0.32		0.35
329	0.65		0.59
546			
10			
10			
20			
10			
9			
50			
24			
40	0.31	0.20	0.38
19	0.31	0.34	0.29
74			
4			
4			
0			
14			
32			
8	0.19	0.14	0.12
46			

Chipps Island, and the ocean fishery. Information on survival of juvenile salmon and the contribution to the adult salmon population will be valuable in evaluating the biological benefits of changes in flow and export rates under VAMP.

SAN JOAQUIN RIVER SALMON PROTECTION

One of the VAMP objectives is to provide improved conditions and increased 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 hoped that these actions to improve conditions for the juveniles would translate to greater adult escapement in future years, especially during low flows, when escapement 2 1/2 years later has been extremely low in the San Joaquin basin (Figure 5-13).

To determine if VAMP in 2002 was successful in protecting juvenile salmon emigrating from the San Joaquin River tributaries, estimates of survival were compared with VAMP and in the absence of VAMP. Catches of unmarked salmon at Mossdale and in salvage at the CVP and SWP facilities were also compared prior to and during the VAMP period.

Unmarked Salmon Recovered at Mossdale

In assessing VAMP's objective to provide increased protection for the natural production of juvenile salmon migrating from the San Joaquin River tributaries, an estimate of survival was calculated with VAMP and in the absence of VAMP. The equation of survival to flow/exports was used to estimate survival under both conditions (Figure 5-11). With VAMP the flow/export ratio during the VAMP period was 2.3. This flow/export ratio generated a survival of 0.15. Without the export curtailments and flow augmentation due to VAMP the flow/export rate was estimated to be 0.35 (given the barrier was still in without the VAMP flow and exports). At this level of flow/export rate survival was estimated to have been 0.08. The export curtailments and increase in flows from VAMP essentially doubled survival from 0.08 to 0.15.

The original time period for VAMP (April 15 to May 15) was chosen based on historical data that indicated a high percentage of the juvenile salmon emigrating from the San Joaquin tributaries was passing into the delta at Mossdale during that time period. The average catch per minute per day of unmarked juvenile salmon caught in Kodiak trawling at Mossdale between March 15 and June 30, 2002 is shown in Figure 5-14. Unmarked salmon do not have an adipose clip and could be fish from the Merced River Hatchery or juveniles from natural spawning. An assessment of the percent of catch per unit effort over time indicated that the

FIGURE 5–13

Natural and Hatchery Escapement Returning to the San Joaquin Basin Between 1953 and 2001.

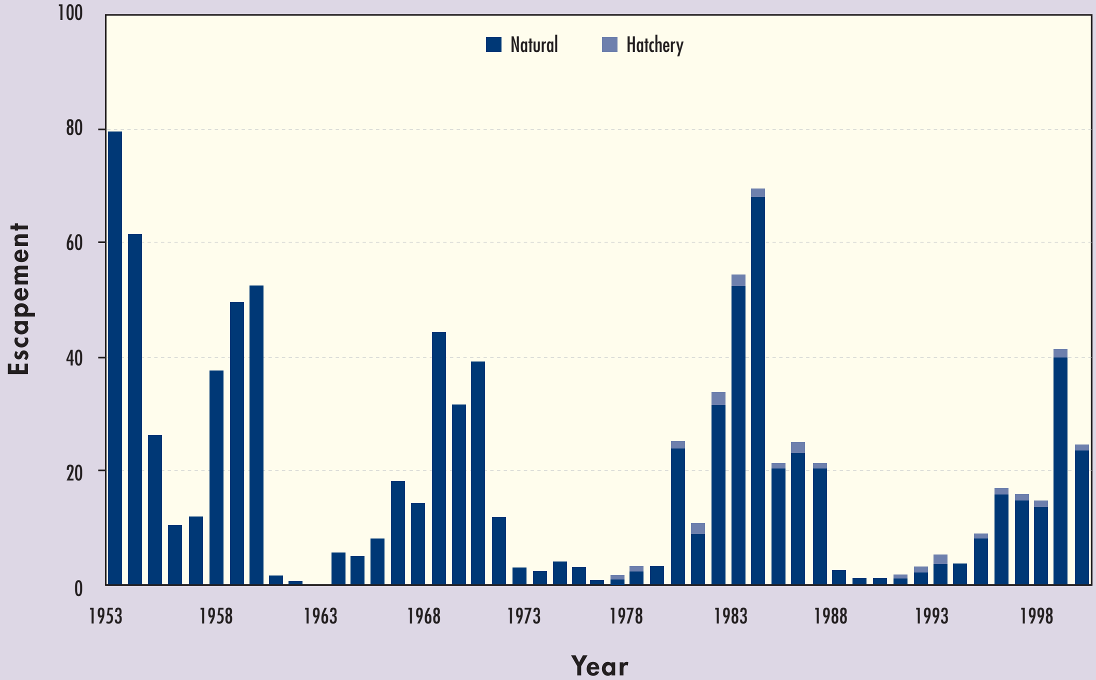


FIGURE 5–14

Catch Per Cubic Meter of all Unmarked Juvenile Chinook Salmon in the Mossdale Kodiak Trawl, March 15, 2002 Through June 30, 2002.

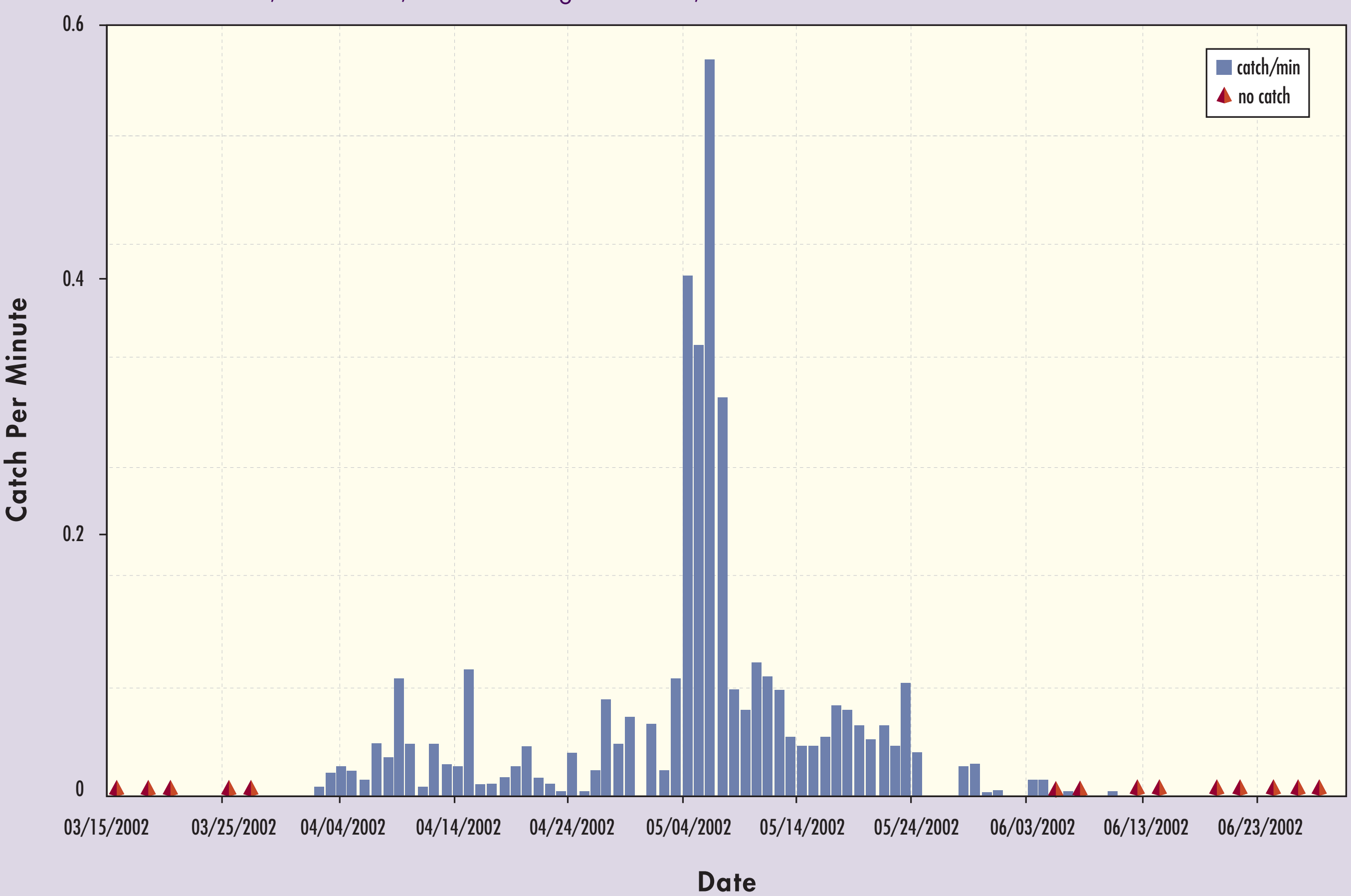
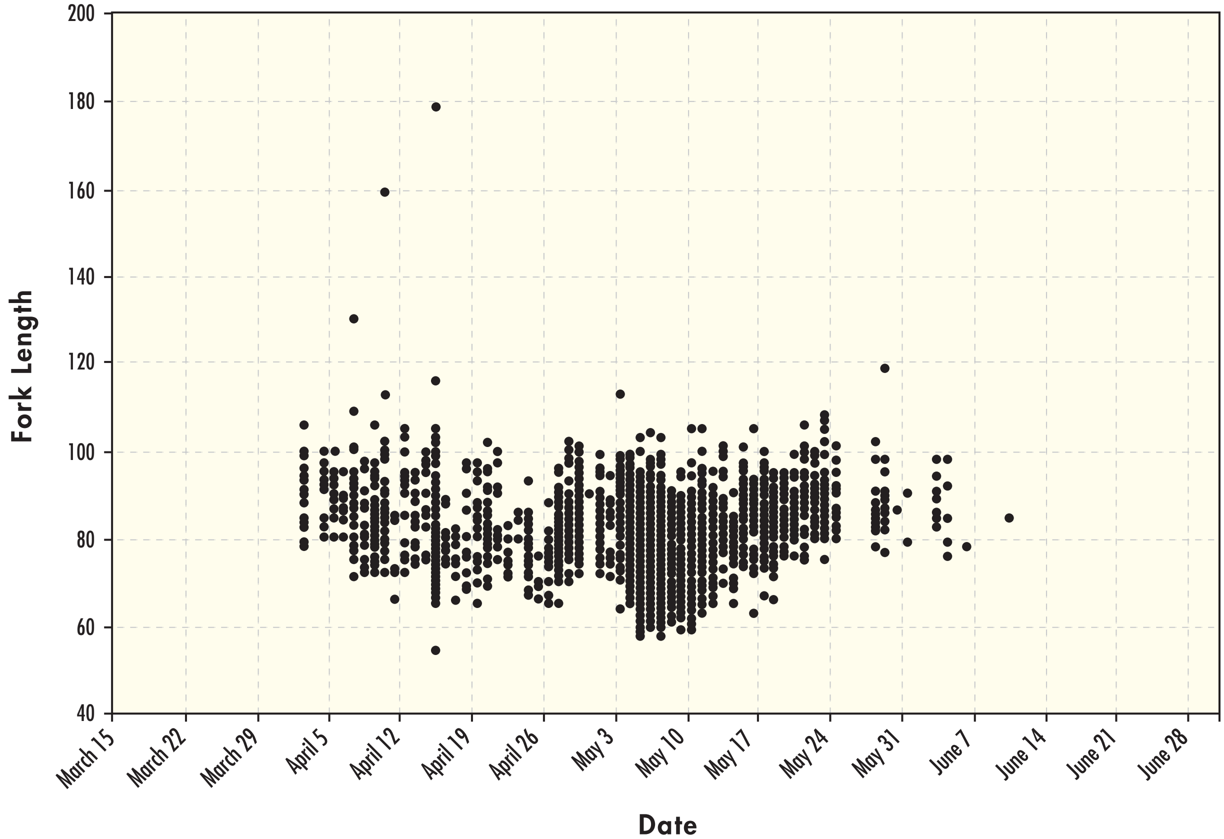


FIGURE 5–15

Individual Fork Lengths for Unmarked Juvenille Chinook in the Mossdale Kodiak Trawl, March 15, 2002 Through June 30, 2002.



majority of juvenile salmon (77%) migrated past Mossdale during the VAMP period. Delaying removal of the HORB until May 24, continuing export curtailments and ramping exports into early June protected an even greater percent of the population (91%). Reducing flows may stimulate movement of the juvenile salmon out of the system. Continuing the export curtailments and keeping the barrier in place for a week after the VAMP period provided some protection to these later out-migrants. These additional protection measures after VAMP appear to have been beneficial to protecting a greater proportion of the population of unmarked juvenile salmon emigrating from the San Joaquin basin.

Each unique size in millimeters of the juvenile salmon caught in the trawl at Mossdale between March 15 and June 30 is shown in Figure 5-15. In early April there were large juvenile salmon observed in the catch. These may be yearlings that have over-summered in the San Joaquin tributaries. Additional protection in early April may be warranted for this component of the population.

Salmon Salvage and Losses at Delta Export Pumps

Fish salvage operations at the CVP and SWP export facilities capture unmarked salmon for transport by tanker truck and release downstream in the western Sacramento-San Joaquin delta. The untagged salmon are either naturally produced or hatchery salmon, 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 CWT recovery data at the facilities to provide some general indications.

The salvage at the facilities is based on expansions from subsamples taken throughout the day. Approximately 4-5 salmon are estimated to be lost per salvaged salmon in the SWP Clifton Court Forebay based on high predation rates. The CVP pumps divert directly from the Old River channel and the loss estimates range from about 50-80% of the number salvaged, or about 6- 8 times less per salvaged salmon than for the SWP. The loss estimates do not include any indirect mortality in the delta due to water export operations or additional mortality associated with trucking and handling. Salvage density of salmon is the number of salvaged fish per acre-foot of water pumped.

The number 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 and density of juvenile salmon salvaged and lost. Density may be the best indicator of when the most juvenile salmon were moving through the salvage system.

FIGURE 5–16

2002 SWP Salmon Salvage and Loss.

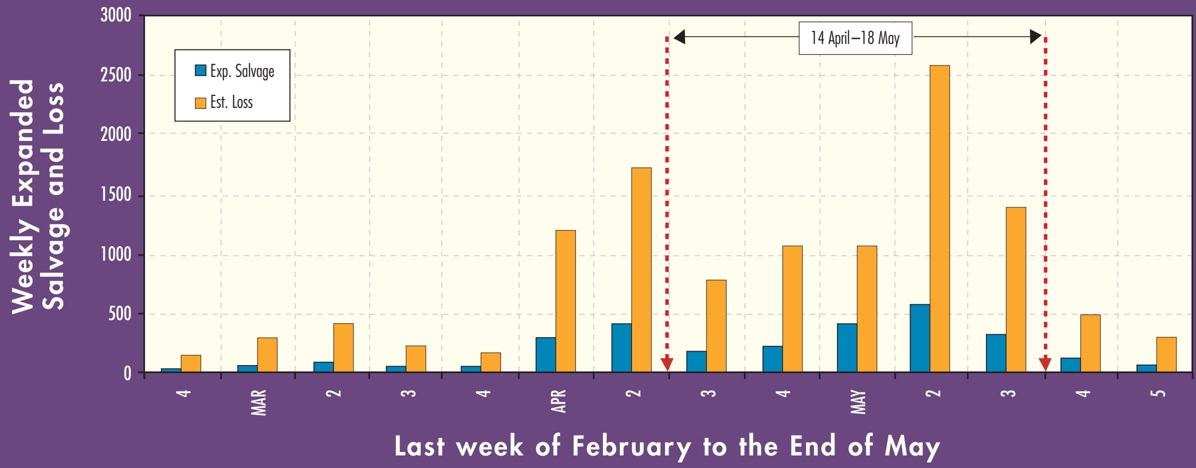


FIGURE 5–17

2002 CVP Salmon Salvage and Loss.

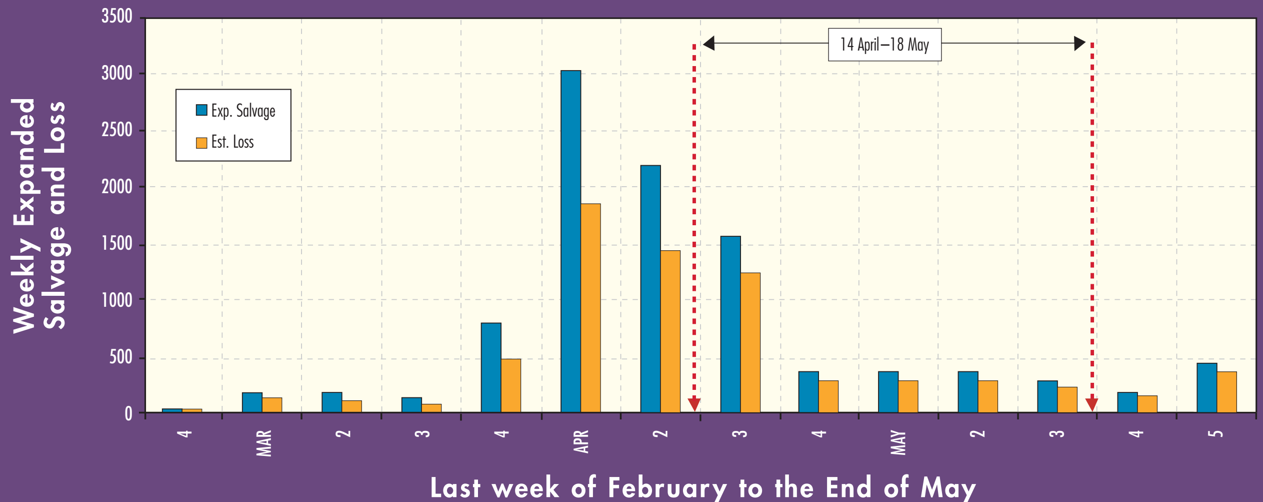
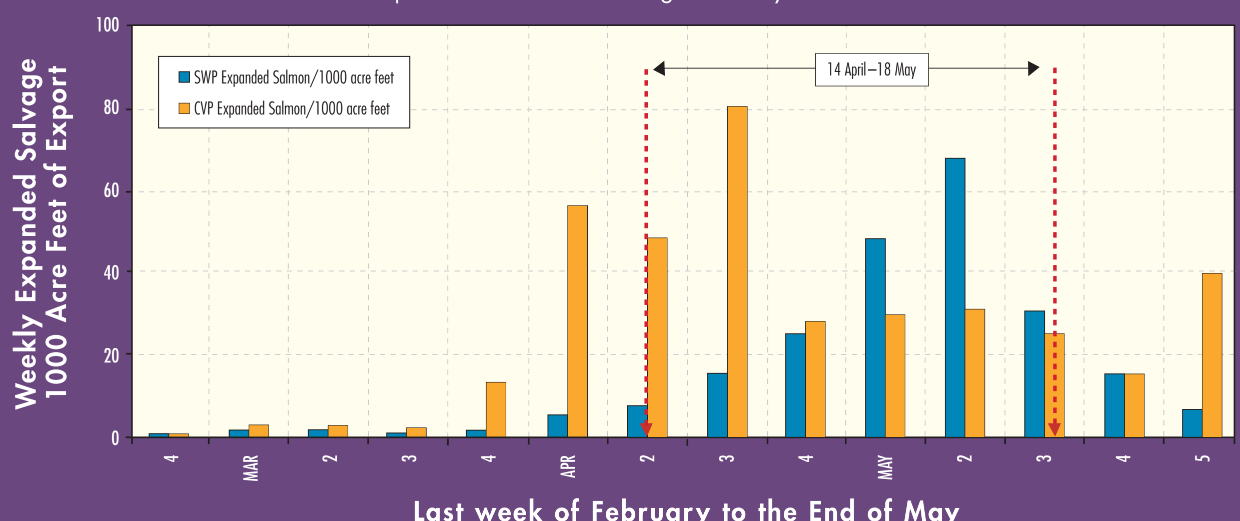


FIGURE 5–18

2002 SWP & CVP Expanded Salmon Salvage Density.



A review of the weekly salvage data around the 2002 VAMP period indicates that the highest salvage and losses occurred during the second week of May at the SWP and in the second week prior to the VAMP period at the CVP (Figures 5-16 and 5-17). Salmon density was highest in the first week of the VAMP period at the CVP facility, which also had high densities in the two preceding weeks, and in the fourth week of the VAMP period at the SWP facility (Figure 5-18). The salvage, loss and density information indicates that the salmon protection measures of VAMP may have been beneficial if they were implemented in the first half of April, similar to 2000 and 2001. Reducing exports during this earlier period of time would not only provide better conditions for juvenile salmon emigrating from the San Joaquin River basin, but from the Sacramento River basin as well.

It is recommended that these ***CONDITIONS*** *be tested as soon as possible to determine if VAMP should continue or if the study design needs to be changed.*

Juvenile spring-, winter-, and fall- run Chinook salmon migrate through the Delta in early April from the Sacramento River basin. Compared to the previous two years, salvage, losses, and density were several times lower in 2002, indicating that overall juvenile abundance was much less this year at the fish facilities.

The size distribution of unmarked salmon during April and May in the Mossdale trawl (Figure 5-15) and at the salvage facilities (Figure 5-19): Source E. Chappell, DWR) were generally similar in 2002, as was observed in 2001.

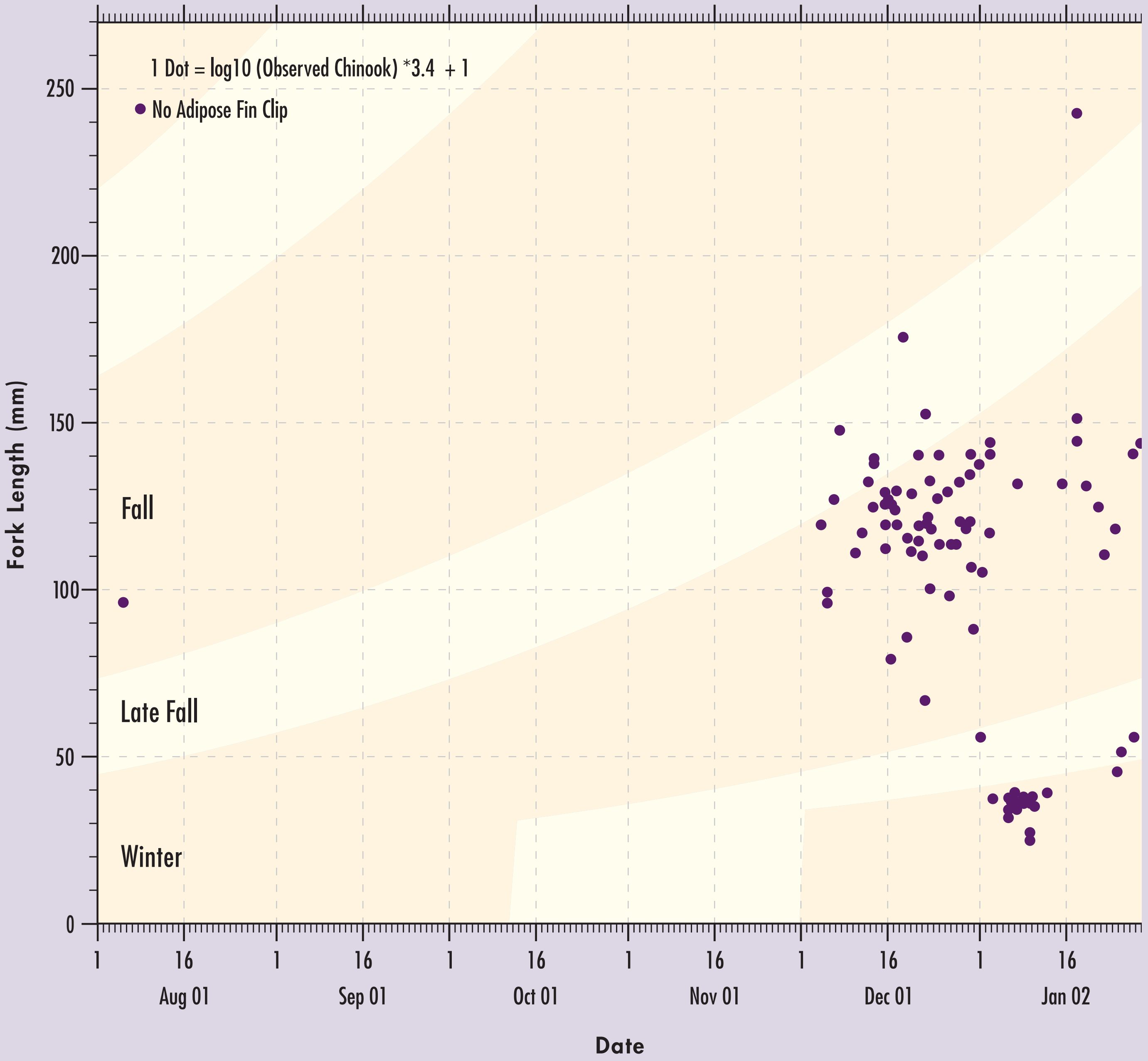
Results of these analysis showed that the VAMP 2002 test period coincided with much of the peak period of salmon smolt emigration. Reductions in SWP and CVP exports and increased San Joaquin River flow provided improved conditions for salmon survival, although starting the VAMP period two weeks earlier may have had substantial benefits. Additional VAMP studies are required, however, to improve quantification of biological benefits over a broader range of environmental conditions.

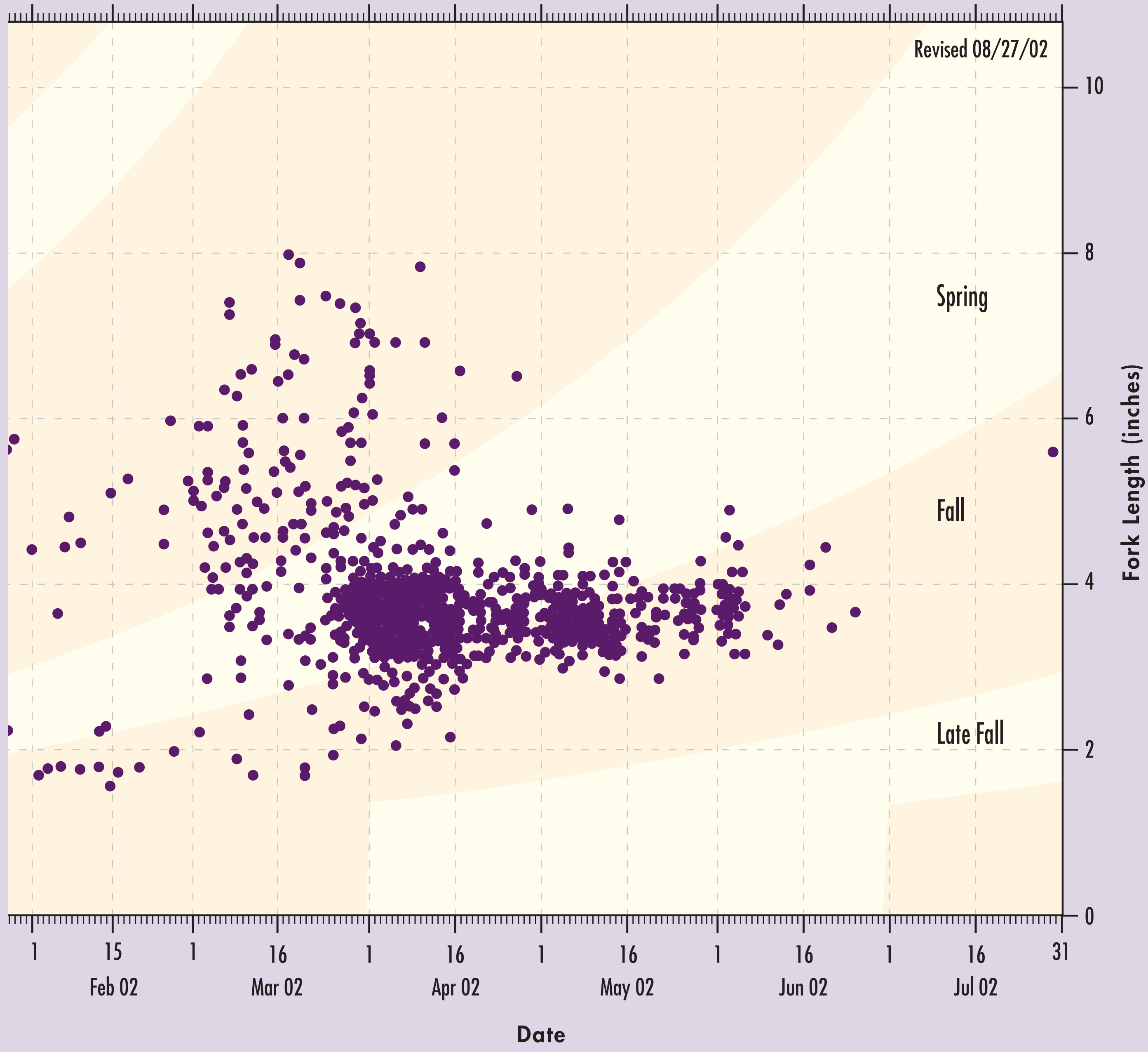
Summary and Recommendations

The variability in survival (recovery rates) at any one flow or flow/export with the HORB makes any preliminary conclusions uncertain based on VAMP results to date. Measuring survival within the narrow ranges of flow and export targets within the VAMP design further limits our ability to detect significant differences between targets. Future studies should prioritize, to the extent possible, flows of 7000 cfs and exports of 1500 cfs to achieve the highest target ratio (4.7) within the VAMP design to better enable us to determine the role of flow and export on salmon smolt survival. It is recommended that these conditions be tested as soon as possible to determine if VAMP should continue or if the study design needs to be changed. It is uncertain how such a condition can be prescribed independently of the hydrology within the existing San Joaquin River Agreement, but the idea should be explored by the VAMP Management Team. Also continued assessment of past data is recommended such that other methodologies or criteria for determining statistical differences between groups may be developed.

FIGURE 5–19

Observed Chinook Salvage at the SWP & CVP Delta Fish Facilities 8/01/01 through 7/31/02.




Revised 08/27/02
Spring
Fall
Late Fall
Fork Length (inches)
0
2
4
6
8
10
1
15
1
16
1
16
1
16
1
16
1
16
31
Feb 02
Mar 02
Apr 02
May 02
Jun 02
Jul 02
Date

CHAPTER 6 | COMPLIMENTARY STUDIES RELATED TO THE VAMP

During the 2002 VAMP period several studies were performed that were considered to be complimentary and are summarized below for the reader. The studies included (1) Survival Estimates for CWT Releases Made in the San Joaquin Tributaries; (2) Radio-Tagged Juvenile Chinook Salmon Release Studies; (3) Striped Bass Predation Monitoring; and (4) the Mokelumne River Juvenile Chinook Salmon Survival Study.

SURVIVAL ESTIMATES FOR CWT RELEASES MADE IN THE SAN JOAQUIN TRIBUTARIES

CWT salmon releases were made in the San Joaquin River tributaries between March 31 and May 4 as part of independent (complimentary) fishery investigations. Releases were made in the upper Merced River (Merced River Fish Facility) and lower Merced River (Hatfield State Park), upper Tuolumne River (La Grange) and on the mainstem San Joaquin River just downstream of the confluence with the Tuolumne River (Old Fisherman's Club). Groups of CWT salmon were also released in the upper (Knights Ferry) and lower (Two Rivers) Stanislaus River.

Group survival indices for salmon released in the tributaries and recovered at Antioch ranged between 0.002 and 0.04 (Appendix C-5). Group survival indices ranged between 0.005 and 0.05 to Chipps Island (Appendix C-5). These indices were much lower than in 2001, where indices ranged from 0.03 to 0.20. These indices include both the survival upstream as well as through the delta. Vernalis flows were lower in 2002 (3,300 cfs vs. 4,200 cfs). The tributary flows were also likely lower.

Comparison of survival indices of the upstream groups relative to the downstream groups provides an index of survival through the tributaries. The survival estimates through the tributaries are provided in Appendix C-5. Survival through the Merced River ranged between 0.0 and 0.11. Again, survival through the tributaries was greater in 2001, with estimates through the Merced River ranging between 0.17 and 0.52. Survival through the Tuolumne Rivers was higher, with upstream release recoveries at Antioch greater than the downstream releases. Using Chipps Island recovery information survival ranged from 0.47 to 0.84 in 2002. In 2001 survival through the Tuolumne River was 0.20. Recoveries from the upstream groups were higher than the downstream group at both Antioch and Chipps Island for releases made on the Stanislaus River in 2002. No recoveries were made from either the upstream or downstream groups on the Stanislaus in 2001.

Survival through the Merced appeared low in 2002, while it appeared higher on the Tuolumne and Stanislaus Rivers in 2002 than in 2001. Recovery numbers from these groups are small and the inherent variability associated with the probability of capture may be the reason estimates are greater than 1.0.

Information on the transit time between release and recovery of the CWT groups released in the San Joaquin River mainstem and tributaries at both Antioch and Chipps Island is summarized in Appendix C-6. As observed for VAMP releases, recovery times were generally similar between Antioch and Chipps Island for the various groups released upstream in the mainstem San Joaquin and tributaries.

RADIO TAGGING STUDIES IN THE LOWER SAN JOAQUIN RIVER

(Contributed by Dave Vogel, Natural Resource Scientists, Inc.)

During April 2002, Natural Resource Scientists, Inc. released and monitored radio-tagged juvenile Chinook salmon in the lower San Joaquin River. Field data collection for this project was designed to acquire information on specific behavior (movements) as juvenile Chinook salmon migrated through delta channels just prior to and during VAMP implementation. The study expanded upon the techniques NRS developed in prior studies on juvenile salmon using radio telemetry, including recent studies at the Delta Cross Channel, north Delta, and south Delta.

Juvenile Chinook salmon with surgically-implanted miniature (1 gram) radio transmitters were released in the San Joaquin River near Fourteen-Mile Slough (downstream of Stockton). Twelve to 14 radio-tagged salmon were released on each of the following dates: April 2, April 10 (pre-VAMP), and April 16, and April 23 (during VAMP). The radio-tagged fish were tracked for 3-4 days after release using mobile receivers on two inboard jet boats. Individual fish movements, migration rates, and behavior in response to tidal cycles and flow splits in Delta channels were important parameters assessed from field observations. In particular, the project was intended to evaluate what occurs during the telemetered salmon migration past the flow splits at Turner Cut, Columbia Cut, and lower Middle and

FIGURE 6–1

Locations of Radio-Tagged Juvenile Salmon Released on April 2, 2002.

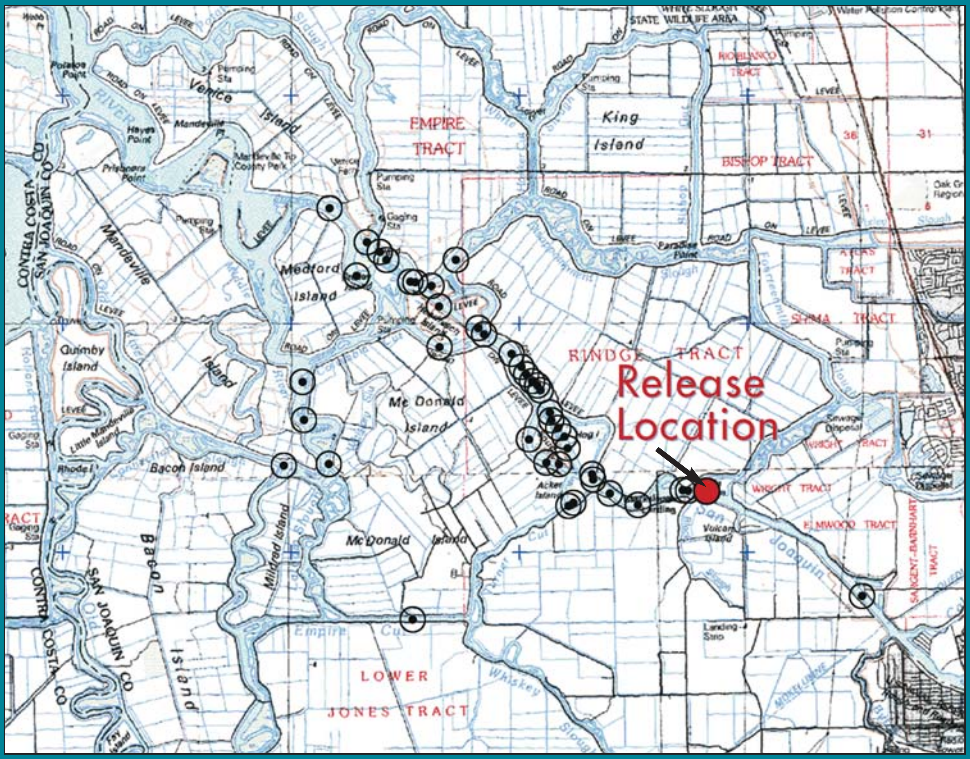
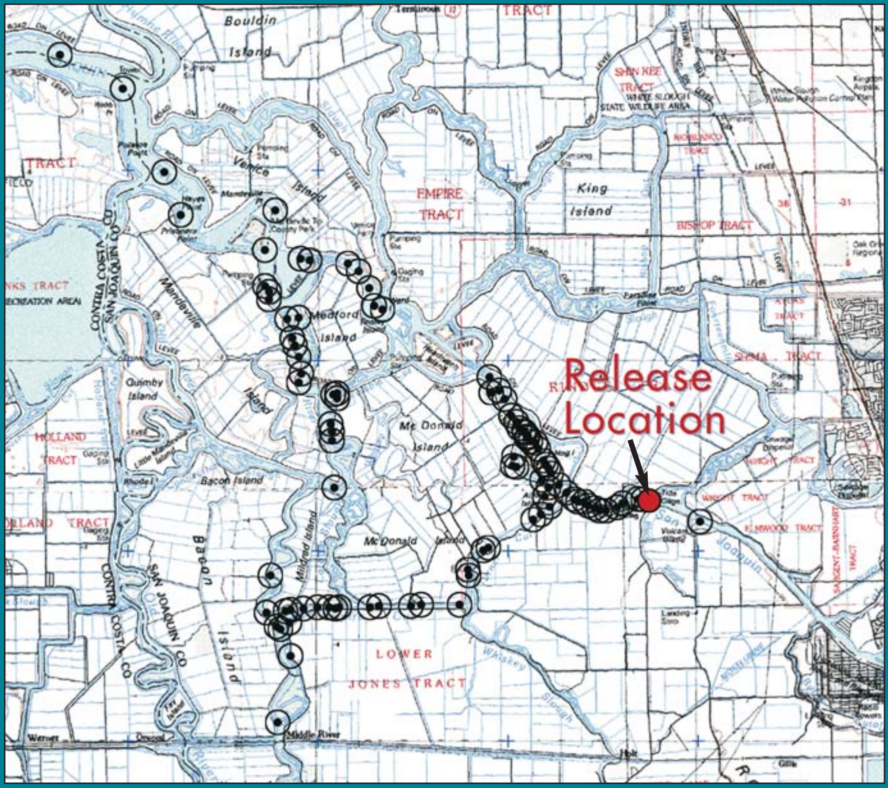


FIGURE 6–2

Locations of Radio-Tagged Juvenile Salmon Released on April 10, 2002.



Old rivers. Each time a radio-tagged fish was located, the exact position (via GPS), time, and any relevant biological and behavioral observations were recorded. Figures 6-1, 6-2, 6-3, and 6-4 show preliminary data on locations of radio-tagged juvenile Chinook salmon released and tracked in the Delta during the four weeks of experiments.

A report on this project will be completed after receipt of DWR tidal flow data measured in the San Joaquin River near Rough and Ready Island.

STRIPED BASS PREDATION MONITORING PROGRAM

(Contributed by Heather McIntire, California Department of Fish and Game)

In early March, EPA (Bruce Herbold) suggested USFWS and DFG coordinate the Striped Bass Predation Monitoring Program with the VAMP smolt release at Mossdale and Durham Ferry. The Striped Bass Predation Monitoring Program is a requirement of DFG's Striped Bass Management Program's ESA Conservation Plan. Based on previous scheduling, DFG collected striped bass at the HORB on April 3, 16, and 25. Salmon releases at Mossdale occurred on the April 19 and 26. Because the smolt release schedules were not confirmed until the day before releases, DFG was unable to coordinate a boat operator and crew to sample immediately during the releases.

DFG sampled striped bass by gillnet and hook and line. Three days of sampling yielded 2 striped bass, 176 catfish, 1 bluegill and 1 black crappie. The stomachs of both striped bass were flushed by gastric lavage and one was sacrificed after lavage to confirm the stomach was empty. Neither fish had any remains in the stomach.

CWT CHINOOK salmon were subsequently recovered in fishery sampling at Antioch and Chipps Island, in addition to recoveries in SWP and CVP salvage operations.

Fishing upstream of the Mossdale bridge on April 16 and 25, yielded a total of 5 striped bass which had empty stomachs based on gastric lavage and dissection. Three of these 5 fish were sacrificed to confirm stomach contents.

MOKELUMNE RIVER JUVENILE CHINOOK SALMON SURVIVAL STUDIES

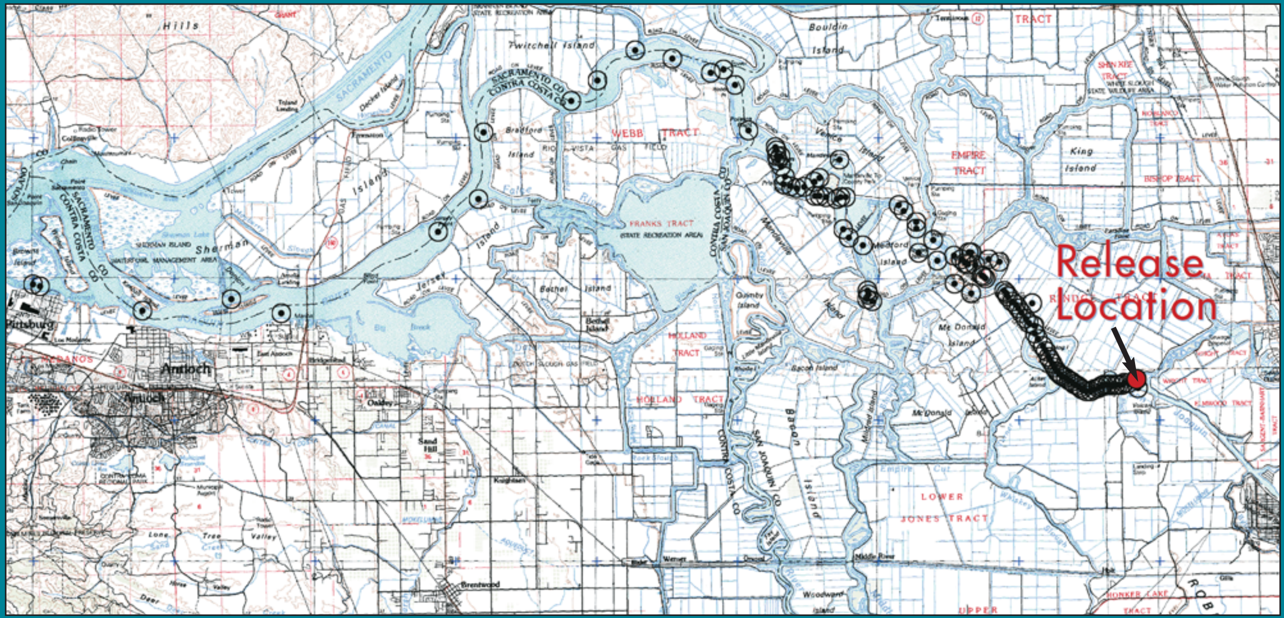
The East Bay Municipal Utility District (EBMUD) conducted a series of juvenile Chinook salmon survival studies in the lower Mokelumne River during spring 2002 that complement VAMP investigations. Juvenile Chinook salmon from the Mokelumne River Fish Hatchery were coded-wire tagged (CWT) for use in these tests. The experimental design included release of CWT salmon into the north fork Mokelumne River (approximately 52,000-54,000 CWT salmon in each release group), the south fork Mokelumne River at New Hope Landing (approximately 103,000 CWT salmon in each release), and a downstream control release at Jersey Point (approximately 51,000–52,000 CWT salmon in each release). Releases were made prior to the 2002 VAMP test period (releases were made on April 4 into the north fork and south fork of the Mokelumne River and April 11 at Jersey Point) and during the VAMP test period (releases were made April 18 into the north fork and south fork Mokelumne River and April 23 at Jersey Point). CWT Chinook salmon were subsequently recovered in fishery sampling at Antioch and Chipps Island, in addition to recoveries in SWP and CVP salvage operations. Hydrologic conditions prior to and during the VAMP test period, including San Joaquin River flows and SWP and CVP export rates, are discussed in Section 2.

FIGURE 6–3

Locations of Radio-Tagged Juvenile Salmon Released on April 16, 2002.

FIGURE 6–4

Locations of Radio-Tagged Juvenile Salmon Released on April 23, 2002.



As part of the Chinook salmon survival studies, EBMUD monitored water temperatures within the Mokelumne River Fish Hatchery, north fork Mokelumne River, south fork Mokelumne River at New Hope Landing, and Jersey Point. Results of water temperature monitoring within the Mokelumne River Hatchery showed that water temperatures typically ranged from approximately 11-13 C (52-55 F) within the raceways prior to release of the CWT Chinook salmon. Water temperatures within the north fork Mokelumne River ranged from approximately 16-19 C (61-66 F) which were similar to water temperatures observed in the south fork Mokelumne River during both the first and second sets of releases. Water temperature observed during the period of these salmon survival studies was within the range considered to be suitable for juvenile emigrating Chinook salmon.

Results of recaptures of CWT Chinook salmon at Chipps Island released prior to the VAMP test period showed that the absolute estimate of survival (based upon the ratio of survival indices calculated for each north and south fork Mokelumne River release group and adjusted for sampling effort, and the downstream Jersey Point control) of juvenile salmon released in the south fork Mokelumne River (survival rate equals 0.10) was greater than the survival rate for fish released into the north fork Mokelumne River (survival rate equals 0.03). In contrast, survival rates for Chinook salmon released during the pre-VAMP period and recaptured at Antioch showed higher survival from the north fork Mokelumne river (survival rate equals 0.27) than observed for salmon from the south fork Mokelumne River (survival rate 0.15). Factors contributing to the contradictory survival results for the pre-VAMP period between recaptures at Antioch and Chipps Island could not be determined from results of the 2002 tests.

For those CWT juvenile Chinook salmon released during the VAMP period and recaptured at Chipps Island, absolute survival rates were comparable between the north fork (survival rate equals 0.11) and south fork Mokelumne River (survival rate equals 0.12). Survival rates during the VAMP period for recaptures at Antioch were similar to results based on recaptures at Chipps Island.

Results of these complimentary survival studies provide insight into the survival of juvenile Chinook salmon emigrating from the lower Mokelumne River through the Delta and the potential effects of changes in San Joaquin River flow and SWP/CVP export rates may have on juvenile Chinook salmon survival.

Results of these complimentary survival studies provide insight into the survival of juvenile Chinook salmon emigrating from the lower MOKELUMNE RIVER...

CHAPTER 7 | CONCLUSIONS AND RECOMMENDATIONS

The 2002 VAMP experimental investigation of juvenile Chinook salmon survival, implemented during spring 2002, represents the third year under the SWRCB D-1641. The Vernalis target flow was 3200 cfs, with SWP and CVP export flow of 1500 cfs. The HORB was successfully installed and maintained throughout the VAMP test period. Estimates of juvenile Chinook salmon smolt survival were calculated based upon releases of CWT juvenile salmon produced in the Merced River Hatchery and released at Durham Ferry, Mossdale, and Jersey Point. Marked salmon were subsequently recaptured in sampling at the HORB, SWP and CVP export facility salvage, and through intensive fishery sampling at Antioch and Chipps Island. Based upon the data and experience gained during the VAMP 2002 investigations, conclusions and recommendations have been developed, as summarized in Table 7-1. The conclusions and recommendations include both technical and policy/management issues that will affect the design and implementation of VAMP 2003 operations and investigations.

TABLE 7–1

Summary of VAMP 2002 Conclusions and Recommendations

CONCLUSIONS	RECOMMENDATIONS
Real-time flow data at Vernalis were improved by weekly flow measurements. 2002 funding provided by CALFED grant.	Continue weekly flow measurements. Investigate alternative flow measurement methods and/or locations. Obtain additional funding for USGS weekly Vernalis gage verification.
Estimation of ungaged flows (accretions, depletions) at Vernalis was improved.	Continue hydrology investigation to improve predictions of ungaged flows.
Disagreement over forecasting New Melones releases impacted planning for tributary flows and related operations.	Hydrology and/or management committee should resolve forecasting issues prior to 2003 VAMP and a set of written procedures for operational planning within each tributary should be established.
Coordination with upstream tributary operations was successful.	Continue coordination among tributary operators.
Maintenance frequency of the HORB was increased.	Continue frequent maintenance of HORB culverts.
HORB construction continued after barrier closure causing debris (rock) problems for fishery sampling after closure of HORB.	Delay CWT releases for five days after HORB closure to allow time for gravel to be flushed from the culverts.
Operation of the HORB was successful in maintaining south delta water levels.	Continue to refine operational criteria for culverts.
Closure of HORB is dependent on completion of other barriers. Construction of multiple barriers in south delta channels may delay HORB closure.	Schedule construction to avoid delay in HORB installation and closure.
An estimate of the flow through HORB culverts needs to be taken so that a continuous record of flow through the culverts can be reported.	Take flow measurements within each culvert and/or install water stage recorders upstream and downstream of the barrier.
HORB did not cause seepage impacts on upper Roberts Island.	Continue seepage monitoring.

CONCLUSIONS CONTINUED	RECOMMENDATIONS CONTINUED
The use of fyke nets was successful in collecting entrained fish at the culverts.	Continue monitoring culverts using fyke nets to document fish entrainment.
A larger number of CWT salmon than expected were collected at HORB.	Increase effort and budget for CWT processing.
The index of salmon entrainment at HORB was substantially higher in 2002 compared to 2001.	Continue barrier monitoring and analysis of factors affecting entrainment.
2002 studies were successful in determining salmon entrainment at HORB culverts, but did not estimate mortality associated with HORB.	Evaluate methods to estimate mortality associated with HORB
CWT loss rate remained similar to 2001 at a rate of about 9.5 percent with a range between 0.5 and 15.0 percent.	Continue CWT quality control to improve retention rates.
The release at Durham Ferry was improved by having the diversion pump at the site curtail operation.	Continue to curtail diversion pump operations during releases – coordinate release schedule with landowner.
Water temperatures were suitable during both sets of releases.	Avoid seasonal delays in barrier installation and survival testing to allow releases when most suitable water temperatures.
Results of net pen studies showed high survival of test fish.	Continue net pen studies and fish health inspections.
Physiological studies provided useful information on fish health and condition and indicated all test fish were healthy.	Re-evaluate physiological tests and modify protocol prior to 2003 VAMP to document fish health and condition within hatchery and at time of release.
Using current statistical methods, differences in survival rates among flows and export rates tested in 2000, 2001, and 2002 were not found to be statistically significant.	Continue to evaluate alternative statistical methods to assess differences in survival rates between release locations, flows, and export conditions.
Differences in survival from Durham Ferry in 2002 were not significantly different from 2000 or 2001. It appears greater differences in flow and export rate may be needed to detect differences in survival.	Conduct survival testing at VAMP flow and export extremes when water is available to do so. Recommend testing at 7,000 cfs flow and 1,500 cfs exports to determine survival under higher flow:export ratio.
San Joaquin River flow downstream of HORB is important to evaluating salmon survival.	Measure the flow in the San Joaquin River downstream of head of Old River.
Complimentary studies to evaluate mechanisms affecting survival of fish from tributaries and across the Delta were conducted .	Encourage an expansion of complementary studies to provide additional information on factors and mechanisms affecting salmon survival.
Relatively few CWT salmon from VAMP releases were recovered at the SWP and CVP salvage facilities.	Continue salvage monitoring to document direct losses at SWP/CVP export facilities.
Estimates of salmon survival rates under flow and export conditions tested in 2000, 2001, and 2002 have not been found to be significantly different. The VAMP program provides improved protection for juvenile salmon when compared to “pre-VAMP” conditions.	Continue VAMP test program. Further tests, over a wider range of flow and export conditions, are needed to evaluate the respective roles of San Joaquin River flow and SWP/CVP exports on juvenile Chinook salmon smolt survival.

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U.S. FISH AND WILDLIFE SERVICE

CALIFORNIA DEPARTMENT OF WATER RESOURCES

CALIFORNIA DEPARTMENT OF FISH AND GAME

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Page 3	**SWRCB Decision 1641**	www.waterrights.ca.gov/hearings/Decisions.htm
Page 4	**VAMP 2001 Annual Technical Report**	www.sjrg.org/technicalreport/2001_tech_report.htm
Page 8	**VAMP Experimental Design**	www.sjrg.org/agreement.htm
Page 12	**Operation Monitoring, CDEC Hourly**	http://cdec.water.ca.gov/cgi-progs/queryGroup?s=fw1
	Operation Monitoring, CDEC Daily	http://cdec.water.ca.gov/cgi-progs/queryDgroups?s=fw2
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Page 18	**Temporary Barrier Program**	http://sdelta.water.ca.gov
Page 21	**Reclamation District 544 Seepage Monitoring Study**	http://sdelta.water.ca.gov/web_pg/pub_doc.htm
Page 29	**HORB on Old River Tidal Stage**	http://cdec.water.ca.gov
Page 55	**USFWS Stockton**	http://www.delta.dfg.ca.gov/usfws/monitoring_main/monitoring_main.html
	Pacific States Marine Fisheries Commission Regional Mark Information System	http://www.rmis.org
	DFG - Bay Delta	http://www.delta.dfg.ca.gov/data/salvage/

APPENDIX TABLE OF CONTENTS

APPENDIX A

Hydrology and Operation Plans 73

A-1 Daily Operation Plans 74

A-2 Accounting of Supplemental Water Contributions 86

A-3 Comparison of "Real-time" and Provisional Flows 87

APPENDIX B

Fall Water Transfer and Delivery Information 90

B-1 Merced I.D. 2002 Fall SJRA Water Transfer Preliminary Schedule 91

B-2 Merced I.D. 2001 Fall Water Transfer Daily Flow, Final 92

B-3 Oakdale I.D Daily Schedule of Additional Water, Preliminary 94

APPENDIX C

Chinook Salmon Survival Investigations 96

C-1 Water Temperature Monitoring Locations 97

C-2 Water Temperature Monitoring Data 99

C-3 Net Pen Sampling Results
Immediately and 48 Hours After Release 106

C-4 Net Pen Sampling Results 108

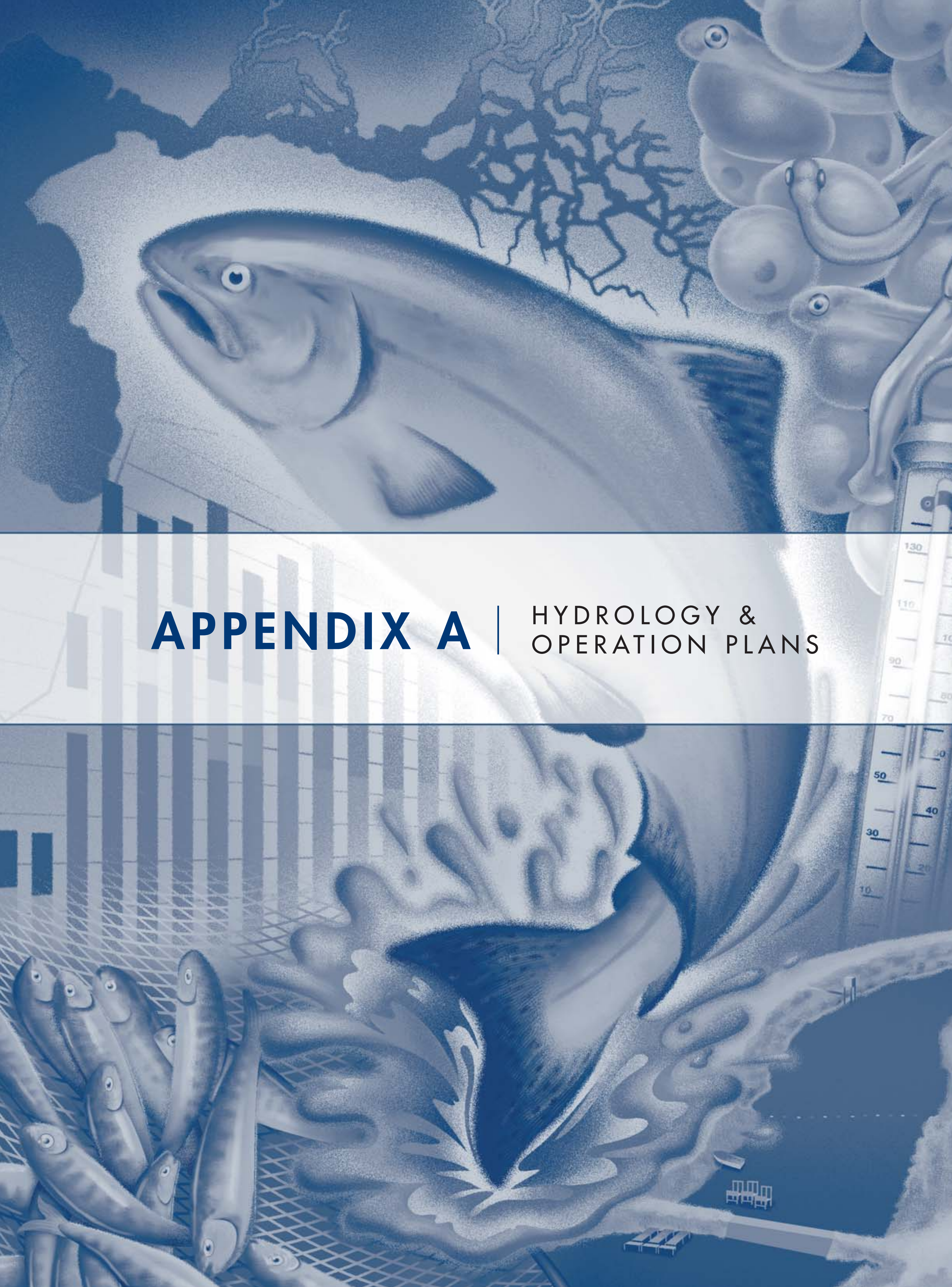
C-5 Coded Wire Tag Release and Recovery Data 114

C-6 Coded Wire Tag TIming of Recovery Data 116

APPENDIX D

Errata 118

Errata for the 2001 Annual Technical Report 119



APPENDIX A | HYDROLOGY & OPERATION PLANS

DAILY OPERATION PLAN, MARCH 13, 2002

Pulse Period: April 15–May 15 • Flow Target: 3,200cfs

Ungaged Flow at Vernalis = 400cfs • (A) Dry~90% Exceedence

	San Joaquin River near Vernalis							Merced River at Cressey			Exchange Contractors	Tuolumne River at LaGrange				Stanislaus River below Goodwin				
	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	VAMP Suppl. Flow	VAMP Flow (3-day lag)	VAMP Suppl. Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol.
	(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	
	[calc]	[calc]		[calc]	[calc]					[calc]					[calc]				[calc]	
Apr 01						290	400	250		250		150	150		150	637			637	
Apr 02						286	400	250		250		150	150		150	637			637	
Apr 03						283	400	250		250		150	150		150	637			637	
Apr 04	1,723				1,723	280	400	250		250		150	150		150	637			637	
Apr 05	1,720				1,720	276	400	250		250		150	150		150	637			637	
Apr 06	1,717				1,717	273	400	250		250		150	150		150	637			637	
Apr 07	1,713				1,713	270	400	250		250		150	150		150	637			637	
Apr 08	1,710				1,710	267	400	250		250		150	150		150	637			637	
Apr 09	1,707				1,707	263	400	250		250		150	150		150	637			637	
Apr 10	1,704				1,704	260	400	250		250		150	150		150	637			637	
Apr 11	1,700				1,700	257	400	250	250	500		150	150		150	637			637	
Apr 12	1,697				1,697	253	400	250	750	1,000		150	150		150	637			637	
Apr 13	1,694	0			1,694	250	400	250	800	1,050		650	650	0	650	637	225	0	862	
Apr 14	1,690	250			1,940	247	400	250	800	1,050		650	650	0	650	637	225	0	862	
Apr 15	2,187	975	0	1.93	3,162	243	400	250	800	1,050		650	650	0	650	637	225	0	862	
Apr 16	2,184	1,025	0	3.97	3,209	240	400	250	805	1,055		650	650	0	650	637	225	0	862	
Apr 17	2,180	1,025	0	6.00	3,205	237	400	250	810	1,060		650	650	0	650	637	225	0	862	
Apr 18	2,177	1,025	0	8.03	3,202	234	400	250	810	1,060		650	650	0	650	637	225	0	862	
Apr 19	2,174	1,030	0	10.08	3,204	230	400	250	815	1,065		650	650	0	650	637	225	0	862	
Apr 20	2,171	1,035	0	12.13	3,206	227	400	250	815	1,065		650	650	0	650	637	225	0	862	
Apr 21	2,167	1,035	0	14.18	3,202	224	400	250	820	1,070		650	650	0	650	637	225	0	862	
Apr 22	2,164	1,040	0	16.24	3,204	220	400	250	590	840		650	650	0	650	637	225	0	862	
Apr 23	2,161	1,040	0	18.31	3,201	217	400	250	190	440		650	650	240	890	637	225	0	862	
Apr 24	2,157	1,045	0	20.38	3,202	214	400	250	190	440		650	650	650	1,300	637	225	0	862	
Apr 25	2,154	1,055	0	22.47	3,209	210	400	250	195	445		650	650	650	1,300	637	225	0	862	
Apr 26	2,151	1,065	0	24.59	3,216	207	400	250	200	450		650	650	650	1,300	637	225	0	862	
Apr 27	2,147	1,065	0	26.70	3,212	204	400	250	200	450		650	650	650	1,300	637	225	0	862	
Apr 28	2,144	1,070	0	28.82	3,214	201	400	250	200	450		650	650	650	1,300	637	225	0	862	
Apr 29	2,141	1,075	0	30.95	3,216	197	400	250	200	450		650	650	650	1,300	637	225	0	862	
Apr 30	2,138	1,075	0	33.08	3,213	194	400	250	600	850		650	650	650	1,300	637	225	0	862	
May 01	2,134	1,075	0	35.22	3,209	191	400	250	860	1,110		650	650	250	900	677	185	0	862	
May 02	2,131	1,075	0	37.35	3,206	187	400	250	860	1,110		650	650	0	650	677	185	0	862	
May 03	2,168	1,035	0	39.40	3,203	184	400	250	860	1,110		650	650	0	650	677	185	0	862	
May 04	2,164	1,045	0	41.47	3,209	181	400	250	865	1,115		650	650	0	650	677	185	0	862	
May 05	2,161	1,045	0	43.55	3,206	177	400	250	870	1,120		650	650	0	650	677	185	0	862	
May 06	2,158	1,045	0	45.62	3,203	174	400	250	875	1,125		650	650	0	650	677	185	0	862	
May 07	2,154	1,050	0	47.70	3,204	171	400	250	875	1,125		650	650	0	650	677	185	0	862	
May 08	2,151	1,055	0	49.80	3,206	168	400	250	880	1,130		650	650	0	650	677	185	0	862	
May 09	2,148	1,060	0	51.90	3,208	164	400	250	880	1,130		650	650	0	650	677	185	0	862	
May 10	2,145	1,060	0	54.00	3,205	161	400	250	880	1,130		650	650	0	650	677	185	0	862	
May 11	2,141	1,065	0	56.11	3,206	158	400	250	880	1,130		650	650	0	650	677	185	0	862	
May 12	2,138	1,065	0	58.22	3,203	154	400	250	750	1,000		650	650	0	650	677	185	0	862	
May 13	2,135	1,065	0	60.34	3,200	151	400	250	250	500		650	650	0	650	677	185	0	862	
May 14	2,131	1,065	0	62.45	3,196	148	400	250		250		400	400		400	677			677	
May 15	2,128	935	0	64.30	3,063	144	400	250		250		250	250		250	677			677	
May 16	1,875	250			2,125	141	400	250		250		175	175		175	677			677	
May 17	1,721	0			1,721	138	400	250		250		175	175		175	677			677	
May 18	1,643	0			1,643	135	400	250		250		175	175		175	677			677	
May 19	1,640	0			1,640	131	400	250		250		175	175		175	677			677	
May 20	1,637	0			1,637	128	400	250		250		175	175		175	677			677	
May 21	1,633	0			1,633	125	400	250		250		175	175		175	677			677	
May 22	1,630	0			1,630	121	400	250		250		175	175		175	677			677	
May 23	1,627	0			1,627	118	400	250		250		175	175		175	677			677	
May 24	1,623	0			1,623	115	400	250		250		175	175		175	677			677	
May 25	1,620	0			1,620	111	400	250		250		175	175		175	677			677	
May 26	1,617	0			1,617	108	400	250		250		175	175		175	677			677	
May 27	1,613	0			1,613	105	400	250		250		175	175		175	677			677	
May 28	1,610	0			1,610	102	400	250		250		175	175		175	677			677	
May 29	1,607	0			1,607	98	400	250		250		175	175		175	677			677	
May 30	1,604	0			1,604	95	400	250		250		175	175		175	677			677	
May 31	1,600	0			1,600	92	400	250		250		140	140		140	677			677	
	VAMP period																			
Mean (cfs):	2,154	1,046			3,200	201	400	250	675	925		650	650	163	813	654	208	0	862	
Suppl. Water (TAF)		64.30							41.50		0.00			10.00			12.80	0.00		

Pulse flow period

Period of desired flow stability

DAILY OPERATION PLAN, MARCH 13, 2002

Pulse Period: April 15–May 15 • Flow Target: 3,200cfs

Ungaged Flow at Vernalis = 800cfs • (B) AVG~50% Exceedence

San Joaquin River near Vernalis							Merced River at Cressey			Exchange Contractors	Tuolumne River at LaGrange				Stanislaus River below Goodwin					
Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	VAMP Suppl. Flow	VAMP Flow (3-day lag)	VAMP Suppl. Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol.	
(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		
[calc]	[calc]		[calc]	[calc]					[calc]					[calc]				[calc]		
					548	800	250		250		150	150		150	685			685		Apr 01
					544	800	250		250		150	150		150	685			685		Apr 02
					540	800	250		250		150	150		150	685			685		Apr 03
2,429				2,429	536	800	250		250		150	150		150	685			685		Apr 04
2,425				2,425	532	800	250		250		150	150		150	685			685		Apr 05
2,421				2,421	528	800	250		250		150	150		150	685			685		Apr 06
2,417				2,417	524	800	250		250		150	150		150	685			685		Apr 07
2,413				2,413	520	800	250		250		150	150		150	685			685		Apr 08
2,409				2,409	516	800	250		250		150	150		150	685			685		Apr 09
2,405				2,405	512	800	250		250		150	150		150	685			685		Apr 10
2,401				2,401	508	800	250		250		150	150		150	685			685		Apr 11
2,397				2,397	504	800	250	250	500		150	150		150	685			685		Apr 12
2,393	0			2,393	500	800	250	300	550		845	680	0	680	685		0	685		Apr 13
2,389	0			2,389	496	800	250	300	550		845	680	0	680	685	0	0	685		Apr 14
2,915	250	0	0.50	3,165	491	800	250	300	550		845	680	0	680	685	0	0	685		Apr 15
2,911	300	0	1.09	3,211	487	800	250	300	550		845	680	0	680	685	0	0	685		Apr 16
2,906	300	0	1.69	3,206	483	800	250	300	550		845	680	0	680	685	0	0	685		Apr 17
2,902	300	0	2.28	3,202	478	800	250	60	310		845	680	0	680	685	0	0	685		Apr 18
2,898	300	0	2.88	3,198	474	800	250	60	310		845	680	0	680	955	0	0	955		Apr 19
2,893	300	0	3.47	3,193	469	800	250	60	310		845	680	0	680	955	0	0	955		Apr 20
3,159	60	0	3.59	3,219	465	800	250	50	300		845	680	0	680	955	0	0	955		Apr 21
3,154	60	0	3.71	3,214	461	800	250	50	300		845	680	0	680	955	0	0	955		Apr 22
3,150	60	0	3.83	3,210	456	800	250	45	295		845	680	0	680	955	0	0	955		Apr 23
3,146	50	0	3.93	3,196	452	800	250	0	250		845	690	0	690	955	0	0	955		Apr 24
3,141	50	0	4.03	3,191	448	800	250	0	250		845	1,300	0	1,300	415	0	0	415		Apr 25
3,147	45	0	4.12	3,192	443	800	250	0	250		845	1,300	0	1,300	415	0	0	415		Apr 26
3,213	0	0	4.12	3,213	439	800	250	0	250		845	1,300	0	1,300	415	0	0	415		Apr 27
3,208	0	0	4.12	3,208	435	800	250	0	250		845	1,300	0	1,300	415	0	0	415		Apr 28
3,204	0	0	4.12	3,204	430	800	250	0	250		845	1,300	0	1,300	415	0	0	415		Apr 29
3,200	0	0	4.12	3,200	426	800	250	0	250		845	1,300	0	1,300	415	0	0	415		Apr 30
3,195	0	0	4.12	3,195	421	800	250	0	250		845	800	0	800	954	0	0	954		May 01
3,191	0	0	4.12	3,191	417	800	250	0	250		845	800	0	800	954	0	0	954		May 02
3,225	0	0	4.12	3,225	413	800	250	0	250		845	800	0	800	954	0	0	954		May 03
3,221	0	0	4.12	3,221	408	800	250	0	250		845	800	0	800	954	0	0	954		May 04
3,217	0	0	4.12	3,217	404	800	250	0	250		845	800	0	800	954	0	0	954		May 05
3,212	0	0	4.12	3,212	400	800	250	0	250		845	800	0	800	954	0	0	954		May 06
3,208	0	0	4.12	3,208	395	800	250	0	250		845	800	0	800	954	0	0	954		May 07
3,204	0	0	4.12	3,204	391	800	250	0	250		845	800	0	800	954	0	0	954		May 08
3,199	0	0	4.12	3,199	386	800	250	0	250		845	800	0	800	954	0	0	954		May 09
3,195	0	0	4.12	3,195	382	800	250	0	250		845	800	0	800	954	0	0	954		May 10
3,190	0	0	4.12	3,190	378	800	250	0	250		845	800	0	800	954	0	0	954		May 11
3,186	0	0	4.12	3,186	373	800	250	0	250		845	800	0	800	954	0	0	954		May 12
3,182	0	0	4.12	3,182	369	800	250		250		845	800	0	800	954	0	0	954		May 13
3,177	0	0	4.12	3,177	365	800	250		250		500	450		450	954			954		May 14
3,173	0	0	4.12	3,173	361	800	250		250		350	300		300	954			954		May 15
2,819	0			2,819	357	800	250		250		250	175		175	954			954		May 16
2,665	0			2,665	353	800	250		250		175	175		175	954			954		May 17
2,536	0			2,536	349	800	250		250		175	175		175	954			954		May 18
2,532	0			2,532	345	800	250		250		175	175		175	954			954		May 19
2,528	0			2,528	341	800	250		250		175	175		175	954			954		May 20
2,524	0			2,524	337	800	250		250		175	175		175	954			954		May 21
2,520	0			2,520	333	800	250		250		175	175		175	954			954		May 22
2,516	0			2,516	329	800	250		250		175	175		175	954			954		May 23
2,512	0			2,512	325	800	250		250		175	175		175	954			954		May 24
2,508	0			2,508	321	800	250		250		175	175		175	954			954		May 25
2,504	0			2,504	317	800	250		250		175	175		175	954			954		May 26
2,500	0			2,500	313	800	250		250		175	175		175	954			954		May 27
2,496	0			2,496	309	800	250		250		175	175		175	954			954		May 28
2,492	0			2,492	305	800	250		250		175	175		175	954			954		May 29
2,488	0			2,488	301	800	250		250		175	175		175	954			954		May 30
2,484	0			2,484	297	800	250		250		140	140		140	954			954		May 31
					VAMP period															
3,133	67			3,200	435	800	250	67	317		845	851	0	851	798	0	0	798		Mean (cfs):
	4.12							4.12		0.00			0.00			0.00	0.00			Suppl. Water (TAF)

Pulse flow period

Period of desired flow stability

DAILY OPERATION PLAN, MARCH 22, 2002

Pulse Period: April 15–May 15 • Flow Target: 3,200cfs

Ungaged Flow at Vernalis = 400 cfs • (A) Low

	San Joaquin River near Vernalis							Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus River below Goodwin				
	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. Flow	Exch Contr VAMP Suppl. Flow	VAMP Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol. S=Stan.
	(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	
	[calc]	[calc]		[calc]	[calc]						[calc]				[calc]				[calc]	
Apr 01						290	400	250			250	150	150		150	637			637	
Apr 02						286	400	250			250	150	150		150	637			637	
Apr 03						283	400	250			250	150	150		150	637			637	
Apr 04	1,723				1,723	280	400	250			250	150	150		150	637			637	
Apr 05	1,720				1,720	276	400	250			250	150	150		150	637			637	
Apr 06	1,717				1,717	273	400	250			250	150	150		150	637			637	
Apr 07	1,713				1,713	270	400	250			250	150	150		150	637			637	
Apr 08	1,710				1,710	267	400	250			250	150	150		150	637			637	
Apr 09	1,707				1,707	263	400	250			250	150	150		150	637			637	
Apr 10	1,704				1,704	260	400	250			250	150	150		150	637			637	
Apr 11	1,700				1,700	257	400	250	50		300	150	150		150	637			637	
Apr 12	1,697				1,697	253	400	250	238	82	570	150	150		150	637			637	
Apr 13	1,694	0			1,694	250	400	250	248	82	580	945	945	0	945	637	393	0	1,030	
Apr 14	1,690	50			1,740	247	400	250	248	82	580	945	945	0	945	637	393	0	1,030	
Apr 15	2,482	713	0	1.41	3,195	243	400	250	258	82	590	945	945	0	945	637	393	0	1,030	
Apr 16	2,479	723	0	2.85	3,202	240	400	250	258	82	590	945	945	0	945	637	393	0	1,030	
Apr 17	2,475	723	0	4.28	3,198	237	400	250	268	82	600	945	945	0	945	637	393	0	1,030	
Apr 18	2,472	733	0	5.74	3,205	234	400	250	268	82	600	945	945	0	945	637	393	0	1,030	
Apr 19	2,469	733	0	7.19	3,202	230	400	250	268	82	600	945	945	0	945	637	393	0	1,030	
Apr 20	2,466	743	0	8.66	3,209	227	400	250	269	81	600	945	945	0	945	637	393	0	1,030	
Apr 21	2,462	743	0	10.14	3,205	224	400	250	269	81	600	945	945	0	945	637	393	0	1,030	
Apr 22	2,459	743	0	11.61	3,202	220	400	250	269	81	600	945	945	0	945	637	383	0	1,020	
Apr 23	2,456	743	0	13.08	3,199	217	400	250	269	81	600	945	945	0	945	637	383	0	1,020	
Apr 24	2,452	733	0	14.54	3,185	214	400	250	269	81	600	945	945	355	1,300	637	63	0	700	T
Apr 25	2,449	733	0	15.99	3,182	210	400	250	269	81	600	945	945	355	1,300	637	63	0	700	T
Apr 26	2,446	768	0	17.52	3,214	207	400	250	269	81	600	945	945	355	1,300	637	63	0	700	T, S
Apr 27	2,442	768	0	19.04	3,210	204	400	250	269	81	600	945	945	355	1,300	637	63	0	700	T, S
Apr 28	2,439	768	0	20.56	3,207	201	400	250	269	81	600	945	945	355	1,300	637	63	0	700	T, S
Apr 29	2,436	768	0	22.09	3,204	197	400	250	279	81	610	945	945	355	1,300	637	63	0	700	T, S
Apr 30	2,433	768	0	23.61	3,201	194	400	250	279	81	610	945	945	355	1,300	637	63	0	700	T, S
May 01	2,429	768	0	25.13	3,197	191	400	250	379	81	710	945	945	355	1,300	677	23	0	700	T, S
May 02	2,426	778	0	26.68	3,204	187	400	250	639	81	970	945	945	265	1,210	677	23	0	700	S
May 03	2,463	738	0	28.14	3,201	184	400	250	649	81	980	945	945	0	945	677	23	0	700	S
May 04	2,459	748	0	29.62	3,207	181	400	250	669	81	1,000	945	945	0	945	677	23	0	700	M
May 05	2,456	743	0	31.10	3,199	177	400	250	669	81	1,000	945	945	0	945	677	23	0	700	M
May 06	2,453	753	0	32.59	3,206	174	400	250	669	81	1,000	945	945	0	945	677	23	0	700	M
May 07	2,449	773	0	34.12	3,222	171	400	250	669	81	1,000	945	945	0	945	677	23	0	700	M
May 08	2,446	773	0	35.66	3,219	168	400	250	669	81	1,000	945	945	0	945	677	23	0	700	M
May 09	2,443	773	0	37.19	3,216	164	400	250	669	81	1,000	945	945	0	945	677	23	0	700	M
May 10	2,440	773	0	38.72	3,213	161	400	250	669	81	1,000	945	945	0	945	677	23	0	700	M
May 11	2,436	773	0	40.26	3,209	158	400	250	669	81	1,000	945	945	0	945	677	23	0	700	M
May 12	2,433	773	0	41.79	3,206	154	400	250	554	81	885	945	945	0	945	677	23	0	700	
May 13	2,430	773	0	43.32	3,203	151	400	250	200		450	945	945	0	945	677	23	0	700	
May 14	2,426	773	0	44.86	3,199	148	400	250			250	500	500		500	677			677	
May 15	2,423	658	0	46.16	3,081	144	400	250			250	350	350		350	677			677	
May 16	1,975	200			2,175	141	400	250			250	250	250		250	677			677	
May 17	1,821	0			1,821	138	400	250			250	175	175		175	677			677	
May 18	1,718	0			1,718	135	400	250			250	175	175		175	677			677	
May 19	1,640	0			1,640	131	400	250			250	175	175		175	677			677	
May 20	1,637	0			1,637	128	400	250			250	175	175		175	677			677	
May 21	1,633	0			1,633	125	400	250			250	175	175		175	677			677	
May 22	1,630	0			1,630	121	400	250			250	175	175		175	677			677	
May 23	1,627	0			1,627	118	400	250			250	175	175		175	677			677	
May 24	1,623	0			1,623	115	400	250			250	175	175		175	677			677	
May 25	1,620	0			1,620	111	400	250			250	175	175		175	677			677	
May 26	1,617	0			1,617	108	400	250			250	175	175		175	677			677	
May 27	1,613	0			1,613	105	400	250			250	175	175		175	677			677	
May 28	1,610	0			1,610	102	400	250			250	175	175		175	677			677	
May 29	1,607	0			1,607	98	400	250			250	175	175		175	677			677	
May 30	1,604	0			1,604	95	400	250			250	175	175		175	677			677	
May 31	1,600	0			1,600	92	400	250			250	140	140		140	677			677	
	VAMP period																			
Mean (cfs):	2,449	751			3,200	201	400	250	407	81	738	945	945	100	1,045	654	163	0	816	
Suppl. Water (TAF)	46.16							25.00	5.00				6.16			10.00	0.00			

Pulse flow period

Period of desired flow stability

DAILY OPERATION PLAN, MARCH 22, 2002

Pulse Period: April 15–May 15 • Flow Target: 3,200cfs

Ungaged Flow at Vernalis=600cfs • (B) High

San Joaquin River near Vernalis							Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus River below Goodwin					
Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. Flow	Exch Contr VAMP Suppl. Flow	VAMP Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol.	
(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		
[calc]	[calc]		[calc]	[calc]						[calc]				[calc]				[calc]		
					548	600	250			250	150	150		150	637			637		Apr 01
					544	600	250			250	150	150		150	637			637		Apr 02
					540	600	250			250	150	150		150	637			637		Apr 03
2,181				2,181	536	600	250			250	150	150		150	637			637		Apr 04
2,177				2,177	532	600	250			250	150	150		150	637			637		Apr 05
2,173				2,173	528	600	250			250	150	150		150	637			637		Apr 06
2,169				2,169	524	600	250			250	150	150		150	637			637		Apr 07
2,165				2,165	520	600	250			250	150	150		150	637			637		Apr 08
2,161				2,161	516	600	250			250	150	150		150	637			637		Apr 09
2,157				2,157	512	600	250			250	150	150		150	637			637		Apr 10
2,153				2,153	508	600	250	50		300	150	150		150	637			637		Apr 11
2,149				2,149	504	600	250	305	0	555	150	150		150	637			637		Apr 12
2,145	0			2,145	500	600	250	400	0	650	945	830	0	830	637		0	637		Apr 13
2,141	50			2,191	496	600	250	400	0	650	945	830	0	830	637	0	0	637		Apr 14
2,817	305	0	0.60	3,122	491	600	250	400	0	650	945	830	0	830	637	0	0	637		Apr 15
2,813	400	0	1.40	3,213	487	600	250	400	0	650	945	830	0	830	637	0	0	637		Apr 16
2,808	400	0	2.19	3,208	483	600	250	410	0	660	945	830	0	830	637	0	0	637		Apr 17
2,804	400	0	2.99	3,204	478	600	250	410	0	660	945	830	0	830	637	0	0	637		Apr 18
2,800	400	0	3.78	3,200	474	600	250	420	0	670	945	830	0	830	637	0	0	637		Apr 19
2,795	410	0	4.59	3,205	469	600	250	420	0	670	945	830	0	830	637	0	0	637		Apr 20
2,791	410	0	5.40	3,201	465	600	250	420	0	670	945	830	0	830	637	0	0	637		Apr 21
2,786	420	0	6.24	3,206	461	600	250	250	0	500	945	830	0	830	637	0	0	637		Apr 22
2,782	420	0	7.07	3,202	456	600	250	0	0	250	945	1,000	0	1,000	637	0	0	637		Apr 23
2,778	420	0	7.90	3,198	452	600	250	0	0	250	945	1,280	0	1,280	637	0	0	637	T	Apr 24
2,943	250	0	8.40	3,193	448	600	250	0	0	250	945	1,280	0	1,280	637	0	0	637	T	Apr 25
3,219	0	0	8.40	3,219	443	600	250	0	0	250	945	1,280	0	1,280	637	0	0	637	T, S	Apr 26
3,215	0	0	8.40	3,215	439	600	250	0	0	250	945	1,280	0	1,280	637	0	0	637	T, S	Apr 27
3,210	0	0	8.40	3,210	435	600	250	0	0	250	945	1,280	0	1,280	637	0	0	637	T, S	Apr 28
3,206	0	0	8.40	3,206	430	600	250	0	0	250	945	1,280	0	1,280	637	0	0	637	T, S	Apr 29
3,202	0	0	8.40	3,202	426	600	250	190	0	440	945	1,280	0	1,280	637	0	0	637	T, S	Apr 30
3,197	0	0	8.40	3,197	421	600	250	430	0	680	945	1,075	0	1,075	677	0	0	677	T, S	May 01
3,193	0	0	8.40	3,193	417	600	250	430	0	680	945	830	0	830	677	0	0	677	S	May 02
3,023	190	0	8.78	3,213	413	600	250	440	0	690	945	830	0	830	677	0	0	677	S	May 03
2,774	430	0	9.63	3,204	408	600	250	455	0	705	945	830	0	830	677	0	0	677	M	May 04
2,770	430	0	10.48	3,200	404	600	250	455	0	705	945	830	0	830	677	0	0	677	M	May 05
2,765	440	0	11.36	3,205	400	600	250	455	0	705	945	830	0	830	677	0	0	677	M	May 06
2,761	455	0	12.26	3,216	395	600	250	455	0	705	945	830	0	830	677	0	0	677	M	May 07
2,757	455	0	13.16	3,212	391	600	250	455	0	705	945	830	0	830	677	0	0	677	M	May 08
2,752	455	0	14.06	3,207	386	600	250	455	0	705	945	830	0	830	677	0	0	677	M	May 09
2,748	455	0	14.97	3,203	382	600	250	455	0	705	945	830	0	830	677	0	0	677	M	May 10
2,743	455	0	15.87	3,198	378	600	250	455	0	705	945	830	0	830	677	0	0	677	M	May 11
2,739	455	0	16.77	3,194	373	600	250	450	0	700	945	830	0	830	677	0	0	677		May 12
2,735	455	0	17.67	3,190	369	600	250	100		350	945	830	0	830	677	0	0	677		May 13
2,730	455	0	18.58	3,185	365	600	250			250	500	500		500	677			677		May 14
2,726	450	0	19.47	3,176	361	600	250			250	350	350		350	677			677		May 15
2,392	100			2,492	357	600	250			250	250	250		250	677			677		May 16
2,238	0			2,238	353	600	250			250	175	175		175	677			677		May 17
2,134	0			2,134	349	600	250			250	175	175		175	677			677		May 18
2,055	0			2,055	345	600	250			250	175	175		175	677			677		May 19
2,051	0			2,051	341	600	250			250	175	175		175	677			677		May 20
2,047	0			2,047	337	600	250			250	175	175		175	677			677		May 21
2,043	0			2,043	333	600	250			250	175	175		175	677			677		May 22
2,039	0			2,039	329	600	250			250	175	175		175	677			677		May 23
2,035	0			2,035	325	600	250			250	175	175		175	677			677		May 24
2,031	0			2,031	321	600	250			250	175	175		175	677			677		May 25
2,027	0			2,027	317	600	250			250	175	175		175	677			677		May 26
2,023	0			2,023	313	600	250			250	175	175		175	677			677		May 27
2,019	0			2,019	309	600	250			250	175	175		175	677			677		May 28
2,015	0			2,015	305	600	250			250	175	175		175	677			677		May 29
2,011	0			2,011	301	600	250			250	175	175		175	677			677		May 30
2,007	0			2,007	297	600	250			250	140	140		140	677			677		May 31
VAMP period																				
2,883	317			3,200	435	600	250	317	0	567	945	945	0	945	654	0	0	654		Mean (cfs):
	19.47							19.47	0.00				0.00			0.00	0.00			Suppl. Water (TAF)

Pulse flow period

Period of desired flow stability

DAILY OPERATION PLAN, MARCH 28, 2002

Pulse Period: April 15–May 15 • Flow Target: 3,200cfs

Ungaged Flow at Vernalis = 400cfs • (A) Low

	San Joaquin River near Vernalis							Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus River below Goodwin				
	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. Flow	Exch Contr VAMP Suppl. Flow	VAMP Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol. S=Stan.
	(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	
	[calc]	[calc]		[calc]	[calc]						[calc]				[calc]				[calc]	
Apr 01						290	400	250			250	150	150		150	637			637	
Apr 02						286	400	250			250	150	150		150	637			637	
Apr 03						283	400	250			250	150	150		150	637			637	
Apr 04	1,723				1,723	280	400	250			250	150	150		150	637			637	
Apr 05	1,720				1,720	276	400	250			250	150	150		150	637			637	
Apr 06	1,717				1,717	273	400	250			250	150	150		150	637			637	
Apr 07	1,713				1,713	270	400	250			250	150	150		150	637			637	
Apr 08	1,710				1,710	267	400	250			250	150	150		150	637			637	
Apr 09	1,707				1,707	263	400	250			250	150	150		150	637			637	
Apr 10	1,704				1,704	260	400	250			250	150	150		150	637			637	
Apr 11	1,700				1,700	257	400	250			250	150	150		150	637			637	
Apr 12	1,697				1,697	253	400	250	165	85	500	150	150		150	637			637	
Apr 13	1,694	0			1,694	250	400	250	190	85	525	945	760	0	760	800	480	0	1,280	
Apr 14	1,690	0			1,690	247	400	250	190	85	525	945	760	0	760	800	480	0	1,280	
Apr 15	2,460	730	0	1.45	3,190	243	400	250	190	85	525	945	760	0	760	800	480	0	1,280	
Apr 16	2,457	755	0	2.95	3,212	240	400	250	190	85	525	945	760	0	760	800	480	0	1,280	
Apr 17	2,453	755	0	4.44	3,208	237	400	250	200	85	535	945	760	0	760	800	480	0	1,280	
Apr 18	2,450	755	0	5.94	3,205	234	400	250	200	85	535	945	760	0	760	800	480	0	1,280	
Apr 19	2,447	755	0	7.44	3,202	230	400	250	200	85	535	945	760	0	760	800	480	0	1,280	
Apr 20	2,444	765	0	8.96	3,209	227	400	250	210	80	540	945	760	0	760	800	480	0	1,280	
Apr 21	2,440	765	0	10.47	3,205	224	400	250	210	80	540	945	760	0	760	800	480	0	1,280	
Apr 22	2,437	765	0	11.99	3,202	220	400	250	260	80	590	945	760	0	760	800	480	0	1,280	
Apr 23	2,434	770	0	13.52	3,204	217	400	250	260	80	590	945	970	10	980	790	240	0	1,030	
Apr 24	2,430	770	0	15.04	3,200	214	400	250	260	80	590	945	1,230	70	1,300	700	0	0	700	T
Apr 25	2,627	590	0	16.21	3,217	210	400	250	270	80	600	945	1,230	70	1,300	700	0	0	700	T
Apr 26	2,794	410	0	17.03	3,204	207	400	250	270	80	600	945	1,230	70	1,300	700	0	0	700	T, S
Apr 27	2,790	410	0	17.84	3,200	204	400	250	280	80	610	945	1,230	70	1,300	700	0	0	700	T, S
Apr 28	2,787	420	0	18.67	3,207	201	400	250	280	80	610	945	1,230	70	1,300	700	0	0	700	T, S
Apr 29	2,784	420	0	19.51	3,204	197	400	250	280	80	610	945	1,230	70	1,300	700	0	0	700	T, S
Apr 30	2,781	430	0	20.36	3,211	194	400	250	280	80	610	945	1,230	70	1,300	700	0	0	700	T, S
May 01	2,777	430	0	21.21	3,207	191	400	250	590	80	920	945	1,230	70	1,300	700	0	0	700	T, S
May 02	2,774	430	0	22.07	3,204	187	400	250	690	80	1,020	945	985	15	1,000	700	0	0	700	S
May 03	2,771	430	0	22.92	3,201	184	400	250	690	80	1,020	945	900	0	900	700	0	0	700	S
May 04	2,522	685	0	24.28	3,207	181	400	250	710	80	1,040	945	900	0	900	700	0	0	700	M
May 05	2,434	770	0	25.80	3,204	177	400	250	710	80	1,040	945	900	0	900	700	0	0	700	M
May 06	2,431	770	0	27.33	3,201	174	400	250	710	80	1,040	945	900	0	900	700	0	0	700	M
May 07	2,427	790	0	28.90	3,217	171	400	250	710	80	1,040	945	900	0	900	700	0	0	700	M
May 08	2,424	790	0	30.47	3,214	168	400	250	710	80	1,040	945	900	0	900	700	0	0	700	M
May 09	2,421	790	0	32.03	3,211	164	400	250	710	80	1,040	945	900	0	900	700	0	0	700	M
May 10	2,418	790	0	33.60	3,208	161	400	250	710	80	1,040	945	900	0	900	700	0	0	700	M
May 11	2,414	790	0	35.17	3,204	158	400	250	710	80	1,040	945	900	0	900	700	0	0	700	M
May 12	2,411	790	0	36.73	3,201	154	400	250	570	80	900	945	900	0	900	700	0	0	700	
May 13	2,408	790	0	38.30	3,198	151	400	250	200		450	945	900	0	900	700	0	0	700	
May 14	2,404	790	0	39.87	3,194	148	400	250			250	500	500		500	677			677	
May 15	2,401	650	0	41.16	3,051	144	400	250			250	350	350		350	677			677	
May 16	1,975	200			2,175	141	400	250			250	250	250		250	677			677	
May 17	1,821	0			1,821	138	400	250			250	175	175		175	677			677	
May 18	1,718	0			1,718	135	400	250			250	175	175		175	677			677	
May 19	1,640	0			1,640	131	400	250			250	175	175		175	677			677	
May 20	1,637	0			1,637	128	400	250			250	175	175		175	677			677	
May 21	1,633	0			1,633	125	400	250			250	175	175		175	677			677	
May 22	1,630	0			1,630	121	400	250			250	175	175		175	677			677	
May 23	1,627	0			1,627	118	400	250			250	175	175		175	677			677	
May 24	1,623	0			1,623	115	400	250			250	175	175		175	677			677	
May 25	1,620	0			1,620	111	400	250			250	175	175		175	677			677	
May 26	1,617	0			1,617	108	400	250			250	175	175		175	677			677	
May 27	1,613	0			1,613	105	400	250			250	175	175		175	677			677	
May 28	1,610	0			1,610	102	400	250			250	175	175		175	677			677	
May 29	1,607	0			1,607	98	400	250			250	175	175		175	677			677	
May 30	1,604	0			1,604	95	400	250			250	175	175		175	677			677	
May 31	1,600	0			1,600	92	400	250			250	140	140		140	677			677	
	VAMP period																			
Mean (cfs):	2,531	669			3,200	201	400	250	407	81	738	945	945	19	964	735	163	0	898	
Suppl. Water (TAF)		41.16							25.00	5.00				1.16			10.00	0.00		

Pulse flow period

Period of desired flow stability

DAILY OPERATION PLAN, MARCH 28, 2002

Pulse Period: April 15–May 15 • Flow Target: 4,450cfs

Ungaged Flow at Vernalis = 600cfs • (B) High

San Joaquin River near Vernalis							Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus River below Goodwin					
Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	MelD VAMP Suppl. Flow	Exch Contr VAMP Suppl. Flow	VAMP Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol.	
(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		
[calc]	[calc]		[calc]	[calc]						[calc]				[calc]				[calc]		
					548	600	250			250	150	150		150	685			685		Apr 01
					544	600	250			250	150	150		150	685			685		Apr 02
					540	600	250			250	150	150		150	685			685		Apr 03
2,229				2,229	536	600	250			250	150	150		150	685			685		Apr 04
2,225				2,225	532	600	250			250	150	150		150	685			685		Apr 05
2,221				2,221	528	600	250			250	150	150		150	685			685		Apr 06
2,217				2,217	524	600	250			250	150	150		150	685			685		Apr 07
2,213				2,213	520	600	250			250	150	150		150	685			685		Apr 08
2,209				2,209	516	600	250			250	150	150		150	685			685		Apr 09
2,205				2,205	512	600	250			250	150	150		150	685			685		Apr 10
2,201				2,201	508	600	250	150		400	150	150		150	685			685		Apr 11
2,197				2,197	504	600	250	465	85	800	150	150		150	685			685		Apr 12
2,193	0			2,193	500	600	250	570	85	905	945	945	15	960	1,295	205	0	1,500		Apr 13
2,189	150			2,339	496	600	250	570	85	905	945	945	15	960	1,295	205	0	1,500		Apr 14
3,590	770	0	1.53	4,360	491	600	250	570	85	905	945	945	15	960	1,295	205	0	1,500		Apr 15
3,586	875	0	3.26	4,461	487	600	250	580	85	915	945	945	15	960	1,295	205	0	1,500		Apr 16
3,581	875	0	5.00	4,456	483	600	250	580	85	915	945	945	15	960	1,295	205	0	1,500		Apr 17
3,577	875	0	6.73	4,452	478	600	250	600	85	935	945	945	15	960	1,295	205	0	1,500		Apr 18
3,573	885	0	8.49	4,458	474	600	250	600	85	935	945	945	15	960	1,295	205	0	1,500		Apr 19
3,568	885	0	10.24	4,453	469	600	250	600	80	930	945	945	15	960	1,295	205	0	1,500		Apr 20
3,564	905	0	12.04	4,469	465	600	250	420	80	750	945	945	15	960	1,295	205	0	1,500		Apr 21
3,559	905	0	13.83	4,464	461	600	250	270	80	600	945	945	200	1,145	1,295	205	0	1,500		Apr 22
3,555	900	0	15.62	4,455	456	600	250	270	80	600	945	945	355	1,300	1,295	205	0	1,500		Apr 23
3,551	905	0	17.41	4,456	452	600	250	330	80	660	945	945	355	1,300	1,295	205	0	1,500		Apr 24
3,546	910	0	19.22	4,456	448	600	250	360	80	690	945	945	355	1,300	1,295	150	0	1,445		Apr 25
3,542	910	0	21.02	4,452	443	600	250	360	80	690	945	945	355	1,300	1,295	135	0	1,430	T, S	Apr 26
3,538	915	0	22.84	4,453	439	600	250	360	80	690	945	945	355	1,300	1,295	135	0	1,430	T, S	Apr 27
3,533	930	0	24.68	4,463	435	600	250	360	80	690	945	945	355	1,300	1,295	135	0	1,430	T, S	Apr 28
3,529	930	0	26.53	4,459	430	600	250	370	80	700	945	945	355	1,300	1,295	135	0	1,430	T, S	Apr 29
3,525	930	0	28.37	4,455	426	600	250	370	80	700	945	945	355	1,300	1,295	135	0	1,430	T, S	Apr 30
3,520	930	0	30.22	4,450	421	600	250	375	80	705	945	945	355	1,300	1,295	135	0	1,430	T, S	May 01
3,516	940	0	32.08	4,456	417	600	250	540	80	870	945	945	355	1,300	1,295	135	0	1,430	S	May 02
3,511	940	0	33.95	4,451	413	600	250	640	80	970	945	945	200	1,145	1,295	135	0	1,430	S	May 03
3,507	945	0	35.82	4,452	408	600	250	670	80	1,000	945	945	100	1,045	1,295	135	0	1,430	M	May 04
3,503	955	0	37.72	4,458	404	600	250	670	80	1,000	945	945	95	1,040	1,295	135	0	1,430	M	May 05
3,498	955	0	39.61	4,453	400	600	250	670	80	1,000	945	945	95	1,040	1,295	135	0	1,430	M	May 06
3,494	980	0	41.55	4,474	395	600	250	670	80	1,000	945	945	95	1,040	1,295	135	0	1,430	M	May 07
3,490	980	0	43.50	4,470	391	600	250	670	80	1,000	945	945	95	1,040	1,295	135	0	1,430	M	May 08
3,485	980	0	45.44	4,465	386	600	250	670	80	1,000	945	945	95	1,040	1,295	135	0	1,430	M	May 09
3,481	980	0	47.39	4,461	382	600	250	670	80	1,000	945	945	95	1,040	1,295	135	0	1,430	M	May 10
3,476	980	0	49.33	4,456	378	600	250	670	80	1,000	945	945	95	1,040	1,295	135	0	1,430	M	May 11
3,472	980	0	51.27	4,452	373	600	250	570	80	900	945	945	95	1,040	1,295	135	0	1,430		May 12
3,468	980	0	53.22	4,448	369	600	250	200		450	945	945	95	1,040	1,295	135	0	1,430		May 13
3,463	980	0	55.16	4,443	365	600	250			250	500	500		500	723			723		May 14
3,459	880	0	56.91	4,339	361	600	250			250	350	350		350	723			723		May 15
2,438	200			2,638	357	600	250			250	250	250		250	723			723		May 16
2,284	0			2,284	353	600	250			250	175	175		175	723			723		May 17
2,180	0			2,180	349	600	250			250	175	175		175	723			723		May 18
2,101	0			2,101	345	600	250			250	175	175		175	723			723		May 19
2,097	0			2,097	341	600	250			250	175	175		175	723			723		May 20
2,093	0			2,093	337	600	250			250	175	175		175	723			723		May 21
2,089	0			2,089	333	600	250			250	175	175		175	723			723		May 22
2,085	0			2,085	329	600	250			250	175	175		175	723			723		May 23
2,081	0			2,081	325	600	250			250	175	175		175	723			723		May 24
2,077	0			2,077	321	600	250			250	175	175		175	723			723		May 25
2,073	0			2,073	317	600	250			250	175	175		175	723			723		May 26
2,069	0			2,069	313	600	250			250	175	175		175	723			723		May 27
2,065	0			2,065	309	600	250			250	175	175		175	723			723		May 28
2,061	0			2,061	305	600	250			250	175	175		175	723			723		May 29
2,057	0			2,057	301	600	250			250	175	175		175	723			723		May 30
2,053	0			2,053	297	600	250			250	140	140		140	723			723		May 31
VAMP period																				
3,525	925			4,450	435	600	250	519	81	850	945	945	163	1,108	1,295	163	0	1,458		Mean (cfs):
	56.91							31.91	5.00				10.00			10.00	0.00			Suppl. Water (TAF)

Pulse flow period

Period of desired flow stability

DAILY OPERATION PLAN, APRIL 8, 2002

Pulse Period: April 15–May 15 • Flow Target: 3,200cfs

Ungaged Flow at Vernalis = 400cfs

	San Joaquin River near Vernalis							Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus River below Goodwin				
	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. Flow	Exch Contr VAMP Suppl. Flow	VAMP Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol. S=Stan.
	(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	
	[calc]	[calc]		[calc]	[calc]						[calc]				[calc]				[calc]	
Apr 01					1,990	428	651	199			199	150	169		169	505			505	
Apr 02					1,810	422	476	189			189	150	171		171	504			504	
Apr 03					1,710	407	400	171			171	150	170		170	501			501	
Apr 04	1,660				1,660	390	364	173			173	150	172		172	504			504	
Apr 05	1,670				1,670	373	403	204			204	150	171		171	574			574	
Apr 06	1,710				1,710	324	473	213			213	150	172		172	603			603	
Apr 07	1,820				1,820	317	529	224			224	150	173		173	603			603	
Apr 08	1,923				1,923	314	620	250			250	150	150		150	637			637	
Apr 09	1,856				1,856	311	550	250			250	150	150		150	637			637	
Apr 10	1,825				1,825	309	500	250			250	150	150		150	637			637	
Apr 11	1,828				1,828	306	480	250			250	150	150		150	637			637	
Apr 12	1,806				1,806	303	460	250	0	0	250	150	150		150	637	363		1,000	
Apr 13	1,783	0			1,783	300	440	250	0	0	250	945	780	0	780	1,500	0	0	1,500	
Apr 14	1,760	363			2,123	297	420	250	0	0	250	945	780	0	780	1,500	0	0	1,500	
Apr 15	3,230	0	0	0.00	3,230	293	400	250	0	0	250	945	780	0	780	1,500	0	0	1,500	
Apr 16	3,227	0	0	0.00	3,227	290	400	250	0	0	250	945	780	0	780	1,500	0	0	1,500	
Apr 17	3,223	0	0	0.00	3,223	286	400	250	0	0	250	945	780	0	780	1,500	0	0	1,500	
Apr 18	3,220	0	0	0.00	3,220	283	400	250	0	0	250	945	780	0	780	1,500	0	0	1,500	
Apr 19	3,216	0	0	0.00	3,216	279	400	250	0	0	250	945	780	0	780	1,500	0	0	1,500	
Apr 20	3,213	0	0	0.00	3,213	276	400	250	0	0	250	945	780	0	780	1,500	0	0	1,500	
Apr 21	3,209	0	0	0.00	3,209	272	400	250	0	0	250	945	780	0	780	1,500	0	0	1,500	
Apr 22	3,206	0	0	0.00	3,206	269	400	250	240	0	490	945	780	0	780	1,500	0	0	1,500	
Apr 23	3,202	0	0	0.00	3,202	265	400	250	270	0	520	945	780	0	780	1,270	0	0	1,270	M
Apr 24	3,199	0	0	0.00	3,199	262	400	250	270	0	520	945	1,300	0	1,300	735	0	0	735	M,T
Apr 25	2,965	240	0	0.48	3,205	258	400	250	270	0	520	945	1,300	0	1,300	735	0	0	735	M,T
Apr 26	2,947	270	0	1.01	3,217	255	400	250	270	0	520	945	1,300	0	1,300	735	0	0	735	M,T,S
Apr 27	2,943	270	0	1.55	3,213	251	400	250	270	0	520	945	1,300	0	1,300	735	0	0	735	M,T,S
Apr 28	2,940	270	0	2.08	3,210	248	400	250	270	0	520	945	1,300	0	1,300	735	0	0	735	M,T,S
Apr 29	2,936	270	0	2.62	3,206	244	400	250	270	0	520	945	1,300	0	1,300	735	0	0	735	M,T,S
Apr 30	2,933	270	0	3.15	3,203	241	400	250	270	0	520	945	1,300	0	1,300	735	0	0	735	M,T,S
May 01	2,929	270	0	3.69	3,199	237	400	250	670	0	920	945	1,300	0	1,300	735	0	0	735	T,S
May 02	2,926	270	0	4.22	3,196	234	400	250	730	0	980	945	910	0	910	735	0	0	735	S
May 03	2,922	270	0	4.76	3,192	230	400	250	730	0	980	945	855	0	855	735	0	0	735	S
May 04	2,529	670	0	6.09	3,199	227	400	250	750	0	1,000	945	855	0	855	735	0	0	735	M
May 05	2,470	730	0	7.54	3,200	223	400	250	750	0	1,000	945	855	0	855	735	0	0	735	M
May 06	2,467	730	0	8.99	3,197	220	400	250	750	0	1,000	945	855	0	855	735	0	0	735	M
May 07	2,463	750	0	10.47	3,213	216	400	250	750	0	1,000	945	855	0	855	735	0	0	735	M
May 08	2,460	750	0	11.96	3,210	213	400	250	750	0	1,000	945	855	0	855	735	0	0	735	M
May 09	2,456	750	0	13.45	3,206	209	400	250	750	0	1,000	945	855	0	855	735	0	0	735	M
May 10	2,453	750	0	14.94	3,203	206	400	250	750	0	1,000	945	855	0	855	735	0	0	735	M
May 11	2,449	750	0	16.42	3,199	202	400	250	750	0	1,000	945	855	0	855	735	0	0	735	M
May 12	2,446	750	0	17.91	3,196	199	400	250	580	0	830	945	855	0	855	735	0	0	735	
May 13	2,442	750	0	19.40	3,192	195	400	250	170		420	945	855	0	855	735	0	0	735	
May 14	2,439	750	0	20.89	3,189	191	400	250			250	500	500		500	677			677	
May 15	2,435	580	0	22.04	3,015	187	400	250			250	350	350		350	677			677	
May 16	2,018	170			2,188	183	400	250			250	250	250		250	677			677	
May 17	1,864	0			1,864	179	400	250			250	175	175		175	677			677	
May 18	1,760	0			1,760	175	400	250			250	175	175		175	677			677	
May 19	1,681	0			1,681	171	400	250			250	175	175		175	677			677	
May 20	1,677	0			1,677	167	400	250			250	175	175		175	677			677	
May 21	1,673	0			1,673	163	400	250			250	175	175		175	677			677	
May 22	1,669	0			1,669	159	400	250			250	175	175		175	677			677	
May 23	1,665	0			1,665	155	400	250			250	175	175		175	677			677	
May 24	1,661	0			1,661	151	400	250			250	175	175		175	677			677	
May 25	1,657	0			1,657	147	400	250			250	175	175		175	677			677	
May 26	1,653	0			1,653	143	400	250			250	175	175		175	677			677	
May 27	1,649	0			1,649	139	400	250			250	175	175		175	677			677	
May 28	1,645	0			1,645	135	400	250			250	175	175		175	677			677	
May 29	1,641	0			1,641	131	400	250			250	175	175		175	677			677	
May 30	1,637	0			1,637	127	400	250			250	175	175		175	677			677	
May 31	1,633	0			1,633	123	400	250			250	140	140		140	677			677	
	VAMP period																			
Mean (cfs):	2,842	358			3,200	248	400	250	358	0	608	945	945	0	945	999	0	0	999	
Suppl. Water (TAF)		22.04							22.04	0.00				0.00			0.00	0.00		

Pulse flow period

Period of desired flow stability

DAILY OPERATION PLAN, APRIL 9, 2002

Pulse Period: April 15–May 15 • Flow Target: 3,200cfs

Ungaged Flow at Vernalis = 400cfs

San Joaquin River near Vernalis							Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus River below Goodwin					
Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. Flow	Exch Contr VAMP Suppl. Flow	VAMP Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol. S=Stan.	
(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		
[calc]	[calc]		[calc]	[calc]						[calc]				[calc]				[calc]		
				1,990	428	651	199			199	150	169		169	505			505		Apr 01
				1,810	422	476	189			189	150	171		171	504			504		Apr 02
				1,710	407	400	171			171	150	170		170	501			501		Apr 03
1,660				1,660	390	364	173			173	150	172		172	504			504		Apr 04
1,670				1,670	373	403	204			204	150	171		171	574			574		Apr 05
1,710				1,710	324	473	213			213	150	172		172	603			603		Apr 06
1,820				1,820	317	529	224			224	150	173		173	603			603		Apr 07
1,940				1,940	315	637	226			226	150	175		175	604			604		Apr 08
1,856				1,856	311	550	250			250	150	150		150	637			637		Apr 09
1,818				1,818	309	500	250			250	150	150		150	637			637		Apr 10
1,804				1,804	306	480	250			250	150	150		150	637			637		Apr 11
1,806				1,806	303	460	250	0	0	250	150	150	165	315	637	363		1,000		Apr 12
1,783	0			1,783	300	440	250	70	0	320	845	700	0	700	1,500	0	0	1,500		Apr 13
1,760	528			2,288	297	420	250	70	0	320	845	700	0	700	1,500	0	0	1,500		Apr 14
3,150	0	0	0.00	3,150	293	400	250	70	0	320	845	700	0	700	1,500	0	0	1,500		Apr 15
3,147	70	0	0.14	3,217	290	400	250	70	0	320	845	700	0	700	1,500	0	0	1,500		Apr 16
3,143	70	0	0.28	3,213	286	400	250	70	0	320	845	700	0	700	1,500	0	0	1,500		Apr 17
3,140	70	0	0.42	3,210	283	400	250	70	0	320	845	700	0	700	1,500	0	0	1,500		Apr 18
3,136	70	0	0.56	3,206	279	400	250	80	0	330	845	700	0	700	1,500	0	0	1,500		Apr 19
3,133	70	0	0.69	3,203	276	400	250	80	0	330	845	700	0	700	1,500	0	0	1,500		Apr 20
3,129	70	0	0.83	3,199	272	400	250	80	0	330	845	700	0	700	1,500	0	0	1,500		Apr 21
3,126	80	0	0.99	3,206	269	400	250	200	0	450	845	700	0	700	1,500	0	0	1,500		Apr 22
3,122	80	0	1.15	3,202	265	400	250	220	0	470	845	795	0	795	1,180	100	0	1,280	M	Apr 23
3,119	80	0	1.31	3,199	262	400	250	220	0	470	845	1,250	0	1,250	720	130	0	850	M,T	Apr 24
2,890	300	0	1.90	3,190	258	400	250	220	0	470	845	1,250	0	1,250	720	130	0	850	M,T	Apr 25
2,882	350	0	2.60	3,232	255	400	250	220	0	470	845	1,250	0	1,250	720	130	0	850	M,T	Apr 26
2,878	350	0	3.29	3,228	251	400	250	220	0	470	845	1,250	0	1,250	720	130	0	850	M,T	Apr 27
2,875	350	0	3.99	3,225	248	400	250	220	0	470	845	1,250	0	1,250	720	130	0	850	M,T	Apr 28
2,871	350	0	4.68	3,221	244	400	250	220	0	470	845	1,250	0	1,250	720	130	0	850	M,T	Apr 29
2,868	350	0	5.38	3,218	241	400	250	425	0	675	845	1,250	0	1,250	720	130	0	850	M,T	Apr 30
2,864	350	0	6.07	3,214	237	400	250	780	0	1,030	845	1,150	0	1,150	750	0	0	750	T,S	May 01
2,861	350	0	6.76	3,211	234	400	250	880	0	1,130	845	800	0	800	750	0	0	750	S	May 02
2,787	425	0	7.61	3,212	230	400	250	880	0	1,130	845	700	0	700	750	0	0	750	S	May 03
2,434	780	0	9.15	3,214	227	400	250	880	0	1,130	845	700	0	700	750	0	0	750	M,S	May 04
2,330	880	0	10.90	3,210	223	400	250	880	0	1,130	845	700	0	700	750	0	0	750	M,S	May 05
2,327	880	0	12.64	3,207	220	400	250	880	0	1,130	845	700	0	700	750	0	0	750	M,S	May 06
2,323	880	0	14.39	3,203	216	400	250	880	0	1,130	845	700	0	700	750	0	0	750	M,S	May 07
2,320	880	0	16.14	3,200	213	400	250	780	0	1,030	845	700	0	700	750	0	0	750	M,S	May 08
2,316	880	0	17.88	3,196	209	400	250	780	0	1,030	845	700	0	700	750	120	0	870	M	May 09
2,313	880	0	19.63	3,193	206	400	250	780	0	1,030	845	700	0	700	750	120	0	870	M	May 10
2,309	900	0	21.41	3,209	202	400	250	780	0	1,030	845	700	0	700	750	120	0	870	M	May 11
2,306	900	0	23.20	3,206	199	400	250	600	0	850	845	700	0	700	750	120	0	870		May 12
2,302	900	0	24.98	3,202	195	400	250	200		450	845	700	0	700	750	120	0	870		May 13
2,299	900	0	26.77	3,199	191	400	250			250	500	500		500	677			677		May 14
2,295	720	0	28.20	3,015	187	400	250			250	350	350		350	677			677		May 15
2,018	200			2,218	183	400	250			250	250	250		250	677			677		May 16
1,864	0			1,864	179	400	250			250	175	175		175	677			677		May 17
1,760	0			1,760	175	400	250			250	175	175		175	677			677		May 18
1,681	0			1,681	171	400	250			250	175	175		175	677			677		May 19
1,677	0			1,677	167	400	250			250	175	175		175	677			677		May 20
1,673	0			1,673	163	400	250			250	175	175		175	677			677		May 21
1,669	0			1,669	159	400	250			250	175	175		175	677			677		May 22
1,665	0			1,665	155	400	250			250	175	175		175	677			677		May 23
1,661	0			1,661	151	400	250			250	175	175		175	677			677		May 24
1,657	0			1,657	147	400	250			250	175	175		175	677			677		May 25
1,653	0			1,653	143	400	250			250	175	175		175	677			677		May 26
1,649	0			1,649	139	400	250			250	175	175		175	677			677		May 27
1,645	0			1,645	135	400	250			250	175	175		175	677			677		May 28
1,641	0			1,641	131	400	250			250	175	175		175	677			677		May 29
1,637	0			1,637	127	400	250			250	175	175		175	677			677		May 30
1,633	0			1,633	123	400	250			250	140	140		140	677			677		May 31
VAMP period																				
2,742	459			3,200	248	400	250	407	0	657	845	845	0	845	999	52	0	1,051		Mean (cfs):
	28.19							25.00	0.00				0.00			3.19	0.00			Suppl. Water (TAF)

Pulse flow period

Period of desired flow stability

DAILY OPERATION PLAN, APRIL 16, 2002

Pulse Period: April 15–May 15 • Flow Target: 3,200cfs

Ungaged Flow at Vernalis = 300cfs

	San Joaquin River near Vernalis							Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus River below Goodwin				
	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. Flow	Exch Contr VAMP Suppl. Flow	VAMP Flow (3-day lag)	FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol. S=Stan.
	(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	
	[calc]	[calc]		[calc]	[calc]						[calc]				[calc]				[calc]	
Apr 01					1,990	428	651	199			199	169	169		169	505			505	
Apr 02					1,810	422	476	189			189	171	171		171	504			504	
Apr 03					1,710	407	400	171			171	170	170		170	501			501	
Apr 04	1,660				1,660	390	364	173			173	172	172		172	504			504	
Apr 05	1,670				1,670	373	403	204			204	171	171		171	574			574	
Apr 06	1,710				1,710	324	473	213			213	172	172		172	603			603	
Apr 07	1,820				1,820	317	529	224			224	173	173		173	603			603	
Apr 08	1,940				1,940	315	637	226			226	175	175		175	604			604	
Apr 09	1,820				1,820	322	514	232			232	174	174		174	602			602	
Apr 10	1,810				1,810	296	492	242			242	170	170		170	644			644	
Apr 11	1,760				1,760	295	436	241			241	170	170		170	654			654	
Apr 12	1,760				1,760	301	418	242	0	0	242	325	322		322	637		152	789	
Apr 13	1,800	0			1,800	300	439	250	59	0	309	845	704	0	704	1,505	0	0	1,505	
Apr 14	2,068	0	152		2,220	276	567	250	68	0	318	845	708	0	708	1,504	0	0	1,504	
Apr 15	2,860	0	0	0.00	2,860	286	109	250	76	0	326	845	709	0	709	1,504	0	0	1,504	
Apr 16	3,038	59	0	0.12	3,097	290	300	250	70	0	320	845	800	0	800	1,500	0	0	1,500	
Apr 17	3,049	68	0	0.25	3,117	286	300	250	70	0	320	845	800	0	800	1,500	0	0	1,500	
Apr 18	3,140	76	0	0.40	3,216	283	300	250	70	0	320	845	800	0	800	1,500	0	0	1,500	
Apr 19	3,136	70	0	0.54	3,206	279	300	250	80	0	330	845	800	0	800	1,500	0	0	1,500	
Apr 20	3,133	70	0	0.68	3,203	276	300	250	80	0	330	845	800	0	800	1,500	0	0	1,500	
Apr 21	3,129	70	0	0.82	3,199	272	300	250	80	0	330	845	800	0	800	1,500	0	0	1,500	
Apr 22	3,126	80	0	0.98	3,206	269	300	250	150	0	400	845	850	0	850	1,500	0	0	1,500	
Apr 23	3,122	80	0	1.14	3,202	265	300	250	150	0	400	845	850	0	850	1,180	250	0	1,430	M
Apr 24	3,169	80	0	1.30	3,249	262	300	250	150	0	400	845	1,200	0	1,200	720	350	0	1,070	M,T
Apr 25	2,845	400	0	2.09	3,245	258	300	250	150	0	400	845	1,250	0	1,250	720	320	0	1,040	M,T
Apr 26	2,732	500	0	3.08	3,232	255	300	250	150	0	400	845	1,250	0	1,250	720	320	0	1,040	M,T
Apr 27	2,778	470	0	4.01	3,248	251	300	250	150	0	400	845	1,250	0	1,250	720	320	0	1,040	M,T
Apr 28	2,775	470	0	4.94	3,245	248	300	250	150	0	400	845	1,250	0	1,250	720	320	0	1,040	M,T
Apr 29	2,771	470	0	5.88	3,241	244	300	250	150	0	400	845	1,250	0	1,250	720	320	0	1,040	M,T
Apr 30	2,768	470	0	6.81	3,238	241	300	250	400	0	650	845	1,250	0	1,250	720	320	0	1,040	M,T
May 01	2,764	470	0	7.74	3,234	237	300	250	770	0	1,020	845	1,250	0	1,250	750	50	0	800	T,S
May 02	2,761	470	0	8.67	3,231	234	300	250	910	0	1,160	845	890	0	890	750	50	0	800	S
May 03	2,787	450	0	9.57	3,237	230	300	250	910	0	1,160	845	720	0	720	750	50	0	800	S
May 04	2,424	820	0	11.19	3,244	227	300	250	930	0	1,180	845	720	0	720	750	50	0	800	M,S
May 05	2,250	960	0	13.10	3,210	223	300	250	930	0	1,180	845	720	0	720	750	50	0	800	M,S
May 06	2,247	960	0	15.00	3,207	220	300	250	930	0	1,180	845	720	0	720	750	50	0	800	M,S
May 07	2,243	980	0	16.94	3,223	216	300	250	930	0	1,180	845	720	0	720	750	50	0	800	M,S
May 08	2,240	980	0	18.89	3,220	213	300	250	860	0	1,110	845	720	0	720	750	50	0	800	M,S
May 09	2,236	980	0	20.83	3,216	209	300	250	860	0	1,110	845	550	0	550	750	330	0	1,080	M
May 10	2,233	980	0	22.78	3,213	206	300	250	860	0	1,110	845	550	0	550	750	330	0	1,080	M
May 11	2,059	1,190	0	25.14	3,249	202	300	250	860	0	1,110	845	550	0	550	750	330	0	1,080	M
May 12	2,056	1,190	0	27.50	3,246	199	300	250	600	0	850	845	550	0	550	750	330	0	1,080	
May 13	2,052	1,190	0	29.86	3,242	195	300	250	200		450	845	550	0	550	750	330	0	1,080	
May 14	2,049	1,190	0	32.22	3,239	191	300	250			250	500	350		350	677			677	
May 15	2,045	930	0	34.06	2,975	187	300	250			250	350	250		250	677			677	
May 16	1,768	200			1,968	183	300	250			250	250	175		175	677			677	
May 17	1,664	0			1,664	179	300	250			250	175	175		175	677			677	
May 18	1,585	0			1,585	175	300	250			250	175	175		175	677			677	
May 19	1,581	0			1,581	171	300	250			250	175	175		175	677			677	
May 20	1,577	0			1,577	167	300	250			250	175	175		175	677			677	
May 21	1,573	0			1,573	163	300	250			250	175	175		175	677			677	
May 22	1,569	0			1,569	159	300	250			250	175	175		175	677			677	
May 23	1,565	0			1,565	155	300	250			250	175	175		175	677			677	
May 24	1,561	0			1,561	151	300	250			250	175	175		175	677			677	
May 25	1,557	0			1,557	147	300	250			250	175	175		175	677			677	
May 26	1,553	0			1,553	143	300	250			250	175	175		175	677			677	
May 27	1,549	0			1,549	139	300	250			250	175	175		175	677			677	
May 28	1,545	0			1,545	135	300	250			250	175	175		175	677			677	
May 29	1,541	0			1,541	131	300	250			250	175	175		175	677			677	
May 30	1,537	0			1,537	127	300	250			250	175	175		175	677			677	
May 31	1,533	0			1,533	123	300	250			250	140	140		140	677			677	
	VAMP period																			
Mean (cfs):	2,645	554			3,199	247	294	250	407	0	656	845	856	0	856	999	147	0	1,147	
Suppl. Water (TAF)		34.06							25.00	0.00				0.00			9.06	0.00		

Pulse flow period

Period of desired flow stability

DAILY OPERATION PLAN, APRIL 19, 2002

Pulse Period: April 15–May 15 • Flow Target: 3,200cfs

Ungaged Flow at Vernalis = 300cfs

San Joaquin River near Vernalis							Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus River below Goodwin					
Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. Flow	Exch Contr VAMP Suppl. Flow	VAMP Flow (3-day lag)	FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol. S=Stan.	
(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		
[calc]	[calc]		[calc]	[calc]						[calc]				[calc]				[calc]		
				1,990	428	651	199			199	169	169		169	505			505		Apr 01
				1,810	422	476	189			189	171	171		171	504			504		Apr 02
				1,710	407	400	171			171	170	170		170	501			501		Apr 03
1,660				1,660	390	364	173			173	172	172		172	504			504		Apr 04
1,670				1,670	373	403	204			204	171	171		171	574			574		Apr 05
1,710				1,710	324	473	213			213	172	172		172	603			603		Apr 06
1,810				1,820	317	519	224			224	173	173		173	603			603		Apr 07
1,930				1,930	315	627	226			226	175	175		175	604			604		Apr 08
1,820				1,820	322	514	232			232	174	174		174	602			602		Apr 09
1,800				1,800	296	482	242			242	170	170		170	644			644		Apr 10
1,750				1,750	295	426	241			241	170	170		170	654			654		Apr 11
1,750				1,750	301	408	242	0	0	242	325	322		322	637		152	789		Apr 12
1,790	0			1,790	300	429	250	59	0	309	845	704	0	704	1,505	0	0	1,505		Apr 13
2,048	0	152		2,200	276	547	250	68	0	318	845	708	0	708	1,504	0	0	1,504		Apr 14
2,839	0	0	0.00	2,839	286	88	250	76	0	326	845	709	0	709	1,504	0	0	1,504		Apr 15
2,901	59	0	0.12	2,960	274	163	250	78	0	328	845	782	0	782	1,503	0	0	1,503		Apr 16
2,922	68	0	0.25	2,990	285	173	250	117	0	367	845	806	0	806	1,508	0	0	1,508		Apr 17
3,054	76	0	0.40	3,130	253	245	250	118	0	368	845	804	0	804	1,503	0	0	1,503		Apr 18
3,149	78	0	0.56	3,227	279	300	250	80	0	330	845	800	0	800	1,500	0	0	1,500		Apr 19
3,110	117	0	0.79	3,227	276	300	250	80	0	330	845	800	0	800	1,500	0	0	1,500		Apr 20
3,129	118	0	1.02	3,247	272	300	250	80	0	330	845	800	0	800	1,500	0	0	1,500		Apr 21
3,126	80	0	1.18	3,206	269	300	250	120	0	370	845	800	0	800	1,500	0	0	1,500		Apr 22
3,122	80	0	1.34	3,202	265	300	250	150	0	400	845	800	0	800	1,180	320	0	1,500	M	Apr 23
3,119	80	0	1.50	3,199	262	300	250	150	0	400	845	1,300	0	1,300	720	290	0	1,010	M,T	Apr 24
2,795	440	0	2.37	3,235	258	300	250	150	0	400	845	1,300	0	1,300	720	280	0	1,000	M,T	Apr 25
2,832	440	0	3.24	3,272	255	300	250	150	0	400	845	1,300	0	1,300	720	280	0	1,000	M,T	Apr 26
2,828	430	0	4.10	3,258	251	300	250	150	0	400	845	1,300	0	1,300	720	280	0	1,000	M,T	Apr 27
2,825	430	0	4.95	3,255	248	300	250	150	0	400	845	1,300	0	1,300	720	280	0	1,000	M,T	Apr 28
2,821	430	0	5.80	3,251	244	300	250	150	0	400	845	1,300	0	1,300	720	280	0	1,000	M,T	Apr 29
2,818	430	0	6.66	3,248	241	300	250	375	0	625	845	1,300	0	1,300	720	280	0	1,000	T	Apr 30
2,814	430	0	7.51	3,244	237	300	250	780	0	1,030	845	1,300	0	1,300	750	0	0	750	T,S	May 01
2,811	430	0	8.36	3,241	234	300	250	1,025	60	1,335	845	885	0	885	750	0	0	750	M,S	May 02
2,837	375	0	9.11	3,212	230	300	250	1,050	35	1,335	845	600	0	600	750	0	0	750	M,S	May 03
2,419	780	0	10.65	3,199	227	300	250	1,050	35	1,335	845	600	0	600	750	0	0	750	M,S	May 04
2,130	1,085	0	12.81	3,215	223	300	250	1,050	35	1,335	845	600	0	600	750	0	0	750	M,S	May 05
2,127	1,085	0	14.96	3,212	220	300	250	1,050	35	1,335	845	600	0	600	750	0	0	750	M,S	May 06
2,123	1,085	0	17.11	3,208	216	300	250	1,050	35	1,335	845	600	0	600	750	0	0	750	M,S	May 07
2,120	1,085	0	19.26	3,205	213	300	250	650	0	900	845	600	0	600	750	0	0	750	S	May 08
2,116	1,085	0	21.41	3,201	209	300	250	650	0	900	845	575	0	575	750	550	0	1,300		May 09
2,113	1,085	0	23.57	3,198	206	300	250	650	0	900	845	575	0	575	750	550	0	1,300		May 10
2,084	1,200	0	25.95	3,284	202	300	250	650	0	900	845	550	0	550	750	550	0	1,300		May 11
2,081	1,200	0	28.33	3,281	199	300	250	650	0	900	845	550	0	550	750	550	0	1,300		May 12
2,052	1,200	0	30.71	3,252	195	300	250	200		450	845	550	0	550	750	550	0	1,300		May 13
2,049	1,200	0	33.09	3,249	191	300	250			250	500	450		450	677			677		May 14
2,045	1,200	0	35.47	3,245	187	300	250			250	350	350		350	677			677		May 15
1,868	200			2,068	183	300	250			250	250	250		250	677			677		May 16
1,764	0			1,764	179	300	250			250	175	175		175	677			677		May 17
1,660	0			1,660	175	300	250			250	175	175		175	677			677		May 18
1,581	0			1,581	171	300	250			250	175	175		175	677			677		May 19
1,577	0			1,577	167	300	250			250	175	175		175	677			677		May 20
1,573	0			1,573	163	300	250			250	175	175		175	677			677		May 21
1,569	0			1,569	159	300	250			250	175	175		175	677			677		May 22
1,565	0			1,565	155	300	250			250	175	175		175	677			677		May 23
1,561	0			1,561	151	300	250			250	175	175		175	677			677		May 24
1,557	0			1,557	147	300	250			250	175	175		175	677			677		May 25
1,553	0			1,553	143	300	250			250	175	175		175	677			677		May 26
1,549	0			1,549	139	300	250			250	175	175		175	677			677		May 27
1,545	0			1,545	135	300	250			250	175	175		175	677			677		May 28
1,541	0			1,541	131	300	250			250	175	175		175	677			677		May 29
1,537	0			1,537	127	300	250			250	175	175		175	677			677		May 30
1,533	0			1,533	123	300	250			250	140	140		140	677			677		May 31
VAMP period																				
2,623	577			3,200	245	283	250	407	8	664	845	845	0	845	1,000	163	0	1,162		Mean (cfs):
	35.47							25.00	0.47				0.00			10.00	0.00			Suppl. Water (TAF)

Pulse flow period

Period of desired flow stability

DAILY OPERATION PLAN, APRIL 25, 2002

Pulse Period: April 15–May 15 • Flow Target: 3,200cfs

Ungaged Flow at Vernalis = 300cfs

	San Joaquin River near Vernalis							Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus River below Goodwin				
	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. Flow	Exch Contr VAMP Suppl. Flow	VAMP Flow (3-day lag)	FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol. S=Stan.
	(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	
	[calc]	[calc]		[calc]	[calc]						[calc]				[calc]				[calc]	
Apr 01					1,990	428	651	199			199	169	169		169	505			505	
Apr 02					1,810	422	476	189			189	171	171		171	504			504	
Apr 03					1,710	407	400	171			171	170	170		170	501			501	
Apr 04	1,660				1,660	390	364	173			173	172	172		172	504			504	
Apr 05	1,670				1,670	373	403	204			204	171	171		171	574			574	
Apr 06	1,710				1,710	324	473	213			213	172	172		172	603			603	
Apr 07	1,810				1,820	317	519	224			224	173	173		173	603			603	
Apr 08	1,930				1,930	315	627	226			226	175	175		175	604			604	
Apr 09	1,820				1,820	322	514	232			232	174	174		174	602			602	
Apr 10	1,800				1,800	296	482	242			242	170	170		170	644			644	
Apr 11	1,750				1,750	295	426	241			241	170	170		170	654			654	
Apr 12	1,750				1,750	301	408	242	0	0	242	325	322		322	637		152	789	
Apr 13	1,790	0			1,790	300	429	250	59	0	309	845	704	0	704	1,505	0	0	1,505	
Apr 14	2,048	0	152		2,200	279	547	250	68	0	318	845	708	0	708	1,504	0	0	1,504	
Apr 15	2,839	0	0	0.00	2,839	292	88	250	76	0	326	845	709	0	709	1,504	0	0	1,504	
Apr 16	2,901	59	0	0.12	2,960	282	160	250	78	0	328	845	782	0	782	1,503	0	0	1,503	
Apr 17	2,922	68	0	0.25	2,990	295	167	250	117	0	367	845	806	0	806	1,508	0	0	1,508	
Apr 18	3,054	76	0	0.40	3,130	263	237	250	118	0	368	845	804	0	804	1,503	0	0	1,503	
Apr 19	3,121	78	0	0.56	3,199	265	262	250	124	0	374	845	807	0	807	1,502	0	0	1,502	
Apr 20	3,193	117	0	0.79	3,310	248	373	250	136	0	386	845	810	0	810	1,504	0	0	1,504	
Apr 21	3,252	118	0	1.02	3,370	261	428	250	141	0	391	845	810	0	810	1,503	0	0	1,503	
Apr 22	3,306	124	0	1.27	3,430	263	494	250	165	0	415	845	811	0	811	1,502	0	0	1,502	
Apr 23	3,114	136	0	1.54	3,250	291	290	250	171	0	421	845	838	0	838	1,180	324	0	1,504	M
Apr 24	3,079	141	0	1.82	3,220	276	253	250	167	0	417	845	1,310	0	1,310	720	360	0	1,080	M,T
Apr 25	2,859	489	0	2.79	3,348	258	300	250	150	0	400	845	1,300	0	1,300	720	280	0	1,000	M,T
Apr 26	2,856	531	0	3.84	3,387	255	300	250	150	0	400	845	1,300	0	1,300	720	280	0	1,000	M,T
Apr 27	2,828	447	0	4.73	3,275	251	300	250	150	0	400	845	1,300	0	1,300	720	230	0	950	M,T
Apr 28	2,825	430	0	5.58	3,255	248	300	250	150	0	400	845	1,300	0	1,300	720	230	0	950	M,T
Apr 29	2,821	380	0	6.34	3,201	244	300	250	150	0	400	845	1,300	0	1,300	720	230	0	950	M,T
Apr 30	2,818	380	0	7.09	3,198	241	300	250	350	0	600	845	1,300	0	1,300	720	230	0	950	T
May 01	2,814	380	0	7.84	3,194	237	300	250	780	0	1,030	845	1,300	0	1,300	750	0	0	750	T,S
May 02	2,811	380	0	8.60	3,191	234	300	250	1,050	0	1,300	845	895	0	895	750	0	0	750	M,S
May 03	2,837	350	0	9.29	3,187	230	300	250	1,050	0	1,300	845	600	0	600	750	0	0	750	M,S
May 04	2,429	780	0	10.84	3,209	227	300	250	1,050	0	1,300	845	600	0	600	750	0	0	750	M,S
May 05	2,130	1,050	0	12.92	3,180	223	300	250	1,050	0	1,300	845	600	0	600	750	0	0	750	M,S
May 06	2,127	1,050	0	15.00	3,177	220	300	250	1,050	0	1,300	845	600	0	600	750	0	0	750	M,S
May 07	2,123	1,050	0	17.09	3,173	216	300	250	1,050	0	1,300	845	600	0	600	750	0	0	750	M,S
May 08	2,120	1,050	0	19.17	3,170	213	300	250	600	0	850	845	600	0	600	750	0	0	750	S
May 09	2,116	1,050	0	21.25	3,166	209	300	250	600	0	850	845	575	0	575	750	540	0	1,290	
May 10	2,113	1,050	0	23.33	3,163	206	300	250	600	0	850	845	575	0	575	750	540	0	1,290	
May 11	2,084	1,140	0	25.59	3,224	202	300	250	600	0	850	845	550	0	550	750	540	0	1,290	
May 12	2,081	1,140	0	27.86	3,221	199	300	250	600	0	850	845	550	0	550	750	540	0	1,290	
May 13	2,052	1,140	0	30.12	3,192	195	300	250	200		450	845	550	0	550	750	540	0	1,290	
May 14	2,049	1,140	0	32.38	3,189	191	300	250			250	500	450		450	677			677	
May 15	2,045	1,140	0	34.64	3,185	187	300	250			250	350	350		350	677			677	
May 16	1,868	200			2,068	183	300	250			250	250	250		250	677			677	
May 17	1,764	0			1,764	179	300	250			250	175	175		175	677			677	
May 18	1,660	0			1,660	175	300	250			250	175	175		175	677			677	
May 19	1,581	0			1,581	171	300	250			250	175	175		175	677			677	
May 20	1,577	0			1,577	167	300	250			250	175	175		175	677			677	
May 21	1,573	0			1,573	163	300	250			250	175	175		175	677			677	
May 22	1,569	0			1,569	159	300	250			250	175	175		175	677			677	
May 23	1,565	0			1,565	155	300	250			250	175	175		175	677			677	
May 24	1,561	0			1,561	151	300	250			250	175	175		175	677			677	
May 25	1,557	0			1,557	147	300	250			250	175	175		175	677			677	
May 26	1,553	0			1,553	143	300	250			250	175	175		175	677			677	
May 27	1,549	0			1,549	139	300	250			250	175	175		175	677			677	
May 28	1,545	0			1,545	135	300	250			250	175	175		175	677			677	
May 29	1,541	0			1,541	131	300	250			250	175	175		175	677			677	
May 30	1,537	0			1,537	127	300	250			250	175	175		175	677			677	
May 31	1,533	0			1,533	123	300	250			250	140	140		140	677			677	
	VAMP period																			
Mean (cfs):	2,636	563			3,199	246	292	250	406	0	656	845	848	0	848	1,000	157	0	1,157	
Suppl. Water (TAF)		34.64							24.99	0.00				0.00			9.65	0.00		

Pulse flow period

Period of desired flow stability

DAILY OPERATION PLAN, MAY 9, 2002

Pulse Period: April 15–May 15 • Flow Target: 3,200cfs

Ungaged Flow at Vernalis = 450cfs

San Joaquin River near Vernalis							Merced River at Cressey				Tuolumne River at LaGrange				Stanislaus River below Goodwin					
Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	MeID VAMP Suppl. Flow	Exch Contr VAMP Suppl. Flow	VAMP Flow (3-day lag)	FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol. S=Stan.	
(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		
[calc]	[calc]		[calc]	[calc]						[calc]				[calc]				[calc]		
				1,990	428	651	199			199	169	169		169	505			505		Apr 01
				1,810	422	476	189			189	171	171		171	504			504		Apr 02
				1,710	407	400	171			171	170	170		170	501			501		Apr 03
1,660				1,660	390	364	173			173	172	172		172	504			504		Apr 04
1,670				1,670	373	403	204			204	171	171		171	574			574		Apr 05
1,710				1,710	324	473	213			213	172	172		172	603			603		Apr 06
1,810				1,820	317	519	224			224	173	173		173	603			603		Apr 07
1,930				1,930	315	627	226			226	175	175		175	604			604		Apr 08
1,820				1,820	322	514	232			232	174	174		174	602			602		Apr 09
1,800				1,800	296	482	242			242	170	170		170	644			644		Apr 10
1,750				1,750	295	426	241			241	170	170		170	654			654		Apr 11
1,750				1,750	301	408	242	0	0	242	325	322		322	637		152	789		Apr 12
1,790	0			1,790	300	429	250	59	0	309	845	704	0	704	1,505	0	0	1,505		Apr 13
2,048	0	152		2,200	279	547	250	68	0	318	845	708	0	708	1,504	0	0	1,504		Apr 14
2,839	0	0	0.00	2,839	292	88	250	76	0	326	845	709	0	709	1,504	0	0	1,504		Apr 15
2,901	59	0	0.12	2,960	282	160	250	78	0	328	845	782	0	782	1,503	0	0	1,503		Apr 16
2,922	68	0	0.25	2,990	295	167	250	117	0	367	845	806	0	806	1,508	0	0	1,508		Apr 17
3,054	76	0	0.40	3,130	263	237	250	118	0	368	845	804	0	804	1,503	0	0	1,503		Apr 18
3,121	78	0	0.56	3,199	265	262	250	124	0	374	845	807	0	807	1,502	0	0	1,502		Apr 19
3,193	117	0	0.79	3,310	248	373	250	136	0	386	845	810	0	810	1,504	0	0	1,504		Apr 20
3,252	118	0	1.02	3,370	261	428	250	141	0	391	845	810	0	810	1,503	0	0	1,503		Apr 21
3,306	124	0	1.27	3,430	263	494	250	165	0	415	845	811	0	811	1,502	0	0	1,502		Apr 22
3,114	136	0	1.54	3,250	291	290	250	171	0	421	845	838	0	838	1,180	324	0	1,504	M	Apr 23
3,079	141	0	1.82	3,220	276	253	250	167	0	417	845	1,310	0	1,310	720	360	0	1,080	M,T	Apr 24
2,811	489	0	2.79	3,300	253	252	250	157	0	407	845	1,310	0	1,310	720	285	0	1,005	M,T	Apr 25
2,879	531	0	3.84	3,410	237	323	250	169	0	419	845	1,290	0	1,290	720	285	0	1,005	M,T	Apr 26
2,997	452	0	4.74	3,449	244	464	250	168	0	418	845	1,310	0	1,310	720	234	0	954	M,T	Apr 27
3,047	442	0	5.62	3,489	252	550	250	164	0	414	845	1,310	0	1,310	720	231	0	951	M,T	Apr 28
3,207	403	0	6.41	3,610	266	683	250	173	0	423	845	1,310	0	1,310	720	231	0	951	M,T	Apr 29
3,171	399	0	7.21	3,570	231	639	250	412	0	662	845	1,310	0	1,310	720	139	0	859	T	Apr 30
2,995	395	0	7.99	3,390	158	449	250	798	0	1,048	845	1,260	0	1,260	756	0	0	756	T,S	May 01
2,998	312	0	8.61	3,310	33	487	250	1,074	0	1,324	845	897	0	897	754	0	0	754	M,S	May 02
2,948	412	0	9.43	3,360	36	524	250	1,116	0	1,366	845	612	0	612	753	0	0	753	M,S	May 03
2,592	798	0	11.01	3,390	64	658	250	1,120	0	1,370	845	599	0	599	752	0	0	752	M,S	May 04
2,346	1,074	0	13.14	3,420	113	695	250	1,102	0	1,352	845	594	0	594	752	0	0	752	M,S	May 05
2,373	1,116	0	15.35	3,489	121	708	250	1,078	0	1,328	845	598	0	598	754	0	0	754	M,S	May 06
2,330	1,120	0	17.57	3,450	128	621	250	1,076	0	1,326	845	600	0	600	759	0	0	759	M,S	May 07
2,248	1,102	0	19.76	3,350	174	525	250	722	0	972	845	599	0	599	759	0	0	759	S	May 08
2,237	1,078	0	21.90	3,315	120	500	250	600	0	850	845	575	0	575	750	350	0	1,100		May 09
2,282	1,076	0	24.03	3,358	120	500	250	600	0	850	845	575	0	575	750	350	0	1,100		May 10
2,195	1,072	0	26.16	3,267	120	500	250	600	0	850	845	550	0	550	750	350	0	1,100		May 11
2,195	950	0	28.04	3,145	120	500	250	600	0	850	845	550	0	550	750	350	0	1,100		May 12
2,170	950	0	29.93	3,120	120	500	250	200		450	845	550	0	550	750	350	0	1,100		May 13
2,170	950	0	31.81	3,120	120	500	250			250	500	450		450	677			677		May 14
2,170	950	0	33.70	3,120	120	500	250			250	350	350		350	677			677		May 15
1,997	200			2,197	120	500	250			250	250	250		250	677			677		May 16
1,897	0			1,897	120	500	250			250	175	175		175	677			677		May 17
1,797	0			1,797	120	500	250			250	175	175		175	677			677		May 18
1,722	0			1,722	120	500	250			250	175	175		175	677			677		May 19
1,722	0			1,722	120	500	250			250	175	175		175	677			677		May 20
1,722	0			1,722	120	500	250			250	175	175		175	677			677		May 21
1,722	0			1,722	120	500	250			250	175	175		175	677			677		May 22
1,722	0			1,722	120	500	250			250	175	175		175	677			677		May 23
1,722	0			1,722	120	500	250			250	175	175		175	677			677		May 24
1,722	0			1,722	120	500	250			250	175	175		175	677			677		May 25
1,722	0			1,722	120	500	250			250	175	175		175	677			677		May 26
1,722	0			1,722	120	500	250			250	175	175		175	677			677		May 27
1,722	0			1,722	120	500	250			250	175	175		175	677			677		May 28
1,722	0			1,722	120	500	250			250	175	175		175	677			677		May 29
1,722	0			1,722	120	500	250			250	175	175		175	677			677		May 30
1,722	0			1,722	120	500	250			250	140	140		140	677			677		May 31
VAMP period																				
2,747	548			3,295	201	446	250	424	0	674	845	848	0	848	1,002	124	0	1,125		Mean (cfs):
	33.70							26.08	0.00				0.00			7.61	0.00			Suppl. Water (TAF)

Pulse flow period

Period of desired flow stability

2002 VERNALIS ADAPTIVE MANAGEMENT PLAN (VAMP)

ACCOUNTING OF SUPPLEMENTAL WATER CONTRIBUTIONS

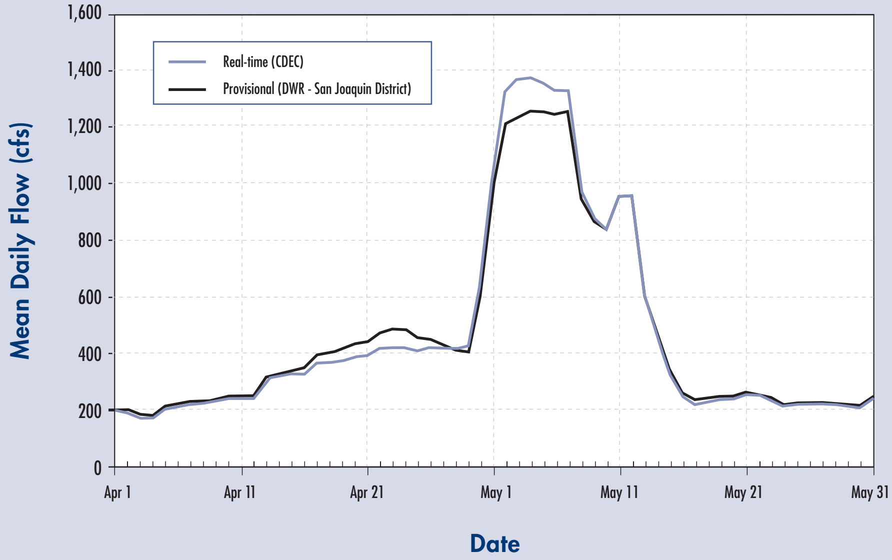
Hydrology Subgroup of the San Joaquin River Technical Committee

Pulse Flow Period: April 15–May 15

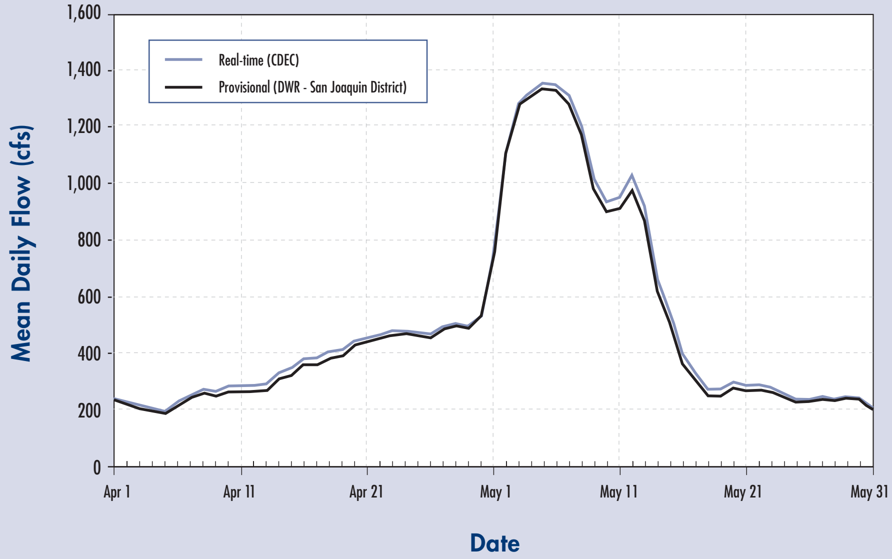
	Merced R. at Cressey (3 Day Travel Time to Vernalis)			Tuolumne R. below LaGrange Dam (2 Day Travel Time to Vernalis)			Stanislaus R. below Goodwin Dam (2 Day Travel Time to Vernalis)			SJRECWA (3 Day)	San Joaquin River at Vernalis		
	Existing Flow	Observed Flow	VAMP Suppl. Water	Existing Flow	Observed Flow	VAMP Suppl. Water	Existing Flow	Observed Flow	VAMP Suppl. Water	VAMP Suppl. Water	Existing Flow	Observed Flow	VAMP Suppl. Water
	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
Apr 01	197	197		169	169		505	505			1,990	1,990	
Apr 02	197	197		171	171		504	504			1,810	1,810	
Apr 03	182	182		170	170		501	501			1,710	1,710	
Apr 04	180	180		172	172		504	504			1,660	1,660	
Apr 05	210	210		171	171		574	574			1,670	1,670	
Apr 06	219	219		172	172		603	603			1,710	1,710	
Apr 07	229	229		173	173		603	603			1,810	1,810	
Apr 08	229	229		175	175		604	604			1,930	1,930	
Apr 09	235	235		174	174		602	602			1,820	1,820	
Apr 10	245	245		170	170		644	644			1,800	1,800	
Apr 11	246	246		170	170		654	654			1,750	1,750	
Apr 12	248	248	0	322	322		789	789		0	1,750	1,750	
Apr 13	250	314	64	704	704	0	1,505	1,505	0	0	1,790	1,790	
Apr 14	250	328	78	708	708	0	1,504	1,504	0	0	2,200	2,200	
Apr 15	250	340	90	709	709	0	1,504	1,504	0	0	2,839	2,839	0
Apr 16	250	347	97	782	782	0	1,503	1,503	0	0	2,896	2,960	64
Apr 17	250	393	143	807	807	0	1,508	1,508	0	0	2,912	2,990	78
Apr 18	250	401	151	804	804	0	1,503	1,503	0	0	3,040	3,130	90
Apr 19	250	411	161	807	807	0	1,502	1,502	0	0	3,103	3,200	97
Apr 20	250	429	179	810	810	0	1,504	1,504	0	0	3,167	3,310	143
Apr 21	250	439	189	810	810	0	1,503	1,503	0	0	3,219	3,370	151
Apr 22	250	472	222	811	811	0	1,502	1,502	0	0	3,269	3,430	161
Apr 23	250	482	232	838	838	0	1,180	1,504	324	0	3,071	3,250	179
Apr 24	250	481	231	1,310	1,310	0	720	1,080	360	0	3,031	3,220	189
Apr 25	250	453	203	1,310	1,310	0	720	1,005	285	0	2,754	3,300	546
Apr 26	250	447	197	1,290	1,290	0	720	1,005	285	0	2,818	3,410	592
Apr 27	250	427	177	1,310	1,310	0	720	954	234	0	2,933	3,449	516
Apr 28	250	406	156	1,310	1,310	0	720	951	231	0	3,001	3,489	488
Apr 29	250	400	150	1,310	1,310	0	720	951	231	0	3,179	3,610	431
Apr 30	250	612	362	1,310	1,310	0	720	859	139	0	3,162	3,570	408
May 01	250	976	726	1,260	1,260	0	756	756	0	0	3,003	3,390	387
May 02	250	1,210	960	897	897	0	754	754	0	0	3,021	3,310	289
May 03	250	1,230	980	620	620	0	753	753	0	0	2,998	3,360	362
May 04	250	1,250	1,000	607	607	0	752	752	0	0	2,664	3,390	726
May 05	250	1,250	1,000	603	603	0	752	752	0	0	2,470	3,430	960
May 06	250	1,240	990	607	607	0	754	754	0	0	2,520	3,500	980
May 07	250	1,250	1,000	608	608	0	759	759	0	0	2,459	3,459	1,000
May 08	250	937	687	607	607	0	759	759	0	0	2,360	3,360	1,000
May 09	250	862	612	584	584	0	750	1,066	316	0	2,250	3,240	990
May 10	250	833	583	591	591	0	750	1,101	351	0	2,170	3,170	1,000
May 11	250	954	704	567	567	0	750	1,113	363	0	2,287	3,290	1,003
May 12	250	956	706	566	566	0	750	1,101	351	0	2,397	3,360	963
May 13	250	595		553	553	0	750	1,106	356		2,454	3,400	946
May 14	250	463		456	456		1,107	1,107			2,155	3,210	1,055
May 15	250	335		358	358		1,105	1,105			1,868	2,930	1,062
May 16	254	254		265	265		1,105	1,105			2,345	2,690	
May 17	229	229		218	218		1,099	1,099			2,237	2,450	
May 18	234	234		219	219		1,104	1,104			2,275	2,360	
May 19	240	240		217	217		1,103	1,103			2,310	2,310	
May 20	243	243		224	224		1,095	1,095			2,340	2,340	
May 21	255	255		222	222		921	921			2,380	2,380	
May 22	248	248		218	218		899	899			2,310	2,310	
May 23	235	235		217	217		901	901			2,140	2,140	
May 24	212	212		216	216		903	903			2,120	2,120	
May 25	217	217		216	216		903	903			2,030	2,030	
May 26	217	217		217	217		901	901			2,100	2,100	
May 27	218	218		216	216		905	905			2,180	2,180	
May 28	214	214		217	217		903	903			2,080	2,080	
May 29	211	211		217	217		754	754			1,950	1,950	
May 30	209	209		223	223		581	581			1,910	1,910	
May 31	241	241		181	181		504	504			1,760	1,760	
Total Supplemental Water (TAF):			25.84			0.00			7.59	0.00			33.43
Pulse Period Average:											2,757	3,301	

Observed Flow Sources:
Merced River at Cressey (CA DWR B05155): DWR San Joaquin District, provisional data received July 2, 2002. • Tuolumne River below LaGrange Dam near LaGrange (USGS 11289650): USGS, provisional data dated July 1, 2002. • Stanislaus River below Goodwin Dam: Goodwin Reservoir Daily Operations report, OID/SSJID/Tri-Dams (published by USBR CVO) • San Joaquin River near Vernalis (USGS 11303500): USGS, provisional data dated July 1, 2002.

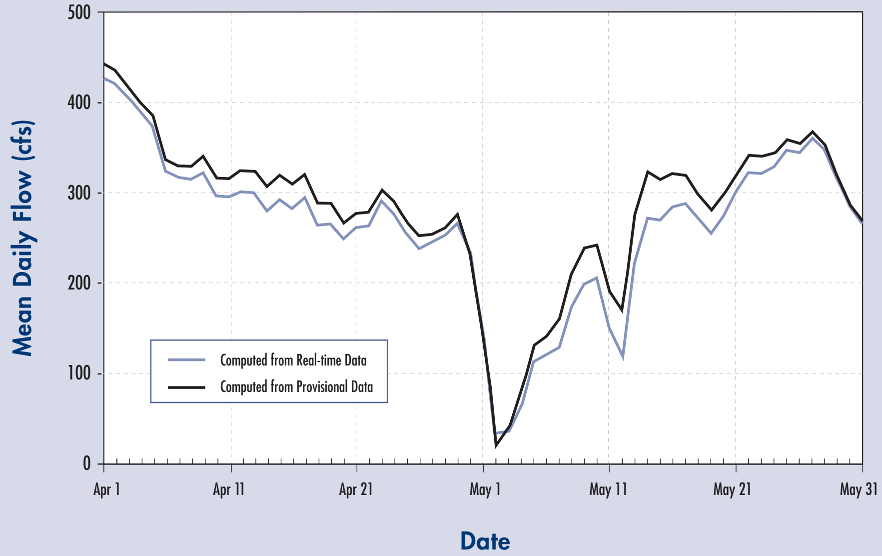
Merced River Near Cressey



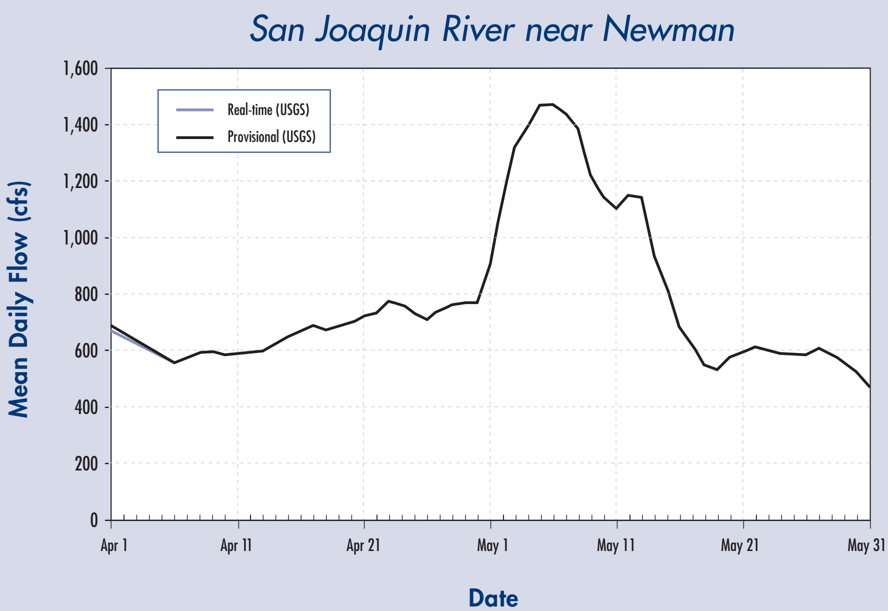
Merced River Near Stevinson

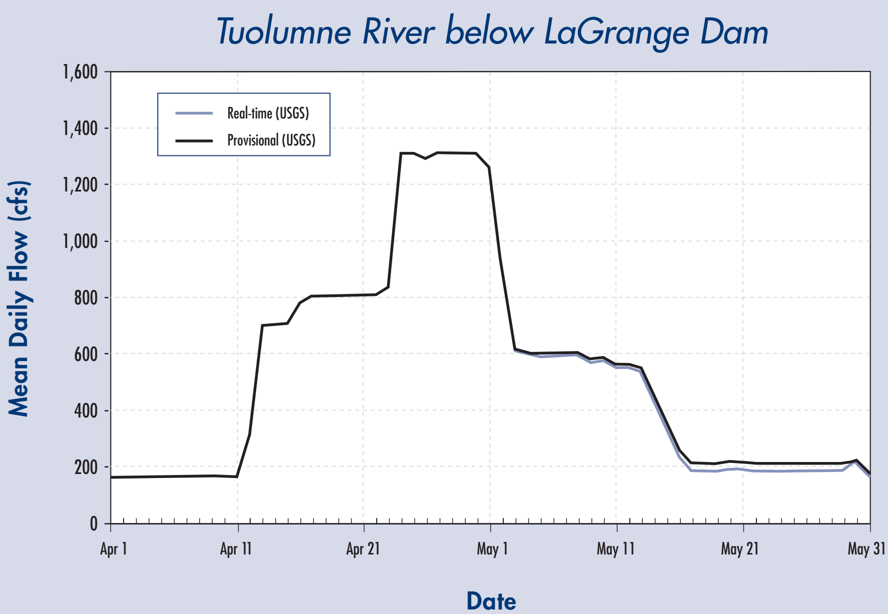


San Joaquin River Above Merced River



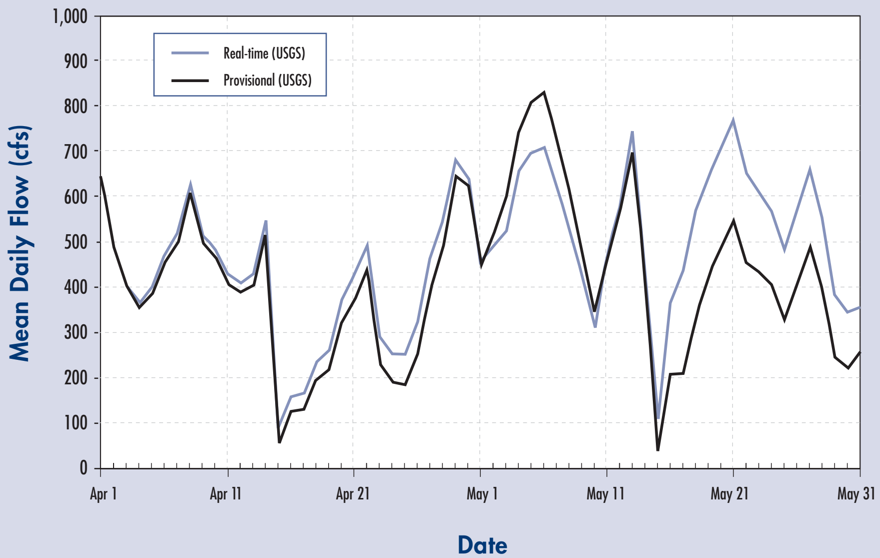
COMPARISON OF "REAL-TIME" AND PROVISIONAL FLOWS

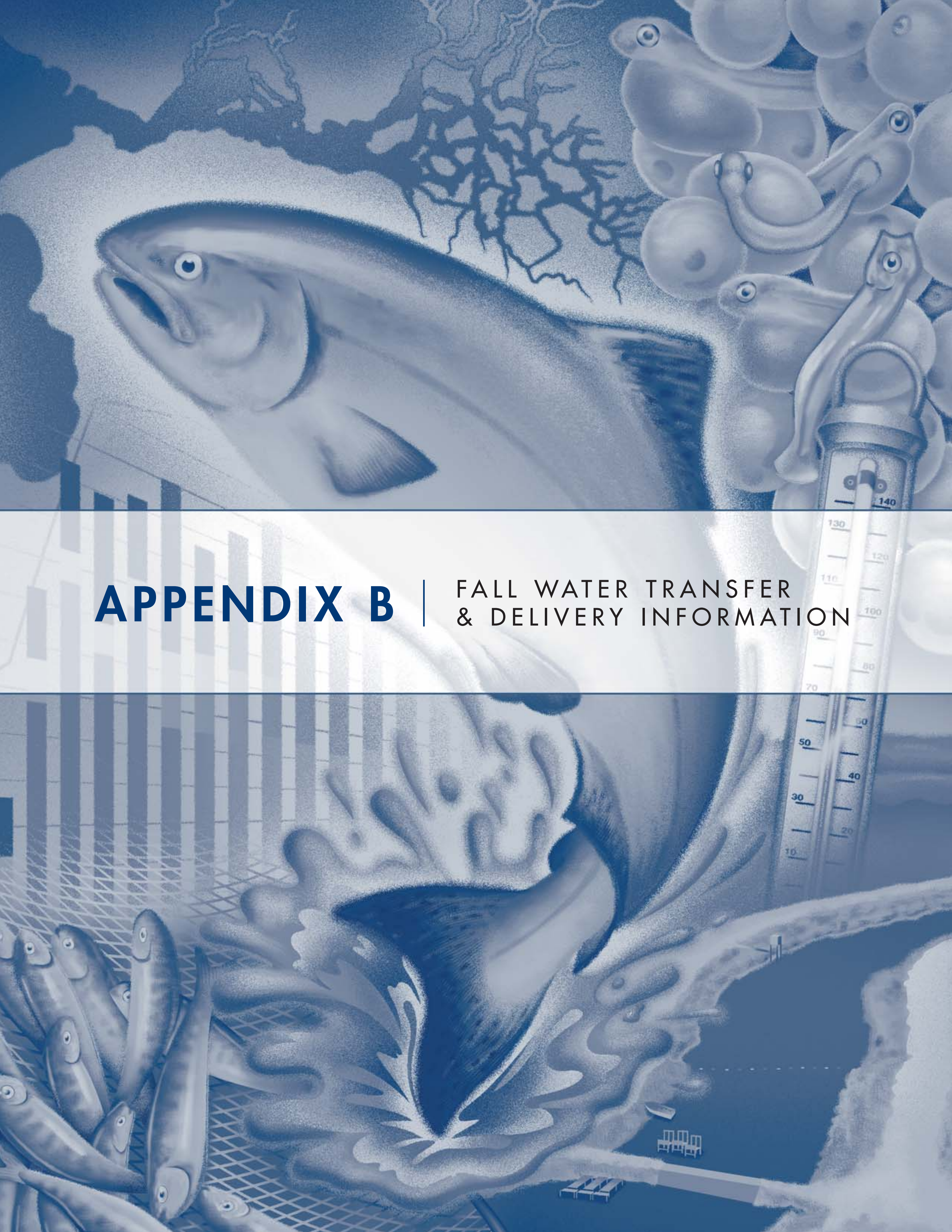




San Joaquin River near Vernalis

Ungaged Flow at Vernalis





APPENDIX B | FALL WATER TRANSFER & DELIVERY INFORMATION

MERCED IRRIGATION DISTRICT (PRELIMINARY)

2002 Fall SJRA Water Transfer • Daily Flow Schedule

	SJRA Transfer Water			
	Merced River at Cressey Base Flow	Flow	Cumulative Volume	Merced River at Cressey Target Flow
	(cfs)	(cfs)	(acre-feet)	(cfs)
Oct 01	30	0	0	30
Oct 02	30	0	0	30
Oct 03	30	0	0	30
Oct 04	30	0	0	30
Oct 05	30	0	0	30
Oct 06	30	0	0	30
Oct 07	30	0	0	30
Oct 08	30	0	0	30
Oct 09	30	0	0	30
Oct 10	30	0	0	30
Oct 11	30	0	0	30
Oct 12	30	0	0	30
Oct 13	30	0	0	30
Oct 14	30	0	0	30
Oct 15	30	220	436	250
Oct 16	85	350	1,131	435
Oct 17	85	625	2,370	710
Oct 18	85	625	3,610	710
Oct 19	85	625	4,850	710
Oct 20	85	625	6,089	710
Oct 21	85	625	7,329	710
Oct 22	85	625	8,569	710
Oct 23	85	625	9,808	710
Oct 24	85	390	10,582	475
Oct 25	85	240	11,058	325
Oct 26	85	120	11,296	205
Oct 27	85	120	11,534	205
Oct 28	85	120	11,772	205
Oct 29	85	120	12,010	205
Oct 30	85	120	12,248	205
Oct 31	85	120	12,486	205

MERCED IRRIGATION DISTRICT (FINAL)

2001 Fall Water Transfer • Daily Flow Summary

	Merced River Base Flow for SJRA Transfer Water (cfs)	Merced River at Cressey Observed Mean Daily Flow (cfs)	SJRA Transfer Water: SJRA Transfer Water (cfs)		SJRA Transfer Water: SJRA Transfer Water Cumulative Volume (ac-ft)	EWA Transfer Water: Observed Livingston Spill (cfs)	EWA Transfer Water: Livingston Spill Applied to Transfer (cfs)	EWA Transfer Water: Merced River Below Livingston Spill - for Transfer (cfs)	EWA Transfer Water: Total EWA Transfer Water Flow (cfs)		EWA Transfer Water: EWA Transfer Balance (ac-ft)
		DWR Provisional	Scheduled	Observed					Scheduled	Observed	
Oct 01	30	111	0	0	0	0	0	111	0	0	0
Oct 02	30	112	0	0	0	0	0	112	0	0	0
Oct 03	30	105	0	0	0	0	0	105	0	0	0
Oct 04	30	105	0	0	0	0	0	105	0	0	0
Oct 05	30	102	0	0	0	1	0	102	0	0	0
Oct 06	30	86	0	0	0	13	0	86	0	0	0
Oct 07	30	111	0	0	0	4	0	111	0	0	0
Oct 08	30	111	0	0	0	1	0	111	0	0	0
Oct 09	30	115	0	0	0	0	0	115	0	0	0
Oct 10	30	114	0	0	0	0	0	114	0	0	0
Oct 11	30	113	0	0	0	0	0	113	0	0	0
Oct 12	30	114	0	0	0	1	0	114	0	0	0
Oct 13	30	116	0	0	0	0	0	116	0	0	0
Oct 14	30	116	0	0	0	0	0	116	0	0	0
Oct 15	30	119	0	0	0	1	0	119	0	0	0
Oct 16	85	173	0	0	0	4	0	173	85	85	169
Oct 17	85	422	0	0	0	8	0	422	335	335	833
Oct 18	85	598	0	0	0	4	0	598	510	510	1,845
Oct 19	85	684	0	0	0	3	0	684	600	599	3,033
Oct 20	85	699	0	0	0	4	0	699	610	610	4,243
Oct 21	85	732	0	0	0	0	0	732	635	635	5,503
Oct 22	85	747	0	0	0	0	0	747	635	635	6,763
Oct 23	85	738	0	0	0	0	0	738	635	635	8,023
Oct 24	85	744	0	0	0	0	0	744	635	635	9,283
Oct 25	85	738	0	0	0	0	0	738	635	635	10,543
Oct 26	85	726	0	0	0	8	0	726	635	635	11,803
Oct 27	85	716	0	0	0	0	0	716	635	631	13,055
Oct 28	85	724	0	0	0	4	0	724	635	635	14,315
Oct 29	85	737	0	0	0	11	0	737	635	635	15,575
Oct 30	85	733	0	0	0	17	0	733	635	635	16,835
Oct 31	85	735	0	0	0	46	0	735	635	635	18,095
Nov 01	220	516	0	0	0	86	86	602	380	380	18,849
Nov 02	220	466	0	0	0	111	111	577	355	355	19,553
Nov 03	220	448	0	0	0	106	106	554	315	315	20,178
Nov 04	220	429	0	0	0	91	91	520	305	300	20,773
Nov 05	220	430	0	0	0	90	90	520	305	300	21,368
Nov 06	220	430	0	0	0	96	96	526	305	305	21,973
Nov 07	220	435	0	0	0	95	95	530	305	305	22,578
Nov 08	220	442	0	0	0	101	101	543	305	305	23,183
Nov 09	220	438	0	0	0	105	105	543	305	305	23,788
Nov 10	220	444	0	0	0	107	107	551	305	305	24,393
Nov 11	220	422	0	0	0	106	106	528	305	305	24,998
Nov 12	220	394	140	140	278	67	0	394	0	0	24,998
Nov 13	220	409	140	140	555	51	0	409	0	0	24,998
Nov 14	220	397	140	140	833	14	0	397	0	0	24,998
Nov 15	220	397	140	140	1,111	4	0	397	0	0	24,998

MERCED IRRIGATION DISTRICT (FINAL)

2001 Fall Water Transfer • Daily Flow Summary

Merced River Base Flow for SJRA Transfer Water (cfs)	Merced River at Cressey Observed Mean Daily Flow (cfs)	SJRA Transfer Water: SJRA Transfer Water (cfs)		SJRA Transfer Water: SJRA Transfer Water Cumulative Volume (ac-ft)	EWA Transfer Water: Observed Livingston Spill (cfs)	EWA Transfer Water: Livingston Spill Applied to Transfer (cfs)	EWA Transfer Water: Merced River Below Livingston Spill - for Transfer (cfs)	EWA Transfer Water: Total EWA Transfer Water Flow (cfs)		EWA Transfer Water: EWA Transfer Balance (ac-ft)	
	DWR Provisional	Scheduled	Observed					Scheduled	Observed		
220	397	140	140	1,388	0	0	397	0	0	24,998	Nov 16
220	402	140	140	1,666	0	0	402	0	0	24,998	Nov 17
220	401	140	140	1,944	0	0	401	0	0	24,998	Nov 18
220	402	140	140	2,221	0	0	402	0	0	24,998	Nov 19
220	412	140	140	2,499	0	0	412	0	0	24,998	Nov 20
220	410	140	140	2,777	0	0	410	0	0	24,998	Nov 21
220	411	140	140	3,055	0	0	411	0	0	24,998	Nov 22
220	408	140	140	3,332	0	0	408	0	0	24,998	Nov 23
220	423	140	140	3,610	0	0	423	0	0	24,998	Nov 24
220	431	140	140	3,888	1	0	431	0	0	24,998	Nov 25
220	419	140	140	4,165	2	0	419	0	0	24,998	Nov 26
220	416	120	120	4,403	0	0	416	0	0	24,998	Nov 27
220	420	120	120	4,641	0	0	420	0	0	24,998	Nov 28
220	424	120	120	4,879	0	0	424	0	0	24,998	Nov 29
220	428	120	120	5,117	0	0	428	0	0	24,998	Nov 30
220	435	120	120	5,355	0	0	435	0	0	24,998	Dec 01
220	426	120	120	5,593	0	0	426	0	0	24,998	Dec 02
220	448	120	120	5,831	3	0	448	0	0	24,998	Dec 03
220	422	120	120	6,069	2	0	422	0	0	24,998	Dec 04
220	416	120	120	6,307	1	0	416	0	0	24,998	Dec 05
220	414	120	120	6,545		0	414	0	0	24,998	Dec 06
220	409	120	120	6,783		0	409	0	0	24,998	Dec 07
220	410	120	120	7,021		0	410	0	0	24,998	Dec 08
220	404	120	120	7,260		0	404	0	0	24,998	Dec 09
220	401	120	120	7,498		0	401	0	0	24,998	Dec 10
220	415	120	120	7,736		0	415	0	0	24,998	Dec 11
220	407	120	120	7,974		0	407	0	0	24,998	Dec 12
220	396	120	120	8,212		0	396	0	0	24,998	Dec 13
220	405	120	120	8,450		0	405	0	0	24,998	Dec 14
220	398	120	120	8,688		0	398	0	0	24,998	Dec 15
220	393	120	120	8,926		0	393	0	0	24,998	Dec 16
220	394	120	120	9,164		0	394	0	0	24,998	Dec 17
220	395	120	120	9,402		0	395	0	0	24,998	Dec 18
220	393	120	120	9,640		0	393	0	0	24,998	Dec 19
220	401	120	120	9,878		0	401	0	0	24,998	Dec 20
220	429	120	120	10,116		0	429	0	0	24,998	Dec 21
220	425	120	120	10,354		0	425	0	0	24,998	Dec 22
220	415	120	120	10,592		0	415	0	0	24,998	Dec 23
220	406	120	120	10,830		0	406	0	0	24,998	Dec 24
220	406	120	120	11,068		0	406	0	0	24,998	Dec 25
220	403	120	120	11,306		0	403	0	0	24,998	Dec 26
220	400	120	120	11,544		0	400	0	0	24,998	Dec 27
220	403	120	120	11,782		0	403	0	0	24,998	Dec 28
220	996	120	120	12,020		0	996	0	0	24,998	Dec 29
220	1,400	120	120	12,258		0	1,400	0	0	24,998	Dec 30
220	1,030	120	120	12,496		0	1,030	0	0	24,998	Dec 31

OAKDALE IRRIGATION DISTRICT (PRELIMINARY)

Daily Schedule of Additional Water Release
Additional Water Available: 22,205 acre-feet

Subject to change

	DFG Base Fish Flow (cfs)	Total Fish Release (cfs)	Scheduled Flow (cfs)	Scheduled Cumulative Volume (ac-ft)
			Oakdale ID Additional Water	
Oct 19 '02	200	200	0	0
Oct 20 '02	200	350	150	298
Oct 21 '02	200	600	400	1,091
Oct 22 '02	200	700	500	2,083
Oct 23 '02	200	700	500	3,074
Oct 24 '02	200	700	500	4,066
Oct 25 '02	200	700	500	5,058
Oct 26 '02	200	700	500	6,050
Oct 27 '02	200	700	500	7,041
Oct 28 '02	200	450	250	7,537
Oct 29 '02	200	250	50	7,636
Oct 30 '02	200	250	50	7,736
Oct 31 '02	200	250	50	7,835
Nov 01 '02	200	250	50	7,934
Nov 02 '02	200	250	50	8,033
Nov 03 '02	200	250	50	8,132
Nov 04 '02	200	250	50	8,231
Nov 05 '02	200	250	50	8,331
Nov 06 '02	200	250	50	8,430
Nov 07 '02	200	275	75	8,579
Nov 08 '02	200	300	100	8,777
Nov 09 '02	200	300	100	8,975
Nov 10 '02	200	300	100	9,174
Nov 11 '02	200	300	100	9,372
Nov 12 '02	200	300	100	9,570
Nov 13 '02	200	300	100	9,769
Nov 14 '02	200	300	100	9,967
Nov 15 '02	200	300	100	10,165
Nov 16 '02	200	300	100	10,364
Nov 17 '02	200	300	100	10,562
Nov 18 '02	200	300	100	10,760
Nov 19 '02	200	300	100	10,959
Nov 20 '02	200	300	100	11,157
Nov 21 '02	200	300	100	11,355
Nov 22 '02	200	300	100	11,554
Nov 23 '02	200	300	100	11,752
Nov 24 '02	200	300	100	11,950
Nov 25 '02	200	300	100	12,149
Nov 26 '02	200	300	100	12,347
Nov 27 '02	200	300	100	12,545
Nov 28 '02	200	300	100	12,744
Nov 29 '02	200	300	100	12,942
Nov 30 '02	200	300	100	13,140
Dec 01 '02	200	275	75	13,289
Dec 02 '02	200	275	75	13,438

OAKDALE IRRIGATION

Daily Schedule of
Additional Water Available:

	DFG Base Fish Flow (cfs)	Total Fish Release (cfs)
Dec 03 '02	200	275
Dec 04 '02	200	275
Dec 05 '02	200	275
Dec 06 '02	200	275
Dec 07 '02	200	275
Dec 08 '02	200	275
Dec 09 '02	200	275
Dec 10 '02	200	275
Dec 11 '02	200	275
Dec 12 '02	200	275
Dec 13 '02	200	275
Dec 14 '02	200	275
Dec 15 '02	200	275
Dec 16 '02	200	275
Dec 17 '02	200	275
Dec 18 '02	200	275
Dec 19 '02	200	275
Dec 20 '02	200	275
Dec 21 '02	200	275
Dec 22 '02	200	275
Dec 23 '02	200	275
Dec 24 '02	200	275
Dec 25 '02	200	275
Dec 26 '02	200	275
Dec 27 '02	200	275
Dec 28 '02	200	275
Dec 29 '02	200	275
Dec 30 '02	200	275
Dec 31 '02	200	275
Jan 01 '03	175	225
Jan 02 '03	175	225
Jan 03 '03	175	225
Jan 04 '03	175	225
Jan 05 '03	175	225
Jan 06 '03	175	225
Jan 07 '03	175	225
Jan 08 '03	175	225
Jan 09 '03	175	225
Jan 10 '03	175	225
Jan 11 '03	175	225
Jan 12 '03	175	225
Jan 13 '03	175	225
Jan 14 '03	175	225
Jan 15 '03	175	225
Jan 16 '03	175	225

DISTRICT (PRELIMINARY)

Additional Water Release
22,205 acre-feet

Subject to change

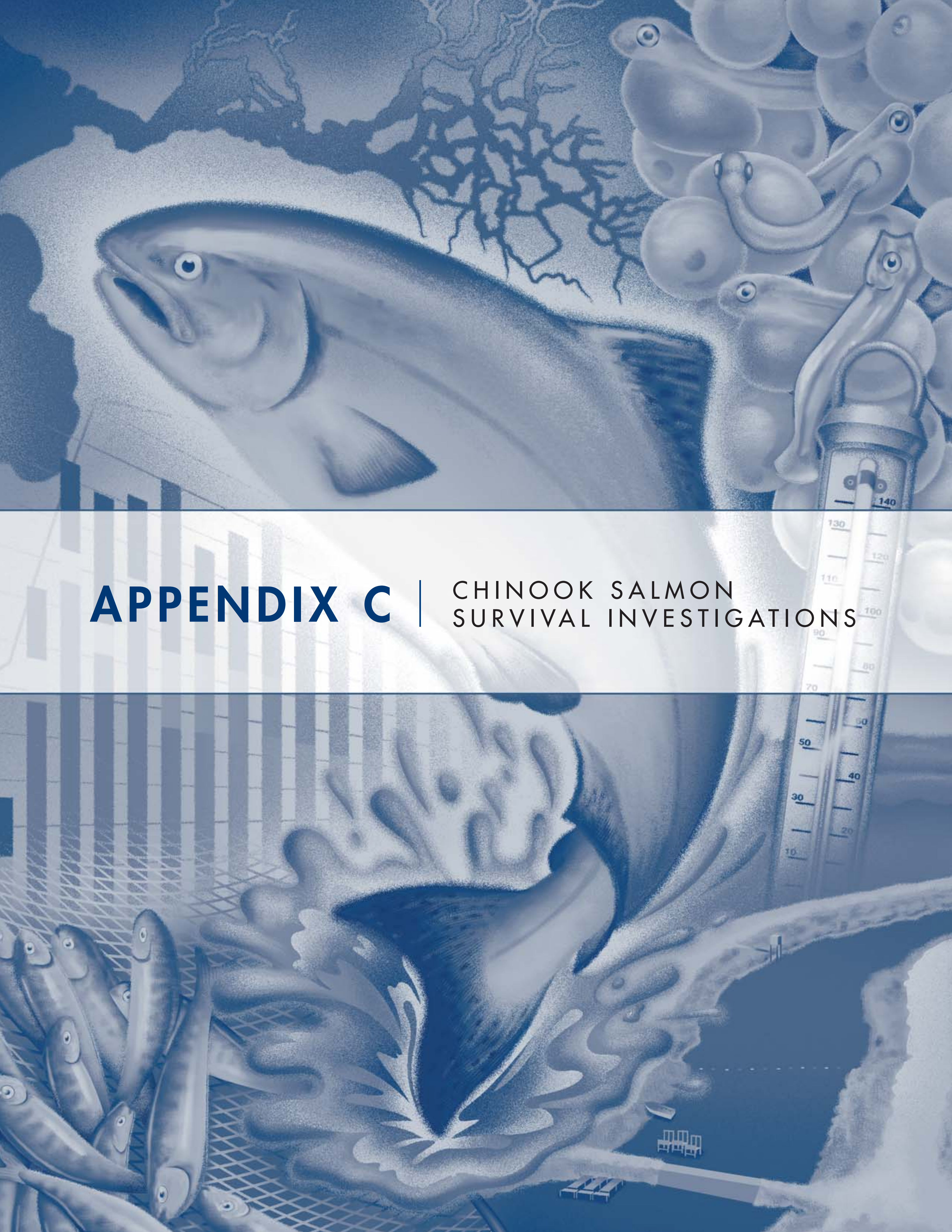
Scheduled Flow (cfs)	Scheduled Cumulative Volume (ac-ft)	
Oakdale ID Additional Water		
75	13,587	Dec 03 '02
75	13,736	Dec 04 '02
75	13,884	Dec 05 '02
75	14,033	Dec 06 '02
75	14,182	Dec 07 '02
75	14,331	Dec 08 '02
75	14,479	Dec 09 '02
75	14,628	Dec 10 '02
75	14,777	Dec 11 '02
75	14,926	Dec 12 '02
75	15,074	Dec 13 '02
75	15,223	Dec 14 '02
75	15,372	Dec 15 '02
75	15,521	Dec 16 '02
75	15,669	Dec 17 '02
75	15,818	Dec 18 '02
75	15,967	Dec 19 '02
75	16,116	Dec 20 '02
75	16,264	Dec 21 '02
75	16,413	Dec 22 '02
75	16,562	Dec 23 '02
75	16,711	Dec 24 '02
75	16,859	Dec 25 '02
75	17,008	Dec 26 '02
75	17,157	Dec 27 '02
75	17,306	Dec 28 '02
75	17,455	Dec 29 '02
75	17,603	Dec 30 '02
75	17,752	Dec 31 '02
50	17,851	Jan 01 '03
50	17,950	Jan 02 '03
50	18,050	Jan 03 '03
50	18,149	Jan 04 '03
50	18,248	Jan 05 '03
50	18,347	Jan 06 '03
50	18,446	Jan 07 '03
50	18,545	Jan 08 '03
50	18,645	Jan 09 '03
50	18,744	Jan 10 '03
50	18,843	Jan 11 '03
50	18,942	Jan 12 '03
50	19,041	Jan 13 '03
50	19,140	Jan 14 '03
50	19,240	Jan 15 '03
50	19,339	Jan 16 '03

OAKDALE IRRIGATION DISTRICT (PRELIMINARY)

Daily Schedule of Additional Water Release
Additional Water Available: 22,205 acre-feet

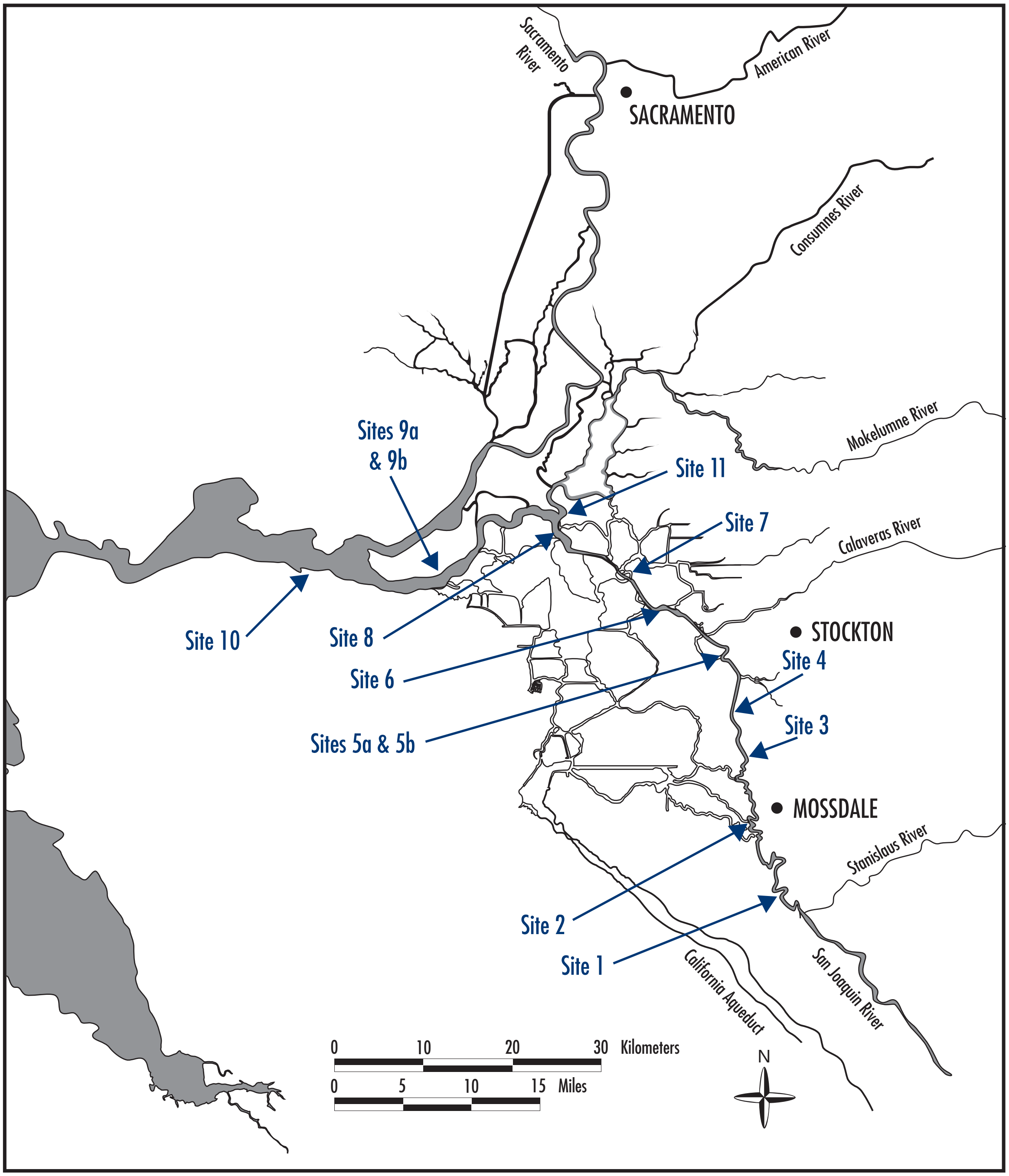
Subject to change

DFG Base Fish Flow (cfs)	Scheduled Total Fish Release (cfs)	Scheduled Flow (cfs)	Scheduled Cumulative Volume (ac-ft)	
		Oakdale ID Additional Water		
175	225	50	19,438	Jan 17 '03
175	225	50	19,537	Jan 18 '03
175	225	50	19,636	Jan 19 '03
175	225	50	19,736	Jan 20 '03
175	225	50	19,835	Jan 21 '03
175	225	50	19,934	Jan 22 '03
175	225	50	20,033	Jan 23 '03
175	225	50	20,132	Jan 24 '03
175	225	50	20,231	Jan 25 '03
175	225	50	20,331	Jan 26 '03
175	225	50	20,430	Jan 27 '03
175	225	50	20,529	Jan 28 '03
175	225	50	20,628	Jan 29 '03
175	225	50	20,727	Jan 30 '03
175	200	25	20,777	Jan 31 '03
150	200	50	20,876	Feb 01 '03
150	175	25	20,926	Feb 02 '03
150	175	25	20,975	Feb 03 '03
150	175	25	21,025	Feb 04 '03
150	175	25	21,074	Feb 05 '03
150	175	25	21,124	Feb 06 '03
150	175	25	21,174	Feb 07 '03
150	175	25	21,223	Feb 08 '03
150	175	25	21,273	Feb 09 '03
150	175	25	21,322	Feb 10 '03
150	175	25	21,372	Feb 11 '03
150	175	25	21,421	Feb 12 '03
150	175	25	21,471	Feb 13 '03
150	175	25	21,521	Feb 14 '03
150	175	25	21,570	Feb 15 '03
150	175	25	21,620	Feb 16 '03
150	175	25	21,669	Feb 17 '03
150	175	25	21,719	Feb 18 '03
150	175	25	21,769	Feb 19 '03
150	175	25	21,818	Feb 20 '03
150	175	25	21,868	Feb 21 '03
150	175	25	21,917	Feb 22 '03
150	175	25	21,967	Feb 23 '03
150	175	25	22,017	Feb 24 '03
150	175	25	22,066	Feb 25 '03
150	175	25	22,116	Feb 26 '03
150	175	25	22,165	Feb 27 '03
150	175	25	22,215	Feb 28 '03



APPENDIX C | CHINOOK SALMON SURVIVAL INVESTIGATIONS

SACRAMENTO-SAN JOAQUIN ESTUARY

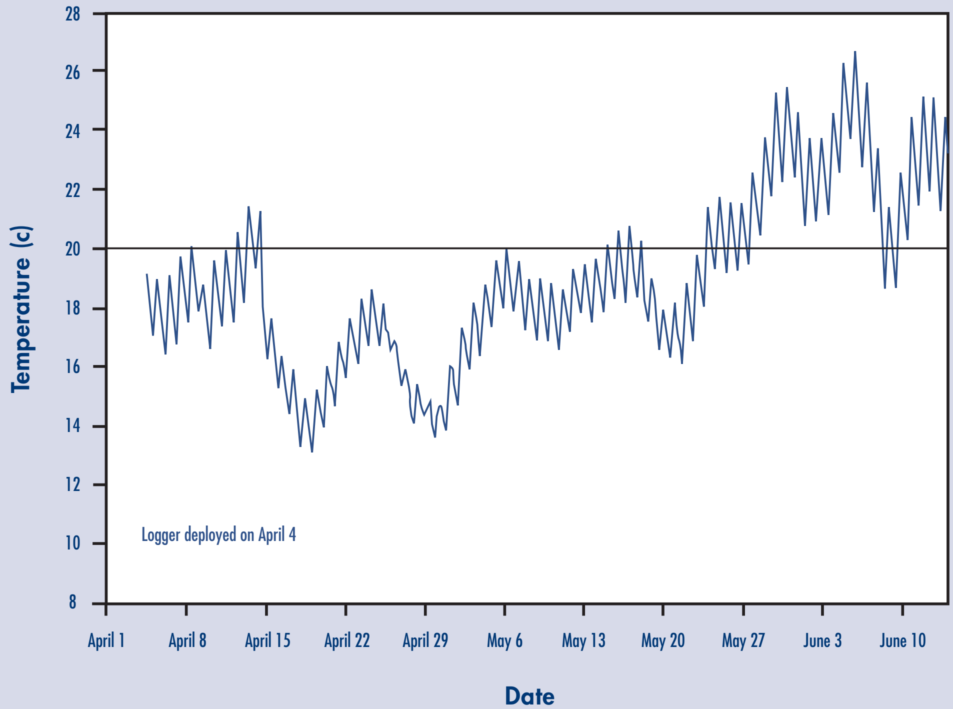


Water Temperature Monitoring Locations During the VAMP 2002 Experiment

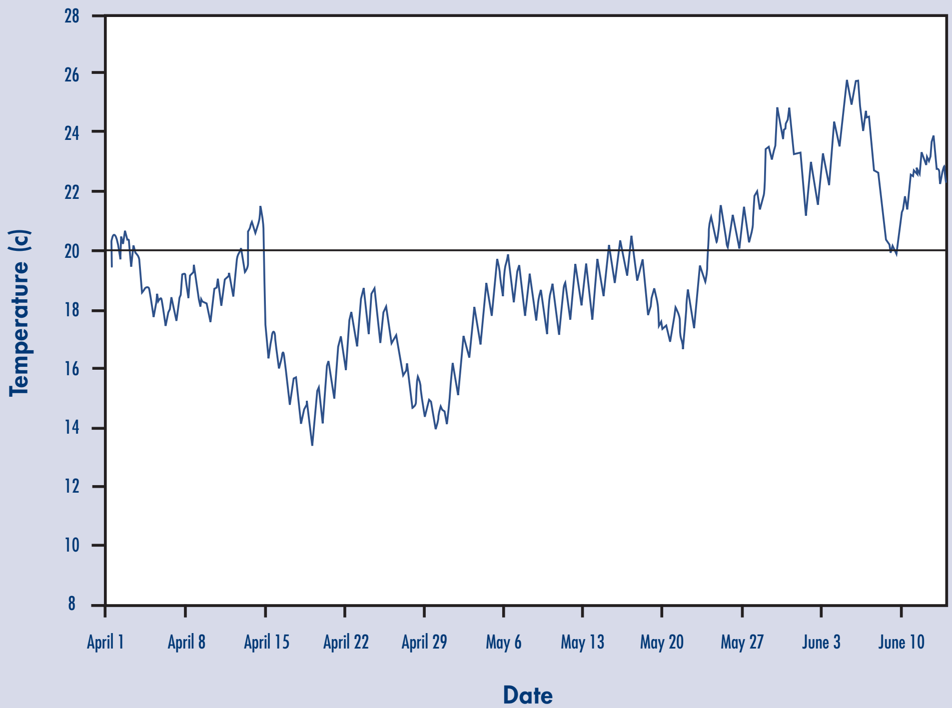
VAMP 2002 WATER TEMPERATURE MONITORING LOCATIONS

Site no.	Temperature Monitoring Location	Latitude	Longitude	Distance from Durham Ferry (mi)	Date Deployed	Date Retrieved	Notes
	Merced River Hatchery–1			n/a	March 15	April 26	In river April 18
	Merced River Hatchery–2			n/a	March 15	April 30	In river April 25
1	Durham Ferry	N 37 41.381	W 121 15.657	n/a	April 4	June 15	In 3 feet of water
2	Mossdale	N 37 47.180	W 121 18.425	11.2	April 1	June 15	In 3 feet of water
3	Dos Reis	N 37 49.808	W 121 18.665	16.4	April 1	June 15	In 3 feet of water
4	DWR Monitoring Station	N 37 51.869	W 121 19.376	19.4	April 1	June 15	In 3 feet of water
5a	Confluence–Top	N 37 56.818	W 121 20.285	26.5	April 1	June 15	2 feet below surface
5b	Confluence–Bottom	N 37 56.818	W 121 20.285	26.5	April 1	June 15	On river bottom
6	Downstream of Channel Marker 30	N 37 59.776	W 121 25.569	33.3	April 1	June 15	In 3 feet of water
7	1/2 mile Upstream of Channel Marker 13	N 38 01.940	W 121 28.769	37.3	April 1	June 15	In 3 feet of water
8	Downstream of Channel Marker 36	N 38 04.522	W 121 34.413	44.7	April 1	June 15	In 3 feet of water
9a	Jersey Point USGS Gauging Station–top	N 38 03.172	W121 41.637	56	April 1	June 15	2 feet below surface
9b	Jersey Point USGS Gauging Station–bottom	N 38 03.172	W121 41.637	56	April 1		Logger lost
10	Chipps Island	N 38 03.084	W 121 55.463	71.5	April 1	June 15	In 3 feet of water
11	Mokelumne River	N 38 06.334	W 121 34.213	40	April 1	June 15	In 3 feet of water

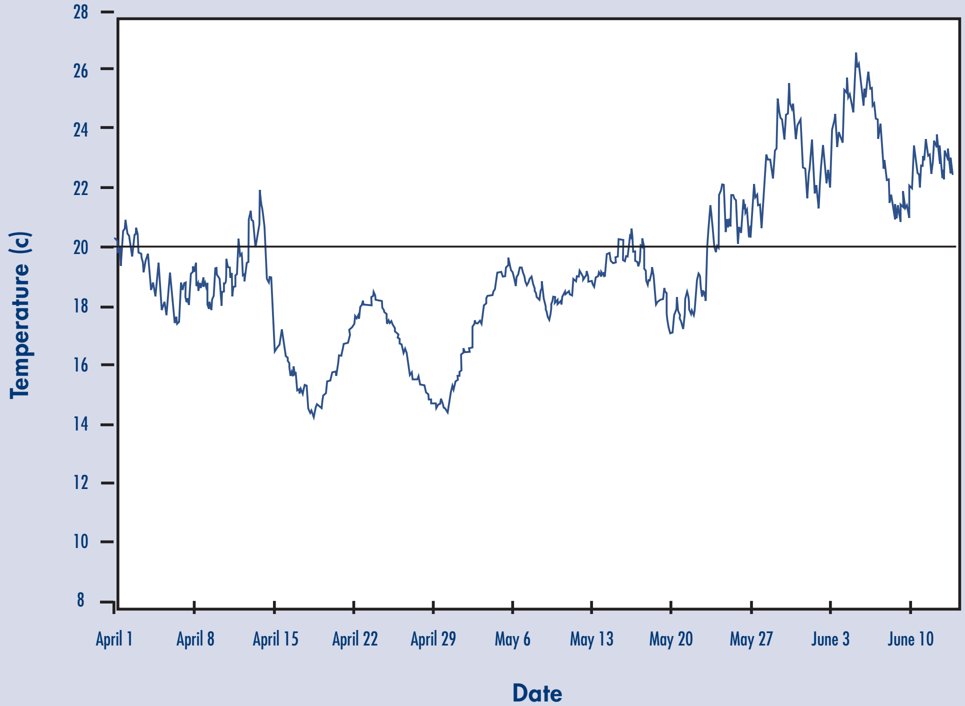
Site 1 • Durham Ferry



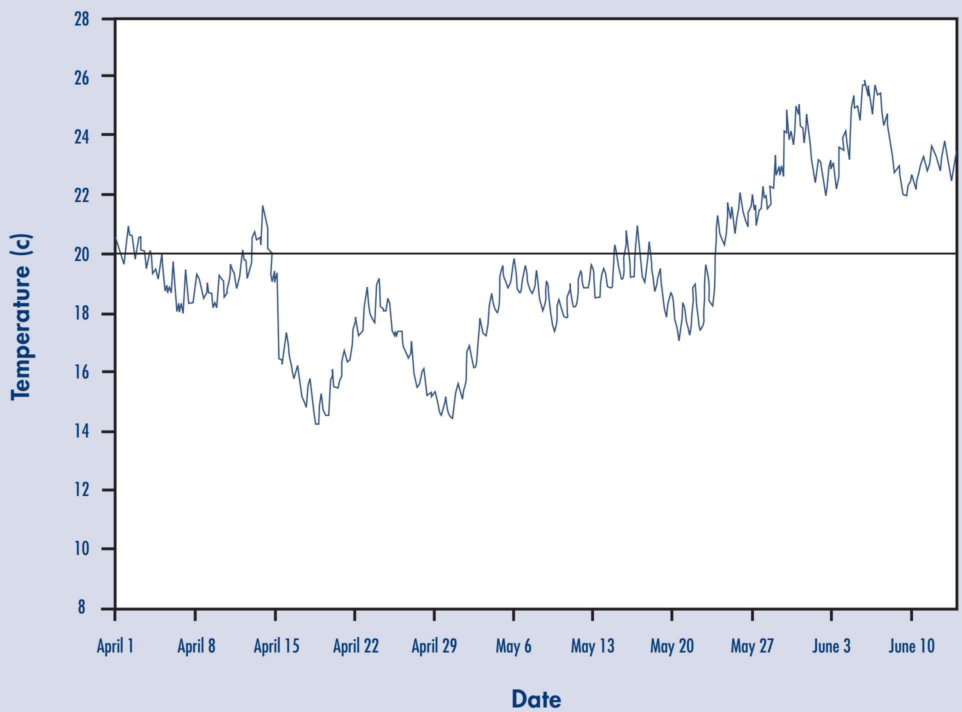
Site 2 • Mossdale



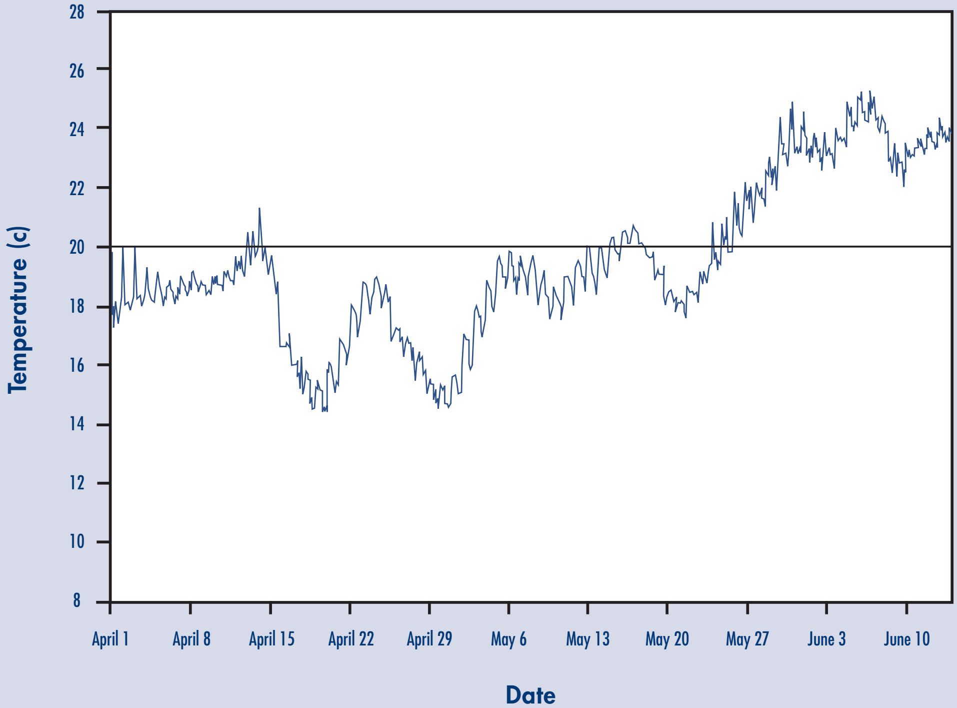
Site 3 • Dos Reis



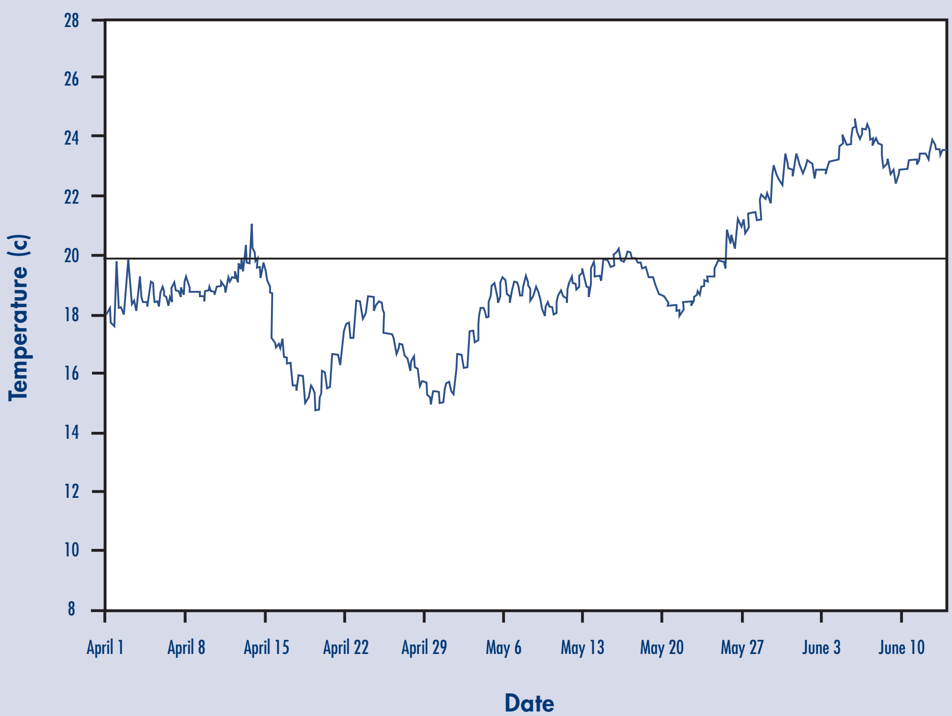
Site 4 • DWR Monitoring Station



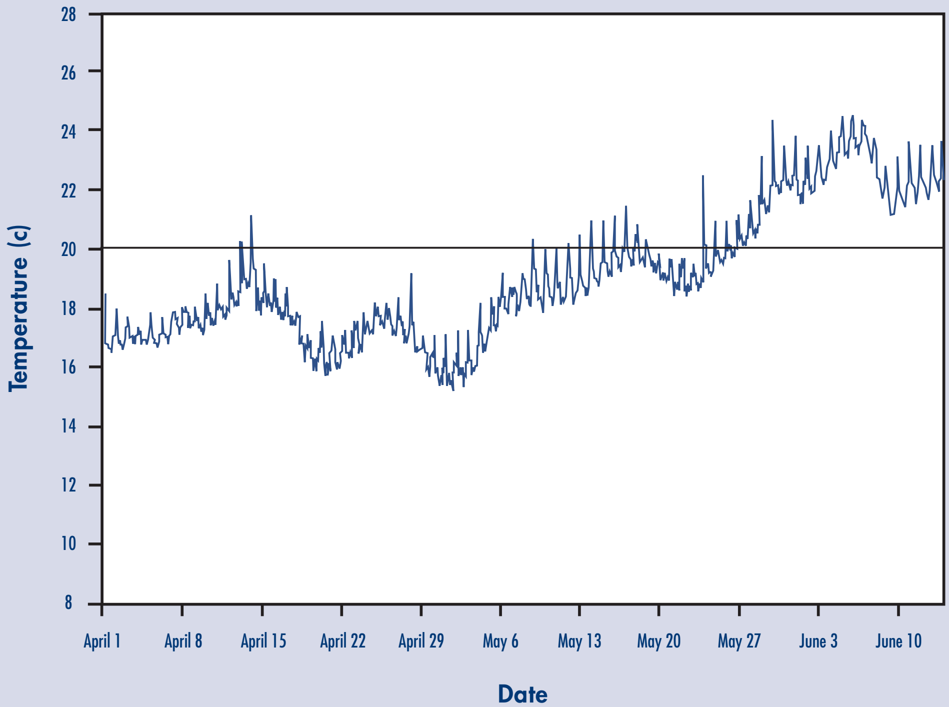
Site 5a • Confluence-Top



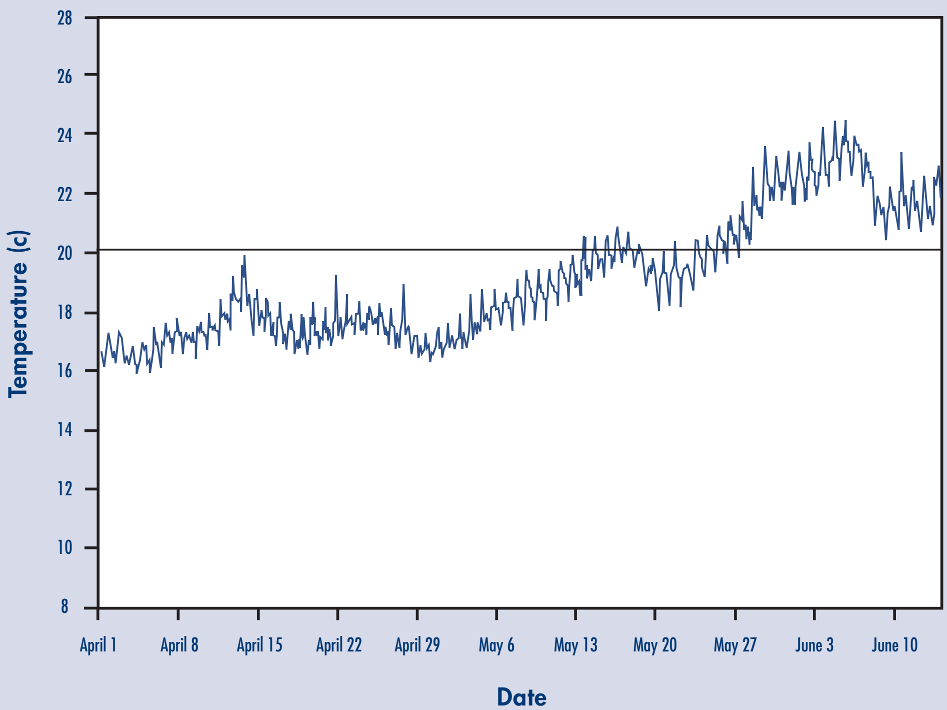
Site 5b • Confluence-Bottom



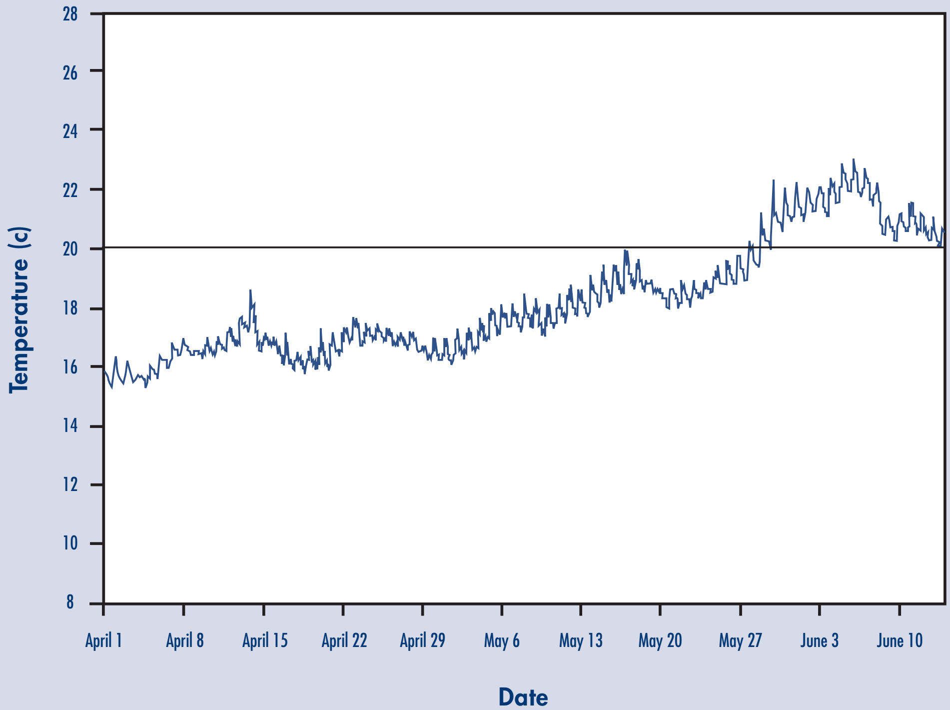
Site 6 • Downstream of Channel Marker 30



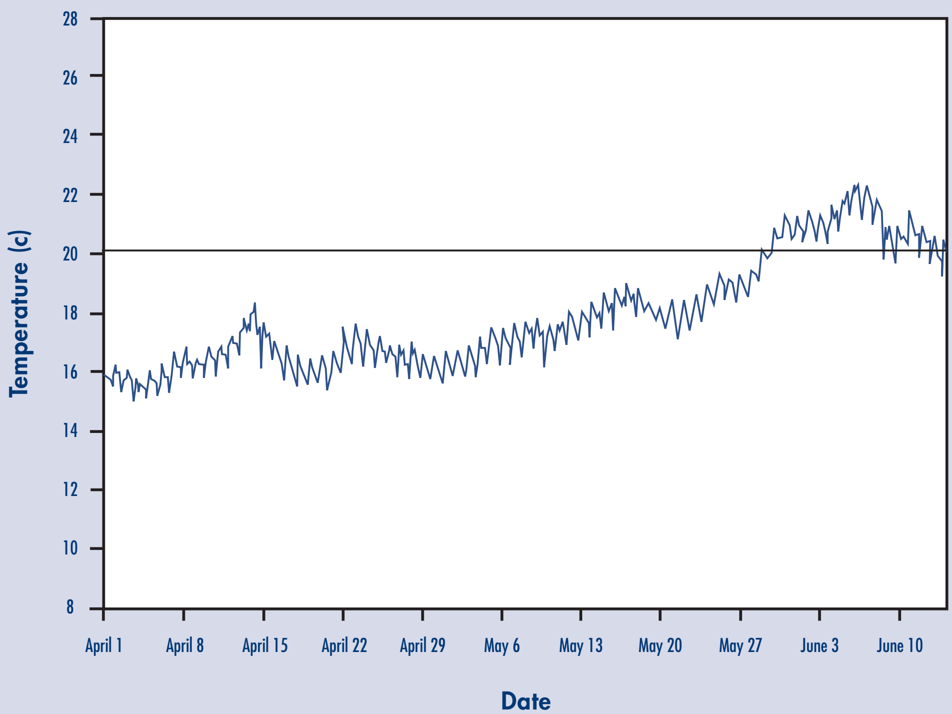
Site 7 • 1/2 Mile Upstream of Channel Marker 13



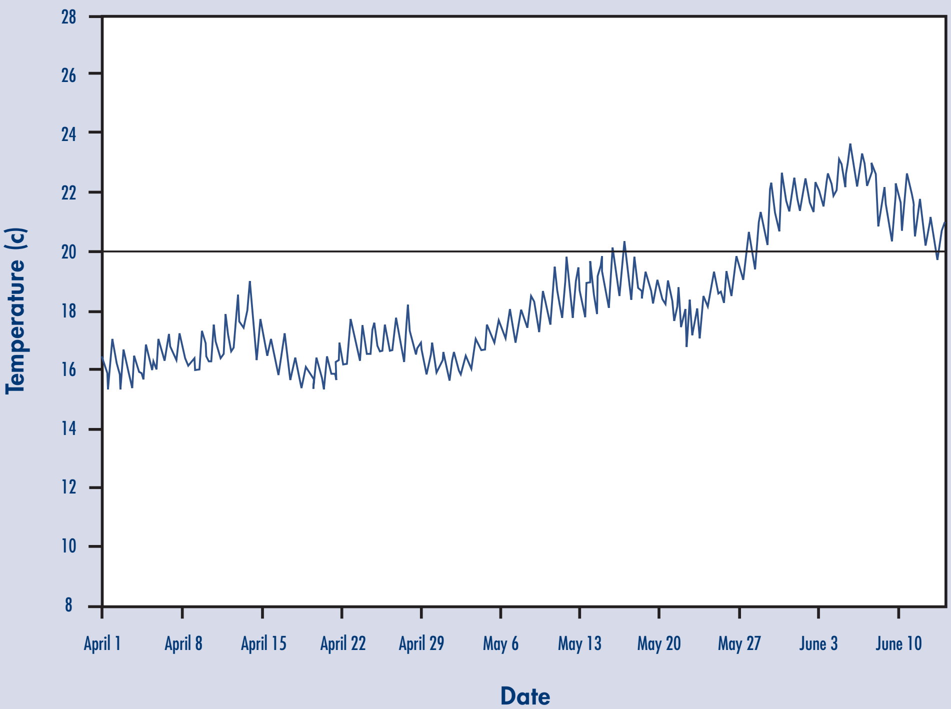
Site 8 • Downstream of Channel Marker 36



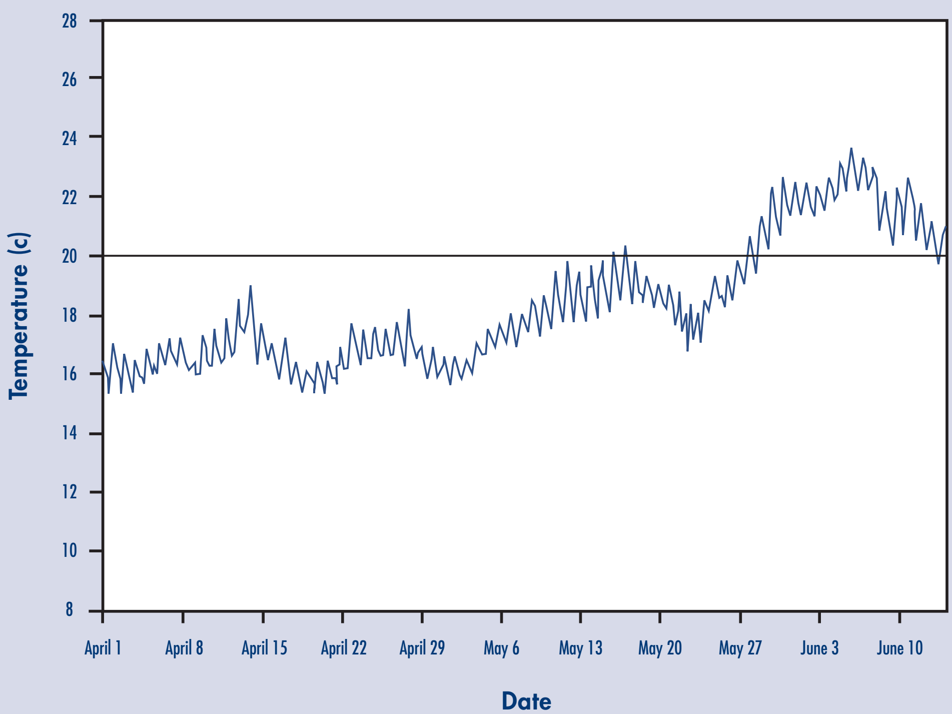
Site 9a • Jersey Point–Top

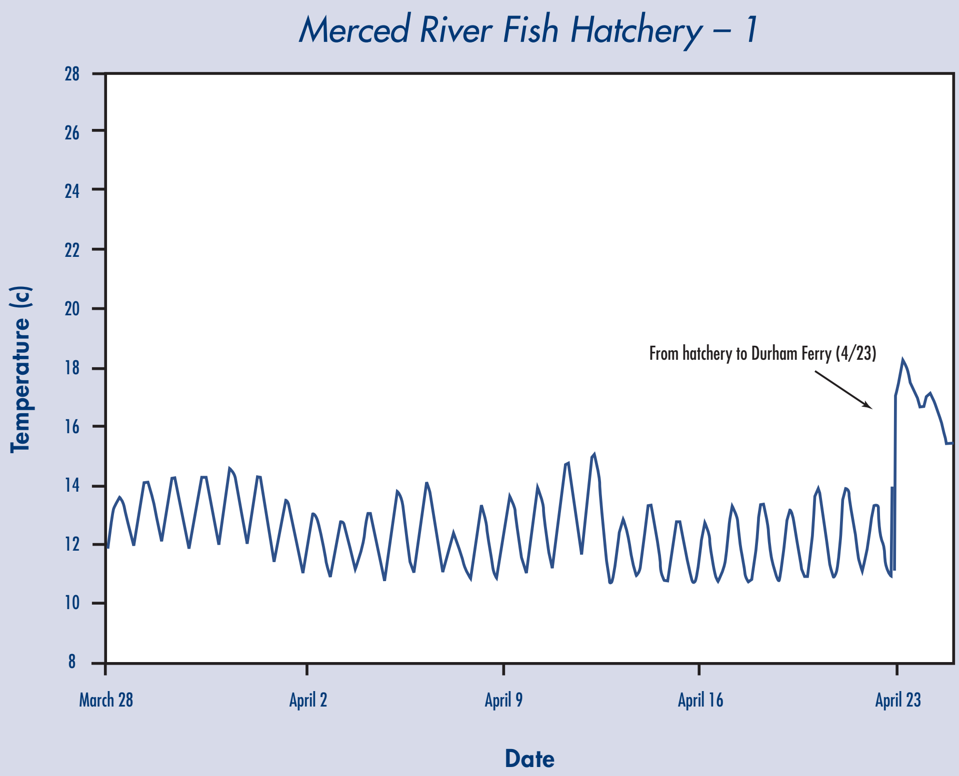


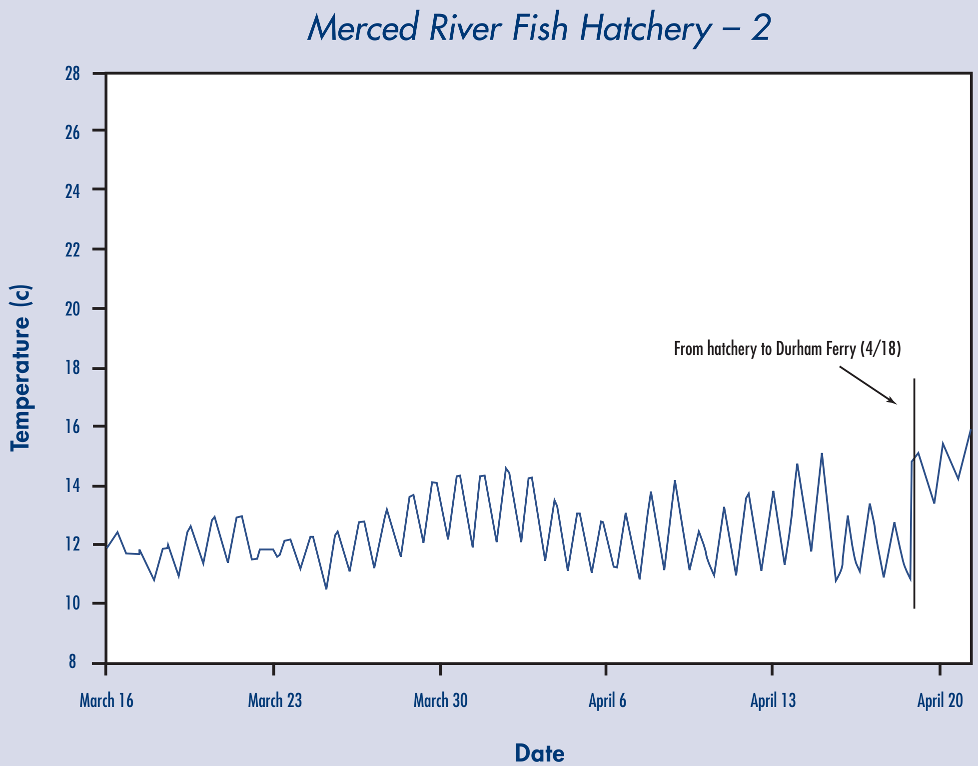
Site 10 • Chipps Island



Site 11 • Mokelumne River




Merced River Fish Hatchery – 1
Temperature (c)
28
26
24
22
20
18
16
14
12
10
8
From hatchery to Durham Ferry (4/23)
March 28
April 2
April 9
April 16
April 23
Date


Merced River Fish Hatchery – 2
Temperature (c)
28
26
24
22
20
18
16
14
12
10
8
From hatchery to Durham Ferry (4/18)
March 16
March 23
March 30
April 6
April 13
April 20
Date

RESULTS OF NET PEN SAMPLING CONDUCTED IMMEDIATELY AFTER RELEASE, VAMP 2002

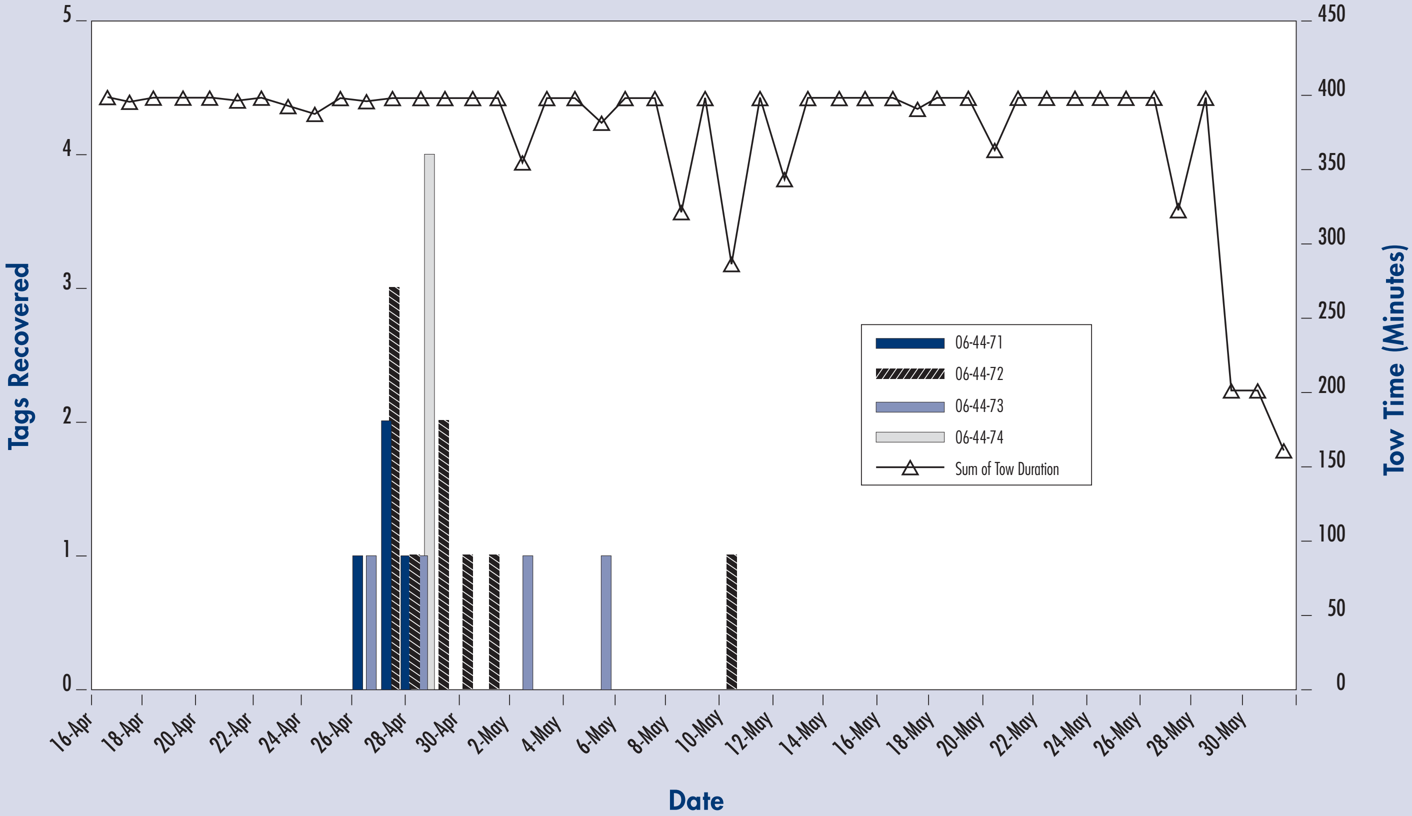
Release location, release date, tag code, number in sample	Mean fork length (and range in millimeters)	Mean weight (and range in grams)	Mean scale loss (and range in percent)	Color	Fin hemorrhaging	Eyes	Gill color	Ad clips, comments and mortalities
Durham Ferry I Pen #1	80.96(64-87)	5.82(2.7-7)	3.8(1-11)	Normal	None	Normal	Normal	0.04 (1 deformed pectoral fin)
Durham Ferry I Pen #2	82.00(74-90)	6.1 (4.4-7.7)	3.6(2-7)	Normal	None	Normal	Normal	
Mossdale I Pen #2	84.5(77-92)	6.7(4.9-8.9)	4.9(1-15)	Normal	None	Normal	Normal	0.04 (1 poor ad clip)
Mossdale I Pen #3	81.9(68-90)	5.9(3.5-8)	3.4(1-15)	Normal	None	Normal	Normal	0.04 (1 deformed pectoral fin)
Jersey Point I Pen #2	85.0(70-95)	6.7(3.6-9.4)	3.6(1-7)	Normal	None	Normal	Normal	0.08 (2 half ad clips) 0.04 (1 deformed pectoral fin)
Jersey Point I Pen #3	82.0(61-92)	6.1(2.4-8.2)	3.3(1-5)	Normal	None	Normal	Normal	0.04 (1 half ad clip) 0.04 (1 deformed pectoral fin)
Group I	82.76(61-95)	6.24(2.4-9.4)	3.77(1-15)					
Durham Ferry II Pen #1	80.1(72-89)	5.8(4.1-8.1)	5.9(2-20)	Normal	None	Normal	Normal	0.04 (1 half adipose fin clip)
Durham Ferry II Pen #2	79.24(67-93)	5.24(3.1-8.4)	12.32(1-25)	Normal	None	Normal	Normal	0.04 (1 caudal fin damage)
Mossdale II Pen #1	82.4(75-104)	6.1(4.4-12.4)	7.3(3-15)	Normal	None	Normal	Normal	0.08 (2 caudal fins damage)
Mossdale II Pen #2	80.2(70-90)	5.43(3.7-7.7)	8.08(2-25)	Normal	None	Normal	Normal	0.04 (caudal/ dorsal clip?) 0.08 (2 no adipose fin clips)
Jersey Point II Pen #2	85.2(77-96)	6.77(4.8-10)	2.44(1-5)	Normal	None	Normal	Normal	
Jersey Point II Pen #3	83.8(75-90)	6.62(4.3-9)	2.32(1-6)	Normal	None	Normal	Normal	0.08 (2 half adipose fin clips) 0.08 (2 deformed pectoral fins)
Group II	81.83(67-104)	5.99(3.1-12.4)	6.39(1-25)					

RESULTS OF NET PEN SAMPLING CONDUCTED 48 HOURS AFTER RELEASE, VAMP 2002

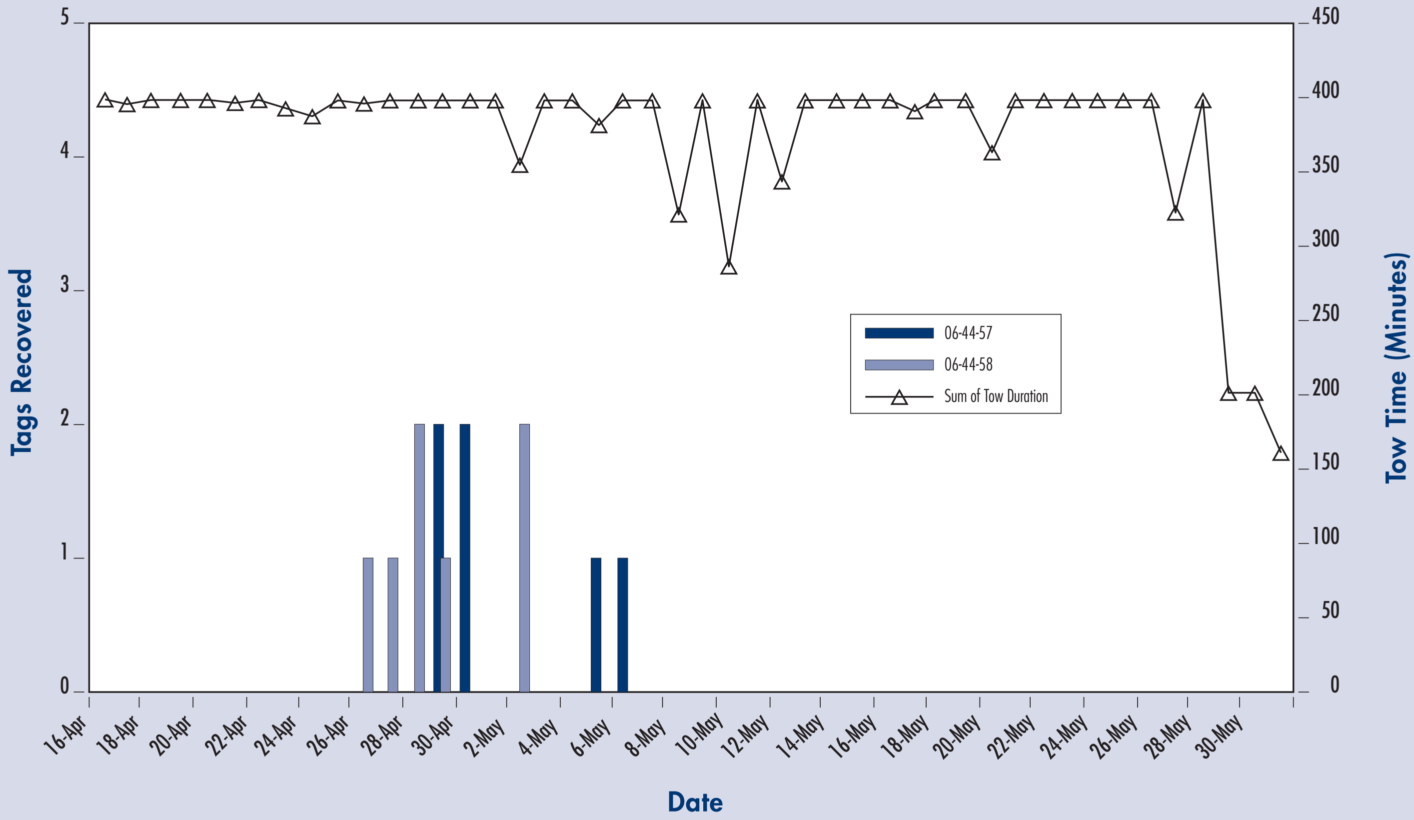
Release location, release date, tag code, number in sample	Mean fork length (and range in millimeters)	Mean weight (and range in grams)	Mean scale loss (and range in percent)	Color	Fin hemorrhaging	Eyes	Gill color	Ad clips, comments and mortalities
Durham Ferry I Pen #1	83(69-102)	6.0(3.2-11.5)	4(2-7)	Normal	None	Normal	Normal	
Durham Ferry I Pen #2	84.4(76-90)	6.2(4.5-7.7)	2.9(1.0-5.0)	Normal	None	Normal	Normal	
Mossdale I Pen #2	82.92(75-91)	6.0(4.3-7.8)	3.7(1-12)	Normal	None	Normal	Normal	
Mossdale I Pen #3	82.4(66-92)	5.8(4-8.2)	2.9(1-7)	Normal	None	Normal	Normal	0.04(scoliosis-spine)
Jersey Point I Pen #2	85.5(76-94)	6.6(4.3-8.1)	12.8(1-40)	Normal	None	Normal	Normal	0.08(half adipose clip)
Jersey Point I Pen #3	83.6(72-95)	5.9(3.8-9.1)	9.1(4.0-15.0)	Normal	None	Normal	Normal	0.04(hemmoraged eye)
Group II	83.6(66-102)	6.1(3.2-11.5)	6(1-40)					
Durham Ferry II Pen #1	80(71-94)	5.4(3.7-8.8)	12.3(2.0-30.0)	Normal	None	Normal	Normal	
Durham Ferry II Pen #2	80.64(71-93)	5.3(3.6-9.3)	6.5(1-21)	Normal	None	Normal	Normal	
Mossdale II Pen#1	80.6(70-89)	5.4(3.6-7.4)	5.2(2.0-10.0)	Normal	None	Normal	Normal	0.04(hemmoraged eye) 0.04(no adipose fin clip)
Mossdale II Pen#2	79.9(67-88)	5.3(3.2-7.0)	6.5(2.0-12.0)	Normal	None	Normal	Normal	
Jersey Point II Pen #2	82.0(71-94)	5.8(3.7-9.2)	4.3(1.0-10.0)	Normal	None	Normal	Normal	0.20(half adipose fin clip) 0.04(deformed pectoral fin)
Jersey Point II Pen #3	82.9(75-93)	6.3(4.4-8.6)	4.9(2.0-9.0)	Normal	None	Normal	Normal	0.16(half adipose fin clip) 0.04(no adipose fin clip)
Group II	80.48(67-82.9)	5.5(9.3-7.9)	6.6(1.0-30.0)					

Note: averages are for first 25 fish worked up in each pen.

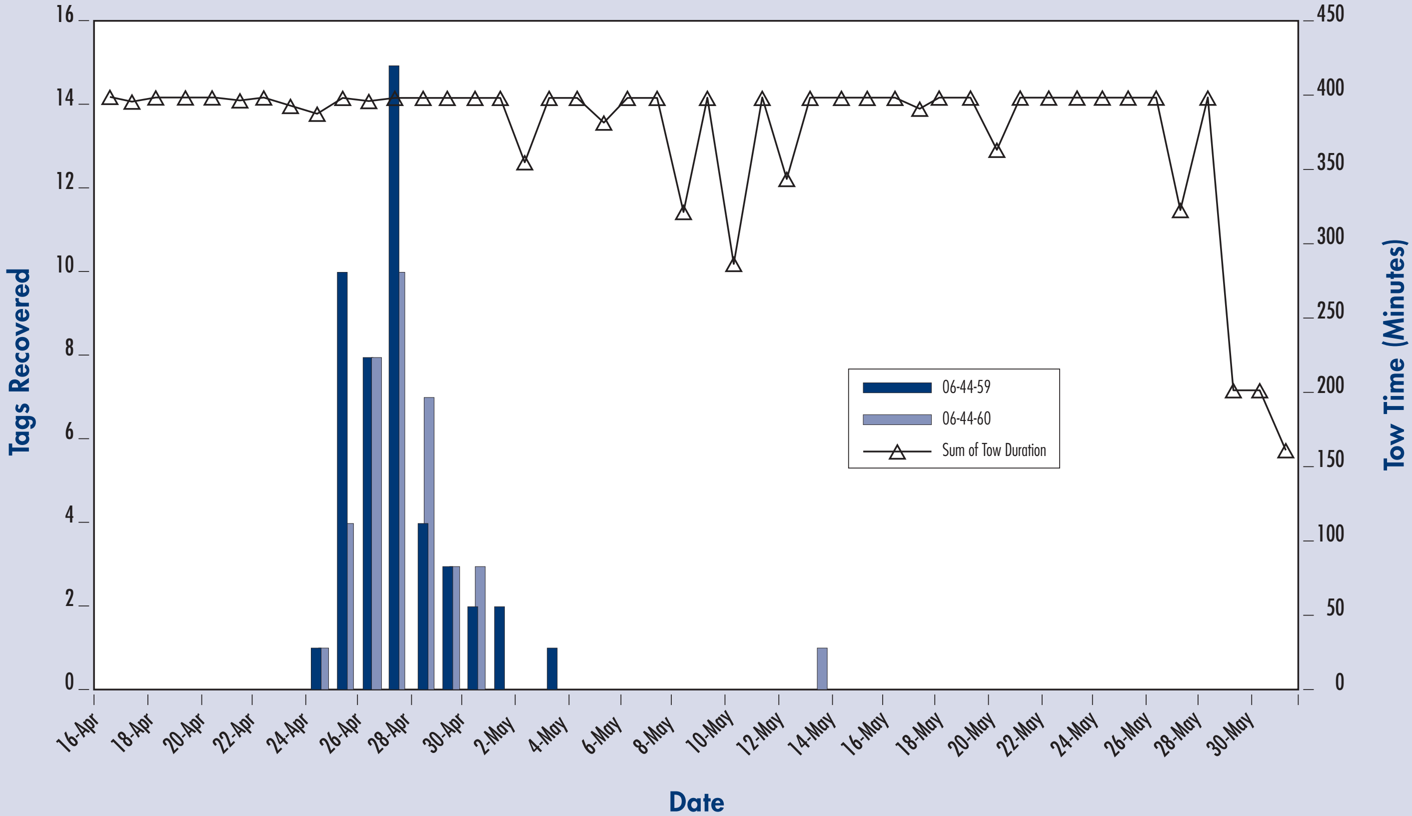
Chipps Island/Durham Ferry I



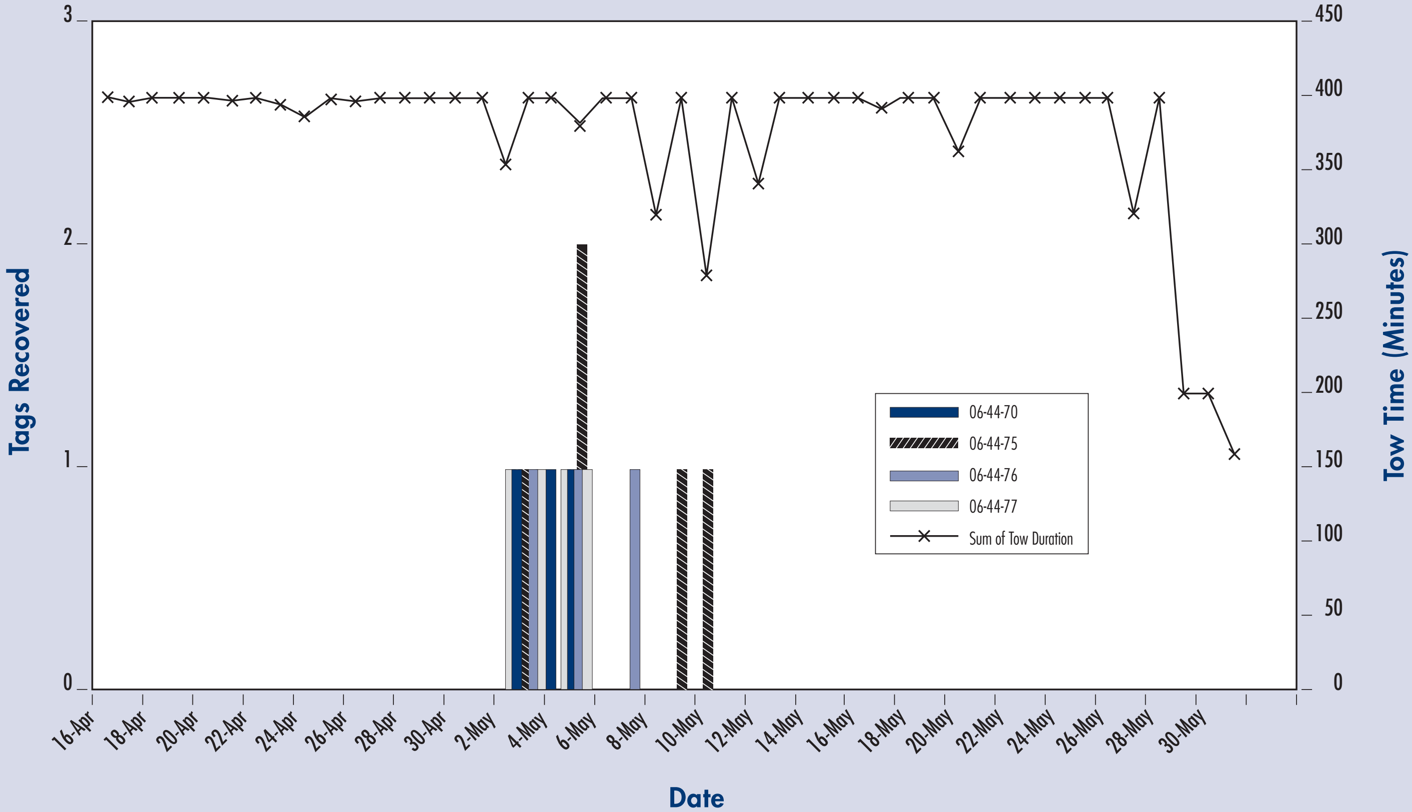
Chipps Island/Mossdale I



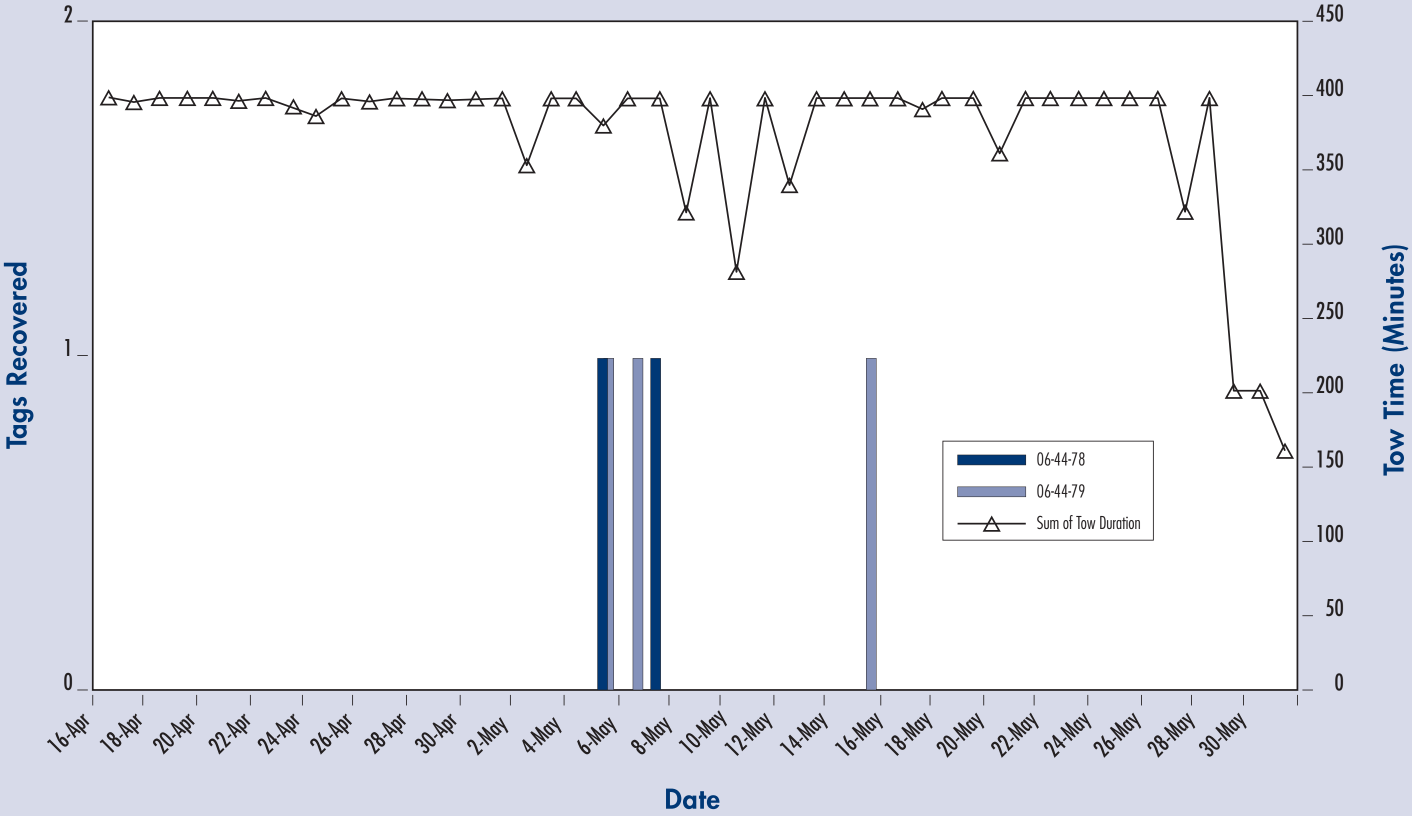
Chipps Island/Jersey Point I



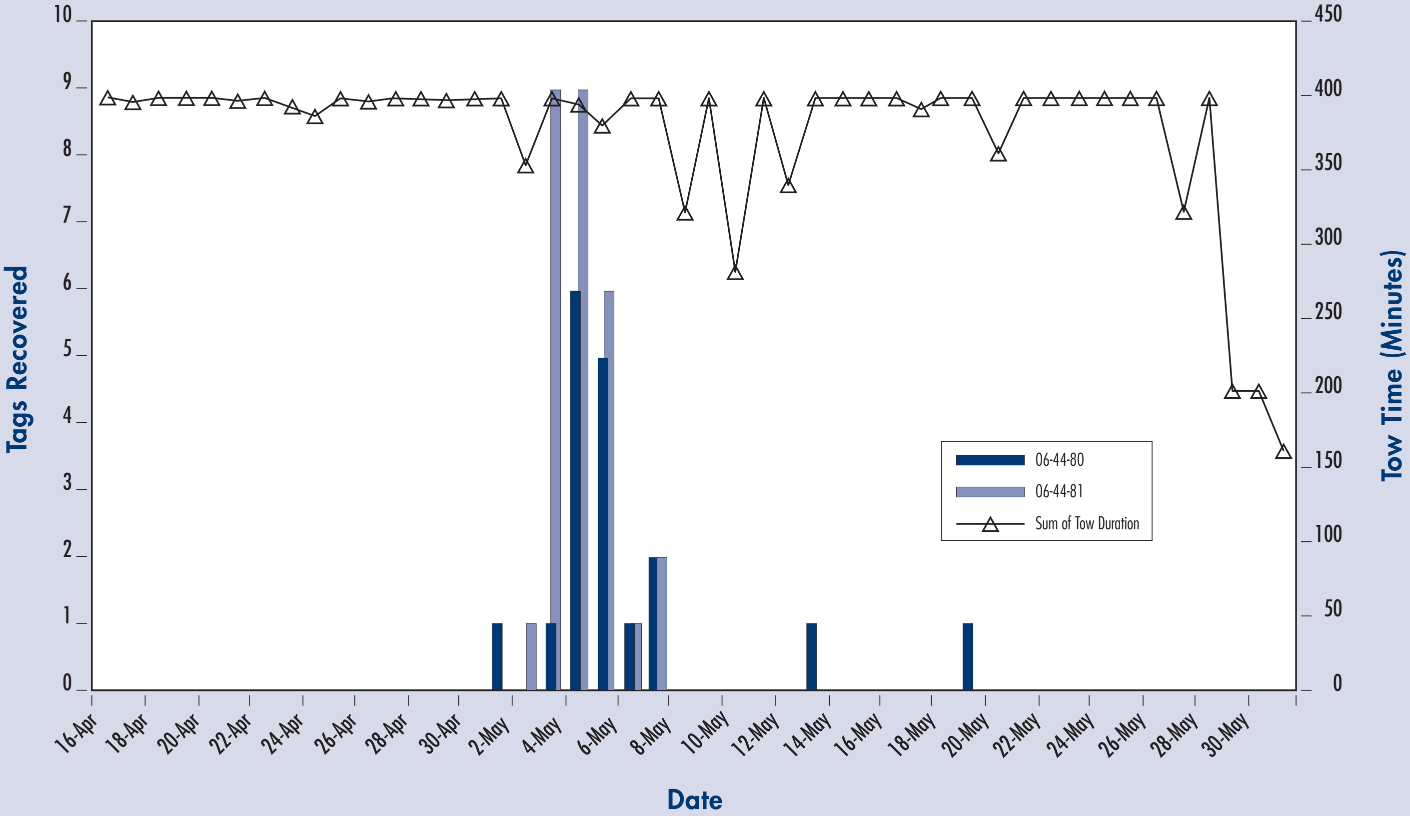
Chipps Island/Durham Ferry II



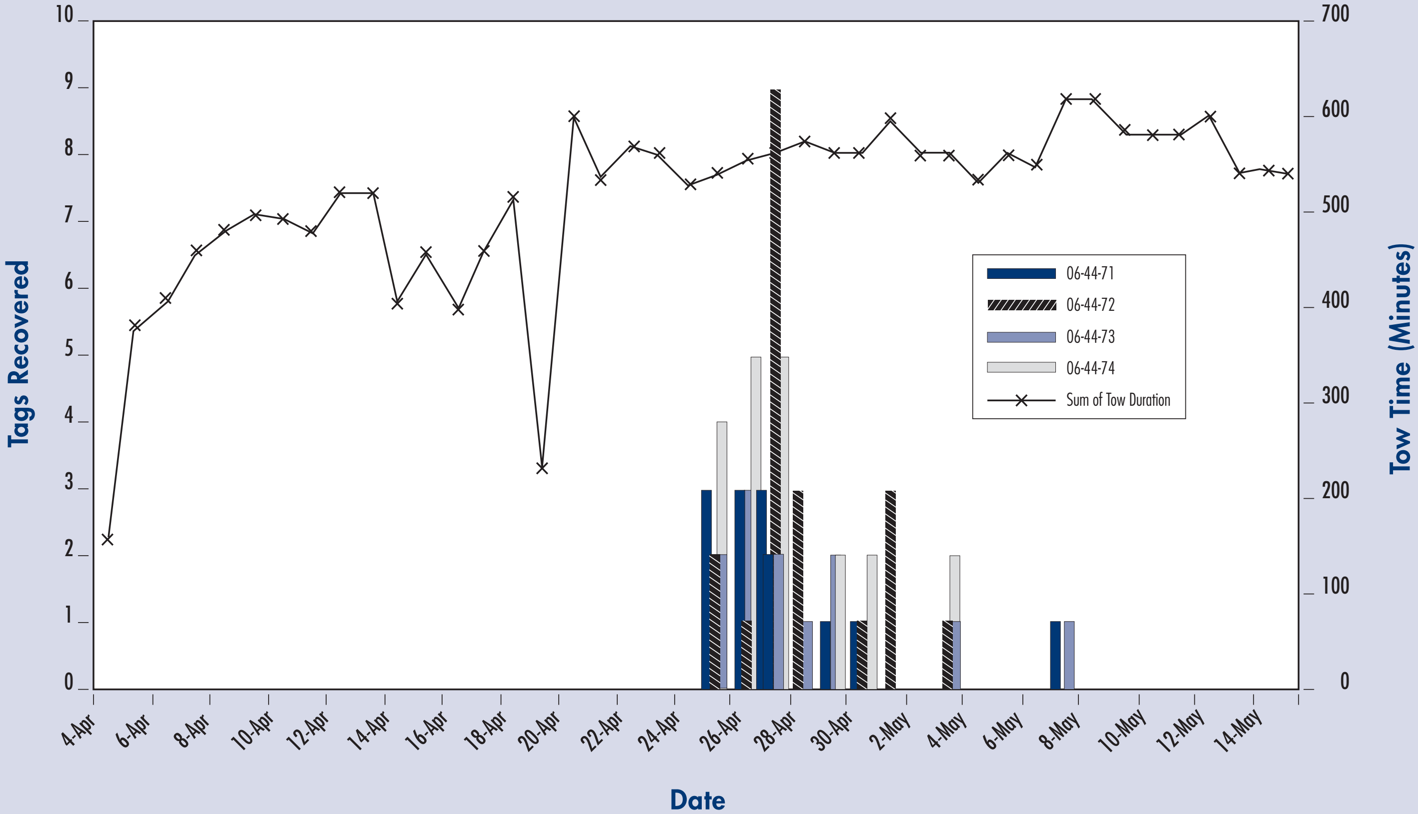
Chipps Island/Mossdale II



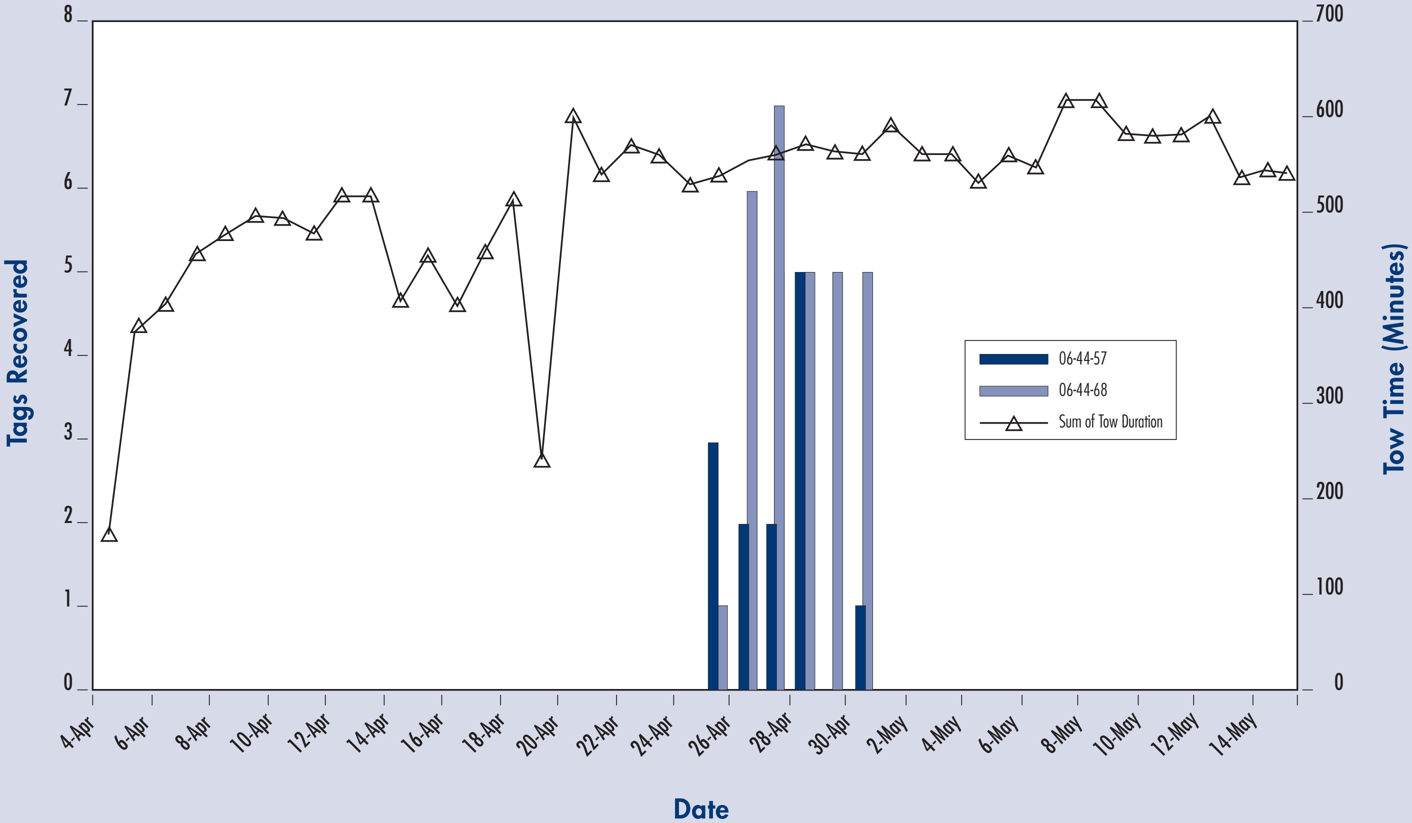
Chipps Island/Jersey Point II



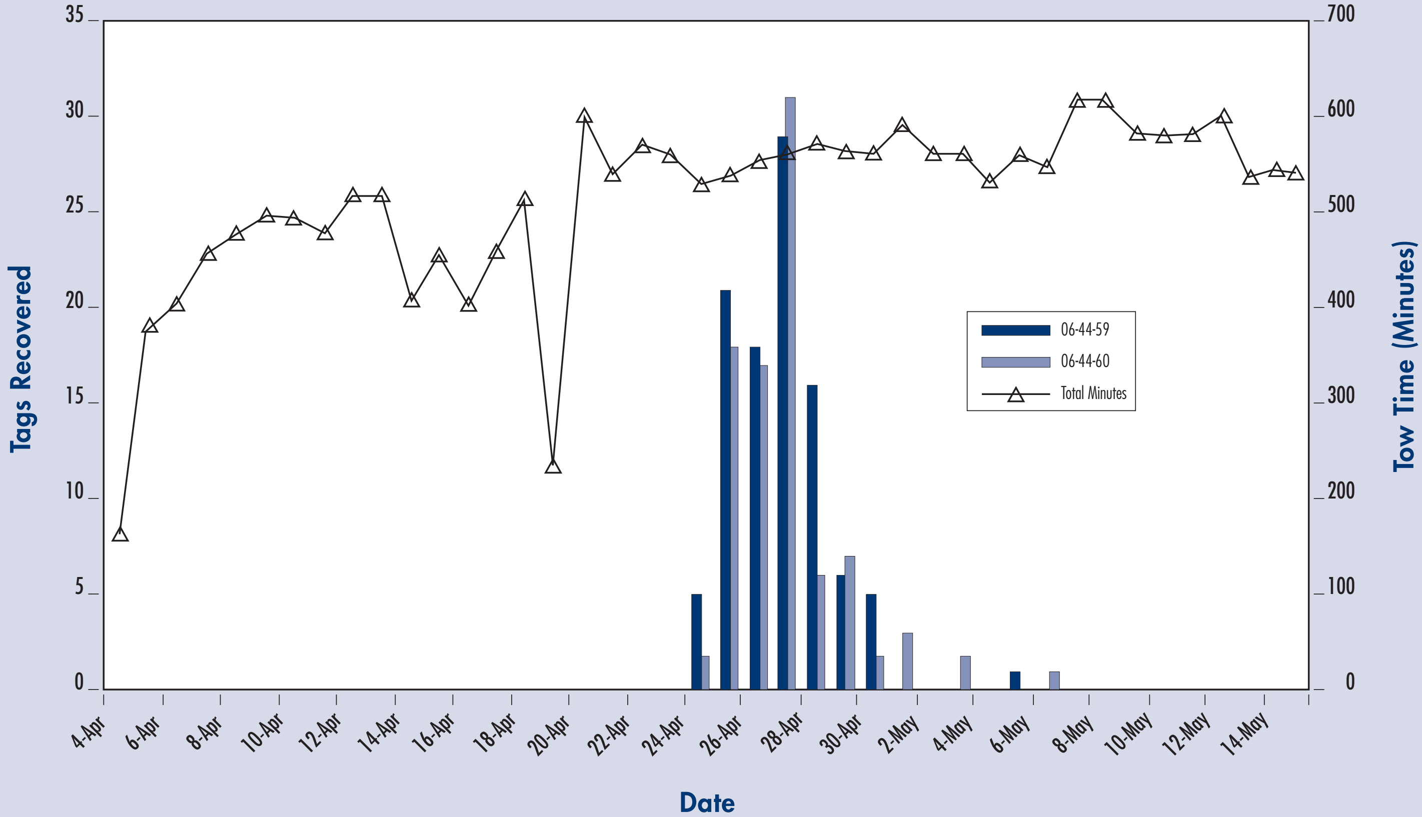
Antioch/Durham Ferry I



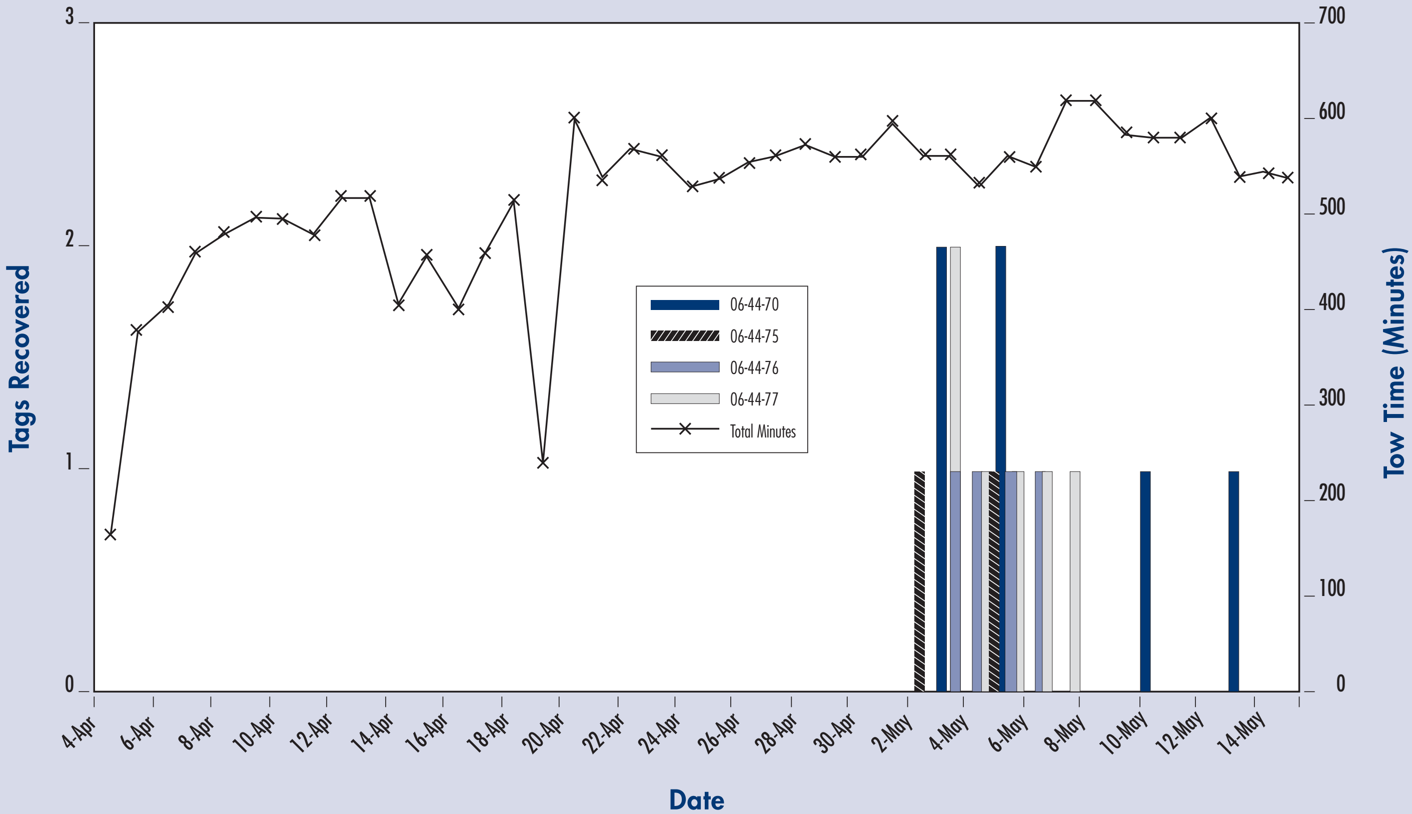
Antioch/Mossdale I



Antioch/Jersey Point I

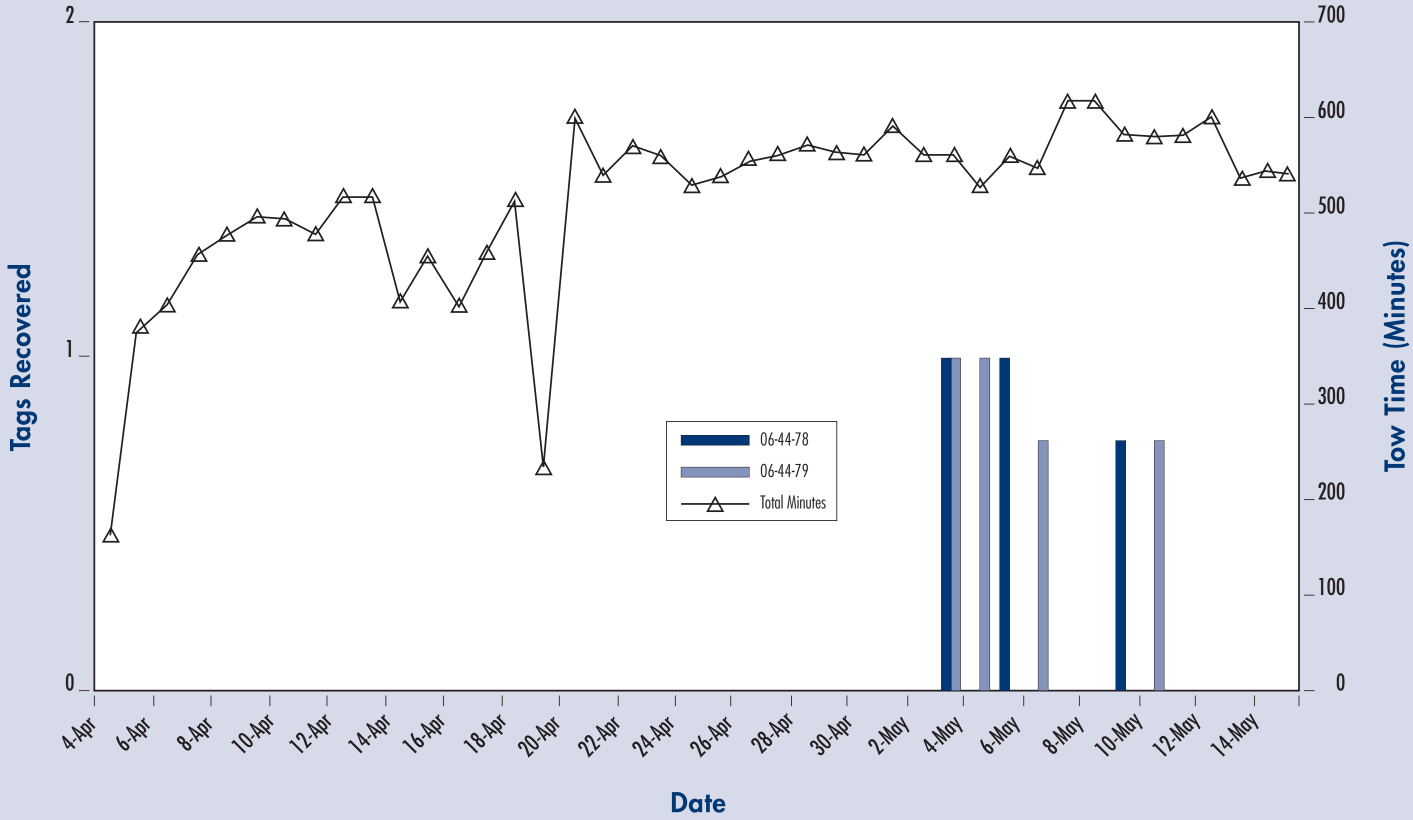


Antioch/Durham Ferry II

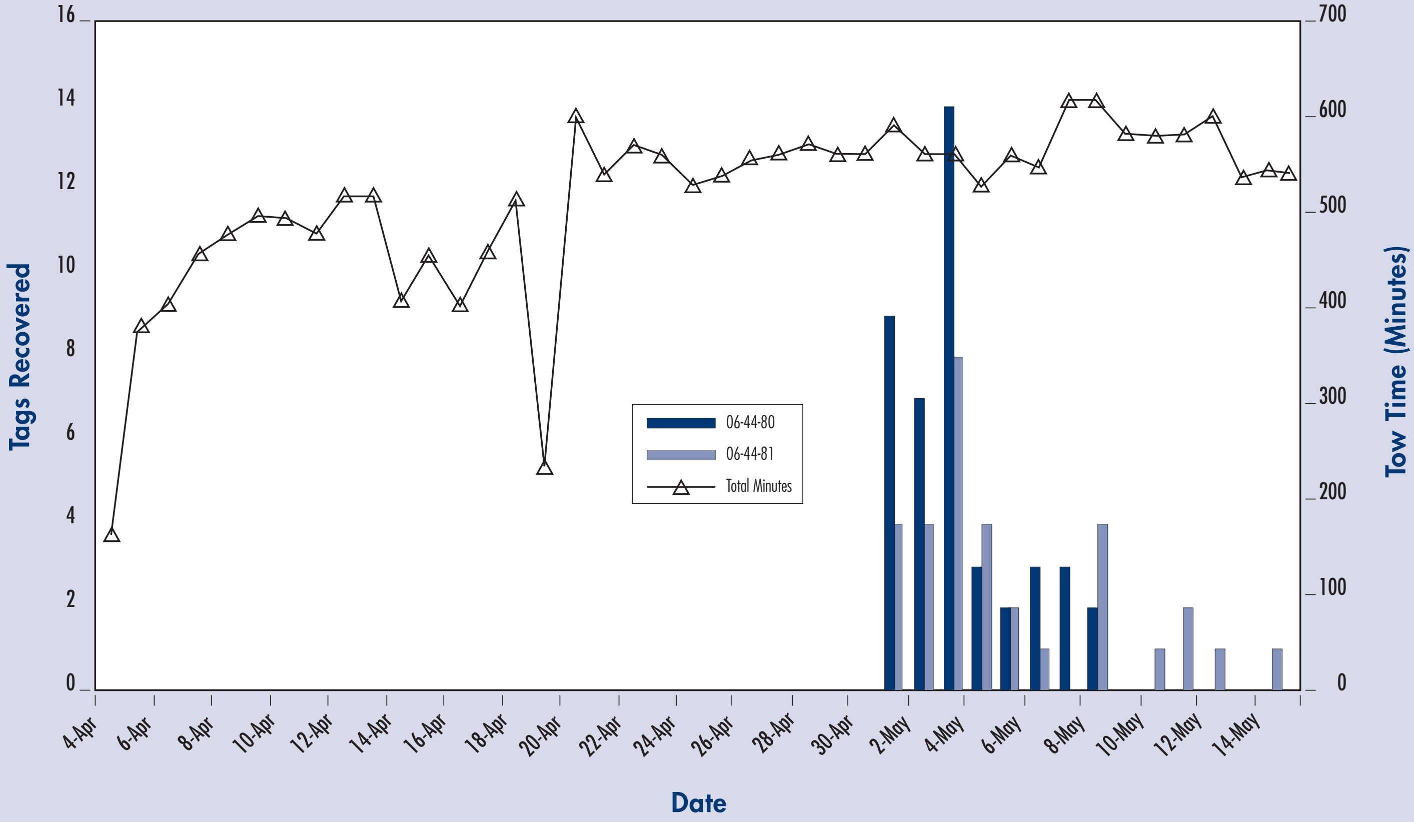


NET PEN SAMPLING RESULTS

Antioch/Mossdale II



Antioch/Jersey Point II



Release and Recovery Information for Coded Wire Tagged Smolts Released in the San Joaquin River and Tributaries in the Spring of 2002.

Tag Code	Release Site/Stock	Date	Truck Temp (F)	River Temp (F)	Number Released	Average Size (mm)
Merced River						
06-44-63	Upper Merced @ MRFF		N/P	N/P	23188	74
06-44-64	Upper Merced @ MRFF		N/P	N/P	23915	74
06-44-65	Upper Merced @ MRFF		N/P	N/P	23775	74
06-44-66	Upper Merced @ MRFF		N/P	N/P	23185	74
	Total	Mar 31			94063	
06-44-51	Hatfield State Park (MRFF)		53.6	62.6	24380	77
06-44-52	Hatfield State Park (MRFF)		53.6	62.6	24228	77
06-45-48	Hatfield State Park (MRFF)		53.6	62.6	24890	77
	Total	Apr 03			73498	
06-44-82	Upper Merced @ MRFF		N/P	N/P	22522	71
06-44-83	Upper Merced @ MRFF		N/P	N/P	23086	71
06-44-84	Upper Merced @ MRFF		N/P	N/P	23140	71
06-44-85	Upper Merced @ MRFF		N/P	N/P	22183	71
	Total	Apr 21			90931	
06-44-86	Hatfield State Park (MRFF)		53.6	60.8	23349	73
06-44-87	Hatfield State Park (MRFF)		53.6	60.8	23363	73
06-44-88	Hatfield State Park (MRFF)		53.6	60.8	23639	73
	Total	Apr 26			70351	
Tuolumne River						
06-44-06	La Grange (MRFF)		57.2	53.6	24976	86
06-44-67	La Grange (MRFF)		57.2	53.6	24813	86
06-44-68	La Grange (MRFF)		57.2	53.6	25220	86
	Total	Apr 24			75009	
San Joaquin River						
06-44-61	Old Fisherman's Club (MRFF)	Apr 26	55.4	62	25701	85
06-44-69	Old Fisherman's Club (MRFF)	Apr 29	55.4	60.8	23870	86
Stanislaus River						
06-44-46	Knight's Ferry (MRFF)		56.3	53.6	23745	82
06-44-47	Knight's Ferry (MRFF)		53.6	52.7	24236	83
	Total	May 01			47981	
06-44-48	Two Rivers (MRFF)	May 04	59	64.4	24646	84

Antioch				Chipps Island				Salvage		Tributary Survival	
Number Recovered	Percent Sampled	Survival Index	Group Index	Number Recovered	Percent Sampled	Survival Index	Group Index	Expanded CVP	Expanded SWP	Antioch	Chipps Island
1	0.316	0.010		1	0.278	0.020		12	6		
0	--	--		0	--	--		0	0		
0	--	--		0	--	--		0	0		
0	--	--		0	--	--		0	0		
1	0.316		0.002	1	0.278		0.005			0.05	0.11
10	0.345	0.086		2	0.272	0.039		480	47		
1	0.389	0.008		1	0.222	0.024		492	34		
3	0.361	0.024		3	0.180	0.087		528	55		
14	0.345		0.040	6	0.238		0.045				
0	--	--		0	--	--		0	0		
1	0.375	0.008		0	--	--		0	0		
0	--	--		0	--	--		0	0		
0	--	--		0	--	--		0	0		
1	0.375		0.002	0	--		--			0.08	0
2	0.410	0.015		2	0.250	0.045		12	6		
5	0.405	0.038		0	--	--		0	12		
2	0.404	0.015		1	0.278	0.020		0	0		
9	0.402		0.023	3	0.250		0.022				
3	0.423	0.020		1	0.264	0.020		12	12		
5	0.392	0.037		7	0.261	0.141		0	12		
3	0.378	0.023		0	--	--		12	18		
11	0.399		0.026	8	0.261		0.053				
1	0.389	0.007		6	0.273	0.111		0	6	3.7	0.47
2	0.408	0.015		3	0.260	0.063		12	15	1.7	0.84
1	0.403	0.008		2	0.257	0.043		12	0	1.04	2.09
5	0.397	0.037		2	0.194	0.055		0	6		
6	0.397		0.023	4	0.236		0.046				
3	0.398	0.022		1	0.236	0.022		0	0		

Timing of Recovery at Antioch and Chipps Island for Coded Wire Tagged Smolts Released in San Joaquin River and Tributaries in the Spring of 2002.

Tag Code	Release Site/Stock	Date	Truck Temp (F)	River Temp (F)	Number Released	Average Size (mm)
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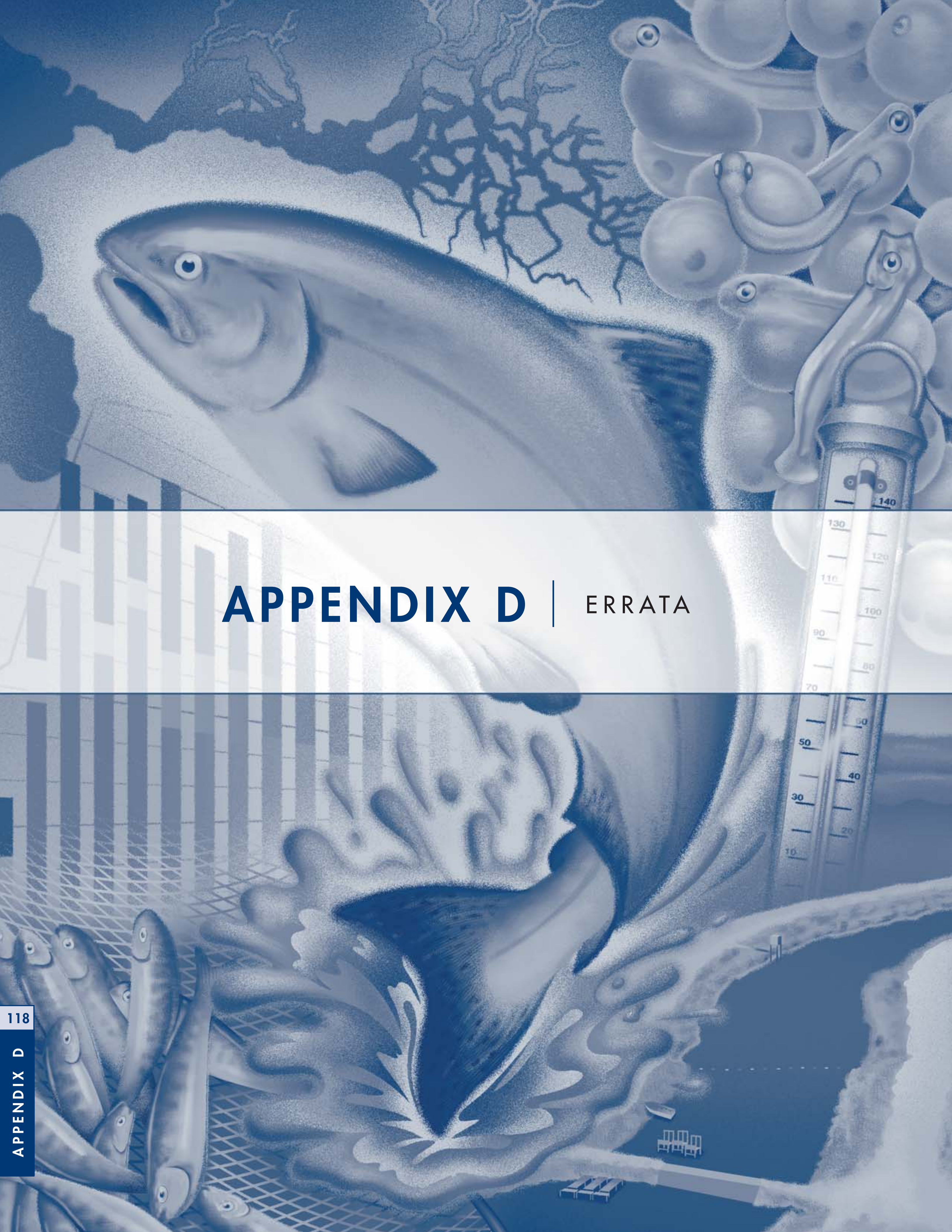
06-44-64	Upper Merced @ MRFF		N/P	N/P	23915	74
06-44-65	Upper Merced @ MRFF		N/P	N/P	23775	74
06-44-66	Upper Merced @ MRFF		N/P	N/P	23185	74
	Total	Mar 31			94063	
06-44-51	Hatfield State Park (MRFF)		53.6	62.6	24380	77
06-44-52	Hatfield State Park (MRFF)		53.6	62.6	24228	77
06-45-48	Hatfield State Park (MRFF)		53.6	62.6	24890	77
	Total	Apr 03			73498	
06-44-82	Upper Merced @ MRFF		N/P	N/P	22522	71
06-44-83	Upper Merced @ MRFF		N/P	N/P	23086	71
06-44-84	Upper Merced @ MRFF		N/P	N/P	23140	71
06-44-85	Upper Merced @ MRFF		N/P	N/P	22183	71
	Total	Apr 21			90931	
06-44-86	Hatfield State Park (MRFF)		53.6	60.8	23349	73
06-44-87	Hatfield State Park (MRFF)		53.6	60.8	23363	73
06-44-88	Hatfield State Park (MRFF)		53.6	60.8	23639	73
	Total	Apr 26			70351	
Tuolumne River						
06-44-06	La Grange (MRFF)		57.2	53.6	24976	86
06-44-67	La Grange (MRFF)		57.2	53.6	24813	86
06-44-68	La Grange (MRFF)		57.2	53.6	25220	86
	Total	Apr 24			75009	
San Joaquin River						
06-44-61	Old Fisherman's Club (MRFF)	Apr 26	55.4	62	25701	85
06-44-69	Old Fisherman's Club (MRFF)	Apr 29	55.4	60.8	23870	86
Stanislaus River						
06-44-46	Knight's Ferry (MRFF)		56.3	53.6	23745	82
06-44-47	Knight's Ferry (MRFF)		53.6	52.7	24236	83
	Total	May 01			47981	
06-44-48	Two Rivers (MRFF)	May 04	59	64.4	24646	84

Antioch						Chipps Island						
First Day Recovered	Last Day Recovered	Number Recovered	Minutes Fished	Survival Index	Group Index	First Day Recovered	Last Day Recovered	Number Recovered	Minutes Fished	Percent Sampled	Survival Index	Group Index
Apr 15	Apr 15	1	455	0.010		Apr 11	Apr 11	1	400	0.278	0.020	
--	--	0	--	--		--	--	0	--	--	--	
--	--	0	--	--		--	--	0	--	--	--	
--	--	0	--	--		--	--	0	--	--	--	
Apr 15	Apr 15	1	455		0.002	Apr 11	Apr 11	1	400	0.278		0.005
Apr 10	Apr 27	10	8937	0.086		Apr 07	Apr 11	2	1960	0.272	0.039	
Apr 27	Apr 27	1	560	0.008		Apr 12	Apr 12	1	320	0.222	0.024	
Apr 12	Apr 12	3	520	0.024		Apr 12	Apr 14	3	777	0.180	0.087	
Apr 10	Apr 27	14	8937		0.040	Apr 07	Apr 14	6	2737	0.238		0.045
--	--	0	--	--	--	--		0	--	--	--	
May 13	May 13	1	540	0.008	--	--		0	--	--	--	
--	--	0	--	--		--	--	0	--	--	--	
--	--	0	--	--		--	--	0	--	--	--	
May 13	May 13	1	540		0.002	--	--	0	--	--		--
May 06	May 12	2	4136	0.015		May 09	May 11	2	1080	0.250	0.045	
May 07	May 14	5	4671	0.038		--	--	0	--	--	--	
May 09	May 11	2	1746	0.015		May 09	May 09	1	400	0.278	0.020	
May 06	May 14	9	5221		0.023	May 09	May 11	3	1080	0.250		0.022
May 07	May 09	3	1826	0.020		May 05	May 05	1	380	0.264	0.020	
May 03	May 07	5	2820	0.037		May 3	May 11	7	3379	0.261	0.141	
May 03	May 04	3	1090	0.023		--	--	0	--	--	--	
May 03	May 09	11	4026		0.026	May 03	May 11	8	3379	0.261		0.053
May 05	May 05	1	560	0.007		May 03	May 05	6	1179	0.273	0.111	
May 05	May 08	2	2350	0.015		May 05	May 08	3	1500	0.260	0.063	
May 11	May 11	1	580	0.008		May 11	May 12	2	740	0.257	0.043	
May 9	May 14	5	3431	0.037		May 10	May 10	2	280	0.194	0.055	
May 9	May 14	6	3431		0.023	May 10	May 12	4	1020	0.236		0.046
May 11	May 13	3	1720	0.022		May 12	May 12	1	340	0.236	0.022	



APPENDIX D | ERRATA

ERRATA FOR THE YEAR 2001 ANNUAL TECHNICAL REPORT
ON IMPLEMENTATION AND MONITORING OF THE SAN JOAQUIN RIVER AGREEMENT AND THE VERNALIS ADAPTIVE MANAGEMENT PLAN

Table 5–6:

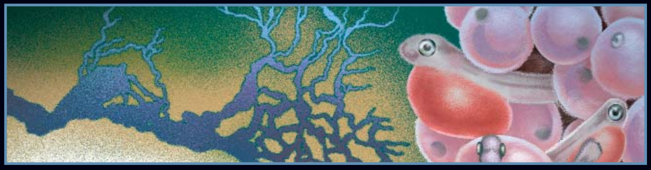
Estimates of Survival Between Durham Ferry and Mossdale (S DF to MD) and Between Mossdale and Jersey Point (S MD to JP), and Survival minus (S–2se) and Plus (S+2se) two Standard errors. The corrected values have been highlighted in the table below.

	REC. AT ANTIOCH	REC. AT CI	# RELEASED	A+C	A+C/R	S DF TO MD	S MD TO JP	S–2SE	S+2SE
Durham 1	28	14	23,354	42	0.001798407				
	30	22	22,837	52	0.002277007				
	18	17	22,491	35	0.001556178				
	76	53	68,682	129	0.001878221	1.33		0.92	1.73
MD 1	18	17	23,000	35	0.001521739				
	15	14	22,177	29	0.001307661				
	33	31	45,177	64	0.00141665		0.16	0.12	0.20
JP 1	156	50	24,443	206	0.008427771				
	173	61	24,992	234	0.009362996				
	329	111	49,435	440	0.008900577				
Durham 2	8	2	24,025	10	0.000416233				
	11	5	24,029	16	0.000665862				
	10	2	24,177	12	0.000496339				
	29	8	72,231	38		0.96		0.48	1.44
MD 2	8	4	23,878	12	0.000502555				
	11	4	25,308	15	0.000592698				
	19	8	49,186	27	0.000548937		0.20	0.12	0.29
JP 2	43	17	25,909	60	0.002315798				
	53	27	25,465	80	0.003141567				
	96	44	51,374	140	0.002725114				

In Appendix C-5, the Expanded salvage/SWP was reported incorrectly in the 2001 Report. The tag code for the group released on April 28 in the San Joaquin River at Old Fisherman's Club was also reported incorrectly. The correct tag codes with changes are provided below.

TAGCODE	RELEASE SITE/STOCK	DATE	EXPANDED SWP
Merced River			
06-44-15	Merced River Fish Facility		0
06-44-16	Merced River Fish Facility		6
06-44-17	Merced River Fish Facility		6
06-44-18	Merced River Fish Facility		0
	Total	Apr. 21	
06-44-33	Old Fisherman's Club	Apr. 28	0

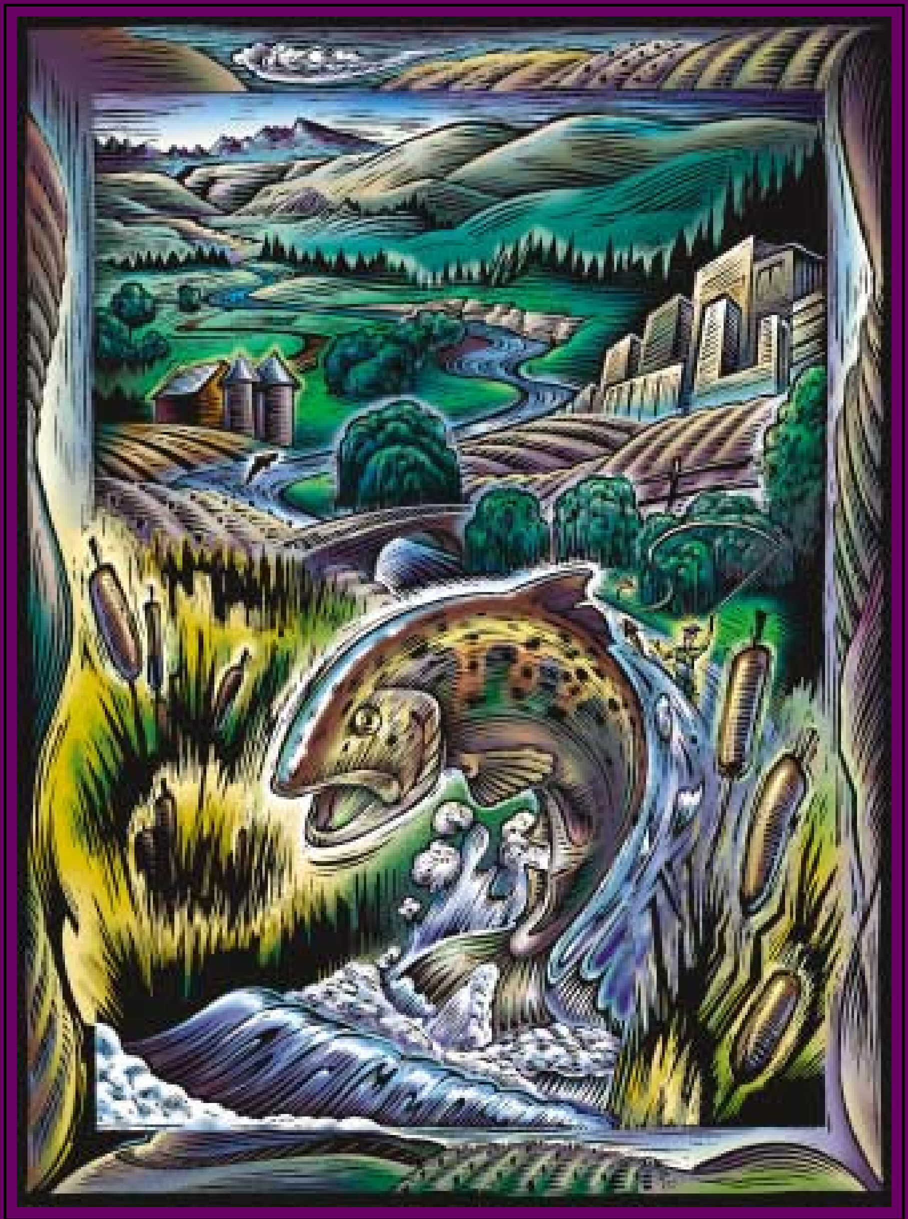
SAN JOAQUIN RIVER GROUP AUTHORITY



P.O. Box 4060, Modesto, CA 95352 • (209)526-7405 • FAX (209)526-7315

Modesto Irrigation District
Turlock Irrigation District
Oakdale Irrigation District
Merced Irrigation District
Friant Water Users Authority
City and County of San Francisco
South San Joaquin Irrigation District
San Joaquin River Exchange Contractors

2001 ANNUAL TECHNICAL REPORT



SAN JOAQUIN RIVER GROUP AUTHORITY

Head of Old River Barrier

2001 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
State Water Resources Control Board

In Compliance with D-1641

January 2002

TABLE OF CONTENTS

EXECUTIVE SUMMARY 4

CHAPTER 1
Introduction 6
Experimental Design Elements 6

CHAPTER 2
VAMP Hydrologic Planning and Implementation 8
VAMP Flow and SWP/CVP Exports 8
VAMP 2001 Hydrologic Planning 9
VAMP 2001 Implementation 10
Results of VAMP 2001 Operations 15

CHAPTER 3
Additional Water Supply Arrangements & Deliveries 19
Merced Irrigation District 19
Oakdale Irrigation District 19

CHAPTER 4
Head of Old River Barrier. 20
Barrier Design, Installation and Operation 20
Fishery Monitoring at the Head of Old River Barrier 22
Results and Discussion. 24

CHAPTER 5
Salmon Smolt Survival Investigations 30
Coded–Wire Tagging. 30
CWT Releases 31
Water Temperature Monitoring 31
Post–Release Live–Car Studies. 35
CWT Recovery Efforts 39
VAMP Chinook Salmon CWT Survival Indices 41
Absolute Chinook Salmon Survival Estimates 42
Ocean Recovery Information from Past Years 49
San Joaquin River Salmon Protection 51

CHAPTER 6
Complementary Studies Related to Vamp 60
Survival Estimates for Juvenile Chinook Salmon Emigrating from the San Joaquin River Tributaries 60
Evaluation of Chinook Salmon Smolt in Old River: Biological Responses to Toxicants. 61
Hydraulic Investigations Associated with the Old River Barrier 63
Hydro–Acoustic Monitoring of Juvenile Chinook Salmon Emigration 64
Statistical Analysis of VAMP Data 64

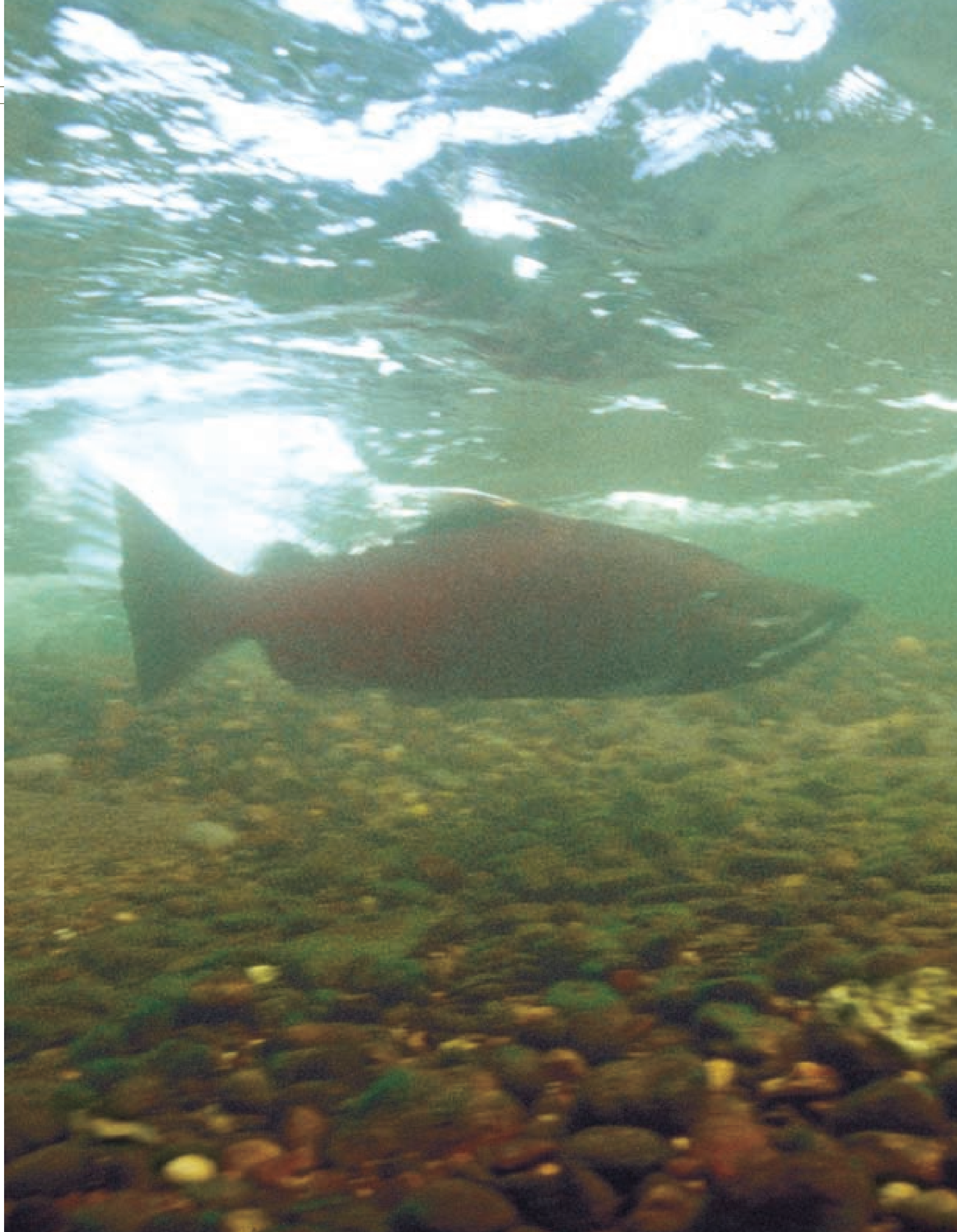
CHAPTER 7
Conclusions and Recommendations 66

LITERATURE CITED. 68

CONTRIBUTING AUTHORS 69

SIGNATORIES TO THE SAN JOAQUIN RIVER AGREEMENT. 70

APPENDIX TABLE OF CONTENTS 72



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). Using a consensus-based approach, the SJRA united a large and diverse group of agricultural, urban, environmental and governmental interests.

The 2001 Annual Technical Report comprises the consolidated annual SJRA Operations Report and Vernalis Adaptive Management Plan (VAMP) Monitoring Report. The VAMP 2001 program represents the second 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 VAMP program. Specifically, this report includes the following information on the implementation of the SJRA: the hydrologic chronicle; management of the additional SJRA water; installation, operation, and monitoring of the Head of Old River Barrier (HORB); results of the juvenile Chinook salmon smolt survival investigations; discussion of complementary investigations; and, conclusions and recommendations. Condition 4.b of D-1641 directs the Department of Water Resources (DWR) and the U.S. Bureau of Reclamation (USBR) to send the Executive Director of the State Board the results of the fishery monitoring studies on an annual basis and Condition 7 of D-1641 directs Merced, Modesto, Turlock, South San Joaquin and Oakdale irrigation districts to submit a report detailing district operations as a result of the SJRA. By letter dated September 8, 2000, the SWRCB approved combining these two reports into a single comprehensive report due to the SWRCB on January 31 of each year.

A key part of this landmark agreement is the VAMP. VAMP is designed to protect juvenile Chinook salmon migrating from the San Joaquin River through the Sacramento-San Joaquin Delta.

VAMP is designed to protect juvenile Chinook salmon migrating from the San Joaquin River through the Sacramento-San Joaquin Delta.

VAMP is also a scientifically recognized 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 and the operation of the HORB.

VAMP employs an adaptive management strategy to use current knowledge of hydrology and environmental conditions to protect Chinook salmon smolt passage, while gathering information to allow more efficient protection in the future. In addition to providing improved protection for juvenile Chinook salmon emigrating from the San Joaquin River system, specific experimental objectives of VAMP 2001 included:

- Quantification of Chinook salmon smolt survival between Durham Ferry and Jersey Point using recapture locations at Antioch and Chipps Island, under target conditions of a San Joaquin River flow at Vernalis of 4,450 cfs, with an installed HORB, and SWP/CVP export rates of 1,500 cfs; and
- Comparison of juvenile Chinook salmon survival between Durham Ferry and Mossdale for use in comparing results of VAMP 2001 with results from earlier survival studies where coded-wire tagged salmon releases occurred at Mossdale.

Based on data gathered during the experimental mark-recapture studies that occurred over a 31-day period in April and May 2001, a set of conclusions and recommendations has been developed. These conclusions and recommendations provide guidance and a foundation for design and implementation of future VAMP operations. Key conclusions and recommendations derived from VAMP 2001 include:

- VAMP 2001 is the second year of full implementation of the program. Average Vernalis flow during the VAMP period was 4,420 cfs. SWP and CVP export rates averaged 1,420 cfs. The VAMP period was between April 20 and May 20, 2001.
- Survival estimates between Durham Ferry and Jersey Point using recaptures at Antioch indicated that was no difference between the two replicates conducted in 2001. Survival estimates using the Chipps Island information indicated the first replicate survived at a higher rate than the second.
- The proportion of CWT salmon released and recaptured from the combined Durham Ferry and Mossdale groups relative to the proportion of CWT salmon released and recaptured from the Jersey Point (control) releases showed that the relative proportions during 2001 (target flow 4,450 cfs and 1,500 cfs exports) were not significantly different than the proportions from the VAMP 2000 study (target flow 5,700 cfs and 2,250 cfs exports).
- No conclusions on the relative roles of San Joaquin River flow and SWP/CVP exports on juvenile Chinook salmon smolt survival can be made with these two years of data. The report recommends that the VAMP experimental test program be continued.
- The quality of the real-time flow data at Vernalis were improved by weekly measurements; however, estimation of ungauged flow (accretions and depletions) requires further investigation for use in establishing annual VAMP target flows. Alternative methods of measuring flow at Vernalis and/or alternative measurement locations should also be investigated.
- Delays in permitting and construction of the HORB delayed implementation of the VAMP 2001 studies, contributed to the second salmon release group being exposed to elevated water temperatures, and may have adversely affected their survival. Due to the high risk of losing major salmon protection benefits and biasing experimental conditions, it is strongly recommended that permitting and construction of the HORB be completed to avoid delays in implementing survival investigations. It is also recommended that modifications be made to the barrier design to avoid debris accumulation on trash racks, facilitate routine maintenance, facilitate fisheries sampling, and provide measurements of flow diverted through each culvert.
- Exposure of juvenile Chinook salmon during the second release to elevated water temperatures within the lower San Joaquin River and Delta and evidence of increased disease were identified as factors potentially affecting salmon smolt survival and the validity of the second VAMP test release in 2001. The proportion of marked salmon recaptured from all release locations was found to be significantly lower during the second VAMP release when compared to the first survival study conducted in 2001. The second set of VAMP 2001 releases may not be comparable to other VAMP data and survival results should be interpreted with caution.
- The variability inherent in conducting salmon smolt survival studies in the lower San Joaquin River and Delta makes it difficult to detect statistically significant differences in salmon survival between VAMP flow and export target conditions, which are relatively similar. It is strongly recommended that, when possible, target flow and export conditions be selected to conduct survival tests at VAMP flow and export extremes to improve the ability to detect potential differences in salmon smolt survival among test conditions.
- Approximately 65 percent of the unmarked salmon migrating past Mossdale in 2001 migrated during the VAMP period (April 20 through May 20) and were, therefore protected by increased San Joaquin River flow, installation of the HORB and decreased export pumping.
- Hydrologic conditions during VAMP 2001 were found to be close to the threshold separating two alternative San Joaquin River flow targets. If hydrologic conditions are close to a decision threshold in the future, it is recommended that target flows be selected representing new VAMP test conditions rather than repeating a previously tested flow/export case.
- The selection and management of VAMP flow conditions should, if possible, minimize or avoid requiring upstream tributary flows that adversely affect potential habitat quality or survival of natural salmon produced within the tributaries. It is therefore recommended that upstream tributary and VAMP studies be coordinated as much as possible.

INTRODUCTION

The Vernalis Adaptive Management Plan (VAMP) was implemented during the spring 2001 to protect juvenile Chinook salmon and evaluate the relationship between San Joaquin River flow and state (SWP) and federal (CVP) water project exports on survival of juvenile Chinook salmon migrating through the Sacramento–San Joaquin Delta. This represents the second official year of the VAMP experiment.

EXPERIMENTAL DESIGN ELEMENTS

The VAMP experimental design measures salmon smolt survival rates under six different combinations of flow and export rates. The experimental design includes two mark-recapture studies performed each year during the mid-April to mid-May outmigration period that provide estimates of salmon survival under each set of conditions. Chinook salmon survival indices under each of the experimental conditions are then calculated based on the numbers of marked salmon released and the number recaptured.

The VAMP 2001 experimental design included both multiple release locations (Durham Ferry, Mossdale, and Jersey Point), and multiple recapture locations (Antioch, Chipps Island, SWP and CVP salvage operations, and in the ocean fishery; (Figure 1-1). Two sets of releases were made at Durham Ferry, Mossdale, and Jersey Point. The use of data from multiple release and recapture locations allows for a more thorough evaluation of juvenile Chinook salmon survival as compared to recapture data from only one sampling location and/or one series of releases. The VAMP releases (Durham Ferry and Jersey Point) and recapture locations (Antioch and Chipps Island) will be consistent from one year to the next, providing a greater opportunity to assess salmon smolt survival over a range of Vernalis flows, SWP/CVP exports, and with and without the presence of the Head of Old River Barrier (HORB). Releases at Jersey Point serve as controls for recaptures at Antioch and Chipps Island, thereby allowing the calculation of survival estimates based on the ratio of survival indices from marked salmon recaptured from upstream (e.g., Durham Ferry) and downstream (control release at Jersey Point) release locations. The use of ratio estimates as part of the VAMP study design substantially reduces the bias associated with differential gear collection efficiency within and among years, improves the precision associated with the individual survival estimates, and improves confidence in detecting differences in salmon smolt survival as a function of Vernalis flows and SWP/CVP exports.

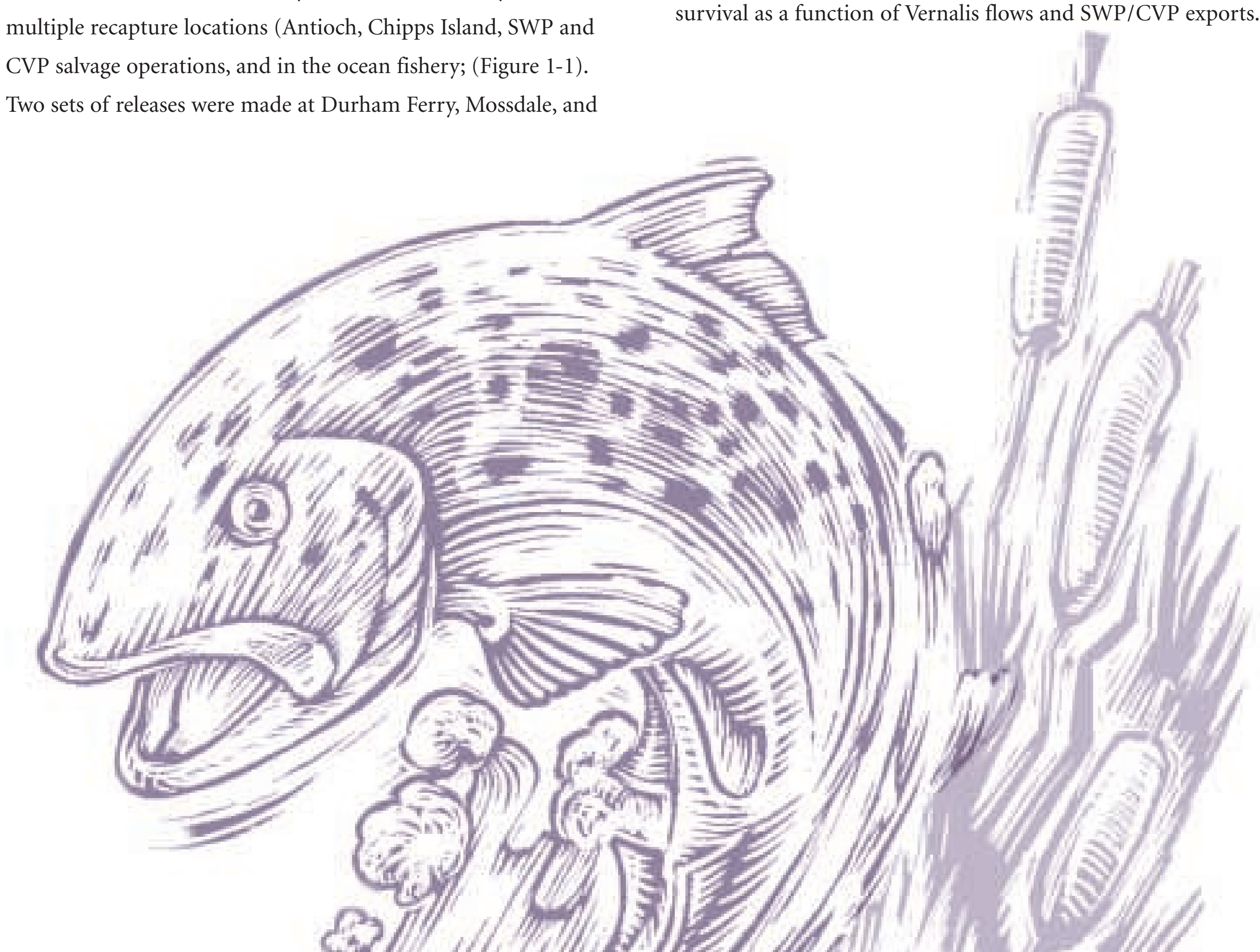


FIGURE 1-1
Sacramento–San Joaquin Estuary

Location of VAMP 2001 release sites (Durham Ferry, Mossdale and Jersey Point), recovery locations (Antioch and Chipps Island), and Head of Old River Barrier location within the Sacramento-San Joaquin River Delta/Estuary.

VAMP HYDROLOGIC PLANNING AND IMPLEMENTATION

This section documents the planning and implementation undertaken by the Hydrology Group of the San Joaquin River Technical Committee (SJRTC) for the 2001 VAMP investigations. Implementation of VAMP is guided by the framework provided in the SJRA and anticipated hydrologic conditions within the watershed.

The Hydrology Group 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 2001, the agencies belonging to the Hydrology Group included: Merced Irrigation District (Merced), Turlock Irrigation District (TID), Modesto Irrigation District (MID), Oakdale Irrigation District (OID), South San Joaquin Irrigation District (SSJID), San Joaquin River Exchange Contractors (Exchange Contractors), 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 installation of the HORB and the planning of Delta exports consistent with the VAMP.

VAMP FLOW AND SWP/CVP EXPORTS

The VAMP investigations are designed to collect data and information on the impacts of San Joaquin River flow and Delta exports (SWP and CVP pumping at the Banks and Tracy pumping plants respectively) on the survival rates of juvenile Chinook salmon emigrating from the San Joaquin River system. The VAMP provides for a 31-day pulse flow at the Vernalis gauge during the months of April and May, along with a corresponding reduction in SWP/CVP exports, as shown in Table 2-1. The magnitude of the pulse flow is based on San Joaquin River flow that would occur during the pulse period absent the VAMP, referred to as the existing flow.

TABLE 2-1
VAMP Vernalis Flow and Delta Export Targets

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
4,500 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 the extent possible	

Based upon hydrologic conditions, the target flow in a given year could either be increased to the next highest value ("double-step") or the supplemental water requirement could be eliminated entirely. A numerical procedure has been established in the SJRA to determine the target flow. The State Board San Joaquin Valley Water Year Hydrologic Classification ("60-20-20" classification) is given a numerical indicator as shown in Table 2-2.

"Double-step" flow years occur when the sum of last year's numerical indicator and the 90 percent exceedence forecast of the current year's numerical indicator is seven (7) or greater.

If the sum of the two previous years' numerical indicators and the 90 percent exceedence forecast of the current year's numerical indicator is four (4) or less, indicative of an extended dry period, the San Joaquin River Group Authority (SJRG) members are not required to provide water above the existing flow. The USBR, however, has a continuing obligation to meet San Joaquin River flows pursuant to the March 6, 1995 Delta Smelt Biological Opinion.

TABLE 2-2
San Joaquin Valley Water Year Hydrologic Year Classifications Used in VAMP

60-20-20 WATER YEAR CLASSIFICATION	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. Based on the targets outlined in Table 2-1, in a double-step year up to 157,000 acre-feet of supplemental water may be required. If the VAMP target flow requires more than 110,000 acre-feet of supplemental water, then additional water may be acquired on a willing seller basis.

VAMP 2001 HYDROLOGIC PLANNING

Hydrology Group Meetings

Beginning in February 2001, and continuing until early April, the Hydrology Group held five planning and coordination meetings (February 13; March 14 and 29; and April 4 and 11). At these meetings, forecasts of hydrologic and operational conditions on the San Joaquin River and its tributaries were discussed and refined.

Monthly Operation Forecasts

As part of the early planning efforts, monthly operation forecasts were developed by the Hydrology Group to estimate the existing flow at Vernalis. Inflows to the tributary reservoirs used in these forecasts were based on DWR Bulletin 120 runoff forecasts. The monthly operation forecasts used the 90 percent and 50 percent probability of exceedence runoff forecasts. The initial monthly operation forecast was prepared in early February and presented at the February 13 Hydrology Group meeting. The 90 percent exceedence forecast called for a VAMP target flow of 3,200 cfs with a need for 73,000 acre-feet of supplemental water; the 50 percent exceedence forecast called for a VAMP target flow of 4,450 cfs with a need for 59,000 acre-feet of supplemental water. Hydrologic projections and planning were subsequently refined as additional information became available in March and April.

Daily Operation Plan

Starting in mid-March, the Hydrology Group began development of a daily operation plan, updating it as hydrologic conditions and operational requirements changed. The daily operation plan calculated an estimated mean daily flow at Vernalis based on estimates of the daily flow at the major tributary control points, estimates of ungauged flow between those control points and Vernalis, and estimates of flow in the San Joaquin River above the major tributaries. The following key assumptions were used in the development of the daily operation plan:

(1) The travel times for flows from the tributary measurement points and upper San Joaquin River to the Vernalis gauge are assumed as follows:

a. Merced River at Cressey to Vernalis — 3 days
b. San Joaquin River above Merced River to Vernalis — 2 days
c. Tuolumne River at LaGrange to Vernalis — 2 days
d. Stanislaus River below Goodwin Dam to Vernalis — 2 days

(2) Based upon a review of the historical flow record, the ungauged flow at Vernalis was assumed to be constant throughout the VAMP period and equal to the trending value entering the period. By definition, the ungauged flow is that unmeasured flow entering the system between Vernalis and the upstream measuring points and is calculated as follows:

Vernalis Ungauged =

VNS - GDWlag - LGNlag - CRSlag - USJRlag

where:

VNS = San Joaquin River near Vernalis
GDWlag = Stanislaus River below Goodwin Dam lagged 2 days
LGNlag = Tuolumne River below LaGrange Dam lagged 2 days
CRSlag = Merced River at Cressey lagged 3 days
USJRlag = San Joaquin River above Merced River lagged 2 days (USJR is not a gauged flow but is the calculated difference between the gauged flows at the San Joaquin River at Newman (NEW) and the Merced River near Stevinson (MST)).

By definition, the VAMP 31-day pulse flow period can occur anytime between April 1 and May 31. Until the VAMP flow period is specifically defined, it is assumed for the purposes of planning to be April 15 through May 15. Flexibility of the VAMP flow period exists so that it can coincide with the period of peak salmon out-migration. Other factors, including installation of HORB, availability of juvenile salmon at the hatchery, and manpower and equipment availability for salmon releases and recapture need to be considered in determining the timing of the VAMP period.

The 60-20-20 classification for water year 2000 was "above normal", giving it a VAMP numerical indicator of 4. If the 90 percent exceedence forecast on April 1 defined water year 2001 as a "below normal" or wetter year, with a VAMP numerical indicator equal to or greater than 3, then the 2001 VAMP would follow the "double-step" criteria. Early forecasts were pointing towards 2001 being a "dry" year (VAMP numerical indicator of 2), therefore all planning efforts were made using the "single step" criteria. In fact, the 90 percent exceedence forecast on April 1 for the San Joaquin Valley was for a "critical" year, resulting in the 2001 VAMP following the "single step" criteria.

Table 2-3 summarizes the various iterations of and demonstrates the evolutionary nature of the daily operation plan. Copies of the daily operation plans are provided in Appendix A.

As noted previously, initial planning efforts assume a VAMP period from April 15 through May 15. At the April 4 Hydrology Group meeting it was apparent that installation of the HORB would not be completed by April 15, therefore the VAMP period would need to begin at a later date. The planning effort preceded using start dates of April 17 and April 19. At the combined meeting of the Hydrology and Biology Groups on April 11, the decision was made to set the VAMP 2001 period at April 20 through May 20.

The greatest uncertainty in the development of the daily operation plan is the assumed ungauged flows between the upstream control points and Vernalis. Analysis of historical data indicates that a reasonable estimate of the ungauged flow for the VAMP period is the ungauged flow at the start of the VAMP period. As a result of rain on April 7 and 8, the ungauged flow, which had been running around 400 cfs, increased to 735 cfs on April 9. Therefore the planning at this point in time was done using assumed ungauged flows of 500 and 800 cfs. By April 12, refinements had been made to the ungauged flow calculations indicating that the ungauged flow prior to the rain of April 7 and 8 had been running around 600 cfs and peaked around 1,000 cfs on April 8, dropping to 832 cfs on April 11. With this information, the Hydrology Group prepared a daily operation plan on April 12 assuming ungauged flow of 650 cfs. As shown in Table 2-3, this operation plan resulted in an existing flow of 3,216 cfs, essentially on the breakpoint between target flows of 3,200 cfs and 4,450 cfs. The computed ungauged flow for April 12 was 771 cfs and still receding from the effects of the early April rain. Uncertain as to whether the ungauged flow would stabilize around the estimate of 650 cfs or continue receding, the Hydrology Group, on April 13, decided to initiate scheduling assuming a 3,200 cfs target flow with the understanding that if the ungauged flow did not recede significantly then the operation would be adjusted to a VAMP target flow of 4,450 cfs. On April 16, the ungauged flow for April 15 was computed to be 730 cfs with a slowing rate of recession, therefore the decision was made to use a target flow of 4,450 cfs, as shown in the daily operation plan of April 16.

Normally, the USGS measures the flow at Vernalis to check the current rating shift on a monthly basis. The real-time flows reported by the USGS and CDEC are dependent on the most current rating shift, therefore a new measurement and 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 March 21 and May 4. The results of these measurements are summarized in Table 2-4. As can be seen in Table 2-4, even with these precautions, the measurement on May 3 resulted in a sudden decrease in the real-time reported flow of just over 300 cfs, the impacts of which will be discussed in a following section.

VAMP 2001 Implementation

Operation Conference Calls

During implementation of the VAMP pulse flow, conference calls were conducted on a regular basis to discuss the status of the pulse flow and to make changes to the operation plan if needed. The calls were held at 6:30 a.m. so that potential operational changes could be implemented on that day. The first call was held on April 19. Starting on April 20 and ending on May 14, the calls were held every Monday, Wednesday and Friday.

Operation Monitoring

During the VAMP flow period, flows at Vernalis and in the San Joaquin River tributaries were continuously monitored using the available real-time data. Similarly, the computed ungauged flow at Vernalis and the flow in the San Joaquin River upstream of the Merced River were continuously updated. The available real-time data sources are summarized in Table 2-5. The monitoring was necessary to verify that supplemental water deliveries were adhering

TABLE 2-3
Summary of 2001 VAMP Daily Operation Plans Prepared During Planning Phase

VAMP FORECAST DATE	PULSE PERIOD	ASSUMED UNGAUGED FLOW AT VERNALIS (CSF)	EXISTING FLOW (CSF)	VAMP TARGET FLOW (CFS)	SUPPLEMENTAL WATER NEEDED TO MEET TARGET FLOW (1,000 AF)
March 14	4/15–5/15	700 1,000	3,943 4,246	4,450 4,450	31.17 12.52
March 20	4/15–5/15	700 1,000	2,833 3,133	4,450 4,450	22.57 4.13
March 23	4/15–5/15	500	2,633	3,200	34.87
April 3	4/15–5/15 4/17–5/17	500 1,000 500 1,000	2,636 3,136 2,628 3,128	3,200 3,200 3,200 3,200	34.66 3.91 35.15 4.40
April 10	4/19–5/19	500 800 500	2,920 3,221 2,594	3,200 4,450 3,600[1]	17.19 75.55 15.13
April 12	4/20–5/20	650	3,216	4,450	57.72
April 16	4/20–5/20	650	3,216	4,450	73.09

[1] Assumes "other supplemental water" is in addition to VAMP supplemental water.

TABLE 2-4
Summary of USGS Flow Measurements at the San Joaquin River

DATE	MEASURED FLOW (CFS)	REPORTED REAL-TIME FLOW (CFS)	PERCENT DIFFERENCE	SHIFT
March 6 at 10:05	5,330	4,570	16.6%	Yes
March 20 at 8:20	2,550	2,970	-14.1%	Yes
March 27 at 10:25	2,210	2,170	1.8%	No
April 3 at 9:40	2,240	2,180	2.8%	No
April 10 at 9:34	2,580	2,430	6.2%	Yes
April 18 at 9:45	2,090	2,140	-2.3%	No
April 25 at 8:42	4,400	4,620	-4.8%	No
May 3 at 10:45	4,220	4,540	-7.0%	Yes
May 8 at 09:45	4,170	4,170	0.0%	No

TABLE 2-5
Real-time Flow Data and Sources

MEASUREMENT LOCATION	REAL-TIME DATA SOURCE
San Joaquin River near Vernalis	USGS
Stanislaus River below Goodwin Dam	USBR Goodwin Dam daily operation report
Tuolumne River below LaGrange Dam (LGN)	CDEC
Merced River at Cressey (CRS)	CDEC
Merced River near Stevinson (MST)	CDEC
San Joaquin River at Newman (NEW)	CDEC

to tributary allocations contained in the SJRA to the extent possible, as well as to determine if changes in hydrologic conditions would require changes to the operation plan.

The daily operation plan was updated throughout the VAMP flow period. A summary of the updated daily operation plans is provided in Table 2-6. Copies of the updated daily operation plans are provided in Appendix A

Operational Highlights

As noted previously, the 2001 VAMP operation started with the uncertainty of whether the target flow would be 3,200 cfs or 4,450 cfs. The final determination was made on April 16 that the target flow would be 4,450 cfs. On April 19 and 20 a significant rain storm passed through the San Joaquin basin, resulting in an apparent peak flow at Vernalis of 4,890 cfs early in the morning of April 22. By the time of the April 23 operation conference call the apparent flow at Vernalis had receded to 4,740 cfs. Since the flow was within the desired operation bounds of plus or minus 7%, no action was taken. An updated daily operation plan was prepared on April 23 to reflect the measured flows to date. The effects of the rain had dissipated by April 26, and the flow at Vernalis appeared to stabilize within a range of plus or minus 100 cfs from the target flow (within 2% of the target). No operation changes were made through May 2 and an updated daily operation plan was prepared to reflect measured flows to date.

Things changed on May 4. The results of the May 3 USGS measurement of the flow at Vernalis indicated that the actual flow was about 300 cfs less than that in the real-time data report (Table 2-4). That is, rather than the reported flow of 4,520 cfs, the flow at Vernalis was actually 4,220 cfs, as illustrated in Figure 2-1. As a result of this news, there was a need to increase the amount of supplemental water being provided. In accordance with the Division Agreement, the additional supplemental water was the responsibility of Merced ID. The disadvantage of this was that with regulatory requirements and travel time, the soonest the increases from the Merced River would be seen at Vernalis would be in about six days. The only other alternative for getting water to Vernalis sooner would have been from the Tuolumne River, but that would have run the risk of disrupting fishery experiments on the Tuolumne as well as causing considerable deviation from the Division Agreement allotments. Since the flow at Vernalis was barely outside of the desired plus or minus 7% range, it was felt that the proper action was to increase the supplemental water contribution on the Merced River. Due to operational constraints and travel time requirements, the mean daily flow at Vernalis went as low as 4,010 cfs (almost 10% below the target) on May 10, before recovering to 4,320 cfs on May 13 and 4,520 cfs on May 14. No other operation changes were made for the duration of the 2001 VAMP period.

TABLE 2-6
Summary of 2001 VAMP Daily Operation Plans Prepared During Implementation Phase

VAMP FORECAST DATE	VAMP PERIOD	ASSUMED UNGAUGED FLOW AT VERNALIS (CFS)	EXISTING FLOW (CFS)	VAMP TARGET FLOW (CFS)	SUPPLEMENTAL WATER NEEDED TO MEET TARGET FLOW (1,000 AF)
April 23	4/20–5/20	650	3,232	4,450	72.15
May 2	4/20–5/20	650	3,211	4,450	73.39
May 4 [1]	4/20–5/20	500	3,026	4,450	86.14
May 7	4/20–5/20	500	3,004	4,450	86.11
May 14	4/20–5/20	500	2,950	4,450	89.48

[1] Rating shift at Vernalis gauge on May 3 resulted in reduced estimate of ungauged flow.

FIGURE 2-1
San Joaquin River Near Vernalis Effects of May 3rd Flow Measurement and Rating Shift

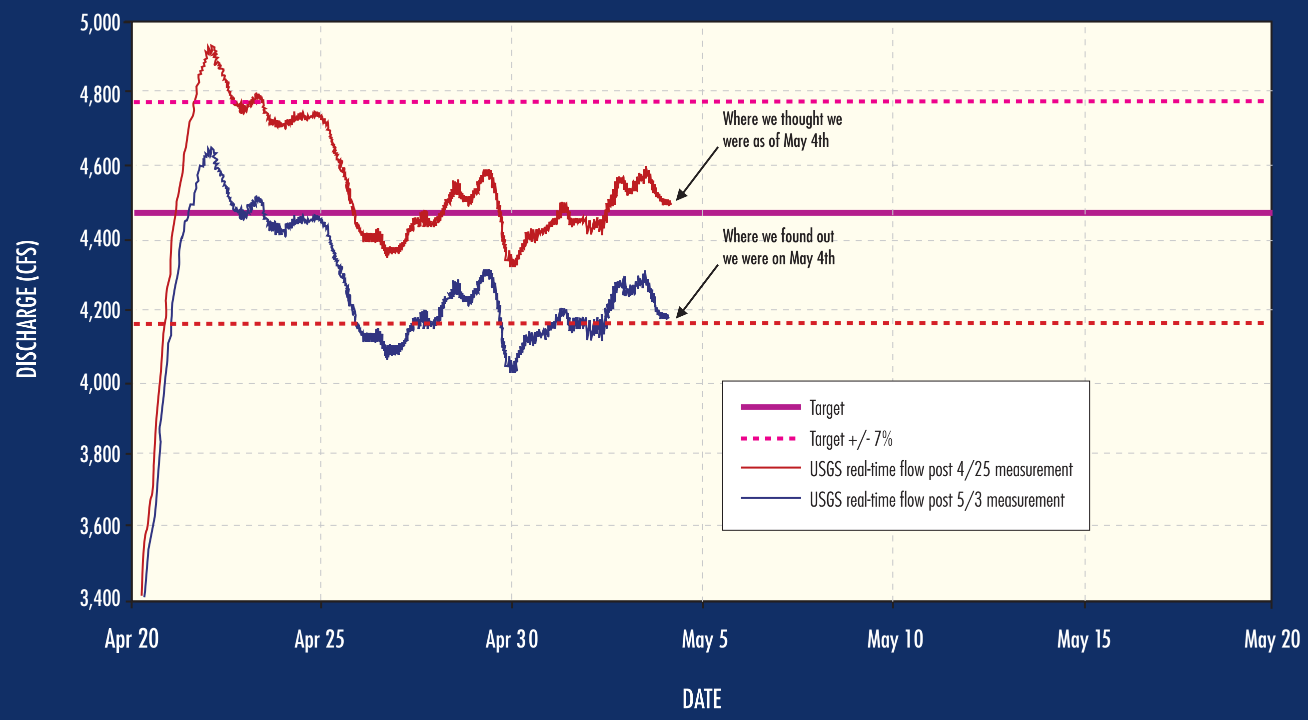


FIGURE 2-2
San Joaquin River Near Vernalis—With and Without VAMP

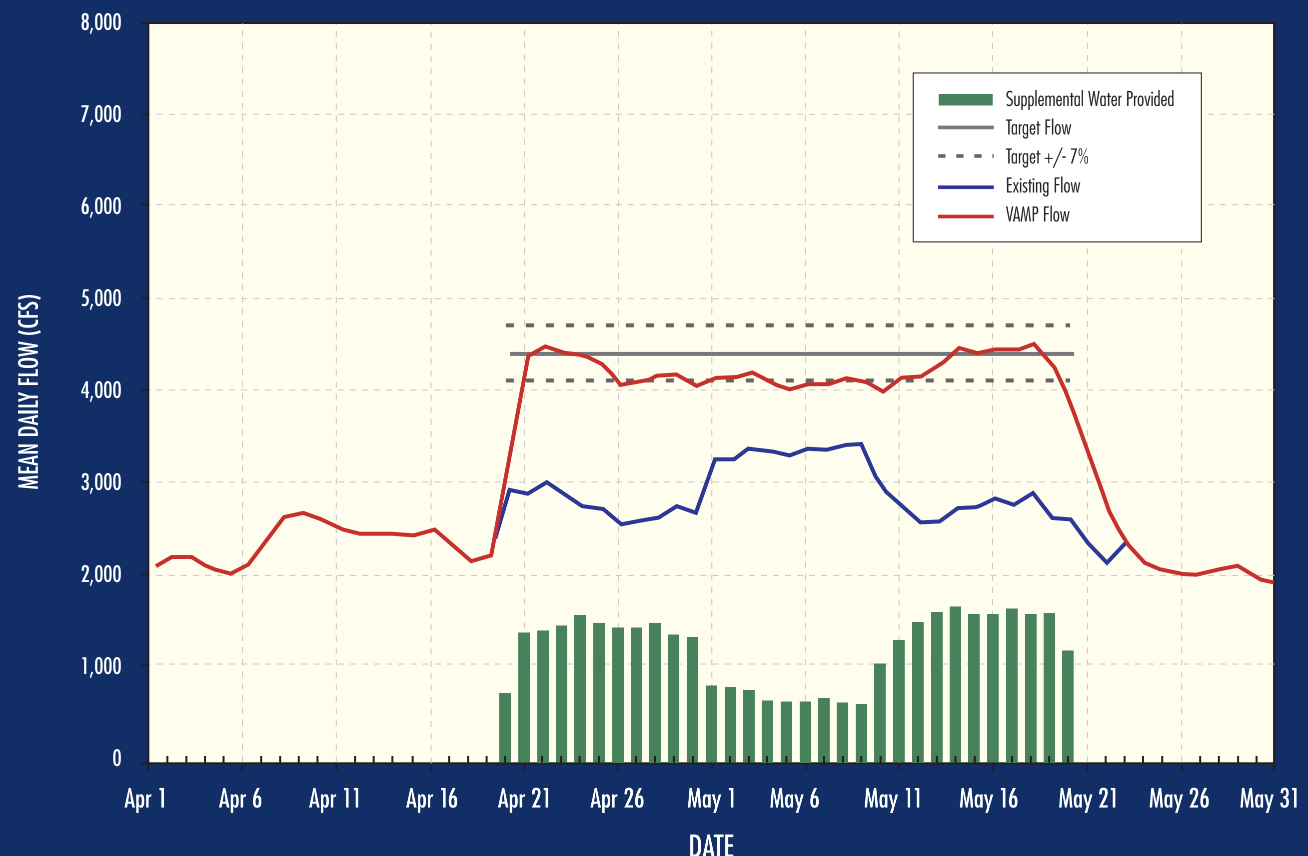


FIGURE 2-3
2001 VAMP—San Joaquin River Near Vernalis With Lagged Contributions From Primary Sources

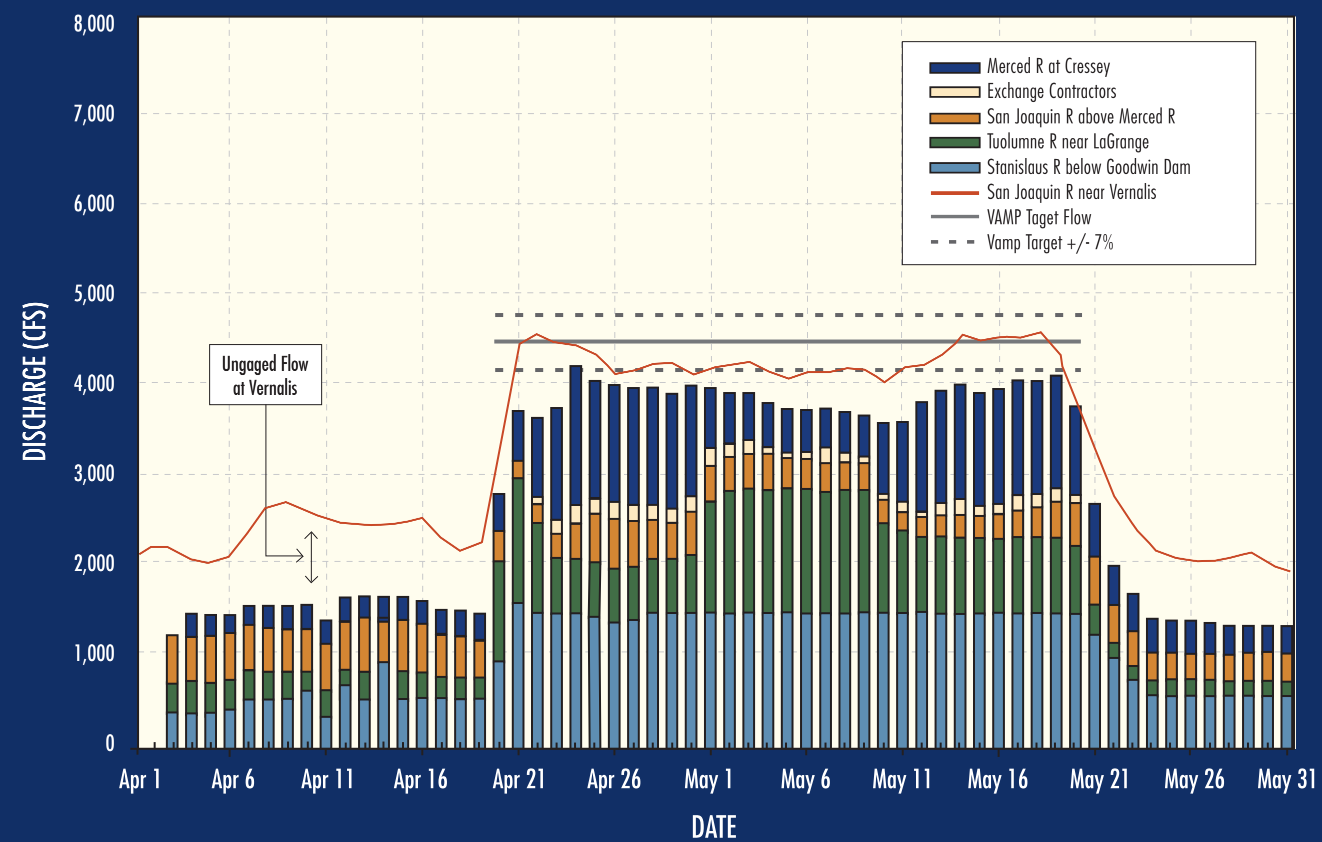
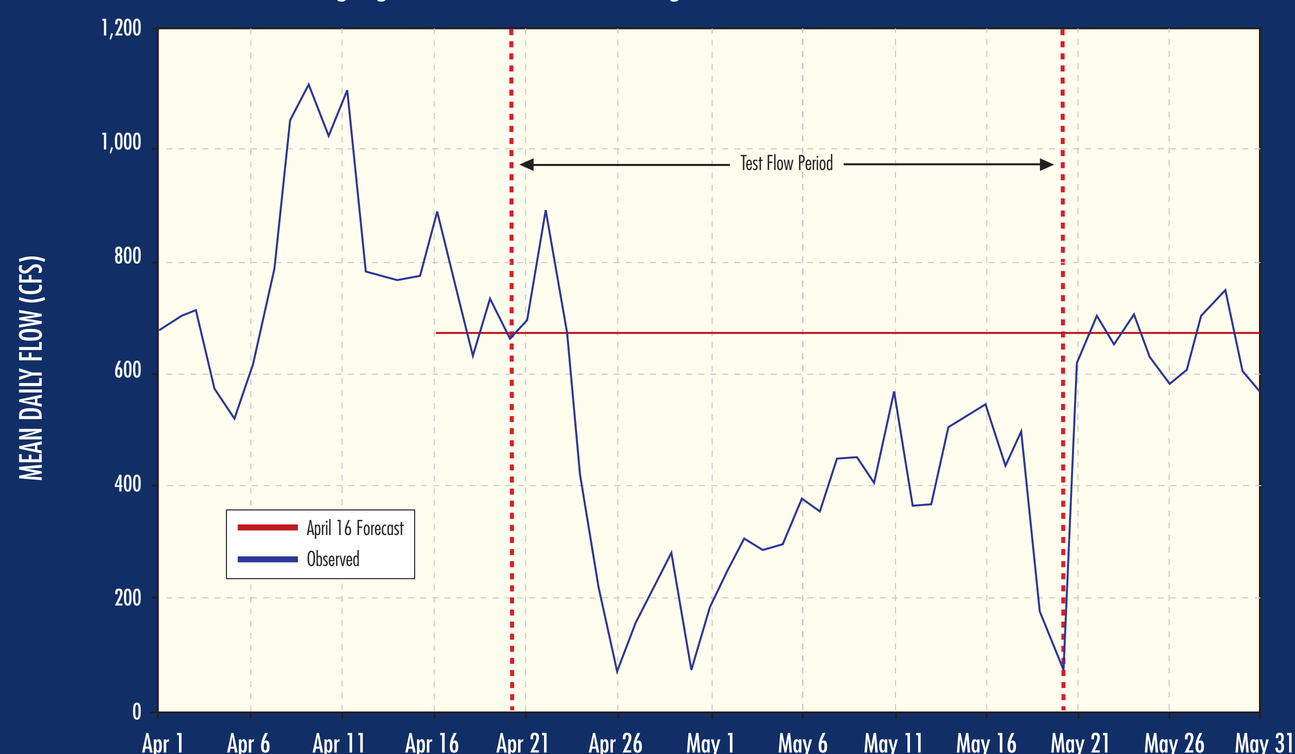


FIGURE 2-4
2001 VAMP—Ungauged Flow at Vernalis During VAMP Flow Period



RESULTS OF VAMP 2001 OPERATIONS

Planning and implementation of the VAMP spring pulse flow operation was accomplished using the best available real-time data, which has not been reviewed for accuracy or adjusted for rating shifts. The final accounting for the VAMP operation is accomplished using provisional mean daily flow data available from USGS and DWR. The provisional data, which is considered to be the best available information, has been reviewed and adjusted for rating shifts but is still considered preliminary and subject to change. To illustrate the differences between the real-time and the provisional data, plots of the real-time and provisional flows at the primary measuring points are provided in Appendix A.

The mean daily flow at the Vernalis gauge averaged 4,220 cfs during the VAMP test flow period, with a maximum of 4,560 cfs and a minimum of 3,450 cfs. The average flow for the test flow period absent the VAMP supplemental water was estimated to be 2,920 cfs. The VAMP operation resulted in a 45 percent increase in flow at Vernalis during the target flow period. Figure 2-2 shows the flow at Vernalis with and without the VAMP pulse flow. Figure 2-3 shows the sources of the flow at Vernalis. A total of 78,650 acre-feet of supplemental water was provided to meet the VAMP target flow. A daily summary of VAMP operations, along with supporting data, is provided in Appendix A.

The combined CVP and SWP export rate averaged 1,420 cfs during the 31-day period, about 5 percent below the target of 1,500 cfs.

As noted earlier, in planning for the VAMP operation the ungauged flow at Vernalis is the most difficult factor to forecast for the test flow period. Currently, estimates are made based on a review of historical data. The sensitivity of the VAMP planning and operation to the estimated ungauged flow was demonstrated this year. On April 16 the predicted ungauged flow was 650 cfs, resulting in an estimated existing flow at Vernalis of 3,216 cfs and a corresponding VAMP target flow of 4,450 cfs. The ungauged flow actually averaged 370 cfs during the test flow period, resulting in an estimated existing flow at Vernalis of 2,920 cfs, which would require a VAMP target flow of 3,200 cfs. In reviewing the data for this year's operation it appears that there may be a factor affecting the ungauged flow that is not accounted for through the use of the historical record, and that is the effects of the pulse flow itself on the ungauged flow. Figure 2-4 shows the ungauged flow during the test flow period and shows a correlation of reduced ungauged flow with the pulse flow. If this effect on the ungauged flow is due to the pulse flow operation, then some of the questions that need to be answered are whether this effect can be quantified, and whether the effect is dependent on the magnitude of the base flow in the San Joaquin River.

The combined CVP and SWP export rate averaged 1,420 cfs during the 31-day period, about 5 percent below the target of 1,500 cfs. The daily SWP and CVP exports during the VAMP test period are shown in Figure 2-5.

SJRG member agencies have entered into the Division Agreement, which allocates responsibility of the members for providing VAMP supplemental water. The distribution of supplemental water for the 2001 VAMP operation, compared to the distribution called for under the Division Agreement, is summarized in Table 2-7.

Storage Impacts

The VAMP supplemental water contributions, with the exception of that provided by the Exchange Contractors, are supplied from reservoir storage: Lake McClure on the Merced River, New Don Pedro Reservoir on the Tuolumne River and New Melones Reservoir on the Stanislaus River. Therefore, the impacts of VAMP operations can be seen directly as changes in reservoir storage. 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.

The storage impacts of the 2000 VAMP operation on Lake McClure were eliminated in May 2000 due to required flood control releases. As per the SJRA, Merced I.D. provided 12,500 acre-feet of

TABLE 2-7
2001 VAMP—Distribution of Supplemental Water

AGENCY	DIVISION AGREEMENT DISTRIBUTION (ACRE-FEET)	SUPPLEMENTAL WATER PROVIDED (ACRE-FEET)	DEVIATION FROM DIVISION AGREEMENT (ACRE-FEET)
Merced I.D.	42,150	42,120	-30
Oakdale I.D./ South San Joaquin I.D.	14,600	14,730	+130
Exchange Contractors	7,300	7,740	+440
Modesto I.D./Turlock I.D.	14,600	14,060	-540

supplemental water in the Fall of 2000. Therefore, prior to the 2001 VAMP operation, the storage impact on Lake McClure due to the SJRA was 12,500 acre-feet. With the 42,120 acre-feet of supplemental water provided for the 2001 VAMP operation along with 1,030 acre-feet of operational ramp-down water, the current impact of the SJRA on Lake McClure storage is 55,650 acre-feet. Figure 2-6 shows Lake McClure storage with and without the SJRA for the period of October 2000 through December 2001.

On the Tuolumne River, the storage impact from previous SJRA operations carried over into water year 2001 was 7,700 acre-feet. However, in late February 2001 precautionary flood control releases were made in excess of 7,700 acre-feet, thereby eliminating the SJRA storage impact. As a result of the 2001 VAMP operation, the current impact of the SJRA on New Don Pedro storage is 14,060 acre-feet. Figure 2-7 shows New Don Pedro Reservoir storage with and without the SJRA for the period of October 2000 through December 2001.

As part of the SJRA, 18,785 acre-feet of "additional" water was purchased from OID by Reclamation and released from New Melones Reservoir between October 17, 2000 and December 10, 2000, thereby resulting in an impact to New Melones storage of 18,785 acre-feet. This impact was carried over into 2001. The impact of the 2001 VAMP operation on New Melones storage was 16,890 acre-feet, of which 14,730 acre-feet was 2001 VAMP supplemental water and 2,160 acre-feet was 2001 VAMP operational ramp-down water. Therefore, the impact of the SJRA to New Melones storage following the 2001 VAMP operation was 35,675 acre-feet. As described in Chapter 3 of this report, Reclamation purchased and released 18,635 acre-feet of "additional" water, bringing the total current SJRA storage impact on New Melones Reservoir to 54,210 acre-feet. Figure 2-8 shows New Melones storage with and without the SJRA for the period of October 2000 through December 2001.

FIGURE 2-5
2001 VAMP – Federal and State Exports

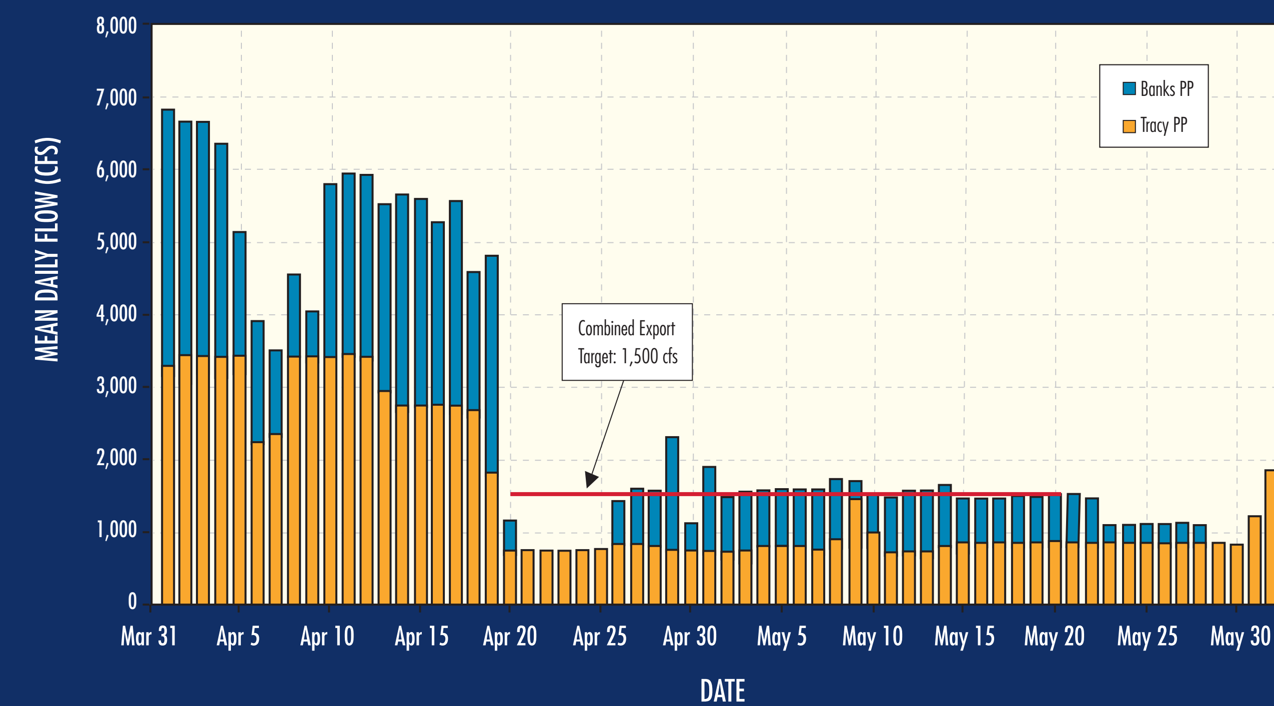


FIGURE 2-6
SJRA Storage Impacts – Lake McClure (Merced River) October 2000 Through December 2001

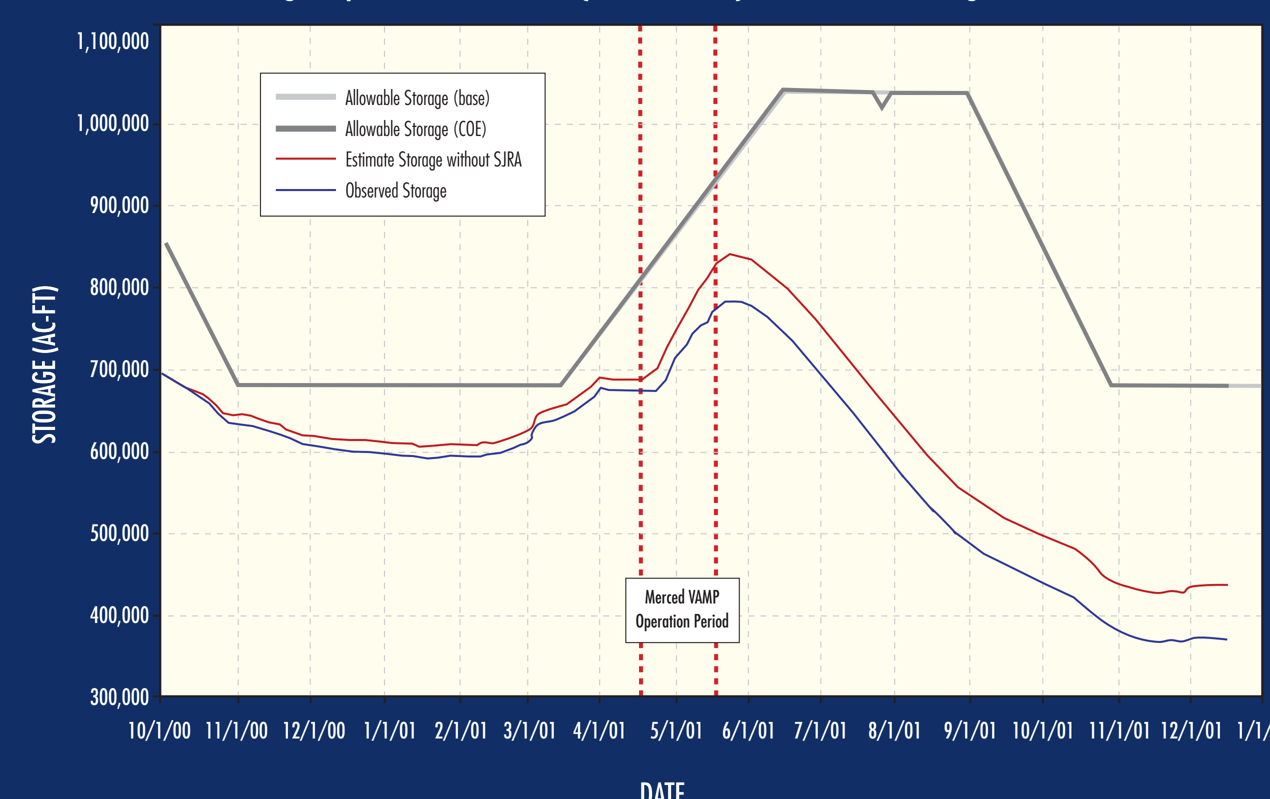


FIGURE 2-7

SJRA Storage Impacts—New Don Pedro Reservoir (Tuolumne River) October 2000 Through December 2001

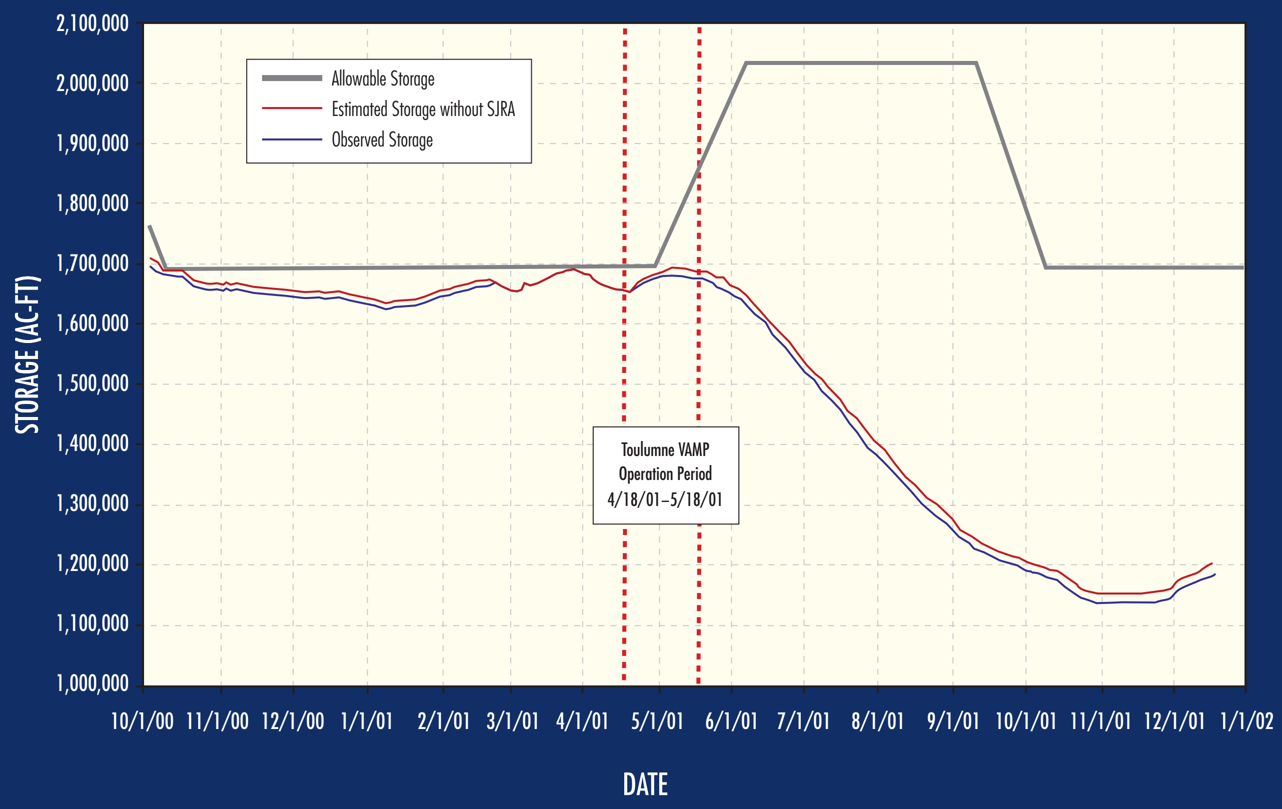
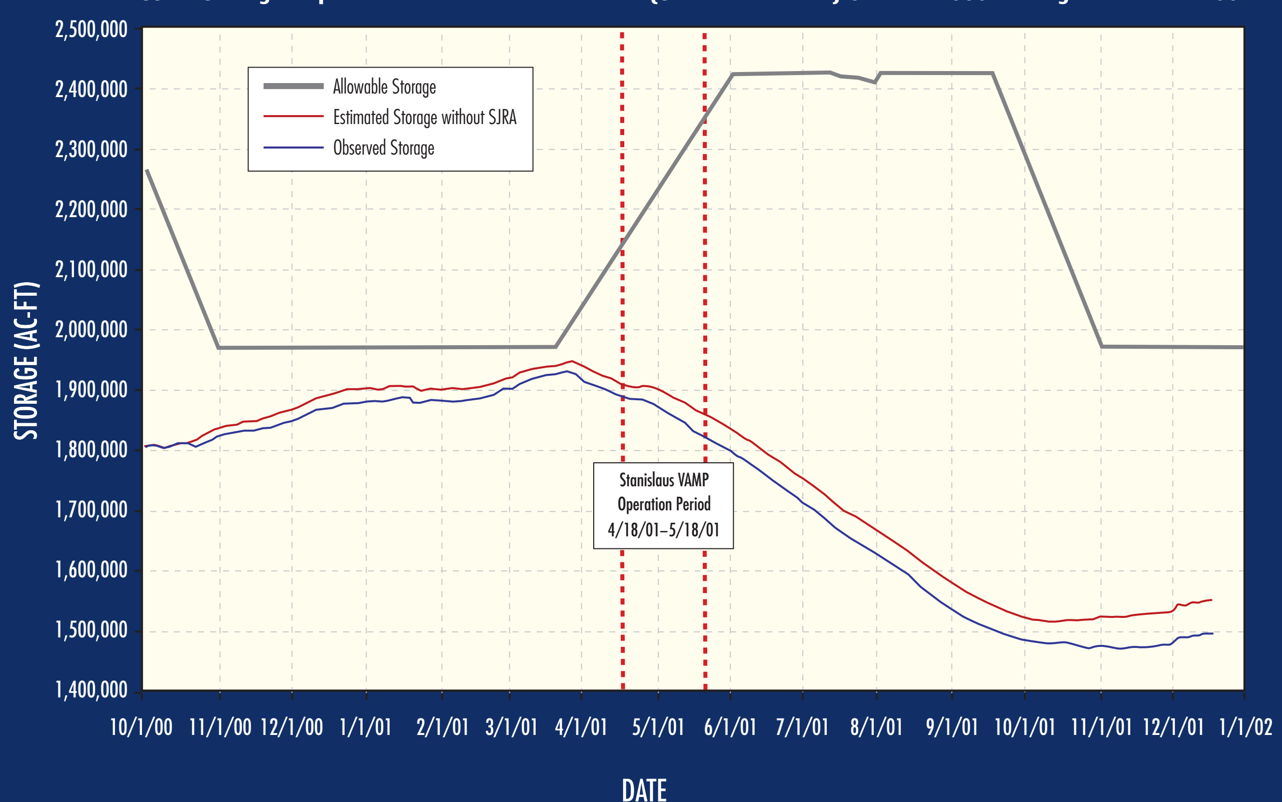


FIGURE 2-8

SJRA Storage Impacts—New Melones Reservoir (Stanislaus River) October 2000 Through December 2001



ADDITIONAL WATER SUPPLY ARRANGEMENTS & DELIVERIES

MERCED IRRIGATION DISTRICT

The SJRA includes a provision (Paragraph 8.4) stating that "Merced Irrigation District (Merced) 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." This water is referred to as the Fall SJRA Transfer Water. The daily schedule for the Fall SJRA Transfer Water is to be developed by Department of Fish and Game (DFG), United States Fish and Wildlife Services (USFWS) and Merced ID.

In addition to providing water in the fall of 2001 pursuant to the SJRA, Merced entered into a contract with DWR to transfer up to 25,000 acre-feet of water to the CALFED Environmental Water Account (EWA). This additional water transfer is referred to as the EWA Transfer. The EWA Transfer water was to be delivered south of the Delta via the SWP, using available excess pumping capacity at the Banks Pumping Plant. Since the likelihood of having excess pumping capacity decreases near the end of the year, the desire in the initial planning for the Fall water transfers was to transfer the EWA Transfer water first and use the Fall SJRA Transfer Water to supplement flows in November and December. A tabulation and plot of the initial daily flow schedule for the Fall water transfers is provided in Appendix B.

In October DWR installs a temporary barrier at the head of Old River. As part of the land use agreement allowing for the construction of the barrier, DWR has agreed to remove it if the flow in the San Joaquin River, as measured at the Vernalis gauge, exceeds 4,500 cfs. The expected flows on the Stanislaus River and Tuolumne River were taken into consideration during the Merced River Fall water transfer schedule development to minimize the risk of the San Joaquin River flow at Vernalis exceeding 4,500 cfs while the barrier was in place.

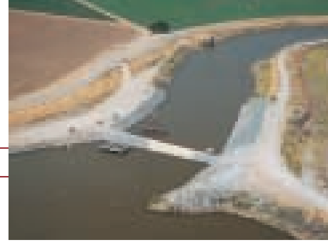
A table summarizing the preliminary data for the observed Merced ID Fall 2001 transferred water is provided in Appendix B. Also provided in Appendix B are the final data for the year 2000 Fall transferred water.

OAKDALE IRRIGATION DISTRICT

Pursuant to Paragraph 8.5 of the SJRA, "Oakdale Irrigation District (OID) shall sell 15,000 acre-feet of water to the USBR in every year of (the) Agreement… In addition to the 15,000 acre-feet, Oakdale will sell the difference between the water made available to VAMP under the SJRGA agreement and 11,000 acre-feet." This water is referred to as the Difference water.

OID provided 7,365 acre-feet of supplemental water for the year 2001 VAMP, resulting in 3,635 acre-feet of Difference water. Therefore, pursuant to Paragraph 8.5 of the Agreement, OID sold a total of 18,635 acre-feet of water to the USBR in 2001.

Release of the OID additional water by the USBR began on October 20, 2001, and was completed on November 21, 2001. A daily tabulation of the OID additional water release is provided in Appendix B.



HEAD OF OLD RIVER BARRIER

BARRIER DESIGN, INSTALLATION AND OPERATION

In 2001, DWR successfully installed and operated the temporary Head of Old River Barrier (HORB) following six months of intense negotiations with regulatory agencies to obtain the necessary permits for this barrier and the three agricultural barriers in the south Delta. The spring HORB is a component of the south Delta Temporary Barriers Project (TBP). The TBP mitigates for low water levels in the south Delta and improves water circulation and quality for agricultural purposes. The HORB, as currently configured, is now fully permitted though 2005.

The spring HORB was first constructed in 1992 and again in 1994, 1996, 1997 (w/two culverts), 2000 (w/six culverts) and 2001 (w/six culverts). The HORB was not installed in 1993, 1995 a nd 1998 due to high San Joaquin River flows. The HORB was not installed in 1999 due to landowner access problems. The HORB, a key component of VAMP, is intended to increase San Joaquin River Chinook salmon smolt survival by preventing them from entering Old River.

The HORB was originally designed to withstand a San Joaquin River flow of about 3,000 cfs. Through the years, the design and installation of the HORB has been revised on several occasions to accommodate different needs. For 2001 and future years, the barrier design includes two versions. A "low-flow" barrier when San Joaquin River target flows are below 7,000 cfs would be built to a height of ten feet mean sea level (MSL). A "high-flow" barrier for target flows of 7,000 cfs and above would be built to a height of 11 feet MSL and additional material would be placed to raise the abutments to 13 feet MSL. Both barrier versions are equipped with six 48-inch diameter operable culverts and an overflow weir back-filled with clay. In 2001, the low-flow version was installed.

The dimensions of the 2001 HORB (Figure 4-1) were similar to the 2000 HORB, but considerably larger than those constructed in past years. The base width of the HORB in 2000 and 2001 was 100 feet and the crest elevation was ten feet MSL. The top of HORB was constructed with a 75-foot wide notch, protected with concrete grid mats and back-filled with clay. This larger HORB was designed to safely operate with flows corresponding to stages up to 8.5 feet MSL.

To help mitigate anticipated low water levels in the south Delta (downstream of the HORB) caused by the operation of the HORB, two open culverts were installed in the barrier in 1997, and six operable culverts were installed beginning in 2000. Operation of the culverts was controlled by a slide gate control structure located on the upstream side of HORB. DWR relied on daily modeling and field data collection to monitor water levels at three locations within the south Delta to determine when and how long to operate the culverts. Generally, the model forecasts would tend to forecast low-low water levels lower than what was occurring in the field. Consequently, DWR would make decisions regarding the culvert operations that would take this into consideration. It is expected that refinements to the model over time will provide modeling results that correspond more closely with field measurements.

The downstream outlet of each culvert was designed so fyke nets could be attached to evaluate fish passage.

The downstream outlet of each culvert was designed so fyke nets could be attached to evaluate fish passage. DFG staff conducted a fishery-monitoring program as part of the 2001 HORB operations.

Barrier Operations and Monitoring Plan

DWR obtained new permits from the Corps of Engineers and the DFG to install and operate the HORB with six 48-inch diameter culverts. The culverts permitted flow through the HORB on an as-needed basis.

A barrier operations and monitoring plan was developed based on forecasting and monitoring of tidal conditions. DWR determined the number of culverts to be opened at the HORB so that water levels at Old River near Tracy Road Bridge, Middle River near Howard Road and Grant Line Canal near Tracy Road Bridge would remain above 0.0 feet MSL. Based on modeling results and/or field monitoring of water levels in the south Delta, all six culvert slide gates remained open from April 26 to May 26 when the HORB was removed.

The average daily flow through the culverts varied in response to tidal and San Joaquin River flow conditions. The characteristics of the flow through the culverts are complicated in that the flow rate is influenced by many variables, including the culvert inlet geometry, slope, size, culvert roughness, and approach and tail water conditions. An approximation of the combined net flow through the culverts, including any seepage through the barrier, was accomplished by measuring the flow in Old River just downstream of the HORB using Acoustic Doppler technology. A fixed Acoustic Doppler Current Meter was installed approximately 840 feet downstream of the HORB which recorded velocity measurements every 15 minutes during the period the HORB was operated (April 26 through May 26, 2001). The flow in Old River was then calculated using the known cross-sectional area of the channel as a function of the stage elevation at that location.

In addition, a boat mounted Acoustic Doppler Current Profiler (ADCP) was used to initially calibrate the fixed Doppler system and then recalibrate it periodically during the barrier operational period. The ACDP measured real time flow by performing several transects across the channel. The channel velocity was then calculated and used to adjust the index velocities that were measured by the fixed Doppler system.

The mean daily flow measured in Old River during the operation of the HORB ranged from 75 to 692 cfs as shown in Table 4-1. On May 26, the barrier was breached, which accounts for the maximum flow of 1,450 cfs shown in Table 4-1. The negative flows listed indicate the channel below the HORB was filling on a flood tide, however, this does not mean that flows through the culverts were negative. As long at the river stages on the upstream side of the barrier remain higher than the downstream side, flows through the culverts will always be positive.

Barrier Emergency Response Plan

In addition to the operation and monitoring plan, DWR implemented an updated 2001 "Emergency Operations Plan for the Spring HORB." The plan provided that if the daily measured or forecasted flow at Vernalis exceeded a flow that would correspond to stage at the HORB of 10.0 feet MSL, and the stage was likely to exceed 11.0 feet MSL (the height of the barrier under the "high-flow" target), the barrier would be removed. Operation of the HORB was uneventful this year. Vernalis flows and stages at the barrier were not high enough in 2001 to warrant action under the emergency operations plan. The barrier remained in place until May 26.

Seepage Monitoring

A seepage-monitoring program was initiated in April 2000 and continued this year, to evaluate the effects of HORB operations on seepage and groundwater on Upper Roberts Island.

Three seepage monitoring well sites were chosen in 2000 on Upper Roberts Island. Each site had two shallow wells, positioned 10 feet and 100 feet from the toe of the levee to monitor seepage gradient to and from the San Joaquin River. In addition, a deeper well was drilled at Site 1 (near the Head of Old River) to determine vertical gradients.

In addition to the groundwater monitoring wells, a temporary gauge was installed in April 2000 to record water surface elevations in the San Joaquin River, about 1,500 feet downstream of the HORB. Installation of a permanent tide gauge is expected in the fall 2001.

FIGURE 4-1
Head of Old River Barrier (HORB)

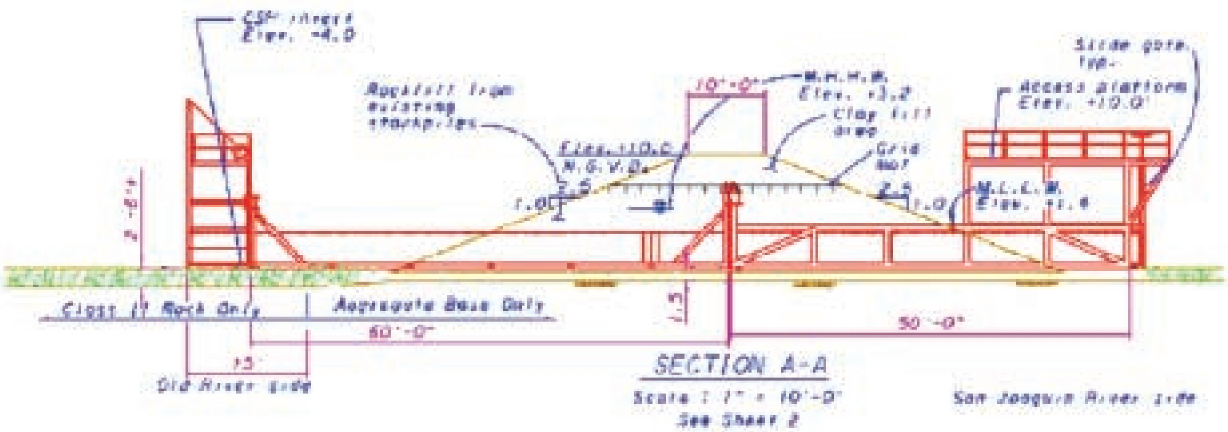


TABLE 4-1
Flow on Old River Downstream of the Head of Old River Barrier–2001

DATE	MEAN DAILY FLOW (CFS)	DAILY MAX FLOW (CFS)	DAILY MIN FLOW (CFS)	DATE	MEAN DAILY FLOW (CFS)	DAILY MAX FLOW (CFS)	DAILY MIN FLOW (CFS)
4/26/01	692	1,033	174	5/14/01	112	434	-130
4/27/01	661	1,053	-186	5/15/01	173	392	-94
4/28/01	675	1,002	346	5/16/01	186	455	-91
4/29/01	530	940	0	5/17/01	112	349	-99
4/30/01	285	821	-463	5/18/01	227	839	-117
5/1/01	331	896	-147	5/19/01	523	817	149
5/2/01	126	673	-565	5/20/01	511	758	267
5/7/01	292	644	-210	5/21/01	360	672	10
5/8/01	321	688	-71	5/22/01	217	527	-79
5/9/01	223	604	-303	5/23/01	216	460	0
5/10/01	221	582	-186	5/24/01	220	542	59
5/11/01	91	474	-246	5/25/01	263	492	31
5/12/01	75	485	-207	5/26/01	533	1,450	62
5/13/01	153	441	-133				

The water surface elevations in the San Joaquin River are compared to groundwater levels on Upper Roberts Island to determine how groundwater levels change relative to changing water level conditions in the river.

In July 2001, DWR completed a "Reclamation District 544 Seepage Monitoring Study". This report documents the seepage monitoring results from Upper Robert Island. (Copies of the report are available from DWR). The report concluded that San Joaquin River stage influences groundwater levels on Upper Roberts Island. When stage increases in the river, groundwater levels will rise toward the land surface, but not as rapidly as the river stage rises. However, over the monitoring period, river stage did not reach levels sufficient to raise groundwater levels to the point where seepage into crop root zones might occur.

Given the results of the seepage monitoring since April 2000, DWR expects that if a VAMP target flow of 7,000 cfs was implemented, stages near the HORB would rise to about 7.5 to 8 feet MSL. This would translate to groundwater levels in the monitoring well closest to the levee of about 6.5 to 7 feet MSL. Because the ground surface elevation is 13 feet MSL near site 1, DWR concludes that seepage should not impact the root zone of crops that could be planted in this area.

It is recommended that the monitoring program be continued in order to gather more data, particularly during high flow periods in the spring.

FISHERY MONITORING AT THE HEAD OF OLD RIVER BARRIER

As mentioned in the previous section, the temporary barrier installed at the HORB in 2001 was equipped with six operable culverts. During the VAMP 2001 test period all six of the culverts were open and diverted water from the San Joaquin River to maintain water quality and water levels within Old River. Juvenile Chinook salmon and other fish species were vulnerable to being entrained into the spring HORB culverts. A fisheries monitoring program was designed and implemented by DFG to evaluate and quantify fish entrainment at the HORB. The specific objectives of the investigation included:

• Determine the total number of juvenile Chinook salmon and other fish species entrained through the culverts at the HORB (entrainment monitoring);

• Determine percentage of coded-wire tagged (CWT) salmon released at Mossdale and Durham Ferry entrained into Old River (entrainment monitoring);

• Determine the effect of tidal stage and day/night conditions on juvenile Chinook salmon entrainment (entrainment special study); and

• Determine migration routes of CWT salmon released at the HORB and recovered at temporary barrier locations in Old River, Middle River, and Grant Line Canal (migration study).

Results of these investigations were intended, in part, to provide information useful in the design and operation of a permanent operable barrier at the Head of Old River in the future.

Materials and Methods

Ten fyke nets were ordered to monitor fish entrainment into the HORB culverts. Due to the delay in the production and delivery of these nets we had to repair three fyke nets from last year's study and borrow three fyke nets to begin this year's study. We replaced these nets as the new fyke nets arrived. The various fyke nets used in the monitoring were (1) 60 feet in length, with ¼-inch braided mesh tapering from a 48-inch cylindrical mouth opening to a 1-foot square cod end; (2) 30 feet in length, made of ¼-inch braided mesh tapering from a 48-inch square mouth opening to a 1-foot square cod end; and (3) 35 feet in length, made of ⅛-inch braided inch, tapering from a 48-inch square mouth opening to a 1-foot square foot cod end. Each of the fyke nets was equipped with a live-box (15.5 x 19.5 x 36 inches), constructed of perforated aluminum sheet metal. Each of the live-boxes included an aluminum baffle designed to reduce water velocities within the live car and improve survival of captured fish.

Operation of all six culverts at the HORB began April 30. The culverts were numbered one through six with one located next to the shoreline and six located mid-channel (Figure 4-2). Only five out of the six culverts had fyke nets attached because one culvert (no. 4) was jammed by debris and could not be closed to allow attachment of a fyke net. Fyke nets were attached to the culverts by connecting the net to the live-box, closing the culvert slide gate, strapping the fyke nets over a 48-inch diameter opening on the tracks, lowering the net over the culvert out-fall, and opening the culvert slide gate. Rubber flaps were used to seal the spaces between the culvert and the net opening to prevent fish loss. The culverts were twisted during construction of the HORB. As a result, the alignment between the net mouth opening and culvert was not exact causing the leakage of some water (and potentially fish) past the net mouth opening. By May 2 the slide gate on a second culvert (no. 2) was jammed by debris and could not be closed. Consequently, the fyke net was removed and sampling was continued on only four of the six culverts. On May 5, all fyke nets were removed to allow work to be done on the San Joaquin River side of the HORB because the trash

FIGURE 4-2
Culvert Numbers for HORB 2001

screens, part of the modifications for 2001, were becoming clogged by debris. However, only culverts two and four, which could no longer be closed due to the blockage of the slide gates, were cleared of debris. Beginning May 7, all six culverts were "operational" and all six fyke nets were re-attached. Sampling continued through May 18. After the 18-day sampling period was completed, the fyke nets were removed, inspected and found to have only minor holes in them.

During monitoring, entrained fish were removed from the live-boxes by closing the culvert slide gate for a period of 30 to 45 minutes with no more than two culverts being closed at one time. During this time the live-boxes were removed from the water, placed onto a boat, and the net and live-boxes checked thoroughly. Once all the nets had been checked and reset the fish that were collected and held in containers were processed. Data recorded for each sample consisted of date, time, water temperature, tidal stage, culvert number, fish species, and species count. Each Chinook salmon collected was measured, categorized as marked (CWT present based on an adipose fin clip), unmarked (natural), or color-dyed, and categorized as dead or alive. All CWT Chinook salmon were retained so tags could be processed; all other fish were released in Old River, downstream of the fyke nets.

Fyke nets were checked routinely on every high and low tide with high tide defined as the time period encompassing the flood and low tide defined as the time period encompassing the ebb. However, starting May 12, all night checks were cancelled due to the low number of Chinook salmon smolts collected. Starting May 15, fyke nets were checked once daily.

Entrainment Monitoring

Loss indices for the CWT salmon released as part of the VAMP survival studies at Durham Ferry and Mossdale were calculated based on data collected from April 30 to May 18. The loss index represents the percentage of CWT salmon entrained into the HORB culverts and is determined by the equation:

$$I = (TC/TR)(TT/ST)$$

Where:

TC = Total number of CWT salmon collected in culvert fyke nets
TR = Total number of CWT released
TT = Total time (hours) during the test period
ST = Total time (hours) sampled at HORB during the test period

Catch-Per-Unit-Effort (CPUE) for unmarked Chinook salmon was calculated as the number collected per hour. The CPUE for salmon collected from each culvert was analyzed using a single factor ANOVA with logarithmic transformation of the data ($X` = \log(X+1)$). CPUE was further analyzed to determine differences between all possible pairs of means using the Tukey multiple comparison test.

Entrainment Special Study:

Eight individually marked (color coded) groups of juvenile Chinook salmon from the Merced River Hatchery were released in the San Joaquin River with respect to the following variables: release site, tidal cycle, and day/night. The first release site was directly in front of the HORB, consisting of approximately 500 juvenile salmon per release group. The second release site located nearly one mile upstream of the HORB consisted of about 3000 juvenile salmon per release group.

Juvenile Chinook salmon used in these tests were color-marked at the hatchery with photonic fluorescent microspheres. The salmon were then transported from the hatchery to the San Joaquin River and placed in 4x10x4 foot live cages lined with 3/16-inch mesh netting. The test fish were held in the live-cages for ten or more hours to reduce handling stress and observe any pre-release mortality. Night releases during high and low tidal cycles were made during the evening of April 30 and early morning of May 1. Though six culverts were in operation during this release, only five fyke nets could be attached for sampling. Day releases for both tidal cycles were made during the morning and afternoon of May 10. All six culverts were in operation for this release and all six fyke nets were attached for sampling.

The percentage of color-marked salmon recovered in the fyke nets compared to the total number released was used as an index of entrainment vulnerability at the HORB.

Migration Study

A pilot study was conducted to determine the migration routes through the south Delta of juvenile Chinook salmon entrained by the HORB. A total of 25,000 CWT Merced River Hatchery juvenile Chinook salmon were released May 12 (0930 hours) into Old River downstream of the HORB. Kodiak trawling was conducted daily over the next seven days upstream and downstream of the Grant Line Canal Barrier (GLCB) and the Old River Barrier near Tracy (OLDRB)(Figure 4-3). Kodiak trawl sampling could not be performed at the Middle River Barrier (MIDRB) because of shallow water depth.

In addition to Kodiak trawl sampling, marked salmon were also recovered in sampling at Chipps Island, Antioch, and at the SWP and CVP fish salvage facilities.

RESULTS AND DISCUSSION

Entrainment Monitoring

Throughout the April 30 to May 18 study period, the number of culverts operated at the HORB and the number of fyke nets sampled varied (Table 4-2). During the sampling period, the six culverts were in operation approximately 2,596 hours. Total sampling time for all fyke nets combined was 2,092 hours. During the entrainment monitoring period, sampling was performed approximately 81% of the time that the culverts were in operation.

Thirty-two fish species were collected in the fyke nets during entrainment monitoring (Table 4-3). Chinook salmon (2,888) and white catfish (2,677) were the two most abundant species collected. No Delta smelt, one splittail, and two steelhead were collected. Of the 2,888 Juvenile Chinook salmon collected in the fyke nets at the culverts:

TABLE 4-2
Culvert and Fyke Net Operations

DATES OF CULVERT OPERATION	NUMBER OF CULVERTS OPERATED	NUMBER OF FYKE NETS SAMPLED
4/30/01–5/2/01	6	5
5/2/01–5/5/01	6	4
5/5/01–5/7/01	6	0
5/7/01–5/8/01	6	4
5/8/01–5/18/01	6	6

FIGURE 4-3
Location of Temporary Barriers Throughout the Southern Delta

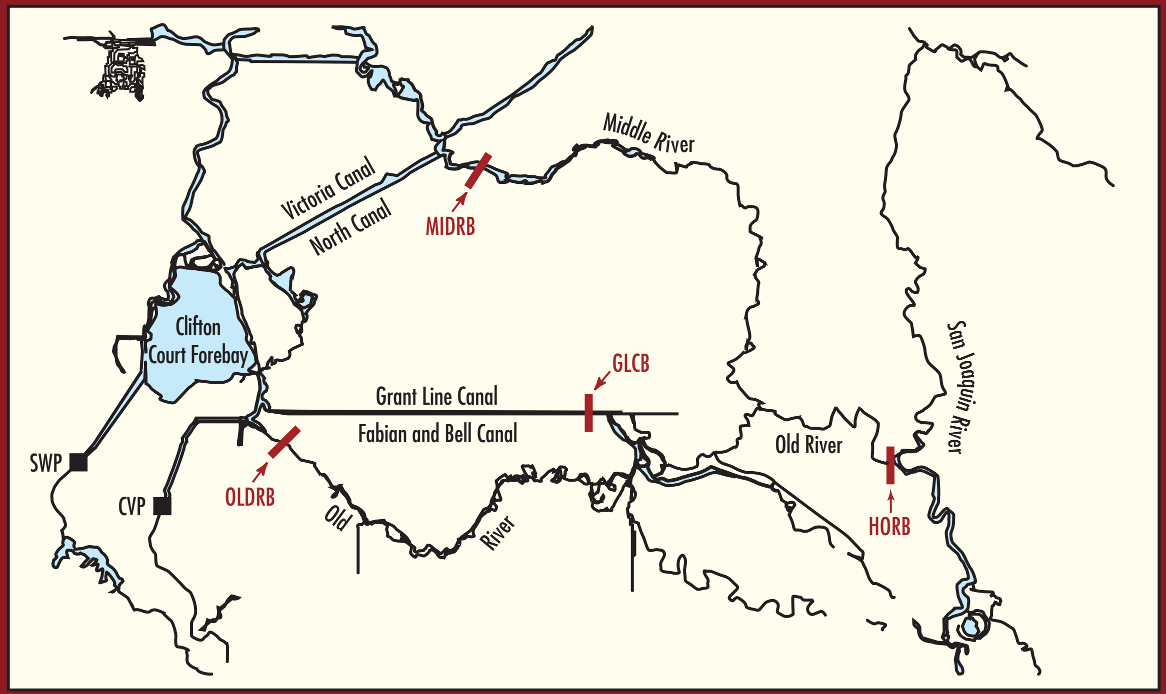
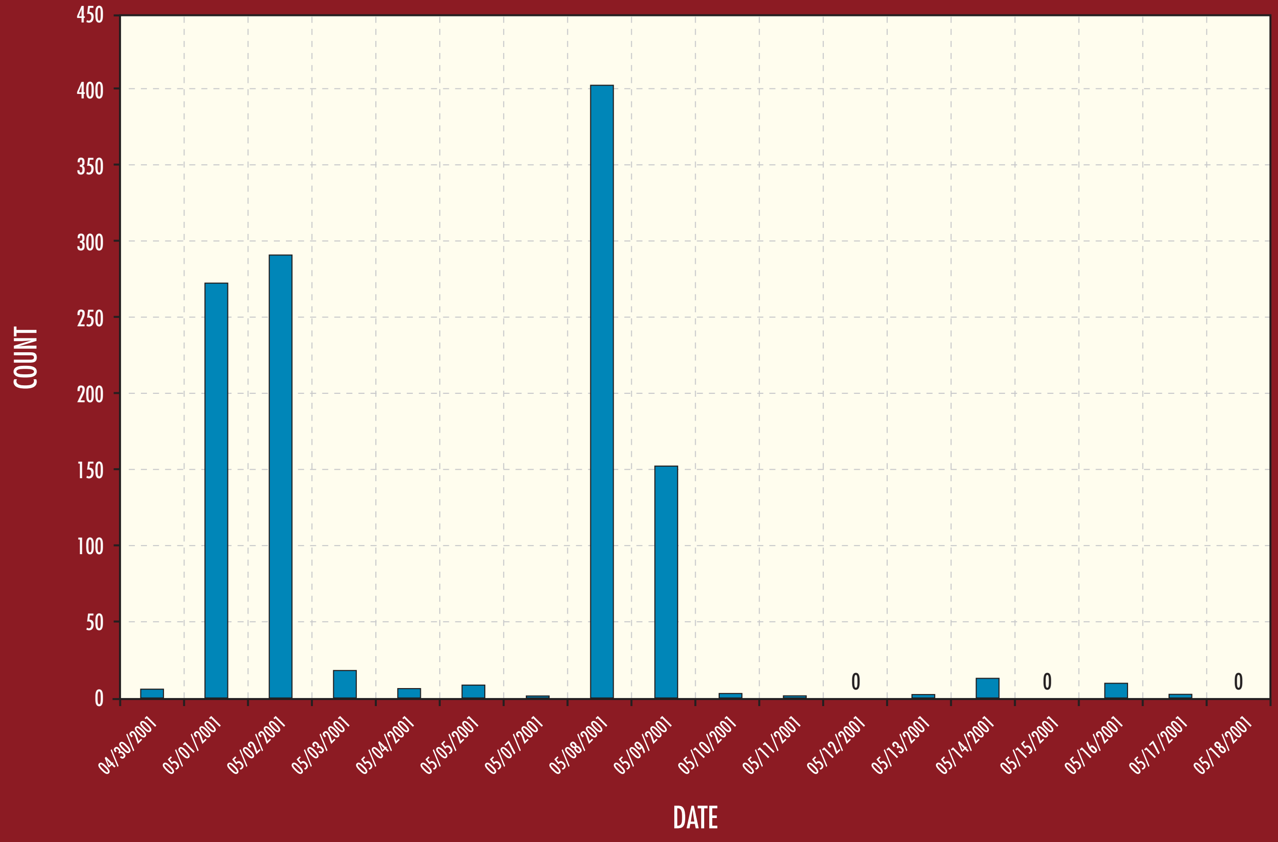


FIGURE 4-4
Number of CWT Chinook Salmon Entrained Per Day From April 30 to May 18, 2001 at HORB



• 1,268 were CWT Chinook salmon (including 92 salmon released on the Merced River, and 21 salmon released on the Tuolumne River);

• 1,014 were unmarked Chinook salmon;

• 475 were color-marked Chinook salmon (Entrainment special study); and

• 131 were mutilated Chinook salmon.

The mutilated salmon smolts observed this year could have come from various sources. The smolts could have died on the San Joaquin side of the HORB and then been diverted through the culverts. In addition, the smolts could have been regurgitated from the many catfish entrained in the fyke nets. The HORB design in 2001 included trash screens placed in front of the culvert openings. Over time, the debris accumulated on the trash screens could have acted like a filter and increased mutilation of entrained salmon.

The entrainment loss index for CWT Chinook salmon released as part of the VAMP 2001 averaged 0.54 percent. The entrainment loss index for releases at Mossdale averaged 0.49 percent (May 1 release entrainment index was 0.61 percent; May 8 release entrainment index was 0.37 percent). The entrainment loss index for releases at Durham Ferry averaged 0.58 percent (April 30 release entrainment index was 0.54 percent; May 7 release entrainment index was 0.62 percent). This year's average entrainment loss index was slightly lower than the previous years (0.75 percent in 2000 and 0.6 percent in 1997). The debris that accumulated on the trash screens, in front of the culvert openings, could have contributed to this lower entrainment loss index. The temporal pattern of CWT salmon collected in entrainment monitoring (Figure 4-4) reflects releases of salmon as part of the VAMP studies at both Durham Ferry and Mossdale. No consistent pattern in entrainment of CWT salmon was apparent under low and high tidal stages (Figure 4-5) and an obvious pattern of entrainment was apparent under day/night (Figure 4-6) with more salmon entrained at night than during the day. However, the tidal cycle did have an effect on CPUE and is represented when only one category (day or night) in Figure 4-6 is singled out and related to the same information (data bars) in Figure 4-5, showing that more salmon were entrained during low tides than high tides. The reason that tidal cycle seems to show no pattern is because day/night is a much stronger influence than tides and therefore hides the tidal cycles' smaller influence. Also, since both factors influence CPUE, they are considered additive influences, meaning a low tide occurring at night will increase the chance of Chinook salmon smolt entrainment as compared to a high tide occurring during the day.

The CPUE for unmarked Chinook salmon ranged from 0.0 to 6.7 fish per net per hour, averaging 0.5 fish per hour. This year's CPUE is approximately three times smaller than last year's estimate (1.7 fish per hour in 2000) and may again be a result of the debris blocking the culvert openings. However, this could also be indicative of a smaller population passing the barrier in 2001 relative to 2000.

Statistical analysis of CPUE for unmarked Chinook salmon showed that entrainment rates among the six culverts were significantly different ($P < 0.002$). Results of the Tukey multiple comparison test showed that CPUE among all six culverts were significantly different from one another ($P < 0.005$) except culverts four and five. Position of the culverts relative to the shoreline, culvert maintenance, eddies and turbulence, and variation in hydraulics and velocities may all be factors contributing to the observed differences in entrainment between culverts.

CPUE for both CWT and unmarked Chinook salmon showed an increasing trend from culvert one to culvert six (Figure 4-7) using data obtained between May 8 and May 18 when all six culverts were sampled. CPUE for CWT and unmarked Chinook salmon are similar for each culvert. Although CPUE was similar between CWT and unmarked salmon, examination of sampling data showed that CWT salmon were collected within two days of release at Durham Ferry and Mossdale. Unmarked salmon were collected throughout the entrainment monitoring period.

Results of entrainment monitoring indicated that day/night and tides might influence Chinook salmon entrainment at the HORB. However, day/night may be a stronger influence than tides. When both influences are occurring simultaneously, the data suggests there is an additive effect. The results also suggest that flow rates through the culverts are not equal and may increase the farther the culvert is from the shoreline.

Entrainment Special Study

Release and recapture information for the entrainment special study is summarized in Table 4-4. The percentage of color-marked salmon collected in each test was extrapolated to account for the number of nets sampled and culverts operated. The percentage of color-marked Chinook salmon recovered was highest for the salmon released adjacent to the HORB and those released during the low tide.

It is evident that the salmon smolts released immediately in front of the HORB were more vulnerable to entrainment than those released further upstream. Therefore, entrainment vulnerability at the HORB for natural or CWT salmon migrating downstream in the San Joaquin River is probably better represented by salmon released upstream of the HORB resulting in greater dispersal and lower percent recoveries.

Furthermore, the finding that the percentage of marked salmon recovered was highest for all release groups during the low tide shows that tidal cycle effects salmon smolt entrainment at the

TABLE 4-3
Species Composition and Number of Fish Species Collected in Fyke Nets From 30 April Through 18 May, 2001.

Mosquitofish	1
Golden Shiner	1
Red Shiner	1
Redear Sunfish	1
Splittail	**1**
White Crappie	1
Yellow Bullhead	1
Yellowfin Goby	1
Black Bullhead	2
Centrarchidae	2
lamprey	2
Steelhead	**2**
Black Crappie	3
Green Sunfish	3
Striped Bass	3
Tule Perch	3
Warmouth Bass	3
Brown Bullhead	5
Goldfish	7
Inland Silverside	7
Sacramento Blackfish	7
Squawfish	17
Log Perch	22
Largemouth Bass	38
American Shad	41
Bluegill	54
Sacramento Sucker	54
Carp	82
Threadfin Shad	105
Channel Catfish	267
White Catfish	2,677
Total Chinook Salmon	**2,888**
CWT Chinook Salmon	1,268
Unmarked Chinook Salmon	1,014
Color-Marked Chinook Salmon	475
Mutilated Chinook Salmon	131
Total	6,302

TABLE 4-4
Number of Color-Marked Chinook Salmon Released During the Entrainment Special Study and Percent Recovered During the Evening (30 April, 1 May) and Day (10 May, 2001).

RELEASE LOCATION	NUMBER OF FISH RELEASED	TIDE	NUMBER COLLECTED	PERCENT RECOVERED	EXTRAPOLATED PERCENT RECOVERED
Night Release (30 April, 1 May)					
Upstream	3,010	High	21	0.70%	0.84%
	3,000	Low	50	1.67%	2.00%
Adjacent	500	High	48	9.60%	11.52%
	502	Low	297	59.16%	71.00%
Day Release (10 May)					
Upstream	3,008	High	2	0.07%	0.07%
	3,024	Low	21	0.69%	0.69%
Adjacent	515	High	4	0.78%	0.78%
	521	Low	15	2.88%	2.88%

TABLE 4-5
Number of CWT Chinook Salmon Released and Recaptured During the 2001 Migration Study.

RELEASE LOCATION	DATE	NUMBER	TIDE
Release Location			
Old River, downstream of HORB	5/12/01	24,398	flood
Recapture Location			
Grant Line Canal Barrier, upstream	5/13	16	ebb
Grant Line Canal Barrier, downstream	5/13	5	ebb
Old River Barrier, upstream	5/14	2	flood
Grant Line Canal Barrier, upstream	5/16	1	ebb
Grant Line Canal Barrier, downstream	5/16	1	ebb
Old River Barrier, upstream	5/17	4	ebb
Chipps Island	5/14 5/16 5/17	2 1 1	
Antioch	5/16	1	
CVP	5/14–5/18	390*	
SWP		0	

*390 is expanded value, 33 is raw value

FIGURE 4-5

CPUE of CWT Chinook Salmon Per Tidal Cycle From April 30 to May 11, 2001 at HORB

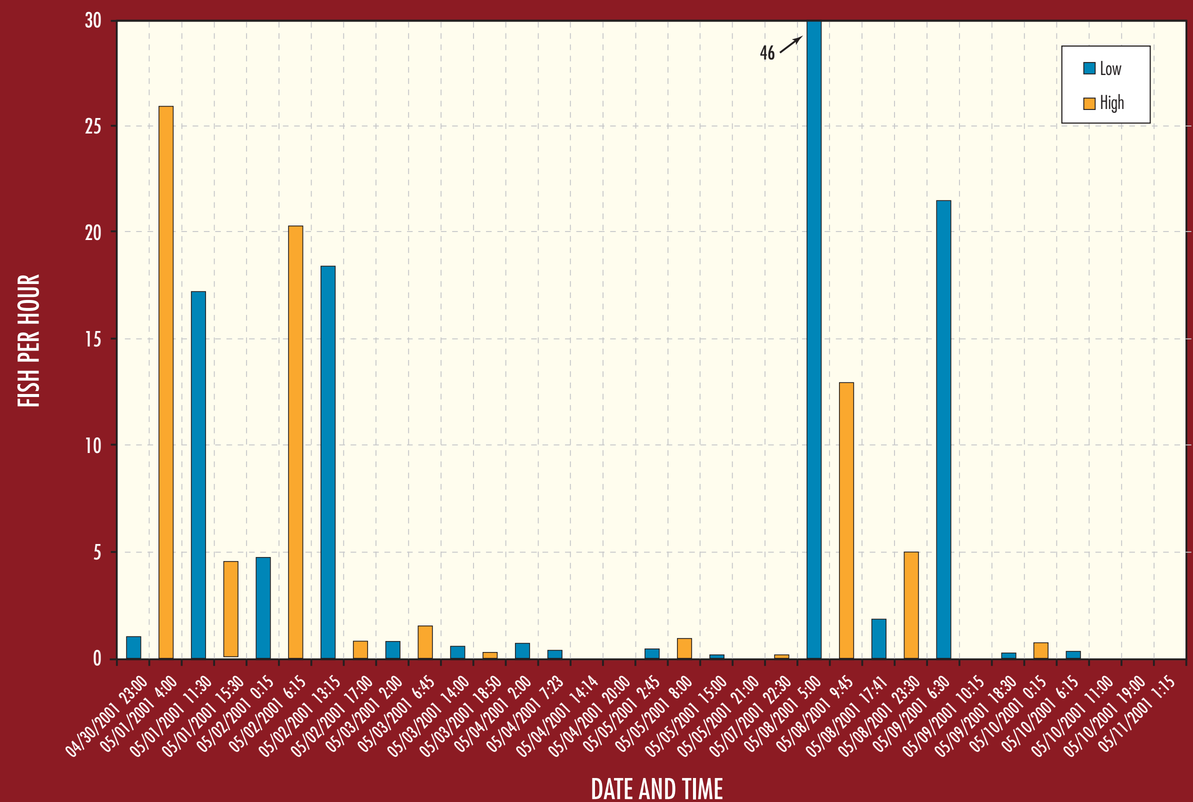


FIGURE 4-6

CPUE of CWT Chinook Salmon Per Day/Night From April 30 to May 11, 2001 at HORB

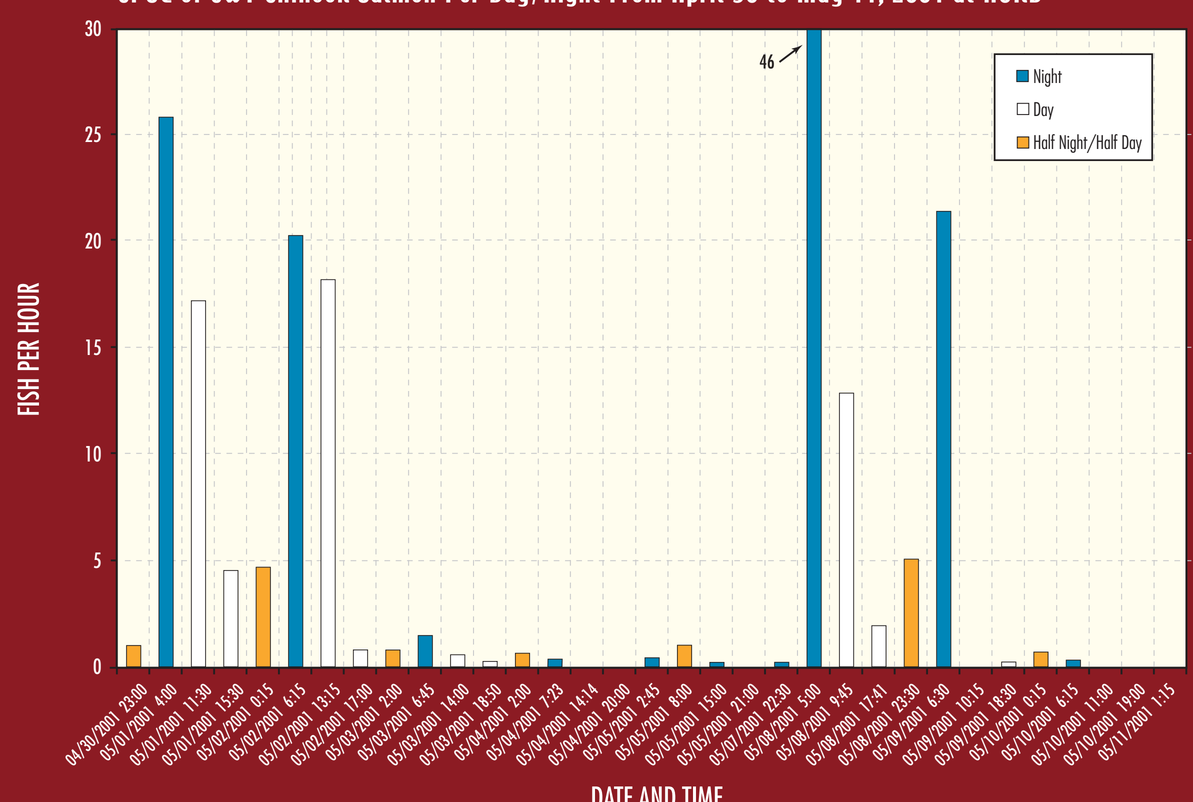
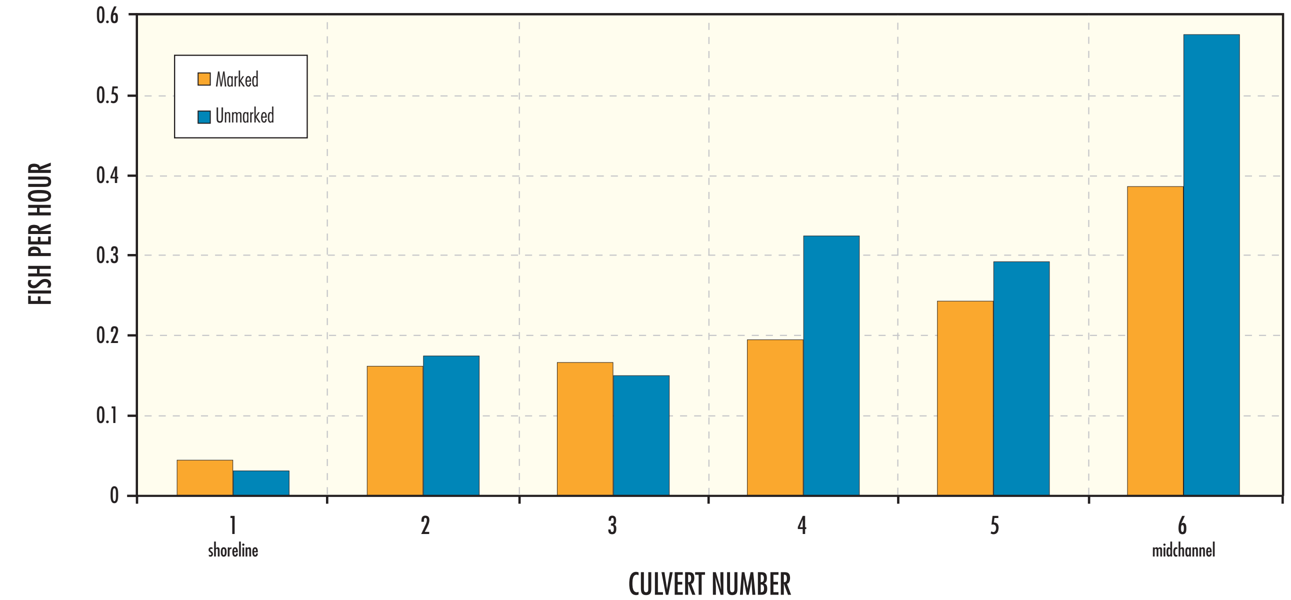


FIGURE 4-7

CPUE of Marked and Unmarked Chinook Salmon From May 8 to May 18, 2001 at HORB



HORB. Low tide creates higher entrainment vulnerability than high tide. Changes in hydraulic characteristics and approach velocities between high and low tidal stages are thought to be factors contributing to the observed entrainment patterns.

Results of the entrainment special study indicated that tides and release location might influence Chinook salmon entrainment at the HORB. Furthermore, the day/night variable could not be examined with confidence due to the nine-day interval between release groups. During this time debris built up on the culvert trash screens possibly effecting entrainment vulnerability.

Migration Study

Release and recapture information for the migration study is summarized in Table 4-5. The majority of the recovered salmon smolts were collected at the CVP fish salvage facilities. No CWT salmon released as part of this test were recaptured at the SWP fish salvage facility. CWT salmon were recaptured at Chipps Island and Antioch, suggesting that a portion of juvenile Chinook salmon entrained into the HORB culverts may successfully emigrate through the south Delta. The survival rate of these fish was not, however, quantified because of the low number of fish released and recaptured. CWT salmon were also recovered upstream and downstream of the GLCB and only upstream of the OLDRB (Figure 4-3). No statistical analysis was performed on the migration data because of the low numbers of fish recaptured at various sampling sites.

Results of the migration study show that a portion of salmon smolts entrained into the south Delta through the HORB can successfully reach Chipps Island. Whether these CWT salmon arrived at Chipps Island on their own or were salvaged at the CVP export facilities, trucked, and released is unknown. The fact is that salmon smolts traveling down Grant Line Canal were able to pass the GLCB. The salmon smolts traveling down Old River were only detected above the OLDRB so it is still unknown whether they are able to pass the OLDRB. Salmon also may have traversed down Middle River, which was not sampled. The factors contributing to the differences in recoveries between the CVP and SWP were not evaluated.

Recommendations

A similar study is planned for 2002 to further evaluate entrainment at the HORB. Modifications to the study design include measurement of flow through each culvert during each sampling event. This will help determine the relationship between flow rates through the culverts and entrainment rates for juvenile salmon and other species. Data that can be statistically analyzed would be beneficial in evaluating factors influencing entrainment rates, including both day/night and tidal effects. If trash screens on the culverts are utilized next year, these screens should be cleaned at regular intervals or constructed so that debris does not block the culverts. Finally, if the migration study is included in next year's plan, the study design and sampling program should be modified to provide statistically reliable data for use in evaluating migration and survival of juvenile salmon released into Old River.

SALMON SMOLT SURVIVAL INVESTIGATION

One of the primary objectives of the VAMP program is to identify the respective roles of San Joaquin River flow, and SWP and CVP export rates with the HORB in place on the survival of juvenile Chinook salmon emigrating from San Joaquin River tributaries. This section describes the methods used in conducting the VAMP 2001 Chinook salmon smolt survival investigations, and presents results of the calculated survival indices and absolute survival estimates for juvenile Chinook salmon during the VAMP 2001 test period. Additional data and information related to the salmon survival investigations are presented in Appendix C.

CODED-WIRE TAGGING

Merced River Hatchery Chinook salmon smolts, released as part of VAMP 2001, were coded-wire tagged (CWT) between March and early April. After the salmon were tagged, they were held in the hatchery for up to 21 days before being released. A sub-sample of the salmon were measured for length and checked for retention of the CWTs a day or two prior to release. The sub-sample was typically comprised of 100 to 300 salmon collected from the top, middle, and bottom of the release group's raceway. Each tag code within a release group was held separately at the hatchery with the exception of the two Durham Ferry releases. Each of these releases were made up of three tag codes that were held together in one section of the raceway.

Although tag retention is usually quite high, as a double check on the tag detector, all salmon from the sub-sample that had no tag detected were sacrificed. These sacrificed salmon were dissected to determine whether they contained an unmagnetized tag. A separate sub-sample of 25 salmon was sacrificed from each release group; the tags were removed and read to detect any incorrect tag codes in the raceways. Table 5-1 summarizes results of the CWT retention rate and the estimate of the effective numbers of salmon released to calculate survival indices. Tag retention rates were determined to be similar to last year, with an overall loss rate of 9.5% among all VAMP groups. The tag retention loss rates varied from 0.5% to 15%. It is recommended that this loss rate be reduced for future VAMP studies.

TABLE 5-1
Coded Wire Tag Retention Rates and Effective Release Numbers for Juvenile Salmon Released as Part of VAMP 2001

RELEASE DATE	CWT CODE	RELEASE SITE	AVERAGE FL(mm)	NUMBER TAGGED	POND LOSS	EFFECTIVE MARKED	TAG RETENTION RATE	EFFECTIVE NUMBER RELEASED
30-Apr	06-44-29	Durham Ferry	88	25,899	97	25,802	90.55%	23,363
	06-44-30	Durham Ferry	88	25,202	97	25,105	91.00%	22,846
	06-44-31	Durham Ferry	88	24,822	97	24,725	91.00%	22,500
1-May	06-44-32	Mossdale	89	25,928	90	25,838	89.05%	23,010
	06-44-33	Mossdale	88	26,199	92	26,107	85.00%	22,191
4-May	06-44-34	Jersey Point	89	25,761	30	25,731	95.00%	24,444
	06-44-35	Jersey Point	88	25,792	26	25,766	97.00%	24,993
7-May	06-44-36	Durham Ferry	87	25,516	88	25,428	94.50%	24,029
	06-44-37	Durham Ferry	87	25,386	88	25,298	95.00%	24,033
	06-44-38	Durham Ferry	87	25,542	88	25,454	95.00%	24,181
8-May	06-44-39	Mossdale	89	25,602	60	25,542	93.50%	23,882
	06-44-40	Mossdale	89	25,768	73	25,695	98.50%	25,310
11-May	06-44-41	Jersey Point	88	26,102	62	26,040	99.50%	25,910
	06-44-42	Jersey Point	88	25,760	37	25,723	99.00%	25,466

CWT RELEASES

Two sets of CWT salmon releases were made as part of the 2001 VAMP experiment. The first set occurred on April 30 at Durham Ferry, May 1 at Mossdale and May 4 at Jersey Point. The second set of releases was made at Durham Ferry on May 7, at Mossdale on May 8, and at Jersey Point on May 11.

Approximately 75,000 salmon, in three distinct tag lots of about 25,000 fish, were released at Durham Ferry, while approximately 50,000 fish, in two tag lots, were used at each Mossdale and Jersey Point release (Table 5-1). Prior to VAMP 2000, each release was made such that all tag lots were trucked from the hatchery mixed and released as a single group. However, during VAMP 2000 and VAMP 2001, a new transport trailer with three tanks allowed each separate CWT lot to be transported to its release site in a separate tank and distinctly released. As mentioned earlier, the three tag lots comprising each of the groups released at Durham Ferry on April 30 and May 7 were already mixed at the hatchery and thus not transported separately by tag lot. Due to logistical difficulties getting the transport truck up the gravel road leading away from the Durham Ferry site, the May 7 release was made from the top of the levee using a combination of flexible aluminum pipe and vinyl hose. The issue of consistently releasing the Durham Ferry group from the top of the levee or near the river needs to be resolved prior to releasing groups in 2002. It is also of note that a nearby agricultural diversion was in operation during the May 7 Durham Ferry release.

In order to test the effectiveness of hydro-acoustic technology for monitoring movement of juvenile Chinook salmon past HORB, the releases at Mossdale were performed over a 12 hour period which was different than had occurred in past years. First, an alternate release site was chosen for delivery of the fish because it had more security and better facilities for watching the fish over the 12-hour period during release. This new site was a boat ramp at the Mossdale Trailer Park, approximately ½-mile upstream and on the opposite bank (west side) from the public ramp traditionally used at the Mossdale County Park. Prior to release, each 25,000 tag lot was taken from the transport truck via dip net and distributed into two large net pens (4' x 4' x 8'). When unloading was complete there were 4 large net pens, each with approximately 12,500 fish. These fish were then held for a few hours and allowed to acclimate to river conditions. Then, on specific points of the tidal cycle, a pen was floated downstream via a small boat, and the fish were freed into the river at approximately mid-channel near the historical release site at the Mossdale public boat ramp. Each group of approximately 12,500 salmon was released approximately 3 hours apart in a similar manner, in an attempt to time the arrival of each group at the HORB on a specific point on the tidal cycle (Table 5-2). These releases were also meant to help determine any day/night release time survival differences. Unfortunately, due to the number of agencies and individuals involved with the Mossdale release strategy, the information on the tag codes for each release time was not retained.

TABLE 5-2
Times of Release at Mossdale on 5/1 and 5/8 for the Four Groups (2 tag codes) Released.

MOSSDALE TIDAL RELEASES					
First Replicate			Second Replicate		
5/1/01	4:15 PM	Day	5/8/01	5:53	Day
	8:35 PM	Night		8:56 PM	Night
5/2/01	2:12 AM	Night	5/9/01	2:00 AM	Night
	7:00 AM	Day		7:12 AM	Day

The release processes at Durham Ferry and Jersey Point were not changed from past years. Releases at Jersey Point were made at the beginning of the flood tide to increase dispersion of the tagged fish before they passed Antioch and Chipps Island. Releases at Mossdale and Durham Ferry were not made on any specific tidal condition.

The water temperature both in the hatchery truck and in the receiving waters was measured at the release site immediately prior to release. These, as well as additional release and recovery data, are provided in Table 5-3.

WATER TEMPERATURE MONITORING

The water temperature was monitored during the VAMP 2001 study using individual computerized temperature recorders (e.g., Onset Stowaway Temperature Monitoring/Data Loggers). The water temperature was measured at locations along the longitudinal gradient of the San Joaquin River and interior Delta channels between Durham Ferry and Jersey Point-locations along the migratory pathways for the juvenile Chinook salmon released as

TABLE 5-3

Release and Recovery Information for Coded Wire Tag Groups Released as Part of VAMP in 2001.

CWT CODE	RELEASE SITE	RELEASE DATE	TRUCK TEMP C°	RELEASE TEMP C°	NUMBER RELEASED	AVERAGE FORK LENGTH (mm)	NUMBER RECOVERED AT ANTIOCH	PERCENT SAMPLED AT ANTIOCH	SURVIVAL INDEX AT ANTIOCH	GROUP SURVIVAL AT ANTIOCH	NUMBER RECOVERED AT CHIPPS	PERCENT SAMPLED AT CHIPPS	SURVIVAL INDEX AT CHIPPS	GROUP SURVIVAL AT CHIPPS	EXPANDED SALVAGE CVP	EXPANDED SALVAGE SWP	ABSOLUTE SURVIVAL ANTIOCH	ABSOLUTE SURVIVAL CHIPPS ISLAND
06-44-29			14.5	21.5	23,354	89	28	0.39	0.22		14	0.28	0.28		12			
06-44-30	Durham Ferry		14.5	21.5	22,837	89	30	0.39	0.24		22	0.28	0.45		24			
06-44-31			14.5	21.5	22,491	89	18	0.39	0.15		17	0.28	0.36		48			
Total		30-Apr			68,682		76	0.39		0.20	53	0.28		0.36			0.17	0.34
06-44-32	Mossdale		15	19.5	23,000	91	18	0.39	0.14		17	0.28	0.35		24	12		
06-44-33	Mossdale		15	19.5	22,177	91	15	0.39	0.13		14	0.28	0.30		12			
Total		1-May			45,177		33	0.39		0.13	31	0.28		0.32			0.11	0.31
06-44-34	Jersey Point		15	20	24,443	88	156	0.39	1.18		50	0.28	0.96					
06-44-35	Jersey Point		15	20	24,992	88	173	0.39	1.27		61	0.28	1.15					
Total		4-May			49,435		329	0.39		1.23	111	0.28		1.06				
06-44-36			14.5	19	24,025	85	8	0.40	0.06		2	0.28	0.04		12	9		
06-44-37	Durham Ferry		14.5	19	24,029	85	11	0.38	0.09		4	0.28	0.08					
06-44-38			14.5	19	24,177	85	10	0.36	0.08		2	0.28	0.04		12	6		
Total		7-May			72,231		29	0.37		0.08	8	0.28		0.05			0.20	0.14
06-44-39	Mossdale		15.5	21	23,878	89	8	0.40	0.06		4	0.28	0.08		12			
06-44-40	Mossdale		15.5	21	25,308	88	11	0.41	0.08		4	0.28	0.07		12	12		
Total		8-May			49,186		19	0.40		0.07	8	0.28		0.08			0.18	0.19
06-44-41	Jersey Point		16	22.5	25,909	88	43	0.40	0.30		17	0.28	0.31					
06-44-42	Jersey Point		16	22.5	25,465	87	53	0.35	0.43		27	0.28	0.50					
Total		11-May			51,374		96	0.35		0.38	44	0.28		0.40				

*** For tag code, 06-44-37, one tag was found to be recovered at Chipps Island on May 9th, only two days after release. The tag was removed from the data set prior to calculating survival and is not included in this table or Appendix C-4.*

TABLE 5-4

Description of the Six Parameters Used to Assess Overall Condition of the Various Tag Groups Released as Part of VAMP in 2001.

	NORMAL	ABNORMAL
Eyes	Normally shaped	Bulging
Color	High contrast dark dorsal surface and light sides	Low contrast dorsal surface and sides, coppery color
Fin Hemorrhaging	No blood ore red at base of fins	Blood at base of fins
Percent Scale Loss	Lower relative numbers better based on 0-100% scale loss	Higher relative numbers worse based on 0-100% scale loss
Gill Color	Dark beet red to cherry red gill filaments	Light red to gray gill filaments
Vigor	Active swimming (prior to anesthesia)	Lethargic or motionless (prior to anesthesia)

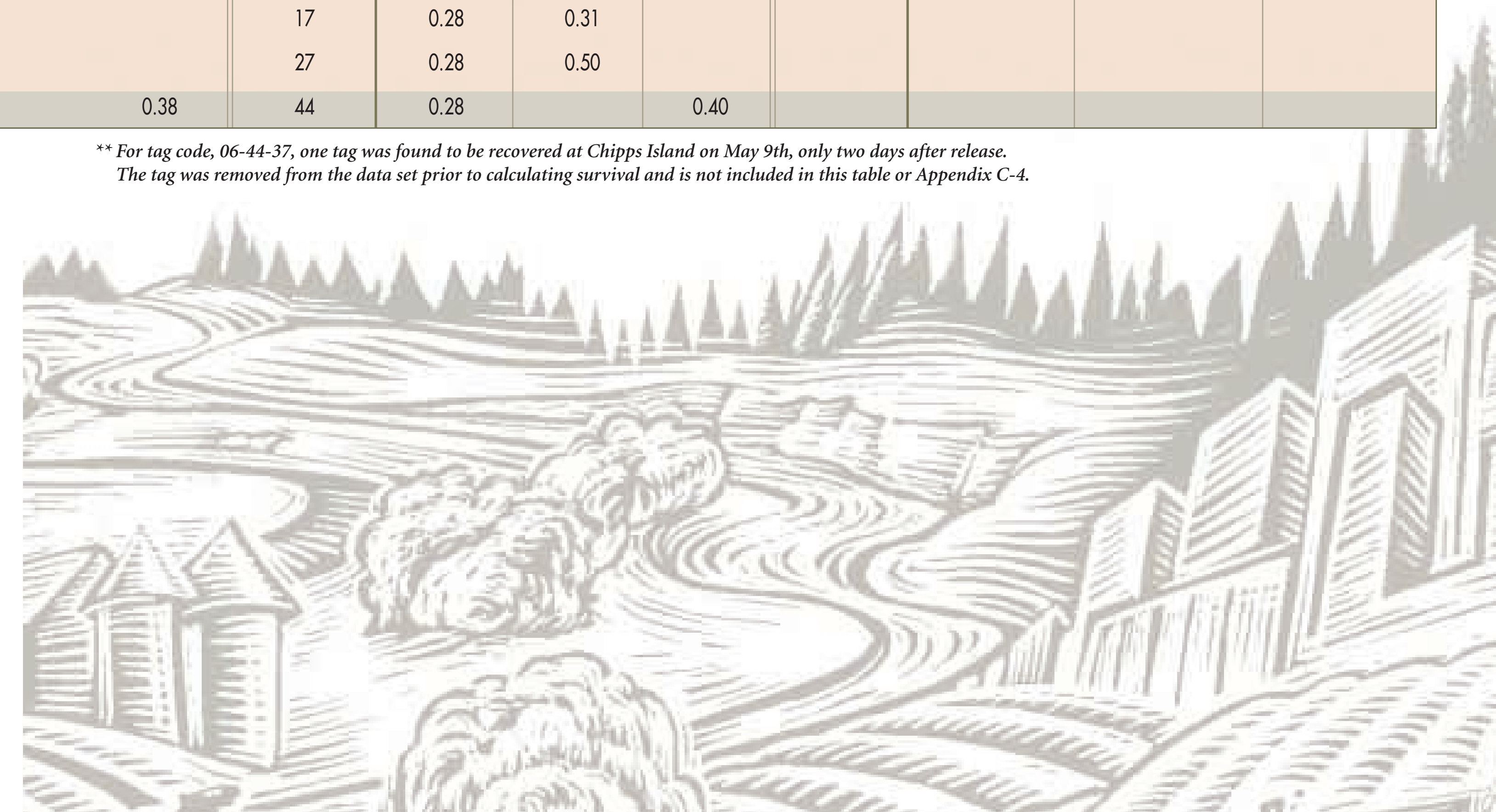


FIGURE 5-1
Results of Water Temperature Monitoring at the Merced River Fish Hatchery.

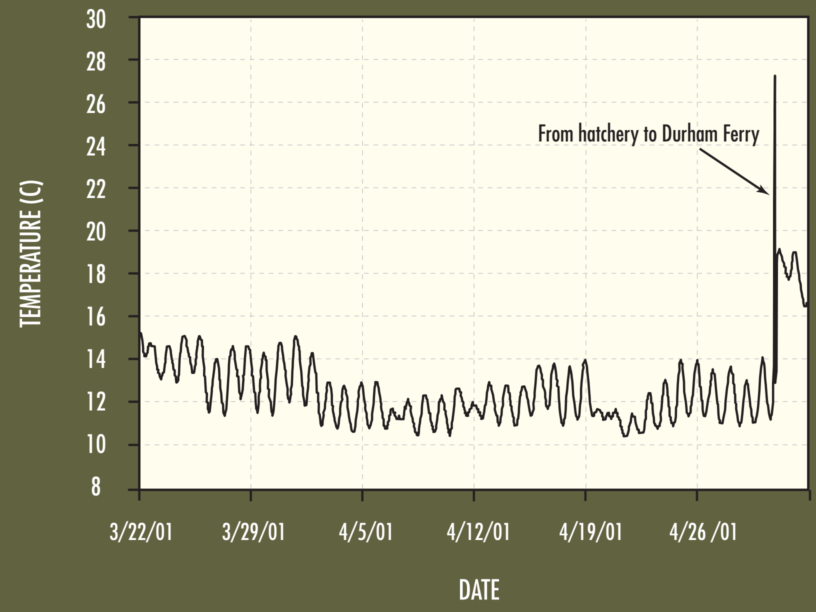


FIGURE 5-2
Water Temperature Measured at Durham Ferry Immediately Following VAMP 2001 Release.

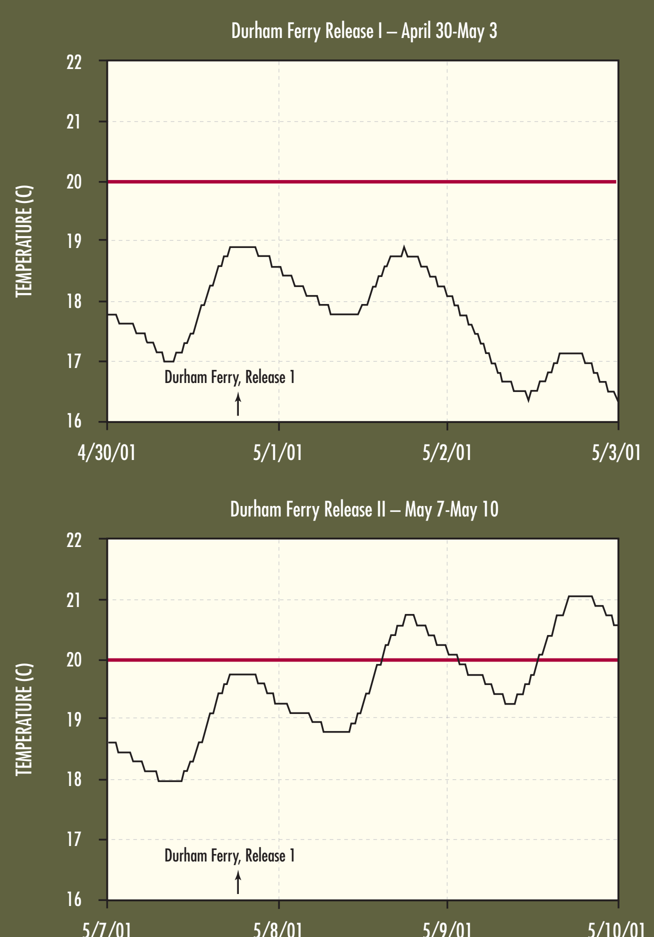
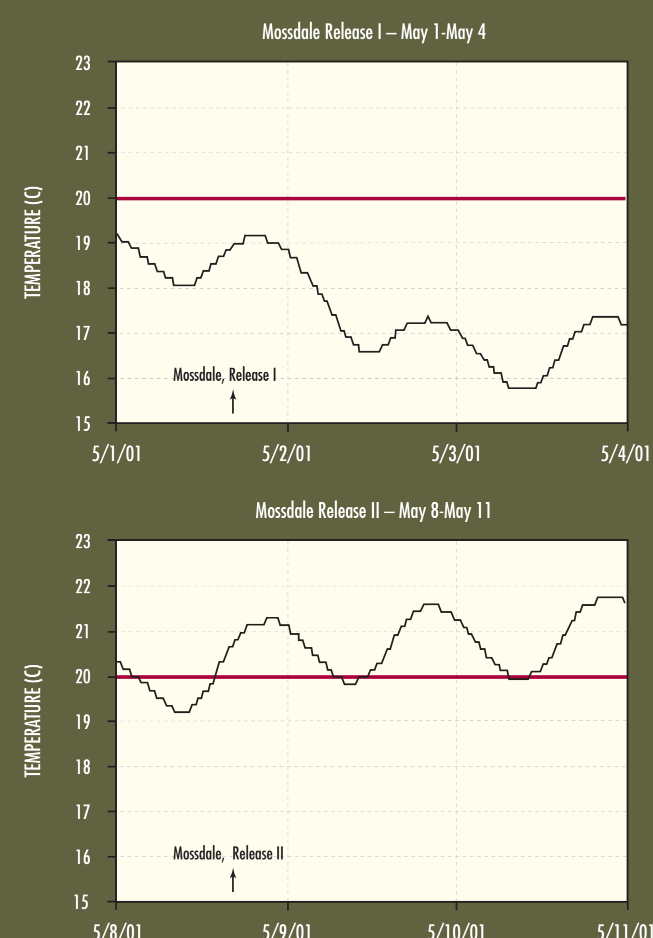


FIGURE 5-3
Water Temperature Measured at Mossdale Immediately Following VAMP 2001 Release.



part of these tests (Appendix C-1). Water temperature was recorded at 24-minute intervals throughout the period of the VAMP 2001 investigations. Water temperature was also recorded within the hatchery raceways at the Merced River Hatchery coincident with the period when juvenile Chinook salmon were being tagged.

Results of water temperature monitoring within the Merced River Hatchery showed that juvenile Chinook salmon were reared in and acclimated to water temperatures of approximately 11.1–13.9 C (52-57 F) prior to release into the lower San Joaquin River (Figure 5-1). Results of water temperature monitoring at Durham Ferry, Mossdale, and Jersey Point following the first and second sets of VAMP 2001 releases are compared in Figures 5-2, 5-3 and 5-4. Results of water temperature monitoring showed that water temperatures at the release locations and throughout the lower San Joaquin River and Delta (Appendix C-2), were higher than those at the hatchery. Water temperatures at the release locations and throughout the lower San Joaquin River and Delta also showed water temperatures were greater coincident with the second VAMP 2001 release, which may have adversely affected juvenile Chinook salmon survival. Within the lower San Joaquin River and Delta, water temperatures during the second VAMP 2001 release and emigration period consistently exceeded 20 C (68 F). High temperatures were identified during the design of the VAMP experiment as an indicator of potential thermal stress adversely affecting juvenile Chinook salmon survival. These high temperatures during the second set of releases in 2001 could affect the interpretation of the flow-export relationship.

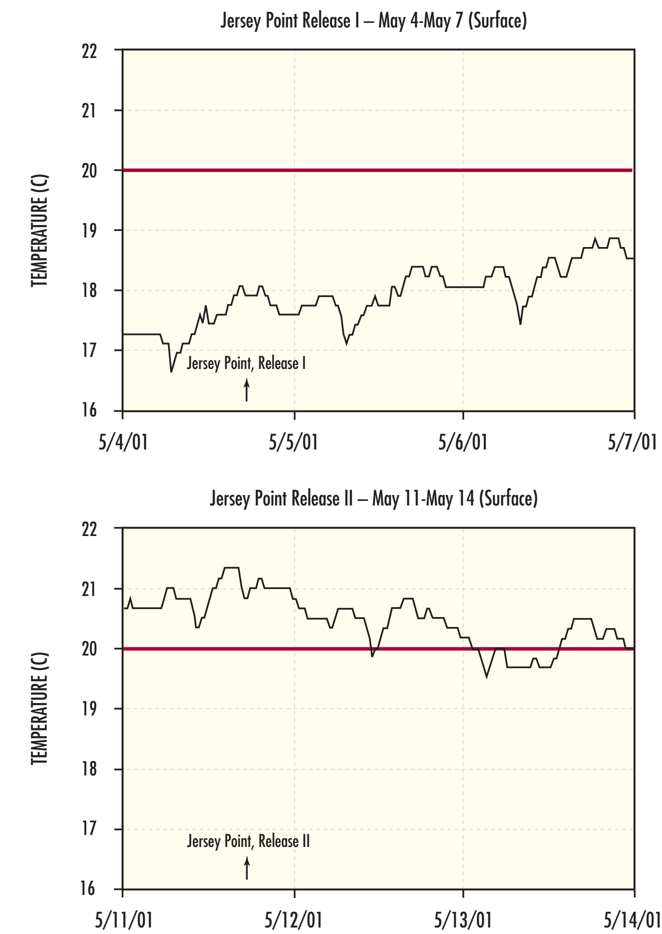
POST-RELEASE LIVE-CAR STUDIES

Survival and Condition

The post-release survival and condition of marked salmon was evaluated as part of the VAMP program using sub-samples of marked salmon from each release group. Approximately 200 salmon from each group were held at the respective release site in net pens for 48 hours after release and were evaluated for general condition and short-term mortality which might be associated with the handling, transport and release process. In addition to the 200 salmon held for 48 hours, 25 salmon from each tag group were evaluated for general condition immediately after release and another 25 salmon were held and similarly evaluated after the 48-hour holding period. To assess overall condition, fork length in millimeters, weight in grams, and six other characteristics were examined (Table 5-4). Obvious abnormalities or deformities were also noted.

Results of the evaluations of marked fish in the net pens, both immediately after release and 48 hours later, showed few abnormalities in the condition assessed characteristics which are

FIGURE 5-4
Water Temperature Measured at Jersey Point Immediately Following VAMP 2001 Releases.



shown in Appendix C-3. Scale loss ranged from 1-20%. All fish examined were noted to have normal coloration and normal eye characteristics. One fish from the May 8 Mossdale release had signs of fin hemorrhaging and 55 fish showed abnormally pale gills. Of the 1,433 salmon assessed, four (0.3%) were found to have a poor or incomplete fin clip. A total of three fish had some type of deformity, two of which had eroded pectoral fins (not uncommon for hatchery raised fish) and one that had a partial operculum. The percentage of salmon deformed within the sample group (0.2%) was within the normal range for hatchery-raised fish (S. Foott, Pers. com.).

A total of 19 mortalities were observed throughout the net pen experiments. Ten of these mortalities were observed in the pens immediately after the second Jersey Point release and were removed from the pens to avoid any possible contamination. The remaining nine mortalities were observed at the end of the 48-hour holding period, four at the first Durham release, one mortality at the first Jersey Point release, three at the second Durham release, and one at the second Mossdale release. There were no additional mortalities observed at the end of the 48-hour period at the second Jersey Point release. The higher incidence of pale gills and the observation of a few mortalities may indicate the juvenile salmon used as part of the VAMP experiments were under some level of stress.

Comparison of Release Groups

Results of previous salmon smolt survival studies have demonstrated a positive relationship between the length and condition of juvenile salmon and their survival. One of the underlying assumptions of the VAMP experimental design is that the length and condition of juvenile Chinook salmon released as part of the survival studies are comparable for fish released at Durham Ferry (treatment) and at Jersey Point (control). The experimental design also assumes that juvenile salmon released during the first set of studies each year are comparable in length and condition to the juvenile Chinook salmon in the second release group. Data on length, weight, and condition factor (length-weight relationship) developed from the sub-sample of fish collected for use in the net pen studies were used to test these underlying assumptions. For purposes of these statistical tests, data were selected from the sub-sample of fish measured at the time of release at both Durham Ferry and Jersey Point. If data was normally distributed, a t-test was used to determine if differences in sub-samples were significantly different. If data was not normally distributed, the non-parameter Mann-Whitney rank sum test was used. Results of these statistical comparisons of salmon released as part of the VAMP 2001 survival tests are summarized in Table 5-5.

Results of these tests showed statistically significant differences in both weight and condition factor in the first set of releases at Durham Ferry and Jersey Point. These statistically significant differences were also detected in the length of juvenile salmon released at Durham Ferry and Jersey Point during the second set of VAMP 2001 tests. Significant differences were also detected in both the length and weight of juvenile salmon released at Durham Ferry between the first and second release groups. Salmon were found to be significantly smaller (both length and weight) in the second set of VAMP 2001 releases at Durham Ferry. These statistical differences in size and condition among various test groups of salmon may or may not influence ultimate smolt survival to any meaningful degree. Future analysis of VAMP survival study results should take into account the potential affect of varying sizes of fish at the time of release at both Durham Ferry and Jersey Point as part of the overall analysis of survival study results.

TABLE 5-5

Statistical Analysis of the Size and Condition (Length-Weight Relationship) for Juvenile Chinook Salmon Released as Part of the VAMP 2001

	DURHAM FERRY RELEASE 1 **MEAN**	JERSEY POINT RELEASE 1 **MEAN**	STATISTICAL TEST	PROBABILITY (P)	SIGNIFICANT DIFFERENCE
Length (mm)	88.7	90.4	t-test	0.13	No
Weight (g)	7.3	7.9	t-test	0.03	Yes
Condition factor	2.6	2.1	Mann-Whitney	0.02	Yes
	DURHAM FERRY RELEASE 2 MEAN	**JERSEY POINT RELEASE 2 MEAN**	**STATISTICAL TEST**	**PROBABILITY (P)**	**SIGNIFICANT DIFFERENCE**
Length (mm)	84.6	87.8	t-test	0.03	Yes
Weight (g)	6.4	7.3	t-test	0.08	No
Condition factor	3.4	2.8	t-test	0.15	No
	DURHAM FERRY RELEASE 1 MEAN	**DURHAM FERRY RELEASE 2 MEAN**	**STATISTICAL TEST**	**PROBABILITY (P)**	**SIGNIFICANT DIFFERENCE**
Length (mm)	88.7	84.6	t-test	0.01	Yes
Weight* (g)	7.3	6.4	t-test	0.03	Yes
Condition factor*	2.6	3.4	t-test	0.08	No

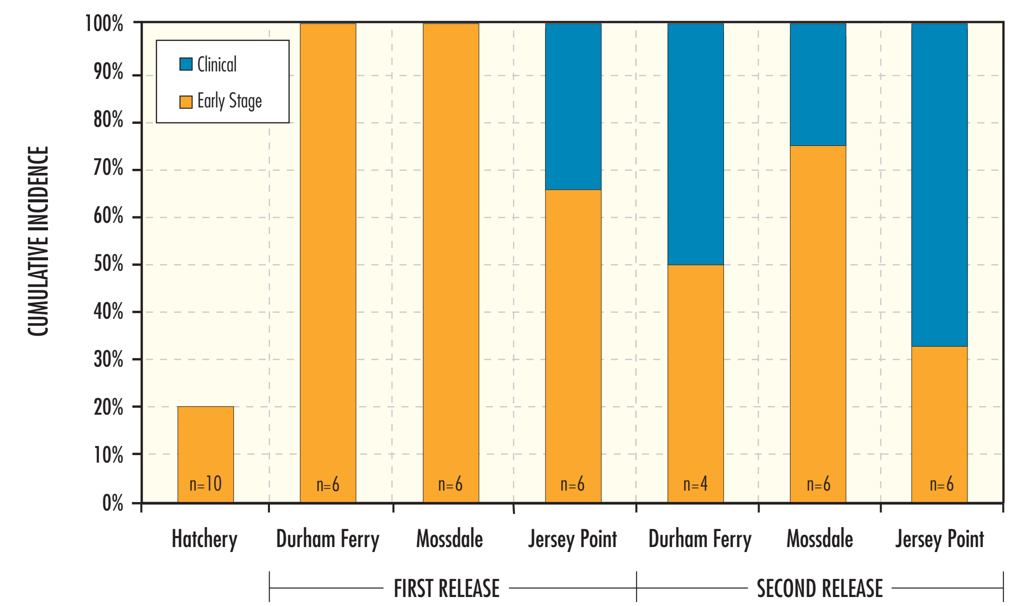
NOTE: Analyses are based on measurements from net pen studies immediately following each release.

*Weight and condition factor were obtained on only 11 of 25 fish.

FIGURE 5-5

Incidence of Early Stage PKX infection (Early Stage) and Clinical Proliferative Kidney Disease (Clinical) in Posterior Kidney Samples.

Early Stage indicates light presence of parasite, but no associated lesion. Clinical indicates presence of parasite with associated lesion likely impairing kidney function.



Tag Quality Control

The subset of 25 salmon from each tag group (a total of 25 from each of the Durham Ferry releases) evaluated for condition as described above were sacrificed to verify purity of tag codes. The additional 200+ fish from each release that were held for condition and survival evaluations were archived in a freezer. Though rare, on few occasions in the past, salmon from different release groups have been mixed at some point prior to release. While performing quality control checks on the May 8 Mossdale releases, two errant tag codes were discovered. The remaining 210 tags were read to verify tag code purity. After reading all tags, it was determined that neither code was tainted. Upon further review, it appears that the original errant tag codes were the result of tags being lost and found, and not reported as lost, in the lab.

Physiology

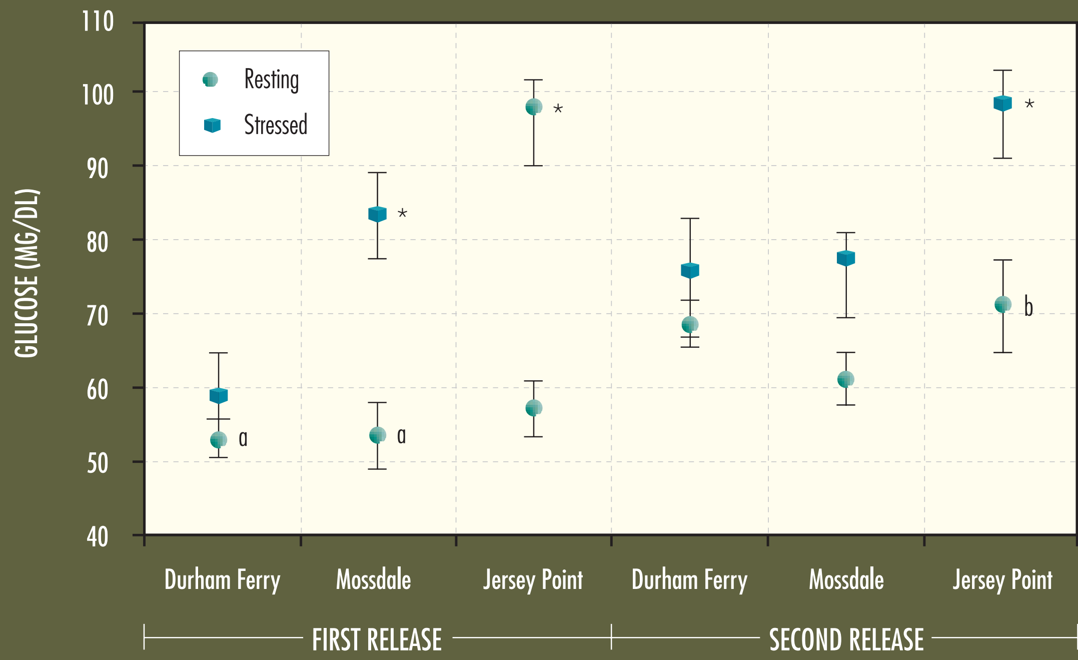
Physiological studies were conducted on a subset of the juvenile salmon used in the VAMP study by the USFWS California-Nevada Fish Health Center (Nichols et al. 2001). The results are briefly summarized below.

Physiological tests were conducted on a subset of the smolts released at Durham Ferry, Mossdale and Jersey Point after they had been held in the live cars for approximately 24 hours. Between 30 and 38 fish were sampled at each site. The fish were euthanized by an overdose of tricaine methane sulfonate (MS222), measured and assessed for external/internal abnormalities. Tissue samples were collected for pathogen and physiological assays. Kidney tissue was checked for bacterial pathogens. Internal organs were examined for parasites and abnormalities. Gill tissue was assayed for gill Na+, K+ - ATPase levels as an indicator of saltwater readiness (smolting). Plasma glucose and chloride levels were used to determine the ability of the fish to adapt to stress. Measurements were made with stressed and unstressed fish. The "unstressed" fish were removed from the net pen as quickly as possible and immediately euthanized. The stressed fish were held out of the water for 30 seconds, and sampled after they were allowed to recover for 30 minutes. To help establish baseline physiological conditions, sixty fish were sampled at random on April 9 from the Merced River Hatchery population. These fish were evaluated in terms of organosomatic analysis, ATPase levels, histology, bacteriology and virology. No stress physiology evaluation was conducted on the Merced River Hatchery fish. Results from the physiological tests indicated that the health of the release groups was poor and declined over time. No bacterial or viral pathogens were detected but infections of the PKX myxosporean parasite (the causative agent of Proliferative Kidney Disease) in the kidney were observed in 20% of Merced River Hatchery samples and 100% of all release groups (Figure 5-5). Infections had progressed to clinical disease in the first Jersey Point and all of the second set of release groups (Figure 5-5). Clinical signs of disease were evident during necropsy in 0-3% of the first release groups and 11-22% of the second release groups. Clinical signs of disease included pale gills, swollen kidney, and swollen spleen.

FIGURE 5-6

Resting and Stressed Plasma Glucose Concentrations in VAMP 2001 Release Groups.

Data given as Mean ± SE. Sample number is 12 for all groups except first Durham Ferry Resting (n=11).

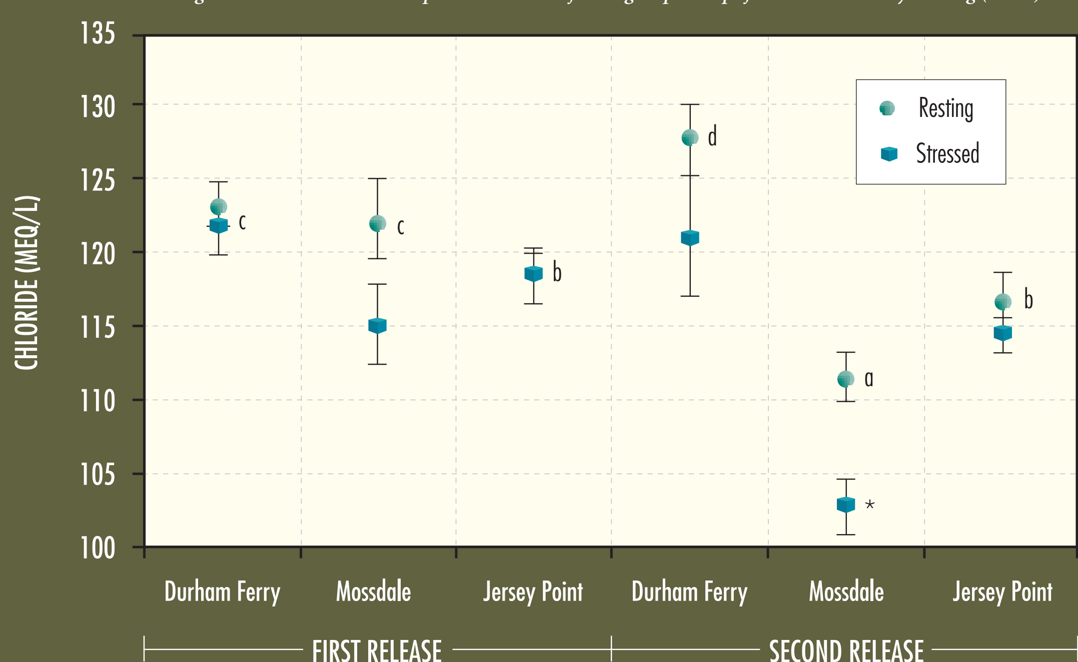


NOTES: * = difference between Resting and Stressed (P<0.05, t-test)
Resting levels labeled a are significantly lower than those labeled b (P<0.05, ANOVA)

FIGURE 5-7

Resting and Stressed Plasma Chloride Concentrations in VAMP 2001 Release Groups.

Data given as Mean += SE. Sample number is 12 for all groups except first Durham Ferry Resting (n=11).



NOTES: * = difference between Resting and Stressed (P<0.05, t-test)
Resting levels labeled a are significantly lower than those labeled c or d (P<0.05)
Resting levels labeled b are significantly lower than those labeled d (P<0.05, ANOVA)

Stress treatments demonstrated healthy energy reserves in half of the release groups (Figure 5-6). Both Durham Ferry and the latter Mossdale groups either did not exhibit a significant glucose stress response or the stress treatment did not allow adequate time for the response to occur. The second Mossdale release demonstrated poor ion balance with low chloride values prior to stress and perilously low values following stress (Figure 5-7). Stress responses of fish from both Jersey Point releases were consistently different from the other groups. This difference was likely due to site conditions, and it was not evident if these differences would lead to increased or decreased survival.

In summary, all test groups showed signs of disease (not just infection) with the second set of release groups having a higher incidence of kidney disease. Stress response was not always healthy, but could have been due to holding conditions. Poor stress tolerance is also typical of PKX infections (Lom and Dyková 1995). Chronic PKX infection could desensitize the stress response of the fish making them more susceptible to the stress of transport and holding conditions.

It is possible that reduced health of the juvenile salmon used in the VAMP 2001 reduced their survival through the Delta. Possible bias in survival results due to reduced fish health was greater in the second set of releases and may be further confounded by exposure of these release groups to elevated water temperatures.

CWT RECOVERY EFFORTS

CWT salmon were recaptured at Antioch and Chipps Island, at CVP and SWP fish salvage facilities and during sampling in upper Old River near the barrier (See Figure 1-1). CWT salmon released upstream of, and at, Mossdale were also recovered in DFG Kodiak trawls at Mossdale but are not discussed in this report. Juvenile Chinook salmon with an adipose fin clip (which identifies CWT salmon) caught at any of these sampling locations were sacrificed, labeled, and frozen pending CWT processing. Coded-wire tag processing was done by USFWS (Stockton) for fish recovered at Chipps Island, HORB, Antioch, and SWP/CVP salvage facilities.

Coded wire tag processing entails dissecting each tagged fish to obtain the half (0.5 millimeters) or full (1 millimeter) cylindrical tag from the snout. Most coded wire tags in 2001 were the newer generation decimal tags, which have the code imprinted several times on each tag, but the print is so small that the reading must be done under a microscope. Tags were read twice, with any discrepancies resolved by a third reader. All tags are archived for future reference. It should be noted that many tags recovered at Chipps Island, Antioch, SWP/CVP salvage, and other locations are from coded wire tag releases not affiliated with VAMP. Since the origin of the tag is unknown until after reading the tag, all tags recovered are read in order to identify the tag recoveries related to VAMP.

SWP/CVP Salvage Recapture Sampling

Sampling at the CVP and SWP fish salvage facilities was conducted approximately every two hours. The number of marked salmon collected (raw salvage) was “expanded” based on the number of minutes sampled during each two hour time period. The estimated expanded total number of CWT salmon, from each release group, was obtained by adding together the expanded number of each tag group for all time periods. Only the CWT salmon recovered in the raw salvage collections were sacrificed for tag decoding. Expanded salvage is only a portion of the direct loss experienced by juvenile salmon at the facilities as it does not include losses prior to, and associated with, pre-screen predation, screening, handling and trucking.

Expanded CVP and SWP salvage estimates of marked salmon released as part of the VAMP 2001 studies are shown in Table 5-3. Salvage numbers were low at both the SWP and CVP. These results are consistent with earlier studies showing that the HORB reduces the number of coded wire tagged salmon entrained at the fish facilities. It is interesting to note that 390 of the 25,000 coded wire tagged smolts released into upper Old River, were estimated to have been salvaged at the CVP. This is a much higher rate of salvage than for smolts released at Mossdale or Durham Ferry. It is likely that most of the salmon smolts released at Durham Ferry and Mossdale that were diverted into upper Old River were recovered and sacrificed in the fyke net sampling at the barrier. It is possible that a few of the recoveries at the CVP and SWP from the Durham Ferry and Mossdale releases could have been from smolts that migrated into upper Old River via the culverts that did not always have a fyke net attached (See Chapter 4).

Once in upper Old River these fish could have migrated downstream to the facilities. It is also possible that the smolts migrated back to the CVP and SWP via Turner or Columbia Cuts or river junctions off the San Joaquin River further downstream.

Antioch Recapture Sampling

Fishery sampling was conducted in the vicinity of Antioch on the lower San Joaquin River using a Kodiak trawl. The Kodiak trawl has a graded stretch mesh, from 2-inch mesh at the mouth to ½-inch mesh at the cod-end. Its overall length is 65 feet, and the mouth opening is six feet deep and 25 feet wide. The net was towed between two skiffs, sampling in an upstream direction. Trawls were performed parallel to the left bank, mid-channel, and right bank to sample CWT salmon emigrating from the San Joaquin River. Each sample was approximately 20 minutes in duration.

All fish collected were transferred immediately from the Kodiak trawl to buckets filled with river water, where the fish were held during processing. Data collected during each trawl included identification and measuring the fork length of fish collected, tow start time and duration and location in the channel. Mortality and damage to fish collected was documented to comply with the Endangered Species Act permit requirements.

Juvenile Chinook salmon with an adipose fin clip were retained for later CWT processing while unmarked salmon, steelhead, Delta smelt, splittail, and other fish were released at a location downstream of the sampling site immediately after identification, enumeration and measurement.

Sampling at Antioch was initiated May 1 and continued through May 25. Each day between 5:00 a.m. and 9:00 p.m., anywhere from 13 to 30, 20-minute tows were conducted. All told, 580 Kodiak trawl samples were collected, representing a total sampling duration of 11,545 minutes. During the sampling, a total of 6,373 unmarked juvenile Chinook salmon and 1,285 salmon with an adipose fin clip (CWT) were collected. In addition, 821 Delta smelt, 188 splittail, and 28 steelhead were caught in the sampling.

Chipps Island Recapture Sampling

As part of VAMP recovery efforts at Chipps Island, trawling was conducted daily between April 30 and June 19. This included at a minimum, a regular schedule of ten, 20-minute tows beginning at about 7:00 am each day, and ending about noon. Between May 3 and June 2, the effort was increased by adding a second shift of trawling in the afternoon/evening, bringing the trawling effort up to twenty, 20-minute tows per day. On these days the first shift was begun at dawn, while the second shift ended at or after sunset, to incorporate the crepuscular periods of Chinook movement. It is hypothesized, based on an analysis of salmon smolts caught during twenty-four hour sampling at Jersey Point in 1997, that a greater number of salmon would be caught around dawn and dusk. Both targeting this crepuscular period and doubling the total trawl effort at Chipps Island were intended to increase the numbers of CWT salmon recaptured and reduce the variability in VAMP survival indices. This second shift was also conducted in 1998, 1999, and 2000.

The trawl at Chipps Island was towed at the surface using a net with a mouth opening 10 feet deep by 30 feet wide, with a total net length of 82 feet. Aluminum hydrofoils were used on the top bridles and steel depressors along with a weighted lead line were used on the bottom bridles to keep the mouth of the net open. The net was variable mesh net starting with 4-inch mesh at the mouth and ending with a ¼-inch cod end.

To sample across the channel, trawling at Chipps Island was conducted in three distinct lanes, one each in the north, south and middle of the channel. Each lane was generally sampled at least three times per shift, with one lane sampled a fourth time during each shift. This lane was chosen at random or selected by the boat operator based on flow conditions.

Coded wire tagged salmon released as part of the VAMP program were recovered at Chipps Island between May 3 and June 2. A total of 256 CWT salmon were recovered at Chipps Island from the VAMP study. During the May 3 through June 2 VAMP recovery period, a total of 7,592 unmarked salmon, 574 CWT salmon from other non VAMP experiments, 165 Delta smelt, 360 Sacramento splittail, 4 clipped steelhead and 14 non-clipped steelhead were also collected at Chipps Island.

VAMP CHINOOK SALMON CWT SURVIVAL INDICES

Survival indices were calculated for marked salmon released at Durham Ferry, Mossdale, and Jersey Point and recovered at Antioch and Chipps Island. Survival indices were calculated by dividing the number of CWT salmon recovered by the effective number released and the fraction of time and channel width sampled. The fraction of the channel width sampled at Chipps Island (0.00769) was the net width (30 feet) divided by an estimate of the channel width (3900 feet). The fraction of the channel width sampled at Antioch (0.01388) was based on the net width (25 feet) used there and an estimate of the channel width (1,800 feet). The fraction of time sampled, at both locations, was calculated based on the number of minutes sampled, between the first and last day of catching each particular tag code or group, divided by the total number of minutes in the time period. The percent of time sampled for the VAMP 2001 release groups at Chipps Island was about 28 percent, while at Antioch it ranged between 35 and 40 percent.

Survival indices were calculated for each separate tag code to provide a sense of the variability associated with the overall group survival index. To generate the group survival index, the recovery numbers and release numbers are combined for the tag codes within a release group. This results in a slightly different index than would be generated by taking the mean of the survival indices of the individual tag codes within a group.

The individual and group survival indices to Antioch and Chipps Island of the CWT salmon released as part of VAMP 2001 are shown in Table 5-3. As in 2000, survival indices from the release locations to Antioch were sometimes lower than those at Chipps Island. It is expected that indices to Antioch would be greater than those to Chipps Island since Antioch is closer to the release locations than Chipps Island. Lower survival indices to Antioch may be a result of the marked salmon not being equally distributed or vulnerable to the trawls throughout the 24-hour period and the expansions for effort may be biasing the Chipps Island estimates high.

Differences between release groups were also evaluated statistically by comparing the recapture rates (the number recaptured divided by the number released) at Antioch or Chipps Island.

The first and second Durham Ferry releases had survival indices to Antioch of 0.20 and 0.08, respectively. Survival indices to Chipps Island were 0.36 and 0.06. The individual tag code survival indices at Antioch and Chipps Island did not overlap and there appeared to be a difference in survival between the first and second Durham Ferry groups. Results of statistical analysis of the Durham Ferry data showed that the proportion of CWT salmon recaptured from the second group was significantly lower ($P < 0.05$) than the proportion recovered from the first release group using the recovery information at both Antioch and Chipps Island.

The two Mossdale releases showed similar differences between the first and second releases. The first releases had survival indices to Antioch of 0.13 and 0.07 respectively and 0.32 and 0.08 to Chipps Island. Again none of the individual tag code survival indices overlapped between groups indicating a real difference between the two groups. Differences in the proportion of CWT salmon recaptured were statistically significant ($P < 0.05$) based on sampling at Chipps Island. Differences in the proportion recaptured based on sampling at Antioch were not significantly different between the first and second releases.

Similarly, the two Jersey Point groups also appeared to survive at different rates; with the first group surviving at a higher rate than the second. The first group released on May 4 had a survival index to Antioch of 1.23. The second group released on May 11 had an index to Antioch of 0.38. Chipps Island recoveries demonstrated the same apparent difference between groups with the first group having an index of 1.06 and the second group having an index of 0.40. Differences in proportion of CWT salmon recaptured were statistically significant at both recapture locations.

Why survival was so much lower for the second group (releases at Durham Ferry, Mossdale, and Jersey Point), relative to the first group is unknown. Flow and export conditions were similar for both groups. Water temperatures increased for some of the releases in the second group and likely contributed to the lower survival. A higher prevalence of PKD (Proliferative Kidney Disease) was also observed in the second set of releases in the physiological studies. Results of the net pen studies indicated a low level of mortality for all release groups, however it was not apparent that the second group had higher mortality in the net pens than the first group.

As part of the VAMP 2001 experimental design, releases were made at both Mossdale and Durham Ferry to determine how survival differed between these two locations. Results of the releases at Durham Ferry on April 30 and May 7 and Mossdale on May 1 and May 8, indicated survival from Durham Ferry and Mossdale was similar in 2001 even though Durham Ferry is 11 miles further upstream than Mossdale. Although the Durham Ferry group may have survived slightly better, indices were variable enough such that there was likely no real difference between the groups. No statistically significant ($P > 0.05$) difference in the proportion of CWT salmon recaptured was detected among salmon released at Durham Ferry and Mossdale based on recaptures at both Antioch and Chipps Island.

More important than the relative survival indices between locations are comparisons of survival indices within the same recovery location and the trends between the groups using the two recovery locations. The use of absolute survival estimates, where the survival index of the upstream release group is divided by the survival index of the downstream group (recovered at the same location), is most useful for within and between recovery locations and year comparisons.

ABSOLUTE CHINOOK SALMON SURVIVAL ESTIMATES

Absolute survival rates were estimated using the ratio of the survival indices of smolts released at Durham Ferry and Mossdale in relation to those released at Jersey Point. These absolute survival estimates are more powerful for use in comparing survival rates, since the use of ratios between upstream and downstream groups theoretically standardizes for differences in catch efficiency between recovery locations and years. Two independent estimates of absolute survival have been calculated for the VAMP 2001 releases using recoveries at both Antioch and Chipps Island. An additional estimate of absolute survival will be possible from recoveries in the ocean fishery, 2 to 4 years following release. Absolute survival estimates for VAMP 2001 are shown in Table 5-3.

Statistical differences between groups, was also assessed based upon the ratio of CWT salmon released and recaptured from Durham Ferry and Mossdale relative to the proportion of CWT salmon released and recaptured from the downstream Jersey Point (control) releases.

Although the relative survival indices indicated that the first groups released survived at a higher rate than the second group, the absolute estimates of survival appear to give conflicting results. Survival between Durham Ferry and Mossdale and Jersey Point for the first group, was higher than the second group using Chipps Island recovery information. It was similar between the first and second releases using the Antioch recovery information. Differences in the proportions of recovery rates among the two test groups from Durham Ferry relative to Jersey Point groups were not found to be statistically significant based on sampling at Antioch. However, there was a statistically significant difference between the proportions of the two Durham Ferry releases relative to the Jersey Point controls using Chipps Island recovery information.

Differences in the proportion recovered of the combined Durham Ferry releases and the combined Mossdale releases were not found to be statistically significant ($p>0.05$) with recoveries from either sampling location.

Survival estimates in 2000 did appear less for the Durham Ferry group than the Mossdale group using recovery information at Antioch. This difference led to the recommendation of making releases at both Durham Ferry and Mossdale in 2001. Additional releases may be needed to fully understand if differences between these two groups are meaningful.

An alternative method for estimating survival from Durham Ferry to Mossdale and Mossdale to Jersey Point was developed by Dr. Ken Newman (See Chapter 6) based on the ratio of marked salmon recaptured from upstream and downstream release sites. Using this alternative calculation method, survival between Durham Ferry and Mossdale was 1.33 and 0.96 for the first and second groups, respectively. Since it is impossible to have over 100% survival between Durham Ferry and Mossdale, these data appear to show that survival was either very high between the two locations, or that the first group of smolts released at Durham Ferry survived at a higher rate than the first group released at Mossdale for some unknown reason. Survival between Mossdale and Jersey Point was 0.16 and 0.20 for the first and second groups released, respectively.

Variance and standard errors were also calculated based on the Delta method provided by Dr. Newman. The estimates of survival, plus or minus two standard errors, is roughly equivalent to the 95% confidence intervals. These confidence intervals are provided in Table 5-6 showing that there is a substantial variability around the survival estimates and that replicates (Durham Ferry to Mossdale and Mossdale to Jersey Point) were not significantly different from each other. These findings are not consistent with results of the statistical analysis using proportions that showed, when using Chipps Island data alone, that the survival rates for the first release groups were higher than the second.

Transit Time

Data on transit times for marked salmon from the release to recapture sites during VAMP 2001 is summarized in tabular and graphic form in Appendix C-4. CWT salmon released April 30 at Durham Ferry took between 5 and 11 days to arrive at Antioch and Chipps Island. The May 1 Mossdale release took between 4 and 11 days to arrive at Antioch and Chipps Island. Jersey Point release groups were recovered between 0 and 10 days after release at Antioch and between 1 and 7 days at Chipps Island. The May 7 Durham Ferry release group arrived at Antioch between 4 and 15 days and between 5 and 13 days at Chipps Island. The May 8 release group at Mossdale was recovered at Antioch between 4 and 12 days and between 5 and 10 days at Chipps Island. The second Jersey Point release group was recovered between 1 and 12 days after release at Antioch and 1 and 11 days after release at Chipps Island. The transit time from release location to Antioch and Chipps Island of both sets of releases was similar. The number of individual recoveries by tag code and the number of minutes towed per day for both Antioch and Chipps Island recoveries are shown in Appendix C-4.

TABLE 5-6
Estimates of Survival Between Durham Ferry and Mossdale (S DF TO MD) and Between Mossdale and Jersey Point (S MD TO JP), and Survival Minus (S–2se) and Plus (S +2se) two Standard Errors.

	REC. AT ANTIOCH	REC. AT CL	# RELEASED	A+C	A+C/R	S DF TO MD	S MD TO JP	S–2SD	S+2SD
Durham 1	28	14	23,354	42	0.001798407				
	30	22	22,837	52	0.002277007				
	18	17	22,491	35	0.001556178				
	76	53	68,682	129	0.001878221	1.33		1.12	1.53
MD 1	18	17	23,000	35	0.001521739				
	15	14	22,177	29	0.001307661				
	33	31	45,177	64	0.00141665		0.16	-0.13	0.45
JP 1	156	50	24,443	206	0.008427771				
	173	61	24,992	234	0.009362996				
	329	111	49,435	440	0.008900577				
Durham 2	8	2	24,025	10	0.000416233				
	11	5	24,029	16	0.000665862				
	10	2	24,177	12	0.000496339				
	29	8	72,231	38		0.96		0.74	1.17
MD 2	8	4	23,878	12	0.000502555				
	11	4	25,308	15	0.000592698				
	19	8	49,186	27	0.000548937		0.20	0.00	0.40
JP 2	43	17	25,909	60	0.002315798				
	53	27	25,465	80	0.003141567				
	96	44	51,374	140	0.002725114				

TABLE 5-7
Absolute Survival Estimates for VAMP Survival Studies

	VAMP 2000		VAMP 2001	
Vernalis Flow (cfs)	5,869		4,220	
SWP/CVP exports (cfs)	2,155		1,420	
Durham Ferry Survival	Release 1	Release 2	Release 1	Release 2
Antioch	0.20	0.14	0.17	0.20
Chipps Island	0.31	0.19	0.34	0.14
Mossdale Survival	Release 1	Release 2	Release 1	Release 2
Antioch	0.34	–	0.11	0.18
Chipps Island	0.31	–	0.31	0.19

Role of Flow and Exports on Absolute Survival

Survival of juvenile Chinook salmon emigrating from the San Joaquin River system has been evaluated within the framework established by the VAMP experimental design during 2000 and 2001. Absolute survival estimates from these studies are summarized in Table 5-7 for the two San Joaquin River flow-export conditions tested.

Results of statistical analysis of these two years of data showed that the proportion of CWT salmon recovered were not significantly different ($P > 0.05$) from the combined Durham Ferry and Mossdale groups relative to the Jersey Point groups under the two flow-export conditions tested during VAMP 2000 and 2001. Given the relatively high variability inherent in conducting salmon smolt survival studies within the lower San Joaquin River and Delta, the lack of statistically significant differences in survival estimates between the two relatively close flow-export conditions tested was not unexpected. Results of these analysis underscore the importance of collecting salmon smolt survival data under the most extreme flow-export conditions identified as VAMP targets. The greater the separation between flow and export condition among tests, the greater the ability of these survival studies to detect the true effects of flow and/or export rate on juvenile Chinook salmon survival.

> *The transit time from release location to Antioch and Chipps Island of both sets of releases was similar.*

The U.S. Fish and Wildlife Service has conducted a number of previous investigations on the effects of San Joaquin River flow and export conditions on juvenile Chinook salmon survival. Although these previous studies vary somewhat from the experimental design established by VAMP, results of these tests provide a useful context and foundation for evaluating and interpreting survival information collected as part of the VAMP investigations (San Joaquin River Group Authority 2000 Annual Technical Report and Appendix D).

Survival estimates from Mossdale to Jersey Point (obtained using Chipps Island recovery information) gathered in 2001 are compared with past years survival data in Table 5-8. The absolute survival estimates obtained from the first groups in 2001 are similar to those obtained during the VAMP 2000 investigations and are relatively high in comparison to survival estimates from similar studies starting in 1994. Only 1999 and 1995 had higher absolute survival estimates between Mossdale and Jersey Point than those obtained in 2000 and for the first groups of 2001. Releases in 1995 were from Feather River Hatchery origin Chinook salmon, which have been shown to survive at lower levels than salmon from the Merced River Hatchery – thus the estimate in 1995 may be biased low. In contrast, data collected in 1999 is thought to be biased (high), based on potentially low recovery of Jersey Point released fish.

As in 2000, comparative releases in 2001 of CWT salmon were made at both Mossdale and Durham Ferry. Prior to 2000, all upstream releases had been made at Mossdale. Using the past data will help in evaluating the effects of SWP and CVP exports and San Joaquin River flow on salmon survival. If the survival estimates from the two release locations were found to be significantly different, then using only Durham Ferry releases would increase the number of years needed to complete the VAMP study. Results in 2001 indicated that survival was not significantly different for salmon smolts released at Durham Ferry and Mossdale and that the absolute survival between the two locations was relatively high.

The relationship to date between absolute survival estimates between Mossdale and Jersey Point and San Joaquin River flow at Vernalis is shown in Figure 5-8. Linear regression analyses were used to assess the potential relationship between absolute survival estimates and river flow at Vernalis. Two regression lines have been developed based on survival data with and without the HORB. The barrier can not be installed and operated at flows greater than 7000 cfs. Statistically neither regression line is significant, although prior to adding the data from 1999, the without barrier relationship was significant ($R^2 = 0.75$, $P = 0.25$).

Figure 5-9 shows the relationship between absolute salmon smolt survival and flow with the HORB, but uses estimated net flow on the San Joaquin River downstream of upper Old River instead of the flow at Vernalis. Because the HORB has had different permeability (culvert operations) over the years, the estimated flow in the San Joaquin River downstream of upper Old River has been used to better reflect the river flow the juvenile salmon experience as they migrate down the San Joaquin River. This estimate is calculated by subtracting the estimated mean daily flow in upper Old River 840 feet downstream of the barrier from the USGS gauged mean daily flow at Vernalis. Figure 5-9 also includes survival estimates between Mossdale (and Durham Ferry) and Jersey Point using recovery information from the Antioch sampling. There is substantial variability at any one flow level based on this combined data from the variety of sources (Antioch and Chipps recoveries, Mossdale and Durham Ferry releases). Variation in estimates of survival

FIGURE 5-8 **Absolute Smolt Survival Between Mossdale and Jersey Point and San Joaquin River Flow at Vernalis, With and Without the HORB.**

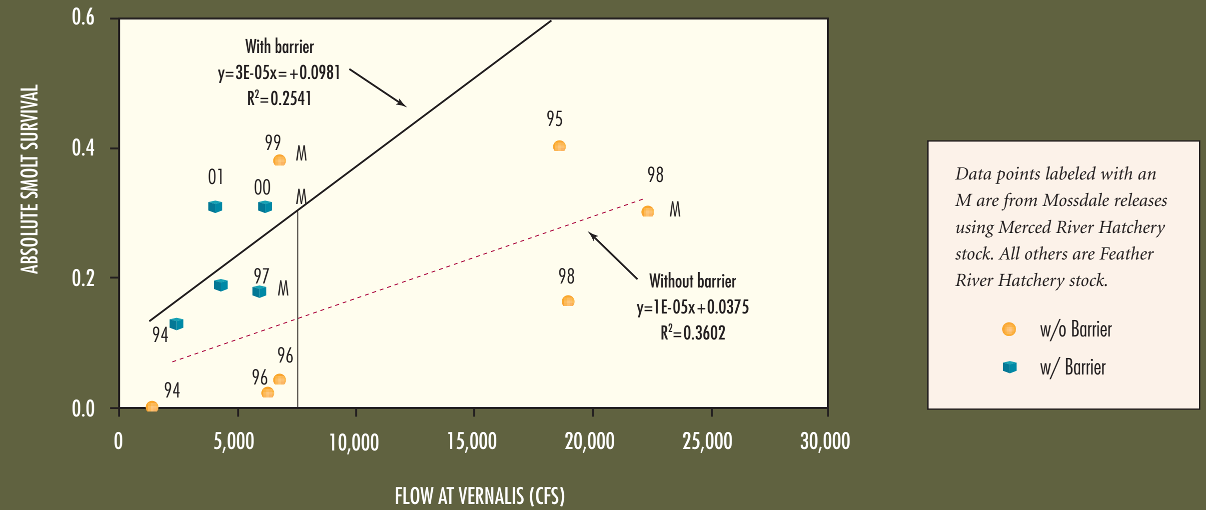


FIGURE 5-9 **Absolute Smolt Survival Between Mossdale (M)/Durham Ferry (DF) and Jersey Point and River Flow on the San Joaquin River Downstream of the Upper Old River With the HORB in Place.**

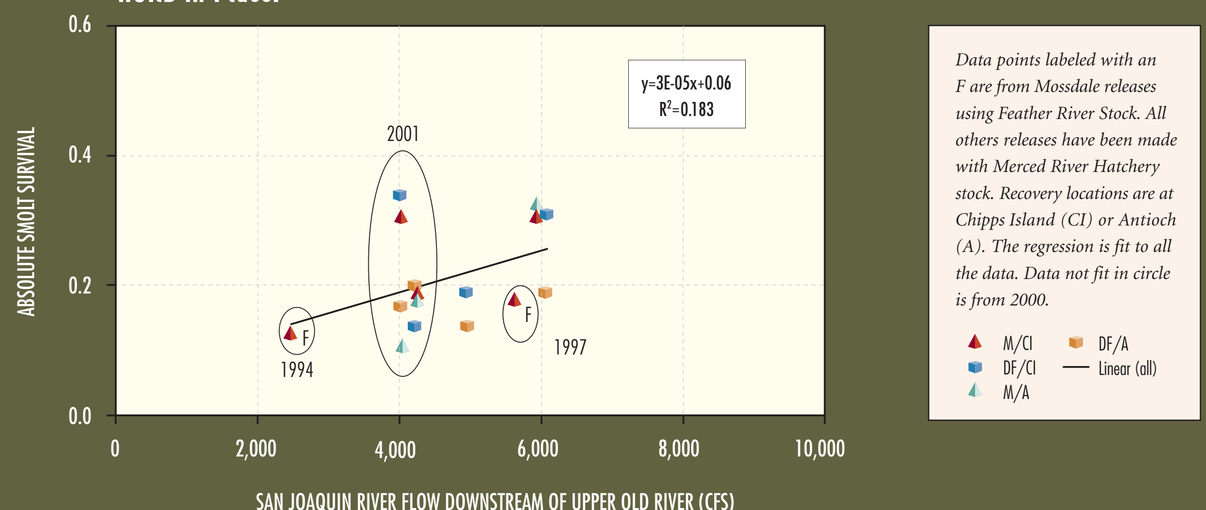


FIGURE 5-10 **Absolute Smolt Survival Between Mossdale/Durham Ferry (DF) and Jersey Point and CVP+SWP Exports (Daily Average in cfs).**

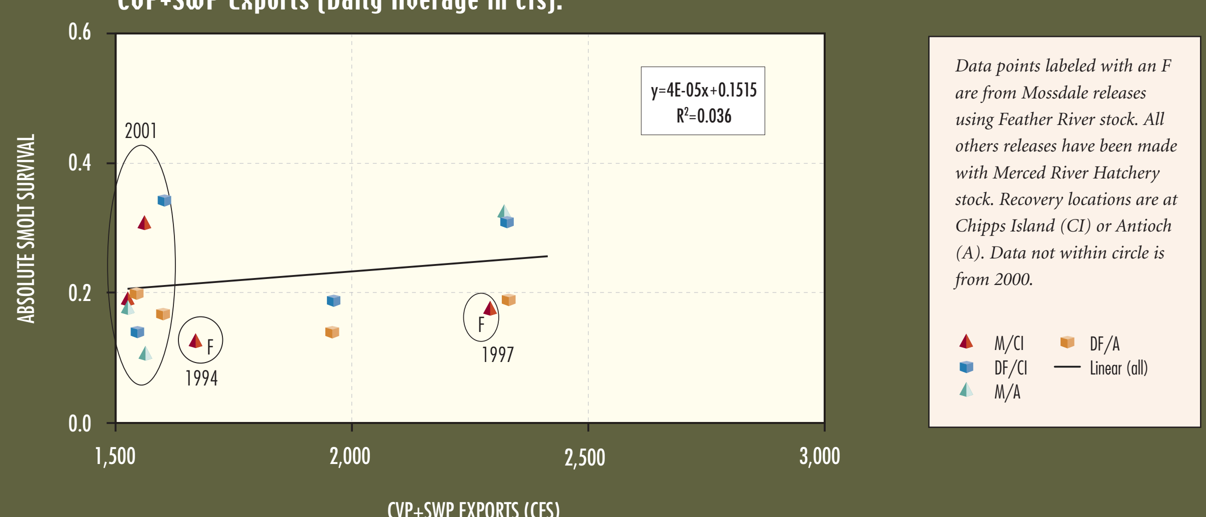


TABLE 5-8
Smolt Survival Data for Smolts Released at Mossdale, Durham Ferry (DF) and Jersey Point Between 1994 and 2000.

YEAR	SURVIVAL INDEX	# FISH RECOV-ERED	RELEASE TEMP	SIZE AT RELEASE	SURVIVAL INDEX	# FISH RECOV-ERED	RELEASE TEMP	SIZE AT RELEASE	HATCHERY STOCK	RATIO	SJR FLOW DOWN-STREAM OF OLD RIVER (CFS)	FLOW AT VERNALIS	CVP+SWP EXPORTS	BARRIER STATUS
	Mossdale				Jersey Point									
1994	0	0	63	74	0.18	10	64	72	FRH	0.00	437	1,387	1,268	no barrier
1994	0.04	2	60	77	0.28	16	63	78	FRH	0.13	2,468	2,468	1,671	barrier
1995	0.19	20	57	70	0.48	26	60	70	FRH	0.40	7,363	18,450	3,666	no barrier
1996	0.02	2	59.5	78	0.5	25	62	78	FRH	0.04	2,631	6,673	1,651	no barrier
1996	0.01	1	64	81	0.45	24	64	87	FRH	0.02	2,475	6,269	1,517	no barrier
1997	0.19	10	60	100	1.03	55	63	99	FRH	0.18	5,605	5,905	2,302	barrier (with 2 culverts)
1998	0.1	7	66	84	0.63	40	66	78	FRH	0.16	7,692	18,850	2,004	no barrier
1998	0.56	88	57	86	1.84	187	62	89	MRFF	0.30	9,140	22,220	1,616	no barrier
1999	0.28	36	62	79	0.73	59	63	81	MRFF	0.38	3,161	6,762	3,161	no barrier
2000	0.19	18	56	79	0.62	65	64	82	MRFF	0.31	5,936	6,196	2,332	barrier (with 2 open culverts
2000	0.19 (DF)	28	57	80	0.62	65	64	82	MRFF	0.31	6,077	6,339	2,335	barrier (with 2 open culverts)
2000	0.15 (DF)	22	62	77	0.78	78	63	77	MRFF	0.19	4,959	5,702	1,964	barrier (with 4 open culverts)
2001	0.32	31	67	91	1.06	111	68	88	MRFF	0.31	4,011	4,126	1,567	barrier (with 6 culverts open)
2001	0.36 (DF)	53	70	89	1.06	111	68	88	MRFF	0.34	4,013	4,125	1,609	barrier (with 6 culverts open)
2001	0.076	8	69.8	88.5	0.4	44	72.5	87.5	MRFF	0.19	4,225	4,337	1,529	barrier (with 6 culverts open)
2001	0.052 (DF)	9	66.2	85	0.4	44	72.5	87.5	MRFF	0.13	4,206	4,297	1,548	barrier (with 6 culverts open)

between the two recovery locations (Antioch and Chipps Island) adds a level of uncertainty to the survival investigations, however, the benefit of having two rather than only one survival estimate per year is of major value.

Figure 5-10 shows salmon smolt survival regressed against averaged CVP+SWP exports for the 10 days after release. The 10-day averaging period used in these analysis has been based on expected exposure periods during emigration as reflected in transit time estimates to the Antioch and Chipps Island recovery locations. In 2000, it was reported that absolute salmon survival appeared to increase as exports increased from 1600 to 2300 cfs. With the addition of the 2001 data the positive relationship between exports in this range and survival is less apparent. There is so much variability in the various estimates that a relationship is not clear.

Evaluating the role of SWP and CVP exports, the HORB, and flow on salmon smolt survival through the south Delta are key elements of VAMP. Presence of the HORB affects both the emigration route of salmon smolts and hydraulic conditions in the lower San Joaquin River and Delta that are thought to alter the vulnerability of juvenile salmon to export-related effects.

Figure 5-11 shows the relationship between salmon survival (between Mossdale and Jersey Point using survival estimates derived from Chipps Island recoveries), San Joaquin River flow downstream of upper Old River and SWP/CVP exports with the HORB in place. It appears that as flows increase, survival increases. High survival has been observed with lower (1,500 cfs) and somewhat higher exports (2,300 cfs).

FIGURE 5-11
Survival from Mossdale to Jersey Point (MDJPSUR) Versus San Joaquin Flow Downstream of Upper Old River (SJRIVERFLOW) and Average Daily Combined CVP+SWP Exports (EXPORTS).

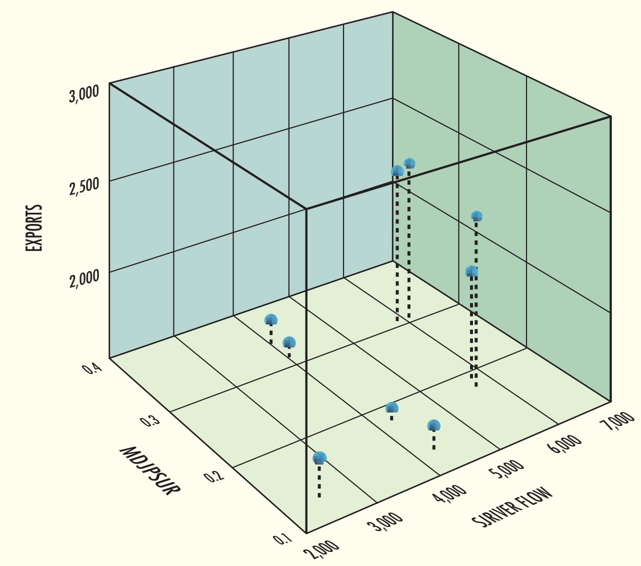
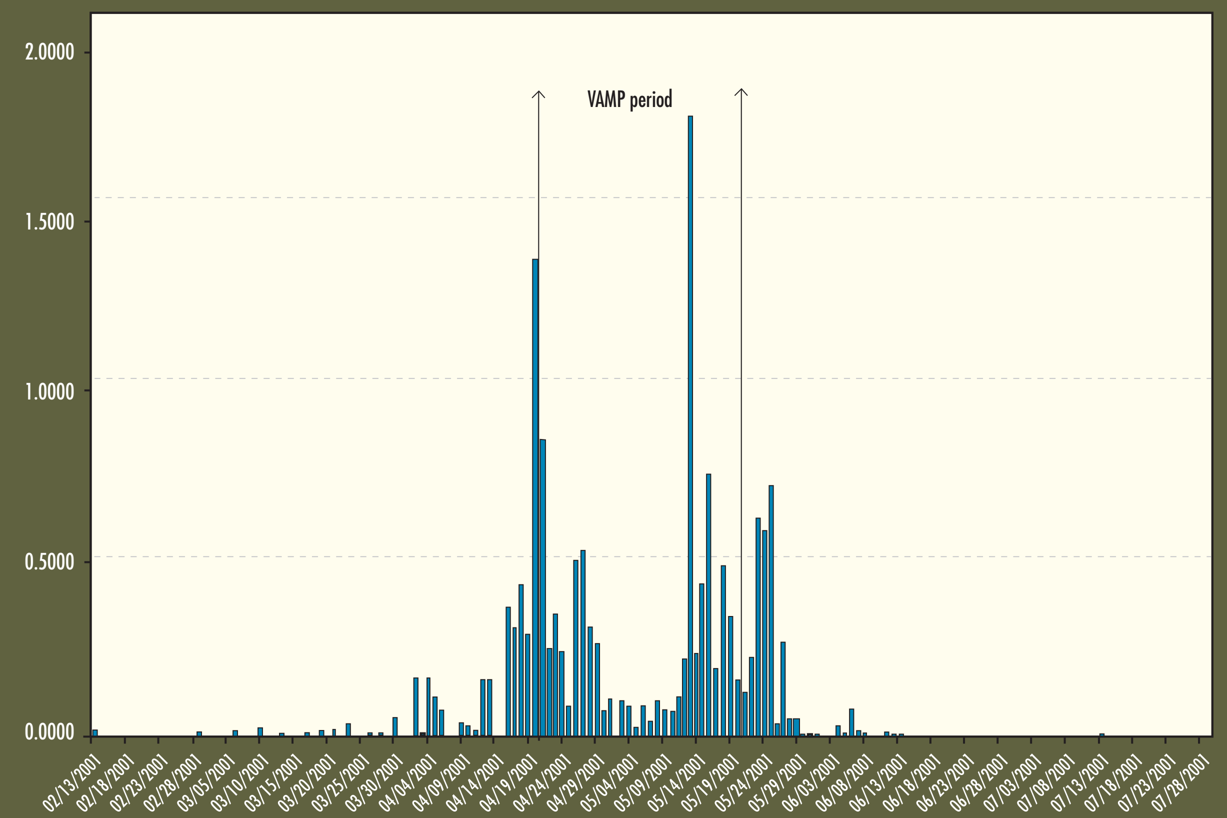


FIGURE 5-12
Average Catch/minute/day of all Non-clipped Chinook Per Day Captured in the Mossdale Kodiak Trawl Between February 13, 2001, and July 31, 2001.
Up to 20 tows per day were conducted between April 24, 2001, and May 28, 2001.



The separate roles of SWP and CVP exports and San Joaquin River flow with the HORB in place is difficult to determine at this time as a result of (1) the few survival studies completed with the HORB in place; (2) variable permeability of the barrier within and among years, and 3) the lack of measuring survival at the extremes of the VAMP flow and export targets. Releases at both Mossdale and Jersey Point have only been made in four years when the HORB was in place. Also, during those four years the barrier design and permeability has changed. In 1994, the HORB was installed without culverts, while in 1997 the barrier had two open culverts that diverted approximately 300 cfs into upper Old River. In 2000, the HORB had six gated culverts, with two open during the Mossdale and first Durham Ferry release and four open during the second Durham Ferry release. In 2001, six culverts were installed and operated throughout the VAMP test period. The varying designs and changes in the culvert operations of the barrier add variability to the limited data, making it more difficult to detect the effects of flow and exports on salmon survival.

In the four years of measuring survival with the barrier in place, average total combined CVP/SWP exports have varied between 1,500 and 2,300 cfs. This is only an 800 cfs difference in exports—a relatively small difference in export rates. No data has been generated with the barrier at exports of 3,000 cfs—the highest export level under the VAMP targets. Gathering data at a 3000 cfs export level may help us further our understanding of the relationship between exports, with the barrier in upper Old River, and juvenile salmon smolt survival. Measuring survival with flows at 7,000 cfs and 3,200 cfs would also help for the same reasons. Future studies should prioritize, to the extent possible, VAMP target levels to be tested at 3,000 cfs exports and 7,000 cfs flow, and 1,500 cfs exports with 3,200 cfs and 7,000 cfs flow. Focusing our survival experiments on these extremes within the VAMP design will enable us to better determine the role of flow and export on salmon smolt survival.

Definitive conclusions about the respective roles of flow and exports on salmon smolt survival are not possible from the VAMP data at this time. It is recommended that further evaluation of VAMP 2000 and 2001 results occur prior to determining the study plan for VAMP 2002. It is also recommended that VAMP experiments continue. Results of these future studies will provide information to make the most appropriate management decisions to protect salmon smolts emigrating from the San Joaquin River basin.

OCEAN RECOVERY INFORMATION FROM PAST YEARS

Ocean recovery data of CWT salmon groups can contribute to a more complete understanding and evaluation of salmon smolt survival studies. These data can provide another independent estimate of the ratio of survival of a test release group relative to a control release group, or "absolute survival", and can be compared with estimates based on juvenile salmon recoveries at Chipps Island and Antioch. Past recoveries at Jersey Point (1997–1999) can not be compared since the Jersey Point trawling site was located upstream of the Jersey Point release site and a ratio between the upstream and downstream sites can not be generated. The ocean harvest data may be particularly reliable due to the number of tag recoveries and the extended recovery period.

Adult recovery data are gathered from commercial and sport ocean harvest checked at various ports by DFG. The Pacific States Marine Fisheries Commission maintains the database of ocean recovery CWT data, which is current through 2000. The ocean CWT recovery data are usually recorded over a 1-4 year period after the year a study release is made as nearly all of a given year class of salmon have either been harvested or spawned by age 5. Consequently, these data are essentially complete for releases made through 1996 and partially available for CWT releases made through 1999, prior to the VAMP evaluations starting in 2000.

Survival estimates based on ocean recoveries for salmon produced at the Merced River Hatchery, and released as part of south Delta survival evaluations, were compared to survival estimates based on Chipps Island recoveries (Table 5-9). Releases were made at Dos Reis (on the San Joaquin River downstream of the upper Old River junction), Mossdale, and Jersey Point. Survival estimates are based on Mossdale or Dos Reis recovery rates relative to the Jersey Point recovery rates. Ocean absolute survival ratios were very similar to those at Chipps Island for the releases made in 1996 and 1999. And although ocean absolute survival ratios were higher than those to Chipps Island for releases in 1997 and 1998, they were generally similar (in the mid-range of survival). The ocean recovery data is incomplete for the 1997-99 releases. No data is yet available for releases made in 2000 and recovered at Chipps Island as well as Antioch. Once the data for these releases and for future releases is available it will be used to compare the three independent estimates of survival (using Antioch, Chipps Island and ocean recoveries).

Results of these comparative analysis of survival estimates for Chinook salmon produced in the Merced River Hatchery show (1) there is generally good agreement between survival estimates based on juvenile CWT salmon recoveries in Chipps Island trawling and adult recoveries from the ocean fishery, (2) survival estimates using Chipps Island recoveries were lower in some years than estimates based on ocean recoveries, and (3) additional comparisons need to be made, as data becomes available from VAMP releases, for recoveries at Antioch, Chipps Island, and the ocean fishery. Information on survival of juvenile salmon and the contribution to the adult salmon population will be valuable in evaluating the biological benefits of changes in flow and export rates under VAMP.

TABLE 5-9

Survival Estimates Based on Chipps Island and Ocean Recoveries of Merced River Hatchery Salmon Released as Part of South Delta Studies Between 1996 and 1999.

RELEASE YEAR	SAN JOAQUIN RIVER *(Merced River Origin)* TAG NO.	RELEASE NUMBER	RELEASE SITE	RELEASE DATE	CHIPPS IS. RECOVS.	EXPANDED ADULT OCEAN RECOVS. (AGE 1+ TO 4+) TOTAL	CHIPPS ISLAND	OCEAN CATCH
		Juvenile Salmon CWT Releases						
1996	H61110412	25,633	DOS REIS	01MAY96	2	3		
	H61110413	28,192	DOS REIS	01MAY96	3	37		
	H61110414	18,533	DOS REIS	01MAY96	1	8		
	H61110415	36,037	DOS REIS	01MAY96	5	10		
	H61110501	53,337	JERSEY PT	03MAY96	39	187		
	Effective Release	107,961	DOS REIS		11	58	0.14	0.15
	Effective Release	51,737	JERSEY PT		39	187		
1997	H62545	50,695	DOS REIS	29APR97	9	178		
	H62546	55,315	DOS REIS	29APR97	7	167		
	H62547	51,588	JERSEY PT	02MAY97	27	349		
	Effective Release	106,010	DOS REIS		16	345	0.29	0.48
	Effective Release	51,588	JERSEY PT		27	349		
	H62548	46,728	DOS REIS	08MAY97	5	91	0.28	0.48
	H62549	47,254	JERSEY PT	12MAY97	18	191		
1998	61110809	26,465	MOSSDALE	16APR98	25	52		
	61110810	25,264	MOSSDALE	16APR98	31	39		
	61110811	25,926	MOSSDALE	16APR98	32	56		
	61110806	26,215	DOS REIS	17APR98	33	46		
	61110807	26,366	DOS REIS	17APR98	23	35		
	61110808	24,792	DOS REIS	17APR98	34	57		
	61110812	24,598	JERSEY PT	20APR98	87	104		
	61110813	25,673	JERSEY PT	20APR98	100	90		
	Effective Release	77,655	MOSSDALE		88	147	0.30	0.49
	Effective Release	77,373	DOS REIS		90	138	0.31	0.46
	Effective Release	50,271	JERSEY PT		187	194		
1999	064606	25,005	MOSSDALE	20APR99	2	1		
	062642	24,715	MOSSDALE	19APR99	8	12		
	062643	24,725	MOSSDALE	19APR99	15	14		
	062644	25,433	MOSSDALE	19APR99	13	0		
	062645	25,014	DOS REIS	19APR99	20	9		
	062646	24,841	DOS REIS	19APR99	19	18		
	0601110815	24,927	JERSEY PT	21APR99	34	25		
	062647	24,193	JERSEY PT	21APR99	25	19		
	Effective Release	99,878	MOSSDALE		38	27	0.32	0.30
	Effective Release	49,855	DOS REIS		39	27	0.65	0.60
	Effective Release	49,120	JERSEY PT		59	44		

NOTE: Ocean recoveries are based on data through 2000

SAN JOAQUIN RIVER SALMON PROTECTION

One of the VAMP objectives is to provide improved conditions and increased survival of juvenile Chinook salmon smolts produced in the San Joaquin River tributaries during their downstream migration through the lower river and Delta. To determine if VAMP in 2001 was successful in protecting juvenile salmon emigrating from the San Joaquin River tributaries, catches of unmarked salmon at Mossdale and in salvage at the CVP and SWP facilities were reviewed prior to and during the VAMP period.

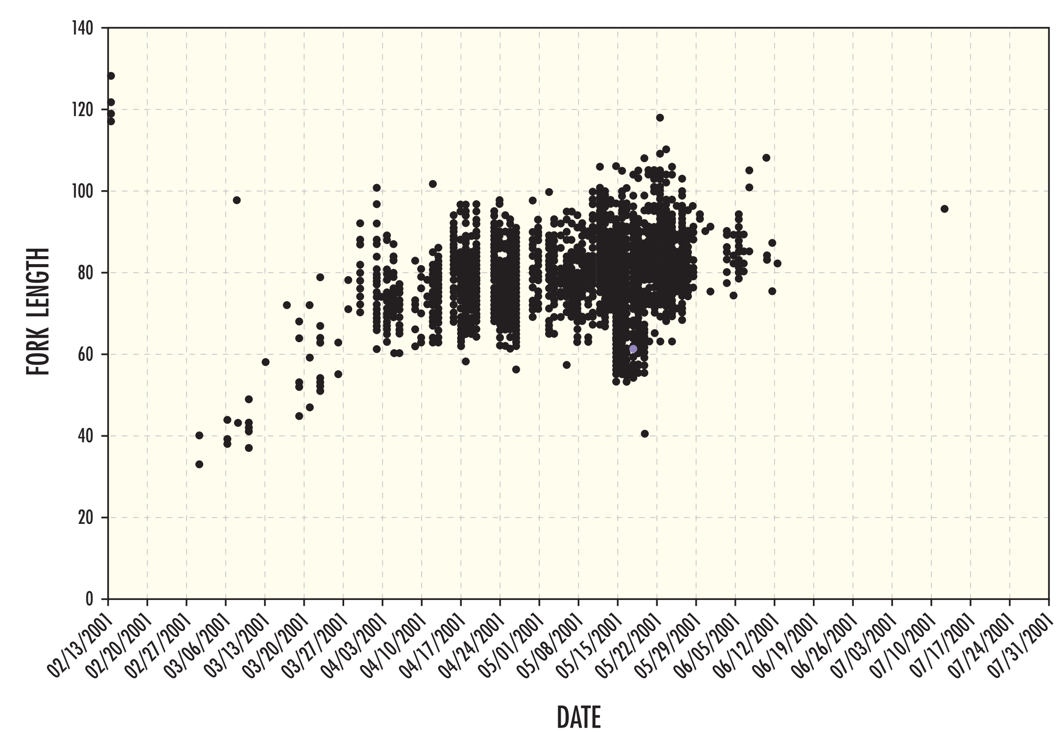
Unmarked Salmon Recovered at Mossdale

The original time period for VAMP (April 15 to May 15) was chosen based on historical data that indicated a high percentage of the juvenile salmon emigrating from the San Joaquin tributaries was passing into the Delta at Mossdale during that time period. In 2001, the VAMP period was delayed until April 20 due to permitting problems associated with installing the barrier at the HORB. Figure 5-12 shows the average catch per minute per day of unmarked juvenile salmon caught in kodiak trawling at Mossdale between February 13 and July 28, 2001. Unmarked salmon do not have an adipose clip and could be unmarked fish from the Merced River Hatchery or juveniles from natural spawning. Figure 5-12 indicates that the majority of juvenile salmon (65%) migrated past Mossdale during the VAMP period. Delaying removal of the HORB until May 26 and continuing export curtailments until early June affected an even greater percent of the population. Reducing flows while continuing the export curtailments and keeping the barrier in place for a week after the VAMP period may provide a way to stimulate movement of the juvenile salmon out of the system, while protecting these last remaining out-migrants. These additional protection measures after VAMP appear to have been beneficial to protecting a greater proportion of the population of unmarked juvenile salmon emigrating from the San Joaquin basin.

Most of the unmarked juveniles passing Mossdale during this time were between 60 and 100 mm in length, although there were a few below 60 mm observed towards the end of the VAMP period (Figure 5-13). It is also interesting to note that there were a few large juveniles (between 115 and 130 mm) migrating past Mossdale in mid-February. Although the VAMP period protects many of the juvenile salmon migrating during the time it is in place, it is also important to protect the diversity of emigration timing and life history expression in the basin.

FIGURE 5-13

Fork Lengths of all Non-clipped Chinook Per Day Captured in the Mossdale Kodiak Trawl Between February 13, 2001, and July 31, 2001.



Up to 20 tows per day were conducted between April 24, 2001, and May 28, 2001.

Salmon Salvage and Losses at Delta Export Pumps

Fish salvage operations at the Central Valley Project (CVP) and State Water Project (SWP) export facilities capture unmarked salmon for transport by tanker truck and release downstream in the western Sacramento-San Joaquin Delta. The untagged salmon are either naturally produced or are untagged hatchery salmon, 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 CWT recovery data at the facilities to provide some general indications. Data from 2000 are included here since they were not in the 2000 report and provide a comparison with the 2001 data.

Results of these analyses showed that the VAMP 2001 test period coincided with much of the peak period of salmon smolt emigration.

The salvage at the facilities is based on expansions from sub-samples taken throughout the day. Loss is estimated at approximately 4-5 salmon lost per salvaged salmon in the SWP Clifton Court Forebay based on high predation rates. The CVP pumps divert directly from the Old River channel and the loss estimates range from about 50–80% of the number salvaged, or about 6–8 times less per salvaged salmon than for the SWP. The loss estimates do not include any indirect mortality in the Delta due to water operations or additional export operations or additional mortality associated with trucking and handling. Salvage density of salmon is the number of salvaged per acre foot of water pumped.

The number 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 would influence the number and density of juvenile salmon salvaged and lost. Density may be the best indicator of when the most juvenile salmon were moving through the salvage system.

A review of the weekly salvage data around the 2001 VAMP period indicates that the highest salvage and losses occurred during the second week of the VAMP period at the SWP and in the week prior to VAMP at the CVP (Figures 5-14 and 5-15). Salmon density was highest in the first week of the VAMP period at both facilities, with the next highest density at CVP in the week before VAMP and at SWP in the second week of VAMP (Figure 5-16). This salvage, loss and density information indicates that delaying the VAMP period in 2001 may have resulted in higher impacts to juvenile salmon adversely affected by the CVP facility than would have occurred had the VAMP period started on April 15 as originally planned.

Comparable data for 2000 show a pattern of high salvage and loss at the CVP and SWP prior to the 2000 VAMP period (Figures 5-17 and 5-18). CVP density was highest prior to the VAMP period and SWP density was highest in the second week of the 2000 VAMP period (Figure 5-19). The data from 2000 also indicates that salvage numbers and densities were high at both facilities just prior to the VAMP period and initiating the VAMP earlier or extending the VAMP could have benefits by reducing the loss of juvenile salmon at the salvage facilities at this time. In 2000, the VAMP period started on April 15. Reducing exports during this earlier period of time would not only provide better conditions for juvenile salmon emigrating from the San Joaquin River basin, but from the Sacramento River basin as well. Juvenile spring-, winter-, and fall- run Chinook salmon migrate through the Delta in early April from the Sacramento River basin.

Salvaged salmon in 2001 showed a length pattern similar to 2000 during the VAMP period, although it generally appears there were more salmon less than 80 mm forklength and fewer greater than 100 mm forklength in 2001 (Figures 5-20 and 5-21).* The size distribution of unmarked salmon in the Mossdale trawl (Figure 5-13) and at the salvage facilities were similar in 2001.

Results of these analysis showed that the VAMP 2001 test period coincided with much of the peak period of salmon smolt emigration. Reductions in SWP and CVP exports and increased San Joaquin River flow provided improved conditions for salmon survival, although starting the VAMP period a week earlier may have had substantial benefits in both 2000 and 2001. Additional VAMP studies are required, however, to improve quantification of biological benefits over a broader range of environmental conditions.

** Provided by Sheila Greene, Department of Water Resources*

FIGURE 5-14
2001 SWP Salmon Salvage and Loss.

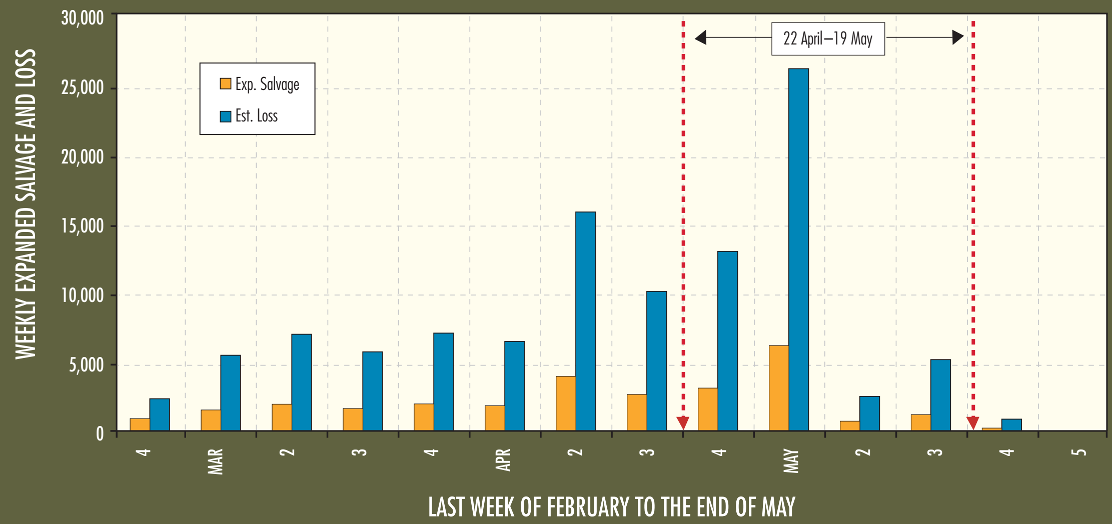


FIGURE 5-15
2001 CVP Salmon Salvage and Loss.

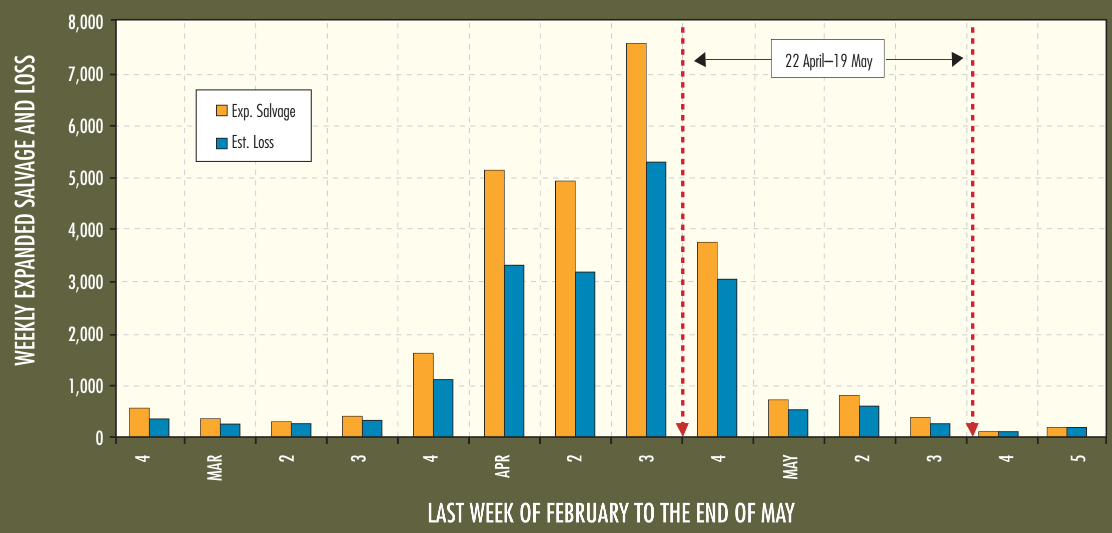


FIGURE 5-16
2001 SWP & CVP Expanded Salmon Salvage Density.

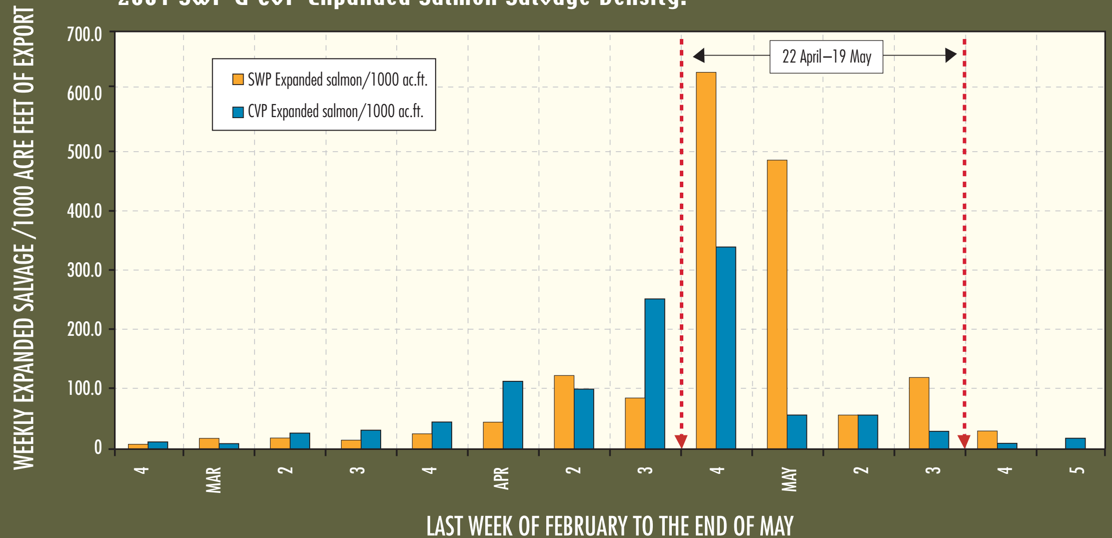


FIGURE 5-17
2000 SWP Salmon Salvage and Loss.

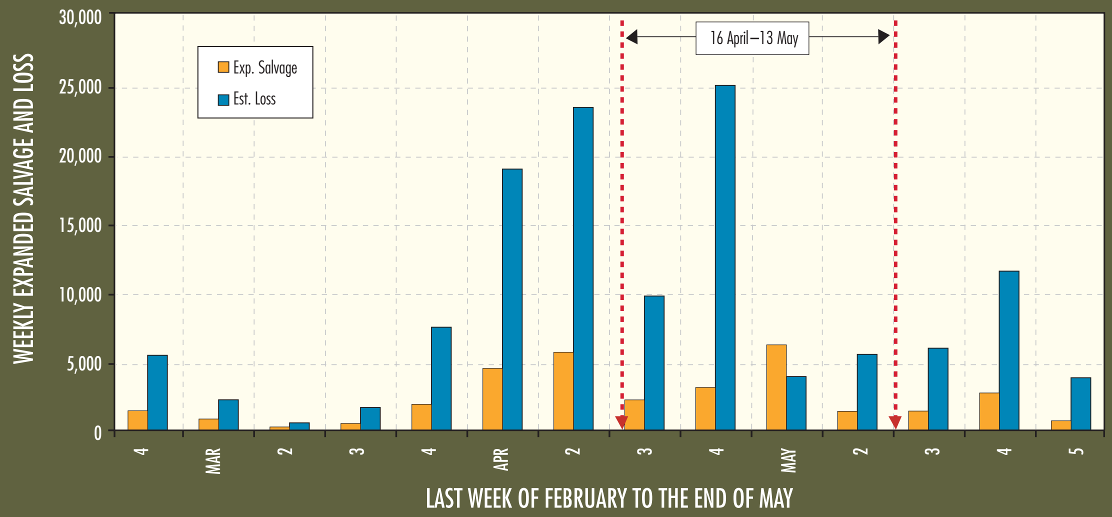


FIGURE 5-18
2000 CVP Salmon Salvage and Loss.

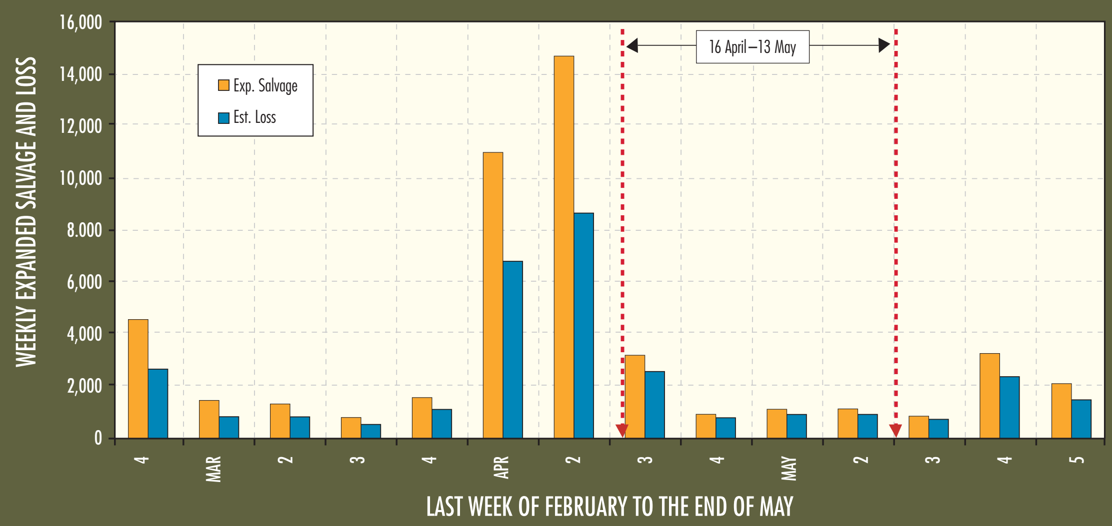


FIGURE 5-19
2000 SWP & CVP Expanded Salmon Salvage Density.

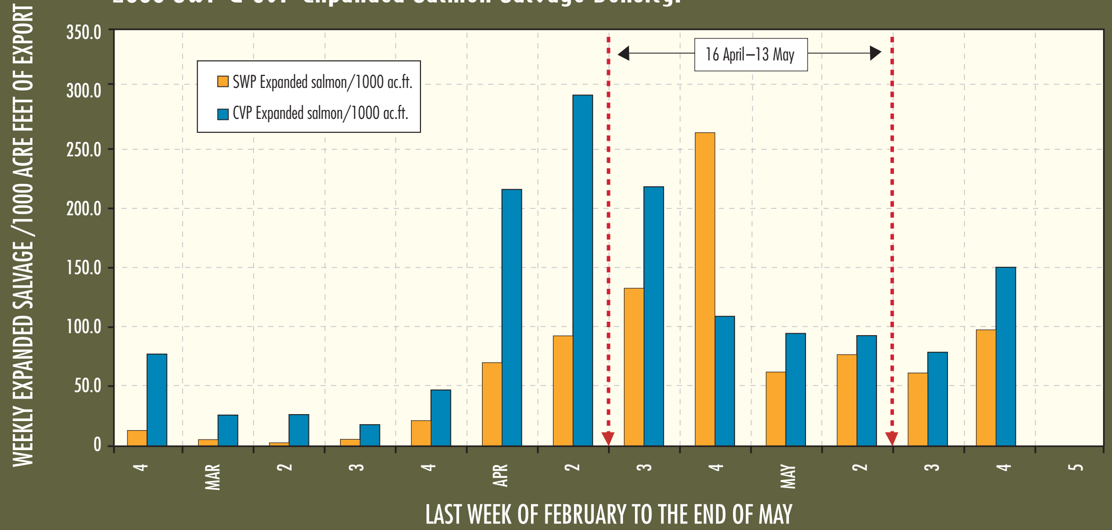


FIGURE 5-20

Salvage Salmon Size Data and Export and Flow Data for 2000–2001 From DWR.

Observed Chinook Salvage at the SWP & CVP Delta Fish Facilities 8/1/00 through 7/31/01.

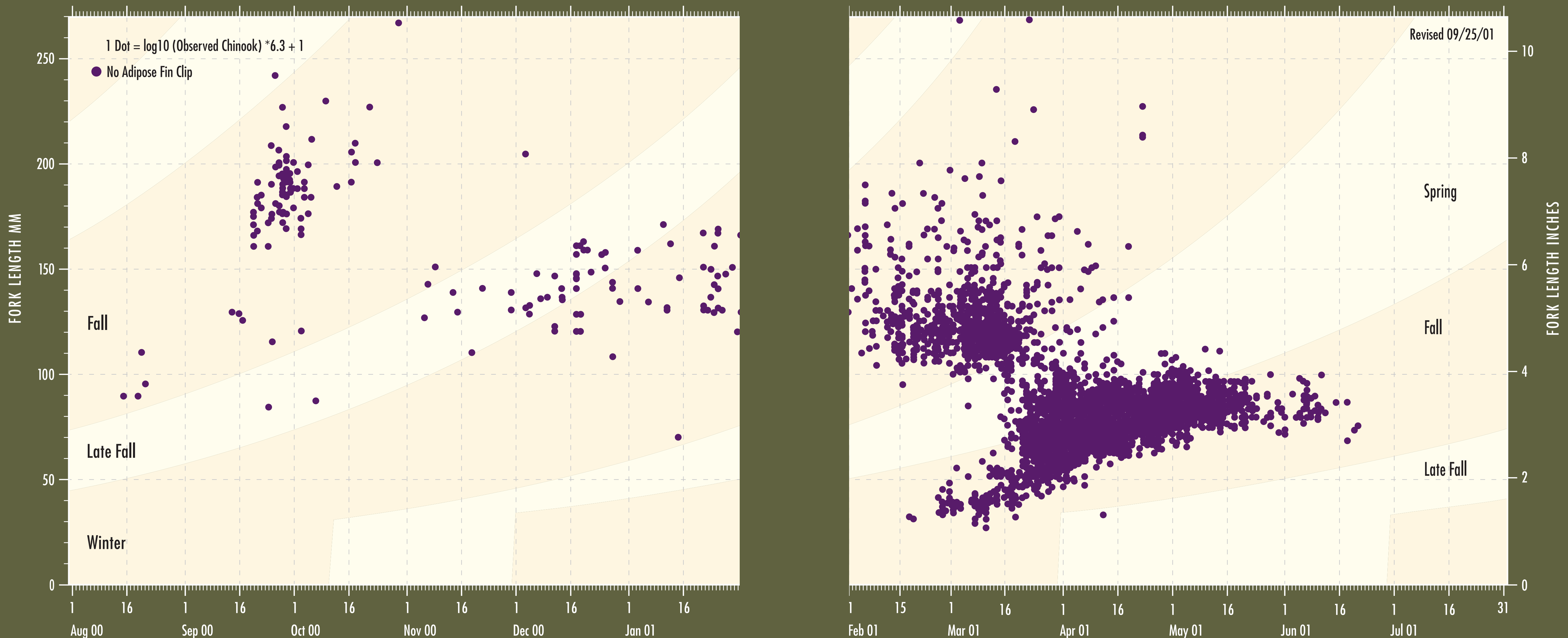
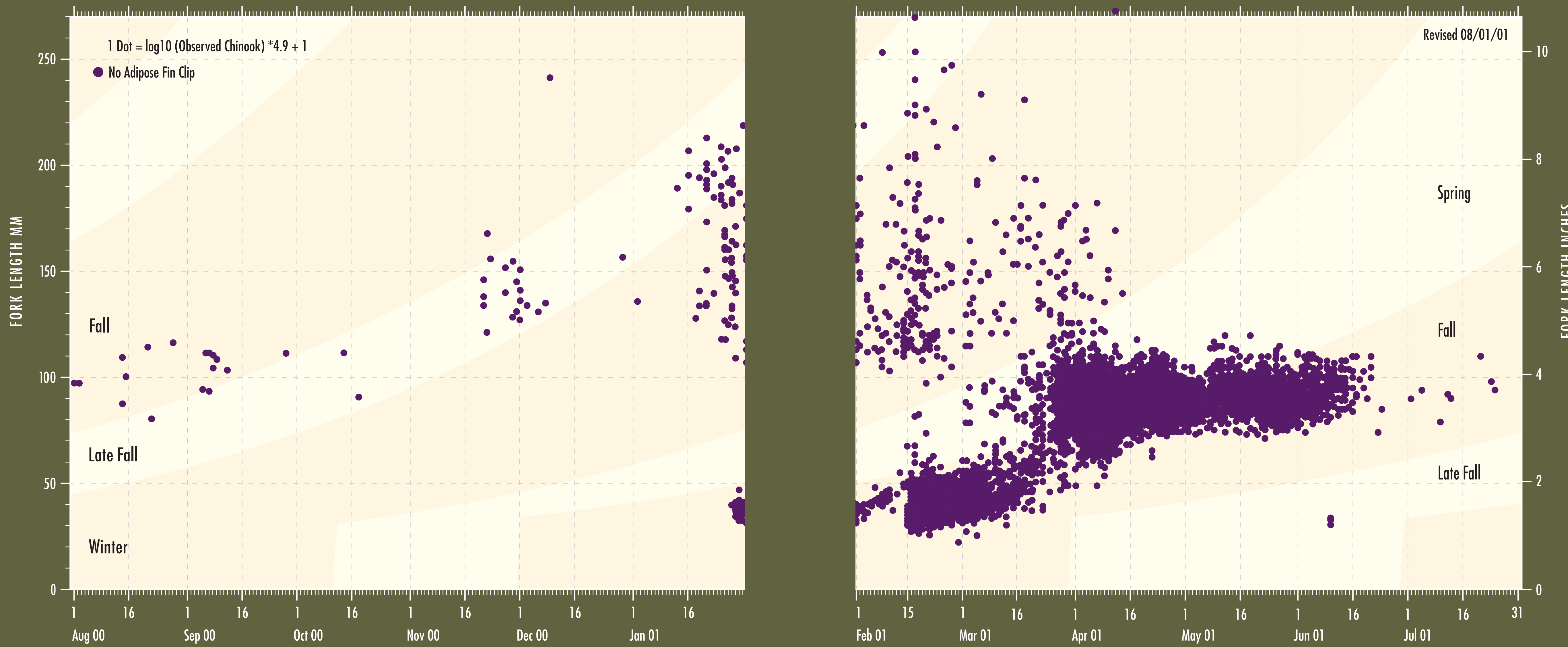


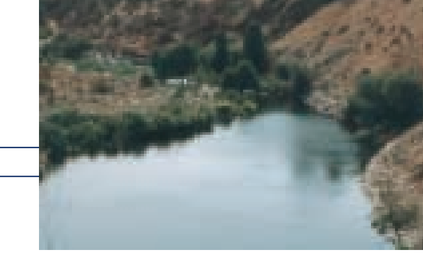
FIGURE 5-21

Salvaged Salmon Size Data and Export and Flow Data for 1999–2000 From DWR.

Observed Chinook Salvage at the SWP & CVP Delta Fish Facilities 8/1/99 through 7/31/00.



COMPLEMENTARY STUDIES RELATED TO VAMP



During the VAMP 2001 test period, several complementary scientific investigations were also conducted to provide additional information on factors affecting survival of juvenile Chinook salmon emigrating from the San Joaquin River and Delta. These complementary investigations included (1) releases of coded-wire tagged juvenile Chinook salmon within San Joaquin River tributaries, which were subsequently recaptured as part of VAMP fisheries sampling, which can be used to provide estimates of salmon smolt survival, (2) results of in-situ toxicity testing within the San Joaquin River and Old River, (3) water velocity and current measurements within the San Joaquin River at the confluence with Old River in the vicinity of the HORB, and (4) pilot studies to investigate the potential use of hydro-acoustic technology to determine the seasonal distribution and density of juvenile Chinook salmon emigrating from the San Joaquin River system. Results of these complementary studies are briefly summarized below.

SURVIVAL ESTIMATES FOR JUVENILE CHINOOK SALMON EMIGRATING FROM THE SAN JOAQUIN RIVER TRIBUTARIES

CWT salmon releases were made in the San Joaquin River tributaries between April 21 and May 13 as part of independent (complementary) fishery investigations. Releases were made in the upper Merced River (Merced River Hatchery), lower Merced River (Hatfield State Park), upper Tuolumne River (La Grange), and on the mainstem San Joaquin River downstream of the confluence with the Tuolumne River (Old Fisherman's Club). Groups of CWT salmon were also released in the upper (Knights Ferry) and lower (Two Rivers) Stanislaus River in late May. Salmon released as part of these studies were produced in the Merced River Hatchery and coded wire tagged using methods similar to those described in Chapter 5.

Coded-wire tagged juvenile salmon released within the tributaries were subsequently recaptured as part of the VAMP sampling program at Antioch and Chipps Island (see Chapter 5). Based upon information regarding the number of coded-wire tagged salmon released, and the number recaptured, estimates of survival for each group of CWT salmon released in the tributaries were calculated.

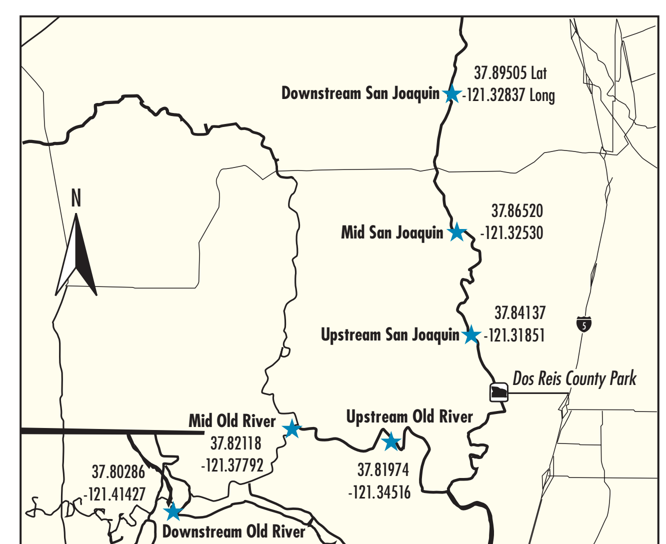
Group survival indices for salmon released in the tributaries and recovered at Antioch ranged between 0.04 and 0.30 (Appendix C-5). Since the groups released in the Stanislaus River were not released until late May, recoveries were not made at Antioch. Group survival indices ranged between 0.02 and 0.28 to Chipps Island and include the Stanislaus River releases (Appendix C-5). Comparisons of upstream groups relative to downstream groups provide a way to index survival through the tributaries (Appendix C-5). It appears that in 2001, survival through both the Merced and Tuolumne rivers was moderate and ranged between 17 and 52 percent. Estimates using recoveries from Antioch and Chipps Island were generally similar. No recoveries were made at Chipps Island from the Stanislaus River releases, even though two shifts of daily sampling continued through June 2 and one shift continued until June 15 (with the exception of June 10 when no sampling occurred). It is unclear from this result whether survival through the Stanislaus River and/or survival through the Delta was low for smolts released in the Stanislaus River. Releases in the Stanislaus were made later in the season than the rest of the releases, which could have adversely affected their survival through both the tributary and Delta.

Information on the transit time between release of CWT groups in the San Joaquin River mainstem and tributaries and recovery at Antioch and Chipps Island is summarized in Appendix C-6. As observed for VAMP releases, recovery times were generally similar between Antioch and Chipps Island for the various groups released upstream in the mainstem San Joaquin River and tributaries.

EVALUATION OF CHINOOK SALMON SMOLT SURVIVAL IN OLD RIVER: BIOLOGICAL RESPONSES TO TOXICANTS

Results of previous salmon smolt survival studies have shown that the survival of fall-run Chinook salmon smolts is generally higher in the San Joaquin River as compared to Old River during their migration to Chipps Island in the western Delta. While it is known that a variety of toxicants are widespread in the Delta, their role in the decreased survival of salmon smolts passing down Old River as compared to the San Joaquin River is unknown. The objective of this complementary investigation is to determine if toxicants play a role in the decreased survival of Chinook salmon smolts that emigrate through Old River. Specific goals of this study were to (1) determine if there are biological effects (DNA strand breaks, acetylcholinesterase activity, stress protein expression, and cytochrome P450 expression) that correspond to chemical exposure in salmon smolts caged in Old River versus the San Joaquin River and (2) test the hypothesis that biomarker responses in salmon smolts vary temporally and spatially in this river system.

FIGURE 6-1
Salmon Caging Sites in the Old and San Joaquin Rivers.



Numbers located by caging sites indicate latitude (Lat) and longitude (Long) positions.

In-situ field studies were scheduled to occur before and after the VAMP test period and during April–May when hydraulic and water quality conditions in south Delta channels vary as a result of VAMP. As described earlier, the VAMP program includes (1) construction of the HORB, (2) augmentation of the San Joaquin River flows by releasing water from reservoirs on upstream tributaries and (3) a reduction in SWP and CVP export rates. In addition to augmented San Joaquin River flows, these actions cause a reduction in Old River flow rates and water turnover. Thus, during the VAMP period of modified flows, toxicants from agricultural runoff or other sources are more concentrated in Old River than before or after and higher concentrations of toxicants in Old River are more likely to affect the survival of outmigrant salmon smolts than in the San Joaquin River. Before the VAMP period, 60% or more of the daily average flow of the San Joaquin River goes down Old River so that differences in toxicity and survival of salmon smolts between rivers should be minimal. After the VAMP period, opening of the Cross Channel gates (combined with a return to higher export rates) causes Sacramento River water to dominate the channels of Old River. As a result, water quality is likely to be less harmful in Old River than in the San Joaquin River, where reservoir releases and total flows decline and the contribution of agricultural return flows in the San Joaquin Valley dominate.

During each of three flow regimes (pre-VAMP, VAMP and post-VAMP) salmon smolts were delivered from the Merced River Hatchery to Dos Reis county park. Fish (n=12 per site) were transported to field sites, and caged at three sites in Old River (OR) and three sites in the San Joaquin River (SJR) for four days (Figure 6-1). Fish and fish cages were obtained, placed, monitored, and retrieved by USFWS personnel. After the four-day exposure, fish were removed from the cages and dissected. During each flow regime, composite water samples were collected for metals analysis (Desert Research Institute, Reno, NV) and pesticides including organophosphates and pyrethroids (USGS, Sacramento, CA). During the VAMP period (not pre- or post-VAMP), non-composite water samples were collected for analysis of organics (PCB, PAHs, and organochlorines, Severn Trent Laboratory, Sacramento, CA), analysis of dissolved and total copper (Desert Research Institute), and mercury analysis (Higashi Laboratory, UC Davis).

FIGURE 6-2

Temperature in the San Joaquin River and Old River on Days in Which Fish Were Caged and Retrieved From Cages.

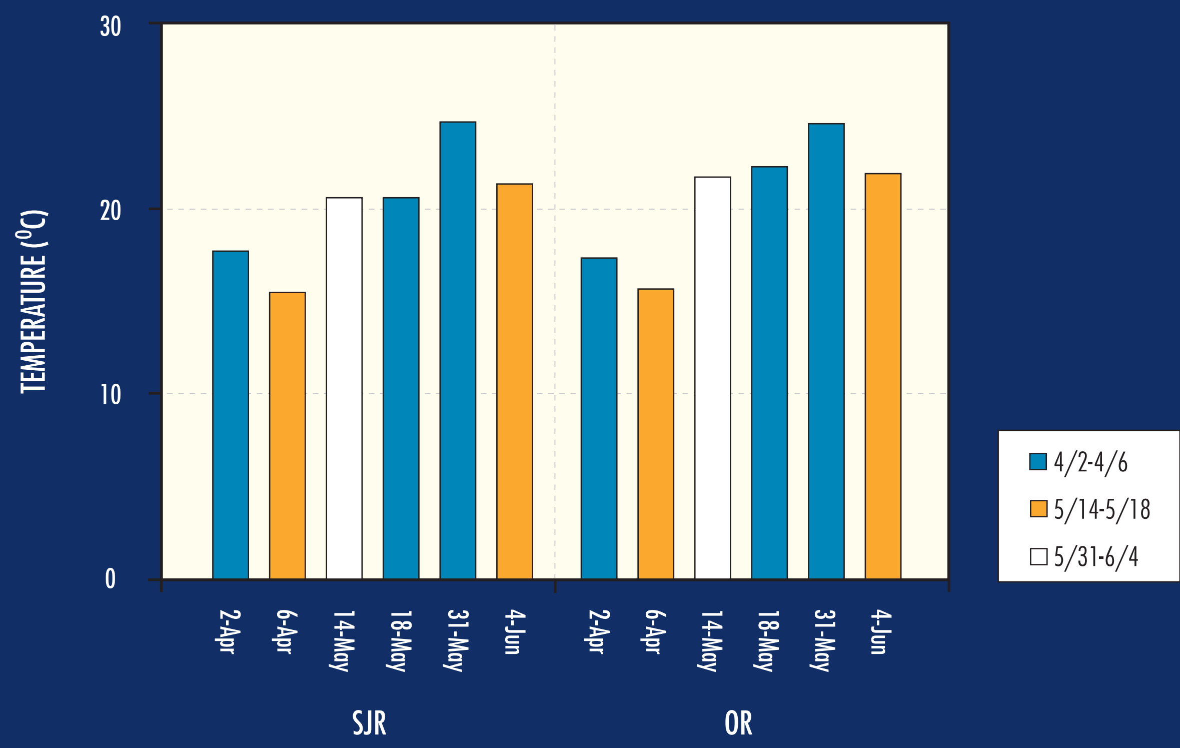
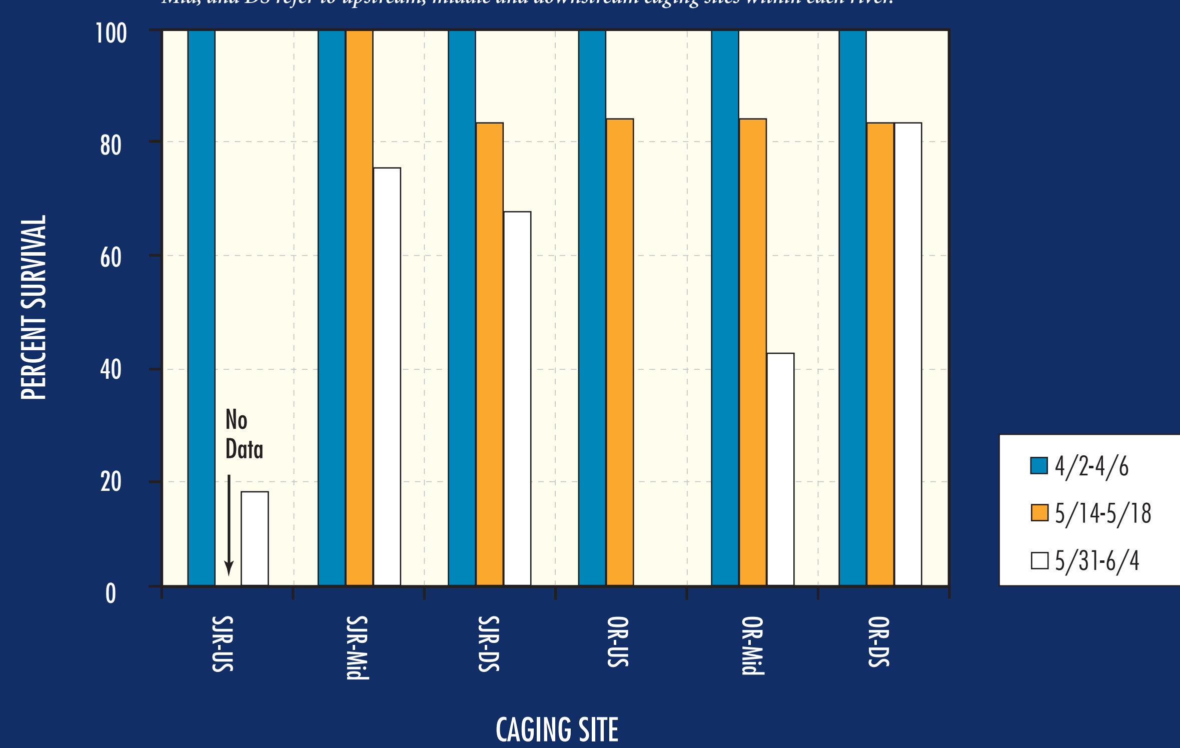


FIGURE 6-3

Percent Survival of Chinook Salmon Smolts in Net Pens During Pre-VAMP (4/2–4/6), VAMP 5/14–5/18), Post-VAMP (5/31–6/4) Flow Regimes in the San Joaquin and Old Rivers.

Mid, and DS refer to upstream, middle and downstream caging sites within each river.



During the pre-VAMP test period, water temperatures on April 2–6 were 15–17°C at all test sites (Figure 6-2). Because completion of the HORB was delayed, the VAMP test period was delayed to May 14–18, at which time water temperatures had reached at least 20°C at all test sites. During the post-VAMP period, temperatures were extremely high the day we placed our cages in both the San Joaquin and Old River sites; water temperatures reached as high as 24°C in both rivers. By the time we retrieved the fish (6/4/01), temperatures had dropped to about 21°C in both rivers (Figure 6-2).

Survival of salmon smolts in the net pens was 100% at all sites during pre-VAMP (4/2–4/6) and varied from 83% (San Joaquin River downstream, Old River all sites) to 100% (San Joaquin River middle site) during the VAMP period (5/14–5/18) as shown in Figure 6-3. During the post-VAMP test period, survival in net pens was 0% at the Old River upstream site, 42% at Old River middle site, 83% at the Old River downstream site, 17% at the San Joaquin River upstream site, 75% at the San Joaquin River middle site, and 67% at the San Joaquin River downstream site.

Analysis of the biological responses of juvenile salmon are currently underway and include acetylcholinesterase activity (Wilson Lab, UC Davis), DNA strand breaks (Anderson Lab, Bodega Marine Laboratory), cytochrome P450 expression (Snyder Lab, Bodega Marine Laboratory), and stress protein expression (Werner Lab, UD Davis). A portion of the controls for background DNA damage in Chinook salmon smolts have been completed (n=9 hatchery controls and n=8 transport controls from the post-VAMP flow regime). Hatchery and transport controls demonstrate 50% and 43% DNA damage levels, respectively, and there was no significant difference in mean DNA damage between treatments.

Analysis of water samples for pesticides is currently underway in the laboratory of Kathy Kuivila (USGS). Data from the analysis of PAHs, PCBs, and organochlorines has been received and shows non-detectable concentrations at all sites during the VAMP period at 1 ppb detection limits (Severn Trent Laboratory). The general metals analysis in water samples from both the San Joaquin River and Old River sites have been completed for all three flow regimes (Desert Research Institute). During the pre-VAMP period, Al levels were approximately 300 ppb at all sites in the SJR and OR. During the VAMP, all levels increased in the SJR sites to 900 or 1000 ppb (but not OR sites) and returned to pre-VAMP levels during the post-VAMP period. A similar trend was observed with Mn and Ni during all three time periods. Mn levels were approximately 100 ppb at all sites in both rivers and increased to 200 ppb in all SJR sites and the OR downstream site during VAMP. Ni levels were approximately 4 ppb or not detected prior to VAMP but increased at all SJR sites and at the OR downstream site to about 8 ppb during VAMP. Cu levels were about 2 ppb in all OR sites but increased to about 6 ppb in all SJR and the OR middle site during the VAMP. Additional metals were analyzed in water samples but did not fluctuate substantially during the three flow regimes or between the two rivers and include the following: Sb (<1 ppb), As (4-10 ppb), Ba (50-70 ppb), Be (<1 ppb), Cd (<1-4 ppb), Cr (1-3 ppb), Co (<1 ppb), Pb (<1 ppb), Mo (3-8 ppb), Se (<20 ppb), Ag (<1 ppb), Tl (<1 ppb), Th (<1 ppb), U (7-10 ppb), V (4-7 ppb), and Zn (4-10 ppb).

HYDRAULIC INVESTIGATIONS ASSOCIATED WITH THE OLD RIVER BARRIER

As part of the VAMP 2001 test program, field measurements were made within the San Joaquin River at the confluence with Old River to evaluate hydraulic characteristics associated with operation of the HORB. Acoustic Doppler current meters and other field measurements were made to determine current patterns and water velocities. Hydraulic measurements were made over a variety of tidal conditions to assess the effects of changes in tidal hydrodynamics and water surface elevation on current patterns and velocities. Information from these field measurements is currently being compiled and analyzed and will be used in designing subsequent complementary field investigations to provide additional information useful in evaluating the role of the HORB on hydraulic conditions within the lower San Joaquin River, and potential effects on salmon smolt survival. One of the concerns that has been identified through field measurements and observations relates to eddies and hydraulic turbulence immediately adjacent to the confluence between the lower San Joaquin River and Old River, related to HORB operations, that may affect the behavioral response and emigration patterns for juvenile Chinook salmon. Turbulence and eddies in the area may also affect the vulnerability of juvenile Chinook salmon to predation mortality. Results of the VAMP 2001 hydraulic measurements will be used to help refine the design and measurement of hydraulic conditions during VAMP 2002, and will also be used to evaluate the affects of various culvert operational strategies as they relate to hydraulic conditions within the San Joaquin River.

HYDRO-ACOUSTIC MONITORING OF JUVENILE CHINOOK SALMON EMIGRATION

A pilot study was designed and conducted as a complementary investigation during the VAMP 2001 test period to evaluate the potential application of hydro-acoustic technologies for monitoring the seasonal patterns in juvenile Chinook salmon movement and salmon densities within the lower San Joaquin River. Currently fisheries monitoring is conducted using conventional trawling methods, (e.g., Kodiak trawl, mid-water trawl) which requires extensive field effort and the capture and handling of juvenile Chinook salmon and other fish species. Development of an alternative fishery monitoring technique, such as hydro-acoustic technologies which have been used for fishery monitoring elsewhere, would offer the potential benefits of reduced monitoring costs, monitoring juvenile salmonid emigration continuously throughout an extended seasonal period, providing continuous monitoring during both day and nighttime conditions, and avoids concerns regarding the capture and handling of protected fish species including both steelhead and Sacramento splittail. Hydro-acoustic technologies, however, do not provide information on the species of fish detected and have not been demonstrated to provide reliable and quantitative information on juvenile salmonid emigration from the lower San Joaquin River. Results of the pilot scale hydro-acoustic studies conducted complementary to VAMP 2001 will be analyzed and evaluated. Results of these evaluations will be used, in part, to help design further field testing and validation of the application of alternative monitoring techniques such as hydro-acoustic technologies as part of the overall VAMP investigations. Results of the pilot scale study conducted during VAMP 2001 will be used to help evaluate and design additional field testing of the technology, if the VAMP 2001 results appear promising, as part of VAMP 2002.

STATISTICAL ANALYSIS OF VAMP DATA

The U.S. Fish and Wildlife Service has contracted to have Dr. Ken Newman conduct various statistical analysis on VAMP salmon smolt survival data. During 2001, Dr. Newman evaluated several aspects of the VAMP data as briefly discussed below.

During his first evaluation, Dr. Newman used CWT salmon recoveries, at Antioch and Chipps Island, of releases made at Durham Ferry, Mossdale and Jersey Point in 2000 to estimate survival between Durham Ferry and Mossdale and between Mossdale and Jersey Point (Newman, Ken,. Pers. com. (a)). He also estimated the standard errors associated with the estimates of survival. The number of recoveries at Antioch and Chipps Island were modeled as trinomial random variables. Implicit in this modeling is the assumption that the three releases have the same survival probabilities over identical reaches of the river and the same capture probabilities. Maximum likelihood estimates for survival in each reach and variances were calculated. The standard errors were the square roots of the estimated variances.

Survival was estimated to be 0.329 between Mossdale and Jersey Point in 2000. Standard errors ranged between 0.031 and 0.054, respectively. Survival (and standard error) between Durham Ferry and Mossdale was estimated at 0.73 (0.145). These estimates compare to survival estimates using the ratio of survival indices of the Mossdale group to the Jersey Point group of 0.33 and 0.31 for the Antioch and Chipps Island recoveries respectively. These two independent methods seem complementary since estimates are very similar using both methods. The maximum likelihood estimates are more informative since they provide standard errors and a way to assess if differences between survival estimates are significant.

It was concluded that maintaining a uniform recovery effort at any given recovery site is crucial to minimizing the bias in estimating survival. Variation in capture probabilities between recovery locations, however, is not a problem. Increasing capture probability lowers the standard error of estimates of survival. Capture probability can be increased by increasing the number of salmon released or increasing the recapture effort. Use of replicate tag codes is valuable for detecting over dispersion, which is a violation of the assumptions underlying the trinomial distribution used for parameter estimation.

In his second evaluation, Dr. Newman conducted a power analysis to determine the probability of detecting flow and export effects on juvenile Chinook salmon survival in the VAMP experiments (Newman, Ken,. Pers. com. (b)). Using 1997, 1998, and 2000 CWT recovery data at Chipps Island, the survival in each year between Mossdale and Jersey Point was estimated. (The 1999 data was not used as it appeared to be an "outlier".) These estimates were used to fit a logistic regression model of survival to flow at Vernalis, export pumping and the presence or absence of the HORB. This analysis also simulated the effect of changing the number of fish released and the recapture rates at Antioch and Chipps Island to detect statistically significant differences in survival for the different VAMP export and flow targets experiments. The probability of detecting a significant difference between targets was greater as release numbers and capture probability increased. The probability of detecting significant differences is greater when the underlying differences are greater between the two different flow and export combinations.

Table 6-1 shows the probabilities that an observed difference in survival for two flow and export combinations would be significantly different at the 0.05 level. It is clear that significant differences are more likely when flow and export target extremes are compared.

This model was then used to compare estimates of survival observed in 2001 to those predicted by the model. The model estimated survival between Mossdale and Jersey Point to be 0.47 for the first group and 0.57 for the second group of releases. This compared to observed estimates of 0.16 and 0.20 (Table 5-6). It appears, from these comparisons, that the model is not tracking the observed data well. The increase from the first group to the second group seems consistent between the model and the data.

Further statistical and power analysis of the available salmon smolt survival data are planned to help in the design of the VAMP 2002 experiments.

TABLE 6-1

Probability That an Observed Difference in Survival for two Flow and Export Combinations is Found Significantly Different at the 0.05 Level.

The probability is labeled Pr, where R is the number released per group, and p equals the capture probability.

					p=0.001			p=0.002		
COMBINATION 1		COMBINATION 2			R=50K	R=100K	R=150K	R=50K	R=100K	R=150K
Flow	Exp	Flow	Exp	Diff.	Pr	Pr	Pr	Pr	Pr	Pr
3,200	1,500	4,500	1,500	0.372	0.846	0.993	1.000	0.988	1.000	1.000
3,200	1,500	5,700	2,250	0.018	0.058	0.048	0.056	0.059	0.078	0.072
3,200	1,500	7,000	1,500	0.666	0.994	1.000	1.000	1.000	1.000	1.000
3,200	1,500	7,000	3,000	0.125	0.389	0.669	0.834	0.627	0.928	0.983
4,500	1,500	5,700	2,250	-0.354	0.797	0.982	0.819	0.984	1.000	1.000
4,500	1,500	7,000	1,500	0.294	0.390	0.649	0.997	0.659	0.898	0.987
4,500	1,500	7,000	3,000	-0.497	0.996	1.000	1.000	1.000	1.000	1.000
5,700	2,250	7,000	1,500	0.649	0.992	1.000	1.000	1.000	1.000	1.000
5,700	2,250	7,000	3,000	-0.143	0.501	0.781	0.906	0.740	0.968	0.995
7,000	1,500	7,000	3,000	-0.791	1.000	1.000	1.000	1.000	1.000	1.000

CONCLUSIONS & RECOMMENDATIONS

The VAMP experimental investigation of juvenile Chinook salmon survival was implemented during spring 2001. The Vernalis target flow was 4,450 cfs, with SWP and CVP export flow of 1,500 cfs. The HORB was successfully installed and maintained throughout the VAMP test period. Estimates of juvenile Chinook salmon smolt survival were calculated based upon releases of CWT juvenile salmon produced in the Merced River Hatchery and released at Durham Ferry, Mossdale, and Jersey Point. Marked salmon were subsequently recaptured in sampling at the HORB, SWP and CVP export facility salvage, and through intensive fisheries sampling at Antioch and Chipps Island. Based upon the data and experience gained during the VAMP 2001 investigations, conclusions and recommendations have been developed, as summarized in Table 7-1. The conclusions and recommendations include both technical and policy/management issues that will affect the design and implementation of VAMP 2002 operations and investigations.

TABLE 7-1
Summary of VAMP 2001 Conclusions and Recommendations

CONCLUSIONS	RECOMMENDATIONS
The quality of the real-time flow data at Vernalis was improved by weekly measurements.	Continue weekly measurements. Investigate alternative flow measurement methods and/or locations.
Estimation of ungauged flow (accretions, depletions) at Vernalis should be improved.	Continue hydrology investigation to improve predictions.
Coordination with upstream tributary operations was successful.	Continue coordination among tributary operators.
Design of the HORB was improved, however debris accumulation on trash screens was a problem.	Modify trash screen design to facilitate trash removal and provide routine maintenance.
Operation of the HORB was successful in maintaining south Delta water levels.	Continue to refine operational criteria for culverts.
Permitting delayed HORB installation.	Secure all permits early and schedule construction to avoid delay in installation.
Hydraulic measurements of flow through HORB culverts need to be taken.	Take flow measurements within each culvert.
HORB has limited impacts on seepage.	Continue monitoring.
Sampling using fyke nets was successful in collecting entrained fish at the culverts.	Continue monitoring culverts using fyke nets to document entrainment.
Experimental design for barrier evaluation did not support consistent quantitative hypothesis testing.	Re-design experimental design of barrier investigations.
CWT retention rate was relatively low.	Investigate CWT quality control to improve retention rates.
Problem with logistics of release at Durham Ferry.	Modify release procedures.
Water temperatures were elevated during the second set of releases and may have adversely affected survival.	Avoid seasonal delays in barrier installation and survival testing.
Results of net pen studies showed evidence of disease and reduced condition of test fish.	Continue net pen studies and fish health inspections.
Results showed substantially lower survival for the second set of releases at all locations compared to the first release. Disease and temperature stress were identified as factors potentially affecting survival.	Do not delay releases otherwise high temperatures may affect results. Second set of CWT survival indices are not comparable to the first set of indices.
Differences in survival between Durham Ferry and Mossdale were not found to be statistically significant.	Continue statistical analysis of survival data. Continue to evaluate need for releases at both Durham Ferry and Mossdale.
Differences in survival from Durham Ferry in 2001 were not significantly different from 2000.	Conduct survival testing at VAMP flow and export extremes.
Flow in the lower San Joaquin River downstream of upper Old River appears to be more relevant than Vernalis flow because of flow through the HORB culverts.	Measure the flow in the San Joaquin River downstream of upper Old River.
Hydrologic conditions during 2001 were close to the threshold separating two alternative flow targets.	If hydrologic conditions are close to a decision threshold, select target flow representing a new VAMP test condition rather than repeating a previously tested flow/export case.
Complementary studies to evaluate mechanisms affecting survival were conducted.	Encourage an expansion of complementary studies to provide additional information on factors and mechanisms affecting salmon survival.
Relatively few CWT salmon from VAMP releases were recovered at the SWP and CVP salvage facilities.	Continue salvage monitoring to document direct losses.
Conclusions are not yet possible on the respective roles of San Joaquin River flow and SWP/CVP exports on juvenile Chinook salmon smolt survival.	Continue VAMP test program.

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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

OAKDALE IRRIGATION DISTRICT*

SOUTH SAN JOAQUIN IRRIGATION DISTRICT*

MODESTO IRRIGATION DISTRICT*

TURLOCK IRRIGATION DISTRICT*

MERCED IRRIGATION DISTRICT*

SAN JOAQUIN RIVER EXCHANGE CONTRACTORS WATER AUTHORITY*

- San Luis Canal Company
- Firebaugh Canal Water District
- Central California Irrigation District
- Columbia Canal Company

FRIANT WATER USERS AUTHORITY*

25 agencies including:

- Delano-Earlimart Irrigation District
- Lower Tule River Irrigation District
- South San Joaquin Municipal Utility District
- Madera Irrigation District

METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

NATURAL HERITAGE INSTITUTE

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*San Joaquin River Group Authority Members

APPENDIX A

Hydrology and Operation Plans 73
Daily Operation Plans 74
Accounting of Supplemental Water Contributions 94
Comparison of "Real-time" and Provisional Flows 95

APPENDIX B

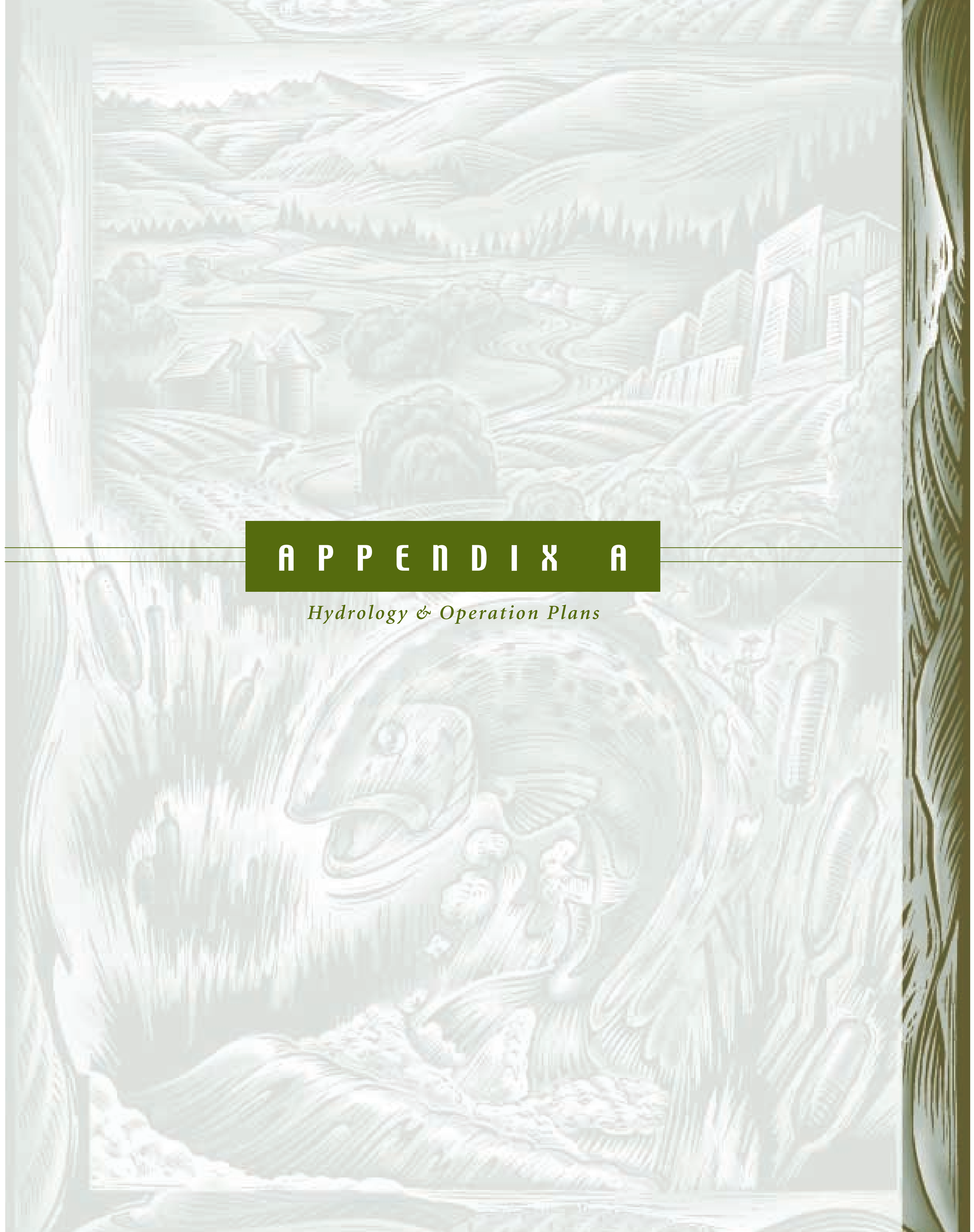
Fall Water Transfer and Delivery Information 97
Merced I.D. Fall 2001 Water Transfer Schedules 98
Preliminary Merced I.D. Fall 2001 Water Transfer Summary 102
Final Merced I.D. Fall 2000 Water Transfer Summary 103
Oakdale I.D. Fall 2001 Additional Water Release 106

APPENDIX C

Chinook Salmon Survival Investigations 107
C-1 Water Temperature Monitoring Locations 108
C-2 Water Temperature Monitoring Data 110
C-3 Net Pen Sampling Results 114
C-4 Coded Wire Tag Recovery Information 116
C-5 Coded Wire Tag Release Data 121
C-6 Coded Wire Tag Recovery Data 122

APPENDIX D

Errata 124
Errata for the San Joaquin River Group Authority
Year 2000 Annual Technical Report on Implementation
and Monitoring of the San Joaquin River Agreement and
the Vernalis Adaptive Management Plan 125



APPENDIX A

Hydrology & Operation Plans

DAILY OPERATION PLAN, MARCH 14

Pulse Period: April 15–May 15 • Flow Target: 4,450cfs

Ungaged Flow at Vernalis = 700cfs

	San Joaquin River near Vernalis						Merced River at Cressey			Exchange Contractors	Tuolumne River at LaGrange				Stan. R blw Goodwin	
	Existing Flow	VAMP Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	VAMP Suppl. Flow	VAMP Flow (3-day lag)	VAMP Suppl. Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	Maintain Priority Flow Level M=Merced T=Tuol.
	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	
	[calc]	[calc]	[calc]	[calc]					[calc]					[calc]		
Apr 01					456	700	250		250			175		175	1,500	
Apr 02					452	700	250		250			175		175	1,500	
Apr 03					448	700	250		250			175		175	1,500	
Apr 04	3,077			3,077	444	700	250		250			175		175	1,500	
Apr 05	3,073			3,073	440	700	250		250			175		175	1,500	
Apr 06	3,069			3,069	436	700	250		250			175		175	1,500	
Apr 07	3,065			3,065	432	700	250		250			175		175	1,500	
Apr 08	3,061			3,061	428	700	250		250			175		175	1,500	
Apr 09	3,057			3,057	424	700	250		250			175		175	1,500	
Apr 10	3,053			3,053	420	700	250		250			175		175	1,500	
Apr 11	3,049	0		3,049	416	700	250	0	250			175		175	1,500	
Apr 12	3,045	0		3,045	412	700	250	300	550	0		175		175	1,500	M
Apr 13	3,041	0		3,041	408	700	250	300	550	0	725	725	300	1,025	1,500	M
Apr 14	3,037	0	0	3,037	404	700	250	250	500	0	1,200	1,200	100	1,300	1,500	M
Apr 15	3,583	600	1.19	4,183	400	700	250	250	500	0	1,400	1,400	0	1,400	1,500	M
Apr 16	4,054	400	1.98	4,454	396	700	250	250	500	0	1,400	1,400	0	1,400	1,500	M
Apr 17	4,250	250	2.48	4,500	392	700	250	250	500	0	1,400	1,400	0	1,400	1,500	M
Apr 18	4,246	250	2.98	4,496	388	700	250	250	500	0	1,400	1,400	0	1,400	1,500	M
Apr 19	4,242	250	3.47	4,492	384	700	250	830	1,080	0	1,400	1,400	0	1,400	1,500	
Apr 20	4,238	250	3.97	4,488	380	700	250	900	1,150	0	700	720	80	800	1,500	
Apr 21	4,234	250	4.46	4,484	376	700	250	900	1,150	0	400	400	320	720	1,500	
Apr 22	3,550	910	6.27	4,460	372	700	250	900	1,150	0	400	400	320	720	1,500	
Apr 23	3,226	1,220	8.69	4,446	368	700	250	900	1,150	0	400	400	320	720	1,500	
Apr 24	3,222	1,220	11.11	4,442	364	700	250	400	650	0	400	400	320	720	1,500	
Apr 25	3,218	1,220	13.53	4,438	360	700	250	50	300	0	1,000	1,000	250	1,250	1,500	T
Apr 26	3,214	1,220	15.95	4,434	356	700	250	50	300	0	1,600	1,600	0	1,600	1,500	T
Apr 27	3,810	650	17.24	4,460	352	700	250	50	300	0	1,600	1,600	0	1,600	1,500	T
Apr 28	4,406	50	17.34	4,456	348	700	250	60	310	0	1,600	1,600	0	1,600	1,500	T
Apr 29	4,402	50	17.43	4,452	344	700	250	60	310	0	1,600	1,600	0	1,600	1,500	T
Apr 30	4,398	50	17.53	4,448	340	700	250	60	310	0	1,600	1,600	0	1,600	1,500	T
May 01	4,394	60	17.65	4,454	336	700	250	70	320	0	1,600	1,600	0	1,600	1,500	T
May 02	4,390	60	17.77	4,450	332	700	250	70	320	0	1,600	1,600	0	1,600	1,500	T
May 03	4,386	60	17.89	4,446	328	700	250	300	550	0	1,600	1,600	0	1,600	1,500	T
May 04	4,382	70	18.03	4,452	324	700	250	700	950	0	1,600	1,400	0	1,400	1,500	M
May 05	4,378	70	18.17	4,448	320	700	250	700	950	0	1,375	1,000	0	1,000	1,500	M
May 06	4,174	300	18.76	4,474	316	700	250	700	950	0	950	1,000	0	1,000	1,500	M
May 07	3,770	700	20.15	4,470	312	700	250	700	950	0	950	1,000	0	1,000	1,500	M
May 08	3,766	700	21.54	4,466	308	700	250	700	950	0	950	1,000	0	1,000	1,500	M
May 09	3,762	700	22.93	4,462	304	700	250	700	950	0	950	1,000	0	1,000	1,500	M
May 10	3,758	700	24.32	4,458	300	700	250	700	950	0	950	1,000	0	1,000	1,500	M
May 11	3,754	700	25.71	4,454	296	700	250	600	850	0	950	1,000	0	1,000	1,500	M
May 12	3,750	700	27.09	4,450	292	700	250	500	750	0	950	1,000	100	1,100	1,500	
May 13	3,746	700	28.48	4,446	288	700	250	0	250		950	1,050	150	1,200	1,500	
May 14	3,742	700	29.87	4,442	284	700	250	0	250		950	1,000		1,000	1,500	
May 15	3,788	650	31.16	4,438	280	700	250		250		950	1,000		1,000	1,500	
May 16	3,734	0		3,734	276	700	250		250			175		175	1,500	
May 17	3,730	0		3,730	272	700	250		250			175		175	1,500	
May 18	2,901	0		2,901	268	700	250		250			175		175	1,500	
May 19	2,897	0		2,897	264	700	250		250			175		175	1,500	
May 20	2,893	0		2,893	260	700	250		250			175		175	1,500	
May 21	2,889	0		2,889	256	700	250		250			175		175	1,500	
May 22	2,885	0		2,885	252	700	250		250			175		175	1,500	
May 23	2,881	0		2,881	248	700	250		250			175		175	1,500	
May 24	2,877	0		2,877	244	700	250		250			175		175	1,500	
May 25	2,873	0		2,873	240	700	250		250			175		175	1,500	
May 26	2,869	0		2,869	236	700	250		250			175		175	1,500	
May 27	2,865	0		2,865	232	700	250		250			175		175	1,500	
May 28	2,861	0		2,861	228	700	250		250			175		175	1,500	
May 29	2,857	0		2,857	224	700	250		250			175		175	1,500	
May 30	2,853	0		2,853	220	700	250		250			175		175	1,500	
May 31	2,849	0		2,849	216	700	250		250			175		175	1,500	
								VAMP period								
Mean (cfs):	3,943	507		4,450	348	700		434	684	0		1,145	73	1,218		
Suppl. Water (TAF)																
Provided		31.16						26.68		0.00			4.48			
Target		31.17						26.68		0.00			4.49			

Pulse flow period

Period of desired flow stability

DAILY OPERATION PLAN, MARCH 14

Pulse Period: April 15–May 15 • Flow Target: 4,450cfs

Ungaged Flow at Vernalis = 1,000cfs

San Joaquin River near Vernalis						Merced River at Cressey			Exchange Contractors	Tuolumne River at LaGrange				Stan. R blw Goodwin		
Existing Flow	VAMP Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	VAMP Suppl. Flow	VAMP Flow (3-day lag)	VAMP Suppl. Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	Maintain Priority Flow Level M=Merced T=Tuol.	
(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		
[calc]	[calc]	[calc]	[calc]					[calc]					[calc]			
				456	1,000	250		250			175		175	1,500		Apr 01
				452	1,000	250		250			175		175	1,500		Apr 02
				448	1,000	250		250			175		175	1,500		Apr 03
3,377			3,377	444	1,000	250		250			175		175	1,500		Apr 04
3,373			3,373	440	1,000	250		250			175		175	1,500		Apr 05
3,369			3,369	436	1,000	250		250			175		175	1,500		Apr 06
3,365			3,365	432	1,000	250		250			175		175	1,500		Apr 07
3,361			3,361	428	1,000	250		250			175		175	1,500		Apr 08
3,357			3,357	424	1,000	250		250			175		175	1,500		Apr 09
3,353			3,353	420	1,000	250		250			175		175	1,500		Apr 10
3,349	0		3,349	416	1,000	250	0	250			175		175	1,500		Apr 11
3,345	0		3,345	412	1,000	250	0	250	0		175		175	1,500	M	Apr 12
3,341	0		3,341	408	1,000	250	0	250	0	725	1,025	0	1,025	1,500	M	Apr 13
3,337	0	0	3,337	404	1,000	250	0	250	0	1,200	1,200	0	1,200	1,500	M	Apr 14
4,183	0	0.00	4,183	400	1,000	250	0	250	0	1,400	1,350	0	1,350	1,500	M	Apr 15
4,354	0	0.00	4,354	396	1,000	250	0	250	0	1,400	1,350	0	1,350	1,500	M	Apr 16
4,500	0	0.00	4,500	392	1,000	250	0	250	0	1,400	1,350	0	1,350	1,500	M	Apr 17
4,496	0	0.00	4,496	388	1,000	250	0	250	0	1,400	1,350	0	1,350	1,500	M	Apr 18
4,492	0	0.00	4,492	384	1,000	250	500	750	0	1,400	1,350	0	1,350	1,500		Apr 19
4,488	0	0.00	4,488	380	1,000	250	500	750	0	700	850	0	850	1,500		Apr 20
4,484	0	0.00	4,484	376	1,000	250	500	750	0	400	850	0	850	1,500		Apr 21
3,980	500	0.99	4,480	372	1,000	250	500	750	0	400	850	0	850	1,500		Apr 22
3,976	500	1.98	4,476	368	1,000	250	500	750	0	400	850	0	850	1,500		Apr 23
3,972	500	2.98	4,472	364	1,000	250	200	450	0	400	850	0	850	1,500		Apr 24
3,968	500	3.97	4,468	360	1,000	250	0	250	0	1,000	1,100	0	1,100	1,500	T	Apr 25
3,964	500	4.96	4,464	356	1,000	250	0	250	0	1,600	1,400	0	1,400	1,500	T	Apr 26
4,210	200	5.36	4,410	352	1,000	250	0	250	0	1,600	1,400	0	1,400	1,500	T	Apr 27
4,506	0	5.36	4,506	348	1,000	250	0	250	0	1,600	1,400	0	1,400	1,500	T	Apr 28
4,502	0	5.36	4,502	344	1,000	250	0	250	0	1,600	1,400	0	1,400	1,500	T	Apr 29
4,498	0	5.36	4,498	340	1,000	250	0	250	0	1,600	1,400	0	1,400	1,500	T	Apr 30
4,494	0	5.36	4,494	336	1,000	250	0	250	0	1,600	1,400	0	1,400	1,500	T	May 01
4,490	0	5.36	4,490	332	1,000	250	0	250	0	1,600	1,400	0	1,400	1,500	T	May 02
4,486	0	5.36	4,486	328	1,000	250	0	250	0	1,600	1,400	0	1,400	1,500	T	May 03
4,482	0	5.36	4,482	324	1,000	250	300	550	0	1,600	1,400	0	1,400	1,500	M	May 04
4,478	0	5.36	4,478	320	1,000	250	450	700	0	1,375	1,075	0	1,075	1,500	M	May 05
4,474	0	5.36	4,474	316	1,000	250	450	700	0	950	950	0	950	1,500	M	May 06
4,145	300	5.95	4,445	312	1,000	250	450	700	0	950	950	0	950	1,500	M	May 07
4,016	450	6.84	4,466	308	1,000	250	450	700	0	950	950	0	950	1,500	M	May 08
4,012	450	7.74	4,462	304	1,000	250	450	700	0	950	950	0	950	1,500	M	May 09
4,008	450	8.63	4,458	300	1,000	250	450	700	0	950	950	0	950	1,500	M	May 10
4,004	450	9.52	4,454	296	1,000	250	450	700	0	950	950	0	950	1,500	M	May 11
4,000	450	10.41	4,450	292	1,000	250	160	410	0	950	950	0	950	1,500		May 12
3,996	450	11.31	4,446	288	1,000	250	0	250		950	950	0	950	1,500		May 13
3,992	450	12.20	4,442	284	1,000	250	0	250		950	950		950	1,500		May 14
3,988	160	12.52	4,148	280	1,000	250		250		950	950		950	1,500		May 15
3,984	0		3,984	276	1,000	250		250			175		175	1,500		May 16
3,980	0		3,980	272	1,000	250		250			175		175	1,500		May 17
3,201	0		3,201	268	1,000	250		250			175		175	1,500		May 18
3,197	0		3,197	264	1,000	250		250			175		175	1,500		May 19
3,193	0		3,193	260	1,000	250		250			175		175	1,500		May 20
3,189	0		3,189	256	1,000	250		250			175		175	1,500		May 21
3,185	0		3,185	252	1,000	250		250			175		175	1,500		May 22
3,181	0		3,181	248	1,000	250		250			175		175	1,500		May 23
3,177	0		3,177	244	1,000	250		250			175		175	1,500		May 24
3,173	0		3,173	240	1,000	250		250			175		175	1,500		May 25
3,169	0		3,169	236	1,000	250		250			175		175	1,500		May 26
3,165	0		3,165	232	1,000	250		250			175		175	1,500		May 27
3,161	0		3,161	228	1,000	250		250			175		175	1,500		May 28
3,157	0		3,157	224	1,000	250		250			175		175	1,500		May 29
3,153	0		3,153	220	1,000	250		250			175		175	1,500		May 30
3,149	0		3,149	216	1,000	250		250			175		175	1,500		May 31
							VAMP period									
4,246	204		4,450	348	1,000		204	454	0		1,148	0	1,148			Mean (cfs):
																Suppl. Water (TAF)
	12.52						12.52		0.00			0.00				Provided
	12.52						12.52		0.00			0.00				Target

Pulse flow period

Period of desired flow stability

DAILY OPERATION PLAN, MARCH 20

Pulse Period: April 15–May 15 • Flow Target: 3,200cfs

Ungaged Flow at Vernalis = 700cfs

	San Joaquin River near Vernalis						Merced River at Cressey			Exchange Contractors	Tuolumne River at LaGrange				Stanislaus R blw Goodwin			
	Existing Flow	VAMP Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	VAMP Suppl. Flow	VAMP Flow (3-day lag)	VAMP Suppl. Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol.
	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	
	[calc]	[calc]	[calc]	[calc]					[calc]					[calc]			[calc]	
Apr 01					456	700	250		250			300		300	704		704	
Apr 02					452	700	250		250			300		300	704		704	
Apr 03					448	700	250		250			300		300	704		704	
Apr 04	2,406			2,406	444	700	250		250			300		300	704		704	
Apr 05	2,402			2,402	440	700	250		250			300		300	704		704	
Apr 06	2,398			2,398	436	700	250		250			300		300	704		704	
Apr 07	2,394			2,394	432	700	250		250			300		300	704		704	
Apr 08	2,390			2,390	428	700	250		250			300		300	704		704	
Apr 09	2,386			2,386	424	700	250		250			300		300	704		704	
Apr 10	2,382			2,382	420	700	250		250			300		300	704		704	
Apr 11	2,378	0		2,378	416	700	250	0	250			300		300	704		704	
Apr 12	2,374	0		2,374	412	700	250	450	700	0		300		300	704		704	M
Apr 13	2,370	0		2,370	408	700	250	530	780	0	510	540	0	540	704	0	704	M
Apr 14	2,366	0	0	2,366	404	700	250	530	780	0	510	540	0	540	704	0	704	M
Apr 15	2,602	450	0.89	3,052	400	700	250	530	780	0	510	540	0	540	780	0	780	M
Apr 16	2,598	530	1.94	3,128	396	700	250	530	780	0	510	540	0	540	780	0	780	M
Apr 17	2,670	530	3.00	3,200	392	700	250	530	780	0	510	540	0	540	780	0	780	M
Apr 18	2,666	530	4.05	3,196	388	700	250	530	780	0	510	540	0	540	780	0	780	M
Apr 19	2,662	530	5.10	3,192	384	700	250	530	780	0	510	540	0	540	780	0	780	
Apr 20	2,658	530	6.15	3,188	380	700	250	530	780	0	510	540	0	540	780	0	780	
Apr 21	2,654	530	7.20	3,184	376	700	250	310	560	0	510	540	0	540	780	0	780	
Apr 22	2,650	530	8.25	3,180	372	700	250	0	250	0	775	790	0	790	780	0	780	
Apr 23	2,646	530	9.30	3,176	368	700	250	0	250	0	1,260	1,200	0	1,200	780	0	780	
Apr 24	2,892	310	9.92	3,202	364	700	250	0	250	0	1,260	1,200	0	1,200	780	0	780	
Apr 25	3,298	0	9.92	3,298	360	700	250	0	250	0	1,260	1,200	0	1,200	780	0	780	T
Apr 26	3,294	0	9.92	3,294	356	700	250	0	250	0	1,260	1,200	0	1,200	780	0	780	T
Apr 27	3,290	0	9.92	3,290	352	700	250	0	250	0	1,260	1,200	0	1,200	780	0	780	T
Apr 28	3,286	0	9.92	3,286	348	700	250	0	250	0	1,260	1,200	0	1,200	780	0	780	T
Apr 29	3,282	0	9.92	3,282	344	700	250	0	250	0	1,260	1,200	0	1,200	780	0	780	T
Apr 30	3,278	0	9.92	3,278	340	700	250	0	250	0	1,260	1,200	0	1,200	780	0	780	T
May 01	3,274	0	9.92	3,274	336	700	250	0	250	0	1,260	1,200	0	1,200	758	0	758	T
May 02	3,270	0	9.92	3,270	332	700	250	370	620	0	1,260	1,200	0	1,200	758	0	758	T
May 03	3,244	0	9.92	3,244	328	700	250	600	850	0	775	790	0	790	758	0	758	T
May 04	3,240	0	9.92	3,240	324	700	250	620	870	0	510	540	0	540	758	0	758	M
May 05	2,826	370	10.65	3,196	320	700	250	620	870	0	510	540	0	540	758	0	758	M
May 06	2,572	600	11.84	3,172	316	700	250	620	870	0	510	540	0	540	758	0	758	M
May 07	2,568	620	13.07	3,188	312	700	250	620	870	0	510	540	0	540	758	0	758	M
May 08	2,564	620	14.30	3,184	308	700	250	620	870	0	510	540	0	540	758	0	758	M
May 09	2,560	620	15.53	3,180	304	700	250	620	870	0	510	540	0	540	758	0	758	M
May 10	2,556	620	16.76	3,176	300	700	250	620	870	0	510	540	0	540	758	0	758	M
May 11	2,552	620	17.99	3,172	296	700	250	620	870	0	510	540	0	540	758	0	758	M
May 12	2,548	620	19.22	3,168	292	700	250	450	700	0	510	540	0	540	758	0	758	
May 13	2,544	620	20.45	3,164	288	700	250	0	250		510	540	0	540	758	0	758	
May 14	2,540	620	21.68	3,160	284	700	250	0	250		345	345		345	758		758	
May 15	2,536	450	22.57	2,986	280	700	250		250			175		175	758		758	
May 16	2,337	0		2,337	276	700	250		250			175		175	694		694	
May 17	2,163	0		2,163	272	700	250		250			175		175	694		694	
May 18	2,095	0		2,095	268	700	250		250			175		175	694		694	
May 19	2,091	0		2,091	264	700	250		250			175		175	694		694	
May 20	2,087	0		2,087	260	700	250		250			175		175	694		694	
May 21	2,083	0		2,083	256	700	250		250			175		175	694		694	
May 22	2,079	0		2,079	252	700	250		250			175		175	694		694	
May 23	2,075	0		2,075	248	700	250		250			175		175	694		694	
May 24	2,071	0		2,071	244	700	250		250			175		175	694		694	
May 25	2,067	0		2,067	240	700	250		250			175		175	694		694	
May 26	2,063	0		2,063	236	700	250		250			175		175	694		694	
May 27	2,059	0		2,059	232	700	250		250			175		175	694		694	
May 28	2,055	0		2,055	228	700	250		250			175		175	694		694	
May 29	2,051	0		2,051	224	700	250		250			175		175	694		694	
May 30	2,047	0		2,047	220	700	250		250			175		175	694		694	
May 31	2,043	0		2,043	216	700	250		250			175		175	694		694	
									VAMP period									
Mean (cfs):	2,833	367		3,200	348	700		367	617	0		769	0	769		0	766	
Suppl. Water (TAF)																		
Provided		22.57						22.57		0.00			0.00			0.00		
Target		22.57						22.57		0.00			0.00			0.00		

Pulse flow period

Period of desired flow stability

DAILY OPERATION PLAN, MARCH 20

Pulse Period: April 15–May 15 • Flow Target: 3,200cfs

Ungaged Flow at Vernalis = 1,000cfs

San Joaquin River near Vernalis						Merced River at Cressey			Exchange Contractors	Tuolumne River at LaGrange				Stanislaus R blw Goodwin				
Existing Flow	VAMP Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	VAMP Suppl. Flow	VAMP Flow (3-day lag)	VAMP Suppl. Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol.	
(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		
[calc]	[calc]	[calc]	[calc]					[calc]					[calc]			[calc]		
				456	1,000	250		250			300		300	704		704		Apr 01
				452	1,000	250		250			300		300	704		704		Apr 02
				448	1,000	250		250			300		300	704		704		Apr 03
2,706			2,706	444	1,000	250		250			300		300	704		704		Apr 04
2,702			2,702	440	1,000	250		250			300		300	704		704		Apr 05
2,698			2,698	436	1,000	250		250			300		300	704		704		Apr 06
2,694			2,694	432	1,000	250		250			300		300	704		704		Apr 07
2,690			2,690	428	1,000	250		250			300		300	704		704		Apr 08
2,686			2,686	424	1,000	250		250			300		300	704		704		Apr 09
2,682			2,682	420	1,000	250		250			300		300	704		704		Apr 10
2,678	0		2,678	416	1,000	250	0	250			300		300	704		704		Apr 11
2,674	0		2,674	412	1,000	250	55	305	0		300		300	704		704	M	Apr 12
2,670	0		2,670	408	1,000	250	55	305	0	510	720	0	720	704	0	704	M	Apr 13
2,666	0	0	2,666	404	1,000	250	55	305	0	510	720	0	720	704	0	704	M	Apr 14
3,082	55	0.11	3,137	400	1,000	250	55	305	0	510	720	0	720	780	0	780	M	Apr 15
3,078	55	0.22	3,133	396	1,000	250	55	305	0	510	720	0	720	780	0	780	M	Apr 16
3,150	55	0.33	3,205	392	1,000	250	55	305	0	510	720	0	720	780	0	780	M	Apr 17
3,146	55	0.44	3,201	388	1,000	250	55	305	0	510	720	0	720	780	0	780	M	Apr 18
3,142	55	0.55	3,197	384	1,000	250	50	300	0	510	720	0	720	780	0	780		Apr 19
3,138	55	0.65	3,193	380	1,000	250	50	300	0	510	720	0	720	780	0	780		Apr 20
3,134	55	0.76	3,189	376	1,000	250	0	250	0	510	720	0	720	780	0	780		Apr 21
3,130	50	0.86	3,180	372	1,000	250	0	250	0	775	800	0	800	780	0	780		Apr 22
3,126	50	0.96	3,176	368	1,000	250	0	250	0	1,260	860	0	860	780	0	780		Apr 23
3,202	0	0.96	3,202	364	1,000	250	0	250	0	1,260	860	0	860	780	0	780		Apr 24
3,258	0	0.96	3,258	360	1,000	250	0	250	0	1,260	860	0	860	780	0	780	T	Apr 25
3,254	0	0.96	3,254	356	1,000	250	0	250	0	1,260	860	0	860	780	0	780	T	Apr 26
3,250	0	0.96	3,250	352	1,000	250	0	250	0	1,260	860	0	860	780	0	780	T	Apr 27
3,246	0	0.96	3,246	348	1,000	250	0	250	0	1,260	860	0	860	780	0	780	T	Apr 28
3,242	0	0.96	3,242	344	1,000	250	0	250	0	1,260	860	0	860	780	0	780	T	Apr 29
3,238	0	0.96	3,238	340	1,000	250	0	250	0	1,260	860	0	860	780	0	780	T	Apr 30
3,234	0	0.96	3,234	336	1,000	250	0	250	0	1,260	860	0	860	758	0	758	T	May 01
3,230	0	0.96	3,230	332	1,000	250	0	250	0	1,260	860	0	860	758	0	758	T	May 02
3,204	0	0.96	3,204	328	1,000	250	160	410	0	775	860	0	860	758	0	758	T	May 03
3,200	0	0.96	3,200	324	1,000	250	160	410	0	510	710	0	710	758	0	758	M	May 04
3,196	0	0.96	3,196	320	1,000	250	160	410	0	510	710	0	710	758	0	758	M	May 05
3,042	160	1.28	3,202	316	1,000	250	160	410	0	510	710	0	710	758	0	758	M	May 06
3,038	160	1.60	3,198	312	1,000	250	160	410	0	510	710	0	710	758	0	758	M	May 07
3,034	160	1.91	3,194	308	1,000	250	160	410	0	510	710	0	710	758	0	758	M	May 08
3,030	160	2.23	3,190	304	1,000	250	160	410	0	510	710	0	710	758	0	758	M	May 09
3,026	160	2.55	3,186	300	1,000	250	160	410	0	510	710	0	710	758	0	758	M	May 10
3,022	160	2.87	3,182	296	1,000	250	160	410	0	510	710	0	710	758	0	758	M	May 11
3,018	160	3.18	3,178	292	1,000	250	160	410	0	510	710	0	710	758	0	758		May 12
3,014	160	3.50	3,174	288	1,000	250	0	250		510	710	0	710	758	0	758		May 13
3,010	160	3.82	3,170	284	1,000	250	0	250		345	345		345	758		758		May 14
3,006	160	4.14	3,166	280	1,000	250		250			175		175	758		758		May 15
2,637	0		2,637	276	1,000	250		250			175		175	694		694		May 16
2,463	0		2,463	272	1,000	250		250			175		175	694		694		May 17
2,395	0		2,395	268	1,000	250		250			175		175	694		694		May 18
2,391	0		2,391	264	1,000	250		250			175		175	694		694		May 19
2,387	0		2,387	260	1,000	250		250			175		175	694		694		May 20
2,383	0		2,383	256	1,000	250		250			175		175	694		694		May 21
2,379	0		2,379	252	1,000	250		250			175		175	694		694		May 22
2,375	0		2,375	248	1,000	250		250			175		175	694		694		May 23
2,371	0		2,371	244	1,000	250		250			175		175	694		694		May 24
2,367	0		2,367	240	1,000	250		250			175		175	694		694		May 25
2,363	0		2,363	236	1,000	250		250			175		175	694		694		May 26
2,359	0		2,359	232	1,000	250		250			175		175	694		694		May 27
2,355	0		2,355	228	1,000	250		250			175		175	694		694		May 28
2,351	0		2,351	224	1,000	250		250			175		175	694		694		May 29
2,347	0		2,347	220	1,000	250		250			175		175	694		694		May 30
2,343	0		2,343	216	1,000	250		250			175		175	694		694		May 31
								VAMP period										
3,133	67		3,200	348	1,000		67	317	0		769	0	769		0	766		Mean (cfs):
																		Suppl. Water (TAF)
	4.14						4.14		0.00			0.00			0.00			Provided
	4.13						4.13		0.00			0.00			0.00			Target

Pulse flow period

Period of desired flow stability

DAILY OPERATION PLAN, MARCH 23

Pulse Period: April 15–May 15 • Flow Target: 3,200cfs

Ungaged Flow at Vernalis = 500cfs

	San Joaquin River near Vernalis						Merced River at Cressey			Exchange Contractors	Tuolumne River at LaGrange				Stanislaus R blw Goodwin			
	Existing Flow	VAMP Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	VAMP Suppl. Flow	VAMP Flow (3-day lag)	VAMP Suppl. Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol.
	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	
	[calc]	[calc]	[calc]	[calc]					[calc]					[calc]			[calc]	
Apr 01					456	500	250		250			300		300	704		704	
Apr 02					452	500	250		250			300		300	704		704	
Apr 03					448	500	250		250			300		300	704		704	
Apr 04	2,206			2,206	444	500	250		250			300		300	704		704	
Apr 05	2,202			2,202	440	500	250		250			300		300	704		704	
Apr 06	2,198			2,198	436	500	250		250			300		300	704		704	
Apr 07	2,194			2,194	432	500	250		250			300		300	704		704	
Apr 08	2,190			2,190	428	500	250		250			300		300	704		704	
Apr 09	2,186			2,186	424	500	250		250			300		300	704		704	
Apr 10	2,182			2,182	420	500	250		250			300		300	704		704	
Apr 11	2,178	0		2,178	416	500	250	0	250			300		300	704		704	
Apr 12	2,174	0		2,174	412	500	250	600	850	0		300		300	704		704	M
Apr 13	2,170	0		2,170	408	500	250	600	850	0	510	510	0	510	704	230	934	M
Apr 14	2,166	0	0	2,166	404	500	250	580	830	0	510	510	0	510	704	230	934	M
Apr 15	2,372	830	1.65	3,202	400	500	250	580	830	0	510	510	0	510	780	200	980	M
Apr 16	2,368	830	3.29	3,198	396	500	250	580	830	0	510	510	0	510	780	200	980	M
Apr 17	2,440	780	4.84	3,220	392	500	250	580	830	0	510	510	0	510	780	200	980	M
Apr 18	2,436	780	6.39	3,216	388	500	250	580	830	0	510	510	0	510	780	200	980	M
Apr 19	2,432	780	7.93	3,212	384	500	250	580	830	0	510	510	0	510	780	200	980	
Apr 20	2,428	780	9.48	3,208	380	500	250	580	830	0	510	510	0	510	780	200	980	
Apr 21	2,424	780	11.03	3,204	376	500	250	320	570	0	510	510	0	510	780	200	980	
Apr 22	2,420	780	12.58	3,200	372	500	250	0	250	0	775	775	0	775	780	200	980	
Apr 23	2,416	780	14.12	3,196	368	500	250	0	250	0	1,260	1,260	0	1,260	780	60	840	
Apr 24	2,677	520	15.15	3,197	364	500	250	0	250	0	1,260	1,260	0	1,260	780	60	840	
Apr 25	3,158	60	15.27	3,218	360	500	250	0	250	0	1,260	1,260	0	1,260	780	60	840	T
Apr 26	3,154	60	15.39	3,214	356	500	250	0	250	0	1,260	1,260	0	1,260	780	60	840	T
Apr 27	3,150	60	15.51	3,210	352	500	250	0	250	0	1,260	1,260	0	1,260	780	60	840	T
Apr 28	3,146	60	15.63	3,206	348	500	250	0	250	0	1,260	1,260	0	1,260	780	60	840	T
Apr 29	3,142	60	15.75	3,202	344	500	250	0	250	0	1,260	1,260	0	1,260	780	65	845	T
Apr 30	3,138	60	15.87	3,198	340	500	250	0	250	0	1,260	1,260	0	1,260	780	70	850	T
May 01	3,134	65	16.00	3,199	336	500	250	0	250	0	1,260	1,260	0	1,260	758	100	858	T
May 02	3,130	70	16.14	3,200	332	500	250	395	645	0	1,260	1,260	0	1,260	758	100	858	T
May 03	3,104	100	16.33	3,204	328	500	250	670	920	0	775	775	0	775	758	195	953	T
May 04	3,100	100	16.53	3,200	324	500	250	670	920	0	510	510	0	510	758	190	948	M
May 05	2,611	590	17.70	3,201	320	500	250	670	920	0	510	510	0	510	758	190	948	M
May 06	2,342	860	19.41	3,202	316	500	250	670	920	0	510	510	0	510	758	195	953	M
May 07	2,338	860	21.11	3,198	312	500	250	670	920	0	510	510	0	510	758	200	958	M
May 08	2,334	865	22.83	3,199	308	500	250	670	920	0	510	510	0	510	758	205	963	M
May 09	2,330	870	24.56	3,200	304	500	250	670	920	0	510	510	0	510	758	205	963	M
May 10	2,326	875	26.29	3,201	300	500	250	670	920	0	510	510	0	510	758	210	968	M
May 11	2,322	875	28.03	3,197	296	500	250	670	920	0	510	510	0	510	758	210	968	M
May 12	2,318	880	29.77	3,198	292	500	250	600	850	0	510	510	0	510	758	210	968	
May 13	2,314	880	31.52	3,194	288	500	250	0	250		510	510	0	510	758	210	968	
May 14	2,310	880	33.26	3,190	284	500	250	0	250		345	345		345	758		758	
May 15	2,306	810	34.87	3,116	280	500	250		250			175		175	758		758	
May 16	2,137	0		2,137	276	500	250		250			175		175	694		694	
May 17	1,963	0		1,963	272	500	250		250			175		175	694		694	
May 18	1,895	0		1,895	268	500	250		250			175		175	694		694	
May 19	1,891	0		1,891	264	500	250		250			175		175	694		694	
May 20	1,887	0		1,887	260	500	250		250			175		175	694		694	
May 21	1,883	0		1,883	256	500	250		250			175		175	694		694	
May 22	1,879	0		1,879	252	500	250		250			175		175	694		694	
May 23	1,875	0		1,875	248	500	250		250			175		175	694		694	
May 24	1,871	0		1,871	244	500	250		250			175		175	694		694	
May 25	1,867	0		1,867	240	500	250		250			175		175	694		694	
May 26	1,863	0		1,863	236	500	250		250			175		175	694		694	
May 27	1,859	0		1,859	232	500	250		250			175		175	694		694	
May 28	1,855	0		1,855	228	500	250		250			175		175	694		694	
May 29	1,851	0		1,851	224	500	250		250			175		175	694		694	
May 30	1,847	0		1,847	220	500	250		250			175		175	694		694	
May 31	1,843	0		1,843	216	500	250		250			175		175	694		694	
									VAMP period									
Mean (cfs):	2,633	567		3,200	348	500		407	657	0		769	0	769		160	926	
Suppl. Water (TAF)																		
Provided		34.87						25.00		0.00			0.00			9.87		
Target		34.87						25.00		0.00			0.00			9.87		

Pulse flow period

Period of desired flow stability

DAILY OPERATION PLAN, APRIL 3

Pulse Period: April 15–May 15 • Flow Target: 3,200cfs

Ungaged Flow at Vernalis = 500cfs • 24 TAF "other" supplemental water on Stanislaus R.

	San Joaquin River near Vernalis							Merced River at Cressey			Exchange Contractors	Tuolumne River at LaGrange				Stanislaus R blw Goodwin (at Orange Blossom Bridge)				
	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	VAMP Suppl. Flow	VAMP Flow (3-day lag)	VAMP Suppl. Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	VAMP Suppl. Flow	b(2) or other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol.
	(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	
	[calc]	[calc]		[calc]	[calc]					[calc]					[calc]				[calc]	
Apr 01					2,071	447	408	350		350			347		347	569			569	
Apr 02					2,069	451	490	340		340			350		350	572			572	
Apr 03						448	500	250		250			300		300	704			704	
Apr 04	2,223				2,223	444	500	250		250			300		300	704			704	
Apr 05	2,292				2,292	440	500	250		250			300		300	704			704	
Apr 06	2,198				2,198	436	500	250		250			300		300	704			704	
Apr 07	2,194				2,194	432	500	250		250			300		300	704			704	
Apr 08	2,190				2,190	428	500	250		250			300		300	704			704	
Apr 09	2,186				2,186	424	500	250		250			300		300	704			704	
Apr 10	2,182				2,182	420	500	250		250			300		300	704			704	
Apr 11	2,178	0			2,178	416	500	250	0	250			300		300	704			704	
Apr 12	2,174	0			2,174	412	500	250	440	690	0		300		300	704			704	M
Apr 13	2,170	0			2,170	408	500	250	440	690	0	510	510	0	510	780	0	720	1,500	M
Apr 14	2,166	0		0	2,166	404	500	250	440	690	0	510	510	0	510	780	0	720	1,500	M
Apr 15	2,448	440	720	0.87	3,608	400	500	250	440	690	0	510	510	0	510	780	0	720	1,500	M
Apr 16	2,444	440	720	1.75	3,604	396	500	250	440	690	0	510	510	0	510	780	0	720	1,500	M
Apr 17	2,440	440	720	2.62	3,600	392	500	250	440	690	0	510	510	0	510	780	0	720	1,500	M
Apr 18	2,436	440	720	3.49	3,596	388	500	250	440	690	0	510	510	0	510	780	0	720	1,500	M
Apr 19	2,432	440	720	4.36	3,592	384	500	250	440	690	0	510	510	0	510	780	0	720	1,500	
Apr 20	2,428	440	720	5.24	3,588	380	500	250	440	690	0	510	510	0	510	780	0	720	1,500	
Apr 21	2,424	440	720	6.11	3,584	376	500	250	440	690	0	510	510	0	510	780	0	720	1,500	
Apr 22	2,420	440	720	6.98	3,580	372	500	250	440	690	0	775	775	0	775	780	0	420	1,200	
Apr 23	2,416	440	720	7.85	3,576	368	500	250	240	490	0	1,260	1,260	0	1,260	780	200	0	980	
Apr 24	2,677	440	420	8.73	3,537	364	500	250	240	490	0	1,260	1,260	0	1,260	780	200	0	980	
Apr 25	3,158	440	0	9.60	3,598	360	500	250	240	490	0	1,260	1,260	0	1,260	780	200	0	980	T
Apr 26	3,154	440	0	10.47	3,594	356	500	250	240	490	0	1,260	1,260	0	1,260	780	200	0	980	T
Apr 27	3,150	440	0	11.35	3,590	352	500	250	240	490	0	1,260	1,260	0	1,260	780	200	0	980	T
Apr 28	3,146	440	0	12.22	3,586	348	500	250	290	540	0	1,260	1,260	0	1,260	780	200	0	980	T
Apr 29	3,142	440	0	13.09	3,582	344	500	250	290	540	0	1,260	1,260	0	1,260	758	200	0	958	T
Apr 30	3,138	440	0	13.96	3,578	340	500	250	290	540	0	1,260	1,260	0	1,260	758	200	0	958	T
May 01	3,112	490	0	14.94	3,602	336	500	250	290	540	0	1,260	1,260	0	1,260	758	200	0	958	T
May 02	3,108	490	0	15.91	3,598	332	500	250	290	540	0	1,260	1,260	0	1,260	758	200	0	958	T
May 03	3,104	490	0	16.88	3,594	328	500	250	540	790	0	775	775	0	775	758	645	0	1,403	T
May 04	3,100	490	0	17.85	3,590	324	500	250	540	790	0	510	510	0	510	758	742	0	1,500	M
May 05	2,611	935	0	19.71	3,546	320	500	250	540	790	0	510	510	0	510	758	742	0	1,500	M
May 06	2,342	1,282	0	22.25	3,624	316	500	250	540	790	0	510	510	0	510	758	742	0	1,500	M
May 07	2,338	1,282	0	24.79	3,620	312	500	250	540	790	0	510	510	0	510	758	0	742	1,500	M
May 08	2,334	1,282	0	27.33	3,616	308	500	250	540	790	0	510	510	0	510	758	0	742	1,500	M
May 09	2,330	540	742	28.41	3,612	304	500	250	540	790	0	510	510	0	510	758	0	742	1,500	M
May 10	2,326	540	742	29.48	3,608	300	500	250	540	790	0	510	510	0	510	758	0	742	1,500	M
May 11	2,322	540	742	30.55	3,604	296	500	250	540	790	0	510	510	0	510	758	0	742	1,500	M
May 12	2,318	540	742	31.62	3,600	292	500	250	455	705	0	510	510	0	510	758	0	742	1,500	
May 13	2,314	540	742	32.69	3,596	288	500	250	0	250		510	510	0	510	758	0	742	1,500	
May 14	2,310	540	742	33.76	3,592	284	500	250	0	250		345	345		345	694			694	
May 15	2,306	455	742	34.66	3,503	280	500	250		250			175		175	694			694	
May 16	2,073	0			2,073	276	500	250		250			175		175	694			694	
May 17	1,899	0			1,899	272	500	250		250			175		175	694			694	
May 18	1,895	0			1,895	268	500	250		250			175		175	694			694	
May 19	1,891	0			1,891	264	500	250		250			175		175	694			694	
May 20	1,887	0			1,887	260	500	250		250			175		175	694			694	
May 21	1,883	0			1,883	256	500	250		250			175		175	694			694	
May 22	1,879	0			1,879	252	500	250		250			175		175	694			694	
May 23	1,875	0			1,875	248	500	250		250			175		175	694			694	
May 24	1,871	0			1,871	244	500	250		250			175		175	694			694	
May 25	1,867	0			1,867	240	500	250		250			175		175	694			694	
May 26	1,863	0			1,863	236	500	250		250			175		175	694			694	
May 27	1,859	0			1,859	232	500	250		250			175		175	694			694	
May 28	1,855	0			1,855	228	500	250		250			175		175	694			694	
May 29	1,851	0			1,851	224	500	250		250			175		175	694			694	
May 30	1,847	0			1,847	220	500	250		250			175		175	694			694	
May 31	1,843	0			1,843	216	500	250		250			175		175	694			694	
										VAMP period										
Mean (cfs):	2,636	564			3,590	348	500		407	657	0		769	0	769		157	390	1,317	
Suppl. Water (TAF)																				
Provided		34.66							25.00		0.00			0.00			9.66	23.99		
Target		34.66							25.00		0.00			0.00			9.66			

Pulse flow period

Period of desired flow stability

DAILY OPERATION PLAN, APRIL 3

Pulse Period: April 15–May 15 • Flow Target: 3,200cfs

Ungaged Flow at Vernalis = 1,000cfs • 45 TAF "other" supplemental water on Stanislaus R.

	San Joaquin River near Vernalis							Merced River at Cressey			Exchange Contractors	Tuolumne River at LaGrange				Stanislaus R blw Goodwin (at Orange Blossom Bridge)				
	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	VAMP Suppl. Flow	VAMP Flow (3-day lag)	VAMP Suppl. Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	VAMP Suppl. Flow	b(2) or other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol.
	(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	
	[calc]	[calc]		[calc]	[calc]					[calc]					[calc]				[calc]	
Apr 01					2,071	447	408	350		350			347		347	569			569	
Apr 02					2,069	451	490	340		340			350		350	572			572	
Apr 03						448	500	250		250			300		300	704			704	
Apr 04	2,223				2,223	444	500	250		250			300		300	704			704	
Apr 05	2,292				2,292	440	500	250		250			300		300	704			704	
Apr 06	2,198				2,198	436	500	250		250			300		300	704			704	
Apr 07	2,194				2,194	432	500	250		250			300		300	704			704	
Apr 08	2,190				2,190	428	500	250		250			300		300	704			704	
Apr 09	2,186				2,186	424	500	250		250			300		300	704			704	
Apr 10	2,182				2,182	420	500	250		250			300		300	704			704	
Apr 11	2,178	0			2,178	416	500	250	0	250			300		300	704			704	
Apr 12	2,174	0			2,174	412	500	250	0	250	0		300		300	704			704	M
Apr 13	2,170	0			2,170	408	500	250	0	250	0	510	510	0	510	780	0	720	1,500	M
Apr 14	2,166	0		0	2,166	404	500	250	0	250	0	510	510	0	510	780	0	720	1,500	M
Apr 15	2,948	0	720	0.00	3,668	400	1,000	250	0	250	0	510	510	0	510	780	0	720	1,500	M
Apr 16	2,944	0	720	0.00	3,664	396	1,000	250	0	250	0	510	510	0	510	780	0	720	1,500	M
Apr 17	2,940	0	720	0.00	3,660	392	1,000	250	0	250	0	510	510	0	510	780	0	720	1,500	M
Apr 18	2,936	0	720	0.00	3,656	388	1,000	250	0	250	0	510	510	0	510	780	0	720	1,500	M
Apr 19	2,932	0	720	0.00	3,652	384	1,000	250	0	250	0	510	510	0	510	780	0	720	1,500	
Apr 20	2,928	0	720	0.00	3,648	380	1,000	250	0	250	0	510	510	0	510	780	0	720	1,500	
Apr 21	2,924	0	720	0.00	3,644	376	1,000	250	0	250	0	510	510	0	510	780	0	720	1,500	
Apr 22	2,920	0	720	0.00	3,640	372	1,000	250	0	250	0	775	775	0	775	780	0	720	1,500	
Apr 23	2,916	0	720	0.00	3,636	368	1,000	250	0	250	0	1,260	1,260	0	1,260	780	0	720	1,500	
Apr 24	3,177	0	720	0.00	3,897	364	1,000	250	0	250	0	1,260	1,260	0	1,260	780	0	720	1,500	
Apr 25	3,658	0	720	0.00	4,378	360	1,000	250	0	250	0	1,260	1,260	0	1,260	780	0	720	1,500	T
Apr 26	3,654	0	720	0.00	4,374	356	1,000	250	0	250	0	1,260	1,260	0	1,260	780	0	720	1,500	T
Apr 27	3,650	0	720	0.00	4,370	352	1,000	250	0	250	0	1,260	1,260	0	1,260	780	0	720	1,500	T
Apr 28	3,646	0	720	0.00	4,366	348	1,000	250	0	250	0	1,260	1,260	0	1,260	780	0	720	1,500	T
Apr 29	3,642	0	720	0.00	4,362	344	1,000	250	0	250	0	1,260	1,260	0	1,260	758	0	742	1,500	T
Apr 30	3,638	0	720	0.00	4,358	340	1,000	250	0	250	0	1,260	1,260	0	1,260	758	0	742	1,500	T
May 01	3,612	0	742	0.00	4,354	336	1,000	250	0	250	0	1,260	1,260	0	1,260	758	0	742	1,500	T
May 02	3,608	0	742	0.00	4,350	332	1,000	250	0	250	0	1,260	1,260	0	1,260	758	0	742	1,500	T
May 03	3,604	0	742	0.00	4,346	328	1,000	250	210	460	0	775	775	0	775	758	0	742	1,500	T
May 04	3,600	0	742	0.00	4,342	324	1,000	250	220	470	0	510	510	0	510	758	0	742	1,500	M
May 05	3,111	0	742	0.00	3,853	320	1,000	250	220	470	0	510	510	0	510	758	0	742	1,500	M
May 06	2,842	210	742	0.42	3,794	316	1,000	250	220	470	0	510	510	0	510	758	0	742	1,500	M
May 07	2,838	220	742	0.85	3,800	312	1,000	250	220	470	0	510	510	0	510	758	0	742	1,500	M
May 08	2,834	220	742	1.29	3,796	308	1,000	250	220	470	0	510	510	0	510	758	0	742	1,500	M
May 09	2,830	220	742	1.73	3,792	304	1,000	250	220	470	0	510	510	0	510	758	0	742	1,500	M
May 10	2,826	220	742	2.16	3,788	300	1,000	250	220	470	0	510	510	0	510	758	0	742	1,500	M
May 11	2,822	220	742	2.60	3,784	296	1,000	250	220	470	0	510	510	0	510	758	0	742	1,500	M
May 12	2,818	220	742	3.03	3,780	292	1,000	250	0	250	0	510	510	0	510	758	0	742	1,500	
May 13	2,814	220	742	3.47	3,776	288	1,000	250	0	250		510	510	0	510	758	0	742	1,500	
May 14	2,810	220	742	3.91	3,772	284	1,000	250	0	250		345	345		345	694			694	
May 15	2,806	0	742	3.91	3,548	280	1,000	250		250			175		175	694			694	
May 16	2,573	0			2,573	276	1,000	250		250			175		175	694			694	
May 17	2,399	0			2,399	272	1,000	250		250			175		175	694			694	
May 18	2,395	0			2,395	268	1,000	250		250			175		175	694			694	
May 19	2,391	0			2,391	264	1,000	250		250			175		175	694			694	
May 20	2,387	0			2,387	260	1,000	250		250			175		175	694			694	
May 21	2,383	0			2,383	256	1,000	250		250			175		175	694			694	
May 22	2,379	0			2,379	252	1,000	250		250			175		175	694			694	
May 23	2,375	0			2,375	248	1,000	250		250			175		175	694			694	
May 24	2,371	0			2,371	244	1,000	250		250			175		175	694			694	
May 25	2,367	0			2,367	240	1,000	250		250			175		175	694			694	
May 26	2,363	0			2,363	236	1,000	250		250			175		175	694			694	
May 27	2,359	0			2,359	232	1,000	250		250			175		175	694			694	
May 28	2,355	0			2,355	228	1,000	250		250			175		175	694			694	
May 29	2,351	0			2,351	224	1,000	250		250			175		175	694			694	
May 30	2,347	0			2,347	220	1,000	250		250			175		175	694			694	
May 31	2,343	0			2,343	216	1,000	250		250			175		175	694			694	
	VAMP period																			
Mean (cfs):	3,136	64			3,931	348	1,000		64	314	0		769	0	769		0	731	1,500	
Suppl. Water (TAF)																				
Provided		3.91							3.91		0.00			0.00			0.00	44.93		
Target		3.91							3.91		0.00			0.00			0.00			

Pulse flow period

Period of desired flow stability

DAILY OPERATION PLAN, APRIL 3

Pulse Period: April 15–May 15 • Flow Target: 3,200cfs

Ungaged Flow at Vernalis = 500cfs • 45 TAF "other" supplemental water on Stanislaus R.

San Joaquin River near Vernalis							Merced River at Cressey			Exchange Contractors	Tuolumne River at LaGrange				Stanislaus R blw Goodwin (at Orange Blossom Bridge)					
Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	VAMP Suppl. Flow	VAMP Flow (3-day lag)	VAMP Suppl. Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol.	
(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		
[calc]	[calc]		[calc]	[calc]					[calc]					[calc]				[calc]		
				2,071	447	408	350		350			347		347	569			569		Apr 01
				2,069	451	490	340		340			350		350	572			572		Apr 02
					448	500	250		250			300		300	704			704		Apr 03
2,223				2,223	444	500	250		250			300		300	704			704		Apr 04
2,292				2,292	440	500	250		250			300		300	704			704		Apr 05
2,198				2,198	436	500	250		250			300		300	704			704		Apr 06
2,194				2,194	432	500	250		250			300		300	704			704		Apr 07
2,190				2,190	428	500	250		250			300		300	704			704		Apr 08
2,186				2,186	424	500	250		250			300		300	704			704		Apr 09
2,182				2,182	420	500	250		250			300		300	704			704		Apr 10
2,178	0			2,178	416	500	250	0	250			300		300	704			704		Apr 11
2,174	0			2,174	412	500	250	550	800	0		300		300	704			704	M	Apr 12
2,170	0			2,170	408	500	250	700	950	0	510	510	90	600	780	0	720	1,500	M	Apr 13
2,166	0		0	2,166	404	500	250	700	950	0	510	510	100	610	780	0	720	1,500	M	Apr 14
2,448	640	720	1.27	3,808	400	500	250	700	950	0	510	510	100	610	780	0	720	1,500	M	Apr 15
2,444	800	720	2.86	3,964	396	500	250	700	950	0	510	510	100	610	780	0	720	1,500	M	Apr 16
2,440	800	720	4.44	3,960	392	500	250	700	950	0	510	510	100	610	780	0	720	1,500	M	Apr 17
2,436	800	720	6.03	3,956	388	500	250	700	950	0	510	510	100	610	780	0	720	1,500	M	Apr 18
2,432	800	720	7.62	3,952	384	500	250	580	830	0	510	510	100	610	780	0	720	1,500		Apr 19
2,428	800	720	9.20	3,948	380	500	250	430	680	0	510	510	235	745	780	0	720	1,500		Apr 20
2,424	800	720	10.79	3,944	376	500	250	230	480	0	510	510	390	900	780	0	720	1,500		Apr 21
2,420	815	720	12.41	3,955	372	500	250	80	330	0	775	775	325	1,100	780	0	720	1,500		Apr 22
2,416	820	720	14.03	3,956	368	500	250	80	330	0	1,260	1,260	0	1,260	780	0	720	1,500		Apr 23
2,677	555	720	15.13	3,952	364	500	250	80	330	0	1,260	1,260	0	1,260	780	0	720	1,500		Apr 24
3,158	80	720	15.29	3,958	360	500	250	80	330	0	1,260	1,260	0	1,260	780	0	720	1,500	T	Apr 25
3,154	80	720	15.45	3,954	356	500	250	80	330	0	1,260	1,260	0	1,260	780	0	720	1,500	T	Apr 26
3,150	80	720	15.61	3,950	352	500	250	80	330	0	1,260	1,260	0	1,260	780	0	720	1,500	T	Apr 27
3,146	80	720	15.77	3,946	348	500	250	80	330	0	1,260	1,260	0	1,260	780	0	720	1,500	T	Apr 28
3,142	80	720	15.93	3,942	344	500	250	80	330	0	1,260	1,260	0	1,260	758	0	742	1,500	T	Apr 29
3,138	80	720	16.09	3,938	340	500	250	100	350	0	1,260	1,260	0	1,260	758	0	742	1,500	T	Apr 30
3,112	80	742	16.24	3,934	336	500	250	100	350	0	1,260	1,260	0	1,260	758	0	742	1,500	T	May 01
3,108	80	742	16.40	3,930	332	500	250	550	800	0	1,260	1,260	0	1,260	758	0	742	1,500	T	May 02
3,104	100	742	16.60	3,946	328	500	250	650	900	0	775	775	0	775	758	0	742	1,500	T	May 03
3,100	100	742	16.80	3,942	324	500	250	680	930	0	510	510	190	700	758	0	742	1,500	M	May 04
2,611	550	742	17.89	3,903	320	500	250	680	930	0	510	510	190	700	758	0	742	1,500	M	May 05
2,342	840	742	19.56	3,924	316	500	250	690	940	0	510	510	190	700	758	0	742	1,500	M	May 06
2,338	870	742	21.28	3,950	312	500	250	700	950	0	510	510	190	700	758	0	742	1,500	M	May 07
2,334	870	742	23.01	3,946	308	500	250	700	950	0	510	510	190	700	758	0	742	1,500	M	May 08
2,330	880	742	24.75	3,952	304	500	250	700	950	0	510	510	190	700	758	0	742	1,500	M	May 09
2,326	890	742	26.52	3,958	300	500	250	700	950	0	510	510	190	700	758	0	742	1,500	M	May 10
2,322	890	742	28.28	3,954	296	500	250	700	950	0	510	510	190	700	758	0	742	1,500	M	May 11
2,318	890	742	30.05	3,950	292	500	250	350	600	0	510	510	190	700	758	0	742	1,500		May 12
2,314	890	742	31.81	3,946	288	500	250	0	250		510	510	190	700	758	0	742	1,500		May 13
2,310	890	742	33.58	3,942	284	500	250	0	250		345	345		345	694			694		May 14
2,306	540	742	34.65	3,588	280	500	250		250			175		175	694			694		May 15
2,073	0			2,073	276	500	250		250			175		175	694			694		May 16
1,899	0			1,899	272	500	250		250			175		175	694			694		May 17
1,895	0			1,895	268	500	250		250			175		175	694			694		May 18
1,891	0			1,891	264	500	250		250			175		175	694			694		May 19
1,887	0			1,887	260	500	250		250			175		175	694			694		May 20
1,883	0			1,883	256	500	250		250			175		175	694			694		May 21
1,879	0			1,879	252	500	250		250			175		175	694			694		May 22
1,875	0			1,875	248	500	250		250			175		175	694			694		May 23
1,871	0			1,871	244	500	250		250			175		175	694			694		May 24
1,867	0			1,867	240	500	250		250			175		175	694			694		May 25
1,863	0			1,863	236	500	250		250			175		175	694			694		May 26
1,859	0			1,859	232	500	250		250			175		175	694			694		May 27
1,855	0			1,855	228	500	250		250			175		175	694			694		May 28
1,851	0			1,851	224	500	250		250			175		175	694			694		May 29
1,847	0			1,847	220	500	250		250			175		175	694			694		May 30
1,843	0			1,843	216	500	250		250			175		175	694			694		May 31
VAMP period																				
2,636	564			3,931	348	500		449	699	0		769	114	883		0	731	1,500		Mean (cfs):
																				Suppl. Water (TAF)
	34.65							27.63		0.00			7.02			0.00	44.93			Provided
	34.66							27.63		0.00			7.02			0.00				Target

Pulse flow period

Period of desired flow stability

DAILY OPERATION PLAN, APRIL 3

Pulse Period: April 17–May 17 • Flow Target: 3,200cfs

Ungaged Flow at Vernalis = 1,000cfs • 45 TAF "other" supplemental water on Stanislaus R.

	San Joaquin River near Vernalis							Merced River at Cressey			Exchange Contractors	Tuolumne River at LaGrange				Stanislaus R blw Goodwin (at Orange Blossom Bridge)				
	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	VAMP Suppl. Flow	VAMP Flow (3-day lag)	VAMP Suppl. Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	VAMP Suppl. Flow	b(2) or other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol.
	(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	
	[calc]	[calc]		[calc]	[calc]					[calc]					[calc]				[calc]	
Apr 01					2,071	447	408	350		350			347		347	569			569	
Apr 02					2,069	451	490	340		340			350		350	572			572	
Apr 03						448	500	250		250			300		300	704			704	
Apr 04	2,223				2,223	444	500	250		250			300		300	704			704	
Apr 05	2,292				2,292	440	500	250		250			300		300	704			704	
Apr 06	2,198				2,198	436	500	250		250			300		300	704			704	
Apr 07	2,194				2,194	432	500	250		250			300		300	704			704	
Apr 08	2,190				2,190	428	500	250		250			300		300	704			704	
Apr 09	2,186				2,186	424	500	250		250			300		300	704			704	
Apr 10	2,182				2,182	420	500	250		250			300		300	704			704	
Apr 11	2,178				2,178	416	500	250		250			300		300	704			704	
Apr 12	2,174				2,174	412	500	250		250			300		300	704			704	
Apr 13	2,670	0			2,670	408	1,000	250	0	250			300		300	704			704	
Apr 14	2,666	0			2,666	404	1,000	250	0	250	0		300		300	704			704	M
Apr 15	2,662	0			2,662	400	1,000	250	0	250	0	510	510	0	510	780	0	720	1,500	M
Apr 16	2,658	0		0	2,658	396	1,000	250	0	250	0	510	510	0	510	780	0	720	1,500	M
Apr 17	2,940	0	720	0.00	3,660	392	1,000	250	0	250	0	510	510	0	510	780	0	720	1,500	M
Apr 18	2,936	0	720	0.00	3,656	388	1,000	250	0	250	0	510	510	0	510	780	0	720	1,500	M
Apr 19	2,932	0	720	0.00	3,652	384	1,000	250	0	250	0	510	510	0	510	780	0	720	1,500	M
Apr 20	2,928	0	720	0.00	3,648	380	1,000	250	0	250	0	510	510	0	510	780	0	720	1,500	M
Apr 21	2,924	0	720	0.00	3,644	376	1,000	250	0	250	0	510	510	0	510	780	0	720	1,500	
Apr 22	2,920	0	720	0.00	3,640	372	1,000	250	0	250	0	510	510	0	510	780	0	720	1,500	
Apr 23	2,916	0	720	0.00	3,636	368	1,000	250	0	250	0	510	510	0	510	780	0	720	1,500	
Apr 24	2,912	0	720	0.00	3,632	364	1,000	250	0	250	0	775	775	0	775	780	0	720	1,500	
Apr 25	2,908	0	720	0.00	3,628	360	1,000	250	0	250	0	1,260	1,260	0	1,260	780	0	720	1,500	
Apr 26	3,169	0	720	0.00	3,889	356	1,000	250	0	250	0	1,260	1,260	0	1,260	780	0	720	1,500	
Apr 27	3,650	0	720	0.00	4,370	352	1,000	250	0	250	0	1,260	1,260	0	1,260	780	0	720	1,500	T
Apr 28	3,646	0	720	0.00	4,366	348	1,000	250	0	250	0	1,260	1,260	0	1,260	780	0	720	1,500	T
Apr 29	3,642	0	720	0.00	4,362	344	1,000	250	0	250	0	1,260	1,260	0	1,260	780	0	720	1,500	T
Apr 30	3,638	0	720	0.00	4,358	340	1,000	250	0	250	0	1,260	1,260	0	1,260	780	0	720	1,500	T
May 01	3,634	0	720	0.00	4,354	336	1,000	250	0	250	0	1,260	1,260	0	1,260	758	0	742	1,500	T
May 02	3,630	0	720	0.00	4,350	332	1,000	250	0	250	0	1,260	1,260	0	1,260	758	0	742	1,500	T
May 03	3,604	0	742	0.00	4,346	328	1,000	250	0	250	0	1,260	1,260	0	1,260	758	0	742	1,500	T
May 04	3,600	0	742	0.00	4,342	324	1,000	250	170	420	0	1,260	1,260	0	1,260	758	0	742	1,500	T
May 05	3,596	0	742	0.00	4,338	320	1,000	250	210	460	0	775	775	0	775	758	0	742	1,500	T
May 06	3,592	0	742	0.00	4,334	316	1,000	250	230	480	0	510	510	0	510	758	0	742	1,500	M
May 07	3,103	170	742	0.34	4,015	312	1,000	250	230	480	0	510	510	0	510	758	0	742	1,500	M
May 08	2,834	210	742	0.75	3,786	308	1,000	250	230	480	0	510	510	0	510	758	0	742	1,500	M
May 09	2,830	230	742	1.21	3,802	304	1,000	250	230	480	0	510	510	0	510	758	0	742	1,500	M
May 10	2,826	230	742	1.67	3,798	300	1,000	250	230	480	0	510	510	0	510	758	0	742	1,500	M
May 11	2,822	230	742	2.12	3,794	296	1,000	250	230	480	0	510	510	0	510	758	0	742	1,500	M
May 12	2,818	230	742	2.58	3,790	292	1,000	250	230	480	0	510	510	0	510	758	0	742	1,500	M
May 13	2,814	230	742	3.03	3,786	288	1,000	250	230	480	0	510	510	0	510	758	0	742	1,500	M
May 14	2,810	230	742	3.49	3,782	284	1,000	250	0	250	0	510	510	0	510	758	0	742	1,500	
May 15	2,806	230	742	3.95	3,778	280	1,000	250	0	250		510	510	0	510	758	0	742	1,500	
May 16	2,802	230	742	4.40	3,774	276	1,000	250	0	250		345	345		345	694			694	
May 17	2,798	0	742	4.40	3,540	272	1,000	250		250			175		175	694			694	
May 18	2,565	0			2,565	268	1,000	250		250			175		175	694			694	
May 19	2,391	0			2,391	264	1,000	250		250			175		175	694			694	
May 20	2,387	0			2,387	260	1,000	250		250			175		175	694			694	
May 21	2,383	0			2,383	256	1,000	250		250			175		175	694			694	
May 22	2,379	0			2,379	252	1,000	250		250			175		175	694			694	
May 23	2,375	0			2,375	248	1,000	250		250			175		175	694			694	
May 24	2,371	0			2,371	244	1,000	250		250			175		175	694			694	
May 25	2,367	0			2,367	240	1,000	250		250			175		175	694			694	
May 26	2,363	0			2,363	236	1,000	250		250			175		175	694			694	
May 27	2,359	0			2,359	232	1,000	250		250			175		175	694			694	
May 28	2,355	0			2,355	228	1,000	250		250			175		175	694			694	
May 29	2,351	0			2,351	224	1,000	250		250			175		175	694			694	
May 30	2,347	0			2,347	220	1,000	250		250			175		175	694			694	
May 31	2,343	0			2,343	216	1,000	250		250			175		175	694			694	
	VAMP period																			
Mean (cfs):	3,128	72			3,931	340	1,000		72	322	0		769	0	769		0	731	1,500	
Suppl. Water (TAF)																				
Provided		4.40							4.40		0.00			0.00			0.00	44.93		
Target		4.40							4.40		0.00			0.00			0.00			

Pulse flow period

Period of desired flow stability

DAILY OPERATION PLAN, APRIL 3

Pulse Period: April 17–May 17 • Flow Target: 3,200cfs

Ungaged Flow at Vernalis = 500cfs • 24 TAF "other" supplemental water on Stanislaus R.

San Joaquin River near Vernalis							Merced River at Cressey			Exchange Contractors	Tuolumne River at LaGrange				Stanislaus R blw Goodwin (at Orange Blossom Bridge)					
Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	VAMP Suppl. Flow	VAMP Flow (3-day lag)	VAMP Suppl. Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	VAMP Suppl. Flow	b(2) or other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol.	
(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		
[calc]	[calc]		[calc]	[calc]					[calc]					[calc]				[calc]		
				2,071	447	408	350		350			347		347	569			569		Apr 01
				2,069	451	490	340		340			350		350	572			572		Apr 02
					448	500	250		250			300		300	704			704		Apr 03
2,223				2,223	444	500	250		250			300		300	704			704		Apr 04
2,292				2,292	440	500	250		250			300		300	704			704		Apr 05
2,198				2,198	436	500	250		250			300		300	704			704		Apr 06
2,194				2,194	432	500	250		250			300		300	704			704		Apr 07
2,190				2,190	428	500	250		250			300		300	704			704		Apr 08
2,186				2,186	424	500	250		250			300		300	704			704		Apr 09
2,182				2,182	420	500	250		250			300		300	704			704		Apr 10
2,178				2,178	416	500	250		250			300		300	704			704		Apr 11
2,174				2,174	412	500	250		250			300		300	704			704		Apr 12
2,170	0			2,170	408	500	250	0	250			300		300	704			704		Apr 13
2,166	0			2,166	404	500	250	440	690	0		300		300	704			704	M	Apr 14
2,162	0			2,162	400	500	250	440	690	0	510	510	0	510	780	0	720	1,500	M	Apr 15
2,158	0		0	2,158	396	500	250	440	690	0	510	510	0	510	780	0	720	1,500	M	Apr 16
2,440	440	720	0.87	3,600	392	500	250	440	690	0	510	510	0	510	780	0	720	1,500	M	Apr 17
2,436	440	720	1.75	3,596	388	500	250	440	690	0	510	510	0	510	780	0	720	1,500	M	Apr 18
2,432	440	720	2.62	3,592	384	500	250	440	690	0	510	510	0	510	780	0	720	1,500	M	Apr 19
2,428	440	720	3.49	3,588	380	500	250	440	690	0	510	510	0	510	780	0	720	1,500	M	Apr 20
2,424	440	720	4.36	3,584	376	500	250	440	690	0	510	510	0	510	780	0	720	1,500		Apr 21
2,420	440	720	5.24	3,580	372	500	250	440	690	0	510	510	0	510	780	0	720	1,500		Apr 22
2,416	440	720	6.11	3,576	368	500	250	440	690	0	510	510	0	510	780	0	720	1,500		Apr 23
2,412	440	720	6.98	3,572	364	500	250	240	490	0	775	775	0	775	780	0	420	1,200		Apr 24
2,408	440	720	7.85	3,568	360	500	250	240	490	0	1,260	1,260	0	1,260	780	200	0	980		Apr 25
2,669	440	420	8.73	3,529	356	500	250	240	490	0	1,260	1,260	0	1,260	780	200	0	980		Apr 26
3,150	440	0	9.60	3,590	352	500	250	240	490	0	1,260	1,260	0	1,260	780	200	0	980	T	Apr 27
3,146	440	0	10.47	3,586	348	500	250	240	490	0	1,260	1,260	0	1,260	780	200	0	980	T	Apr 28
3,142	440	0	11.35	3,582	344	500	250	240	490	0	1,260	1,260	0	1,260	780	200	0	980	T	Apr 29
3,138	440	0	12.22	3,578	340	500	250	290	540	0	1,260	1,260	0	1,260	780	200	0	980	T	Apr 30
3,134	440	0	13.09	3,574	336	500	250	290	540	0	1,260	1,260	0	1,260	758	200	0	958	T	May 01
3,130	440	0	13.96	3,570	332	500	250	290	540	0	1,260	1,260	0	1,260	758	200	0	958	T	May 02
3,104	490	0	14.94	3,594	328	500	250	290	540	0	1,260	1,260	0	1,260	758	200	0	958	T	May 03
3,100	490	0	15.91	3,590	324	500	250	290	540	0	1,260	1,260	0	1,260	758	200	0	958	T	May 04
3,096	490	0	16.88	3,586	320	500	250	540	790	0	775	775	0	775	758	645	0	1,403	T	May 05
3,092	490	0	17.85	3,582	316	500	250	540	790	0	510	510	0	510	758	742	0	1,500	M	May 06
2,603	935	0	19.71	3,538	312	500	250	540	790	0	510	510	0	510	758	742	0	1,500	M	May 07
2,334	1,282	0	22.25	3,616	308	500	250	540	790	0	510	510	0	510	758	742	0	1,500	M	May 08
2,330	1,282	0	24.79	3,612	304	500	250	540	790	0	510	510	0	510	758	0	742	1,500	M	May 09
2,326	1,282	0	27.33	3,608	300	500	250	540	790	0	510	510	0	510	758	0	742	1,500	M	May 10
2,322	540	742	28.41	3,604	296	500	250	540	790	0	510	510	0	510	758	0	742	1,500	M	May 11
2,318	540	742	29.48	3,600	292	500	250	540	790	0	510	510	0	510	758	0	742	1,500	M	May 12
2,314	540	742	30.55	3,596	288	500	250	540	790	0	510	510	0	510	758	0	742	1,500	M	May 13
2,310	540	742	31.62	3,592	284	500	250	455	705	0	510	510	0	510	758	0	742	1,500		May 14
2,306	540	742	32.69	3,588	280	500	250	0	250		510	510	0	510	758	0	742	1,500		May 15
2,302	540	742	33.76	3,584	276	500	250	0	250		345	345		345	694			694		May 16
2,298	455	742	34.66	3,495	272	500	250		250			175		175	694			694		May 17
2,065	0			2,065	268	500	250		250			175		175	694			694		May 18
1,891	0			1,891	264	500	250		250			175		175	694			694		May 19
1,887	0			1,887	260	500	250		250			175		175	694			694		May 20
1,883	0			1,883	256	500	250		250			175		175	694			694		May 21
1,879	0			1,879	252	500	250		250			175		175	694			694		May 22
1,875	0			1,875	248	500	250		250			175		175	694			694		May 23
1,871	0			1,871	244	500	250		250			175		175	694			694		May 24
1,867	0			1,867	240	500	250		250			175		175	694			694		May 25
1,863	0			1,863	236	500	250		250			175		175	694			694		May 26
1,859	0			1,859	232	500	250		250			175		175	694			694		May 27
1,855	0			1,855	228	500	250		250			175		175	694			694		May 28
1,851	0			1,851	224	500	250		250			175		175	694			694		May 29
1,847	0			1,847	220	500	250		250			175		175	694			694		May 30
1,843	0			1,843	216	500	250		250			175		175	694			694		May 31
VAMP period																				
2,628	564			3,582	340	500		407	657	0		769	0	769		157	390	1,317		Mean (cfs):
																				Suppl. Water (TAF)
	34.66							25.00		0.00			0.00			9.66	23.99			Provided
	35.15							25.00		0.15			0.00			10.00				Target

Pulse flow period

Period of desired flow stability

DAILY OPERATION PLAN, APRIL 10

Pulse Period: April 19–May 19 • Flow Target: 3,200cfs

Ungaged Flow at Vernalis = 500cfs • No "other" supplemental water on Stanislaus R.

	San Joaquin River near Vernalis							Merced River at Cressey			Exchange Contractors	Tuolumne River at LaGrange				Stanislaus R blw Goodwin (at Orange Blossom Bridge)				
	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	VAMP Suppl. Flow	VAMP Flow (3-day lag)	VAMP Suppl. Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol.
	(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	
	[calc]	[calc]		[calc]	[calc]					[calc]					[calc]				[calc]	
Apr 01					2,071	447	407	350		350			347		347	569			569	
Apr 02					2,069	451	481	340		340			350		350	572			572	
Apr 03					2,163	459	466	310		310			345		345	572			572	
Apr 04	2,041				2,041	466	318	323		323			339		339	572			572	
Apr 05	1,974				1,974	447	258	348		348			328		328	638			638	
Apr 06	2,069				2,069	425	382	370		370			317		317	666			666	
Apr 07	2,303				2,303	393	567	396		396			325		325	710			710	
Apr 08	2,535				2,535	386	779	376		376			323		323	725			725	
Apr 09	2,533				2,533	422	735	370		370			318		318	722			722	
Apr 10	2,330				2,330	420	500	250		250			300		300	704			704	
Apr 11	2,338				2,338	416	500	250		250			300		300	704			704	
Apr 12	2,294				2,294	412	500	250		250			300		300	704			704	
Apr 13	2,170	0			2,170	408	500	250	0	250			300		300	704			704	
Apr 14	2,166	0			2,166	404	500	250	0	250			300		300	704			704	
Apr 15	2,162	0			2,162	400	500	250	250	500			150		150	704			704	
Apr 16	2,158	0			2,158	396	500	250	655	905	0		150		150	704			704	M
Apr 17	2,004	0	0		2,004	392	500	250	660	910	0	475	700	0	700	704	0	0	704	M
Apr 18	2,000	250	0		2,250	388	500	250	660	910	0	475	700	0	700	704	0	0	704	M
Apr 19	2,546	655	0	1.30	3,201	384	500	250	665	915	0	475	700	0	700	704	0	0	704	M
Apr 20	2,542	660	0	2.61	3,202	380	500	250	670	920	0	475	700	0	700	704	0	0	704	M
Apr 21	2,538	660	0	3.92	3,198	376	500	250	675	925	0	475	700	0	700	704	0	0	704	M
Apr 22	2,534	665	0	5.24	3,199	372	500	250	180	430	0	475	700	0	700	704	0	0	704	M
Apr 23	2,530	670	0	6.57	3,200	368	500	250	180	430	0	475	1,200	0	1,200	704	0	0	704	
Apr 24	2,526	675	0	7.90	3,201	364	500	250	185	435	0	475	1,200	0	1,200	704	0	0	704	
Apr 25	3,022	180	0	8.26	3,202	360	500	250	190	440	0	475	1,200	0	1,200	704	0	0	704	
Apr 26	3,018	180	0	8.62	3,198	356	500	250	195	445	0	750	1,200	0	1,200	704	0	0	704	
Apr 27	3,014	185	0	8.99	3,199	352	500	250	200	450	0	1,230	1,200	0	1,200	704	0	0	704	
Apr 28	3,010	190	0	9.36	3,200	348	500	250	200	450	0	1,230	1,200	0	1,200	704	0	0	704	
Apr 29	3,006	195	0	9.75	3,201	344	500	250	205	455	0	1,230	1,200	0	1,200	704	0	0	704	T
Apr 30	3,002	200	0	10.15	3,202	340	500	250	65	315	0	1,230	1,200	0	1,200	704	0	0	704	T
May 01	2,998	200	0	10.54	3,198	336	500	250	70	320	0	1,230	550	0	550	1,500	0	0	1,500	T
May 02	2,994	205	0	10.95	3,199	332	500	250	70	320	0	1,230	550	0	550	1,500	0	0	1,500	T
May 03	3,136	65	0	11.08	3,201	328	500	250	75	325	0	1,230	550	0	550	1,500	0	0	1,500	T
May 04	3,132	70	0	11.22	3,202	324	500	250	80	330	0	1,230	550	0	550	1,500	0	0	1,500	T
May 05	3,128	70	0	11.36	3,198	320	500	250	85	335	0	1,230	550	0	550	1,500	0	0	1,500	T
May 06	3,124	75	0	11.50	3,199	316	500	250	90	340	0	1,230	550	0	550	1,500	0	0	1,500	T
May 07	3,120	80	0	11.66	3,200	312	500	250	130	380	0	750	550	0	550	1,500	0	0	1,500	T
May 08	3,116	85	0	11.83	3,201	308	500	250	130	380	0	475	515	0	515	1,500	0	0	1,500	M
May 09	3,112	90	0	12.01	3,202	304	500	250	135	385	0	475	515	0	515	1,500	0	0	1,500	M
May 10	3,073	130	0	12.27	3,203	300	500	250	140	390	0	475	515	0	515	1,500	0	0	1,500	M
May 11	3,069	130	0	12.53	3,199	296	500	250	140	390	0	475	515	0	515	1,500	0	0	1,500	M
May 12	3,065	135	0	12.79	3,200	292	500	250	150	400	0	475	515	0	515	1,500	0	0	1,500	M
May 13	3,061	140	0	13.07	3,201	288	500	250	150	400	0	475	515	0	515	1,500	0	0	1,500	M
May 14	3,057	140	0	13.35	3,197	284	500	250	155	405	0	475	515	0	515	1,500	0	0	1,500	M
May 15	3,053	150	0	13.65	3,203	280	500	250	740	990	0	475	515	0	515	1,500	0	0	1,500	M
May 16	3,049	150	0	13.94	3,199	276	500	250	740	990	0	475	515	0	515	918	0	0	918	
May 17	3,045	155	0	14.25	3,200	272	500	250	250	500		475	515	0	515	918	0	0	918	
May 18	2,459	740	0	15.72	3,199	268	500	250		250		300	300		300	918			918	
May 19	2,455	740	0	17.19	3,195	264	500	250		250			150		150	918			918	
May 20	2,236	250			2,486	260	500	250		250			150		150	918			918	
May 21	2,082	0			2,082	256	500	250		250			150		150	918			918	
May 22	2,078	0			2,078	252	500	250		250			150		150	918			918	
May 23	2,074	0			2,074	248	500	250		250			150		150	918			918	
May 24	2,070	0			2,070	244	500	250		250			150		150	918			918	
May 25	2,066	0			2,066	240	500	250		250			150		150	918			918	
May 26	2,062	0			2,062	236	500	250		250			150		150	918			918	
May 27	2,058	0			2,058	232	500	250		250			150		150	918			918	
May 28	2,054	0			2,054	228	500	250		250			150		150	918			918	
May 29	2,050	0			2,050	224	500	250		250			150		150	918			918	
May 30	2,046	0			2,046	220	500	250		250			150		150	918			918	
May 31	2,042	0			2,042	216	500	250		250			150		150	918			918	
	VAMP period																			
Mean (cfs):	2,920	280			3,200	332	500		280	530	0		735	0	735		0	0	1,103	
Suppl. Water (TAF)																				
Provided		17.19							17.19		0.00			0.00			0.00	0.00		
Target		17.19							17.19		0.00			0.00			0.00			

Pulse flow period

Period of desired flow stability

DAILY OPERATION PLAN, APRIL 10

Pulse Period: April 19–May 19 • Flow Target: 4,450cfs

Ungaged Flow at Vernalis = 800cfs • No "other" supplemental water on Stanislaus R.

	San Joaquin River near Vernalis							Merced River at Cressey			Exchange Contractors	Tuolumne River at LaGrange				Stanislaus R blw Goodwin (at Orange Blossom Bridge)				
	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	VAMP Suppl. Flow	VAMP Flow (3-day lag)	VAMP Suppl. Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol.
	(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	
	[calc]	[calc]		[calc]	[calc]					[calc]					[calc]				[calc]	
Apr 01					2,071	447	407	350		350			347		347	569			569	
Apr 02					2,069	451	481	340		340			350		350	572			572	
Apr 03					2,163	459	466	310		310			345		345	572			572	
Apr 04	2,041				2,041	466	318	323		323			339		339	572			572	
Apr 05	1,974				1,974	447	258	348		348			328		328	638			638	
Apr 06	2,069				2,069	425	382	370		370			317		317	666			666	
Apr 07	2,303				2,303	393	567	396		396			325		325	710			710	
Apr 08	2,535				2,535	386	779	376		376			323		323	725			725	
Apr 09	2,533				2,533	422	735	370		370			318		318	722			722	
Apr 10	2,630				2,630	420	800	250		250			300		300	704			704	
Apr 11	2,638				2,638	416	800	250		250			300		300	704			704	
Apr 12	2,594				2,594	412	800	250		250			300		300	704			704	
Apr 13	2,470	0			2,470	408	800	250	0	250			300		300	704			704	
Apr 14	2,466	0			2,466	404	800	250	0	250			300		300	704			704	
Apr 15	2,462	0			2,462	400	800	250	200	450			150		150	704			704	
Apr 16	2,458	0			2,458	396	800	250	610	860	100		150		150	704			704	M
Apr 17	2,304	0	0		2,304	392	800	250	610	860	100	475	475	325	800	704	796	0	1,500	M
Apr 18	2,300	200	0		2,500	388	800	250	615	865	100	475	475	325	800	704	796	0	1,500	M
Apr 19	2,621	1,831	0	3.63	4,452	384	800	250	620	870	100	475	475	325	800	704	796	0	1,500	M
Apr 20	2,617	1,831	0	7.26	4,448	380	800	250	625	875	100	475	475	325	800	704	796	0	1,500	M
Apr 21	2,613	1,836	0	10.91	4,449	376	800	250	630	880	100	475	475	325	800	704	796	0	1,500	M
Apr 22	2,609	1,841	0	14.56	4,450	372	800	250	680	930	100	475	475	325	800	704	796	0	1,500	M
Apr 23	2,605	1,846	0	18.22	4,451	368	800	250	1,185	1,435	150	475	475	325	800	704	751	0	1,455	
Apr 24	2,601	1,851	0	21.89	4,452	364	800	250	1,165	1,415	150	475	475	425	900	704	96	0	800	
Apr 25	2,597	1,856	0	25.57	4,453	360	800	250	915	1,165	100	475	475	450	925	704	96	0	800	
Apr 26	2,593	1,856	0	29.25	4,449	356	800	250	915	1,165	100	750	750	480	1,230	704	96	0	800	
Apr 27	2,589	1,861	0	32.94	4,450	352	800	250	920	1,170	100	1,230	1,230	0	1,230	704	96	0	800	
Apr 28	2,860	1,591	0	36.10	4,451	348	800	250	920	1,170	100	1,230	1,230	0	1,230	704	96	0	800	
Apr 29	3,336	1,111	0	38.30	4,447	344	800	250	890	1,140	100	1,230	1,230	0	1,230	704	96	0	800	T
Apr 30	3,332	1,116	0	40.52	4,448	340	800	250	390	640	0	1,230	1,230	0	1,230	704	96	0	800	T
May 01	3,328	1,116	0	42.73	4,444	336	800	250	240	490	100	1,230	1,230	0	1,230	1,500	0	0	1,500	T
May 02	3,324	1,086	0	44.88	4,410	332	800	250	240	490	100	1,230	1,230	0	1,230	1,500	0	0	1,500	T
May 03	4,116	390	0	45.66	4,506	328	800	250	245	495	100	1,230	1,230	0	1,230	1,500	0	0	1,500	T
May 04	4,112	340	0	46.33	4,452	324	800	250	250	500	100	1,230	1,230	0	1,230	1,500	0	0	1,500	T
May 05	4,108	340	0	47.01	4,448	320	800	250	255	505	100	1,230	1,230	0	1,230	1,500	0	0	1,500	T
May 06	4,104	345	0	47.69	4,449	316	800	250	260	510	100	1,230	1,230	0	1,230	1,500	0	0	1,500	T
May 07	4,100	350	0	48.38	4,450	312	800	250	650	900	130	750	750	480	1,230	1,500	0	0	1,500	T
May 08	4,096	355	0	49.09	4,451	308	800	250	650	900	150	475	475	325	800	1,500	0	0	1,500	M
May 09	3,612	840	0	50.76	4,452	304	800	250	650	900	150	475	475	325	800	1,500	0	0	1,500	M
May 10	3,333	1,105	0	52.95	4,438	300	800	250	655	905	150	475	475	325	800	1,500	0	0	1,500	M
May 11	3,329	1,125	0	55.18	4,454	296	800	250	660	910	150	475	475	325	800	1,500	0	0	1,500	M
May 12	3,325	1,125	0	57.41	4,450	292	800	250	660	910	150	475	475	325	800	1,500	0	0	1,500	M
May 13	3,321	1,130	0	59.65	4,451	288	800	250	665	915	150	475	475	325	800	1,500	0	0	1,500	M
May 14	3,317	1,135	0	61.90	4,452	284	800	250	670	920	150	475	475	325	800	1,500	0	0	1,500	M
May 15	3,313	1,135	0	64.15	4,448	280	800	250	625	875	200	475	475	325	800	1,500	0	0	1,500	M
May 16	3,309	1,140	0	66.41	4,449	276	800	250	625	875	200	475	475	325	800	918	582	0	1,500	
May 17	3,305	1,145	0	68.69	4,450	272	800	250	0	250		475	475	325	800	918	582	0	1,500	
May 18	2,719	1,732	0	72.12	4,451	268	800	250		250		300	300		300	918			918	
May 19	2,715	1,732	0	75.56	4,447	264	800	250		250			150		150	918			918	
May 20	2,536	0			2,536	260	800	250		250			150		150	918			918	
May 21	2,382	0			2,382	256	800	250		250			150		150	918			918	
May 22	2,378	0			2,378	252	800	250		250			150		150	918			918	
May 23	2,374	0			2,374	248	800	250		250			150		150	918			918	
May 24	2,370	0			2,370	244	800	250		250			150		150	918			918	
May 25	2,366	0			2,366	240	800	250		250			150		150	918			918	
May 26	2,362	0			2,362	236	800	250		250			150		150	918			918	
May 27	2,358	0			2,358	232	800	250		250			150		150	918			918	
May 28	2,354	0			2,354	228	800	250		250			150		150	918			918	
May 29	2,350	0			2,350	224	800	250		250			150		150	918			918	
May 30	2,346	0			2,346	220	800	250		250			150		150	918			918	
May 31	2,342	0			2,342	216	800	250		250			150		150	918			918	
	VAMP period																			
Mean (cfs):	3,221	1,229			4,450	332	800		635	885	119		736	237	974		238	0	1,340	
Suppl. Water (TAF)																				
Provided		75.56							39.05		7.30			14.60			14.60	0.00		
Target		75.55							39.05		7.30			14.60			14.60			

Pulse flow period

Period of desired flow stability

DAILY OPERATION PLAN, APRIL 10

Pulse Period: April 19–May 19 • Flow Target: 3,200cfs

Ungaged Flow at Vernalis = 500cfs • 24.4 "other" supplemental water on Stanislaus R.

	San Joaquin River near Vernalis							Merced River at Cressey			Exchange Contractors	Tuolumne River at LaGrange				Stanislaus R blw Goodwin (at Orange Blossom Bridge)				
	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	VAMP Suppl. Flow	VAMP Flow (3-day lag)	VAMP Suppl. Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol.
	(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	
	[calc]	[calc]		[calc]	[calc]					[calc]					[calc]				[calc]	
Apr 01					2,071	447	407	350		350			347		347	569			569	
Apr 02					2,069	451	481	340		340			350		350	572			572	
Apr 03					2,163	459	466	310		310			345		345	572			572	
Apr 04	2,041				2,041	466	318	323		323			339		339	572			572	
Apr 05	1,974				1,974	447	258	348		348			328		328	638			638	
Apr 06	2,069				2,069	425	382	370		370			317		317	666			666	
Apr 07	2,303				2,303	393	567	396		396			325		325	710			710	
Apr 08	2,535				2,535	386	779	376		376			323		323	725			725	
Apr 09	2,533				2,533	422	735	370		370			318		318	722			722	
Apr 10	2,330				2,330	420	500	250		250			300		300	704			704	
Apr 11	2,338				2,338	416	500	250		250			300		300	704			704	
Apr 12	2,294				2,294	412	500	250		250			300		300	704			704	
Apr 13	2,170	0			2,170	408	500	250	0	250			300		300	704			704	
Apr 14	2,166	0			2,166	404	500	250	0	250			300		300	704			704	
Apr 15	2,162	0			2,162	400	500	250	0	250			150		150	704			704	
Apr 16	2,158	0			2,158	396	500	250	250	500	0		150		150	704			704	M
Apr 17	2,004	0	0		2,004	392	500	250	250	500	0	475	700	0	700	704	0	796	1,500	M
Apr 18	2,000	0	0		2,000	388	500	250	250	500	0	475	700	0	700	704	0	796	1,500	M
Apr 19	2,546	250	796	0.50	3,592	384	500	250	250	500	0	475	700	0	700	704	0	796	1,500	M
Apr 20	2,542	250	796	0.99	3,588	380	500	250	250	500	0	475	700	0	700	704	0	796	1,500	M
Apr 21	2,538	250	796	1.49	3,584	376	500	250	250	500	0	475	700	0	700	704	0	796	1,500	M
Apr 22	2,534	250	796	1.98	3,580	372	500	250	250	500	0	475	700	0	700	704	0	796	1,500	M
Apr 23	2,530	250	796	2.48	3,576	368	500	250	250	500	0	475	700	0	700	704	0	796	1,500	
Apr 24	2,526	250	796	2.98	3,572	364	500	250	250	500	0	475	700	0	700	704	0	796	1,500	
Apr 25	2,522	250	796	3.47	3,568	360	500	250	225	475	0	475	700	0	700	704	0	796	1,500	
Apr 26	2,518	250	796	3.97	3,564	356	500	250	125	375	0	750	770	0	770	704	0	796	1,500	
Apr 27	2,514	250	796	4.46	3,560	352	500	250	125	375	0	1,230	900	0	900	704	0	796	1,500	
Apr 28	2,580	225	796	4.91	3,601	348	500	250	125	375	0	1,230	900	0	900	704	0	796	1,500	
Apr 29	2,706	125	796	5.16	3,627	344	500	250	125	375	0	1,230	900	0	900	704	0	796	1,500	T
Apr 30	2,702	125	796	5.40	3,623	340	500	250	125	375	0	1,230	900	0	900	704	0	796	1,500	T
May 01	2,698	125	796	5.65	3,619	336	500	250	130	380	0	1,230	900	0	900	1,500	0	0	1,500	T
May 02	2,694	125	796	5.90	3,615	332	500	250	130	380	0	1,230	900	0	900	1,500	0	0	1,500	T
May 03	3,486	125	0	6.15	3,611	328	500	250	135	385	0	1,230	900	0	900	1,500	0	0	1,500	T
May 04	3,482	130	0	6.41	3,612	324	500	250	135	385	0	1,230	900	0	900	1,500	0	0	1,500	T
May 05	3,478	130	0	6.66	3,608	320	500	250	125	375	0	1,230	900	0	900	1,500	0	0	1,500	T
May 06	3,474	135	0	6.93	3,609	316	500	250	275	525	0	1,230	900	0	900	1,500	0	0	1,500	T
May 07	3,470	135	0	7.20	3,605	312	500	250	360	610	0	750	770	0	770	1,500	0	0	1,500	T
May 08	3,466	125	0	7.45	3,591	308	500	250	360	610	0	475	700	0	700	1,500	0	0	1,500	M
May 09	3,332	275	0	7.99	3,607	304	500	250	360	610	0	475	700	0	700	1,500	0	0	1,500	M
May 10	3,258	360	0	8.71	3,618	300	500	250	360	610	0	475	700	0	700	1,500	0	0	1,500	M
May 11	3,254	360	0	9.42	3,614	296	500	250	360	610	0	475	700	0	700	1,500	0	0	1,500	M
May 12	3,250	360	0	10.14	3,610	292	500	250	360	610	0	475	700	0	700	1,500	0	0	1,500	M
May 13	3,246	360	0	10.85	3,606	288	500	250	360	610	0	475	700	0	700	1,500	0	0	1,500	M
May 14	3,242	360	0	11.56	3,602	284	500	250	360	610	0	475	700	0	700	1,500	0	0	1,500	M
May 15	3,238	360	0	12.28	3,598	280	500	250	360	610	0	475	700	0	700	1,500	0	0	1,500	M
May 16	3,234	360	0	12.99	3,594	276	500	250	360	610	0	475	700	0	700	918	0	582	1,500	
May 17	3,230	360	0	13.71	3,590	272	500	250	0	250		475	700	0	700	918	0	582	1,500	
May 18	2,644	360	582	14.42	3,586	268	500	250		250		300	345		345	918			918	
May 19	2,640	360	582	15.13	3,582	264	500	250		250			150		150	918			918	
May 20	2,281	0			2,281	260	500	250		250			150		150	918			918	
May 21	2,082	0			2,082	256	500	250		250			150		150	918			918	
May 22	2,078	0			2,078	252	500	250		250			150		150	918			918	
May 23	2,074	0			2,074	248	500	250		250			150		150	918			918	
May 24	2,070	0			2,070	244	500	250		250			150		150	918			918	
May 25	2,066	0			2,066	240	500	250		250			150		150	918			918	
May 26	2,062	0			2,062	236	500	250		250			150		150	918			918	
May 27	2,058	0			2,058	232	500	250		250			150		150	918			918	
May 28	2,054	0			2,054	228	500	250		250			150		150	918			918	
May 29	2,050	0			2,050	224	500	250		250			150		150	918			918	
May 30	2,046	0			2,046	220	500	250		250			150		150	918			918	
May 31	2,042	0			2,042	216	500	250		250			150		150	918			918	
											VAMP period									
Mean (cfs):	2,954	246			3,597	332	500		246	496	0		769	0	769		0	397	1,500	
Suppl. Water (TAF)																				
Provided		15.13							15.13		0.00			0.00			0.00	24.41		
Target		15.13							15.13		0.00			0.00			0.00			

Pulse flow period

Period of desired flow stability

DAILY OPERATION PLAN, APRIL 12

Pulse Period: April 20–May 20 • Flow Target: 4,450cfs

Ungaged Flow at Vernalis = 650cfs • 18.14 "other" supplemental water on Stanislaus R.

	San Joaquin River near Vernalis							Merced River at Cressey			Exchange Contractors	Tuolumne River at LaGrange				Stanislaus R blw Goodwin (at Orange Blossom Bridge)				
	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	VAMP Suppl. Flow	VAMP Flow (3-day lag)	VAMP Suppl. Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol.
	(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	
	[calc]	[calc]		[calc]	[calc]					[calc]					[calc]				[calc]	
Apr 01					2,071	515	639	220		220			347		347	412			412	
Apr 02					2,069	519	749	210		210			350		350	447			447	
Apr 03					2,163	527	685	180		180			345		345	463			463	
Apr 04	2,041				2,041	534	505	193		193			339		339	448			448	
Apr 05	1,978				1,978	515	433	218		218			328		328	488			488	
Apr 06	2,078				2,078	493	577	240		240			317		317	578			578	
Apr 07	2,329				2,329	461	805	266		266			325		325	650			650	
Apr 08	2,610				2,610	454	1,004	246		246			323		323	627			627	
Apr 09	2,654				2,654	490	978	240		240			318		318	592			592	
Apr 10	2,578				2,578	541	908	232		232			327		327	553			553	
Apr 11	2,478				2,478	546	832	241		241			326		326	564			564	
Apr 12	2,361				2,361	505	700	250		250			300		300	600			600	
Apr 13	2,318	0			2,318	486	650	250	0	250			300		300	600			600	
Apr 14	2,296	0			2,296	468	650	250	0	250			300		300	600			600	
Apr 15	2,286	0			2,286	450	650	250	0	250		250	250		250	600			600	
Apr 16	2,268	0			2,268	446	650	250	0	250		250	250		250	600			600	
Apr 17	2,200	0	0		2,200	442	650	250	250	500	50	250	250	0	250	600	0		600	
Apr 18	2,196	0	0		2,196	438	650	250	740	990	100	475	475	575	1,050	1,205	0	295	1,500	
Apr 19	2,192	0	0		2,192	433	650	250	840	1,090	100	475	475	360	835	1,205	0	295	1,500	
Apr 20	3,018	875	295	1.74	4,188	429	650	250	840	1,090	100	475	475	225	700	1,205	0	295	1,500	T
Apr 21	3,013	1,200	295	4.12	4,508	425	650	250	840	1,090	100	475	475	225	700	1,205	0	295	1,500	T
Apr 22	3,009	1,165	295	6.43	4,469	421	650	250	840	1,090	100	475	475	225	700	1,205	0	295	1,500	T
Apr 23	3,005	1,165	295	8.74	4,465	417	650	250	840	1,090	100	475	475	225	700	1,205	0	295	1,500	T
Apr 24	3,001	1,165	295	11.05	4,461	413	650	250	840	1,090	100	475	475	225	700	1,205	0	295	1,500	T
Apr 25	2,997	1,165	295	13.36	4,457	408	650	250	840	1,090	100	475	475	225	700	1,205	0	295	1,500	T
Apr 26	2,993	1,165	295	15.67	4,453	404	650	250	840	1,090	100	475	475	225	700	1,205	0	295	1,500	T
Apr 27	2,988	1,165	295	17.98	4,448	400	650	250	385	635	60	700	700	0	700	1,205	0	295	1,500	T
Apr 28	2,984	1,165	295	20.29	4,444	396	650	250	130	380	50	1,230	1,230	0	1,230	1,205	0	295	1,500	
Apr 29	3,205	940	295	22.16	4,440	392	650	250	130	380	50	1,230	1,230	270	1,500	1,205	0	295	1,500	
Apr 30	3,731	445	295	23.04	4,471	388	650	250	130	380	50	1,230	1,230	270	1,500	1,205	0	295	1,500	
May 01	3,727	450	295	23.93	4,472	383	650	250	130	380	50	1,230	1,230	270	1,500	1,205	0	295	1,500	
May 02	3,723	450	295	24.82	4,468	379	650	250	135	385	50	1,230	1,230	270	1,500	1,205	0	295	1,500	
May 03	3,718	450	295	25.72	4,463	375	650	250	140	390	50	1,230	1,230	270	1,500	1,205	0	295	1,500	
May 04	3,714	450	295	26.61	4,459	371	650	250	140	390	50	1,230	1,230	270	1,500	1,205	0	295	1,500	
May 05	3,710	455	295	27.51	4,460	367	650	250	140	390	50	1,230	1,230	270	1,500	1,205	0	295	1,500	
May 06	3,706	460	295	28.42	4,461	363	650	250	140	390	60	1,230	1,230	270	1,500	1,205	0	295	1,500	
May 07	3,702	460	295	29.34	4,457	358	650	250	140	390	100	1,230	1,230	270	1,500	1,205	0	295	1,500	
May 08	3,698	460	295	30.25	4,453	354	650	250	520	770	100	800	800	700	1,500	1,205	0	295	1,500	
May 09	3,693	470	295	31.18	4,458	350	650	250	725	975	100	475	475	620	1,095	1,205	0	295	1,500	M
May 10	3,259	940	295	33.04	4,494	346	650	250	725	975	100	475	475	425	900	1,205	0	295	1,500	M
May 11	2,930	1,240	295	35.50	4,465	342	650	250	725	975	100	475	475	425	900	1,205	0	295	1,500	M
May 12	2,926	1,250	295	37.98	4,471	338	650	250	725	975	100	475	475	425	900	1,205	0	295	1,500	M
May 13	2,922	1,250	295	40.46	4,467	333	650	250	725	975	100	475	475	425	900	1,205	0	295	1,500	M
May 14	2,918	1,250	295	42.94	4,463	329	650	250	725	975	100	475	475	425	900	1,205	0	295	1,500	M
May 15	2,913	1,250	295	45.42	4,458	325	650	250	725	975	100	475	475	425	900	1,205	0	295	1,500	M
May 16	2,909	1,250	295	47.90	4,454	321	650	250	725	975	100	475	475	425	900	1,205	0	295	1,500	M
May 17	2,905	1,250	295	50.38	4,450	317	650	250	725	975	50	475	475	425	900	1,205	0	295	1,500	
May 18	2,901	1,250	295	52.86	4,446	313	650	250	250	500		475	475	425	900	1,205	0	295	1,500	
May 19	2,897	1,250	295	55.34	4,442	309	650	250		250		300	300		300	600			600	
May 20	2,893	1,200	295	57.72	4,388	305	650	250		250			150		150	600			600	
May 21	2,109	250			2,359	301	650	250		250			150		150	600			600	
May 22	1,955	0			1,955	297	650	250		250			150		150	600			600	
May 23	1,951	0			1,951	293	650	250		250			150		150	600			600	
May 24	1,947	0			1,947	289	650	250		250			150		150	600			600	
May 25	1,943	0			1,943	285	650	250		250			150		150	600			600	
May 26	1,939	0			1,939	281	650	250		250			150		150	600			600	
May 27	1,935	0			1,935	277	650	250		250			150		150	600			600	
May 28	1,931	0			1,931	273	650	250		250			150		150	600			600	
May 29	1,927	0			1,927	269	650	250		250			150		150	600			600	
May 30	1,923	0			1,923	265	650	250		250			150		150	600			600	
May 31	1,919	0			1,919	261	650	250		250			150		150	600			600	
											VAMP period									
Mean (cfs):	3,216	939			4,450	375	650		532	782	81		736	325	1,062	1,205	0	295	1,500	
Suppl. Water (TAF)																				
Provided		57.72							32.72		5.00			20.00			0.00	18.14		
Target		57.72							32.72		5.00			20.00			0.00			

Pulse flow period

Period of desired flow stability

DAILY OPERATION PLAN, APRIL 16

Pulse Period: April 20–May 20 • Flow Target: 4,450cfs

Ungaged Flow at Vernalis = 650cfs • 2.8 TAF "other" supplemetntal water on Stanislaus R.

	San Joaquin River near Vernalis							Merced River at Cressey			Exchange Contractors	Tuolumne River at LaGrange				Stanislaus R blw Goodwin (at Orange Blossom Bridge)				
	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	VAMP Suppl. Flow	VAMP Flow (3-day lag)	VAMP Suppl. Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol.
	(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	
	[calc]	[calc]		[calc]	[calc]					[calc]					[calc]				[calc]	
Apr 01					2,071	515	639	220		220			347		347	410			410	
Apr 02					2,069	519	749	210		210			350		350	450			450	
Apr 03					2,163	527	685	180		180			345		345	460			460	
Apr 04	2,044				2,041	534	505	193		193			339		339	450			450	
Apr 05	1,975				1,978	515	433	218		218			328		328	490			490	
Apr 06	2,080				2,078	493	577	240		240			317		317	580			580	
Apr 07	2,331				2,329	461	805	266		266			325		325	650			650	
Apr 08	2,612				2,610	454	1,004	246		246			323		323	630			630	
Apr 09	2,654				2,654	490	978	240		240			318		318	590			590	
Apr 10	2,581				2,578	541	908	232		232			327		327	550			550	
Apr 11	2,476				2,478	546	832	241		241			326		326	560			560	
Apr 12	2,429				2,432	547	771	245		245			328		328	570			570	
Apr 13	2,428	0			2,432	545	764	253		253			329		329	570			570	
Apr 14	2,425	0			2,422	499	739	255		255			319		319	570			570	
Apr 15	2,419	0			2,423	469	730	263		263		250	256		256	570			570	
Apr 16	2,291	0			2,291	446	650	250	0	250		250	250		250	600			600	
Apr 17	2,200	0	0		2,200	442	650	250	140	390	0	250	250	0	250	600	0		600	
Apr 18	2,209	0	0		2,209	438	650	250	180	430	0	475	475	825	1,300	1,205	250	45	1,500	
Apr 19	2,192	0	0		2,192	433	650	250	585	835	50	475	475	825	1,300	1,205	250	45	1,500	
Apr 20	3,018	1,215	45	2.41	4,278	429	650	250	950	1,200	150	475	475	425	900	1,205	250	45	1,500	T
Apr 21	3,013	1,255	45	4.90	4,313	425	650	250	950	1,200	150	475	475	135	610	1,205	250	45	1,500	T
Apr 22	3,009	1,310	45	7.50	4,364	421	650	250	900	1,150	150	475	475	135	610	1,205	250	45	1,500	T
Apr 23	3,005	1,485	45	10.44	4,535	417	650	250	900	1,150	150	475	475	135	610	1,205	250	45	1,500	T
Apr 24	3,001	1,485	45	13.39	4,531	413	650	250	900	1,150	150	475	475	135	610	1,205	250	45	1,500	T
Apr 25	2,997	1,435	45	16.23	4,477	408	650	250	900	1,150	150	475	475	135	610	1,205	250	45	1,500	T
Apr 26	2,993	1,435	45	19.08	4,473	404	650	250	850	1,100	150	475	475	135	610	1,205	250	45	1,500	T
Apr 27	2,988	1,435	45	21.93	4,468	400	650	250	400	650	150	700	650	0	650	1,205	250	45	1,500	T
Apr 28	2,984	1,435	45	24.77	4,464	396	650	250	350	600	150	1,230	1,230	0	1,230	1,205	200	45	1,450	
Apr 29	3,155	1,250	45	27.25	4,450	392	650	250	250	500	100	1,230	1,230	0	1,230	1,205	200	45	1,450	
Apr 30	3,731	750	45	28.74	4,526	388	650	250	250	500	100	1,230	1,230	160	1,390	1,205	200	45	1,450	
May 01	3,727	700	45	30.13	4,472	383	650	250	250	500	100	1,230	1,230	160	1,390	1,205	200	45	1,450	
May 02	3,723	710	45	31.54	4,478	379	650	250	250	500	100	1,230	1,230	160	1,390	1,205	200	45	1,450	
May 03	3,718	710	45	32.95	4,473	375	650	250	250	500	100	1,230	1,230	160	1,390	1,205	200	45	1,450	
May 04	3,714	710	45	34.35	4,469	371	650	250	250	500	100	1,230	1,230	160	1,390	1,205	220	45	1,470	
May 05	3,710	710	45	35.76	4,465	367	650	250	250	500	100	1,230	1,230	160	1,390	1,205	230	45	1,480	
May 06	3,706	730	45	37.21	4,481	363	650	250	250	500	100	1,230	1,230	160	1,390	1,205	230	45	1,480	
May 07	3,702	740	45	38.68	4,487	358	650	250	550	800	130	1,230	1,230	160	1,390	1,205	230	45	1,480	
May 08	3,698	740	45	40.15	4,483	354	650	250	700	950	150	800	850	180	1,030	1,205	250	45	1,500	
May 09	3,693	740	45	41.61	4,478	350	650	250	800	1,050	150	475	475	420	895	1,205	250	45	1,500	M
May 10	3,309	1,110	45	43.81	4,464	346	650	250	800	1,050	150	475	475	290	765	1,205	250	45	1,500	M
May 11	2,930	1,520	45	46.83	4,495	342	650	250	800	1,050	150	475	475	290	765	1,205	250	45	1,500	M
May 12	2,926	1,490	45	49.79	4,461	338	650	250	800	1,050	150	475	475	290	765	1,205	250	45	1,500	M
May 13	2,922	1,490	45	52.74	4,457	333	650	250	800	1,050	150	475	475	290	765	1,205	250	45	1,500	M
May 14	2,918	1,490	45	55.70	4,453	329	650	250	800	1,050	150	475	475	290	765	1,205	250	45	1,500	M
May 15	2,913	1,490	45	58.65	4,448	325	650	250	800	1,050	150	475	475	290	765	1,205	250	45	1,500	M
May 16	2,909	1,490	45	61.61	4,444	321	650	250	800	1,050	100	475	475	290	765	1,205	250	45	1,500	M
May 17	2,905	1,490	45	64.56	4,440	317	650	250	790	1,040	50	475	475	290	765	1,205	250	45	1,500	
May 18	2,901	1,490	45	67.52	4,436	313	650	250	250	500		475	475	275	750	1,205	250	45	1,500	
May 19	2,897	1,440	45	70.37	4,382	309	650	250		250		300	300		300	600			600	
May 20	2,893	1,365	45	73.08	4,303	305	650	250		250			150		150	600			600	
May 21	2,109	250			2,359	301	650	250		250			150		150	600			600	
May 22	1,955	0			1,955	297	650	250		250			150		150	600			600	
May 23	1,951	0			1,951	293	650	250		250			150		150	600			600	
May 24	1,947	0			1,947	289	650	250		250			150		150	600			600	
May 25	1,943	0			1,943	285	650	250		250			150		150	600			600	
May 26	1,939	0			1,939	281	650	250		250			150		150	600			600	
May 27	1,935	0			1,935	277	650	250		250			150		150	600			600	
May 28	1,931	0			1,931	273	650	250		250			150		150	600			600	
May 29	1,927	0			1,927	269	650	250		250			150		150	600			600	
May 30	1,923	0			1,923	265	650	250		250			150		150	600			600	
May 31	1,919	0			1,919	261	650	250		250			150		150	600			600	
	VAMP period																			
Mean (cfs):	3,216	1,189			4,450	375	650		595	845	119		736	237	974	1,205	237	45	1,487	
Suppl. Water (TAF)																				
Provided		73.08							36.59		7.30			14.60			14.60	2.77		
Target		73.09							36.59		7.30			14.60			14.60			

Pulse flow period

Period of desired flow stability

DAILY OPERATION PLAN, APRIL 23

Pulse Period: April 20–May 20 • Flow Target: 4,450cfs

Ungaged Flow at Vernalis = 650cfs • 2.8 TAF "other" supplemetntal water on Stanislaus R.

San Joaquin River near Vernalis							Merced River at Cressey			Exchange Contractors	Tuolumne River at LaGrange				Stanislaus R blw Goodwin (at Orange Blossom Bridge)					
Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	VAMP Suppl. Flow	VAMP Flow (3-day lag)	VAMP Suppl. Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	VAMP Flow (2-day lag)	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	VAMP Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol.	
(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		
[calc]	[calc]		[calc]	[calc]					[calc]					[calc]				[calc]		
				2,071	515	534	220		220			347		347	407			407		Apr 01
				2,069	519	543	210		210			350		350	409			409		Apr 02
				2,163	527	560	180		180			345		345	411			411		Apr 03
1,911				2,041	534	413	193		193			339		339	439			439		Apr 04
1,848				1,978	515	355	218		218			328		328	558			558		Apr 05
1,948				2,078	493	456	240		240			317		317	556			556		Apr 06
2,199				2,329	461	605	266		266			325		325	551			551		Apr 07
2,480				2,610	454	896	246		246			323		323	561			561		Apr 08
2,524				2,654	490	947	240		240			318		318	347			347		Apr 09
2,448				2,578	541	844	232		232			327		327	548			548		Apr 10
2,348				2,478	546	947	241		241			326		326	551			551		Apr 11
2,302				2,432	547	646	245		245			328		328	551			551		Apr 12
2,432	0			2,432	545	777	253		253			329		329	550			550		Apr 13
2,422	0			2,422	499	755	255		255			319		319	555			555		Apr 14
2,423	0			2,423	469	754	263		263		250	256		256	548			548		Apr 15
2,489	0			2,489	453	863	261	0	261		250	255		255	552			552		Apr 16
2,284	0	0		2,284	422	756	250	124	374	0	250	255	0	255	553	0		553		Apr 17
2,128	0	0		2,128	357	605	250	172	422	0	475	475	667	1,142	1,205	0	0	967		Apr 18
2,206	0	0		2,206	282	715	250	585	835	50	475	475	966	1,441	1,205	311	90	1,606		Apr 19
2,984	791	0	1.57	3,537	203	697	250	939	1,189	150	475	475	547	1,022	1,205	260	45	1,510	T	Apr 20
3,067	1,449	90	4.44	4,606	239	855	250	1,009	1,259	150	475	475	150	625	1,205	254	45	1,504	T	Apr 21
3,310	1,442	45	7.30	4,796	379	1,177	250	999	1,249	150	475	475	148	623	1,205	251	45	1,501	T	Apr 22
3,169	1,493	45	10.26	4,707	417	1,000	250	900	1,150	150	475	475	135	610	1,205	200	45	1,450	T	Apr 23
2,959	1,558	45	13.35	4,562	413	650	250	900	1,150	150	475	475	135	610	1,205	150	45	1,400	T	Apr 24
2,997	1,484	45	16.30	4,526	408	650	250	900	1,150	150	475	475	135	610	1,205	200	45	1,450	T	Apr 25
2,993	1,335	45	18.95	4,373	404	650	250	900	1,150	150	475	475	135	610	1,205	235	45	1,485	T	Apr 26
2,988	1,385	45	21.69	4,418	400	650	250	900	1,150	150	700	610	0	610	1,205	250	45	1,500	T	Apr 27
2,984	1,420	45	24.51	4,449	396	650	250	350	600	150	1,230	650	0	650	1,205	250	45	1,500		Apr 28
3,115	1,300	45	27.09	4,460	392	650	250	200	450	100	1,230	1,230	0	1,230	1,205	250	45	1,500		Apr 29
3,151	1,300	45	29.67	4,496	388	650	250	200	450	100	1,230	1,230	130	1,360	1,205	250	45	1,500		Apr 30
3,727	750	45	31.15	4,522	383	650	250	200	450	100	1,230	1,230	130	1,360	1,205	250	45	1,500		May 01
3,723	680	45	32.50	4,448	379	650	250	200	450	100	1,230	1,230	130	1,360	1,205	250	45	1,500		May 02
3,718	680	45	33.85	4,443	375	650	250	200	450	100	1,230	1,230	130	1,360	1,205	250	45	1,500		May 03
3,714	680	45	35.20	4,439	371	650	250	200	450	100	1,230	1,230	130	1,360	1,205	250	45	1,500		May 04
3,710	680	45	36.55	4,435	367	650	250	200	450	100	1,230	1,230	130	1,360	1,205	250	45	1,500		May 05
3,706	680	45	37.90	4,431	363	650	250	200	450	100	1,230	1,230	130	1,360	1,205	250	45	1,500		May 06
3,702	680	45	39.25	4,427	358	650	250	535	785	130	1,230	1,230	130	1,360	1,205	250	45	1,500		May 07
3,698	680	45	40.60	4,423	354	650	250	640	890	150	800	850	135	985	1,205	250	45	1,500		May 08
3,693	680	45	41.94	4,418	350	650	250	775	1,025	150	475	535	355	890	1,205	250	45	1,500	M	May 09
3,309	1,050	45	44.03	4,404	346	650	250	775	1,025	150	475	535	265	800	1,205	250	45	1,500	M	May 10
2,990	1,395	45	46.79	4,430	342	650	250	775	1,025	150	475	535	265	800	1,205	250	45	1,500	M	May 11
2,986	1,440	45	49.65	4,471	338	650	250	775	1,025	150	475	535	265	800	1,205	250	45	1,500	M	May 12
2,982	1,440	45	52.51	4,467	333	650	250	775	1,025	150	475	535	265	800	1,205	250	45	1,500	M	May 13
2,978	1,440	45	55.36	4,463	329	650	250	775	1,025	150	475	535	265	800	1,205	250	45	1,500	M	May 14
2,973	1,440	45	58.22	4,458	325	650	250	775	1,025	150	475	535	265	800	1,205	250	45	1,500	M	May 15
2,969	1,440	45	61.08	4,454	321	650	250	775	1,025	100	475	535	265	800	1,205	250	45	1,500	M	May 16
2,965	1,440	45	63.93	4,450	317	650	250	750	1,000	50	475	535	265	800	1,205	250	45	1,500		May 17
2,961	1,440	45	66.79	4,446	313	650	250	250	500		475	535	265	800	1,205	250	45	1,500		May 18
2,957	1,390	45	69.54	4,392	309	650	250		250		300	300		300	600			600		May 19
2,953	1,315	45	72.15	4,313	305	650	250		250			150		150	600			600		May 20
2,109	250			2,359	301	650	250		250			150		150	600			600		May 21
1,955	0			1,955	297	650	250		250			150		150	600			600		May 22
1,951	0			1,951	293	650	250		250			150		150	600			600		May 23
1,947	0			1,947	289	650	250		250			150		150	600			600		May 24
1,943	0			1,943	285	650	250		250			150		150	600			600		May 25
1,939	0			1,939	281	650	250		250			150		150	600			600		May 26
1,935	0			1,935	277	650	250		250			150		150	600			600		May 27
1,931	0			1,931	273	650	250		250			150		150	600			600		May 28
1,927	0			1,927	269	650	250		250			150		150	600			600		May 29
1,923	0			1,923	265	650	250		250			150		150	600			600		May 30
1,919	0			1,919	261	650	250		250			150		150	600			600		May 31
VAMP period																				
3,230	1,173			4,441	353	686		594	844	119		736	224	959	1,205	237	45	1,480		Mean (cfs):
																				Suppl. Water (TAF)
	72.15							36.50		7.30			13.75			14.60	2.77			Provided
	72.25							36.50		7.30			13.85			14.60				Target

Pulse flow period

Period of desired flow stability

DAILY OPERATION PLAN, MAY 2

Pulse Period: April 20–May 20 • Flow Target: 4,450cfs

Ungaged Flow at Vernalis=650cfs • 2.8 TAF "other" supplemetntal water on Stanislaus R.

Date	San Joaquin River near Vernalis: Existing Flow (cfs)	VAMP Suppl. Flow (cfs) [calc]	Other Suppl. Flow (cfs)	Cum. VAMP Suppl. Flow (TAF) [calc]	VAMP Flow (cfs) [calc]	SJR above Merced R. (2-day lag) (cfs)	Ungaged Flow above Vernalis (cfs)	Merced River at Cressey: Existing Flow (cfs)	VAMP Suppl. Flow (cfs)	VAMP Flow (3-day lag) (cfs) [calc]	Exchange Contractors: VAMP Suppl. Flow (3-day lag) (cfs)	Tuolumne River at LaGrange: Desired FERC Pulse (cfs)	Existing Flow – Adjusted FERC Pulse (cfs)	VAMP Suppl. Flow (cfs)	VAMP Flow (2-day lag) (cfs) [calc]	Stanislaus R blw Goodwin (at Orange Blossom Bridge): Existing Flow (cfs)	VAMP Suppl. Flow (cfs)	Other Suppl. Flow (cfs)	VAMP Flow (2-day lag) (cfs) [calc]	Maintain Priority Flow Level M=Merced T=Tuol.
Apr 01					2,071	515	534	220		220			347		347	407			407	
Apr 02					2,069	519	543	210		210			350		350	409			409	
Apr 03					2,163	527	560	180		180			345		345	411			411	
Apr 04	1,911				2,041	534	413	193		193			339		339	439			439	
Apr 05	1,848				1,978	515	355	218		218			328		328	558			558	
Apr 06	1,948				2,078	493	456	240		240			317		317	556			556	
Apr 07	2,199				2,329	461	605	266		266			325		325	551			551	
Apr 08	2,480				2,610	454	896	246		246			323		323	561			561	
Apr 09	2,524				2,654	490	947	240		240			318		318	347			347	
Apr 10	2,448				2,578	541	844	232		232			327		327	548			548	
Apr 11	2,348				2,478	546	947	241		241			326		326	551			551	
Apr 12	2,302				2,432	547	646	245		245			328		328	551			551	
Apr 13	2,432	0			2,432	545	777	253		253			329		329	550			550	
Apr 14	2,422	0			2,422	499	755	255		255			319		319	555			555	
Apr 15	2,423	0			2,423	469	754	263		263		250	256		256	548			548	
Apr 16	2,489	0			2,489	453	863	261	0	261		250	255		255	552			552	
Apr 17	2,284	0	0		2,284	422	756	250	124	374	0	250	255	0	255	553	0		553	
Apr 18	2,135	0	0		2,135	357	612	250	172	422	0	475	475	667	1,142	1,205	0	0	967	
Apr 19	2,214	0	0		2,206	282	723	250	585	835	50	475	475	966	1,441	1,205	311	90	1,606	
Apr 20	2,994	791	0	1.57	3,537	202	707	250	939	1,189	150	475	475	547	1,022	1,205	260	45	1,510	T
Apr 21	3,078	1,449	90	4.44	4,606	236	866	250	1,009	1,259	150	475	475	150	625	1,205	254	45	1,504	T
Apr 22	3,323	1,442	45	7.30	4,796	376	1,192	250	999	1,249	150	475	475	148	623	1,205	251	45	1,501	T
Apr 23	3,187	1,493	45	10.26	4,714	519	1,022	250	970	1,220	150	475	475	148	623	1,205	212	45	1,462	T
Apr 24	3,102	1,558	45	13.35	4,695	509	797	250	978	1,228	150	475	475	147	622	1,205	149	45	1,399	T
Apr 25	3,031	1,509	45	16.35	4,585	450	583	250	982	1,232	150	475	475	149	624	1,205	176	45	1,426	T
Apr 26	2,913	1,416	45	19.16	4,372	392	475	250	999	1,249	150	475	475	147	622	1,205	249	45	1,499	T
Apr 27	2,903	1,453	45	22.04	4,400	351	523	250	1,010	1,260	150	700	610	9	619	1,205	252	45	1,502	T
Apr 28	2,901	1,528	45	25.07	4,473	406	579	250	435	685	150	1,230	650	4	654	1,205	252	45	1,502	
Apr 29	3,027	1,410	45	27.87	4,482	381	612	250	324	574	100	1,230	1,230	0	1,221	1,205	254	45	1,504	
Apr 30	2,903	1,416	45	30.67	4,364	362	393	250	298	548	100	1,230	1,230	140	1,370	1,205	251	45	1,501	
May 01	3,556	839	45	32.34	4,431	361	491	250	271	521	100	1,230	1,230	145	1,375	1,205	254	45	1,504	
May 02	3,697	815	45	33.96	4,557	379	650	250	200	450	100	1,230	1,230	130	1,360	1,205	250	45	1,500	
May 03	3,696	797	45	35.54	4,538	375	650	250	200	450	100	1,230	1,230	130	1,360	1,205	250	45	1,500	
May 04	3,714	751	45	37.03	4,510	371	650	250	200	450	100	1,230	1,230	130	1,360	1,205	250	45	1,500	
May 05	3,710	680	45	38.37	4,435	367	650	250	200	450	100	1,230	1,230	130	1,360	1,205	250	45	1,500	
May 06	3,706	680	45	39.72	4,431	363	650	250	200	450	100	1,230	1,230	130	1,360	1,205	250	45	1,500	
May 07	3,702	680	45	41.07	4,427	358	650	250	535	785	130	1,230	1,230	130	1,360	1,205	250	45	1,500	
May 08	3,698	680	45	42.42	4,423	354	650	250	640	890	150	800	850	135	985	1,205	250	45	1,500	
May 09	3,693	680	45	43.77	4,418	350	650	250	775	1,025	150	475	535	355	890	1,205	250	45	1,500	M
May 10	3,309	1,050	45	45.85	4,404	346	650	250	775	1,025	150	475	535	265	800	1,205	250	45	1,500	M
May 11	2,990	1,395	45	48.62	4,430	342	650	250	775	1,025	150	475	535	265	800	1,205	250	45	1,500	M
May 12	2,986	1,440	45	51.48	4,471	338	650	250	775	1,025	150	475	535	265	800	1,205	250	45	1,500	M
May 13	2,982	1,440	45	54.33	4,467	333	650	250	775	1,025	150	475	535	265	800	1,205	250	45	1,500	M
May 14	2,978	1,440	45	57.19	4,463	329	650	250	775	1,025	150	475	535	265	800	1,205	250	45	1,500	M
May 15	2,973	1,440	45	60.04	4,458	325	650	250	775	1,025	150	475	535	265	800	1,205	250	45	1,500	M
May 16	2,969	1,440	45	62.90	4,454	321	650	250	775	1,025	100	475	535	265	800	1,205	250	45	1,500	M
May 17	2,965	1,440	45	65.76	4,450	317	650	250	750	1,000	50	475	535	265	800	1,205	250	45	1,500	
May 18	2,961	1,440	45	68.61	4,446	313	650	250	250	500		475	535	265	800	1,205	250	45	1,500	
May 19	2,957	1,390	45	71.37	4,392	309	650	250		250		300	300		300	600			600	
May 20	2,953	1,315	45	73.98	4,313	305	650	250		250			150		150	600			600	
May 21	2,109	250			2,359	301	650	250		250			150		150	600			600	
May 22	1,955	0			1,955	297	650	250		250			150		150	600			600	
May 23	1,951	0			1,951	293	650	250		250			150		150	600			600	
May 24	1,947	0			1,947	289	650	250		250			150		150	600			600	
May 25	1,943	0			1,943	285	650	250		250			150		150	600			600	
May 26	1,939	0			1,939	281	650	250		250			150		150	600			600	
May 27	1,935	0			1,935	277	650	250		250			150		150	600			600	
May 28	1,931	0			1,931	273	650	250		250			150		150	600			600	
May 29	1,927	0			1,927	269	650	250		250			150		150	600			600	
May 30	1,923	0			1,923	265	650	250		250			150		150	600			600	
May 31	1,919	0			1,919	261	650	250		250			150		150	600			600	
VAMP period																				
Mean (cfs):	3,211	1,203			4,450	357	664		620	870	119		736	227	962	1,205	238	45	1,480	
Suppl. Water (TAF) Provided		73.98							38.12		7.30			13.93			14.63	2.77		
Target		73.39							36.89		7.30			14.60			14.60			

Pulse flow period

Period of desired flow stability

DAILY OPERATION PLAN, MAY 4

Pulse Period: April 20–May 20 • Flow Target: 4,450cfs

Ungaged Flow at Vernalis=500cfs • 1.4 TAF "other" supplemetntal water on Stanislaus R.

Date	San Joaquin River near Vernalis: Existing Flow (cfs)	VAMP Suppl. Flow (cfs) [calc]	Other Suppl. Flow (cfs)	Cum. VAMP Suppl. Flow (TAF) [calc]	VAMP Flow (cfs) [calc]	SJR above Merced R. (2-day lag) (cfs)	Ungaged Flow above Vernalis (cfs)	Merced River at Cressey: Existing Flow (cfs)	VAMP Suppl. Flow (cfs)	VAMP Flow (3-day lag) (cfs) [calc]	Exchange Contractors: VAMP Suppl. Flow (3-day lag) (cfs)	Tuolumne River at LaGrange: Desired FERC Pulse (cfs)	Existing Flow – Adjusted FERC Pulse (cfs)	VAMP Suppl. Flow (cfs)	VAMP Flow (2-day lag) (cfs) [calc]	Stanislaus R blw Goodwin (at Orange Blossom Bridge): Existing Flow (cfs)	VAMP Suppl. Flow (cfs)	Other Suppl. Flow (cfs)	VAMP Flow (2-day lag) (cfs) [calc]	Maintain Priority Flow Level M=Merced T=Tuol.
Apr 01					2,071	515	534	220		220			347		347	407			407	
Apr 02					2,069	519	543	210		210			350		350	409			409	
Apr 03					2,163	527	560	180		180			345		345	411			411	
Apr 04	1,911				2,041	534	413	193		193			339		339	439			439	
Apr 05	1,848				1,978	515	355	218		218			328		328	558			558	
Apr 06	1,948				2,078	493	456	240		240			317		317	556			556	
Apr 07	2,199				2,329	461	605	266		266			325		325	551			551	
Apr 08	2,480				2,610	454	896	246		246			323		323	561			561	
Apr 09	2,524				2,654	490	947	240		240			318		318	347			347	
Apr 10	2,448				2,578	541	844	232		232			327		327	548			548	
Apr 11	2,348				2,478	546	947	241		241			326		326	551			551	
Apr 12	2,302				2,432	547	646	245		245			328		328	551			551	
Apr 13	2,432	0			2,432	545	777	253		253			329		329	550			550	
Apr 14	2,422	0			2,422	499	755	255		255			319		319	555			555	
Apr 15	2,423	0			2,423	469	754	263		263		250	256		256	548			548	
Apr 16	2,489	0			2,489	453	863	261	0	261		250	255		255	552			552	
Apr 17	2,284	0	0		2,284	422	756	250	124	374	0	250	255	0	255	553	0		553	
Apr 18	2,135	0	0		2,135	357	612	250	172	422	0	475	475	667	1,142	1,205	0	0	967	
Apr 19	2,014	0	0		2,206	282	523	250	535	785	50	475	475	966	1,441	1,205	311	90	1,606	
Apr 20	2,794	791	0	1.57	3,347	202	507	250	889	1,139	150	475	475	547	1,022	1,205	260	45	1,510	T
Apr 21	2,878	1,449	90	4.44	4,417	236	666	250	959	1,209	150	475	475	150	625	1,205	254	45	1,504	T
Apr 22	3,123	1,392	45	7.20	4,560	376	992	250	949	1,199	150	475	475	148	623	1,205	251	45	1,501	T
Apr 23	2,987	1,443	45	10.07	4,475	519	822	250	920	1,170	150	475	475	148	623	1,205	212	45	1,462	T
Apr 24	2,902	1,508	45	13.06	4,455	509	597	250	928	1,178	150	475	475	147	622	1,205	149	45	1,399	T
Apr 25	2,831	1,459	45	15.95	4,335	450	383	250	932	1,182	150	475	475	149	624	1,205	176	45	1,426	T
Apr 26	2,713	1,366	45	18.66	4,124	392	275	250	949	1,199	150	475	475	147	622	1,205	249	45	1,499	T
Apr 27	2,703	1,403	45	21.44	4,151	351	323	250	960	1,210	150	700	610	9	619	1,205	252	45	1,502	T
Apr 28	2,701	1,478	45	24.37	4,224	406	379	250	385	635	150	1,230	650	4	654	1,205	252	45	1,502	
Apr 29	2,827	1,360	45	27.07	4,232	381	412	250	274	524	100	1,230	1,230	0	1,221	1,205	254	45	1,504	
Apr 30	2,703	1,366	45	29.78	4,114	362	193	250	248	498	100	1,230	1,230	140	1,370	1,205	251	45	1,501	
May 01	3,356	789	45	31.35	4,181	361	291	250	221	471	100	1,230	1,230	145	1,375	1,205	254	45	1,504	
May 02	3,392	765	45	32.86	4,202	340	345	250	225	475	100	1,230	1,230	139	1,369	1,205	253	45	1,503	
May 03	3,436	747	45	34.35	4,228	287	390	250	202	452	100	1,230	1,230	143	1,373	1,205	251	45	1,501	
May 04	3,425	713	45	35.76	4,183	371	400	250	200	450	100	1,230	1,230	130	1,360	1,205	295	0	1,500	
May 05	3,472	719	45	37.19	4,236	367	500	250	200	450	100	1,230	1,230	130	1,360	1,205	295	0	1,500	
May 06	3,556	727	0	38.63	4,283	363	500	250	200	450	100	1,230	1,230	130	1,360	1,205	295	0	1,500	
May 07	3,552	725	0	40.07	4,277	358	500	250	535	785	150	1,230	1,230	130	1,360	1,205	295	0	1,500	
May 08	3,548	725	0	41.50	4,273	354	500	250	640	890	200	800	850	135	985	1,205	295	0	1,500	
May 09	3,543	725	0	42.94	4,268	350	500	250	1,000	1,250	200	475	535	355	890	1,205	295	0	1,500	M
May 10	3,159	1,115	0	45.15	4,274	346	500	250	1,000	1,250	200	475	535	265	800	1,205	295	0	1,500	M
May 11	2,840	1,490	0	48.11	4,330	342	500	250	1,000	1,250	200	475	535	265	800	1,205	295	0	1,500	M
May 12	2,836	1,760	0	51.60	4,596	338	500	250	1,000	1,250	200	475	535	265	800	1,205	295	0	1,500	M
May 13	2,832	1,760	0	55.09	4,592	333	500	250	1,000	1,250	200	475	535	265	800	1,205	295	0	1,500	M
May 14	2,828	1,760	0	58.58	4,588	329	500	250	1,000	1,250	200	475	535	265	800	1,205	295	0	1,500	M
May 15	2,823	1,760	0	62.07	4,583	325	500	250	1,000	1,250	150	475	535	265	800	1,205	295	0	1,500	M
May 16	2,819	1,760	0	65.56	4,579	321	500	250	1,000	1,250	100	475	535	265	800	1,205	295	0	1,500	M
May 17	2,815	1,760	0	69.05	4,575	317	500	250	750	1,000	50	475	535	265	800	1,205	295	0	1,500	
May 18	2,811	1,710	0	72.45	4,521	313	500	250	250	500		475	535	265	800	1,205	295	0	1,500	
May 19	2,807	1,660	0	75.74	4,467	309	500	250		250		300	300		300	600			600	
May 20	2,803	1,360	0	78.44	4,163	305	500	250		250			150		150	600			600	
May 21	1,959	250			2,209	301	500	250		250			150		150	600			600	
May 22	1,805	0			1,805	297	500	250		250			150		150	600			600	
May 23	1,801	0			1,801	293	500	250		250			150		150	600			600	
May 24	1,797	0			1,797	289	500	250		250			150		150	600			600	
May 25	1,793	0			1,793	285	500	250		250			150		150	600			600	
May 26	1,789	0			1,789	281	500	250		250			150		150	600			600	
May 27	1,785	0			1,785	277	500	250		250			150		150	600			600	
May 28	1,781	0			1,781	273	500	250		250			150		150	600			600	
May 29	1,777	0			1,777	269	500	250		250			150		150	600			600	
May 30	1,773	0			1,773	265	500	250		250			150		150	600			600	
May 31	1,769	0			1,769	261	500	250		250			150		150	600			600	
VAMP period																				
Mean (cfs):	3,026	1,276			4,317	353	483		658	908	131		736	227	963	1,205	260	23	1,480	
Suppl. Water (TAF) Provided		78.44							40.46		8.03			13.97			15.97	1.43		
Target		86.12							45.00		8.52			14.60			18.00			

Pulse flow period

Period of desired flow stability

DAILY OPERATION PLAN, MAY 7

Pulse Period: April 20–May 20 • Flow Target: 4,450cfs

Ungaged Flow at Vernalis = 500cfs • 2.8 TAF "other" supplemetntal water on Stanislaus R.

	San Joaquin River near Vernalis							Merced River at Cressey			Exchange Contractors	Tuolumne River at LaGrange				Stanislaus R blw Goodwin (at Orange Blossom Bridge)				
	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	VAMP Suppl. Flow	Flow (3-day lag)	VAMP Suppl. Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	Flow (2-day lag)	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol.
	(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	
	[calc]	[calc]		[calc]	[calc]					[calc]					[calc]				[calc]	
Apr 01					2,070	515	663	220		220			347		347	407			407	
Apr 02					2,170	519	674	210		210			350		350	409			409	
Apr 03					2,160	527	687	180		180			345		345	411			411	
Apr 04	2,040				2,040	534	542	193		193			339		339	439			439	
Apr 05	1,980				1,980	515	487	218		218			328		328	558			558	
Apr 06	2,080				2,080	493	588	240		240			317		317	556			556	
Apr 07	2,330				2,330	461	736	266		266			325		325	551			551	
Apr 08	2,610				2,610	454	1,026	246		246			323		323	561			561	
Apr 09	2,660				2,660	490	1,083	240		240			318		318	347			347	
Apr 10	2,580				2,580	541	976	232		232			327		327	548			548	
Apr 11	2,480				2,480	546	1,079	241		241			326		326	551			551	
Apr 12	2,430				2,430	547	774	245		245			328		328	551			551	
Apr 13	2,430	0			2,430	545	775	253		253			329		329	550			550	
Apr 14	2,420	0			2,420	499	753	255		255			319		319	555			555	
Apr 15	2,420	0			2,420	469	751	263		263		250	256		256	548			548	
Apr 16	2,490	0			2,490	453	864	261	0	261		250	255		255	552			552	
Apr 17	2,280	0	0		2,280	422	752	250	74	324	0	250	255	0	255	553	0		553	
Apr 18	2,130	0	0		2,130	357	607	250	122	372	0	475	475	667	1,142	1,205	0	0	967	
Apr 19	2,200	0	0		2,200	282	709	250	535	785	50	475	475	966	1,441	1,205	311	90	1,606	
Apr 20	2,937	741	0	1.47	3,440	202	650	250	889	1,139	150	475	475	547	1,022	1,205	260	45	1,510	T
Apr 21	2,911	1,399	90	4.24	4,400	236	699	250	959	1,209	150	475	475	150	625	1,205	254	45	1,504	T
Apr 22	3,093	1,392	45	7.01	4,530	376	962	250	949	1,199	150	475	475	148	623	1,205	251	45	1,501	T
Apr 23	2,952	1,443	45	9.87	4,440	519	787	250	920	1,170	150	475	475	148	623	1,205	212	45	1,462	T
Apr 24	2,877	1,508	45	12.86	4,430	509	572	250	928	1,178	150	475	475	147	622	1,205	149	45	1,399	T
Apr 25	2,806	1,459	45	15.75	4,310	450	358	250	932	1,182	150	475	475	149	624	1,205	176	45	1,426	T
Apr 26	2,691	1,366	45	18.46	4,102	392	253	250	949	1,199	150	475	475	147	622	1,205	249	45	1,499	T
Apr 27	2,682	1,403	45	21.24	4,130	351	303	250	960	1,210	150	700	610	9	619	1,205	252	45	1,502	T
Apr 28	2,677	1,478	45	24.18	4,200	406	356	250	385	635	150	1,230	650	4	654	1,205	252	45	1,502	
Apr 29	2,805	1,360	45	26.87	4,210	382	390	250	274	524	100	1,230	1,230	0	1,221	1,205	254	45	1,504	
Apr 30	2,679	1,366	45	29.58	4,090	366	169	250	248	498	100	1,230	1,230	140	1,370	1,205	251	45	1,501	
May 01	3,335	789	45	31.15	4,160	360	269	250	221	471	100	1,230	1,230	145	1,375	1,205	254	45	1,504	
May 02	3,370	765	45	32.67	4,180	346	319	250	225	475	100	1,230	1,230	139	1,369	1,205	253	45	1,503	
May 03	3,438	747	45	34.15	4,230	287	393	250	202	452	100	1,230	1,230	143	1,373	1,205	251	45	1,501	
May 04	3,352	713	45	35.56	4,110	281	321	250	199	449	100	1,230	1,230	134	1,364	1,205	255	45	1,505	
May 05	3,296	719	45	36.99	4,060	282	324	250	192	442	100	1,230	1,230	106	1,336	1,205	249	45	1,499	
May 06	3,374	691	45	38.36	4,110	296	408	250	209	459	100	1,230	1,230	140	1,370	1,205	250	45	1,500	
May 07	3,467	654	45	39.66	4,166	358	500	250	535	785	130	1,230	1,230	130	1,360	1,205	250	45	1,500	
May 08	3,481	682	45	41.01	4,208	354	500	250	640	890	150	800	850	135	985	1,205	250	45	1,500	
May 09	3,543	689	45	42.37	4,277	350	500	250	1,000	1,250	150	475	535	400	935	1,205	250	45	1,500	M
May 10	3,159	1,050	45	44.46	4,254	346	500	250	1,000	1,250	150	475	535	300	835	1,205	250	45	1,500	M
May 11	2,840	1,440	45	47.31	4,325	342	500	250	1,000	1,250	150	475	535	300	835	1,205	250	45	1,500	M
May 12	2,836	1,700	45	50.69	4,581	338	500	250	1,000	1,250	150	475	535	300	835	1,205	250	45	1,500	M
May 13	2,832	1,700	45	54.06	4,577	333	500	250	1,000	1,250	150	475	535	300	835	1,205	250	45	1,500	M
May 14	2,828	1,700	45	57.43	4,573	329	500	250	1,000	1,250	150	475	535	300	835	1,205	250	45	1,500	M
May 15	2,823	1,700	45	60.80	4,568	325	500	250	1,000	1,250	150	475	535	300	835	1,205	250	45	1,500	M
May 16	2,819	1,700	45	64.17	4,564	321	500	250	1,000	1,250	100	475	535	300	835	1,205	250	45	1,500	M
May 17	2,815	1,700	45	67.55	4,560	317	500	250	750	1,000	50	475	535	300	835	1,205	250	45	1,500	
May 18	2,811	1,700	45	70.92	4,556	313	500	250	250	500		475	535	265	800	1,205	250	45	1,500	
May 19	2,807	1,650	45	74.19	4,502	309	500	250		250		300	300		300	600			600	
May 20	2,803	1,315	45	76.80	4,163	305	500	250		250			150		150	600			600	
May 21	1,959	250			2,209	301	500	250		250			150		150	600			600	
May 22	1,805	0			1,805	297	500	250		250			150		150	600			600	
May 23	1,801	0			1,801	293	500	250		250			150		150	600			600	
May 24	1,797	0			1,797	289	500	250		250			150		150	600			600	
May 25	1,793	0			1,793	285	500	250		250			150		150	600			600	
May 26	1,789	0			1,789	281	500	250		250			150		150	600			600	
May 27	1,785	0			1,785	277	500	250		250			150		150	600			600	
May 28	1,781	0			1,781	273	500	250		250			150		150	600			600	
May 29	1,777	0			1,777	269	500	250		250			150		150	600			600	
May 30	1,773	0			1,773	265	500	250		250			150		150	600			600	
May 31	1,769	0			1,769	261	500	250		250			150		150	600			600	
	VAMP period																			
Mean (cfs):	3,004	1,249			4,291	345	469		655	905	119		736	237	973	1,205	238	45	1,480	
Suppl. Water (TAF)																				
Provided		76.80							40.26		7.30			14.60			14.64	2.77		
Target based on provided									40.30		7.30			14.60			14.60			
Target for perfect op		86.11							45.00		8.51			14.60			18.00			

Pulse flow period

Period of desired flow stability

DAILY OPERATION PLAN, MAY 14

Pulse Period: April 20–May 20 • Flow Target: 4,450cfs

Ungaged Flow at Vernalis = 500cfs • 2.8 TAF "other" supplemetntal water on Stanislaus R.

San Joaquin River near Vernalis							Merced River at Cressey			Exchange Contractors	Tuolumne River at LaGrange				Stanislaus R blw Goodwin (at Orange Blossom Bridge)					
Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Cum. VAMP Suppl. Flow	VAMP Flow	SJR above Merced R. (2-day lag)	Ungaged Flow above Vernalis	Existing Flow	VAMP Suppl. Flow	Flow (3-day lag)	VAMP Suppl. Flow (3-day lag)	Desired FERC Pulse	Existing Flow – Adjusted FERC Pulse	VAMP Suppl. Flow	Flow (2-day lag)	Existing Flow	VAMP Suppl. Flow	Other Suppl. Flow	Flow (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol.	
(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)		
[calc]	[calc]		[calc]	[calc]					[calc]					[calc]				[calc]		
				2,070	515	663	220		220			347		347	407			407		Apr 01
				2,170	519	674	210		210			350		350	409			409		Apr 02
				2,160	527	687	180		180			345		345	411			411		Apr 03
2,040				2,040	534	542	193		193			339		339	439			439		Apr 04
1,980				1,980	515	487	218		218			328		328	558			558		Apr 05
2,080				2,080	493	588	240		240			317		317	556			556		Apr 06
2,330				2,330	461	736	266		266			325		325	551			551		Apr 07
2,610				2,610	454	1,026	246		246			323		323	561			561		Apr 08
2,660				2,660	490	1,083	240		240			318		318	347			347		Apr 09
2,580				2,580	541	976	232		232			327		327	548			548		Apr 10
2,480				2,480	546	1,079	241		241			326		326	551			551		Apr 11
2,430				2,430	547	774	245		245			328		328	551			551		Apr 12
2,430	0			2,430	545	775	253		253			329		329	550			550		Apr 13
2,420	0			2,420	499	753	255		255			319		319	555			555		Apr 14
2,420	0			2,420	469	751	263		263		250	256		256	548			548		Apr 15
2,490	0			2,490	453	864	261	0	261		250	255		255	552			552		Apr 16
2,280	0	0		2,280	422	752	250	74	324	0	250	255	0	255	553	0		553		Apr 17
2,130	0	0		2,130	357	607	250	122	372	0	475	475	667	1,142	1,205	0	0	967		Apr 18
2,200	0	0		2,200	282	709	250	535	785	50	475	475	966	1,441	1,205	311	90	1,606		Apr 19
2,937	741	0	1.47	3,440	202	650	250	889	1,139	150	475	475	547	1,022	1,205	260	45	1,510	T	Apr 20
2,911	1,399	90	4.24	4,400	236	699	250	959	1,209	150	475	475	150	625	1,205	254	45	1,504	T	Apr 21
3,093	1,392	45	7.01	4,530	376	962	250	949	1,199	150	475	475	148	623	1,205	251	45	1,501	T	Apr 22
2,952	1,443	45	9.87	4,440	519	787	250	920	1,170	150	475	475	148	623	1,205	212	45	1,462	T	Apr 23
2,877	1,508	45	12.86	4,430	509	572	250	928	1,178	150	475	475	147	622	1,205	149	45	1,399	T	Apr 24
2,806	1,459	45	15.75	4,310	450	358	250	932	1,182	150	475	475	149	624	1,205	176	45	1,426	T	Apr 25
2,691	1,366	45	18.46	4,102	392	253	250	949	1,199	150	475	475	147	622	1,205	249	45	1,499	T	Apr 26
2,682	1,403	45	21.24	4,130	351	303	250	960	1,210	150	700	610	9	619	1,205	252	45	1,502	T	Apr 27
2,677	1,478	45	24.18	4,200	406	356	250	385	635	150	1,230	650	4	654	1,205	252	45	1,502		Apr 28
2,805	1,360	45	26.87	4,210	382	390	250	274	524	100	1,230	1,230	0	1,221	1,205	254	45	1,504		Apr 29
2,679	1,366	45	29.58	4,090	366	169	250	248	498	100	1,230	1,230	140	1,370	1,205	251	45	1,501		Apr 30
3,335	789	45	31.15	4,160	360	269	250	221	471	100	1,230	1,230	145	1,375	1,205	254	45	1,504		May 01
3,370	765	45	32.67	4,180	346	319	250	225	475	100	1,230	1,230	139	1,369	1,205	253	45	1,503		May 02
3,438	747	45	34.15	4,230	287	393	250	202	452	100	1,230	1,230	143	1,373	1,205	251	45	1,501		May 03
3,352	713	45	35.56	4,110	281	321	250	199	449	100	1,230	1,230	134	1,364	1,205	255	45	1,505		May 04
3,296	719	45	36.99	4,060	282	324	250	192	442	100	1,230	1,230	106	1,336	1,205	249	45	1,499		May 05
3,374	691	45	38.36	4,110	296	408	250	209	459	100	1,230	1,230	140	1,370	1,205	250	45	1,500		May 06
3,411	654	45	39.66	4,110	261	444	250	556	806	130	1,230	1,230	134	1,364	1,205	252	45	1,502		May 07
3,423	682	45	41.01	4,150	196	442	250	671	921	150	800	850	137	987	1,205	253	45	1,503		May 08
3,390	695	45	42.39	4,130	134	444	250	994	1,244	150	475	535	377	912	1,205	254	45	1,504	M	May 09
2,899	1,076	45	44.52	4,020	152	398	250	1,040	1,290	150	475	535	302	837	1,205	254	45	1,504	M	May 10
2,664	1,452	45	47.40	4,160	182	540	250	1,069	1,319	150	475	535	316	851	1,205	255	45	1,505	M	May 11
2,446	1,700	45	50.77	4,190	194	304	250	1,075	1,325	150	475	535	306	841	1,205	256	45	1,506	M	May 12
2,511	1,761	45	54.27	4,320	195	340	250	1,091	1,341	150	475	535	304	839	1,205	253	45	1,503	M	May 13
2,684	1,781	45	57.80	4,510	329	500	250	1,000	1,250	150	475	535	300	835	1,205	250	45	1,500	M	May 14
2,685	1,782	45	61.33	4,512	325	500	250	1,000	1,250	150	475	535	300	835	1,205	250	45	1,500	M	May 15
2,819	1,791	45	64.89	4,655	321	500	250	1,000	1,250	100	475	535	300	835	1,205	250	45	1,500	M	May 16
2,815	1,700	45	68.26	4,560	317	500	250	750	1,000	50	475	535	300	835	1,205	250	45	1,500		May 17
2,811	1,700	45	71.63	4,556	313	500	250	250	500		475	535	265	800	1,205	250	45	1,500		May 18
2,807	1,650	45	74.90	4,502	309	500	250		250		300	300		300	600			600		May 19
2,803	1,315	45	77.51	4,163	305	500	250		250			150		150	600			600		May 20
1,959	250			2,209	301	500	250		250			150		150	600			600		May 21
1,805	0			1,805	297	500	250		250			150		150	600			600		May 22
1,801	0			1,801	293	500	250		250			150		150	600			600		May 23
1,797	0			1,797	289	500	250		250			150		150	600			600		May 24
1,793	0			1,793	285	500	250		250			150		150	600			600		May 25
1,789	0			1,789	281	500	250		250			150		150	600			600		May 26
1,785	0			1,785	277	500	250		250			150		150	600			600		May 27
1,781	0			1,781	273	500	250		250			150		150	600			600		May 28
1,777	0			1,777	269	500	250		250			150		150	600			600		May 29
1,773	0			1,773	265	500	250		250			150		150	600			600		May 30
1,769	0			1,769	261	500	250		250			150		150	600			600		May 31
VAMP period																				
2,950	1,261			4,247	309	450		665	915	119		736	238	973	1,205	239	45	1,481		Mean (cfs):
																				Suppl. Water (TAF)
	77.51							40.90		7.30			14.62			14.70	2.77			Provided
								41.01		7.30			14.60			14.60				Target based on provided
	89.48							45.00		9.00			17.48			18.00				Target for perfect op

Pulse flow period

Period of desired flow stability

2001 VERNALIS ADAPTIVE MANAGEMENT PLAN (VAMP)

ACCOUNTING OF SUPPLEMEMTAL WATER CONTRIBTIONS

Hydrology Subgroup of the San Joaquin River Technical Committee

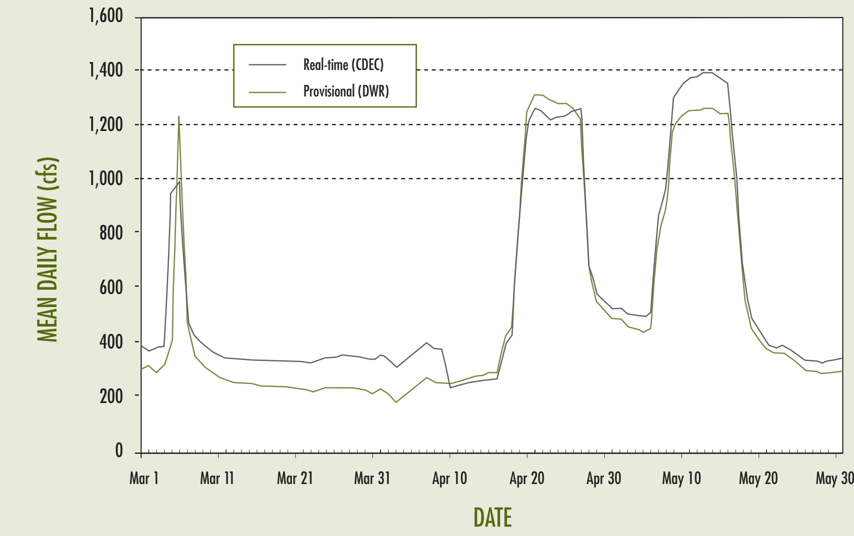
Pulse Flow Period: April 20–May 20

	Merced R. at Cresy (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)				SJRECWA (3day)	San Joaquin River at Vernalis		
	Existing Flow	Observed Flow	VAMP Suppl. Water	Exisitng Flow	Observed Flow	VAMP Suppl. Water	Existing Flow	Observed Flow	Other Suppl. Water	VAMP Suppl. Water	VAMP Suppl. Water	Existing Flow	Observed Flow	VAMP Suppl. Water
	(cfs)		(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
Apr 01	220	225		347	343		407	407				2,070	2,070	
Apr 02	210	210		350	344		409	409				2,170	2,170	
Apr 03	180	177		345	336		411	411				2,160	2,160	
Apr 04	193	195		339	331		439	439				2,039	2,039	
Apr 05	218	224		328	319		558	558				1,980	1,980	
Apr 06	240	246		317	309		556	556				2,080	2,080	
Apr 07	266	267		325	316		551	551				2,330	2,330	
Apr 08	246	252		323	314		561	561				2,610	2,610	
Apr 09	240	247		318	307		347	347				2,650	2,650	
Apr 10	232	245		327	314		548	548				2,580	2,580	
Apr 11	241	255		326	315		551	551				2,480	2,480	
Apr 12	245	260		328	316		551	551				2,430	2,430	
Apr 13	253	270		329	316		550	550				2,430	2,430	
Apr 14	255	274		319	305		555	555				2,420	2,420	
Apr 15	263	285		256	245		548	548				2,418	2,420	
Apr 16	261	284		255	243		552	552				2,487	2,490	
Apr 17	250	404	154	255	243		553	553			0	2,272	2,280	
Apr 18	250	458	208	475	1,100	625	1,205	967	0	0	0	2,120	2,130	
Apr 19	250	876	626	475	1,400	925	1,205	1,606	90	311	67	2,189	2,200	
Apr 20	250	1,240	990	475	1,000	525	1,205	1,510	45	260	152	2,908	3,449	779
Apr 21	250	1,310	1,060	475	601	126	1,205	1,504	45	254	207	2,876	4,410	1,444
Apr 22	250	1,310	1,060	475	598	123	1,205	1,501	45	251	160	3,007	4,530	1,478
Apr 23	250	1,290	1,040	475	598	123	1,205	1,462	45	212	199	2,873	4,440	1,522
Apr 24	250	1,280	1,030	475	595	120	1,205	1,399	45	149	183	2,734	4,420	1,641
Apr 25	250	1,280	1,030	475	594	119	1,205	1,426	45	176	163	2,710	4,310	1,555
Apr 26	250	1,260	1,010	475	593	118	1,205	1,499	45	249	170	2,547	4,100	1,508
Apr 27	250	1,220	970	610	601	0	1,205	1,502	45	252	174	2,577	4,130	1,508
Apr 28	250	656	406	650	654	4	1,205	1,502	45	252	205	2,595	4,200	1,560
Apr 29	250	544	294	1,230	1,210	0	1,205	1,504	45	254	177	2,742	4,210	1,432
Apr 30	250	515	265	1,230	1,360	130	1,205	1,501	45	251	149	2,644	4,089	1,400
May 01	250	486	236	1,230	1,380	150	1,205	1,504	45	254	71	3,270	4,160	865
May 02	250	485	235	1,230	1,370	140	1,205	1,503	45	253	66	3,283	4,180	852
May 03	250	458	208	1,230	1,370	140	1,205	1,501	45	251	94	3,367	4,230	818
May 04	250	449	199	1,230	1,370	140	1,205	1,505	45	255	168	3,365	4,110	700
May 05	250	436	186	1,230	1,340	110	1,205	1,499	45	249	107	3,313	4,050	692
May 06	250	450	200	1,230	1,370	140	1,205	1,500	45	250	85	3,368	4,110	697
May 07	250	788	538	1,230	1,370	140	1,205	1,502	45	252	78	3,339	4,110	726
May 08	250	899	649	850	994	144	1,205	1,503	45	253	97	3,432	4,160	683
May 09	250	1,190	940	535	916	381	1,205	1,504	45	254	80	3,408	4,130	677
May 10	250	1,230	980	535	838	303	1,205	1,504	45	254	134	2,952	4,010	1,013
May 11	250	1,250	1,000	535	850	315	1,205	1,505	45	255	183	2,744	4,170	1,381
May 12	250	1,250	1,000	535	841	306	1,205	1,506	45	256	114	2,568	4,190	1,577
May 13	250	1,260	1,010	535	837	302	1,205	1,503	45	253	116	2,591	4,320	1,684
May 14	250	1,260	1,010	535	833	298	1,205	1,502	45	252	167	2,730	4,520	1,745
May 15	250	1,240	990	535	839	304	1,205	1,504	45	254	118	2,746	4,460	1,669
May 16	250	1,240	990	535	843	308	1,205	1,506	45	256	138	2,834	4,510	1,676
May 17	250	971	721	535	845	310	1,205	1,502	45	252	79	2,765	4,500	1,735
May 18	250	569		535	755	220	1,205	1,502	45	252		2,888	4,560	1,672
May 19	250	449		300	333		600	1,271				2,620	4,310	1,690
May 20	250	405		150	167		600	1,017				2,598	3,870	1,272
May 21	250	372		150	173		600	772				2,330	3,320	
May 22	250	356		150	170		600	603				2,124	2,740	
May 23	250	360		150	176		600	603				2,360	2,360	
May 24	250	341		150	177		600	603				2,140	2,140	
May 25	250	322		150	175		600	604				2,050	2,050	
May 26	250	294		150	160		600	604				2,010	2,010	
May 27	250	293		150	175		600	604				2,010	2,010	
May 28	250	283		150	165		600	605				2,070	2,070	
May 29	250	284		150	160		600	604				2,100	2,100	
May 30	250	286		150	171		600	604				1,980	1,980	
May 31	250	293		150	162		600	604				1,910	1,910	
Total Supplemental Water (TAF):			**42.12**			**14.06**			**2.77**	**14.73**	**7.74**			**78.65**
Pulse Period Average:												2,916	4,224	

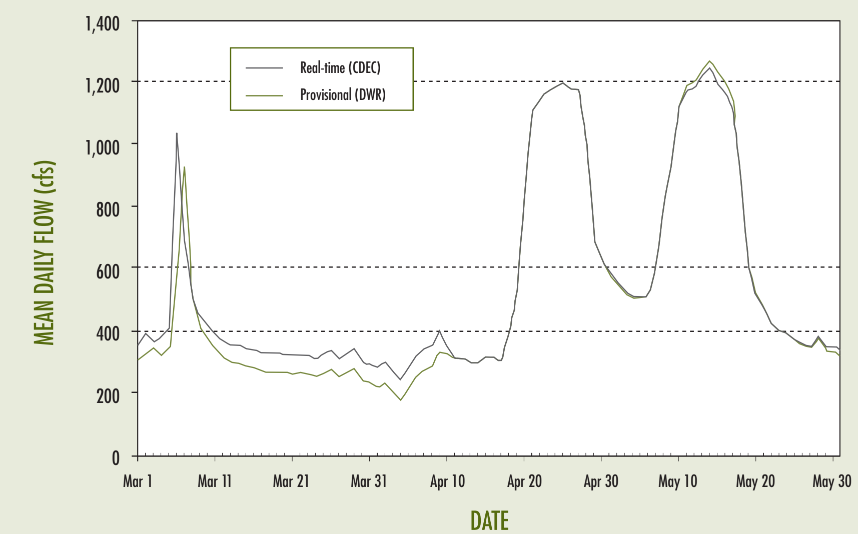
Observed Flow Sources:
Merced River at Cressey (CA DWR B05155): DWR San Joaquin District, provisional data received June 12, 2001. • Tuolumne River below LaGrange Dam near LaGrange (USGS 11289650): USGS, provisional data dated July 25, 2001.
Stanislaus River below Goodwin Dam: Goodwin Reservoir Daily Operations report, OID/SSJID/Tri-Dams (published by USBR CVO) • San Joaquin River near Vernalis (USGS 11303500): USGS, provisional data dated July 25, 2001.

COMPARISON OF "REAL-TIME" AND PROVISIONAL FLOWS

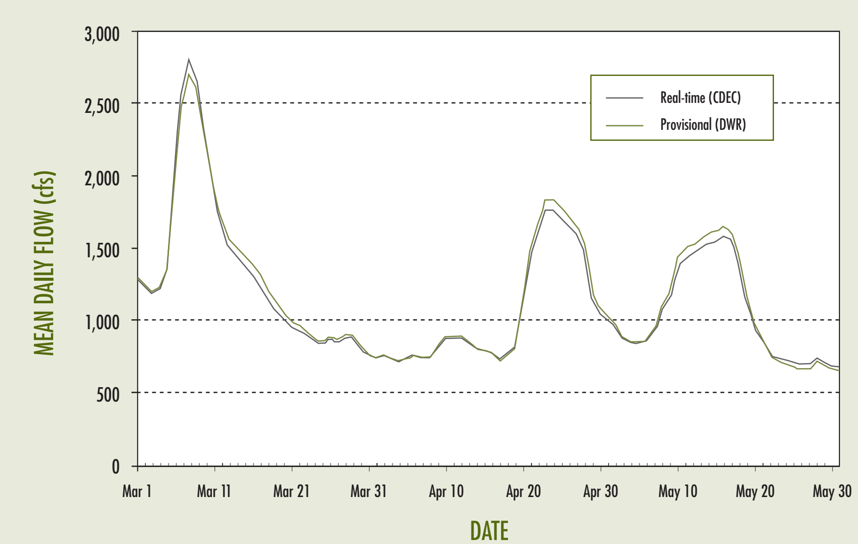
Merced River Near Cressey



Merced River Near Stevinson

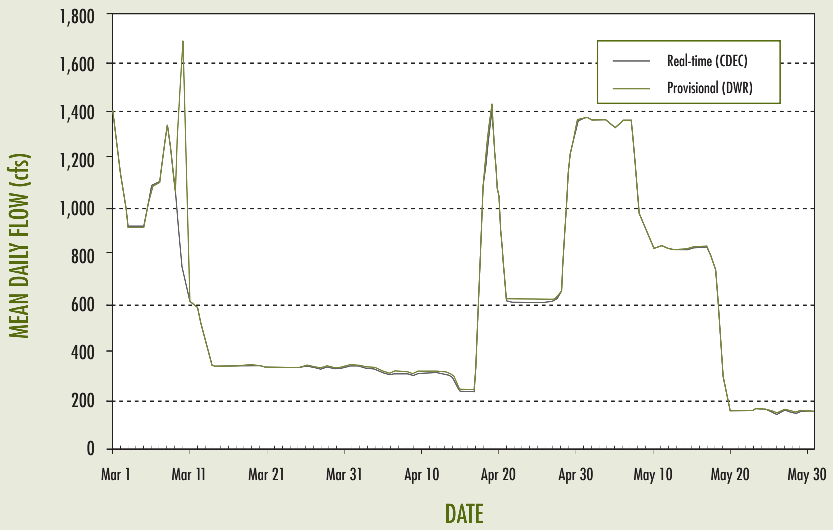


San Joaquin River Near Newman

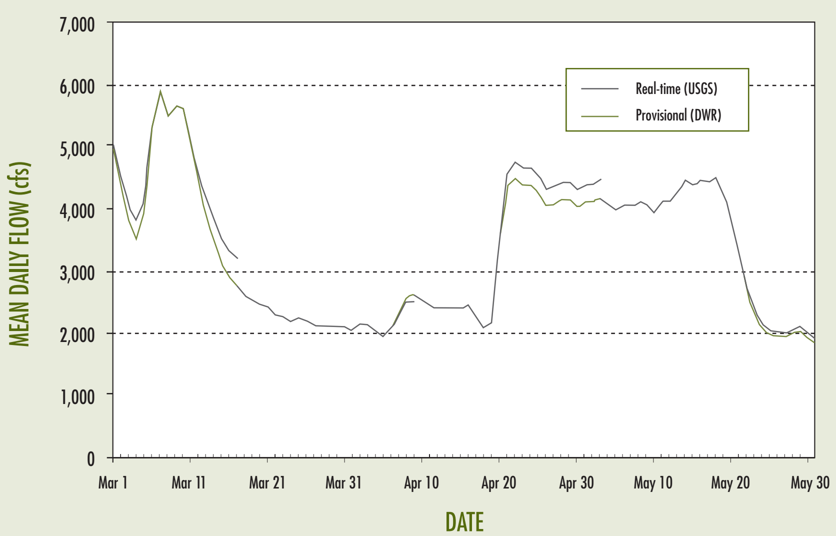


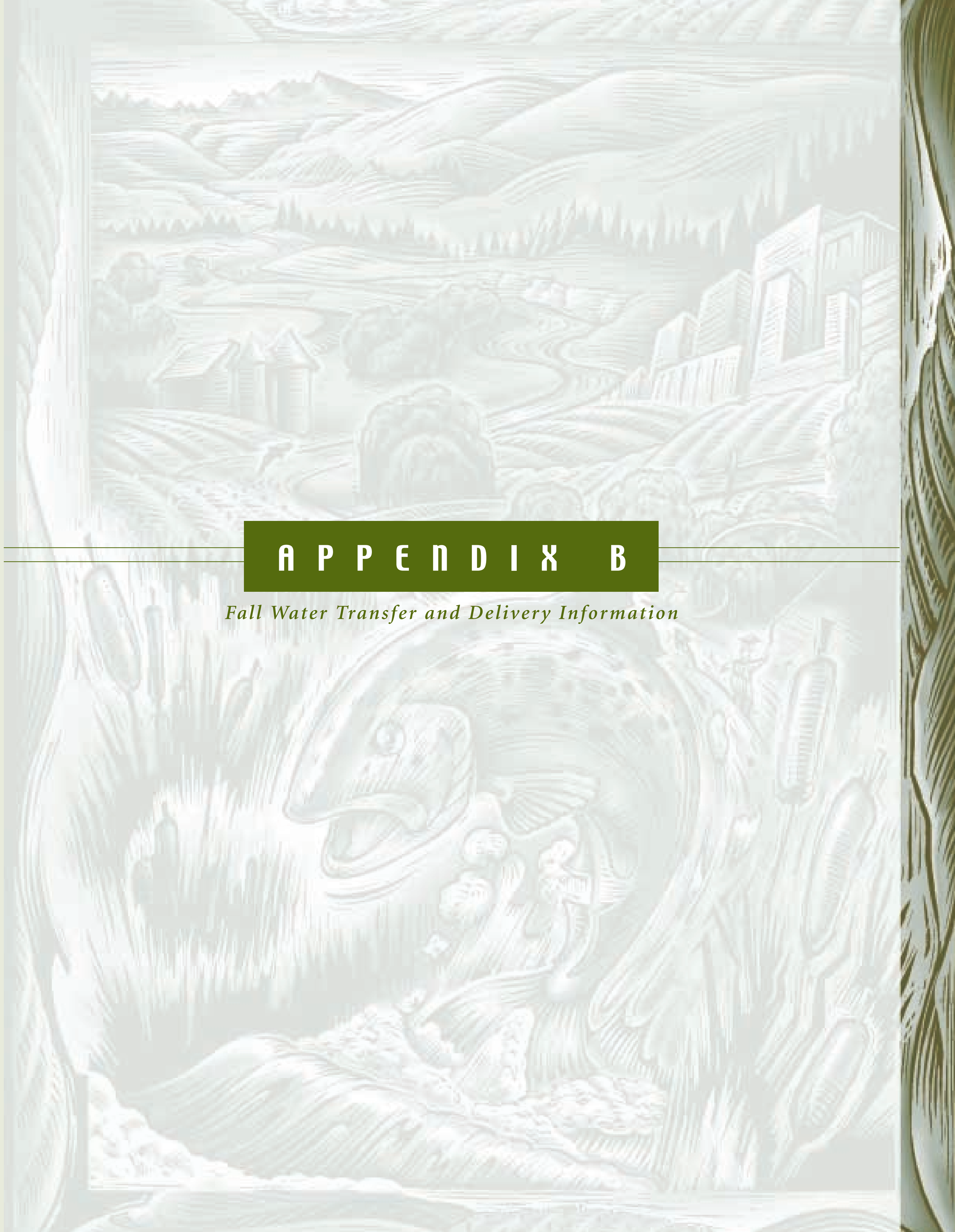
COMPARISON OF "REAL-TIME" AND PROVISIONAL FLOWS

Tuolumne River Below LaGrange Dam



San Joaquin River Near Vernalis





APPENDIX B

Fall Water Transfer and Delivery Information

MERCED IRRIGATION DISTRICT (PRELIMINARY)

2001 Fall SJRA and EWA Water Transfers • Initial Daily Flow Schedule

October 11, 2001

	SJRA Transfer Water			EWA Transfer Water					
	Shaffer Br/Cressey Base Flow for SJRA Transfer Water	SJRA Transfer Water Schedule	Cumulative SJRA Transfer Water Volume	Shaffer Br/Cressey Base Flow for EWA Transfer Water [1] + [2]	EWA Transfer Water Schdule – RIVER	Shaffer Br/Cressey Target Flow [4] + [5]	EWA Transfer Water Schedule – BYPASS	EWA Transfer Water [5] + [7]	EWA Transfer Balance
	(cfs)	(cfs)	(acre-foot)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(acre-foot)
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]
Oct 01	30	0	0	30	0	30	0	0	0
Oct 02	30	0	0	30	0	30	0	0	0
Oct 03	30	0	0	30	0	30	0	0	0
Oct 04	30	0	0	30	0	30	0	0	0
Oct 05	30	0	0	30	0	30	0	0	0
Oct 06	30	0	0	30	0	30	0	0	0
Oct 07	30	0	0	30	0	30	0	0	0
Oct 08	30	0	0	30	0	30	0	0	0
Oct 09	30	0	0	30	0	30	0	0	0
Oct 10	30	0	0	30	0	30	0	0	0
Oct 11	30	0	0	30	0	30	0	0	0
Oct 12	30	0	0	30	0	30	0	0	0
Oct 13	30	0	0	30	0	30	0	0	0
Oct 14	30	0	0	30	0	30	0	0	0
Oct 15	30	0	0	30	0	30	0	0	0
Oct 16	85	0	0	85	215	300	0	215	426
Oct 17	85	0	0	85	615	700	0	615	1,646
Oct 18	85	0	0	85	615	700	0	615	2,866
Oct 19	85	0	0	85	615	700	0	615	4,086
Oct 20	85	0	0	85	615	700	0	615	5,306
Oct 21	85	0	0	85	615	700	0	615	6,526
Oct 22	85	0	0	85	615	700	0	615	7,745
Oct 23	85	0	0	85	615	700	0	615	8,965
Oct 24	85	0	0	85	615	700	0	615	10,185
Oct 25	85	0	0	85	615	700	0	615	11,405
Oct 26	85	0	0	85	615	700	0	615	12,625
Oct 27	85	0	0	85	615	700	0	615	13,845
Oct 28	85	0	0	85	615	700	0	615	15,064
Oct 29	85	0	0	85	615	700	0	615	16,284
Oct 30	85	0	0	85	615	700	0	615	17,504
Oct 31	85	0	0	85	615	700	0	615	18,724
Nov 01	220	0	0	220	265	485	100	365	19,448
Nov 02	220	0	0	220	180	400	100	280	20,003
Nov 03	220	0	0	220	180	400	100	280	20,559
Nov 04	220	0	0	220	180	400	100	280	21,114
Nov 05	220	0	0	220	180	400	100	280	21,669
Nov 06	220	0	0	220	180	400	100	280	22,225
Nov 07	220	0	0	220	180	400	100	280	22,780
Nov 08	220	0	0	220	180	400	100	280	23,336
Nov 09	220	0	0	220	180	400	100	280	23,891
Nov 10	220	0	0	220	180	400	100	280	24,446
Nov 11	220	0	0	220	180	400	100	280	25,002
Nov 12	220	140	278	360	0	360	0	0	25,002
Nov 13	220	140	555	360	0	360	0	0	25,002
Nov 14	220	140	833	360	0	360	0	0	25,002
Nov 15	220	140	1,111	360	0	360	0	0	25,002

MERCED IRRIGATION DISTRICT (PRELIMINARY)

2001 Fall SJRA and EWA Water Transfers • Initial Daily Flow Schedule

October 11, 2001

SJRA Transfer Water			EWA Transfer Water						
Shaffer Br/Cressey Base Flow for SJRA Transfer Water	SJRA Transfer Water Schedule	Cumulative SJRA Transfer Water Volume	Shaffer Br/Cressey Base Flow for EWA Transfer Water [1] + [2]	EWA Transfer Water Schdule – RIVER	Shaffer Br/Cressey Target Flow [4] + [5]	EWA Transfer Water Schedule – BYPASS	EWA Transfer Water [5] + [7]	EWA Transfer Balance	
(cfs)	(cfs)	(acre-foot)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(acre-foot)	
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	
220	140	1,388	360	0	360	0	0	25,002	Nov 16
220	140	1,666	360	0	360	0	0	25,002	Nov 17
220	140	1,944	360	0	360	0	0	25,002	Nov 18
220	140	2,221	360	0	360	0	0	25,002	Nov 19
220	140	2,499	360	0	360	0	0	25,002	Nov 20
220	140	2,777	360	0	360	0	0	25,002	Nov 21
220	140	3,055	360	0	360	0	0	25,002	Nov 22
220	140	3,332	360	0	360	0	0	25,002	Nov 23
220	140	3,610	360	0	360	0	0	25,002	Nov 24
220	140	3,888	360	0	360	0	0	25,002	Nov 25
220	140	4,165	360	0	360	0	0	25,002	Nov 26
220	120	4,403	340	0	340	0	0	25,002	Nov 27
220	120	4,641	340	0	340	0	0	25,002	Nov 28
220	120	4,879	340	0	340	0	0	25,002	Nov 29
220	120	5,117	340	0	340	0	0	25,002	Nov 30
220	120	5,355	340	0	340		0	25,002	Dec 01
220	120	5,593	340	0	340		0	25,002	Dec 02
220	120	5,831	340	0	340		0	25,002	Dec 03
220	120	6,069	340	0	340		0	25,002	Dec 04
220	120	6,307	340	0	340		0	25,002	Dec 05
220	120	6,545	340	0	340		0	25,002	Dec 06
220	120	6,783	340	0	340		0	25,002	Dec 07
220	120	7,021	340	0	340		0	25,002	Dec 08
220	120	7,260	340	0	340		0	25,002	Dec 09
220	120	7,498	340	0	340		0	25,002	Dec 10
220	120	7,736	340	0	340		0	25,002	Dec 11
220	120	7,974	340	0	340		0	25,002	Dec 12
220	120	8,212	340	0	340		0	25,002	Dec 13
220	120	8,450	340	0	340		0	25,002	Dec 14
220	120	8,688	340	0	340		0	25,002	Dec 15
220	120	8,926	340	0	340		0	25,002	Dec 16
220	120	9,164	340	0	340		0	25,002	Dec 17
220	120	9,402	340	0	340		0	25,002	Dec 18
220	120	9,640	340	0	340		0	25,002	Dec 19
220	120	9,878	340	0	340		0	25,002	Dec 20
220	120	10,116	340	0	340		0	25,002	Dec 21
220	120	10,354	340	0	340		0	25,002	Dec 22
220	120	10,592	340	0	340		0	25,002	Dec 23
220	120	10,830	340	0	340		0	25,002	Dec 24
220	120	11,068	340	0	340		0	25,002	Dec 25
220	120	11,306	340	0	340		0	25,002	Dec 26
220	120	11,544	340	0	340		0	25,002	Dec 27
220	120	11,782	340	0	340		0	25,002	Dec 28
220	120	12,020	340	0	340		0	25,002	Dec 29
220	120	12,258	340	0	340		0	25,002	Dec 30
220	120	12,496	340	0	340		0	25,002	Dec 31

	Oct	Nov	Dec	Total
SJRA Transfer Water (AF):	0	5,117	7,379	12,496
EWA Transfer Water (AF):	18,724	6,278	0	25,002

MERCED IRRIGATION DISTRICT (PRELIMINARY)

2001 Fall SJRA and EWA Water Transfers

Using data available as of Dec. 19, 2001 • Subject to change

	Merced River at Cressey Flow (cfs)	SJRA Transfer Water				EWA Transfer Water							
		Base Flow	SJRA Transfer Water Flow (cfs)		SJRA Transfer Water Cumulative Volume (ac-ft)	Base Flow	EWA Transfer Water Flow-RIVER (CFS)		EWA Transfer Water BYPASS - Livingston Spill (cfs)		Total EWA Transfer Water Flow (cfs)	Daily EWA Transfer Water Volume (ac-ft)	Cumulative EWA Transfer Water Volume (ac-ft)
	DWR Provisional		Scheduled	Observed			Scheduled	Observed	Scheduled	Observed			
Oct 01	111	30	0				0		0				
Oct 02	112	30	0				0		0				
Oct 03	105	30	0				0		0				
Oct 04	105	30	0				0		0				
Oct 05	102	30	0				0		0				
Oct 06	86	30	0				0		0				
Oct 07	111	30	0				0		0				
Oct 08	111	30	0				0		0				
Oct 09	115	30	0				0		0				
Oct 10	114	30	0				0		0				
Oct 11	113	30	0				0		0				
Oct 12	114	30	0				0		0				
Oct 13	116	30	0				0		0				
Oct 14	116	30	0				0		0				
Oct 15	119	30	0				0		0				
Oct 16	173	85	0	0	0	85	215	88	0		88	175	175
Oct 17	422	85	0	0	0	85	615	337	0		337	668	843
Oct 18	598	85	0	0	0	85	615	513	0		513	1,018	1,861
Oct 19	684	85	0	0	0	85	615	599	0		599	1,188	3,049
Oct 20	699	85	0	0	0	85	615	614	0		614	1,218	4,267
Oct 21	732	85	0	0	0	85	615	615	0		615	1,220	5,487
Oct 22	747	85	0	0	0	85	615	615	0		615	1,220	6,707
Oct 23	738	85	0	0	0	85	615	615	0		615	1,220	7,927
Oct 24	744	85	0	0	0	85	615	615	0		615	1,220	9,147
Oct 25	738	85	0	0	0	85	615	615	0		615	1,220	10,367
Oct 26	726	85	0	0	0	85	615	615	0		615	1,220	11,587
Oct 27	716	85	0	0	0	85	615	615	0		615	1,220	12,807
Oct 28	724	85	0	0	0	85	615	615	0		615	1,220	14,027
Oct 29	737	85	0	0	0	85	615	615	0		615	1,220	15,247
Oct 30	733	85	0	0	0	85	615	615	0		615	1,220	16,467
Oct 31	735	85	0	0	0	85	615	615	0		615	1,220	17,687
Nov 01	220	0				265		100	86				
Nov 02	220	0				180		100	111				
Nov 03	220	0				180		100	106				
Nov 04	220	0				180		100	91				
Nov 05	220	0				180		100	90				
Nov 06	220	0				180		100	96				
Nov 07	220	0				180		100	95				
Nov 08	220	0				180		100	101				
Nov 09	220	0				180		100	105				
Nov 10	220	0				180		100	107				
Nov 11	220	0				180		100	106				
Nov 12	220	140				0		0					
Nov 13	220	140				0		0					
Nov 14	220	140				0		0					
Nov 15	220	140				0		0					

MERCED IRRIGATION DISTRICT (PRELIMINARY)

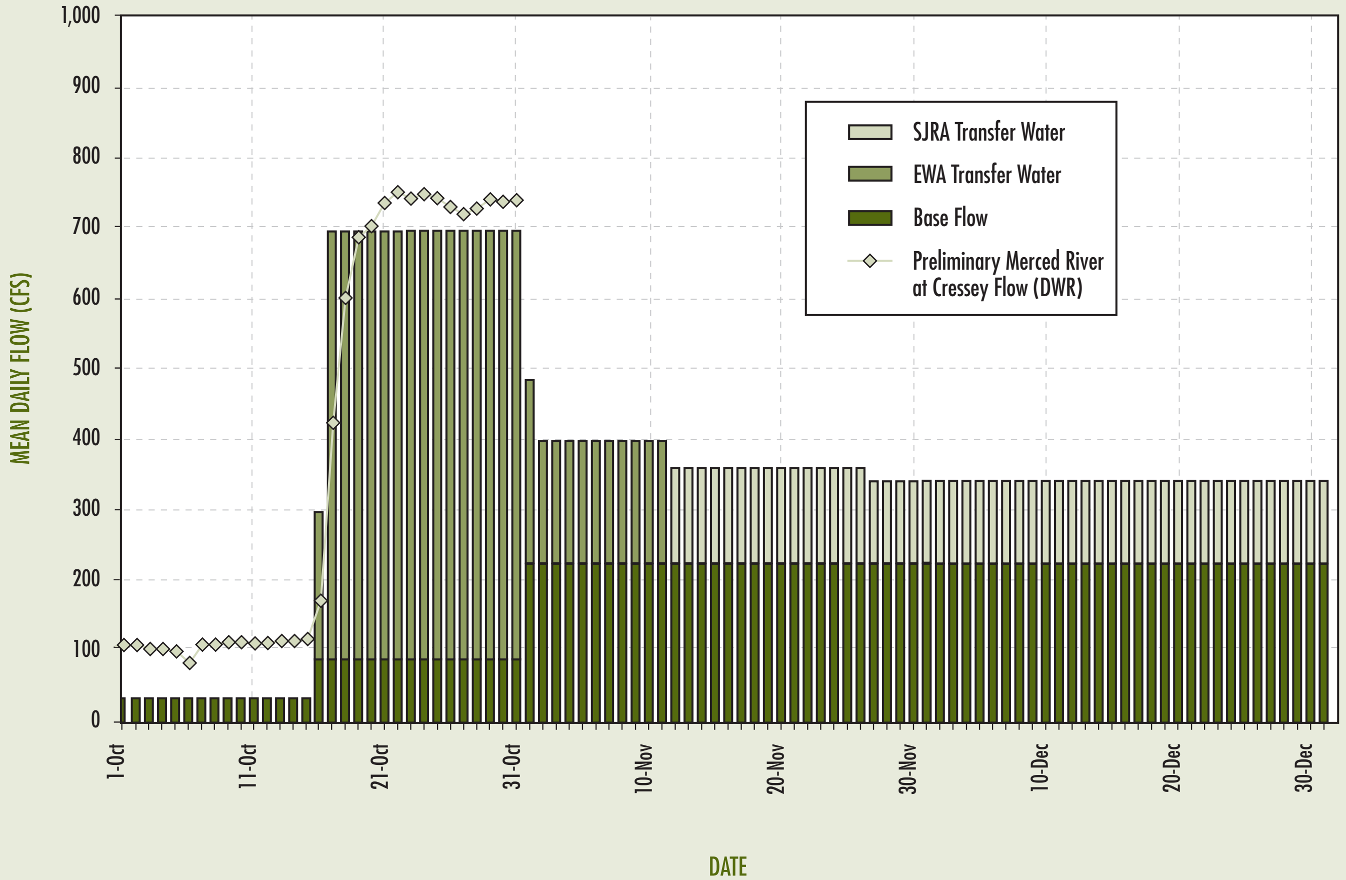
2001 Fall SJRA and EWA Water Transfers

Using data available as of Dec. 19, 2001 • Subject to change

Merced River at Cressey Flow (cfs)	SJRA Transfer Water				EWA Transfer Water								
	Base Flow	SJRA Transfer Water Flow (cfs)		SJRA Transfer Water Cumulative Volume (ac-ft)	Base Flow	EWA Transfer Water Flow-RIVER (CFS)		EWA Transfer Water BYPASS - Livingston Spill (cfs)		Total EWA Transfer Water Flow (cfs)	Daily EWA Transfer Water Volume (ac-ft)	Cumulative EWA Transfer Water Volume (ac-ft)	
DWR Provisional		Scheduled	Observed			Scheduled	Observed	Scheduled	Observed				
220	140				0		0						Nov 16
220	140				0		0						Nov 17
220	140				0		0						Nov 18
220	140				0		0						Nov 19
220	140				0		0						Nov 20
220	140				0		0						Nov 21
220	140				0		0						Nov 22
220	140				0		0						Nov 23
220	140				0		0						Nov 24
220	140				0		0						Nov 25
220	140				0		0						Nov 26
220	120				0		0						Nov 27
220	120				0		0						Nov 28
220	120				0		0						Nov 29
220	120				0		0						Nov 30
220	120				0		0						Dec 01
220	120				0		0						Dec 02
220	120				0		0						Dec 03
220	120				0		0						Dec 04
220	120				0		0						Dec 05
220	120				0		0						Dec 06
220	120				0		0						Dec 07
220	120				0		0						Dec 08
220	120				0		0						Dec 09
220	120				0		0						Dec 10
220	120				0		0						Dec 11
220	120				0		0						Dec 12
220	120				0		0						Dec 13
220	120				0		0						Dec 14
220	120				0		0						Dec 15
220	120				0		0						Dec 16
220	120				0		0						Dec 17
220	120				0		0						Dec 18
220	120				0		0						Dec 19
220	120				0		0						Dec 20
220	120				0		0						Dec 21
220	120				0		0						Dec 22
220	120				0		0						Dec 23
220	120				0		0						Dec 24
220	120				0		0						Dec 25
220	120				0		0						Dec 26
220	120				0		0						Dec 27
220	120				0		0						Dec 28
220	120				0		0						Dec 29
220	120				0		0						Dec 30
220	120				0		0						Dec 31

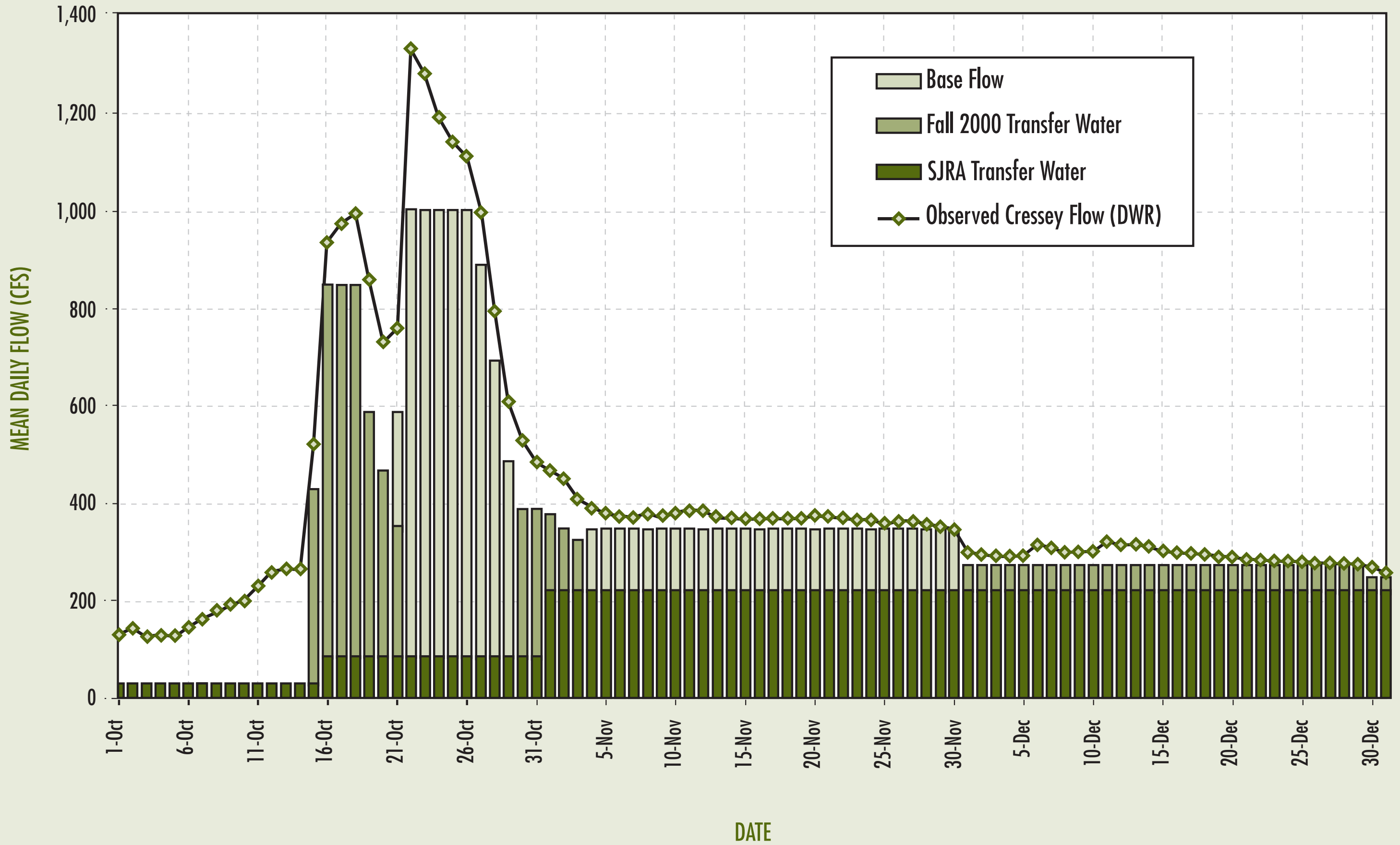
MERCED IRRIGATION DISTRICT FALL 2001 WATER TRANSFERS (PRELIMINARY)

Merced River Flow at Shaffer Bridge/Cressey



MERCED IRRIGATION DISTRICT FALL 2000 WATER TRANSFERS (FINAL)

Merced River Flow at Shaffer Bridge/Cressey



MERCED IRRIGATION DISTRICT (FINAL)

2000 Fall Water Transfers

		SJRA Transfer Water				Fall 2000 Transfer Water							
	Merced River at Cressey Flow (cfs)	Base Flow	SJRA Transfer Water Flow (cfs)		SJRA Transfer Water Cumulative Volume (ac-ft)	Base Flow	Fall 2000 Transfer Water Flow RIVER (cfs)		Fall 2000 Transfer Water-BYPASS - Livingston Spill (cfs)		Total Fall 2000 Transfer Water Flow (cfs)	Daily Fall 2000 Transfer Water Volume (ac-ft)	Cumulative Fall 2000 Transfer Water Volume (ac-ft)
	DWR		Scheduled	Observed			Scheduled	Observed	Scheduled	Observed			
Oct 01	130	30	0				0		0				
Oct 02	144	30	0				0		0				
Oct 03	129	30	0				0		0				
Oct 04	130	30	0				0		0				
Oct 05	129	30	0				0		0				
Oct 06	147	30	0				0		0				
Oct 07	164	30	0				0		0				
Oct 08	182	30	0				0		0				
Oct 09	195	30	0				0		0				
Oct 10	201	30	0				0		0				
Oct 11	232	30	0				0		0				
Oct 12	256	30	0				0		0				
Oct 13	266	30	0				0		0				
Oct 14	266	30	0				0		0				
Oct 15	518	30	397	397	787	427	0	0	0		0	0	0
Oct 16	933	85	760	760	2,295	845	0	0	0		0	0	0
Oct 17	972	85	760	760	3,802	845	0	0	0		0	0	0
Oct 18	993	85	760	760	5,310	845	0	0	0		0	0	0
Oct 19	859	85	500	500	6,301	585	0	0	0		0	0	0
Oct 20	731	85	380	380	7,055	465	0	0	0		0	0	0
Oct 21	758	85	265	265	7,581	350	235	235	0		235	466	466
Oct 22	1,310	85	0	0	7,581	85	915	915	0		915	1,815	2,281
Oct 23	1,260	85	0	0	7,581	85	915	915	0		915	1,815	4,096
Oct 24	1,180	85	0	0	7,581	85	915	915	0		915	1,815	5,911
Oct 25	1,140	85	0	0	7,581	85	915	915	0		915	1,815	7,726
Oct 26	1,100	85	0	0	7,581	85	915	915	0		915	1,815	9,540
Oct 27	993	85	0	0	7,581	85	800	800	0		800	1,587	11,127
Oct 28	793	85	0	0	7,581	85	605	605	0		605	1,200	12,327
Oct 29	606	85	0	0	7,581	85	400	400	0		400	793	13,121
Oct 30	527	85	300	300	8,176	385	0	0	0		0	0	13,121
Oct 31	484	85	300	300	8,771	385	0	0	0		0	0	13,121
Nov 01	462	220	155	155	9,078	375	0	0	0	51	0	0	13,121
Nov 02	450	220	125	125	9,326	345	0	0	0	34	0	0	13,121
Nov 03	407	220	100	100	9,525	320	0	0	0	10	0	0	13,121
Nov 04	392	220	0	0	9,525	220	125	125	0	6	125	248	13,369
Nov 05	382	220	0	0	9,525	220	125	125	0	37	125	248	13,617
Nov 06	379	220	0	0	9,525	220	125	125	100	94	219	434	14,051
Nov 07	376	220	0	0	9,525	220	125	125	100	123	225	446	14,497
Nov 08	381	220	0	0	9,525	220	125	125	100	122	225	446	14,943
Nov 09	382	220	0	0	9,525	220	125	125	100	115	225	446	15,390
Nov 10	384	220	0	0	9,525	220	125	125	100	113	225	446	15,836
Nov 11	391	220	0	0	9,525	220	125	125	100	114	225	446	16,282
Nov 12	393	220	0	0	9,525	220	125	125	100	113	225	446	16,729
Nov 13	380	220	0	0	9,525	220	125	125	100	111	225	446	17,175
Nov 14	368	220	0	0	9,525	220	125	125	100	111	225	446	17,621
Nov 15	363	220	0	0	9,525	220	125	125	100	110	225	446	18,067

MERCED IRRIGATION DISTRICT (FINAL)

2000 Fall Water Transfers

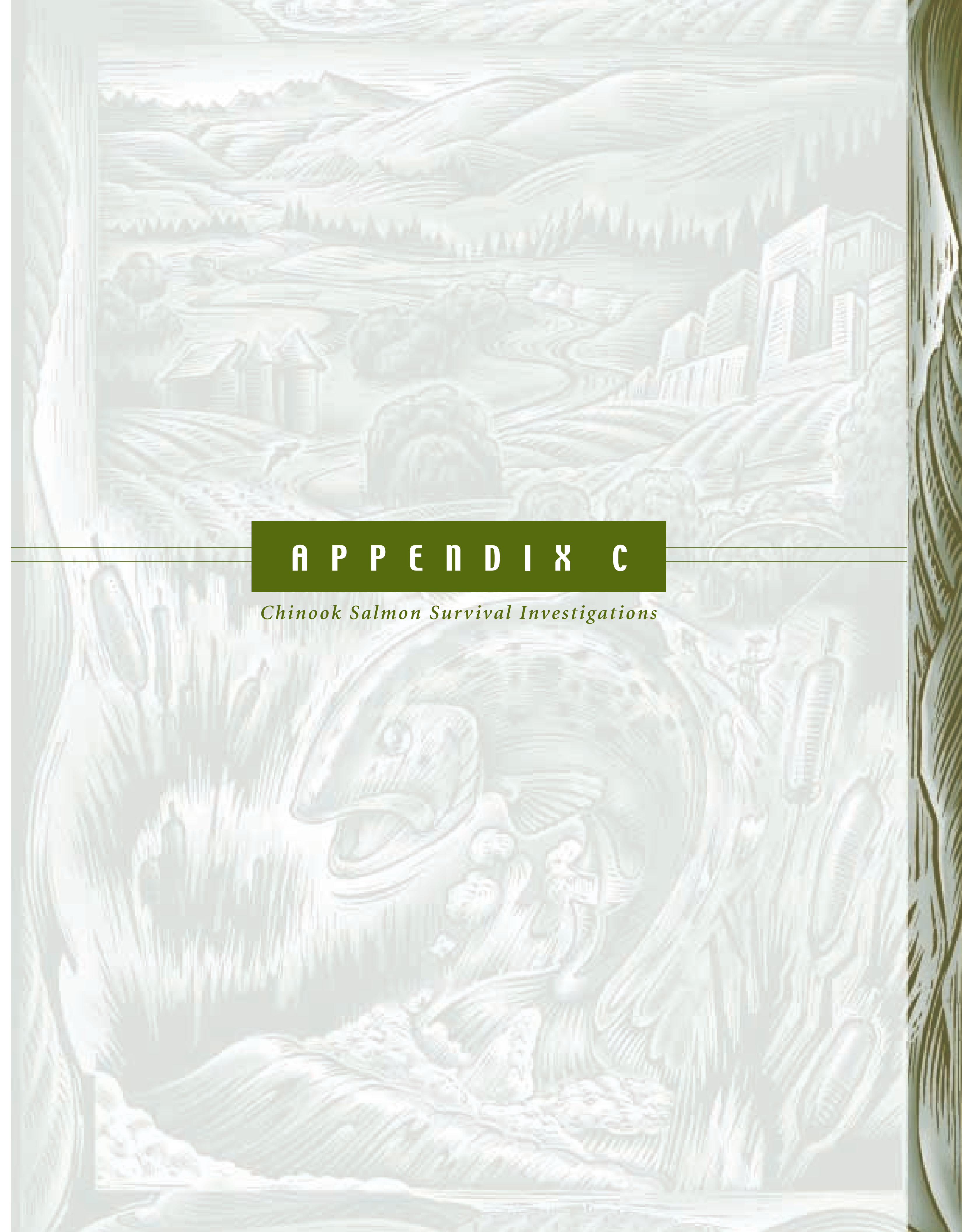
	SJRA Transfer Water				Fall 2000 Transfer Water								
Merced River at Cressey Flow (cfs)	Base Flow	SJRA Transfer Water Flow (cfs)		SJRA Transfer Water Cumulative Volume (ac-ft)	Base Flow	Fall 2000 Transfer Water Flow RIVER (cfs)		Fall 2000 Transfer Water-BYPASS - Livingston Spill (cfs)		Total Fall 2000 Transfer Water Flow (cfs)	Daily Fall 2000 Transfer Water Volume (ac-ft)	Cumulative Fall 2000 Transfer Water Volume (ac-ft)	
DWR		Scheduled	Observed			Scheduled	Observed	Scheduled	Observed				
363	220	0	0	9,525	220	125	125	100	111	225	446	18,514	Nov 16
363	220	0	0	9,525	220	125	125	100	112	225	446	18,960	Nov 17
359	220	0	0	9,525	220	125	125	100	110	225	446	19,406	Nov 18
359	220	0	0	9,525	220	125	125	100	111	225	446	19,853	Nov 19
364	220	0	0	9,525	220	125	125	100	111	225	446	20,299	Nov 20
362	220	0	0	9,525	220	125	125	100	111	225	446	20,745	Nov 21
359	220	0	0	9,525	220	125	125	100	111	225	446	21,191	Nov 22
362	220	0	0	9,525	220	125	125	100	111	225	446	21,638	Nov 23
361	220	0	0	9,525	220	125	125	100	111	225	446	22,084	Nov 24
353	220	0	0	9,525	220	125	125	100	113	225	446	22,530	Nov 25
357	220	0	0	9,525	220	125	125	100	114	225	446	22,977	Nov 26
355	220	0	0	9,525	220	125	125	100	111	225	446	23,423	Nov 27
348	220	0	0	9,525	220	125	125	100	111	225	446	23,869	Nov 28
344	220	0	0	9,525	220	125	125	100	112	225	446	24,315	Nov 29
336	220	0	0	9,525	220	125	118	100	112	218	432	24,748	Nov 30
306	220	50	50	9,624	270	0	0	0		0	0	24,748	Dec 01
295	220	50	50	9,723	270	0	0	0		0	0	24,748	Dec 02
291	220	50	50	9,822	270	0	0	0		0	0	24,748	Dec 03
290	220	50	50	9,921	270	0	0	0		0	0	24,748	Dec 04
287	220	50	50	10,020	270	0	0	0		0	0	24,748	Dec 05
289	220	50	50	10,120	270	0	0	0		0	0	24,748	Dec 06
310	220	50	50	10,219	270	0	0	0		0	0	24,748	Dec 07
304	220	50	50	10,318	270	0	0	0		0	0	24,748	Dec 08
295	220	50	50	10,417	270	0	0	0		0	0	24,748	Dec 09
295	220	50	50	10,516	270	0	0	0		0	0	24,748	Dec 10
297	220	50	50	10,616	270	0	0	0		0	0	24,748	Dec 11
317	220	50	50	10,715	270	0	0	0		0	0	24,748	Dec 12
311	220	50	50	10,814	270	0	0	0		0	0	24,748	Dec 13
311	220	50	50	10,913	270	0	0	0		0	0	24,748	Dec 14
306	220	50	50	11,012	270	0	0	0		0	0	24,748	Dec 15
297	220	50	50	11,111	270	0	0	0		0	0	24,748	Dec 16
294	220	50	50	11,211	270	0	0	0		0	0	24,748	Dec 17
294	220	50	50	11,310	270	0	0	0		0	0	24,748	Dec 18
291	220	50	50	11,409	270	0	0	0		0	0	24,748	Dec 19
288	220	50	50	11,508	270	0	0	0		0	0	24,748	Dec 20
283	220	50	50	11,607	270	0	0	0		0	0	24,748	Dec 21
280	220	50	50	11,706	270	0	0	0		0	0	24,748	Dec 22
279	220	50	50	11,806	270	0	0	0		0	0	24,748	Dec 23
277	220	50	50	11,905	270	0	0	0		0	0	24,748	Dec 24
276	220	50	50	12,004	270	0	0	0		0	0	24,748	Dec 25
274	220	50	50	12,103	270	0	0	0		0	0	24,748	Dec 26
273	220	50	50	12,202	270	0	0	0		0	0	24,748	Dec 27
273	220	50	50	12,301	270	0	0	0		0	0	24,748	Dec 28
272	220	50	50	12,401	270	0	0	0		0	0	24,748	Dec 29
263	220	25	25	12,450	245	0	0	0		0	0	24,748	Dec 30
255	220	25	25	12,500	245	0	0	0		0	0	24,748	Dec 31

OAKDALE IRRIGATION DISTRICT (PRELIMINARY)

Daily Tabulation of Additional Water Release • Additional Water Available: 18,635 acre-feet

Using data available as of December 19, 2001 • Subject to change

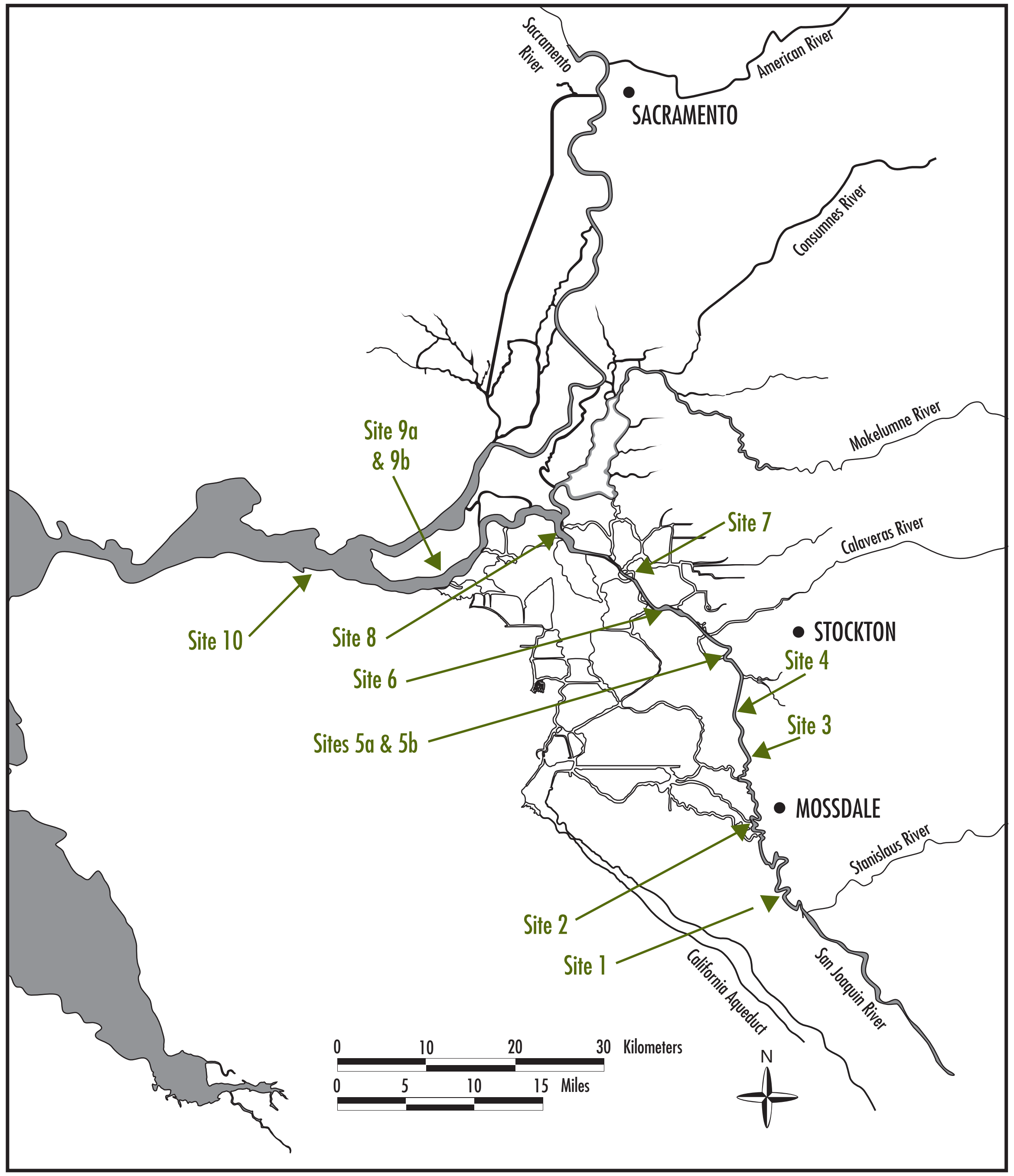
	Pre CVPIA Base Condition Release (cfs)	Goodwin Dam Release (cfs)	B(2) Water (cfs)	Flow (cfs)	Cumulative Volume (ac-ft)
				Oakdale ID Additional Water	
	[1]	[2]		[2] - [1]	
Oct 19	355	235		0	0
Oct 20	355	942		587	1,164
Oct 21	355	1,009		654	2,461
Oct 22	355	1,009		654	3,759
Oct 23	355	1,011		656	5,060
Oct 24	355	1,011		656	6,361
Oct 25	355	1,008		653	7,656
Oct 26	355	1,002		647	8,939
Oct 27	355	1,003		648	10,225
Oct 28	355	913		558	11,332
Oct 29	200	363		163	11,655
Oct 30	200	349		149	11,950
Oct 31	200	351		151	12,250
Nov 01	200	347		147	12,541
Nov 02	200	349		149	12,837
Nov 03	200	352		152	13,139
Nov 04	200	354		154	13,444
Nov 05	200	364		164	13,769
Nov 06	200	363		163	14,093
Nov 07	200	354		154	14,398
Nov 08	200	354		154	14,703
Nov 09	200	357		157	15,015
Nov 10	200	357		157	15,326
Nov 11	200	355		155	15,634
Nov 12	200	355		155	15,941
Nov 13	200	353		153	16,245
Nov 14	200	357		157	16,556
Nov 15	200	356		156	16,865
Nov 16	200	354		154	17,171
Nov 17	200	354		154	17,476
Nov 18	200	353		153	17,780
Nov 19	200	353		153	18,083
Nov 20	200	355		155	18,391
Nov 21	200	354	31	123	18,635
Nov 22	200	353	153		



APPENDIX C

Chinook Salmon Survival Investigations

SACRAMENTO–SAN JOAQUIN ESTUARY

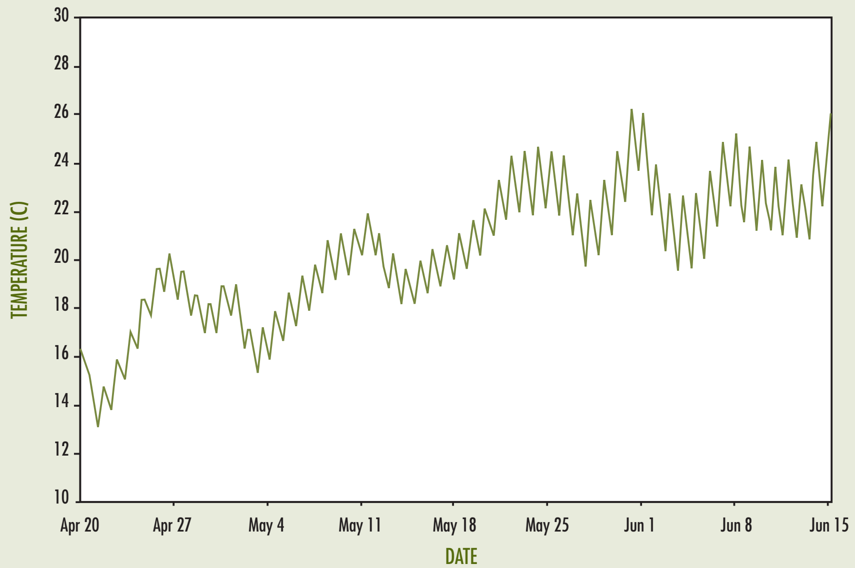


Water temperature monitoring locations during the VAMP 2001 experiment.

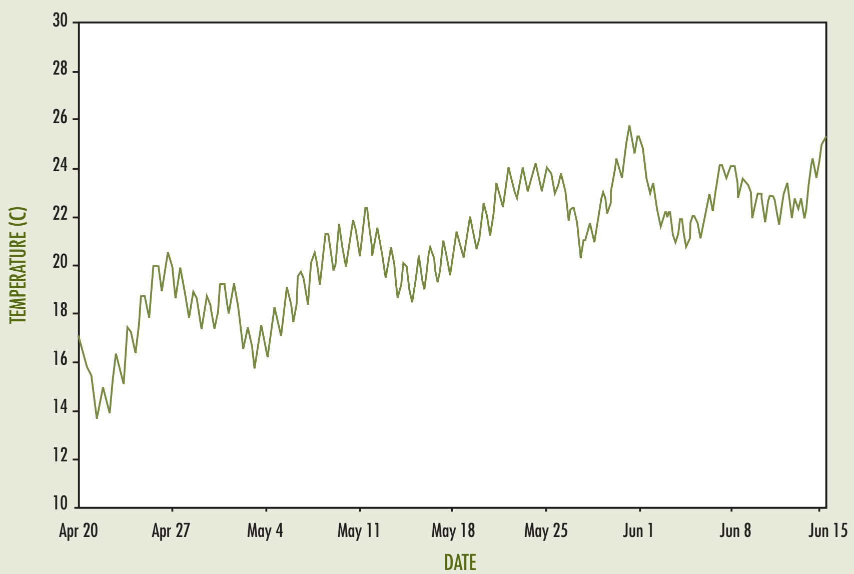
VAMP 2001 WATER TEMPERATURE MONITORING LOCATIONS

Site no.	Temperature Monitoring Location	Latitude	Longitude	Distance from Durham Ferry (mi)	Date Deployed	Date Retrieved	Notes
	Merced River Hatchery			n/a	March 21	May 3	In river April 30
1	Durham Ferry	N 37 41.381	W 121 15657	n/a	April 19	June 17	In 2.5 feet of water
2	Mossdale	N 37 47.180	W 121 18.425	11.2	April 19	June 17	In 2 feet of water
3	Dos Reis	N 37 49.808	W 121 18.665	16.4	April 19	June 17	In 2 feet of water
4	DWR Monitoring Station	N 37 51.869	W 121 19.376	19.4	April 19	June 17	In 1 foot of water
5a	Confluence – Top	N 37 56.818	W 121 20.285	26.5	April 19	June 17	2 feet below surface
5b	Confluence – Bottom	N 37 56.818	W 121 20.285	26.5	April 19	June 17	On river bottom
6	Downstream of Channel Marker 30	N 37 59.611	W 121 25.805	33.3	April 19	June 17	In 1.5 feet of water
7	1/2 mile Upstream of Channel Marker 13	N 38 01.940	W 121 28.769	37.3	April 19	June 17	In 1.5 feet of water
8	Downstream of Channel Marker 36	N 38 04.522	W 121 34.413	44.7	April 19	June 17	In 2 feet of water
9a	Jersey Point USGS Gauging Station – top	N 38 03.172	W121 41.637	56.0	April 19	June 17	In 3 feet of water
9b	Jersey Point USGS Gauging Station – bottom	N 38 03.172	W121 41.637	56.0	April 19	June 17	Completely on the bottom
10	Chipps Island	N 38 03.084	W 121 55.463	71.5	April 19		Logger lost

Site 1 • Durham Ferry

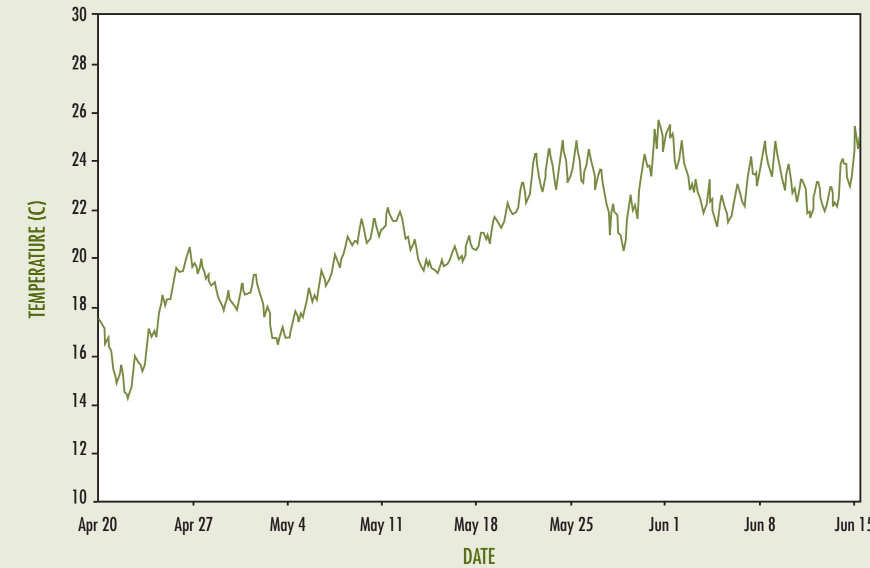


Site 2 • Mossdale

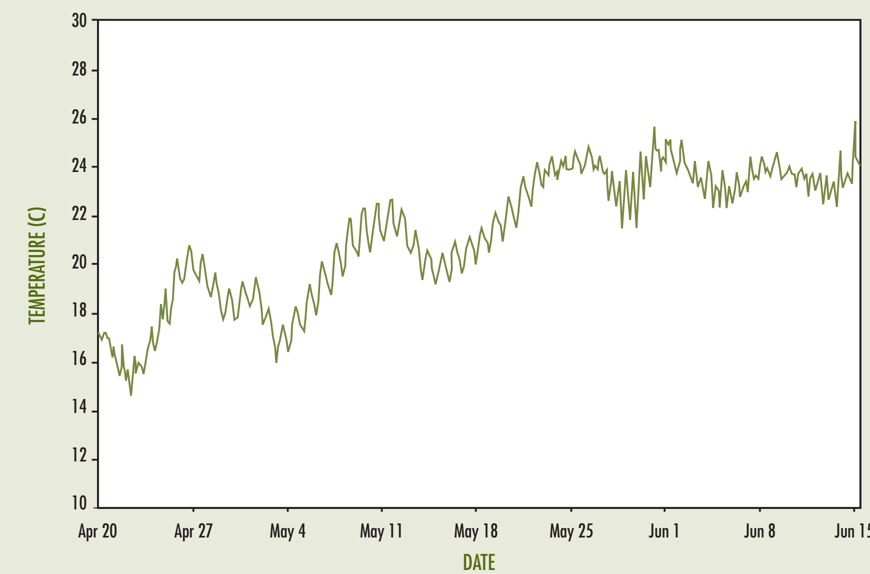


Site 3 • Dos Reis

Site 4 • DWR Monitoring Station

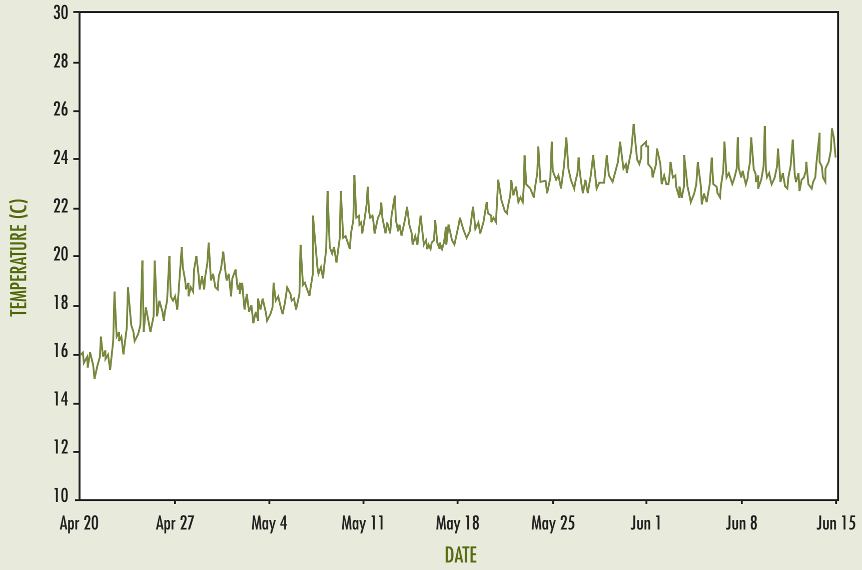


Site 5a • Confluence-Top

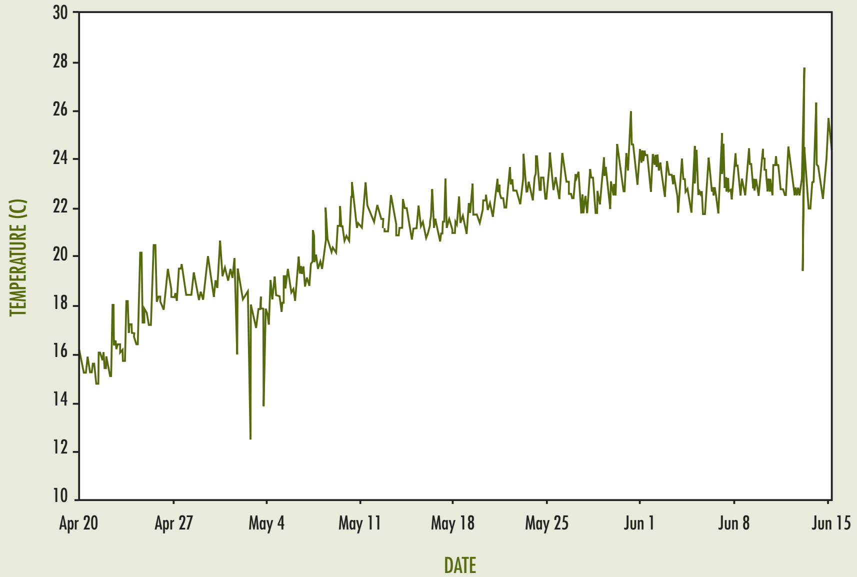


Site 5b • Confluence-Bottom

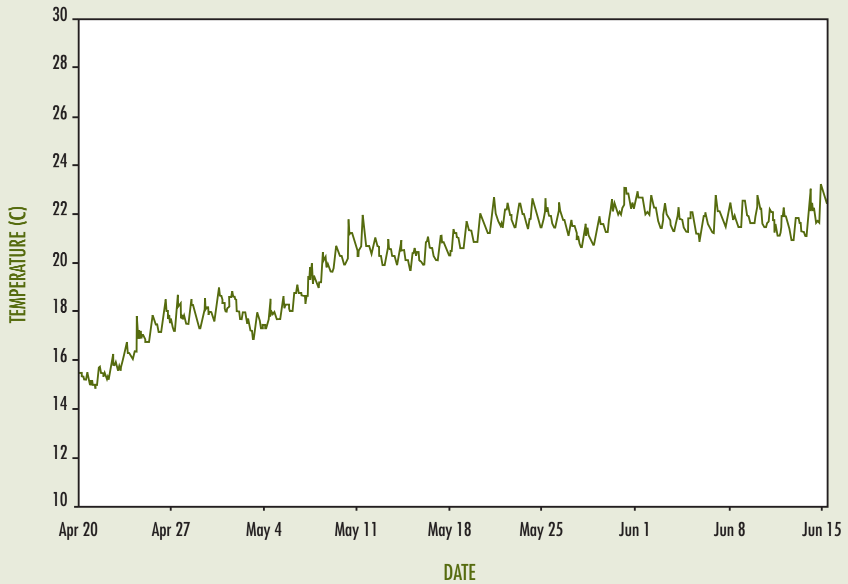
Site 6 • Downstream of Channel Marker 30



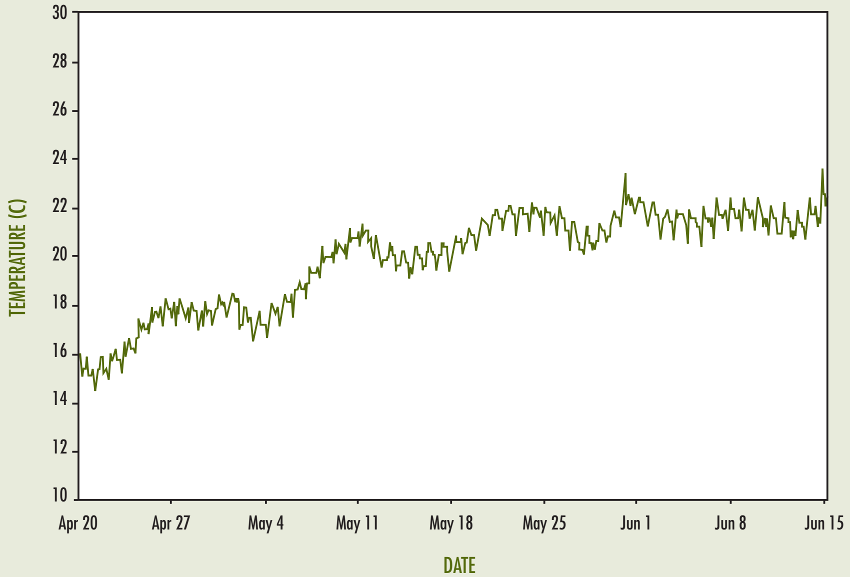
Site 7 • 1/2 Mile Upstream of Channel Marker 13



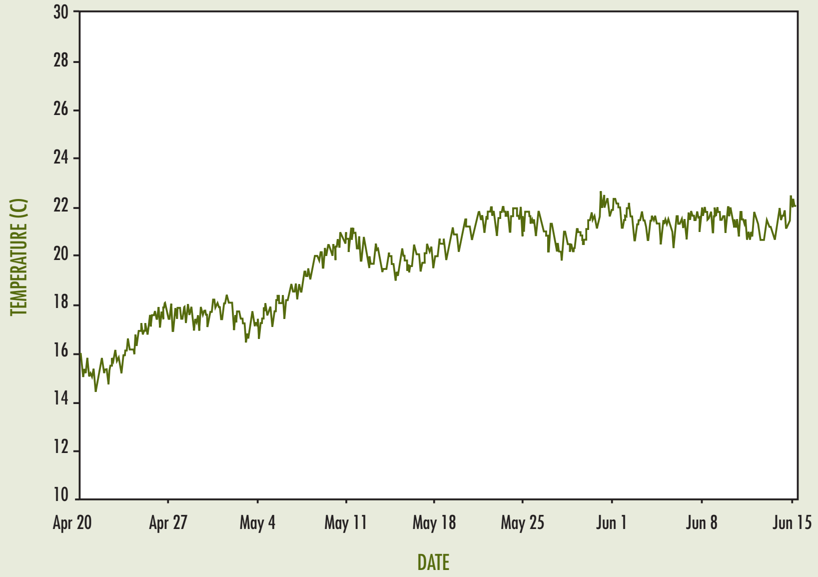
Site 8 • Downstream of Channel Marker 36



Site 9a • Jersey Point USGS Gauging Station



Site 9b • Jersey Point USGS Gauging Station



RESULTS OF NET PEN SAMPLING CONDUCTED IMMEDIATELY AFTER RELEASE AS PART OF VAMP STUDIES IN 2001

Release location, release date, tag code, number in sample	Mean fork length (and range in millimeters)	Mean weight (and range in grams)	Mean scale loss (and range) percent	Color	Fin hemorrhaging	Eyes	Gill color	Ad clips, comments
Durham Ferry I Apr 30 06-44-29, 30, 31 25 at release	88.7 (78-94)	7.3 (5.9-9.4)	3.3 (2-10)	Normal	None	Normal	1 with pale gill	
Mossdale I May 1 06-44-32 25 at release	88.4 (62-95)	7.2 (2-8.7)	3.2 (2-7)	Normal	None	Normal	Normal	All fish netted out of truck and placed in 2 separate net pens
Mossdale I May 1 06-44-33 25 at release	89.6 (77-103)	7.5 (5.4-10)	4.6 (2-8)	Normal	None	Normal	Normal	All fish netted out of truck and placed in 2 separate net pens
Jersey Point I May 4 06-44-35 25 at release	89.4 (79-98)	7.7 (5.3-9.7)	1.6 (1-6)	Normal	None	Normal	1 pale 4% pale gills	one poor ad clip
Jersey Point I May 4 06-44-34 25 at release	91.4 (84-100)	8.1 (5.3-11.2)	2.4 (1-4)	Normal	None	Normal	2 pale 8% pale gills	
Durham Ferry II May 7 06-44-36, 37, 38 25 at release	84.5 (77-91)	6.4 (5.3-7.7) only 11 fish weighed	5.3 (3-12)	Normal	None	Normal	3 pale 12% pale gills	
Mossdale II May 8 06-44-40 25 at release	87.9 (80-99)	7.7 (5.6-10.2)	3.2 (1-6)	Normal	one with anal and pelvic (pink)	Normal	5 pale 1 very pale 24% pale gills	2 poor ad clips All fish netted out of truck and placed in 2 separate net pens
Mossdale II May 8 06-44-39 25 at release	88.9 (86-97)	7.8 (5.7-9.6)	4.3 (2-8)	Normal	None	Normal	5 pale 20% pale gills	1 poor ad clip All fish netted out of truck and placed in 2 separate net pens
Jersey Point II May 11 06-44-41 25 at release	88.1 (80-105)	7.4 (5.1-11.8)	5 (3-9)	Normal	None	Normal	9 pale 40% pale gills	5 morts removed from pens immediately after release
Jersey Point II May 11 06-44-42 25 at release	87.5 (80-99)	7.2 (5-10.4)	5.9 (3-15)	Normal	None	Normal	8 pale 32% pale gills	5 morts removed from pens immediately after release

RESULTS OF NET PEN AFTER FISH WERE HELD FOR 48 HOURS, CONDUCTED AS PART OF VAMP STUDIES IN 2001

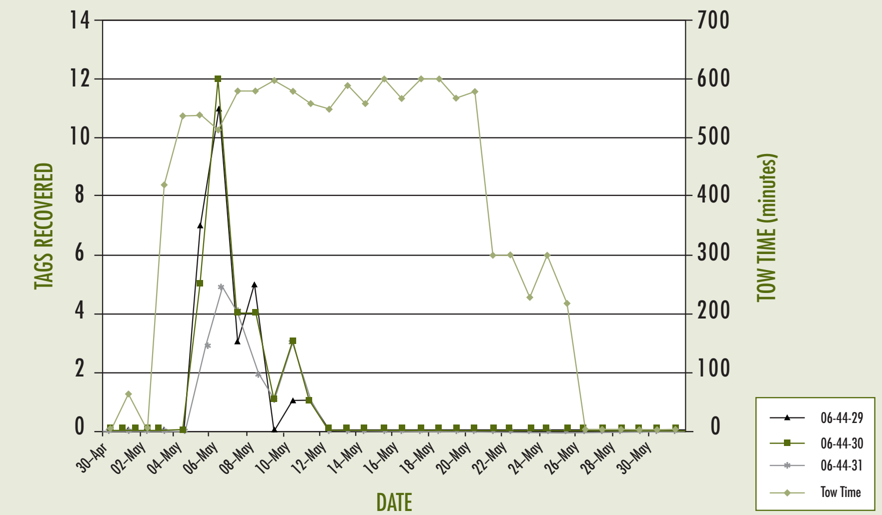
Release location, release date, tag code, number in sample	Mean fork length (and range in millimeters)	Mean weight (and range in grams)	Mean scale loss (and range) percent	Color	Fin hemorrhaging	Eyes	Gill color	Ad clips, comments and mortalities
Durham Ferry I Apr 30 06-44-29, 30, 31 200 processed	87.2 (75-96)	6.9 (3.8-9.8)	3.6 (2-15)	Normal	None	Normal	5 pale 20% pale gills	one fish bloated 4 mortalities
Mossdale I May 1 06-44-32 131 processed	88.7 (76-97)	7.2 (4.7-9.6)	3.6 (1-8)	Normal	None	Normal	3 pale 12% pale gills	
Mossdale I May 1 06-44-33 79 processed	90.3 (79-105)	7.6 (5.7-10.4)	3.8 (1-7)	Normal	None	Normal	3 pale 12% pale gills	
Jersey Point I May 4 06-44-35 92 processed	90.4 (70-104)	6.0 (3.8-12.2)	2.9 (1-8)	Normal	None	Normal	Normal	
Jersey Point I May 4 06-44-34 94 processed	91 (83-101)	7.8 (5.3-10.6)	3.2 (1-8)	Normal	None	Normal	3 pale 12% pale gills	1 mortality
Durham Ferry II May 7 06-44-36, 37, 38 185 processed	86.1 (74-97)	6.7 (4.1-8.9)	4.1 (2-10)	Normal	None	Normal	Normal	one w/partial operculum 3 mortalities
Mossdale II May 8 06-44-40 91 processed	88 (78-100)	7 (4.7-10.3)	3.7 (1-10)	Normal	None	Normal	Normal	one w/left pectoral eroded 1 mortality
Mossdale II May 8 06-44-39 102 processed	87.6 (74-102)	6.9 (4.4-11.3)	6.4 (3-12)	Normal	None	Normal	1 pale 4% pale gills	one with left pectoral eroded
Jersey Point II May 11 06-44-41 85 processed	89.1 (74-102)	7.4 (3-10.6)	5.6 (2-20)	Normal	None	Normal	2 pale 8% pale gills	
Jersey Point II May 11 06-44-42 88 processed	88.1 (73-101)	7.2 (3.9-12.2)	3.8 (1-8)	Normal	None	Normal	3 pale 12% pale gills	

2001 CODED WIRE TAG RECOVERY INFORMATION

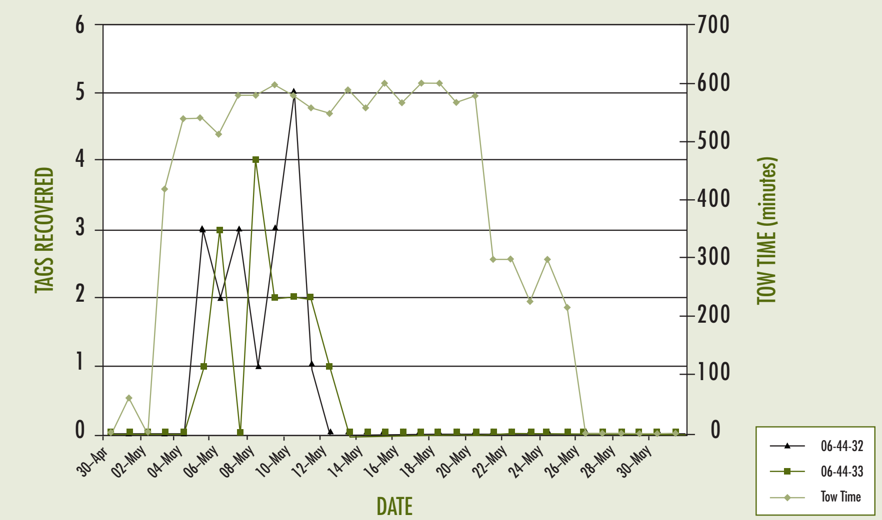
at Antioch and Chipps Island for Marked Fish Release as part of the Vernalis Adaptive Management Program

Tag Code	Release Site/Stock	Date	First Day Recovered	Last Day Recovered	Number Recovered	Minutes Fished	Survival Index	Group Index	First Day Recovered	Last Day Recovered	Number Recovered	Minutes Fished	Survival Index	Group Index
			Antioch Recovery Information						Chipps Island Recovery Information					
06-44-29	Durham Ferry		May 05	May 11	28	3,955	0.220		May 06	May 10	14	1,994	0.281	
06-44-30	Durham Ferry		May 05	May 11	30	3,955	0.241		May 05	May 11	22	2,782	0.454	
06-44-31	Durham Ferry		May 05	May 10	18	3,395	0.147		May 05	May 10	17	2,384	0.356	
	Total	Apr 30	May 05	May 11	76	3,955		0.203	May 05	May 11	53	2,782		0.363
06-44--32	Mossdale		May 05	May 11	18	3,955	0.144		May 07	May 12	17	2,392	0.347	
06-44-33	Mossdale		May 05	May 12	15	4,505	0.125		May 05	May 11	14	2,782	0.297	
	Total	May 01	May 05	May 12	33	4,505		0.134	May 05	May 12	31	3,182		0.323
06-44-34	Jersey Point		May 04	May 09	156	3,355	1.183		May 05	May 11	50	2,782	0.964	
06-44-35	Jersey Point		May 04	May 14	173	6,195	1.274		May 05	May 11	61	2,782	1.150	
	Total	May 04	May 04	May 14	329	6,195		1.225	May 05	May 11	111	2,782		1.058
06-44-36	Durham Ferry		May 12	May 15	8	2,300	0.060		May 13	May 15	2	1,200	0.039	
06-44-37	Durham Ferry		May 11	May 21	11	6,080	0.086		May 12	May 17	4	3,593	0.078	
06-44-38	Durham Ferry		May 14	May 22	10	4,680	0.082		May14	May 20	2	2,800	0.039	
	Total	May 07	May 11	May 22	29	6,380		0.078	May 09	May 20	8	4,793		0.052
06-44-39	Mossdale		May 12	May 17	8	3,470	0.060		May 13	May 16	4	1,600	0.078	
06-44-40	Mossdale		May 13	May 20	11	4,670	0.077		May 14	May 18	4	2,000	0.074	
	Total	May 08	May 12	May 20	19	5,220		0.069	May 13	May 18	8	2,400		0.076
06-44-41	Jersey Point		May 12	May 20	43	5,220	0.297		May 12	May 17	17	2,400	0.307	
06-44-40	Jersey Point		May 12	May 23	53	6,050	0.428		May 12	May 22	27	4,400	0.496	
	Total	May 11	May 12	May 23	96	6,050		0.384	May 12	May 22	44	4,400		0.401

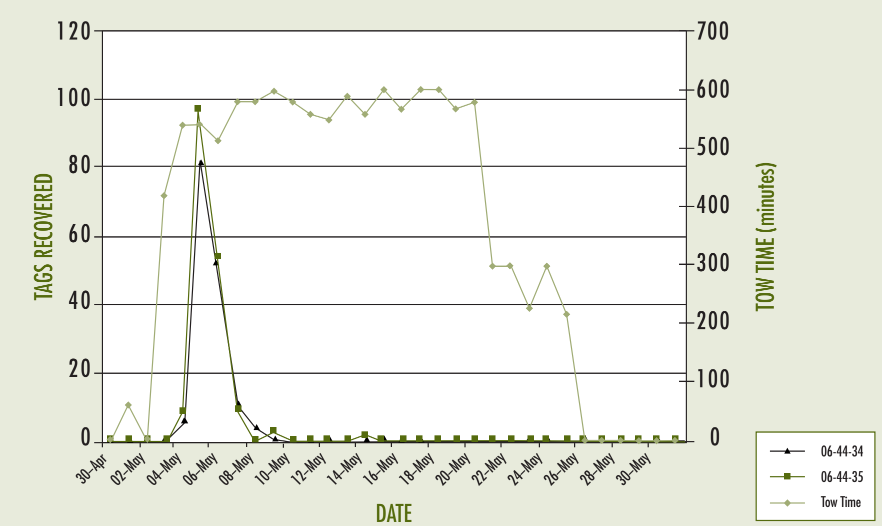
April 30th Durham Ferry Release Recovered at Antioch



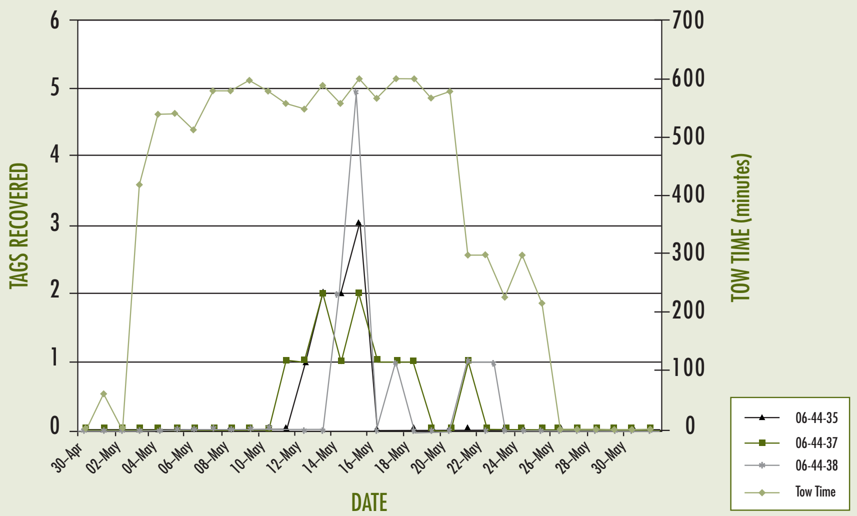
May 1st Mossdale Release Recovered at Antioch



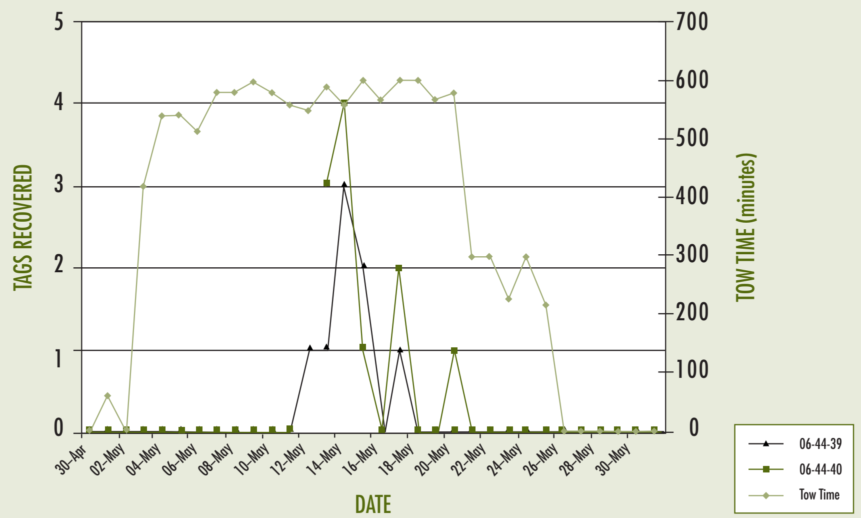
May 4th Jersey Point Release Recovered at Antioch



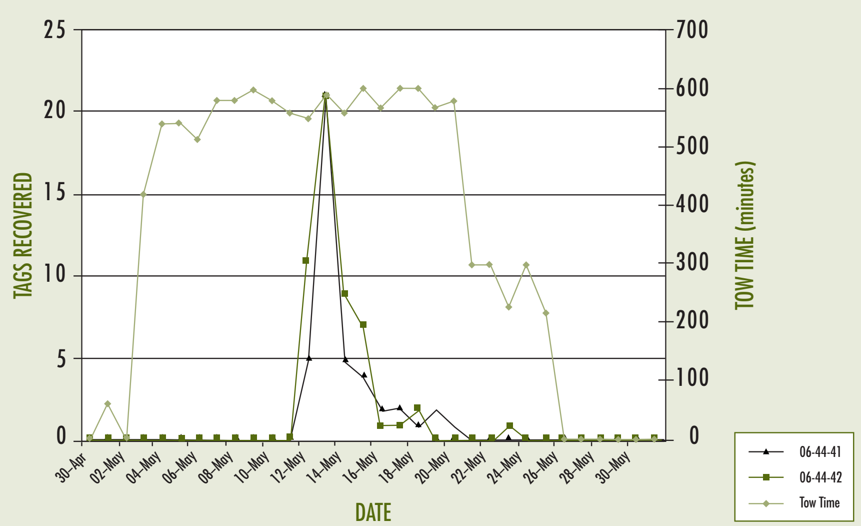
May 7th Durham Ferry Release Recovered at Antioch



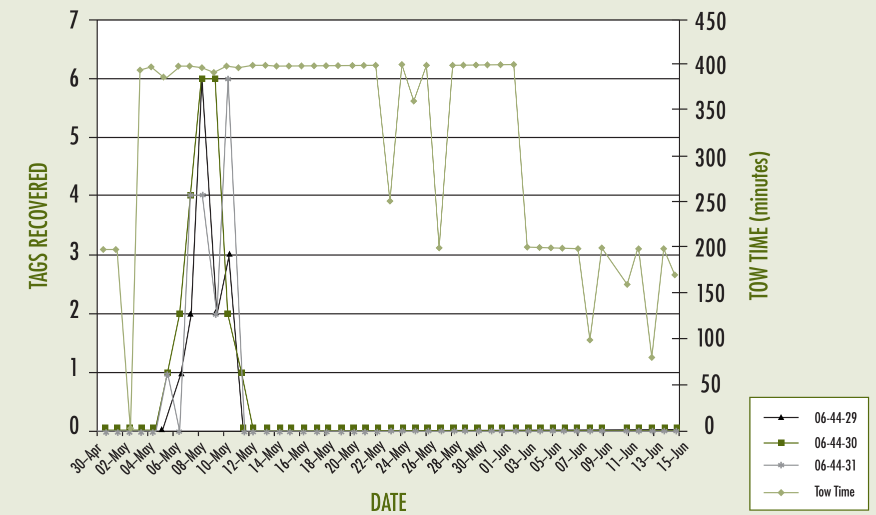
May 8th Mossdale Release Recovered at Antioch



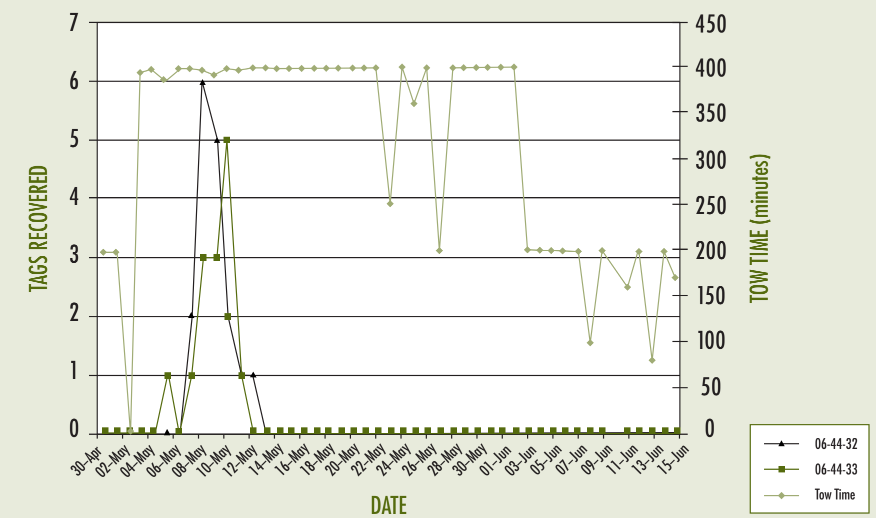
May 11th Jersey Point Release Recovered at Antioch



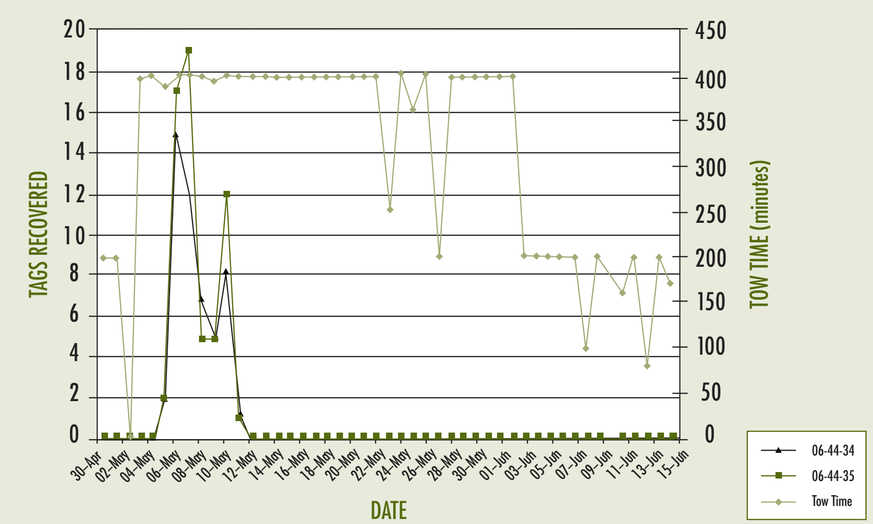
April 30th Durham Ferry Release Recovered at Chipps Island



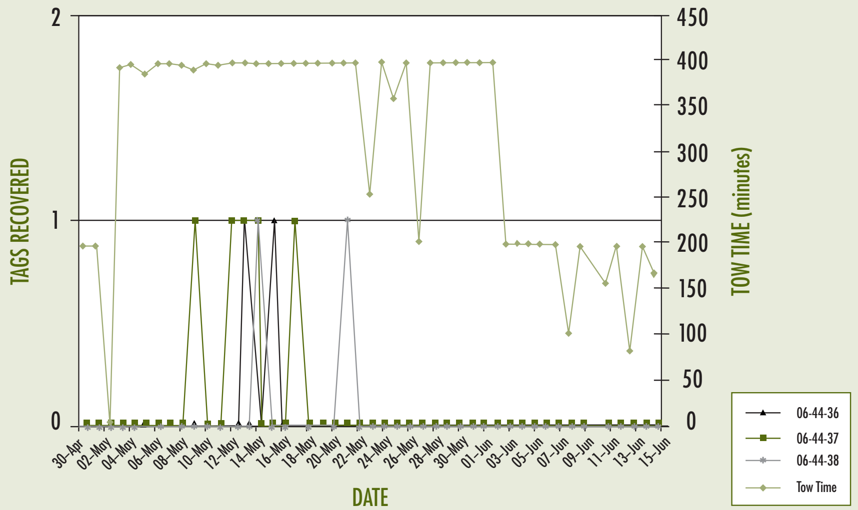
May 1st Mossdale Release Recovered at Chipps Island



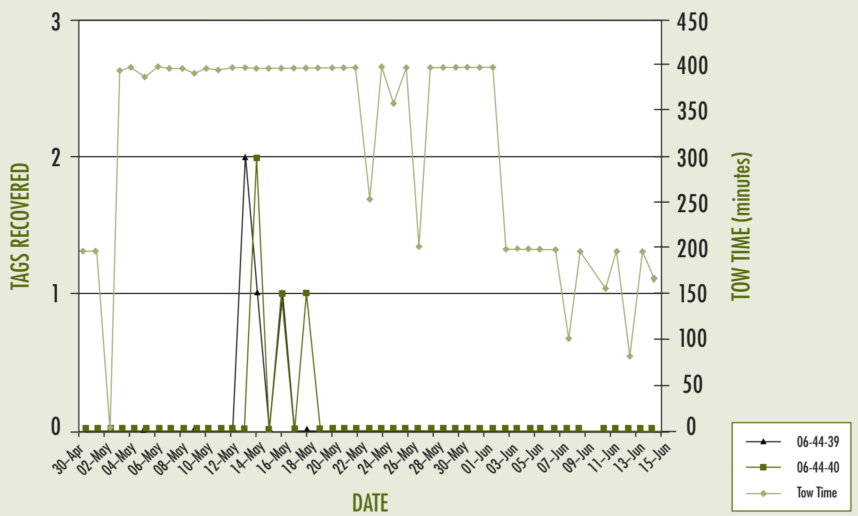
May 4th Jersey Point Release Recovered at Chipps Island



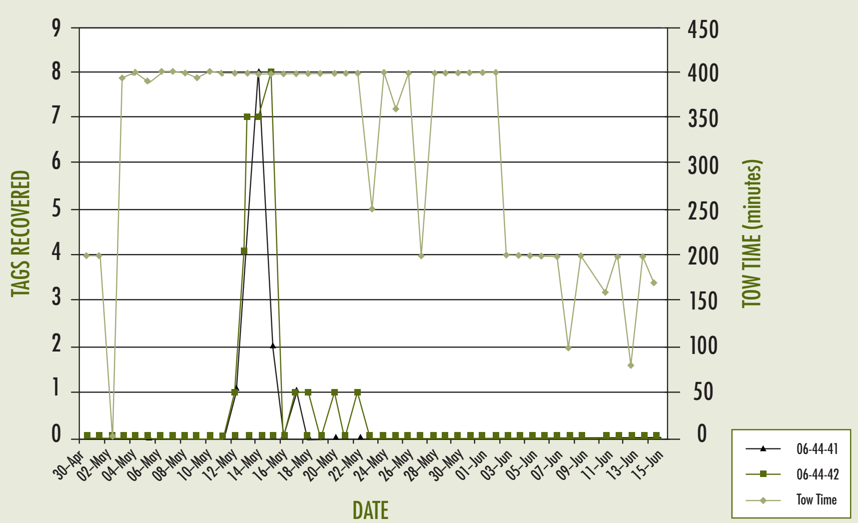
May 7th Durham Ferry Release Recovered at Chipps Island



May 8th Mossdale Release Recovered at Chipps Island



May 11th Jersey Point Release Recovered at Chipps Island



2001 CODED WIRE TAG RELEASE

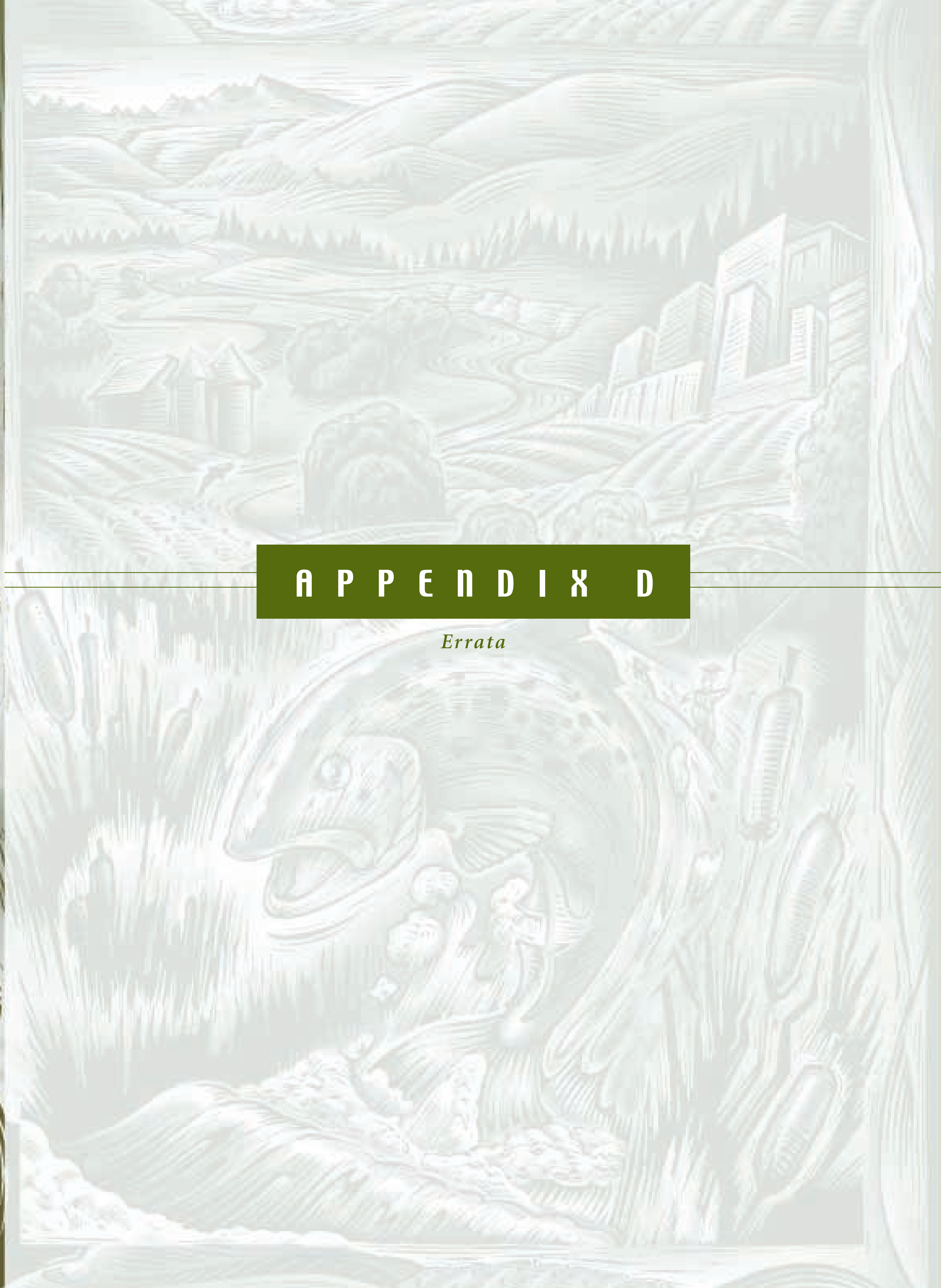
Release and Recovery Information for Coded Wire-Tagged Smolts Released in the San Joaquin River and Tributaries

							Antioch				Chipps Island				Salvage		Survival through tributary	
Tag Code	Release Site/ Stock	Date	Truck Temp C	River Temp C	No. Released	Average Size (mm)	No. Rec-overed	Percent Sampled	Survival Index	Group Survival	No. Recovered	Percent Sampled	Survival Index	Group Survival	Expanded CVP	Expanded SWP	Antioch	Chipps Island
Merced River																		
06-44-15	Merced River Fish Facility			10.0	25,029	81	3	0.369	0.023		3	0.275	0.057		0	20		
06-44-16	Merced River Fish Facility			10.0	24,077	81	10	0.378	0.079		3	0.276	0.059		0	51		
06-44-17	Merced River Fish Facility			10.0	24,342	81	1	0.375	0.008		1	0.278	0.019		0	41		
06-44-18	Merced River Fish Facility			10.0	24,034	81	7	0.378	0.055		0				0	47		
Total		Apr 21			97,482		21	0.378		0.041	7	0.276		0.034			0.32	0.17
06-44-19	Hatfield (lower Merced)		13.0	16.5	24,925	85	11	0.391	0.081		8	0.276	0.151		0	18		
06-44-20	Hatfield (lower Merced)		13.0	16.5	24,958	85	17	0.390	0.126		6	0.276	0.113		24	18		
06-44-21	Hatfield (lower Merced)		13.0	16.5	24,885	85	24	0.390	0.178		17	0.276	0.322		0	18		
Total		Apr 26			74,768		52	0.390		0.128	31	0.276		0.195				
06-44-22	Merced River Fish Facility				24,722	83	10	0.408	0.071		2	0.278	0.038		0	0		
06-44-23	Merced River Fish Facility				24,121	83	9	0.373	0.072		1	0.278	0.019		0	0		
06-44-24	Merced River Fish Facility				25,972	83	12	0.408	0.082		1	0.278	0.018		0	0		
06-44-25	Merced River Fish Facility				23,074	83	7	0.326	0.067		0				0	0		
Total		May 08			97,889		38	0.349		0.080	4	0.278		0.019			0.52	0.36
06-44-26	Hatfield (lower Merced)	May 11	13.0	18.0	23,038	85	19	0.299	0.199		1	0.278	0.020		0	0		
06-44-27	Hatfield (lower Merced)		13.0	18.0	23,227	85	20	0.341	0182		1	0.278	0.020		0	0		
06-44-28	Hatfield (lower Merced)		13.0	18.0	23,428	85	14	0.356	0.121		4	0.262	0.085		0	6		
Total		May 13			46,655		34	0.341		0.154	5	0.262		0.053				
Tuolumne River																		
06-44-12	La Grange		10.0	11.0	24,572	82	2	0.403	0.015		2	0.275	0.038		0	0		
06-44-12	La Grange				22,757	82	6	0.367	0.052		2	0.275	0.041		12	0		
06-44-13	La Grange				21,524	82	10	0.391	0.086		4	0.275	0.088		0	0		
Total		Apr 22			68,853		18	0.379		0.050	8	0.276		0.055			0.20	0.21
San Joaquin River																		
06-44-44	Old Fisherman's Club	Apr 26	14.0	21.0	24,303	85	25	0.390	0.190		12	0.275	0.233		12	12		
06-44-45	Old Fisherman's Club	Apr 28	12.5	19.0	21,965	91	35	0.388	0.295		13	0.277	0.278		0	0		
Stanislaus River																		
06-01-11-08-04	Knights Ferry		11.5	13.5	24,137	90	0				0				24	0		
06-01-11-08-05	Knights Ferry		11.0	13.0	24,037	91	0				0				24	0		
Total		May 22			48,174						0							
06-01-11-07-15	Two Rivers	May 25	10.0	20.0	23,630	94	0				0							
05-24-18	Head of Old River Barrier	May 12	15.0	20.0	24,401	84	1	0.396	0.007		4	0.278	0.077		390	267		

TIMING OF RECOVERY AT ANTIOCH AND CHIPPS ISLAND FOR CODED WIRE TAGGED SMOLTS RELEASED IN SAN JOAQUIN RIVER AND TRIBUTARIES IN THE SPRING OF 2001

							Antioch						Chipps Island					
Tag Code	Release Site/Stock	Date	Truck Temp C	River Temp C	Number Released	Average Size (mm)	First Day Recovered	Last Day Recovered	Number Recovered	Minutes Sampled	Survival Index	Group Index	First Day Recovered	Last Day Recovered	Number Recovered	Percent Sampled	Survival Index	Group Index
Merced River																		
06-44-15	Merced River Fish Facility			10.0	25,029	81	May 4	May 6	3	0.369	0.023		May 4	May 6	3	0.275	0.057	
06-44-16	Merced River Fish Facility			10.0	24,077	81	May 3	May 10	10	0.378	0.079		May 5	May 9	3	0.276	0.059	
06-44-17	Merced River Fish Facility			10.0	24,342	81	May 5	May 5	1	0.375	0.008		May 6	May 6	1	0.278	0.019	
06-44-18	Merced River Fish Facility			10.0	24,034	81	May 3	May 10	7	0.378	0.055				0	–	–	
	Total	Apr 21			97,482		May 3	May 10	21	0.378		0.041	May 4	May 9	7	0.276		0.034
06-44-19	Hatfield (lower Merced)		13.0	16.5	24,925	85	May 5	May 9	11.000	0.391	0.081		May 5	May 9	8	0.276	0.151	
06-44-20	Hatfield (lower Merced)		13.0	16.5	24,958	85	May 4	May 10	17.000	0.390	0.126		May 5	May 9	6	0.276	0.113	
06-44-21	Hatfield (lower Merced)		13.0	16.5	24,885	85	May 3	May 18	24.000	0.390	0.178		May 3	May 9	17	0.276	0.322	
	Total	Apr 26			74,768		May 3	May 18	52.000	0.390		0.128	May 3	May 9	31	0.276		0.195
06-44-22	Merced River Fish Facility				24,722	83	May 17	May 20	10	0.408	0.071		May 17	May 22	2	0.278	0.038	
06-44-23	Merced River Fish Facility				24,121	83	May 16	May 21	9	0.373	0.072		MAy 22	May 22	1	0.278	0.019	
06-44-24	Merced River Fish Facility				25,972	83	MAy 17	May 20	12	0.408	0.082		May 19	May 19	1	0.278	0.018	
06-44-25	Merced River Fish Facility				23,074	83	May 18	May 22	7	0.326	0.067				0	–	–	
	Total	May 8			97,889		May 16	May 22	38	0.349		0.080	May 17	May 22	4	0.278		0.019
06-44-26	Hatfield (lower Merced)	May 11	13.0	18.0	23,038	85	May 18	May 23	19	0.299	0.199		May 20	May 20	1	0.278	0.020	
06-44-27	Hatfield (lower Merced)		13.0	18.0	23,227	85	May 17	May 22	20	0.341	0.182		May 21	May 21	1	0.278	0.020	
06-44-28	Hatfield (lower Merced)		13.0	18.0	23,428	85	May 18	May 21	14	0.356	0.121		May 19	May 26	4	0.262	0.085	
	Total	May 13			46,655		May 17	May 22	34	0.341		0.154	May 19	May 26	5	0.262		0.053
Tuolumne River																		
06-44-12	La Grange		10.0	11.0	24,572	82	May 9	May 11	2	0.403	0.015		May 3	May 5	2	0.275	0.038	
06-44-13	La Grange				22,757	82	May 3	May 8	6	0.367	0.052		May 5	May 7	2	0.275	0.041	
06-44-14	La Grange				21,524	82	May 5	May 9	10	0.391	0.086		May 4	May 6	4	0.275	0.088	
	Total	Apr 22			68,853		May 3	May 11	18	0.379		0.050	May 3	May 7	8	0.276		0.055
San Joaquin River																		
06-44-44	Old Fisherman's Club	Apr 26	14.0	21.0	24,303	85	May 3	May 18	25	0.390	0.190		May 5	May 7	12	0.275	0.233	
06-44-43	Old Fisherman's Club	Apr 28	12.5	19.0	21,965	91	May 4	May 9	35	0.388	0.295		May 6	May 13	13	0.277	0.278	
06-01-11-08-04	Knights Ferry		11.5	13.5	24,137	90			0	–	–				0	–	–	
06-01-11-08-05	Knights Ferry		11.0	13.0	24,037	91			0	–	–				0	–	–	
	Total	May 22			48,174							–			0			–
06-01-11-07-15	Two Rivers	May 25	10.0	20.0	23,630	94			0	–	–				0	–	–	
05-24-18	Head of Old River Barrier	May 12	15.0	20.0	24,401	84	May 16	May 16	1	0.396	0.007		May 14	May 17	4	0.278	0.077	

*tag code 06-44-45 was released between 4/11/01 to 5/24/01; these fish were also spray-dyed



APPENDIX D

Errata

ERRATA FOR THE YEAR 2000 ANNUAL TECHNICAL REPORT
ON IMPLEMENTATION AND MONITORING OF THE SAN JOAQUIN RIVER AGREEMENT AND THE VERNALIS ADAPTIVE MANAGEMENT PLAN

Page 22, Paragraph 5, 4th sentence: Delete "further"

Page 31, Paragraph 1, last sentence should read: "Statistically, neither regression line is significant, although prior to adding the data from 1999, the without barrier relationship was significant (R2= 0.75, p=0.025, n=6)."

Page 32, First full paragraph, first and second sentences should read: "However, even given this noise, the data to date appears to show that smolt survival between Mossdale/Durham Ferry and Jersey Point increases as exports increase from 1600 to 2300 with the barrier in place (figure 5-2). This relationship is not statistically significant, likely because of small sample size."

Page 32, 3rd full paragraph, 3rd sentence: replace sentence 3 through 6 with: "One set of studies allows the approximation of the relative effects of flows and exports on smolt survival with a barrier in place, although the barrier was not installed during most of the releases. (Only one release had been made with the Barrier in place.) Marked fish released at Dos Reis (on the San Joaquin River downstream of the Upper Old River junction) and at Jersey Point were used to estimate survival between these two locations. Absolute survival was then compared with river flow and project exports. The results of this analysis indicated that there was a significant relationship of smolt survival from Dos Reis to Jersey Point with San Joaquin River flow at Stockton (R2 = 0.33, p < 0.03, n= 14), even with an obvious outlier from data obtained in 1999. There was not a significant relationship between survival and exports either alone or in combination with flow, although survival did appear to decrease as exports increased. The effect of exports is likely underrepresented using this approximation, since the effects of exports are likely less in this reach of the river when there is no Barrier.

A second set of studies evaluated the role of exports on smolt survival, without a barrier in place. The data for releases made at Mossdale and Jersey Point (absolute survival), were regressed against flow at Vernalis and CVP and SWP exports. The absolute survival estimate between Mossdale and Jersey Point was positively correlated to exports (R2= 0.71, p=0.017, n= 7) and flow and exports (R2= 0.84, p=0.025, n=7) and were statistically significant. These data appear to show that as exports and flows increase survival increases when there is no Barrier in place. However, data has only been gathered at exports between approximately 1500 and 4000 cfs.

Some data gathered in 1989 and 1990 may support the conclusion that survival between Mossdale and Jersey Point, without a barrier in place, is greater at higher exports. These data appeared to show that survival through Upper Old River relative to that at Jersey Point was higher during the higher export period, but overall still about half that of the survival of smolts released at Dos Reis (Brandes and McLain, forthcoming). Unfortunately, survival indices for the smolts released in Upper Old River in these years were all low making conclusions based on comparisons suspect. However, if these differences are true, and many of the smolts migrate through Upper Old River when there is no barrier in place, survival may be higher through this reach at higher exports.

Other confounding aspects to these data include using different stocks of hatchery fish to conduct the experiments, changing the level of sampling effort in recent years, getting biased results at times and not being able to measure survival at high flows with low exports with the barrier in place. For further explanation of these limitations see Brandes, 2000. These limitations may have lessened our ability to draw definitive conclusions from the past data. While future efforts will attempt to minimize changes in the study design, it is possible that confounding aspects of the data will continue and studies will need to be extended beyond the anticipated twelve years before relationships between smolt survival and flow and exports are definitive."

LITERATURE CITED:

Add: Brandes, P. 2000. 1999 South Delta Salmon Smolt Survival Studies. U.S. Fish and Wildlife Service, 4001 N. Wilson Way, Stockton CA. 95205. 5/26/00

Delete: Brandes, P and M. Pierce, 1998. 1997 Salmon smolt survival studies in the South Delta. Interagency Ecological Program for the Sacramento-San Joaquin estuary Newsletter., Vol 11, No. 1 - Winter 1998.

As a result of final revisions to the 2000 coded-wire tag database, a few calculations for the trawling effort and survival data from Chipps Island need to be updated. The following changes should be made to Table 5.2, pp. 24-25 and Appendix C, pg. 76.

Tag Code	Release Site	Release Date	Minutes Fished	Percent Sampled	Survival Index	Group Minutes Fished	Group Percent Sampled	Group Survival Index
06-01-11-08-14	Durham Ferry	4/28/00	6655	0.257	0.212	6955	0.254	0.151

In addition, the following changes should be made in Appendix C, pp. 82 and 84.

Tag Code	Release Site	Release Date	Minutes Fished	Percent Sampled	Survival Index	Group Minutes Fished	Group Percent Sampled	Group Survival Index
06-45-58	La Grange	4/15/00	10675	0.247	0.120	10675	0.247	0.072
06-44-07	Knights Ferry	5/19/00	1060	0.082	0.187	N/A	N/A	N/A
06-44-10	Two Rivers	5/20/00	980	0.136	0.149	980	0.136	0.076

THE SAN JOAQUIN RIVER AGREEMENT

2000 TECHNICAL REPORT

Vernalis Adaptive Management Plan (VAMP)

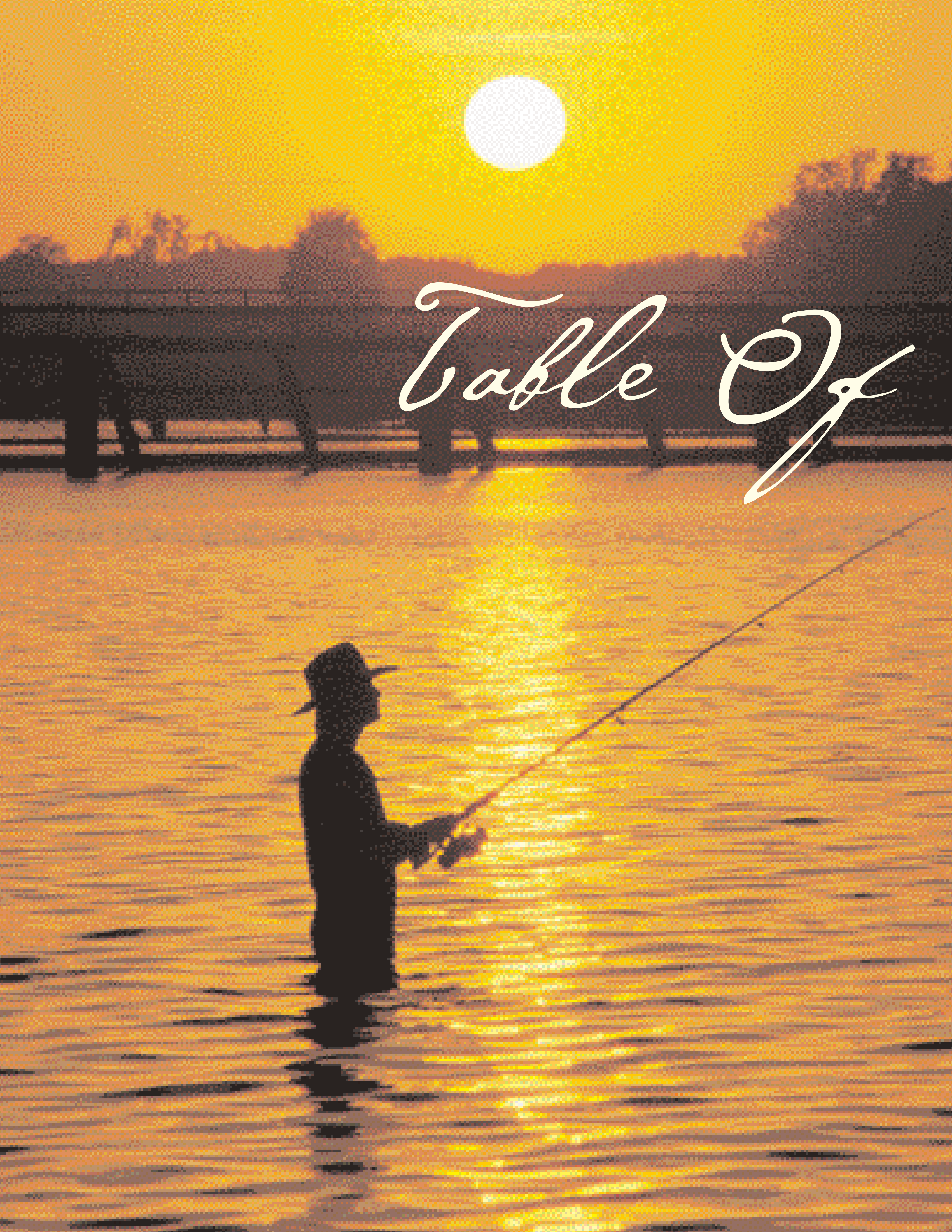


Table Of

Contents

Executive Summary *2–3*

VAMP 2000 .... *4–5*

VAMP Hydrologic Planning & Implementation *6–13*

Additional Water Supply Agreements and Deliveries *14–15*

Old River Barrier *16–21*

VAMP 2000 Salmon Smolt Survival Investigations *22–33*

Discussions & Recommendations *34–35*

Literature Cited *36*

Appendices A, B and C *39–84*

Executive Summary

THE SAN JOAQUIN AGREEMENT

The San Joaquin Agreement (SJRA or Agreement) is the cornerstone of a history-making commitment to implement the State Board's 1995 Water Quality Control Plan (WQCP) for the lower San Joaquin River and the San Francisco Bay-Delta Estuary (Bay-Delta). Using a consensus-based approach, the Agreement united a large and diverse group of agricultural, urban, environmental and governmental interests.

The 2000 Annual Technical Report comprises the consolidated annual San Joaquin River Agreement Operations and Vernalis Adaptive Management Plan (VAMP) Monitoring Report. While exploratory studies were conducted in 1998 and 1999 to help establish the experimental protocols, the VAMP 2000 program represents the first year of formal compliance with State Water Resources Control Board (State Board) Decision 1641 (D-1641). D-1641 requires the preparation of an annual report documenting the implementation and results of the VAMP program.

Specifically, this report includes the following information on the implementation of the Agreement: the hydrologic chronicle; the management of the additional SJRA water; installation, operation, and monitoring of the Head of Old River Barrier (Old River Barrier); results of the juvenile Chinook salmon smolt survival investigations; and, conclusions and recommendations. Condition 4.b of D-1641 directs the Department of Water Resources (DWR) and the U.S. Bureau of Reclamation (USBR) to send the Executive Director of the State Board the results of the fishery monitoring studies on an annual basis and Condition 7 of D-1641 directs Merced, Modesto, Turlock, South San Joaquin and Oakdale irrigation districts to submit a report detailing district operations as a result of the SJRA. By letter dated September 8, 2000, the State Board approved combining these two reports into a single comprehensive report.

A key part of this landmark agreement is the Vernalis Adaptive Management Plan (VAMP). VAMP is designed to protect juvenile Chinook salmon migrating from the San Joaquin River through the Sacramento-San Joaquin Delta. VAMP is also a scientifically recognized 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 and the installation of the Old River Barrier.

VAMP employs an adaptive management strategy to use current knowledge of hydrology and environmental conditions to protect Chinook salmon smolt passage, while gathering information to allow more efficient protection in the future.

In addition to providing improved protection for juvenile Chinook salmon emigrating from the San Joaquin River system, specific experimental objectives of VAMP 2000 included:

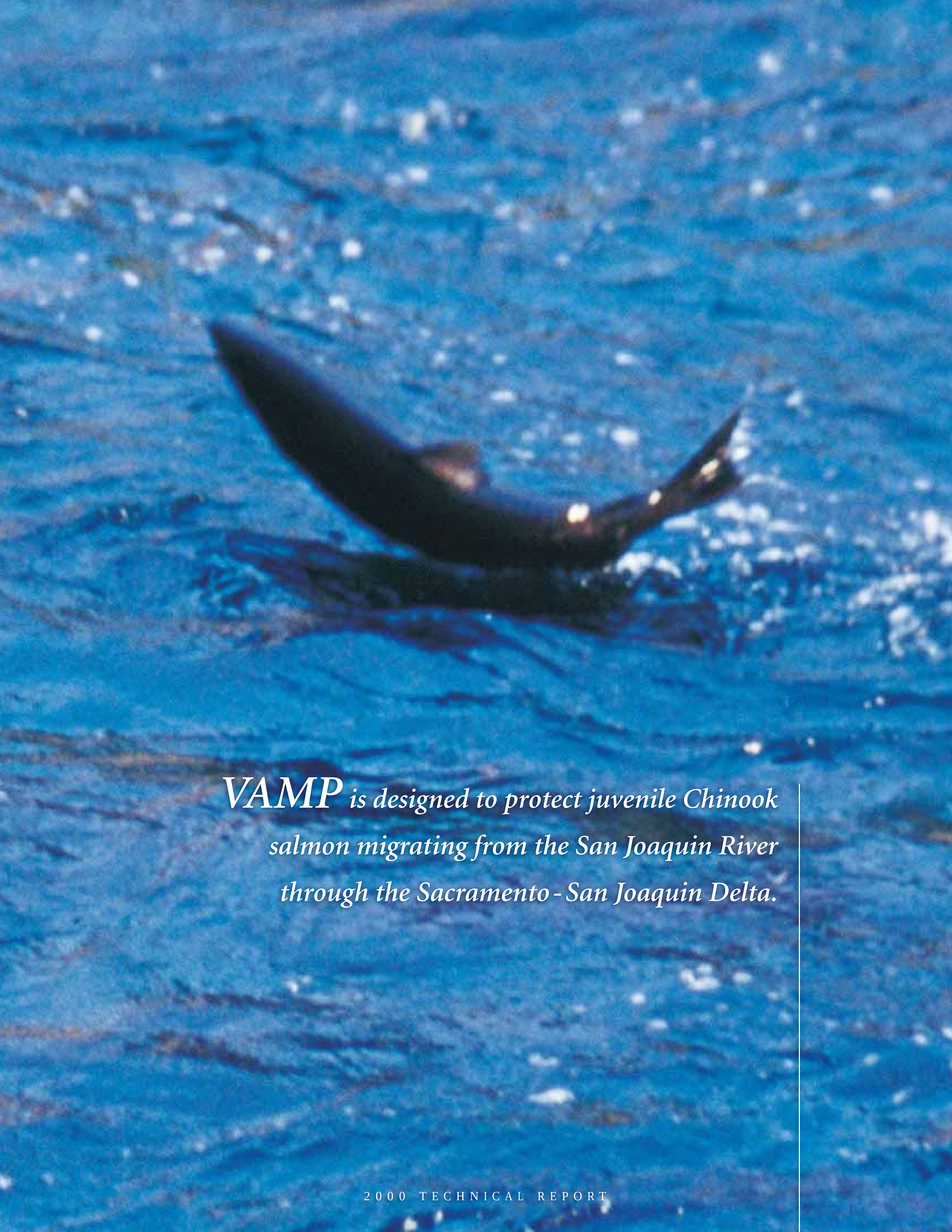
- *Quantification of Chinook salmon smolt survival between Durham Ferry and Jersey Point using recapture locations at Antioch and Chipps Island, under conditions of a San Joaquin River flow at Vernalis of 5,700 cfs, with an installed Head of Old River Barrier, and SWP/CVP export rates of 2,250 cfs; and*
- *Comparison of juvenile Chinook salmon survival between Durham Ferry and Mossdale for use in comparing results of VAMP 2000 with results from earlier survival studies where coded-wire tagged salmon releases occurred at Mossdale.*

A secondary objective of the VAMP 2000 experimental salmon smolt survival studies is the comparison of the survival of juvenile Chinook salmon of Merced and Mokelumne River origin released at Jersey Point.

Based on data gathered during the experimental mark-recapture studies that occurred over a 31-day period in April and May 2000, a set of conclusions and recommendations have been developed. These conclusions and recommendations, described in detail on pages 34–35 of this report, provide guidance and a foundation for design and implementation of future VAMP operations.

Key policy and management conclusions and recommendations derived from VAMP 2000 include:

- *VAMP 2000 is the first year of full implementation of the program. No conclusions on the relative roles of San Joaquin River flow and SWP/CVP exports on juvenile Chinook salmon smolt survival can be made with this documented data. The report recommends that the VAMP experimental test program be continued;*
- *The design and installation of the temporary Old River Barrier in 2000 provided unreliable operations at San Joaquin River flows of 7,000 cfs. The report recommends resolution of concerns regarding the Old River Barrier design and operations and future VAMP test flows be maintained as a high priority item;*
- *Budgeting and planning for the VAMP program should be expanded beyond one year. The report recommends that a three-year plan and budget be developed, including anticipated capital and operation costs, to facilitate VAMP implementation.*



***VAMP** is designed to protect juvenile Chinook salmon migrating from the San Joaquin River through the Sacramento - San Joaquin Delta.*

Introduction

VAMP 2000

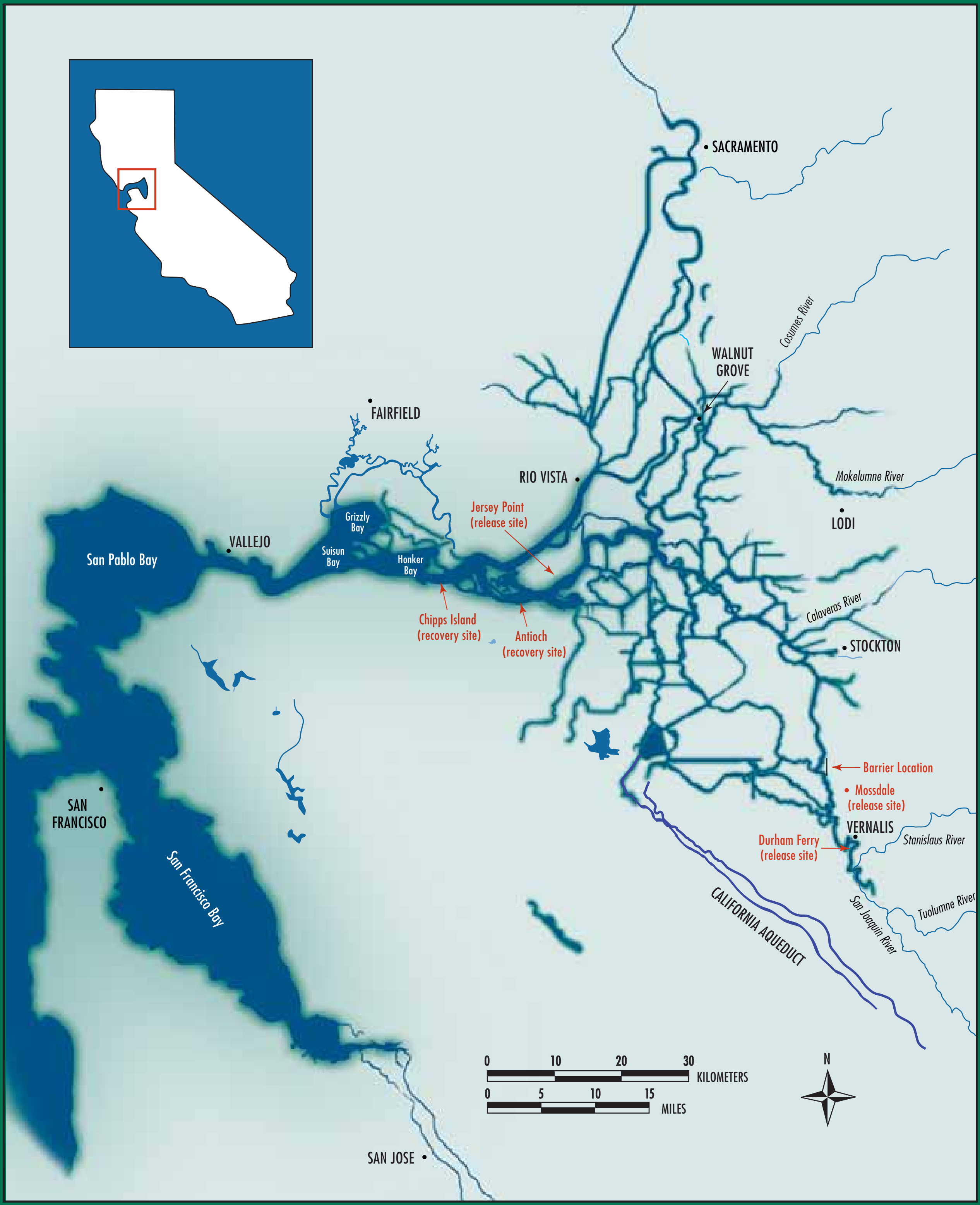
The VAMP experimental design measures salmon smolt survival rates under six different combinations of flow and export rates (see pages 6–13). The experimental design includes two mark-recapture studies performed each year during the mid-April to mid-May out-migration period that provide estimates of salmon survival under each set of conditions. Chinook salmon survival rates under each of the experimental conditions are then calculated based on the numbers of marked salmon released and the number recaptured (see page 28).

EXPERIMENTAL DESIGN ELEMENTS

The VAMP 2000 experimental design included both multiple release locations (Durham Ferry, Mossdale, and Jersey Point), and multiple recapture locations (Antioch, Chipps Island, SWP and CVP salvage operations, and in the ocean fisheries (**Figure 1-1**). Two sets of releases were made at Durham Ferry and Jersey Point. The use of data from multiple release and recapture locations allows for a more thorough evaluation of juvenile Chinook salmon survival as compared to recapture data from only one sampling location and one series of releases. The VAMP release (Durham Ferry and Jersey Point) and recapture locations (Antioch and Chipps Island) will be consistent from one year to the next, providing a greater opportunity to assess salmon smolt survival over a range of Vernalis flows, SWP/CVP exports, and with and without the presence of the Old River Barrier. Releases at Jersey Point serve as controls for recaptures at Antioch and Chipps Island, thereby allowing the calculation of survival estimates based on the ratio of survival indices from marked salmon recaptured from upstream (e.g., Durham Ferry) and the downstream (control) release at Jersey Point. The use of ratio estimates as part of the VAMP study design substantially reduces the bias associated with differential gear collection efficiency within and among years, improves the precision associated with the individual indices, and improves confidence in differences in salmon smolt survival as a function of Vernalis flows and SWP/CVP exports.

Figure 1.1

SACRAMENTO-SAN JOAQUIN ESTUARY



Location of VAMP 2000 release sites (Durham Ferry, Mossdale, and Jersey Point), recovery locations (Antioch, and Chipps Island), and Upper Old River Barrier location within the Sacramento-San Joaquin River Delta/Estuary.

Hydrologic Planning

VAMP HYDROLOGIC PLANNING & IMPLEMENTATION

This section documents the planning and implementation of the VAMP 2000 investigations as undertaken by the Hydrology Group of the San Joaquin River Technical Committee (SJRTC). Implementation of VAMP is guided by the framework provided in the Agreement and anticipated hydrologic conditions within the watershed.

The Hydrology Group 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 2000, the agencies belonging to the Hydrology Group included: Merced Irrigation District (Merced), Turlock Irrigation District (TID), Modesto Irrigation District (MID), Oakdale Irrigation District (OID), South San Joaquin Irrigation District (SSJID), San Joaquin River Exchange Contractors (Exchange Contractors), 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 installation of the Old River Barrier and the planning of Delta exports consistent with the VAMP.

VAMP FLOW AND SWP/CVP EXPORTS

The VAMP investigations are designed to collect data and information on the impacts of San Joaquin River flow and Delta exports (SWP and CVP pumping at the Tracy and Banks pumping plants) on the survival rates of juvenile Chinook salmon emigrating from the San Joaquin River system. The VAMP provides for a 31-day pulse flow at the Vernalis gage during the months of April and May, along with a corresponding reduction in SWP/CVP exports, as shown in **Table 2-1**. The magnitude of the pulse flow is based on San Joaquin River flow that would occur during the pulse period absent the VAMP, referred to as the existing flow.

Based upon hydrologic conditions, the target flow in a given year could either be increased to the next highest value ("double-step") or the supplemental water requirement could be eliminated entirely. A numerical procedure has been established in the SJRA to determine the target flow. The State Board San Joaquin Valley Water Year Hydrologic Classification ("60-20-20" classification) is given a numerical indicator as shown in **Table 2-2**.

"Double-step" flow years occur when the sum of last year's numerical indicator and the 90 percent exceedence forecast of the current year's numerical indicator is seven (7) or greater. If the sum of the two previous years' numerical indicators and the 90 percent exceedence forecast of the current year's numerical indicator is four (4) or less, which is an extremely dry period, the San Joaquin River Group Authority (SJRG) members are not required to provide water above the existing flow. The USBR has a continuing obligation to meet San Joaquin River flows pusuant to the March 6, 1995 Biological Opinion.

Under the Agreement, the maximum amount of supplemental water to be provided to meet VAMP target flows in any given year is 110,000 acre-feet. If the VAMP target flow requires more than 110,000 acre-feet of supplemental water (based on the targets outlined in **Table 2-1**, under double-step conditions, historically up to 157,000 acre-feet of supplemental water may be required), then additional water may be acquired on a willing seller basis.

VAMP 2000 HYDROLOGIC PLANNING

Hydrology Group Meetings

Beginning in February 2000, and continuing until early April, the Hydrology Group held five planning and coordination meetings (February 10; March 2, 16, and 30; and April 6). At these meetings, forecasts of hydrologic and operational conditions on the San Joaquin River and its tributaries were discussed and refined.

Monthly Operation Forecasts

As part of the early planning efforts, monthly operation forecasts were developed by the Hydrology Group to estimate the existing flow at Vernalis. Inflows to the tributary reservoirs used in these forecasts were based on DWR Bulletin 120 runoff forecasts. The monthly operation forecasts used the 90 percent and 50 percent probability of exceedence runoff forecasts. The initial monthly

Table 2.1

VAMP VERNALIS FLOW & DELTA EXPORT TARGETS

EXISTING FLOW (CFS)	VAMP TARGET PULSE 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
4,500 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 the extent possible	

Table 2.2

SAN JOAQUIN VALLEY WATER YEAR
HYDROLOGIC CLASSIFICATIONS USED IN VAMP

60-20-20 CLASSIFICATION	VAMP NUMERICAL INDICATOR
Wet	5
Above Normal	4
Below Normal	3
Dry	2
Critical	1

Table 2.3

SUMMARY OF VAMP 2000 MONTHLY FORECASTS

VAMP FORECAST DATE	RUNOFF FORECAST DATE	RUNOFF EXCEEDENCE	VAMP CRITERIA	EXISTING FLOW (CFS)	VAMP TARGET FLOW (CFS)	SUPPLEMENTAL WATER (1,000 ACRE-FEET (AF)
				SPRING PULSE PERIOD (APRIL 15 - MAY 15)		
Feb 09	Feb 01	90 %	Single step	2,895	3,200	19
		50 %	Double step	4,370	5,700	84
Feb 22	Feb 15	90 %	Single step	3,785	4,450	41
		50 %	Double step	4,940	7,000	127

operation forecast was prepared in early February. An additional monthly forecast was prepared using mid-February runoff forecast updates. The monthly forecasts are summarized in **Table 2-3**. Based upon the early forecast efforts, it was apparent that the planning for the 2000 VAMP would require consideration of a broad range of possibilities.

DAILY OPERATION PLANS

The Hydrology Group developed a daily operation plan beginning in mid-March, updating it as hydrologic conditions and operational requirements changed. The daily operation plans calculated an estimated mean daily flow at Vernalis based on measured flows at the major tributary's control points and in the upper San Joaquin River with the following key assumptions:

(**1**) The travel times for flows from the tributary measurement points and upper San Joaquin River to the Vernalis gage are assumed as follows:

a. Merced River at Cressey to Vernalis	3 days
b. San Joaquin River above Merced River to Vernalis	2 days
c. Tuolumne River at LaGrange to Vernalis	2 days
d. Stanislaus River below Goodwin Dam (at Orange Blossom Bridge) to Vernalis	2 days

(**2**) Based upon a review of the historical flow record, the ungaged flow at Vernalis was assumed to be constant throughout the pulse period and equal to the trending value entering the pulse period. By definition, the ungaged flow is that unmeasured flow entering the system between Vernalis and the upstream measuring points and is calculated as follows:

Vernalis Ungaged =

VNS - OBBlag - LGNlag - CRSlag - USJRlag

where:

VNS	=	San Joaquin River near Vernalis
OBBlag	=	Stanislaus River at Orange Blossom Bridge lagged 2 days
LGNlag	=	Tuolumne River at LaGrange lagged 2 days
CRSlag	=	Merced River at Cressey lagged 3 days
USJRlag	=	San Joaquin River above Merced River lagged 2 days (USJR is not gaged but is calculated as the difference between the gaged flows at the San Joaquin River at Newman (NEW) and the Merced River at Stevinson (MST)).

A summary of the daily operation plans developed during the planning of the 2000 VAMP is provided in **Table 2-4**. Copies of the daily operation plans are provided in **Appendix A**.

By definition, the VAMP 31-day pulse flow period can occur anytime between April 1 and May 31. Until the pulse flow is specifically defined, it is assumed for the purposes of planning to be April 15 through May 15. Flexibility of dates for the pulse flow period exists so that they coincide with the period of peak salmon out-migration. Other factors, including installation of Old River Barrier, availability of juvenile salmon at the hatchery, and manpower and equipment availability for fish releases and sampling fish also need to be considered in determining the timing of the pulse period.

Early forecasts indicated that 2000 would be a "double-step" year with a flow target of 7,000 cfs and concurrent combined CVP and SWP pumping at Tracy and Banks at 3,000 or 1,500 cfs. From a biological standpoint, 1,500 cfs was the preferred option. A wet February and early March resulted in high San Joaquin River flows and raised concerns about the chances of installing the Old River Barrier. The high San Joaquin River flows also caused speculation that the VAMP period would have to be delayed, however, a sustained dry period with essentially no rainfall in the San Joaquin basin between March 19 and April 12 reduced the forecasted flows such that the VAMP planning returned to the April 15 through May 15 nominal schedule. To ensure that the flows in the San Joaquin River remained below 5,000 cfs during installation of the Old River Barrier, Stanislaus River flows were reduced from 1,500 cfs to approximately 850 cfs. Tuolumne River flows were also reduced from about 1,200 cfs to 420 cfs. Construction of the Old River Barrier began on April 5.

Late March and early April operation plans indicated that supplemental water in excess of 110,000 acre-feet would be required to achieve the target flow of 7,000 cfs for the 31-day pulse flow period. This additional water could be supplied through purchases by the USBR from willing sellers. In preparation for this possibility, the SJRG and USBR prepared a draft Environmental Assessment and Initial Study for additional water acquisition.

By April 13, construction of Old River Barrier was nearly complete and upstream releases for the scheduled VAMP pulse flow had begun, timed to arrive at Vernalis coincident with the April 15 start of the target flow period. However, the flow at Vernalis as measured by USGS on April 13 indicated that the actual flow (3,210 cfs) was about 1,000 cfs less than that being reported on the California Data Exchange Center (CDEC) (4,280 cfs). The revised flow at Vernalis resulted in a revision of the projected existing flow from 5,018 cfs to 4,412 cfs—near the threshold of two VAMP target flows (5,700 cfs and 7,000 cfs). A base flow less than 4,450 cfs requires a target flow of 5,700 cfs and a base flow greater than

Table 2.4

SUMMARY OF VAMP 2000 DAILY OPERATION PLANS

VAMP FORECAST DATE	PULSE PERIOD	ASSUMED UNGAGED FLOW AT VERNALIS (CFS)	EXISTING FLOW (CFS)	VAMP TARGET FLOW (CFS)	SUPPLEMENTAL WATER 1,000 ACRE-FEET (AF)	NOTES
Mar 15	Apr 15–May 15 May 01–May 31	1,000 1,000	6,447 6,184	7,000 7,000	34.9 55.0	
Mar 23	Apr 20–May 20	1,000	4,934	7,000	127.0	Pulse period set at April 20 to May 20 to accomodate Head of Old River Barrier (HORB) construction.
Mar 29	Apr 20–May 20	1,000	4,934	7,000	127.1	
Apr 04	Apr 15–May 15	1,000	4,949	7,000	128.8	Pulse period changed to Apr 15 to May 15 due to revised HORB construction schedule.
Apr 05	Apr 15–May 15	1,000	4,949	7,000	128.8	
Apr 11	Apr 15–May 15	1,000–1,800	5,018	7,000	125.0	
Apr 13	Apr 15–May 15	550–700	4,412	5,700	86.0	Existing flow and ungaged flow at Vernalis reduced significantly due to rating shift at Vernalis gage.
Apr 14	Apr 15–May 15	500	4,320	5,700	89.5	
Apr 17	Apr 15–May 15	500	4,265	5,700	89.5	

4,450 cfs requires a target flow of 7,000 cfs. After convening a special session of the SJRTC to evaluate the latest data, the decision was made to set the VAMP 2000 flow target at 5,700 cfs with a Delta export target of 2,250 cfs. Important to this decision was the need for a target flow that could be sustained for 31 days as opposed to establishing a higher target that could not be sustained during the entire pulse flow period.

Due to travel time considerations, releases were already underway to achieve the earlier 7,000 cfs Vernalis target flow, with a 3,800 cfs fishery study pulse flow under way on the Tuolumne River. In order to move the projected flow at Vernalis closer to the new target of 5,700 cfs without disrupting the Tuolumne River pulse flow, the flow in the Stanislaus River was reduced from 1,500 cfs to 1,100 cfs. Nevertheless, it was still anticipated that the flow at Vernalis would exceed the 5,700 cfs target flow to some degree for the duration of the first Tuolumne River pulse flow test period.

VAMP 2000 IMPLEMENTATION

Operation Conference Calls

During implementation of the VAMP pulse flow, conference calls were conducted on a regular basis to discuss the status of the pulse flow and to make changes to the operation plan if needed. The calls were held at 6:30 a.m. so that potential operational changes could be implemented on that day. Daily conference calls occurred from April 13 through April 19, excluding the weekend, and then every Monday, Wednesday and Friday thereafter through May 12.

Operation Monitoring

During the pulse flow period, supplemental water contributions from San Joaquin tributaries were continuously monitored using the available real-time data. Data at each of the measurement locations (Merced River at Cressey, Tuolumne River below LaGrange Dam, Stanislaus River at Orange Blossom Bridge, San Joaquin River near Vernalis, Merced River at Stevinson, and San Joaquin River at Newman) was compiled by CDEC. Monitoring was necessary to verify that supplemental water deliveries were adhering to tributary allocations contained in the Agreement to the extent possible. An example of the spreadsheet used to monitor the operation is provided in **Appendix A**.

Operational Highlights

On April 17, a strong storm moved into the San Joaquin basin and produced record or near record amounts of rainfall. It was anticipated that the storm would elevate flows at Vernalis by approximately 1,000 cfs. Preservation of the pulse on the Tuolumne River was deemed more important than modifying operations to attempt to maintain the Vernalis flow target. Since the Old River Barrier was designed to be safe with flows approaching 9,000 cfs, problems were not anticipated. As a result of storm runoff and irrigation cutbacks, the Vernalis flow responded dramatically, increasing to what was initially believed to be about 6,400 cfs. Just as the peak was reached, personnel on site at the Old River Barrier reported that the water level on the San Joaquin River side of the Old River Barrier was far closer to the crest than anticipated, and concern was expressed about the safety of the Old River Barrier at these flows. At nearly the same time, on April 18, USGS measured a flow of 7,140 cfs at the Vernalis gage, 730 cfs higher than the 6,410 cfs being reported on CDEC. As a result of these events, immediate reductions in reservoir releases were implemented. The Tuolumne River flow was reduced by about 1,000 cfs, and the Stanislaus River flow was reduced from 1,100 cfs to 800 cfs. The peak flow passed the Old River Barrier uneventfully, and the Stanislaus River flow was returned to its 1,500 cfs target. However, the slow recession of the storm hydrograph kept flows above the Vernalis target flow of 5,700 cfs for a longer period than expected.

After the effects of the April 17 storm subsided, San Joaquin River flows became fairly stable and predictable for the remainder of the VAMP pulse period. A small storm at the end of the first week in May caused some concern but proved to have a relatively small impact on the flow at Vernalis with an increase in flow of approximately 300 to 400 cfs. From April 15 through April 24, Vernalis flows averaged 6,360 cfs, ranging from 7,060 to 5,760 cfs. From April 25 through May 15, the mean daily flow at Vernalis averaged 5,750 cfs, ranging from 5,230 cfs to 6,050 cfs, a deviation of -8 percent to +6 percent from the target flow of 5,700 cfs.

RESULTS OF VAMP 2000 OPERATIONS

Planning and implementation of the VAMP spring pulse flow operation was accomplished using the best available real-time data which has not been reviewed for accuracy or adjusted for the long range impacts of rating shifts. The final accounting for the VAMP operation is accomplished using provisional mean daily flow data available from USGS and DWR. The provisional data, which is considered to be the best available information, has been reviewed and adjusted for rating shifts but is still considered provisional and is subject to change. To illustrate the differences between real-time and provisional data, plots of the real-time and provisional flows at the primary measuring points are provided in **Appendix A**.

Daily Vernalis flows during the VAMP 2000 test period are shown in **Figure 2-1**. The mean daily flow at the Vernalis gage ranged from 5,230 cfs to 7,060 cfs, resulting in an average of 5,869 cfs during the 31-day target flow period. The maximum mean daily flow of 7,060 cfs, which occurred on April 18, was the result of both the large amount of rain that occurred the previous day and the initial flow schedule that was based on a target flow of 7,000 cfs. The average flow for the target flow period absent the VAMP supplemental water was estimated to be 4,815 cfs. **Figure 2-1** shows the flow at Vernalis and sources of that flow. **Figure 2-2** compares the flow at Vernalis with and without the VAMP pulse flow. The VAMP resulted in a 25 percent increase in flow at Vernalis during the target flow period. A total of 77,680 acre-feet of supplemental water was provided to meet the VAMP target flow. A daily summary of VAMP operations, along with supporting data, is provided in **Appendix A**.

The combined CVP and SWP export rate averaged 2,155 cfs during the 31-day period, about 4 percent below the target of 2,250 cfs. **Figure 2-3** summarizes daily SWP and CVP exports.

SJRG member agencies have entered into the Division Agreement which allocates responsibility of the members for providing VAMP supplemental water. The members may also make additional agreements among themselves regarding delivery of the supplemental water. For VAMP 2000, SJRG contributing agencies agreed to provide the SSJID supplemental water as follows: 54.55 percent by Merced, 15.91 percent by OID, 15.91 percent by MID and 13.64 percent by TID. It was also agreed that the OID supplemental water would be provided entirely by MID due to the 1,500 cfs flow limitation on the Stanislaus River.

The distribution of supplemental water for the VAMP 2000 target flow, compared to the distribution as the Division Agreement, is summarized in **Table 2-5**.

Figure 2.1

SAN JOAQUIN RIVER NEAR VERNALIS

WITH LAGGED CONTRIBUTIONS FROM PRIMARY SOURCE

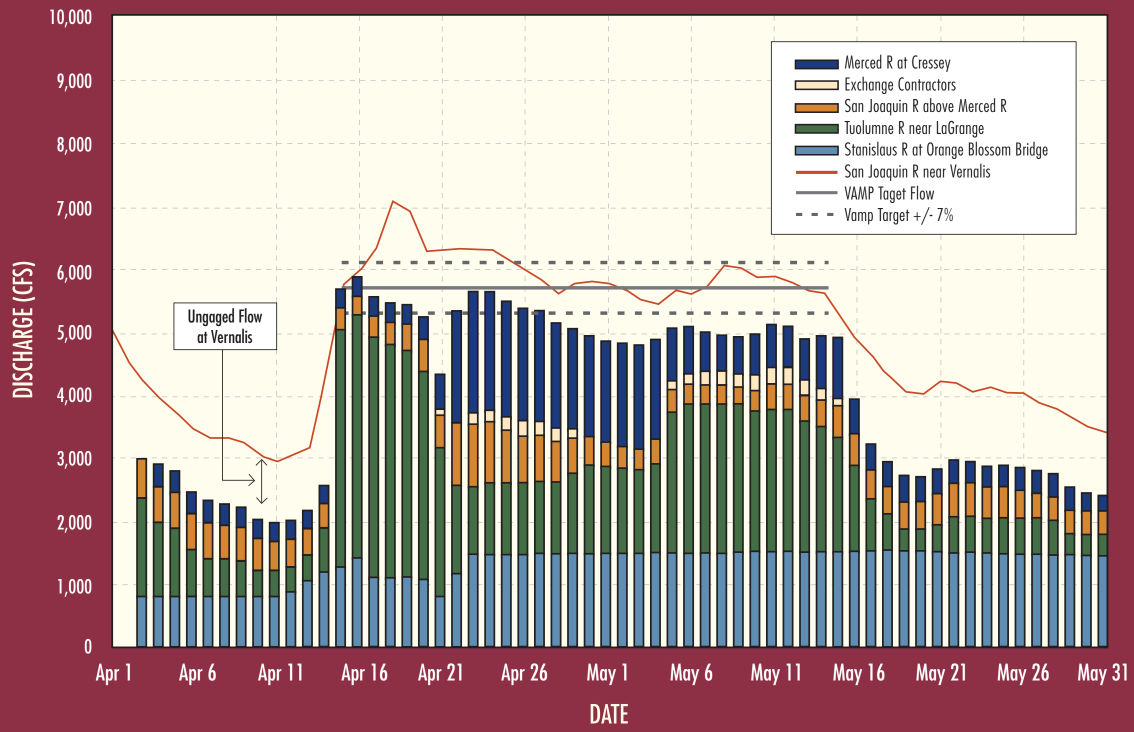


Figure 2.2

SAN JOAQUIN RIVER NEAR VERNALIS

WITH & WITHOUT VAMP

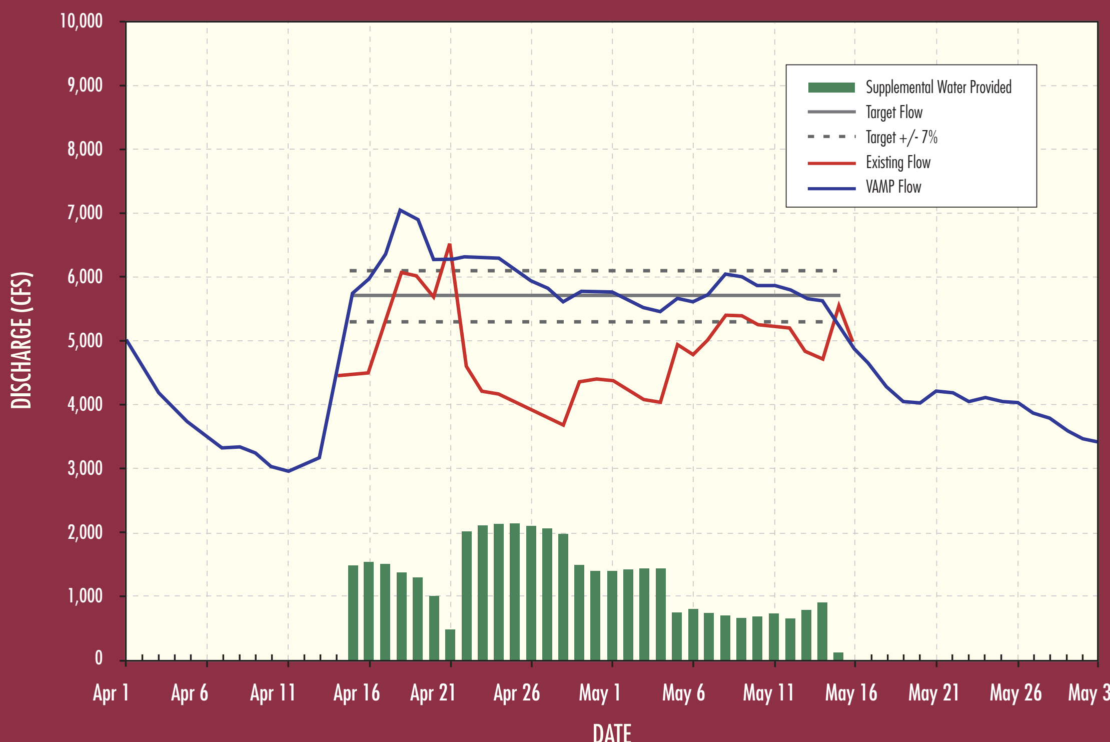


Figure 2.3

FEDERAL & STATE EXPORTS

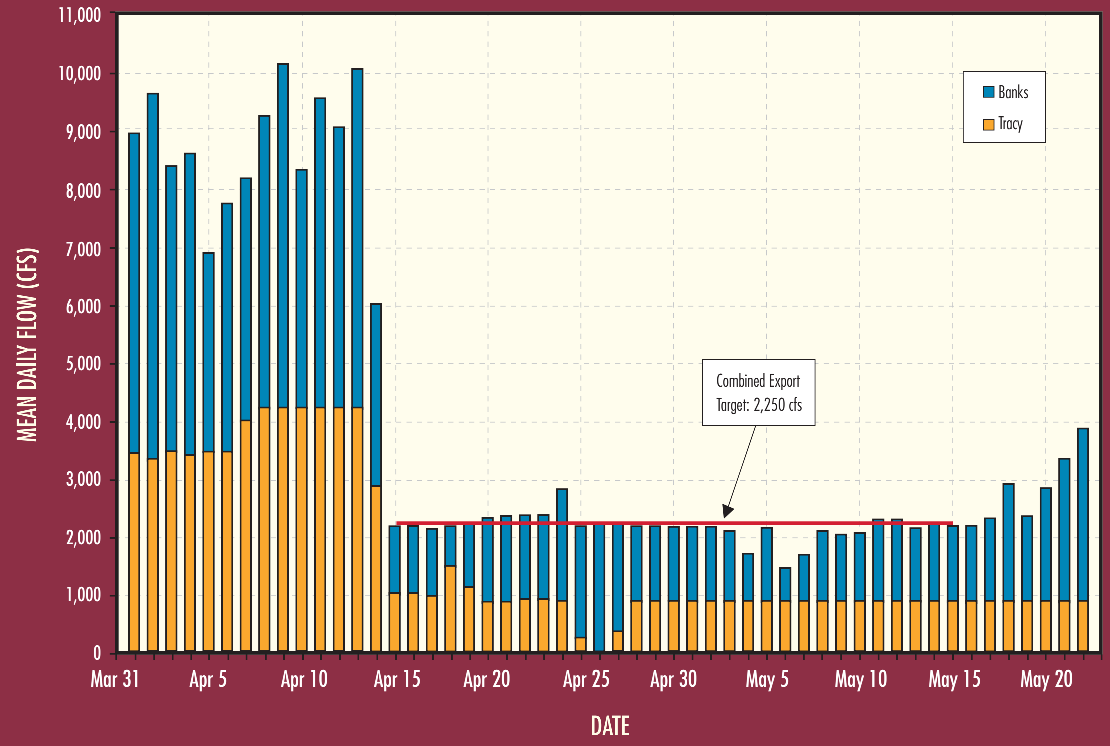
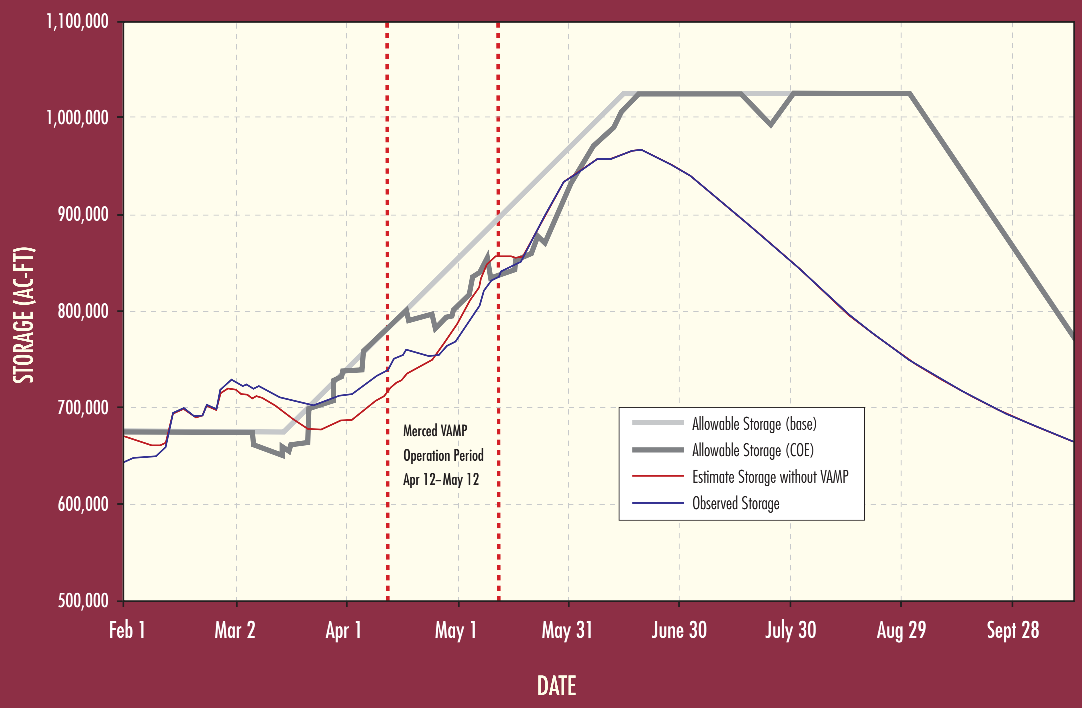


Figure 2.4

STORAGE IMPACTS LAKE McCLURE MERCED RIVER



STORAGE IMPACTS

Supplemental water from the Merced and Tuolumne Rivers was primarily supplied from storage from Lake McClure on the Merced River and from New Don Pedro Reservoir on the Tuolumne River. Therefore, the impacts of VAMP operations can be seen directly as changes in reservoir storage. 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.

On the Merced River, flood control releases were required in May, thereby eliminating the storage impacts in Lake McClure that had resulted from the VAMP 2000 operations. **Figure 2-4** shows Lake McClure storage with and without the VAMP operation.

On the Tuolumne River, the storage impact of approximately 23,800 acre-feet was reduced to about 7,700 acre-feet due to flood control releases required at the end of September 2000 under the "No VAMP" scenario. This 7,700 acre-feet storage impact will continue until further flood control releases are made. **Figure 2-5** shows New Don Pedro Reservoir storage with and without VAMP 2000 operations, assuming the encroachment into the Don Pedro flood control space would have occurred without VAMP releases would have been allowed.

Table 2.5

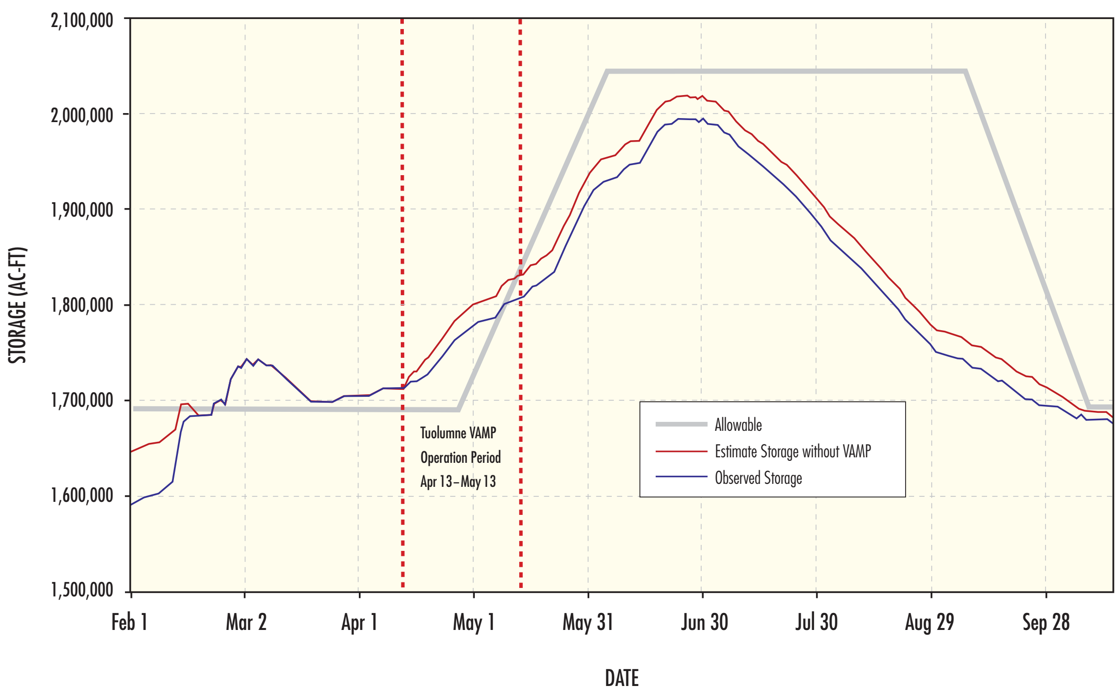
DISTRIBUTION OF 77.68 THOUSANDS ACRE-FEET (TAF) OF SUPPLEMENTAL WATER

AGENCY	DIVISION AGREEMENT DISTRIBUTION (TAF)		SUPPLEMENTAL WATER PROVIDED	DEVIATION FROM DIVISION AGREEMENT
	Base	*Adjusted*		
Merced	41.18	45.16[3]	46.75	+1.59
OID	7.30[1]			
SSJID	7.30[2]			
Exchange Contractors	7.30	7.30	8.28	+0.98
MID	7.30	16.92[4]	15.20	-1.72
TID	7.30	8.30[5]	7.45	-0.85

[1] Provided by MID
[2] Provided by: Merced (54.55%), OID (15.91%), MID (15.91%), TID (13.64%)
[3] Includes 3.98 TAF of SSJID water
[4] Includes 7.30 TAF of OID water and 2.32 TAF of SSJID water
[5] Includes 1.00 TAF of SSJID water

Figure 2.5

STORAGE IMPACTS NEW DON PEDRO RESERVOIR (TUOLUMNE RIVER)



Water Supply

ADDITIONAL WATER SUPPLY ARRANGEMENTS & DELIVERIES

MERCED IRRIGATION DISTRICT (MERCED)

The Agreement includes a provision (Paragraph 8.4) stating, "Merced Irrigation District shall provide, and the USBR shall purchase 12,500 acre-feet of water… during October of all years." This water is referred to as the Fall SJRA Transfer Water. The daily schedule for the SJRA Fall Transfer Water is to be developed by Department of Fish and Game (DFG), United States Fish and Wildlife Services (USFWS) and Merced.

In addition to providing water in the fall of 2000 pursuant to the Agreement, Merced entered into a contract with USBR to transfer up to 25,000 acre-feet of water to be used to benefit wildlife refuges south of the Delta. This additional water transfer is referred to as the Fall 2000 Transfer. The Fall 2000 Transfer water was to be delivered via the SWP, using available excess pumping capacity at the Banks Pumping Plant. Because the likelihood of available pumping capacity decreases near the end of the year, and due to the benefits to salmon returning to spawn in the Merced River or at the Merced River Hatchery, the decision was made to transfer 16,000 acre-feet in October and 9,000 acre-feet in November.

During October, DWR installed a temporary barrier. As part of the land use agreement allowing for the construction of the Old River Barrier, DWR agreed to remove it if the flow in the San Joaquin River, as measured at the Vernalis gage, exceeded 4,500 cfs. This was an important issue in the scheduling of the Fall Transfer Water.

It became evident in the early stages of planning that in order to meet the desired flow schedule for the Fall 2000 Transfer and not put the Old River Barrier at risk, it would be necessary to schedule some of the Fall SJRA Transfer Water outside of October. Additionally, being able to use the transfer water to bolster flows in November and December would be beneficial to the fisheries. Paragraph 8.4.4 of the Agreement stipulates, "Water purchased pursuant to Paragraph 8.4 may be scheduled for months other than October provided Merced, DFG and USFWS all agree." By letter agreement, Merced, DFG and USFWS agreed to exercise Paragraph 8.4 and allow for the release of Fall SJRA Transfer water in November and December.

The initial daily schedule for the Fall SJRA Transfer called for 7,580 acre-feet to be delivered in October and 4,920 acre-feet to be delivered in December. The initial daily schedule for the Fall 2000 Transfer called for 14,310 acre-feet to be provided in October and 10,690 acre-feet in November (for initial daily schedules, see **Appendix B**).

Due to a lack of available pumping capacity at the Banks Pumping Plant, the Fall 2000 Transfer was terminated on October 31. As a result, a revised transfer schedule was developed, moving the December Fall SJRA Transfer water to October and November (see **Appendix B** for the revised schedule). The revised Fall SJRA Transfer water schedule, developed October 31, provided for release of 8,770 acre-feet in October and 3,730 acre-feet in November. At the time of termination of the Fall 2000 Transfer, preliminary data indicated that 13,120 acre-feet had been provided in October.

On November 3, it was announced that excess pumping capacity at Banks Pumping Plant would be available beginning November 6, resulting in another revision to the transfer schedule. This revised Fall SJRA Transfer water schedule (**Appendix B**) resulted in 8,770 acre-feet provided in October, 750 acre-feet in November and 2,980 acre-feet in December. The revised Fall 2000 Transfer schedule provided 13,120 acre-feet in October and 11,650 acre-feet in November. These values are all preliminary and subject to change.

A preliminary summary of Merced additional water transferred to date is provided in **Appendix B**.

OAKDALE IRRIGATION DISTRICT (OID)

Pursuant to Paragraph 8.5 of the SJRA, "Oakdale Irrigation District shall sell 15,000 acre-feet of water to the USBR in every year of (the) Agreement… In addition to the 15,000 acre-feet, Oakdale will sell the difference between the water made available to VAMP under the SJRGA agreement and 11,000 acre-feet."

Table 3.1

DAILY TABULATION OF OAKDALE IRRIGATION DISTRICT ADDITIONAL WATER RELEASE

PRELIMINARY
SUBJECT TO CHANGE

[1] CVPIA is the acronym for Central Valley Project Improvement Act.

[2] "Section 3406 b (2) of CVPIA states that 800,000 acre-feet of Central Valley Project yield is dedicated to fish and wildlife."

[3] "Section 3406 b (3) of CVPIA is a program to acquire water for fish and wildlife."

As noted on page 10, OID provided 7,300 acre-feet of supplemental water for the year 2000 VAMP, leaving 3,700 acre-feet of "difference" water. Therefore, pursuant to Paragraph 8.5 of the Agreement, OID sold a total of 18,700 acre-feet of water to the USBR in 2000.

The OID additional water (3,700 acre-feet) was made available to the USBR on August 16. The 15,000 acre-feet was released by the USBR between October 17 and November 20. Release of the 3,700 acre-feet of "difference" water commenced on November 20 and was completed on December 10. A daily tabulation of the OID additional water release is provided in **Table 3-1**.

DATE	GOODWIN DAM RELEASE	[1]PRE CVPIA BASE CONDITION RELEASE	[2]B(2) WATER	OAKDALE ID ADDITIONAL WATER RELEASED BY USBR– [3][B(3) WATER]		CUMULATIVE OAKDALE ID ADDITIONAL WATER RELEASED
	(cfs)	(cfs)	(cfs)	(cfs)	(acre-feet)	(acre-feet)
Oct 10	311	300	11			
Oct 11	307	300	7			
Oct 12	307	300	7			
Oct 13	313	300	13			
Oct 14	309	300	9			
Oct 15	305	300	5			
Oct 16	304	300	4			
Oct 17	676	300		376	746	746
Oct 18	1,085	300		785	1,557	2,303
Oct 19	1,108	300		808	1,603	3,905
Oct 20	1,109	300		809	1,605	5,510
Oct 21	1,113	300		813	1,613	7,123
Oct 22	1,060	300		760	1,507	8,630
Oct 23	865	300		565	1,121	9,751
Oct 24	659	300		359	712	10,463
Oct 25	478	300		178	353	10,816
Oct 26	382	300		82	163	10,979
Oct 27	379	300		79	157	11,135
Oct 28	383	300		83	165	11,300
Oct 29	384	300		84	167	11,466
Oct 30	376	300		76	151	11,617
Oct 31	376	300		76	151	11,768
Nov 01	386	300		86	171	11,939
Nov 02	388	300		88	175	12,113
Nov 03	386	300		86	171	12,284
Nov 04	384	300		84	167	12,450
Nov 05	382	300		82	163	12,613
Nov 06	380	300		80	159	12,772
Nov 07	382	300		82	163	12,934
Nov 08	383	300		83	165	13,099
Nov 09	382	300		82	163	13,261
Nov 10	378	300		78	155	13,416
Nov 11	379	300		79	157	13,573
Nov 12	377	300		77	153	13,726
Nov 13	376	300		76	151	13,876
Nov 14	378	300		78	155	14,031
Nov 15	385	300		85	169	14,200
Nov 16	385	300		85	169	14,368
Nov 17	384	300		84	167	14,535
Nov 18	383	300		83	165	14,699
Nov 19	380	300		80	159	14,858
Nov 20	377	300		77	153	15,011
Nov 21	383	300		83	165	15,176
Nov 22	378	300		78	155	15,330
Nov 23	380	300		80	159	15,489
Nov 24	381	300		81	161	15,650
Nov 25	382	300		82	163	15,812
Nov 26	385	300		85	169	15,981
Nov 27	378	300		78	155	16,136
Nov 28	378	300		78	155	16,290
Nov 29	380	300		80	159	16,449
Nov 30	380	300		80	159	16,608
Dec 01	386	275		111	220	16,828
Dec 02	385	275		110	218	17,046
Dec 03	383	275		108	214	17,260
Dec 04	383	275		108	214	17,474
Dec 05	386	275		111	220	17,695
Dec 06	386	275		111	220	17,915
Dec 07	387	275		112	222	18,137
Dec 08	384	275		109	216	18,353
Dec 09	382	275		107	212	18,565
Dec 10	386	275		111	220	18,785
Dec 11	384	275	109			
Dec 12	382	275	107			
Dec 13	381	275	106			
Dec 14	382	275	107			
Dec 15	382	275	107			

Old River Barrier

OLD RIVER BARRIER

In 2000, DWR successfully installed and operated the temporary Old River Barrier that included permitting, engineering design, and a short construction schedule. The spring Old River Barrier is a component of the south Delta Temporary Barriers Project (TBP). The TBP mitigates for low water levels in the south Delta and improves water circulation and quality for agricultural purposes.

The spring Old River Barrier was first constructed in 1992 and again in 1994, 1996, 1997 and 2000. The Old River Barrier was not installed in 1993, 1995 and 1998 due to high San Joaquin River flows. The Old River Barrier was not installed in 1999 due to landowner access problems. The Old River Barrier, a key component of VAMP, is intended to increase San Joaquin River Chinook salmon smolt survival by preventing them from entering Old River.

The Old River Barrier was originally designed to withstand a San Joaquin River flow of about 3,000 cfs. Through the years, the design and installation of Old River Barrier has been revised on several occasions to accommodate different needs. The most recent design of Old River Barrier provides a wider base to withstand significantly higher flows in the San Joaquin River. The 2000 Old River Barrier was equipped with six 48-inch operable culverts and a weir back-filled with clay.

BARRIER DESIGN AND INSTALLATION

The dimensions of the 2000 Old River Barrier were considerably larger than those constructed in past years **Figure 4-1**. The base width of the Old River Barrier was increased to 100 feet and the crest elevation was raised to ten feet mean sea level (MSL). The top of Old River Barrier was built with a 75-foot wide notch, protected with concrete grid mats and back-filled with clay. The larger Old River Barrier was designed to withstand flow stages up to 8.5 feet MSL. A 7,000 cfs VAMP target flow is likely to fluctuate plus or minus 500 cfs under normal circumstances. This fluctuation could result in stages at Old River Barrier within the minimum freeboard zone. A sudden storm event could raise stages enough to cause the Barrier to overtop. Given the experience with Old River Barrier in 2000, and the current flow rating information for Vernalis, DWR does not recommend the 2000 barrier design for study years when VAMP target flows are 7,000 cfs. Also, to safely construct or remove the Barrier, flows at Vernalis must be held below 5,000 cfs.

To help mitigate anticipated low water levels in the south Delta (downstream of the Barrier) caused by the operation of the Old River Barrier, six operable culverts were installed. Operation of the culverts is controlled by a slide gate control structure located on the upstream side of Old River Barrier (**Figure 4-1**). DWR relied on daily modeling and field data collection to monitor water levels at three locations within the south Delta to determine when and how long to operate the culverts.

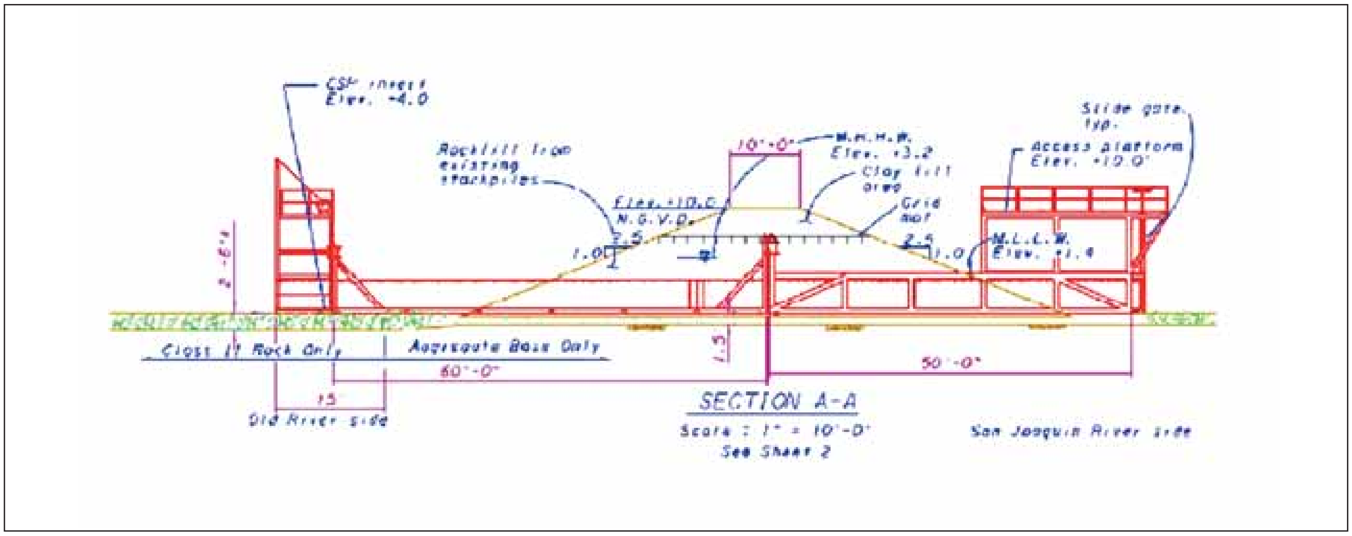
The downstream outlet of each culvert was designed so fyke nets could be attached to evaluate fish passage. DFG staff conducted a fishery-monitoring program as part of the 2000 Old River Barrier operations (for additional information, see page 18).

Because of the increase in the design flow and the addition of the culverts in the Barrier, DWR protected the existing levees adjacent to Old River Barrier with additional riprap. The riprap extended 300 feet downstream of the Old River Barrier on both banks—protecting the levee from erosion that might occur during the culvert operations or during an emergency breaching.

Head of Old River Barrier

Figure 4.1

HEAD OF OLD RIVER BARRIER CROSS SECTION



BARRIER OPERATIONS AND MONITORING PLAN

DWR obtained permits from the Corps of Engineers and the DFG to install and operate six 48-inch diameter culverts in the Old River Barrier. The culverts permitted flow through the Old River Barrier on an as-needed basis, while ensuring improved flows in the mainstem San Joaquin River.

DWR developed a Barrier operations and monitoring plan. Based on the forecast and monitoring of tidal conditions, DWR would determine the number of culverts to be opened at the Old River Barrier so that water levels at Old River near Tracy Road Bridge, Middle River near Howard Road and Grant Line Canal near Tracy Road Bridge would remain above 0.0 feet MSL. As a result of modeling and/or field monitoring of water levels in the south Delta, culvert slide gates were operated and modified four times between April 16 and May 16. On April 17, two culverts were opened and remained open until the Old River Barrier was removed. On April 27 and 28, the third and the fourth culverts were opened, respectively. The last two culverts were opened on May 11, and all six culverts remained open until the Old River Barrier was breached on May 16.

The daily flows diverted through the culverts varied in response to local tidal conditions and San Joaquin River flow conditions. The characteristics of the flow through the culvert are complicated in that the flow is controlled by many variables, including the culvert inlet geometry, slope, size, culvert roughness, and approach and tail water conditions. It is estimated that when the difference in water level across the Old River Barrier is eight feet, the discharge is approximately 150 cfs through each culvert, or a total of about 900 cfs when all six culverts are open.

BARRIER EMERGENCY RESPONSE PLAN

In addition to the operation and monitoring plan, DWR also developed an "Emergency Operations Plan for the Spring 2000 Head of Old River Barrier". In 2000, the plan provided that if the daily flow at Vernalis was measured or forecasted to exceed 8,500 cfs, the Old River Barrier would be removed.

Operation of the Old River Barrier was uneventful with the exception of the first week, as mentioned on page 6. Flow at Vernalis of approximately 7,100 cfs resulted in about 1.8 feet of freeboard remaining on the upstream side of Old River Barrier. During this period, the DWR Division of Flood Management and Division of Engineering evaluated the situation and recommended that the Old River Barrier not be breached. The barrier remained in place until May 15.

SEEPAGE MONITORING

A seepage-monitoring program was initiated in April to evaluate the effects of the operation of the Old River Barrier on seepage and groundwater on Upper Roberts Island.

Three seepage monitoring well sites were chosen on Upper Roberts Island. Each site had two shallow wells, positioned 10 feet and 100 feet from the toe of the levee to monitor seepage gradient to and from the San Joaquin River. In addition, a deeper well was drilled at Site 1 to determine vertical gradients.

Hourly groundwater levels in each well were recorded with an in situ datalogger/transducer.

In addition to the groundwater monitoring wells, a temporary gage was installed in April 2000 to record water surface stages in the San Joaquin River, about 1,500 feet downstream from the Old

River Barrier. Installation of a permanent tide gage is scheduled for late 2001. The water surface stages are compared to groundwater levels on Upper Roberts Island to determine how groundwater levels change relative to changing water level conditions in the San Joaquin River.

The 2000 data for San Joaquin River elevations and groundwater elevations indicates that a strong relationship exists at Site 1, while weaker relationships exist for Sites 2 and 3. There was an almost immediate response between tidal variation and groundwater level fluctuations, indicating water was moving quickly to the islands upper water bearing zones and to the wells. The data indicated however, that while the Old River Barrier was installed in spring 2000, water levels in the wells did not rise high enough to be a concern for farming operations on Upper Roberts Island near the Old River Barrier.

There was an almost immediate response between tidal variation and groundwater level fluctuations, indicating water was moving quickly to the islands upper water bearing zones and to the wells.

FISHERY MONITORING AT THE OLD RIVER BARRIER

Because the potential existed for juvenile Chinook salmon and other fish species to become entrained into the Old River Barrier culverts, fisheries monitoring was designed and conducted by DFG staff. The objectives of fishery monitoring at the Old River Barrier during the 2000 VAMP program were to:

1. Determine the total number of juvenile Chinook salmon and other fish species diverted through the culverts at the Old River Barrier;

2. Determine the entrainment vulnerability of juvenile Chinook salmon during different tidal stages during day and night; and

3. Assess the entrainment loss of coded-wire tagged (CWT) juvenile Chinook salmon released as a result of entrainment in culverts at the Old River Barrier.

Materials and Methods

Nine fyke nets and six live-boxes were constructed for the purpose of sampling in Old River, into the Old River Barrier. Fyke nets, 30 feet in length, were made of 1/4-inch braided mesh. The fyke nets were square in cross-section tapering from approximately 48 inches at the mouth to one square foot at the cod end. Each fyke net was equipped with a live box. Live-boxes (15.5 x 19.5 x 36 inches) were constructed of perforated aluminum sheet metal. An aluminum baffle was placed inside each live-box to reduce the flow of water and improve salmon survival.

The mouth of the fyke net was strapped over a 48-inch diameter opening on tracks and lowered down over the culverts out-fall. Rubber flaps were used to seal the spaces between the culvert and the net opening to prevent fish loss. The culverts were slightly twisted during construction of the Old River Barrier and, as a result, the alignment between the net mouth opening and culvert was not exact. Because the alignment was not exact, some leakage of water past the net mouth opening occurred.

Sampling of the live-boxes was accomplished by boat. Most of the time the hydraulic force moving through the net prevented pulling the live-box completely out of the water or from detaching it from the net. As a result, routine inspection of the nets for holes was not possible during sampling.

Operation of two culverts at the Old River Barrier began April 17. Fyke nets were attached to both culvert outlets. While the culverts were being opened, excess bedding material was washed into the fyke nets, immediately filling both nets with small pebbles and rocks. The rock load in both nets during the first few minutes of culvert operation was such that only one net was able to be emptied and retrieved; the second net had to be detached, set adrift, and replaced with another net.

Fyke nets could not be sampled continuously for the duration that the culverts were open. Continuous clogging of nets and live-boxes, coupled with high water velocities through the culverts, placed additional stress on the nets, which eventually tore beyond salvaging. The nets were removed on April 19 and, to prevent scouring and net damage, a heavy-duty vinyl tarp was tied to the bottom of the nets. The modified nets were subsequently used between April 24 and 28. Scouring of the vinyl tarps and damage to the nets persisted until only two good nets remained. Routine sampling was discontinued to preserve the two remaining nets for use in the pending entrainment studies.

Catch-Per-Unit-Effort (CPUE) for unmarked Chinook salmon was calculated as the number collected per hour. For purposes of these calculations, net efficiency was assumed to be 100 percent, regardless of the number of holes and tears that were found in the nets. In reality however, net efficiencies were probably much lower.

A loss index for CWT salmon released upstream of the Old River Barrier as part of VAMP survival studies was calculated from data collected April 17 through 28. Based on the number of CWT

salmon released as part of VAMP at Durham Ferry and Mossdale, and the total number of CWT salmon collected during sampling at the Old River Barrier, an index of CWT salmon loss downstream of the Old River Barrier was calculated as:

$$I = (TC/TR)(TT/ST)$$

Where:

TC *Total number of CWT salmon collected*
TR *Total number of CWT salmon released*
TT *Total time (hours) during the test period*
ST = *Total time sampled at the Old River Barrier during the test period*

Entrainment Study

One day and one night release of individually marked groups of juvenile Chinook salmon from the Merced River Hatchery were made at two different locations—directly in front of the Old River Barrier and approximately 500 feet upstream of the Old River Barrier in the San Joaquin River—during the low ebb and high flood tidal cycles. A release scheduled to occur on May 4 during the peak low tide was delayed by a few hours due to difficulties in identifying color-marked salmon.

Merced River Hatchery juvenile Chinook salmon were color-marked at the hatchery with either Meta-Jet dye or photonic fluorescent microspheres. The salmon were then transported from the hatchery to the San Joaquin River and placed in 4x10x4 foot live cages lined with 3⁄16-inch mesh netting. The test fish were held in the live-cages for ten or more hours to both reduce handling stress and observe any mortality before being released.

Groups of approximately 2,000 juvenile salmon were released immediately upstream of the Old River Barrier. Further upstream, the groups consisted of about 3,000 marked salmon. One particular release group of 2,000 fish experienced 92 percent mortality due largely to being accidentally dropped on the riprap bank before being placed in the live-cages.

Night releases during high and low tidal cycles were made during the evening of May 3 and early morning of May 4. Day releases for both tidal cycles were made during the morning and afternoon of May 11.

Though four culverts were in operation during the May 3 and 4 entrainment tests, only two nets were in suitable condition for sampling. The two nets were removed from the culverts after the first study to avoid damage prior to their use in the second entrainment study. During the second entrainment study, all six culverts were in operation, while again only two nets were available and suitable for sampling.

After both entrainment studies were completed, the nets were inspected and found to have only minor holes in them. The percent of color-marked fish recovered in the nets relative to the number released was used as an index of entrainment vulnerability at the Old River Barrier.

Results and Discussion

Throughout the April 17 to May 16 study period, the number of culverts operated at the Old River Barrier and the number of fyke nets installed varied (**Table 4-1**). The total hours that the culverts were in operation during the April 17 through May 11 sampling period was approximately 1,800 hours. This was the sum of hours that each culvert was in operation. Total sampling time for all fyke nets combined was 374 hours and ranged from 0.83 to 25.4 hours.

Twenty-six fish species were collected in the fyke nets during Old River Barrier fish monitoring (**Table 4-2**). Chinook salmon (3,813) and white catfish (1,009) were the two most abundant species collected. Very few delta smelt (1) or splittail (5) were collected (**Table 4-2**).

A total of 3,813 Chinook salmon were collected in the fyke nets at the Old River Barrier culverts, including:

- 499 CWT Chinook salmon
- 631 Unmarked Chinook salmon (Natural)
- 2,683 Color-marked Chinook salmon (Entrainment study)

The CPUE for unmarked Chinook salmon ranged from 0.0 to 18.8 per net per hour, averaging 1.7 fish per hour. The greatest number of unmarked Chinook salmon (245) was collected on May 4. However, this was during the entrainment study and it is possible that some of the color-marks may not have been identified, and were therefore placed in the unmarked (natural) category. The greatest number of CWT salmon (318) was collected on April 18.

The CPUE for CWT salmon was not calculated because of the variability in release dates and sampling dates. Instead, a period of time (April 17–28) when fyke nets were sampling coincident with CWT Chinook salmon releases upstream of the Old River Barrier at Mossdale and Durham Ferry was selected (see **Figure 1-1**). During this period, CWT salmon releases upstream as part of VAMP and DFG gear effieciency studies at Mossdale, totaled 133,412 fish. The fyke nets sampled for 265 hours between April 17 and 28, while the culverts were in operation for 566 hours. A total of 471 CWT salmon were collected during that period at the Old River Barrier. Assuming the nets were installed long enough for CWT salmon to move beyond the Old River Barrier and that there was no mortality or predation during transit to the Old River Barrier, using an "overestimated" measure of net efficiency (100 percent), an index of entrainment through the culverts was calculated as approximately 0.75 percent. A more exact percentage by release group can be estimated once the tags from the CWT salmon are read.

In 1997, a similar study was performed when two culverts were constructed within the Old River Barrier. The entrainment index for CWT Chinook salmon in 1997 was 0.6 percent. Release and recapture information for the entrainment study is summarized in **Table 4-3**.

The percent of color-marked salmon collected was extrapolated to account for the number of nets used and culverts operated. The percent recoveries for color-marked Chinook salmon through the culverts ranged from 68.1 to 138.2 percent (see **Table 4-3**) for those groups released adjacent to the Old River Barrier, and 0.1 to 17.1 percent for those released upstream of the Barrier. The percent recoveries greater than 100 percent suggest that Chinook salmon smolts are probably more susceptible to entrainment by certain culverts.

The largest range in percent recoveries between tides for color-marked salmon occurred during the day, suggesting that juvenile salmon may congregate more during the day and may disperse in the water column during the evening. The percent recoveries of color-marked Chinook salmon were highest for all release groups during the low tide, except for one color-marked group released upstream of the Old River Barrier three hours after the low tide. This group was released during the flood tide, which could have affected the results.

It is evident that color-marked salmon released in front of the Old River Barrier were more vulnerable to entrainment than those released further upstream because they were less able to disperse and avoid the culverts. Therefore, entrainment vulnerability at the 2000 Old River Barrier for natural or CWT salmon migrating downstream in the San Joaquin River is probably better represented by salmon released upstream of the Barrier resulting in greater dispersal and lower percent recoveries (0.1 to 17 percent). This compares to an estimate of 0.75 for the CWT salmon in the monitoring study. Also, the percent recovery for salmon released upstream of the Old River Barrier was not consistent between tidal cycles during day and night releases. This may indicate that there is less influence from tidal cycles on juvenile salmon further upstream of the Old River Barrier, or that there is some degree of loss between upstream releases and the Barrier. The results of this study indicate that tides and the photoperiod may influence Chinook salmon entrainment at the Old River Barrier. A similar study is planned for 2001 with improved net design to increase their longevity and thus, provide for a more continuous sampling downstream of the Old River Barrier. In addition, DFG plans to implement a juvenile Chinook salmon South Delta survival study to monitor migration routes and survival of marked Merced Fish Hatchery juvenile Chinook salmon through South Delta channels downstream of the Old River Barrier.

Table 4.1

CULVERT & NET OPERATION SCHEDULE
AT THE OLD RIVER BARRIER

DATES OF CULVERT OPERATION	NUMBER OF CULVERTS OPERATED	DATES FYKE NETS WERE USED	NUMBER OF FYKE NETS USED
Apr 17–Apr 27	2	Apr 17–Apr 19 & Apr 24–Apr 27	2
Apr 27–Apr 28	3	Apr 27–Apr 28	3
Apr 28–May 11	4	Apr 28 & May 2–May 4	4 2
May 11–May 16	6	May 11	2

Table 4.2

NUMBER OF FISH SPECIES COLLECTED IN FYKE NETS
FROM APRIL 17 THROUGH MAY 11, 2000

American Shad	1
Delta Smelt	**1**
Shimofuri Goby	1
Smallmouth Bass	1
Tule Perch	1
White Crappie	1
Brown Bullhead	2
Black Bullhead	2
Inland Silverside	2
Riffle Sculpin	2
Green Sunfish	3
Largemouth Bass	3
Log Perch	4
Sacramento Blackfish	4
Splittail	**5**
Goldfish	6
Redear Sunfish	8
Striped Bass	9
Black Crappie	10
Bluegill	18
Threadfin Shad	41
Sacramento Sucker	46
Channel Catfish	104
Carp	148
White Catfish	1,009
Total Chinook Salmon	**3,813**
CWT Chinook Salmon	499
Unmarked Chinook Salmon	631
Color-Marked Chinook Salmon	2,683
Total	5,245

Table 4.3

NUMBER OF COLOR-MARKED CHINOOK SALMON RELEASED & PERCENT RECOVERED DURING THE EVENING
(MAY 3 AND 4) & DAY (MAY 11, 2000)

RELEASE LOCATION	NUMBER OF FISH RELEASED	TIDE PHASE AT RELEASE	NUMBER COLLECTED	PERCENT RECOVERED	EXTRAPOLATED PERCENT RECOVERED
		Night Releases (May 3 and 4)			
Upstream	3,009	High	93	3.10	6.20
	3,017	Low	16	0.50	1.10
Adjacent	2,014	High	934	46.40	92.80
	157	Low	104	66.20	132.50
		Day Releases (May 11)			
Upstream	2,998	High	1	0.03	0.10
	2,999	Low	171	5.69	17.10
Adjacent	2,141	High	486	22.70	68.10
	1,904	Low	877	46.10	138.20

Smolt Survival

VAMP 2000 SALMON SMOLT SURVIVAL INVESTIGATIONS

This section describes the methods used in conducting the VAMP 2000 Chinook salmon survival investigations and presents results of the calculated survival indices and absolute survival rates for juvenile Chinook salmon during the VAMP 2000 test period. Additional data and information related to the salmon survival investigations are presented in **Appendix C**.

CODED-WIRE TAGGING

Merced River Hatchery Chinook salmon smolts, released as part of VAMP 2000, were coded-wire tagged between March and early April. After the salmon were tagged, they were held in the hatchery for 14 to 21 days before being released. The day before a group of salmon was to be released, a sub-sample of the salmon was measured for length and checked for retention of the coded-wire tags. The sub-sample was typically comprised of 100 to 300 salmon collected from the top, middle, and bottom of the release group's raceway. Each tag code within a release group was held separately at the hatchery with the exception of the three tag codes made up of the second Durham Ferry release that were held together in one section of the raceway. This group was released on April 28.

Though tag retention is usually quite high, as a double check on the tag detector, all salmon from the sub-sample that had no tag detected were sacrificed. These sacrificed salmon were dissected to determine whether they might contain an unmagnetized tag. A separate sub-sample of 25 salmon was sacrificed from each release group; the tags were removed and read to detect any incorrect tag codes in the raceways. The year 2000 tag retention rates were slightly lower than observed in previous years. As a result of the observed tag retention rates, tagging machines will be evaluated prior to VAMP 2001. Old tagging machines require more frequent maintenance and more careful examination to insure the best quality tagging. **Table 5-1** summarizes the results of the CWT retention rate and the estimate of the effective numbers of salmon released to calculate survival indices.

CWT RELEASES

CWT salmon from Merced River Hatchery were released at Durham Ferry, Mossdale, and Jersey Point (see **Figure 1-1**). VAMP 2000 was the first year in which salmon have been released at Durham Ferry, located approximately 11 miles upstream of Mossdale. The release site at Durham Ferry was selected to address the concern that salmon released at Mossdale could disperse into Upper Old River at a higher rate than those originating from the San Joaquin River tributaries during periods when the Old River Barrier was not in place. Releasing the fish at Durham Ferry allowed them to disperse more similarly to juvenile salmon originating from the San Joaquin tributaries. In order to compare the results from one year to the next, the Durham Ferry site will be used in future VAMP survival studies.

CWT salmon were released on April 17 at Durham Ferry, April 18 at Mossdale and April 20 at Jersey Point (see **Table 5-1**). A second set of releases were made at Durham Ferry on April 28 and at Jersey Point on May 1. Because of the limited number of CWT salmon from the Merced River Hatchery, an additional release was made at Jersey Point on May 1 from the Mokelumne River Hatchery. The use of salmon from the Mokelumne River Hatchery at Jersey Point provided an opportunity to explore the possibility of using further such stock in future years to supplement downstream VAMP releases.

Approximately 75,000 salmon, in three separate tag lots, were released at Durham Ferry, while 50,000, in two tag lots, were released at both Mossdale and Jersey Point (see **Table 5-1**). While in past years, each release group was trucked from the hatchery and released simultaneously as one large composite group, during VAMP 2000, groups of 25,000 CWT salmon were transported to the sites in separate compartments of the trailer and each tag lot was released five to 15 minutes apart. The group released at Durham Ferry on April 28 had the three tag lots mixed and did not adhere to this protocol.

Merced River Hatchery

Table 5.1

NUMBER OF CODED-WIRE TAGGED JUVENILE CHINOOK SALMON
FROM THE MERCED RIVER HATCHERY RELEASED AS PART OF VAMP 2000.

RELEASE DATE	CWT CODE	RELEASE SITE	AVERAGE FLOW	NUMBER RELEASED	TAG RETENTION RATE	EFFECTIVE NUMBER RELEASED
Apr 17	064563	Durham Ferry	80	26,476	0.924	24,457
Apr 17	060401	Durham Ferry	80	25,980	0.906	23,529
Apr 17	060402	Durham Ferry	80	25,904	0.924	24,177
Apr 18	064401	Mossdale	79	26,391	0.865	23,465
Apr 18	064402	Mossdale	79	25,969	0.858	22,784
Apr 20	064404	Jersey Point	82	26,335	0.981	25,824
Apr 20	064403	Jersey Point	82	26,301	0.971	25,527
Apr 28	0601060915	Durham Ferry	77	28,295	0.947	26,805
Apr 28	0601110814	Durham Ferry	77	25,216	0.947	23,889
Apr 28	0601060914	Durham Ferry	77	25,014	0.947	23,698
May 1	0601061001	Jersey Point	78	26,059	0.981	25,572
May 1	0601061002	Jersey Point	76	26,235	0.940	24,661
April 19–May 3	064405	Mossdale	86	25,798	0.906	23,371

The group released at Jersey Point from the Mokelumne River Hatchery included two 50,000 tag codes, released as a single group of 100,000 salmon.

The water temperature in the hatchery truck and San Joaquin River was measured at the release site immediately prior to release. This information, as well as additional release information, is provided in **Table 5-2**.

WATER TEMPERATURE MONITORING

The water temperature was monitored during the VAMP 2000 study using individual computerized temperature recorders (e.g., Onset Stowaway Temperature Monitoring/Data Loggers). The water temperature was measured at locations along the longitudinal gradient of the San Joaquin River and interior Delta channels between Durham Ferry and Chipps Island—locations of the migratory pathways for the juvenile Chinook salmon that were released as part of these tests. The water temperature was recorded at 24-minute intervals throughout the period of the VAMP 2000 investigations.

The water temperature was also recorded within the hatchery raceways at both the Merced and Mokelumne River hatcheries coincident with the period when juvenile Chinook salmon were being tagged. The water temperature was also recorded for one release group from each hatchery in the transport truck, and for a two-day post release observation period. Results of water temperature monitoring during the VAMP 2000 study period are summarized in **Appendix C.**

POST-RELEASE LIVE-CAR STUDIES

Survival and Condition

The post-release survival of marked salmon was evaluated as part of the VAMP program using sub-samples of marked salmon from each release group. Net pen studies were conducted where approximately 200 salmon from each CWT release group were held in live cars for 48 hours after release in order to monitor for any direct and short-term mortality. In addition to the salmon examined in the net pen studies, two groups of 25 salmon from each tag group were evaluated based upon overall condition at release and 48 hours after release. To assess overall condition, fork length in millimeters, weight in grams, eye condition, body color, the presence of fin hemorrhaging, percent scale loss, gill color and vigor were examined. Obvious abnormalities or deformities were also noted.

Table 5.2

VAMP 2000 CODED WIRE TAG RELEASES & RECAPTURES

AT ANTIOCH, CHIPPS ISLAND, & CENTRAL VALLEY PROJECT (CVP), & STATE WATER PROJECT (SWP) FISH FACILITIES

TAG CODE	RELEASE SITE / STOCK	DATE	TRUCK TEMP	RELEASE TEMP (centigrade)	NUMBER RELEASED	AVERAGE SIZE (mm)	NUMBER RECOVERED AT ANTIOCH	PERCENT SAMPLED AT ANTIOCH
06-04-01	Durham Ferry (MRFF)		13.0	14.0	23,529	80	6	0.337
06-04-02	Durham Ferry (MRFF)		13.0	14.0	24,177	80	10	0.337
06-45-63	Durham Ferry (MRFF)		12.5	14.0	24,457	80	11	0.342
	Total	Apr 17			72,163		27	0.342
06-44-01	Mossdale (MRFF)		11.1	13.3	23,465	79	14	0.332
06-44-02	Mossdale (MRFF)		11.1	13.3	22,784	79	16	0.340
	Total	Apr 18			46,249		30	0.340
06-44-03	Jersey Point (MRFF)		12.2	18.0	25,527	82	50	0.325
06-44-04	Jersey Point (MRFF)		11.7	18.0	25,824	82	47	0.327
	Total	Apr 20			51,351		97	0.327
06-01-06-09-14	Durham Ferry (MRFF)		11.1	16.7	23,698	77	8	0.408
06-01-06-09-15	Durham Ferry (MRFF)		11.1	16.7	26,805	77	15	0.313
06-01-11-08-14	Durham Ferry (MRFF)		11.1	16.7	23,889	77	8	0.350
	Total	Apr 28			74,392		31	0.313
06-01-06-10-01	Jersey Point (MRFF)		11.7	17.2	25,572	78	76	0.353
06-01-06-10-02	Jersey Point (MRFF)		11.7	17.2	24,661	76	76	0.315
	Total	May 1			50,233		152	0.315
06-02-53	Jersey Point (MOK)				50,445	87	106	0.355
06-02-54	Jersey Point (MOK)				51,167	85	110	0.353
	Total	May 1			101,612		216	0.355
06-44-05	Mossdale (MRFF)	April 19–May 3	13.0	16.0	23,288	86	9	0.339

NOTE: *MRFF denotes Merced River stock.*
MOK denotes Mokelumne River stock.

AND SURVIVAL INDICES

SURVIVAL INDEX AT ANTIOCH	GROUP SURVIVAL AT ANTIOCH	NUMBER RECOVERED AT CHIPPS	PERCENT SAMPLED AT CHIPPS	SURVIVAL INDEX AT CHIPPS	GROUP SURVIVAL AT CHIPPS	EXPANDED SALVAGE CVP	EXPANDED SALVAGE SWP
0.054		7	0.26	0.149		24	144
0.088		10	0.261	0.206		24	132
0.095		11	0.259	0.226		12	185
	0.079	28	0.261		0.193		
0.130		9	0.259	0.192		12	213
0.149		9	0.258	0.199		12	220
	0.137	18	0.259		0.195		
0.433		24	0.264	0.463		0	0
0.401		41	0.264	0.782		0	0
	0.416	65	0.264		0.623		
0.059		7	0.256	0.150		12	75
0.128		5	0.254	0.096		24	96
0.069		10	0.264	0.206		12	60
	0.096	22	0.262		0.147		
0.606		48	0.257	0.949		0	3
0.704		30	0.254	0.623		0	3
	0.692	78	0.258		0.782		
0.427		95	0.252	0.971		0	5
0.439		74	0.256	0.734		0	0
	0.431	169	0.254		0.8512		
0.082		7	0.258	0.151		12	144

The eye condition was assessed based on whether the eyes appeared normally shaped or were bulging while the body color was assessed relative to the darkness of the black spot pigmentation on the dorsal side of the fish and its contrast to the green body color. Fin hemorrhaging was judged based on whether there were spots of blood on or at the base of the fins. Percent scale loss was judged on a scale between 0 to 100 percent and gill color was based on lifting the operculum and ranking the darkness of red of the gills. Normal was considered beet red to dark cherry red and poor was considered light red to grayish/whitish in color. Vigor was considered normal if the fish were active and poor if the salmon were lethargic or motionless.

Results of the evaluations of marked fish in the live cars both immediately after release and 48 hours later showed very few abnormalities in the condition characteristics assessed (**Appendix C**). Of the 1,283 salmon assessed, 10 had no adipose fin clip while 23 were found to have a poor fin clip. A total of nine had deformation, four of which were caudal and five of which were operculum. In summary, the percentage of salmon deformed within the sample group, 0.7, is within the normal range at a hatchery. (S. Foott, personal communication.)

It appears that overall the salmon used for VAMP 2000 survival experiments were healthy and in good condition, though one was found dead in the live-car and another, in addition to most of those in the net pen at the April 17th Durham Ferry release, appeared to have escaped during the 48-hour post-release holding and observation period.

It appears that overall the salmon used for VAMP 2000 survival experiments were healthy and in good condition …

Physiology

Physiological studies were conducted by the USFWS California-Nevada Fish Health Center on VAMP 2000 salmon as reported by Nichols et al. (2000). Tests were conducted on a sub-sample of the salmon smolts released at Durham Ferry, Mossdale and Jersey Point after they had been held in the live cars for approximately 24 hours. Forty-two salmon were sampled at each site, with the exception of those from the first release at Durham Ferry where only 12 were available because the rest escaped from the net pens. The salmon were euthanized with an overdose of tricain methane sulfonate (MS222), and then measured and evaluated using organosomatic analyses. Tissue samples were collected for pathogen and physiological assays. Organosomatic analysis included length, weight, and observations of any abnormalities. Blood samples were processed to determine hematocrit and leukocrit measurements and to collect plasma.

Conditions factors (K) were calculated for each fish based on fork length and weight based on the formula: $K=Wt/L^3 * 10^5$. Kidney tissue was checked for bacterial pathogens and the internal organs were examined for parasites and abnormalities. Samples of gill tissue were assayed for gill Na+, K+ - ATPase levels as an indicator of saltwater readiness (smolting). Plasma glucose and chloride levels were analyzed to determine the ability of the salmon to adapt to stress. Measurements were made using both stressed and unstressed salmon. The "unstressed" salmon were removed from the net pen as quickly as possible and immediately euthanized while the stressed fish were held out of the water for 30 seconds, and sampled after they were allowed to recover for 45 minutes.

On April 13, 60 salmon were sampled at random from the entire hatchery population in the Merced River Hatchery. These salmon were evaluated in terms of organosomatic analysis, ATPase, histology, bacteriology and virology. Stress physiology evaluations were not conducted on salmon from the Merced River Hatchery.

Results from the physiological tests indicated that all release groups appeared healthy with no significant abnormalities. No viral or bacterial pathogens were detected. Early infections of the PKX parasite (early stage of proliferative kidney disease) were detected in two salmon by histology. Stress treatments demonstrated healthy energy reserves and plasma ion levels in all groups examined.

Based on physiological testing, Nichols et al. (2000) reported that, "Eosinophilic granular cells (EGC's) were quite prominent in the lamina propria layer of the intestine and pyloric caeca from approximately half of each sample group. These immunodefensive cells are found in many organs, particularly those in direct contact with the environment such as gill, skin, and digestive tract. They are often associated with parasitic infections and contain both peroxicdase and lysozyme (Sveinbjornsson et al. 1996, Sire and Vernier, 1995). Earlier assumptions that EGC's acted as mast cells have been found to be incorrect as histamine is not present (Sire and Vernier 1995). While it is not unusual to see in adult Chinook, they have not been observed in such high numbers in the intestines of juvenile Chinook salmon from the Sacramento and Klamath rivers. No lesions or parasites were associated with the EGC's found in the Merced River Hatchery salmon."

Not only were these high EGC levels found in Chinook salmon at the Merced River Hatchery, they were also found in samples from the natural stock in the San Joaquin basin (Scott Foott, personal communication). Although Nichols et al. (2000) suggests that the observed high levels of EGC cells in San Joaquin River salmon stocks may be due to genetic differences (Chinook from the San Joaquin basin are at the farthest southern extent of their range), further evaluation of these results may be warranted.

Tag Quality Control

The subset of 25 salmon from each tag group (25 from the April 28 Durham Ferry release group) held in the net pens (50 to 75 per release group) were sacrificed and used to verify tag codes. Though rare, on few occasions in the past, salmon from different release groups have been mixed. It is not certain why the mixing of salmon from different release groups occurs. Additional CWT salmon from each release group have been archived, if needed, to further evaluate VAMP 2000 tag quality control.

CWT SALMON RECAPTURE SAMPLING

CWT salmon were recaptured at Antioch and Chipps Island and at CVP and SWP Fish Salvage Facilities (See **Figure 1-1**). Juvenile Chinook salmon with adipose fin clips caught at any of these sampling locations and during the Old River Barrier sampling were sacrificed, labeled, and frozen pending CWT processing. An adipose fin clip identifies juvenile Chinook salmon that are CWT. CWT processing and reading was done in the FWS Stockton laboratory for fish recovered at Chipps Island, Antioch, and SWP/CVP salvage facilities. Both the Stockton FWS office and the DFG Region 4 laboratory in Fresno processed marked salmon recovered in the Old River Barrier sampling. CWT salmon released upstream of Mossdale were also recovered in DFG Kodiak trawls at Mossdale. Any CWT's recovered in the Mossdale trawl sampling were processed by DFG Region 4 in Fresno.

CWT processing entails dissecting each tagged fish to obtain the half (0.5 millimeters) and full (1 millimeter) cylindrical tag from its snout. The tags are then "read" under the microscope by determining the code etched on multiple sides of the tag. Tags were read twice, with any discrepancies resolved by a third reader. All tags were archived for future reference.

SWP/CVP Salvage Recapture Sampling

Sampling at the CVP and SWP Fish Salvage Facilities was conducted approximately every two hours. The number of marked salmon collected (raw salvage) were "expanded" based on the number of minutes sampled during each two hour time period. The estimated expanded total number of CWT salmon, from each release group, was obtained by adding together the expanded number of each tag group estimated for each time period. Only the CWT salmon recovered in the raw salvage collections were sacrificed for tag decoding. Expanded salvage does not include losses prior to, and associated with, pre-screen predation, screening, handling and trucking.

Expanded CVP and SWP salvage estimates of marked salmon released as part of the VAMP 2000 studies are shown in **Table 5-2**. Salvage numbers were low at the CVP and higher at the SWP.

The Old River Barrier appears to lessen the number of marked salmon recovered at the CVP as compared to the number recovered at the SWP: in 1999, when the Old River Barrier did not exist, expanded salvage was more similar between the two facilities (Brandes and McLain forthcoming). Results of CWT recaptures for marked salmon released in the San Joaquin River tributary studies are documented in **Appendix C**.

Antioch Recapture Sampling

Fishery sampling was conducted in the vicinity of Antioch on the lower San Joaquin River (see **Figure 1-1**) using a Kodiak trawl. The Kodiak trawl has a graded stretch mesh, from 2-inch mesh at the mouth to 1⁄4-inch mesh at the cod-end. Its overall length is 65 feet, and the mouth opening is six feet deep and 25 feet wide. The net was towed between two skiffs, sampling in an upstream direction. Trawls were performed parallel to the left bank, mid-channel, and right bank to sample CWT salmon emigrating from the San Joaquin River. Each sample was approximately 20 minutes in duration.

All fish collected were transferred immediately from the Kodiak trawl to buckets filled with river water, where the fish were held during processing. Data collected during each trawl included identification and measuring the fork length of fish collected, tow start time and duration and location in the channel. Mortality and damage to fish collected was documented to comply with the Endangered Species Act permit compliance.

Juvenile Chinook salmon with an adipose fin clip were retained for later CWT processing while unmarked salmon, steelhead, delta smelt, splittail, and other fish were released at a location downstream of the sampling site immediately after identification, enumeration and measurement.

Sampling at Antioch was initiated April 19 and continued through May 21. Each day between 5:00 a.m. and 9:00 p.m., anywhere from 12 to 29 20-minute tows were conducted. All told, 751 Kodiak trawl samples were collected, representing a total sampling duration of 14,842 minutes. During the sampling, a total of 4,827 unmarked juvenile Chinook salmon and 1,257 salmon with an adipose fin clip (CWT) were collected.

Chipps Island Recapture Sampling

Sampling at Chipps Island (see **Figure 1-1**) was conducted daily between April 1 and June 19. One shift of trawling (approximately ten, 20-minute tows per day) was conducted between April 1 and April 17 and again between May 21 and June 19. Between April 17 and May 20, two daily shifts (20, 20 minute tows per day) were conducted. The two shifts included dawn and dusk sampling, similar to the sampling regime used in 1998 and 1999.

Prior to 1998, ten 20-minute tows were made per day with sampling beginning at approximately 7:00 a.m. and ending around 12:00 (noon). With the addition of a second shift, the first shift began at daybreak. The second shift began in the late afternoon and concluded just after dark. It was hypothesized, based on an analysis of salmon smolts caught at Jersey Point throughout a 24-hour sampling period in 1997, that the greatest number of salmon would be caught during dawn and dusk. Changing the starting time of the first shift and doubling the effort at Chipps Island was intended to increase the numbers of CWT salmon recaptured and reduce the variability in VAMP survival indices.

The mid-water trawl net, towed at the surface near Chipps Island, had a mouth opening of ten by 30 feet. The net tapered from the mouth to the cod end with its length totaling 82 feet. Net mesh varied from four inches to 1/4 inch at the cod end. Lead weights were attached to the bottom rib line of the net and floats attached to the top rib line. A metal depressor door was fastened to each bottom bridle line and an aluminum hydrofoil was fastened to each top bridle line to keep the net orientated and fishing properly.

Sampling at Chipps Island was conducted in three trawl lanes: north, south and middle of the channel. Each lane was generally sampled at least three times per shift, with one lane sampled four times. This was an attempt to sample evenly across the channel to provide the best estimate of the number of marked salmon surviving to Chipps Island.

CWT salmon released as part of the VAMP program were recovered at Chipps Island between April 22 and May 21. During this period, a total of 12,843 unmarked salmon, 1,999 CWT salmon, 97 delta smelt, 1,125 splittail, 11 adipose-clipped steelhead and 20 wild steelhead were recovered. Of the 1,999 CWT salmon recovered, only 211 were from Merced River Hatchery origin released as part of the VAMP study (see **Table 5-2**). A total of 169 CWT salmon were recovered as part of the Jersey Point release using Mokelumne River fish.

VAMP 2000 CHINOOK SALMON CWT SURVIVAL INDICES

Survival indices were calculated for marked salmon released at Durham Ferry, Mossdale, and Jersey Point and recovered at Chipps Island and Antioch. Survival indices were calculated by dividing the number of CWT salmon recovered by the effective number released and the fraction of time and channel width sampled. The fraction of the channel width sampled at Chipps Island (0.00769) was the net width (30 feet) divided by an estimate of the channel width (3,900 feet). The fraction of the channel width sampled at Antioch (0.01388) was based on the net width (25 feet) used at Antioch divided by an estimate of the channel width (1,800 feet) at Antioch. The fraction of time sampled, at both locations, was calculated based on the number of minutes sampled, between the first and last day of catching each particular tag code or group, divided by the total number of minutes in the time period. The percent of time sampled for the VAMP 2000 release groups at Chipps Island was roughly 26 percent, while at Antioch it ranged between 31 and 41percent.

The survival indices of the separate tag codes are calculated to provide a sense of the variability associated with the index. To generate the survival index for each group, the recovery numbers and release numbers are combined within the group to estimate a composite survival index for the combined tag codes within a release group. This results in a slightly different index than would be generated by taking the mean of the survival indices of the individual tag codes within a group. Although it has not been done, it may now be more appropriate to calculate a mean survival from the two or three independent tag groups released within a group for the 2000 VAMP releases when they were held and released as independent groups.

The survival indices to Antioch and Chipps Island of the CWT salmon released as part of VAMP 2000 are shown in **Table 5-2**. Survival indices for the composite release groups are summarized in **Table 5-3**.

Survival indices from the release locations to Antioch were generally lower than those at Chipps Island. This is contrary to what would be expected since Antioch is closer to the release locations than Chipps Island. This may be a result of the marked salmon not being equally distributed or vulnerable to the trawls throughout the 24-hour period and the expansions for effort may be biasing the Chipps Island estimates high. Further evaluation of these differences is warranted.

More important than the raw survival indices between locations are the comparisons of the survival indices within the same recovery location and the trends between the groups using the two recovery locations. The use of absolute survival estimates, where the survival index of the upstream release group is divided by the survival index of the downstream group (recovered at the same location), is most useful for between year comparisons.

The first and second Durham Ferry releases had survival indices at Antioch of 0.08 and 0.10, respectively. Survival indices at Chipps Island were 0.19 and 0.15. The individual tag code survival indices at Antioch and Chipps Island showed overlap within each of the groups and similar values between the two Durham Ferry groups, such that there may be no true difference between the two groups (see **Table 5-2**). Based on this information, it appears that the two Durham Ferry groups survived at similar rates.

The survival indices of the first and second releases at Jersey Point ranged from 0.42 to 0.69 at Antioch and 0.62 and 0.78 at Chipps Island. The second group released at Jersey Point on May 1 appeared to survive at a higher rate than the first group, based on results from both recovery locations. However, the overlap in individual tag code survival indices at Chipps Island between the two Jersey Point groups suggest that there may not be a true difference between these two releases (see **Table 5-2**). Recoveries at Antioch suggest that the second Jersey Point release group (May 1) did survive at a higher rate than the first release group (April 18). As part of the VAMP 2000 experimental design, releases were made at both Mossdale and Durham Ferry to determine how survival differed between these two locations. Results of the release at

Table 5.3

SURVIVAL INDICES CALCULATED FOR VAMP 2000

RELEASE SITE & RELEASE DATE	RECAPTURE SITE	
	Antioch	*Chipps Island*
Durham Ferry: April 17	0.08	0.19
Mossdale: April 18	0.14	0.20
Jersey Point: April 20	0.42	0.62
Durham Ferry: April 28	0.10	0.15
Jersey Point: May 1[1]	0.69	0.78
Jersey Point: May 1[2]	0.43	0.85
Mossdale: April 19–May 3	0.08	0.15

[1] Merced River Hatchery stock [2] Mokelumne River Hatchery stock

Mossdale on April 18 and at Durham Ferry on April 19, using Antioch recoveries, indicated that the survival index was higher from the release at Mossdale (0.14) than for the Durham Ferry release (0.08). This result was expected considering that migration for marked salmon released at Durham Ferry is approximately 11 miles longer than salmon released at Mossdale. In contrast, survival indices calculated based on the recoveries at Chipps Island indicate that there was no substantial or detectable mortality between Durham Ferry (0.19) and Mossdale (0.20). Individual survival indices in the Durham Ferry and Mossdale groups did not overlap between groups using the Antioch recovery indices, but did overlap for Chipps Island recoveries (see **Table 5-2**). Further exploration to define true differences in survival for Mossdale and Durham Ferry releases would be helpful.

Two sets of releases were made at Mossdale that provide an additional comparison between the two recovery locations. The first group, released on April 18, was released as part of the VAMP 2000 studies. The second group was released between April 19 and May 3 to provide efficiency estimates of the DFG Kodiak trawl used at Mossdale to estimate survival for upstream tributary releases made by the DFG, Region 4. The survival index, for the DFG group released at Mossdale for the trawl effieciency evaluation between April 19 and May 3, would normally be calculated by first subtracting those recovered in the Mossdale trawl. But because so few were actually caught (6), subtracting prior to calculating survival indices was not done. The Antioch survival indices were 0.14 and 0.08, while the survival indices at Chipps Island were 0.20 and 0.15, respectively for the April 18 and April 19–May 3 Mossdale releases. Both sets of indices support the conclusion that the second release made over the course of 15 days survived at a lower rate than the group released on April 18. No overlap in the individual tag code survival indices between groups for either the Antioch or Chipps Island recoveries existed (see **Table 5-2**), giving more credence to the conclusion that survival rates were different between the two release groups.

Potential differences between the survival indices for the paired groups of Merced and Mokelumne hatchery salmon released at Jersey Point on May 1 are not as clear. The recoveries at Antioch appeared to show that the Mokelumne River Hatchery stock had a lower survival than the Merced River Hatchery stock. In contrast, recoveries at Chipps Island indicated that survival was higher for the Mokelumne group than for the Merced group. Again, there seemed to be greater overlap within the group survival indices using the Chipps Island recovery information than the Antioch recovery information, giving less confidence in the true differences in the Chipps Island recovery data (see **Table 5-2**). It is recommended that further investigations and analyses be performed to compare survival for Mokelumne River and Merced River stocks released at Jersey Point, and to further understand why the trends between groups are not consistent between the survival indices generated using Antioch and Chipps Island recoveries.

ABSOLUTE CHINOOK SALMON SURVIVAL ESTIMATES FOR VAMP 2000

Absolute survival rates (or standardized survival) were estimated using the ratio of the survival indices of smolts released at Durham Ferry and Mossdale in relation to those released at Jersey Point. These absolute survival estimates are more powerful for use in comparing survival rates as a function of flow and export rates among years, since the use of ratios between upstream and downstream groups theoretically standardizes for differences in catch efficiency between recovery locations and years. Thus, two independent estimates of absolute survival have been calculated for VAMP 2000 using recoveries at both Chipps Island and Antioch. An additional estimate of absolute survival will be possible from recoveries from the ocean fishery in 2 1/2 years following release.

Absolute survival estimates for VAMP 2000 are summarized in **Table 5-4**, using data from **Table 5-2**.

These absolute estimates of survival and both sets of recovery information indicate that the April 17 Durham Ferry group survived at a slightly higher rate than the April 28 group. The variability around each estimate is likely such that there is no true difference in survival between the two Durham Ferry releases.

Absolute estimates of survival between Mossdale and Jersey Point were 0.33 based on the Antioch indices versus 0.31 based

Table 5.4

ABSOLUTE CHINOOK SALMON SURVIVAL ESTIMATES FOR VAMP 2000

REACH	RECOVERY SITE	
	Antioch	*Chipps Island*
Durham Ferry to Jersey Point [1]	0.19	0.31
Durham Ferry to Jersey Point [2]	0.14	0.19
Mossdale to Jersey Point [3]	0.33	0.31

[1] April 17 Durham Ferry Release [2] April 28 Durham Ferry Release
[3] April 18 Mossdale Release

on the Chipps Island indices indicating a good agreement between survival estimates based on the two separate recovery locations.

Comparison of absolute survival estimates between Mossdale (April 18) and Durham Ferry (April 17) release groups indicated that survival was lower for the Durham Ferry release based on Antioch survival indices, whereas absolute survival indices were similar using the Chipps Island recovery data. This apparent discrepancy in absolute survival between the two recovery locations requires further analysis and investigation. It was hoped that with absolute survival estimates and multiple recovery locations, similar trends in salmon survival would be detected and provide additional support for evaluating the effects of river flow and exports on salmon smolt survival. Inconsistent trends and survival estimates between the two recovery sites may be the result of high variability in one or both sets of recovery data. Further investigation of the variability in survival between the two recovery locations is needed.

TRANSIT TIME

Data on transit times for marked salmon from the release to recapture sites during VAMP 2000 is summarized in tabular and graphic form in **Appendix C**. CWT salmon released April 17 at Durham Ferry took between five and 18 days to arrive at Antioch and between five and 32 days to arrive at Chipps Island. The April 28 Durham Ferry release arrived at Antioch between six and 21 days and between five and 23 days at Chipps Island. The April 18 Mossdale release took between four and 26 days to arrive at Antioch and between five and 16 days to arrive at Chipps Island. Significant variability was observed between last days of recovery for the April 17 Durham Ferry release group and the Mossdale release group at the Antioch and Chipps Island recovery locations. These differences may reflect variability associated with recovering individual fish when numbers are low toward the end of the group's migration period. The number of individual recoveries by tag code and the number of minutes towed per day for both Antioch and Chipps Island recoveries are shown in **Appendix C**.

SURVIVAL ESTIMATES FOR CWT RELEASES MADE IN THE SAN JOAQUIN TRIBUTARIES

CWT salmon releases were made in the San Joaquin River tributaries between April 12 and May 19 as part of the independent fishery investigations. Releases were made in the upper and lower Merced (Hatfield State Park) River, upper Tuolumne River (La Grange) and on the main-stem San Joaquin River just downstream of the confluence with the Tuolumne River (Old Fisherman's Club). Releases were also made on the upper (Knights Ferry) and lower (Two Rivers) Stanislaus River. As mentioned earlier, one additional group was released at Mossdale between April 19 and May 3 to evaluate the efficiency of the DFG trawl at Mossdale used to estimate survival for upstream release groups.

Survival indices for salmon released in the tributaries and recovered at Antioch ranged between 0.02 and 0.12 (**Appendix C**). No survival indices to Antioch were available for tagged fish released after May 18. Survival indices ranged between 0.02 and 0.13 to Chipps Island and include most of the San Joaquin River tributary releases (**Appendix C**). Unfortunately, in most cases, the variability in survival indices within a group at each recovery location was large enough that the detection of real differences between upstream and downstream locations may be limited (see **Appendix C**). The ability to detect differences is a function of the precision and magnitude of the survival measurement. Both factors influence the ability to detect differences between treatment groups.

Inconsistent trends and survival estimates between the two recovery sites may be the result of high variability in one or both sets of recovery data.

Information on the transit time between release and recovery of the CWT groups released in the San Joaquin River mainstem and tributaries at both Antioch and Chipps Island is summarized in **Appendix C**. As observed for VAMP releases, there was substantial variability in the last days of recovery for the various groups released upstream in the tributaries. Though it was anticipated that it would take longer for the marked salmon to reach Chipps Island because it is further downstream than Antioch, as described throughout this section, based on the last day that salmon were recovered this was not always the case. This may reflect the lower probability of catching the marked salmon at the end of the group's migration period since fewer salmon are available for capture.

DISCUSSION

The data obtained using Chipps Island recovery information gathered in 2000 is shown in relationship to past years data using the same recovery location in **Appendix C**. The survival ratios obtained in 2000 were relatively high in comparison to other survival ratios measured since survival ratios were compared starting in 1994. Only 1999 and 1995 had higher survival ratio estimates between Mossdale and Jersey Point than that obtained in 2000. Past absolute survival estimates and survival indices between Mossdale and Jersey Point from VAMP 2000 are shown in relationship to Vernalis flow and the presence of an Old River Barrier in **Figure 5-1**. Simple regression analyses were used to compare absolute survival estimates to river flow at Vernalis. Two regression lines have been developed based on historical survival data with and without the Old River Barrier. Statistically, neither regression is significant.

Evaluating the role of SWP and CVP exports on salmon smolt survival through the South Delta and the affect of the Old River Barrier are key elements of VAMP. Presence of the Old River Barrier affects both the emigration route of salmon smolts and hydraulic conditions in the lower San Joaquin River and Delta that are thought to alter the vulnerability of juvenile salmon to export-related effects.

The role of SWP and CVP exports with the Old River Barrier in place is difficult to determine at this time, in part, because of the few releases made with the Barrier in place and the different permeability of the Barrier when it has been in place. Releases at both Mossdale and Jersey Point have only been made in the three years when the Old River Barrier was in place. In 1994, the Old River Barrier was installed without culverts, while in 1997 the Old River Barrier had two open culverts that passed approximately 300 cfs into Upper Old River. And in 2000, the Old River Barrier had six gated culverts, with two open during the Mossdale and first Durham Ferry release and four open during the second Durham Ferry release. The varying designs and changes to the permeability of the Barrier add noise to the resulting data, making it more difficult to detect the effects of flow and export on salmon survival.

Additional noise is added to the data from changing the upstream release location from Mossdale to Durham Ferry. Future investigations, using releases at both Durham Ferry and Mossdale are needed to assure that releases made at Mossdale and Durham Ferry result in similar survivals so that past data can be used in evaluating the effects of SWP and CVP exports on salmon survival. If the survivals between the two release locations are not similar, then using only Durham Ferry data will increase the number of years needed to complete the VAMP study. Variation in survival results and trends between the two recovery locations (Antioch and Chipps Island) also adds a level of uncertainty but the benefit of having two rather than only one survival estimate per year is of major value.

However, given this noise, the data to data appears to show that smolt survival between Mossdale/Durham Ferry and Jersey Point increases as exports increase from 1,600 to 2,300 cfs with the Old River Barrier in place (**Figure 5-2**). This relationship is statistically significant, likely because of small sample size. **Figure 5-3** shows salmon survival, river flow (at Stockton) and exports with the Old River Barrier in place. Flow at Stockton was selected for use in these analyses to account for flow diverted from the lower San Joaquin River through the operable culverts at the Old River Barrier. Water diverted through the Old River Barrier directly affects flows downstream within the lower San Joaquin River that need to be taken into account when evaluating the flow—survival relationship for juvenile Chinook salmon emigrating from the San Joaquin River and Delta. Further analysis of San Joaquin River flow measurements and the effects of water diversions through the Old River Barrier need to be taken into account in the analysis and interpretation of VAMP 2000 and subsequent Chinook salmon survival investigations.

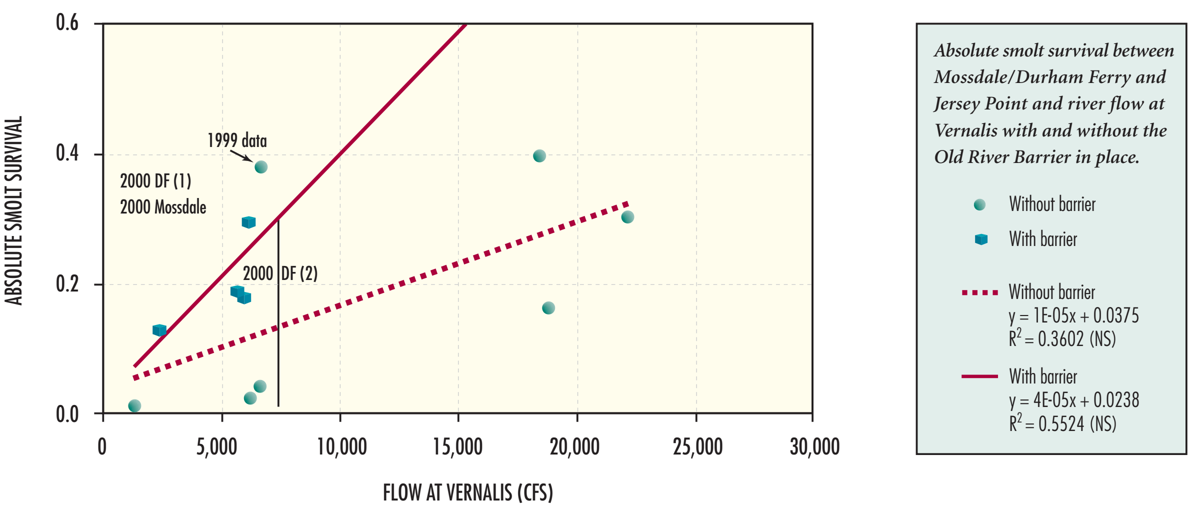
Although the multiple regression is not statistically significant (**Figure 5-3**), as San Joaquin River flow at Stockton and exports increase, in the narrow range measured, survival between Mossdale and Jersey Point increases. It is difficult to separate the respective roles of the two factors since they are both increasing as survival increases. Typical river flow and exports have a much wider range of variability than those used in the VAMP experiment period.

There have been a number of recent fishery studies conducted to determine the effects of flow, export, and migration route on smolt survival. These studies serve as a foundation for the VAMP studies. The results of these past studies shed some light on the roles of flow, exports, and the barrier in Upper Old River, but are clouded by confounding aspects of the data, which we hope to overcome with more replicates, that should improve our accuracy and precision and allow future conclusions to be better justified. There have been several past studies focused on providing an indirect evaluation of the effect of flows and exports to smolt survival with a barrier for determining absolute survival between Dos Reis and Jersey Point. Paired experiments with salmon from the Merced and Feather River hatcheries have shown that absolute survival is higher for salmon originating from the Merced River Hatchery (Brandes and Pearce, 1998). Studies in 1998, 1999, and 2000 were conducted to determine smolt survival at Chipps Island. Studies of smolt survival through Upper Old River relative to Jersey Point produced low survival indices (Brandes and McLain, 2000). The mixed results of the historical studies support the continuance of additional VAMP studies to support scientific conclusions concerning the role of flow, exports, and the Old River Barrier in smolt survival.

Definitive conclusions about the respective roles of flow and exports on salmon smolt survival are not possible from the VAMP data at this time. It is recommended that further evaluation of VAMP 2000 results occur prior to determining the study plan for VAMP 2001. It is also recommended that VAMP experiments continue. Results of these studies will hopefully provide the information needed to make appropriate management decisions to protect salmon smolts emigrating from the San Joaquin basin.

Figure 5-1

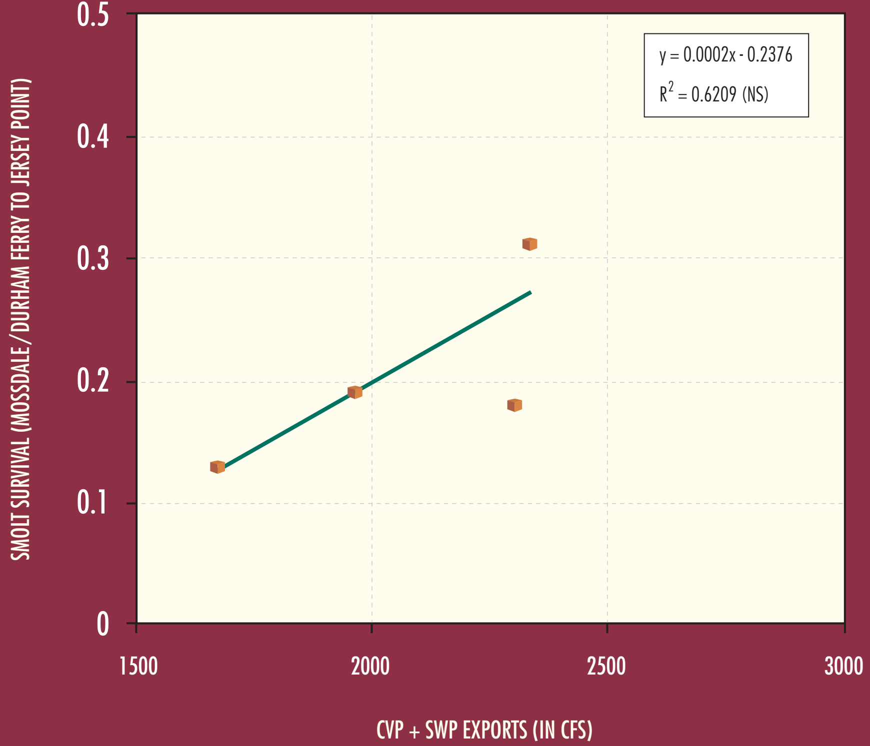
ABSOLUTE SMOLT SURVIVAL



Absolute smolt survival between Mossdale/Durham Ferry and Jersey Point and river flow at Vernalis with and without the Old River Barrier in place.

Figure 5-2

SURVIVAL VS. EXPORTS WITH BARRIER

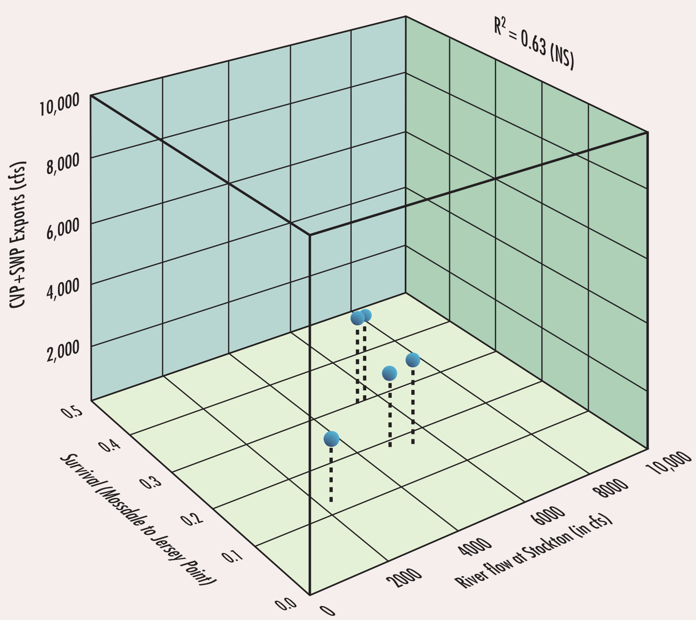


Absolute smolt survival versus CVP+SWP Exports (in cfs) in years with a Barrier in Upper Old River

Figure 5-3

SURVIVAL VS. RIVER FLOW AND EXPORTS

The relationship between the absolute estimate of survival between Mossdale (Durham Ferry) and Jersey Point and San Joaquin River flow at Stockton and CVP+SWP Exports with barrier at Upper Old River.



Conclusions

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS AND RECOMMENDATIONS

The VAMP pulse flow and experimental investigation of juvenile Chinook salmon survival was implemented during spring 2000. The Vernalis target flow was 5,700 cfs, with SWP and CVP export flow of 2,250 cfs. The Old River Barrier was successfully installed and maintained throughout the VAMP test period, but was characterized by variable culvert operations. Estimates of juvenile Chinook salmon smolt survival were calculated based upon releases of CWT juvenile salmon produced in the Merced River Fish Hatchery and released at Durham Ferry, Mossdale, and Jersey Point. Marked salmon were subsequently recaptured in sampling at the Old River Barrier, SWP and CVP export facility salvage, and through intensive fisheries sampling conducted at Antioch and Chipps Island. Based upon the data and experience gained during the VAMP 2000 investigations, conclusions and recommendations have been developed, as summarized in **Table 6-1**. The conclusions and recommendations include both technical and policy/management issues that will affect the design and implementation of VAMP 2001 operations and investigations.

Table 6.1

SUMMARY OF VAMP 2000 CONCLUSIONS AND RECOMMENDATIONS.

CONCLUSIONS	RECOMMENDATIONS
Technical Elements	
Durham Ferry appears to be an appropriate site for upstream treatment releases.	Use Durham Ferry as the upstream release site in subsequent VAMP studies.
There appeared to be significant mortality between Durham Ferry and Mossdale using Antioch recoveries while survival was similar for the two groups using Chipps Island recoveries.	Do more releases at Mossdale to compare survival differences between Durham Ferry and Mossdale.
Jersey Point appears to be an appropriate downstream release location.	Continue to use Jersey Point as the downstream control group.
Antioch and Chipps Island appear to be suitable as recovery locations. Trends between release groups however, sometimes varied between the two recovery locations.	Use both recapture sites next year. Further evaluations are necessary to determine why trends sometimes differ between locations and to potentially modify methodology/design for 2001 study. Pilot sampling at Benicia may help address these differences between recovery locations.
Releases of 50,000 salmon are adequate at Jersey Point (control release).	Use release groups of 50,000 fish again. Evaluate individual tag codes to determine if smaller releases sizes are appropriate.
Variation was high between the two recapture sites for fish released from Jersey Point.	Paired upstream (treatment) and downstream (control) releases are justified.
Survival indices for Mokelumne and Merced River salmon released at Jersey Point were different, with results differing by recovery locations.	No recommendation is made regarding the use of Mokelumne River fish as a Jersey Point control for VAMP at this time. Redo study and pursue additional analysis.
Further evaluation of the high variance in survival indices and variation of indices between recovery locations may result in changes in techniques and experimental design of the salmon survival investigations to lessen variability.	Solicit peer review from statisticians and CALFED science program. Evaluate bias and ways to lessen variance. Redo power analyses to determine true potential to achieve VAMP goals.
Quantifying salmon movement through the Old River Barrier culverts is difficult and results are unclear.	Refine sampling technique. Explore other study design options. Develop flow measures in Old River. Develop a sound culvert design including effective net attachments to quantify potential impacts.
Policy/Management Elements	
Coordination of project operations was adequate but timing of field measurement at Vernalis needs refinement.	Measure flows at Vernalis site earlier and more frequently. Explore other gaging station sites and flow descriptors.
Design of Old River Barrier in 2000 was inadequate at 7,000 cfs.	High priority for resolution of conflicts between flows and Barrier – develop issue paper.
Old River Barrier seems to have limited impacts on seepage and related issues.	Continue present monitoring.
Budgeting and planning should be expanded beyond one year.	Begin three-year planning. Reevaluate budget to determine if cost savings are possible.
No complementary studies, such as water quality and radio tagging, have been integrated to date into the VAMP framework.	Seek out and support linked studies. Encourage proposal development through CALFED, AFRP, and other funding opportunities. Achieve peer review and set up coordination plan.
Conclusions are not yet possible on the respective roles of San Joaquin River flow and SWP/CVP exports on juvenile Chinook salmon smolt survival.	Continue VAMP test program.

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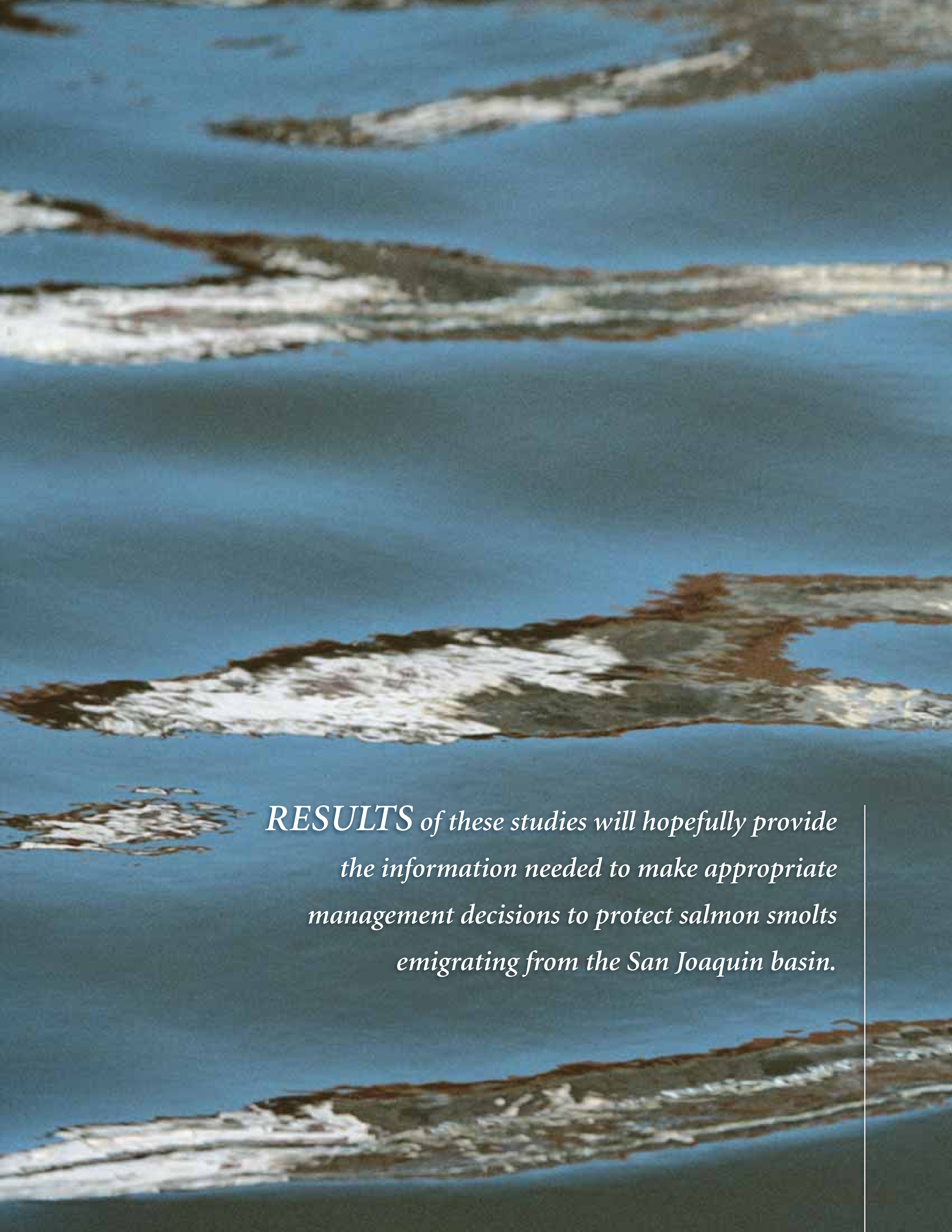

RESULTS of these studies will hopefully provide the information needed to make appropriate management decisions to protect salmon smolts emigrating from the San Joaquin basin.

Signatories

SIGNATORIES TO THE SAN JOAQUIN RIVER AGREEMENT

U.S. BUREAU OF RECLAMATION

U.S. FISH AND WILDLFE SERVICE

CALIFORNIA DEPARTMENT OF WATER RESOURCES

CALIFORNIA DEPARTMENT OF FISH AND GAME

OAKDALE IRRIGATION DISTRICT*

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- Central California Irrigation District
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APPENDIX A

VAMP HYDROLOGY & OPERATIONAL INFORMATION

DAILY OPERATION PLAN, MARCH 15

Pulse Period: April 15-May 15 · Flow Target: 7,000cfs

	SJR nr Vernalis Existing	VAMP Suppl. flow at Vernalis	SJR nr Vernalis w/VAMP	SJR above Merced R. (2-day lag)	Vernalis Accretion	Merced R . at Cressey Existing	Merced R. at Cressey Suppl.	Merced R. at Cressey w/VAMP	Exchange Contractors Suppl. (3-day lag)	Tuolumne R. at LaGrange FERC pulse Desired	Tuolumne R. at LaGrange FERC pulse Existing	Tuolumne R. at LaGrange Suppl.	Tuolumne R. at LaGrange w/VAMP (2-day lag)	Stan. R. blw Goodwin (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol.
	[calc]	[calc]	[calc]				[calc]	[calc]					[calc]		
	cfs	cfs	cfs	cfs	cfs		cfs	cfs	cfs		cfs	cfs	cfs	cfs	
					250			250		1,500	1,500		1,500	1,500	
			2,400		250			250		1,500	1,500		1,500	1,500	
			2,400		250			250		1,500	1,500		1,500	1,500	
Apr 01	6,650	0	6,650	2,400	1,000	250		250	0	1,500	1,500		1,500	1,500	
Apr 02	6,650	0	6,650	2,383	1,000	250		250	0	1,500	1,500		1,500	1,500	
Apr 03	6,650	0	6,650	2,367	1,000	250		250	0	1,500	1,500		1,500	1,500	
Apr 04	6,633	0	6,633	2,350	1,000	250		250	0	1,500	1,500		1,500	1,500	
Apr 05	6,617	0	6,617	2,333	1,000	250		250	0	1,500	1,500		1,500	1,500	
Apr 06	6,600	0	6,600	2,317	1,000	250		250	0	1,500	1,500		1,500	1,500	
Apr 07	6,583	0	6,583	2,300	1,000	250		250	0	1,500	1,500		1,500	1,500	
Apr 08	6,567	0	6,567	2,283	1,000	250		250	0	1,500	1,500		1,500	1,500	
Apr 09	6,550	0	6,550	2,267	1,000	250		250	0	1,500	1,500		1,500	1,500	
Apr 10	6,533	0	6,533	2,250	1,000	250		250	0	1,500	1,500		1,500	1,500	
Apr 11	6,517	0	6,517	2,233	1,000	250		250	0	1,500	1,500		1,500	1,500	
Apr 12	6,500	0	6,500	2,217	1,000	250	0	250	0	1,500	1,500		1,500	1,500	M
Apr 13	6,483	0	6,483	2,200	1,000	250	0	250	0	1,800	2,050	0	2,050	1,500	M
Apr 14	6,467	0	6,467	2,183	1,000	250	0	250	0	250	2,100	0	2,100	1,500	M
Apr 15	7,000	0	7,000	2,167	1,000	250	0	250	0	3,400	2,200	0	2,200	1,500	M
Apr 16	7,033	0	7,033	2,150	1,000	250	0	250	0	3,400	2,200	0	2,200	1,500	M
Apr 17	7,117	0	7,117	2,133	1,000	250	0	250	0	3,100	2,200	0	2,200	1,500	M
Apr 18	7,100	0	7,100	2,117	1,000	250	0	250	0	3,000	2,200	0	2,200	1,500	M
Apr 19	7,083	0	7,083	2,100	1,000	250	167	417	0	3,000	2,200	0	2,200	1,500	
Apr 20	7,067	0	7,067	2,083	1,000	250	183	433	0	300	2,000	0	2,000	1,500	T
Apr 21	7,050	0	7,050	2,067	1,000	250	200	450	0	300	2,000	0	2,000	1,500	T
Apr 22	6,833	167	7,000	2,050	1,000	250	217	467	0	2,000	2,000	0	2,000	1,500	T
Apr 23	6,817	183	7,000	2,033	1,000	250	233	483	0	1,800	2,000	0	2,000	1,500	T
Apr 24	6,800	200	7,000	2,017	1,000	250	250	500	0	1,000	2,000	0	2,000	1,500	T
Apr 25	6,783	217	7,000	2,000	1,000	250	967	1,217	0	1,000	2,000	0	2,000	1,500	T
Apr 26	6,767	233	7,000	1,983	1,000	250	983	1,233	0	1,000	1,300	0	1,300	1,500	M
Apr 27	6,750	250	7,000	1,967	1,000	250	1,000	1,250	0	1,000	1,300	0	1,300	1,500	M
Apr 28	6,033	967	7,000	1,950	1,000	250	1,017	1,267	0	1,000	1,300	0	1,300	1,500	M
Apr 29	6,017	983	7,000	1,933	1,000	250	1,033	1,283	0	1,000	1,300	0	1,300	1,500	M
Apr 30	6,000	1,000	7,000	1,917	1,000	250	1,050	1,300	0	1,000	1,300	0	1,300	1,500	M
May 01	5,983	1,017	7,000	1,900	1,000	250	1,072	1,322	0	1,000	1,300	0	1,300	1,500	M
May 02	5,967	1,033	7,000	1,878	1,000	250	193	443	0	1,000	1,300	0	1,300	1,500	
May 03	5,950	150	7,000	1,857	1,000	250	215	465	0	1,665	1,800	400	2,200	1,500	T
May 04	5,928	702	7,000	1,835	1,000	250	237	487	0	1,665	1,800	400	2,200	1,500	T
May 05	6,407	593	7,000	1,813	1,000	250	258	508	0	1,665	1,800	400	2,200	1,500	T
May 06	6,385	615	7,000	1,792	1,000	250	280	530	0	1,665	1,800	400	2,200	1,500	T
May 07	6,363	637	7,000	1,770	1,000	250	302	552	0	1,665	1,800	400	2,200	1,500	T
May 08	6,342	658	7,000	1,748	1,000	250	1,023	1,273	0	1,665	1,800	400	2,200	1,500	T
May 09	6,320	680	7,000	1,727	1,000	250	1,045	1,295	0	1,665	1,500	0	1,500	1,500	M
May 10	6,298	702	7,000	1,705	1,000	250	1,067	1,317	0	1,665	1,500	0	1,500	1,500	M
May 11	5,977	1,023	7,000	1,683	1,000	250	108	1,338	0	695	1,500	0	1,500	1,500	M
May 12	5,955	1,045	7,000	1,662	1,000	250	1,110	1,360	0	300	1,500	0	1,500	1,500	T
May 13	5,933	1,067	7,000	1,640	1,000	250		250	0	300	1,500	0	1,500	1,500	T
May 14	5,912	1,088	7,000	1,618	1,000	250		250	0	300	1,500		1,500	1,500	T
May 15	5,890	1,110	7,000	1,597	1,000	250		250	0	300	1,500		1,500	1,500	T
May 16	5,868	0	5,868	1,575	1,000	250		250	0	300	300		300	1,500	
May 17	5,847	0	5,847	1,553	1,000	250		250	0	300	300		300	1,500	
May 18	4,625	0	4,625	1,532	1,000	250		250	0	300	300		300	1,500	
May 19	4,603	0	4,603	1,510	1,000	250		250	0	300	300		300	1,500	
May 20	4,582	0	4,582	1,488	1,000	250		250	0	300	300		300	1,500	
May 21	4,560	0	4,560	1,467	1,000	250		250	0	300	300		300	1,500	
May 22	4,538	0	4,538	1,445	1,000	250		250	0	300	300		300	1,500	
May 23	4,517	0	4,517	1,423	1,000	250		250	0	300	300		300	1,500	
May 24	4,495	0	4,495	1,402	1,000	250		250	0	300	300		300	1,500	
May 25	4,473	0	4,473	1,380	1,000	250		250	0	300	300		300	1,500	
May 26	4,452	0	4,452	1,358	1,000	250		250	0	300	300		300	1,500	
May 27	4,430	0	4,430	1,337	1,000	250		250	0	300	300		300	1,500	
May 28	4,408	0	4,408	1,315	1,000	250		250	0	300	300		300	1,500	
May 29	4,387	0	4,387	1,293	1,000	250		250	0	300	300		300	1,500	
May 30	4,365	0	4,365	1,272	1,000	250		250	0	300	300		300	1,500	
May 31	4,343	0	4,343	1,250	1,000	250		250	0	300	300		300	1,500	
				VAMP 31-day period*											
Mean (cfs)	6,447	567	7,015	1,900			490	740	0		1,760	77	1,837	1,500	
total (KAF)		34.9					30.1		0.0			4.8			

Tuolumne FERC volume (TAF) = 89.9 94.5

* April 15– May 15 Adjusted for lag time

DAILY OPERATION PLAN, MARCH 15

Pulse Period: May 1-May 31 · Flow Target: 7,000cfs

	SJR nr Vernalis Existing	VAMP Suppl. flow at Vernalis	SJR nr Vernalis w/VAMP	SJR above Merced R. (2-day lag)	Vernalis Accretion	Merced R. at Cressey Existing	Merced R. at Cressey Suppl.	Merced R. at Cressey w/VAMP	Exchange Contractors Suppl. (3-day lag)	Tuolumne R. at LaGrange FERC pulse Desired	Tuolumne R. at LaGrange FERC pulse Existing	Tuolumne R. at LaGrange Suppl.	Tuolumne R. at LaGrange w/VAMP (2-day lag)	Stan. R. blw Goodwin (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol.	
	[calc]	[calc]	[calc]				[calc]	[calc]					[calc]			
	cfs	cfs	cfs	cfs	cfs		cfs	cfs	cfs		cfs	cfs	cfs	cfs		
				250		250		1,500		1,500			1,500	1,500		
				2,400		250		250		1,500	1,500		1,500	1,500		
				2,400		250		250		1,500	1,500		1,500	1,500		
	6,650	0	6,650	2,400	1,000	250	0	250	0	1,500	1,500		1,500	1,500		Apr 01
	6,650	0	6,650	2,383	1,000	250	0	250	0	1,500	1,500		1,500	1,500		Apr 02
	6,650	0	6,650	2,367	1,000	250	0	250	0	1,500	1,500		1,500	1,500		Apr 03
	6,633	0	6,633	2,350	1,000	250	0	250	0	1,500	1,500		1,500	1,500		Apr 04
	6,617	0	6,617	2,333	1,000	250	0	250	0	1,500	1,500		1,500	1,500		Apr 05
	6,600	0	6,600	2,317	1,000	250	0	250	0	1,500	1,500		1,500	1,500		Apr 06
	6,583	0	6,583	2,300	1,000	250	0	250	0	1,500	1,500		1,500	1,500		Apr 07
	6,567	0	6,567	2,283	1,000	250	0	250	0	1,500	1,500		1,500	1,500		Apr 08
	6,550	0	6,550	2,267	1,000	250	0	250	0	1,500	1,500		1,500	1,500		Apr 09
	6,533	0	6,533	2,250	1,000	250	0	250	0	1,500	1,500		1,500	1,500		Apr 10
	6,517	0	6,517	2,233	1,000	250	0	250	0	1,500	1,500		1,500	1,500		Apr 11
	6,500	0	6,500	2,217	1,000	250	0	250	0	1,500	1,500		1,500	1,500		Apr 12
	6,483	0	6,483	2,200	1,000	250	0	250	0	1,500	1,500		1,500	1,500		Apr 13
	6,467	0	6,467	2,183	1,000	250	0	250	0	1,500	1,500		1,500	1,500		Apr 14
	6,450	0	6,450	2,167	1,000	250	0	250	0	1,500	1,500		1,500	1,500		Apr 15
	6,433	0	6,433	2,150	1,000	250	0	250	0	1,500	1,500		1,500	1,500		Apr 16
	6,417	0	6,417	2,133	1,000	250	0	250	0	1,500	1,500		1,500	1,500		Apr 17
	6,400	0	6,400	2,117	1,000	250	0	250	0	1,500	1,500		1,500	1,500		Apr 18
	6,383	0	6,383	2,100	1,000	250	0	250	0	1,500	1,500		1,500	1,500		Apr 19
	6,367	0	6,367	2,083	1,000	250	0	250	0	1,500	1,500		1,500	1,500		Apr 20
	6,350	0	6,350	2,067	1,000	250	0	250	0	1,500	1,500		1,500	1,500		Apr 21
	6,333	0	6,333	2,050	1,000	250	0	250	0	1,500	1,500		1,500	1,500		Apr 22
	6,317	0	6,317	2,033	1,000	250	0	250	0	1,500	1,500		1,500	1,500		Apr 23
	6,300	0	6,300	2,017	1,000	250	0	250	0	1,500	1,500		1,500	1,500		Apr 24
	6,283	0	6,283	2,000	1,000	250	0	250	0	1,500	1,500		1,500	1,500		Apr 25
	6,267	0	6,267	1,983	1,000	250	0	250	0	1,500	1,500		1,500	1,500		Apr 26
	6,250	0	6,250	1,967	1,000	250	0	250	0	1,500	1,500		1,500	1,500		Apr 27
	6,233	0	6,233	1,950	1,000	250	0	250	0	1,500	1,500		1,500	1,500	M	Apr 28
	6,217	0	6,217	1,933	1,000	250	0	250	0	1,500	2,350	0	2,350	1,500	M	Apr 29
	6,200	0	6,200	1,917	1,000	250	0	250	0	1,500	2,350	0	2,350	1,500	M	Apr 30
	7,033	0	7,033	1,900	1,000	250	0	250	0	1,800	2,350	0	2,350	1,500	M	May 01
	7,017	0	7,017	1,878	1,000	250	0	250	0	2,500	2,400	0	2,400	1,500	M	May 02
	7,000	0	7,000	1,857	1,000	250	15	265	0	3,400	2,400	0	2,400	1,500	M	May 03
	7,028	0	7,028	1,835	1,000	250	0	250	0	3,400	2,400	0	2,400	1,500	M	May 04
	7,007	0	7,007	1,813	1,000	250	0	250	0	3,100	2,500	0	2,500	1,500		May 05
	6,985	15	7,000	1,792	1,000	250	0	250	0	3,000	2,500	0	2,500	1,500	T	May 06
	7,063	0	7,063	1,770	1,000	250	2	252	0	3,000	2,500	0	2,500	1,500	T	May 07
	7,042	0	7,042	1,748	1,000	250	23	273	0	3,000	2,500	0	2,500	1,500	T	May 08
	7,020	0	7,020	1,727	1,000	250	45	295	0	3,000	2,500	0	2,500	1,500	T	May 09
	6,998	2	7,000	1,705	1,000	250	67	317	0	2,000	2,500	0	2,500	1,500	T	May 10
	6,977	23	7,000	1,683	1,000	250	1,638	1,888	0	1,800	2,500	0	2,500	1,500	T	May 11
	6,955	45	7,000	1,662	1,000	250	1,410	1,660	250	1,000	950	0	950	1,500	M	May 12
	6,933	67	7,000	1,640	1,000	250	1,432	1,682	250	1,000	950	0	950	1,500	M	May 13
	5,362	1,638	7,000	1,618	1,000	250	1,403	1,653	250	1,000	950	0	950	1,500	M	May 14
	5,340	1,660	7,000	1,597	1,000	250	1,425	1,675	250	1,000	1,000	0	1,000	1,500	M	May 15
	5,318	1,682	7,000	1,575	1,000	250	1,447	1,697	250	1,000	1,000	0	1,000	1,500	M	May 16
	5,347	1,653	7,000	1,553	1,000	250	1,468	1,718	250	1,000	1,000	0	1,000	1,500	M	May 17
	5,325	1,675	7,000	1,532	1,000	250	0	250	250	1,000	1,000	0	1,000	1,500		May 18
	5,303	1,697	7,000	1,510	1,000	250	0	250	250	1,000	1,700	1,300	3,000	1,500	T	May 19
	5,282	1,718	7,000	1,488	1,000	250	0	250	250	1,000	1,700	1,300	3,000	1,500	T	May 20
	5,960	1,550	7,510	1,467	1,000	250	0	250	250	1,665	1,700	1,300	3,000	1,500	T	May 21
	5,938	1,550	7,488	1,445	1,000	250	0	250	0	1,665	1,700	1,300	3,000	1,500	T	May 22
	5,917	1,550	7,467	1,423	1,000	250	0	250	0	1,665	1,700	1,300	3,000	1,500	T	May 23
	5,895	1,550	7,445	1,402	1,000	250	1,370	1,620	0	1,665	1,700	1,300	3,000	1,500	T	May 24
	5,873	1,300	7,173	1,380	1,000	250	1,392	1,642	0	1,665	1,500	0	1,500	1,500	M	May 25
	5,852	1,300	7,152	1,358	1,000	250	1,413	1,663	0	1,665	1,500	0	1,500	1,500	M	May 26
	5,630	1,370	7,000	1,337	1,000	250	1,435	1,685	0	1,665	1,500	0	1,500	1,500	M	May 27
	5,608	1,392	7,000	1,315	1,000	250	1,457	1,707	0	1,665	1,500	0	1,500	1,500	T	May 28
	5,587	1,413	7,000	1,293	1,000	250		250	0	1,695	1,500	0	1,500	1,500	T	May 29
	5,565	1,435	7,000	1,272	1,000	250		250	0	300	1,500	0	1,500	1,500	T	May 30
	5,543	1,457	7,000	1,250	1,000	250		250	0	300	1,500		1,500	1,500	T	May 31
								VAMP 31-day period*								
Mean (cfs)	6,184	895	7,079				563	813	81		1,816	252	2,068	1,500		
total (KAF)		55.0					34.6		5.0			15.5				

Tuolumne FERC volume (TAF) = 89.9   89.9

* April 15 – May 15 Adjusted for lag time

DAILY OPERATION PLAN, MARCH 23

Pulse Period: April 20-May 20 · Flow Target: 7,000cfs

	SJR nr Vernalis Existing	VAMP Suppl. flow at Vernalis	SJR nr Vernalis w/VAMP	SJR above Merced R. (2-day lag)	Vernalis Accretion	Merced R. at Cressey Existing	Merced R. at Cressey Suppl.	Merced R. at Cressey w/VAMP	Exchange Contractors Suppl. (3-day lag)	Tuolumne R. at LaGrange FERC pulse Desired	Tuolumne R. at LaGrange FERC pulse Existing	Tuolumne R. at LaGrange Suppl.	Tuolumne R. at LaGrange w/VAMP (2-day lag)	Stan. R. blw Goodwin (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol.
	[calc]	[calc]	[calc]				[calc]	[calc]					[calc]		
	cfs	cfs	cfs	cfs	cfs		cfs	cfs	cfs		cfs	cfs	cfs	cfs	
Apr 01				1,477	1,000	250		250		1,500	1,500		1,500	1,200	
Apr 02				1,432	1,000	250		250		1,500	1,500		1,500	1,200	
Apr 03				1,359	1,000	250		250		1,500	1,500		1,500	1,200	
Apr 04	5,382	0	5,382	1,292	1,000	250		250		1,500	1,500		1,500	1,200	
Apr 05	5,309	0	5,309	1,158	1,000	250		250		1,500	1,500		1,500	1,200	
Apr 06	5,242	0	5,242	1,042	1,000	250		250		1,500	1,500		1,500	1,200	
Apr 07	5,108	0	5,108	997	1,000	250		250		1,500	1,500		1,500	1,200	
Apr 08	4,992	0	4,992	952	1,000	250		250		1,500	1,500		1,500	1,200	
Apr 09	4,947	0	4,947	900	1,000	250		250		1,500	1,500		1,500	1,200	
Apr 10	4,902	0	4,902	940	1,000	250		250		1,500	1,500		1,500	1,200	
Apr 11	4,850	0	4,850	938	1,000	250		250		1,500	1,500		1,500	1,200	
Apr 12	4,890	0	4,890	861	1,000	250		250		1,500	1,500		1,500	1,200	
Apr 13	4,888	0	4,888	779	1,000	250		250		1,500	1,500		1,500	1,200	
Apr 14	4,811	0	4,811	724	1,000	250		250		1,500	1,500		1,500	1,200	
Apr 15	4,729	0	4,729	669	1,000	250		250		1,500	1,500		1,500	1,200	
Apr 16	4,674	0	4,674	659	1,000	250		250		1,500	1,500		1,500	1,200	
Apr 17	4,619	0	4,619	620	1,000	250	2,355	2,605	300	1,500	1,500		1,500	1,200	M
Apr 18	4,609	0	4,609	595	1,000	250	2,369	2,619	300	600	600	400	1,000	1,500	M
Apr 19	4,570	0	4,570	581	1,000	250	2,359	2,609	320	600	600	400	1,000	1,500	M
Apr 20	3,945	3,055	7,000	571	1,000	250	2,351	2,601	340	600	600	400	1,000	1,500	M
Apr 21	3,931	3,069	7,000	559	1,000	250	2,362	2,612	400	600	600	400	1,000	1,500	M
Apr 22	3,921	3,079	7,000	488	1,000	250	2,364	2,614	420	600	600	400	1,000	1,500	M
Apr 23	3,909	3,091	7,000	466	1,000	250	2,372	2,622	0	600	600	400	1,000	1,500	M
Apr 24	3,838	3,162	7,000	478	1,000	250	67	317	0	1,400	1,400	0	1,400	1,500	
Apr 25	3,816	3,184	7,000	483	1,000	250	79	329	0	2,300	2,300	1,400	3,700	1,500	T
Apr 26	4,628	2,372	7,000	471	1,000	250	106	356	0	2,300	2,300	1,400	3,700	1,500	T
Apr 27	5,533	1,467	7,000	444	1,000	250	107	357	0	2,300	2,300	1,400	3,700	1,500	T
Apr 28	5,521	1,479	7,000	443	1,000	250	105	355	0	2,300	2,300	1,400	3,700	1,500	T
Apr 29	5,494	1,506	7,000	445	1,000	250	93	343	0	2,300	2,300	1,400	3,700	1,500	T
Apr 30	5,493	1,507	7,000	457	1,000	250	84	334	200	2,300	2,300	1,400	3,700	1,500	T
May 01	5,495	1,505	7,000	466	1,000	250	1,768	2,018	300	2,200	2,200	1,300	3,500	1,500	M
May 02	5,507	1,493	7,000	482	1,000	250	1,778	2,028	300	1,500	1,500	200	1,700	1,500	M
May 03	5,416	1,584	7,000	472	1,000	250	1,776	2,026	300	1,500	1,500	200	1,700	1,500	M
May 04	4,732	2,268	7,000	474	1,000	250	1,796	2,046	300	1,500	1,500	200	1,700	1,500	M
May 05	4,722	2,278	7,000	454	1,000	250	1,813	2,063	300	1,500	1,500	200	1,700	1,500	M
May 06	4,724	2,276	7,000	437	1,000	250	1,847	2,097	300	1,500	1,500	200	1,700	1,500	M
May 07	4,704	2,296	7,000	403	1,000	250	324	574	300	1,500	1,500	200	1,700	1,500	
May 08	4,687	2,313	7,000	426	1,000	250	230	480	400	2,200	2,200	1,000	3,200	1,500	T
May 09	4,653	2,347	7,000	420	1,000	250	239	489	400	2,200	2,200	1,000	3,200	1,500	T
May 10	5,376	1,624	7,000	411	1,000	250	224	474	400	2,200	2,200	1,000	3,200	1,500	T
May 11	5,370	1,630	7,000	426	1,000	250	309	559	300	2,200	2,200	1,000	3,200	1,500	T
May 12	5,361	1,639	7,000	441	1,000	250	321	571	300	2,200	2,200	1,000	3,200	1,500	T
May 13	5,376	1,624	7,000	429	1,000	250	328	578	300	2,200	2,200	1,000	3,200	1,500	T
May 14	5,391	1,609	7,000	422	1,000	250	1,303	1,553	100	2,200	2,200	1,000	3,200	1,500	M
May 15	5,379	1,621	7,000	447	1,000	250	1,307	1,557	100	2,000	2,000	400	2,400	1,500	M
May 16	5,372	1,628	7,000	443	1,000	250	1,308	1,558	400	2,000	2,000	400	2,400	1,500	M
May 17	5,197	1,803	7,000	442	1,000	250	1,419	1,669	500	2,000	2,000	100	2,100	1,500	T
May 18	5,193	1,807	7,000	431	1,000	250		250		1,900	1,900	0	1,900	1,500	T
May 19	5,192	1,808	7,000	431	1,000	250		250		1,200	1,200		1,200	1,500	T
May 20	5,081	1,919	7,000	414	1,000	250		250		720	720		720	1,500	T
May 21	4,381	0	4,381	395	1,000	250		250		300	300		300	1,500	
May 22	3,884	0	3,884	393	1,000	250		250		300	300		300	1,500	
May 23	3,445	0	3,445	372	1,000	250		250		300	300		300	1,500	
May 24	3,443	0	3,443	389	1,000	250		250		300	300		300	1,500	
May 25	3,422	0	3,422	397	1,000	250		250		300	300		300	1,500	
May 26	3,439	0	3,439	398	1,000	250		250		300	300		300	1,500	
May 27	3,447	0	3,447	365	1,000	250		250		300	300		300	1,500	
May 28	3,448	0	3,448	326	1,000	250		250		300	300		300	1,500	
May 29	3,415	0	3,415	337	1,000	250		250		300	300		300	1,500	
May 30	3,376	0	3,376	343	1,000	250		250		300	300		300	1,500	
May 31	3,387	0	3,387	332	1,000	250		250		300	300		300	1,500	
	VAMP 31-day period *														
Mean (cfs)	4,934	2,066	7,000				1,138	1,388	245		1,719	684	2,403	1,500	
total (KAF)		127.0					69.9		15.0			42.0			

Construction period for the Old River Barrier. (grey)

Pulse flow period and tributary flow to meet the pulse flow. (green)

Tuolumne FERC volume (TAF) = 89.9   89.9

* April 15 – May 15 Adjusted for lag time

DAILY OPERATION PLAN, MARCH 29

PULSE PERIOD: APRIL 20-MAY 20 · FLOW TARGET: 7,000CFS

	SJR nr Vernalis Existing	VAMP Suppl. flow at Vernalis	VAMP Cum. Suppl. Flow	SJR nr Vernalis w/VAMP	SJR above Merced R. (2-day lag)	Vernalis Accretion	Merced R. at Cressey Existing	Merced R. at Cressey Suppl.	Merced R. at Cressey w/VAMP (3-day lag)	Exchange Contractors Suppl. (3-day lag)	Tuolumne R. at LaGrange FERC pulse Desired	Tuolumne R. at LaGrange FERC pulse Existing	Tuolumne R. at LaGrange Suppl.	Tuolumne R. at LaGrange w/VAMP (2-day lag)	Stan. R. blw Goodwin (2-day lag)	Maintain Priority Flow Level M=Mercede T=Tuol.	
	[calc]	[calc]	[calc]	[calc]				[calc]	[calc]					[calc]			
	cfs	cfs	TAF	cfs	cfs	cfs		cfs	cfs	cfs		cfs	cfs	cfs	cfs		
					1,480	1,000	250		250		1,500	1,500		1,500	1,200		Apr 01
					1,430	1,000	250		250		1,500	1,500		1,500	1,200		Apr 02
					1,360	1,000	250		250		1,500	1,500		1,500	1,200		Apr 03
	5,380	0		5,380	1,290	1,000	250		250		1,500	1,500		1,500	1,200		Apr 04
	5,310	0		5,310	1,160	1,000	250		250		1,500	1,500		1,500	1,200		Apr 05
	5,240	0		5,240	1,040	1,000	250		250		1,500	1,500		1,500	1,200		Apr 06
	5,110	0		5,110	1,000	1,000	250		250		1,500	1,500		1,500	1,200		Apr 07
	4,990	0		4,990	950	1,000	250		250		1,500	1,500		1,500	1,200		Apr 08
	4,950	0		4,950	900	1,000	250		250		1,500	1,500		1,500	1,200		Apr 09
	4,900	0		4,900	940	1,000	250		250		1,500	1,500		1,500	1,200		Apr 10
	4,850	0		4,850	940	1,000	250		250		1,500	1,500		1,500	1,200		Apr 11
	4,890	0		4,890	860	1,000	250		250		1,500	1,500		1,500	1,200		Apr 12
	4,890	0		4,890	780	1,000	250		250		1,500	1,500		1,500	1,200		Apr 13
	4,810	0		4,810	720	1,000	250		250		1,500	1,500		1,500	1,200		Apr 14
	4,730	0		4,730	670	1,000	250		250		1,500	1,500		1,500	1,200		Apr 15
	4,670	0		4,670	660	1,000	250	1,100	1,350		1,500	1,500		1,500	1,200		Apr 16
	4,620	0		4,620	620	1,000	250	2,350	2,600	300	1,500	1,500		1,500	1,200	M	Apr 17
	4,610	0		4,610	600	1,000	250	2,370	2,620	300	600	600	400	1,000	1,500	M	Apr 18
	4,570	1,100	0	5,670	580	1,000	250	2,360	2,610	320	600	600	400	1,000	1,500	M	Apr 19
	3,950	3,050	6	7,000	570	1,000	250	2,350	2,600	340	600	600	400	1,000	1,500	M	Apr 20
	3,930	3,070	12.1	7,000	560	1,000	250	2,360	2,610	400	600	600	400	1,000	1,500	M	Apr 21
	3,920	3,080	18.2	7,000	490	1,000	250	2,160	2,410	420	600	600	400	1,000	1,500	M	Apr 22
	3,910	3,090	24.4	7,000	470	1,000	250	1,370	1,620	0	600	600	600	1,200	1,500	M	Apr 23
	3,840	3,160	30.6	7,000	480	1,000	250	0	250	0	1,400	1,400	1,000	2,400	1,500		Apr 24
	3,820	3,180	37.0	7,000	480	1,000	250	0	250	0	2,300	2,300	1,500	3,800	1,500	T	Apr 25
	4,630	2,370	41.7	7,000	470	1,000	250	10	260	0	2,300	2,300	1,500	3,800	1,500	T	Apr 26
	5,530	1,500	44.6	7,030	440	1,000	250	10	260	0	2,300	2,300	1,500	3,800	1,500	T	Apr 27
	5,520	1,500	47.6	7,020	440	1,000	250	0	250	0	2,300	2,300	1,500	3,800	1,500	T	Apr 28
	5,490	1,510	50.6	7,000	450	1,000	250	0	250	0	2,300	2,300	1,500	3,800	1,500	T	Apr 29
	5,490	1,510	53.6	7,000	460	1,000	250	880	1,130	200	2,300	2,300	1,500	3,800	1,500	T	Apr 30
	5,500	1,500	56.6	7,000	470	1,000	250	1,870	2,120	300	2,200	2,200	500	2,700	1,500	M	May 01
	5,510	1,500	59.5	7,010	480	1,000	250	1,880	2,130	300	1,500	1,500	100	1,600	1,500	M	May 02
	5,420	1,580	62.7	7,000	470	1,000	250	1,880	2,130	300	1,500	1,500	100	1,600	1,500	M	May 03
	4,730	2,270	67.2	7,000	470	1,000	250	1,900	2,150	300	1,500	1,500	100	1,600	1,500	M	May 04
	4,720	2,280	71.7	7,000	450	1,000	250	1,910	2,160	300	1,500	1,500	100	1,600	1,500	M	May 05
	4,720	2,280	76.2	7,000	440	1,000	250	1,900	2,150	300	1,500	1,500	100	1,600	1,500	M	May 06
	4,700	2,300	80.8	7,000	400	1,000	250	720	970	300	1,500	1,500	150	1,650	1,500		May 07
	4,690	2,310	85.4	7,000	430	1,000	250	230	480	400	2,200	2,200	600	2,800	1,500	T	May 08
	4,650	2,350	90.0	7,000	420	1,000	250	240	490	400	2,200	2,200	1,000	3,200	1,500	T	May 09
	5,380	1,620	93.2	7,000	410	1,000	250	220	470	400	2,200	2,200	1,000	3,200	1,500	T	May 10
	5,370	1,630	96.5	7,000	430	1,000	250	310	560	300	2,200	2,200	1,000	3,200	1,500	T	May 11
	5,360	1,640	99.7	7,000	440	1,000	250	320	570	300	2,200	2,200	1,000	3,200	1,500	T	May 12
	5,380	1,620	102.9	7,000	430	1,000	250	330	580	300	2,200	2,200	1,000	3,200	1,500	T	May 13
	5,390	1,610	106.1	7,000	420	1,000	250	1,300	1,550	100	2,200	2,200	1,000	3,200	1,500	M	May 14
	5,380	1,620	109.3	7,000	450	1,000	250	1,310	1,560	100	2,000	2,000	400	2,400	1,500	M	May 15
	5,370	1,630	112.6	7,000	440	1,000	250	1,310	1,560	400	2,000	2,000	400	2,400	1,500	M	May 16
	5,200	1,800	116.2	7,000	440	1,000	250	1,420	1,670	500	2,000	2,000	100	2,100	1,500	T	May 17
	5,190	1,810	119.7	7,000	430	1,000	250	700	950		1,900	1,900	0	1,900	1,500	T	May 18
	5,190	1,810	123.3	7,000	430	1,000	250		250		1,200	1,200		1,200	1,500	T	May 19
	5,080	1,920	127.1	7,000	410	1,000	250		250		720	720		720	1,500	T	May 20
	4,380	700		5,080	400	1,000	250		250		300	300		300	1,500		May 21
	3,880	0		3,880	390	1,000	250		250		300	300		300	1,500		May 22
	3,450	0		3,450	370	1,000	250		250		300	300		300	1,500		May 23
	3,440	0		3,440	390	1,000	250		250		300	300		300	1,500		May 24
	3,420	0		3,420	400	1,000	250		250		300	300		300	1,500		May 25
	3,440	0		3,440	400	1,000	250		250		300	300		300	1,500		May 26
	3,450	0		3,450	370	1,000	250		250		300	300		300	1,500		May 27
	3,450	0		3,450	330	1,000	250		250		300	300		300	1,500		May 28
	3,420	0		3,420	340	1,000	250		250		300	300		300	1,500		May 29
	3,380	0		3,380	340	1,000	250		250		300	300		300	1,500		May 30
	3,390	0		3,390	330	1,000	250		250		300	300		300	1,500		May 31
	VAMP 31-day period *																
Mean (cfs)	4,934	2,068		7,002				1,138	1,388	245		1,719	685	2,405	1,500		
total (KAF)		127.1						70.0		15.0			42.1				

Construction period for the Old River Barrier. (gray shading)

Pulse flow period and tributary flow to meet the pulse flow. (green shading)

Tuolumne FERC volume (TAF) = 91.2 91.2

* April 15 – May 15 Adjusted for lag time

DAILY OPERATION PLAN, APRIL 4

Pulse Period: April 15-May 15 · Flow Target: 7,000cfs

	SJR nr Vernalis Existing	VAMP Suppl. flow at Vernalis	VAMP Cum. Suppl. Flow	SJR nr Vernalis w/VAMP	SJR above Merced R. (2-day lag)	Vernalis Accretion	Merced R. at Cressey Existing	Merced R. at Cressey Suppl.	Merced R. at Cressey w/VAMP (3-day lag)	Exchange Contractors Suppl. (3-day lag)	Tuolumne R. at LaGrange FERC pulse Desired	Tuolumne R. at LaGrange FERC pulse Existing	Tuolumne R. at LaGrange Suppl.	Tuolumne R. at LaGrange w/VAMP (2-day lag)	Stan. R. blw Goodwin (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol.
	[calc]	[calc]	[calc]	[calc]				[calc]	[calc]					[calc]		
	cfs	cfs		cfs	cfs	cfs		cfs	cfs	cfs		cfs	cfs	cfs	cfs	
Mar 29							250		250		2,519	2,519		2,519	800	
Mar 30							250		250		2,628	2,628		2,628	800	
Mar 31							250		250		2,039	2,039		2,039	800	
Apr 01	4,678			4,678	1,480	1,000	250		250		1,567	1,567		1,567	800	
Apr 02	4,089			4,089	1,430	1,000	250		250		1,126	1,126		1,126	800	
Apr 03	5,097			5,097	1,360	1,000	250		250		1,000	1,000		1,000	800	
Apr 04	4,606			4,606	1,290	1,000	250		250		1,000	1,000		1,000	800	
Apr 05	4,410			4,410	1,160	1,000	250		250		1,000	1,000		1,000	800	
Apr 06	4,340			4,340	1,040	1,000	250		250		1,000	1,000		1,000	800	
Apr 07	4,210			4,210	1,000	1,000	250		250		1,000	1,000		1,000	800	
Apr 08	4,090			4,090	950	1,000	250		250		1,000	1,000		1,000	800	
Apr 09	4,050			4,050	900	1,000	250		250		1,000	1,000		1,000	800	
Apr 10	4,000			4,000	940	1,000	250		250		1,000	1,000		1,000	800	
Apr 11	3,950			3,950	938	1,000	250		250		1,000	1,000		1,000	800	
Apr 12	3,990			3,990	861	1,000	250	0	250	0	1,400	1,400		1,400	800	M
Apr 13	3,988			3,988	779	1,000	250	0	250	0	2,300	2,300	1,500	3,800	1,500	T
Apr 14	4,311			4,311	724	1,000	250	0	250	0	2,300	2,300	1,500	3,800	1,500	T
Apr 15	5,829	1,500	3	7,329	669	1,000	250	0	250	0	2,300	2,300	1,500	3,800	1,500	T
Apr 16	5,774	1,500	6	7,274	659	1,000	250	0	250	0	2,300	2,300	1,500	3,800	1,500	T
Apr 17	5,719	1,500	9	7,219	620	1,000	250	0	250	0	2,300	2,300	1,500	3,800	1,500	T
Apr 18	5,709	1,500	12	7,209	595	1,000	250	0	250	0	2,300	2,300	1,500	3,800	1,500	T
Apr 19	5,670	1,500	15	7,170	581	1,000	250	1,279	1,529	300	2,200	2,200	1,500	3,700	1,500	T
Apr 20	5,645	1,500	18	7,145	571	1,000	250	2,691	2,941	300	600	600	1,500	2,100	1,500	T
Apr 21	5,531	1,500	21	7,031	559	1,000	250	2,762	3,012	300	600	600	100	700	1,500	
Apr 22	3,921	3,079	27	7,000	488	1,000	250	2,784	3,034	300	600	600	100	700	1,500	
Apr 23	3,909	3,091	33	7,000	466	1,000	250	2,872	3,122	300	600	600	100	700	1,500	
Apr 24	3,838	3,162	39	7,000	478	1,000	250	2,067	2,317	300	600	600	0	600	1,500	M
Apr 25	3,816	3,184	46	7,000	483	1,000	250	2,079	2,329	300	600	600	800	1,400	1,500	M
Apr 26	3,828	3,172	52	7,000	471	1,000	250	2,056	2,306	250	600	600	800	1,400	1,500	M
Apr 27	3,833	3,167	58	7,000	444	1,000	250	2,057	2,307	250	1,500	1,500	0	1,500	1,500	M
Apr 28	3,821	3,179	65	7,000	443	1,000	250	2,055	2,305	250	1,500	1,500	0	1,500	1,500	M
Apr 29	4,694	2,306	69	7,000	445	1,000	250	2,043	2,293	250	1,500	1,500	0	1,500	1,500	M
Apr 30	4,693	2,307	74	7,000	457	1,000	250	2,034	2,284	250	1,500	1,500	0	1,500	1,500	M
May 01	4,695	2,305	78	7,000	466	1,000	250	2,018	2,268	250	1,500	1,500	0	1,500	1,500	M
May 02	4,707	2,293	83	7,000	482	1,000	250	1,378	1,628	200	1,500	1,500	0	1,500	1,500	M
May 03	4,716	2,284	87	7,000	472	1,000	250	376	626	200	2,200	2,200	0	2,200	1,500	T
May 04	4,732	2,268	92	7,000	474	1,000	250	396	646	200	2,200	2,200	1,000	3,200	1,500	T
May 05	5,422	1,578	95	7,000	454	1,000	250	463	713	150	2,200	2,200	1,000	3,200	1,500	T
May 06	5,424	1,576	98	7,000	437	1,000	250	547	797	100	2,200	2,200	1,000	3,200	1,500	T
May 07	5,404	1,596	101	7,000	403	1,000	250	624	874	0	2,200	2,200	1,000	3,200	1,500	T
May 08	5,387	1,613	104	7,000	426	1,000	250	630	880	0	2,200	2,200	1,000	3,200	1,500	T
May 09	5,353	1,647	108	7,000	420	1,000	250	839	1,089	0	2,200	2,200	1,000	3,200	1,500	T
May 10	5,376	1,624	111	7,000	411	1,000	250	924	1,174	300	2,000	2,000	1,000	3,000	1,500	T
May 11	5,370	1,630	114	7,000	426	1,000	250	1,309	1,559	300	2,000	2,000	600	2,600	1,500	
May 12	5,161	1,839	118	7,000	441	1,000	250	1,621	1,871	300	2,000	2,000	200	2,200	1,500	
May 13	5,176	1,824	121	7,000	429	1,000	250		250		1,900	1,900	0	1,900	1,500	
May 14	5,191	1,809	125	7,000	422	1,000	250		250		500	500		500	1,500	
May 15	5,079	1,921	129	7,000	447	1,000	250		250		500	500		500	1,500	
May 16	3,672	0		3,672	443	1,000	250		250		300	300		300	1,500	
May 17	3,697	0		3,697	442	1,000	250		250		300	300		300	1,500	
May 18	3,493	0		3,493	431	1,000	250		250		300	300		300	1,500	
May 19	3,492	0		3,492	431	1,000	250		250		300	300		300	1,500	
May 20	3,481	0		3,481	414	1,000	250		250		300	300		300	1,500	
May 21	3,481	0		3,481	395	1,000	250		250		300	300		300	1,500	
May 22	3,464	0		3,464	393	1,000	250		250		300	300		300	1,500	
May 23	3,445	0		3,445	372	1,000	250		250		300	300		300	1,500	
May 24	3,443	0		3,443	389	1,000	250		250		300	300		300	1,500	
May 25	3,422	0		3,422	397	1,000	250		250		300	300		300	1,500	
May 26	3,439	0		3,439	398	1,000	250		250		300	300		300	1,500	
May 27	3,447	0		3,447	365	1,000	250		250		300	300		300	1,500	
May 28	3,448	0		3,448	326	1,000	250		250		300	300		300	1,500	
May 29	3,415	0		3,415	337	1,000	250		250		300	300		300	1,500	
May 30	3,376	0		3,376	343	1,000	250		250		300	300		300	1,500	
May 31	3,387	0		3,387	332	1,000	250		250		300	300		300	1,500	
VAMP 31-day period *																
Mean (cfs)	4,949	2,095		7,044				1,223	1,473	173		1,694	700	2,394	1,500	
total (KAF)		128.8						75.2		10.6			43.0			

Construction period for the Old River Barrier.

Pulse flow period and tributary flow to meet the pulse flow.

Tuolumne FERC volume (TAF) = 89.9 91.2

* April 15 – May 15 Adjusted for lag time

DAILY OPERATION PLAN, APRIL 5

PULSE PERIOD: APRIL 15-MAY 15 · FLOW TARGET: 7,000CFS

	SJR nr Vernalis Existing	VAMP Suppl. flow at Vernalis	VAMP Cum. Suppl. Flow	SJR nr Vernalis w/VAMP	SJR above Merced R. (2-day lag)	Vernalis Accretion	Merced R. at Cressey Existing	Merced R. at Cressey Suppl.	Merced R. at Cressey w/VAMP (3-day lag)	Exchange Contractors Suppl. (3-day lag)	Tuolumne R. at LaGrange FERC pulse Desired	Tuolumne R. at LaGrange FERC pulse Existing	Tuolumne R. at LaGrange Suppl.	Tuolumne R. at LaGrange w/VAMP (2-day lag)	Stan. R. blw Goodwin (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol.	
	[calc]	[calc]	[calc]	[calc]				[calc]	[calc]					[calc]			
	cfs	cfs		cfs	cfs	cfs		cfs	cfs	cfs		cfs	cfs	cfs	cfs		
							250		250		2,519	2,519		2,519	800		Mar 29
							250		250		2,628	2,628		2,628	800		Mar 30
							250		250		2,039	2,039		2,039	800		Mar 31
	4,678			4,678	1,480	1,000	250		250		1,567	1,567		1,567	800		Apr 01
	4,089			4,089	1,430	1,000	250		250		1,126	1,126		1,126	800		Apr 02
	5,097			5,097	1,360	1,000	250		250		1,182	1,182		1,182	800		Apr 03
	4,606			4,606	1,290	1,000	250		250		738	738		738	800		Apr 04
	4,592			4,592	1,160	1,000	250		250		1,000	1,000		1,000	800		Apr 05
	4,078			4,078	1,040	1,000	250		250		1,000	1,000		1,000	800		Apr 06
	4,210			4,210	1,000	1,000	250		250		1,000	1,000		1,000	800		Apr 07
	4,090			4,090	950	1,000	250		250		1,000	1,000		1,000	800		Apr 08
	4,050			4,050	900	1,000	250		250		1,000	1,000		1,000	800		Apr 09
	4,000			4,000	940	1,000	250		250		1,000	1,000		1,000	800		Apr 10
	3,950			3,950	938	1,000	250		250		1,000	1,000		1,000	800		Apr 11
	3,990			3,990	861	1,000	250	0	250	0	1,400	1,400		1,400	800	M	Apr 12
	3,988			3,988	779	1,000	250	0	250	0	2,300	2,300	1,500	3,800	1,500	T	Apr 13
	4,311			4,311	724	1,000	250	0	250	0	2,300	2,300	1,500	3,800	1,500	T	Apr 14
	5,829	1,500	3	7,329	669	1,000	250	0	250	0	2,300	2,300	1,500	3,800	1,500	T	Apr 15
	5,774	1,500	6	7,274	659	1,000	250	0	250	0	2,300	2,300	1,500	3,800	1,500	T	Apr 16
	5,719	1,500	9	7,219	620	1,000	250	0	250	0	2,300	2,300	1,500	3,800	1,500	T	Apr 17
	5,709	1,500	12	7,209	595	1,000	250	0	250	0	2,300	2,300	1,500	3,800	1,500	T	Apr 18
	5,670	1,500	15	7,170	581	1,000	250	879	1,129	300	2,200	2,200	1,500	3,700	1,500	T	Apr 19
	5,645	1,500	18	7,145	571	1,000	250	1,991	2,241	300	600	600	1,900	2,500	1,500	T	Apr 20
	5,531	1,500	21	7,031	559	1,000	250	2,062	2,312	300	600	600	800	1,400	1,500		Apr 21
	3,921	3,079	27	7,000	488	1,000	250	2,084	2,334	300	600	600	800	1,400	1,500		Apr 22
	3,909	3,091	33	7,000	466	1,000	250	2,072	2,322	300	600	600	800	1,400	1,500		Apr 23
	3,838	3,162	39	7,000	478	1,000	250	2,067	2,317	300	600	600	800	1,400	1,500	M	Apr 24
	3,816	3,184	46	7,000	483	1,000	250	2,079	2,329	300	600	600	800	1,400	1,500	M	Apr 25
	3,828	3,172	52	7,000	471	1,000	250	2,056	2,306	250	600	600	800	1,400	1,500	M	Apr 26
	3,833	3,167	58	7,000	444	1,000	250	2,057	2,307	250	1,500	1,500	0	1,500	1,500	M	Apr 27
	3,821	3,179	65	7,000	443	1,000	250	2,055	2,305	250	1,500	1,500	0	1,500	1,500	M	Apr 28
	4,694	2,306	69	7,000	445	1,000	250	2,043	2,293	250	1,500	1,500	0	1,500	1,500	M	Apr 29
	4,693	2,307	74	7,000	457	1,000	250	2,034	2,284	250	1,500	1,500	0	1,500	1,500	M	Apr 30
	4,695	2,305	78	7,000	466	1,000	250	2,018	2,268	250	1,500	1,500	0	1,500	1,500	M	May 01
	4,707	2,293	83	7,000	482	1,000	250	1,478	1,728	100	1,500	1,500	0	1,500	1,500	M	May 02
	4,716	2,284	87	7,000	472	1,000	250	676	926	100	2,200	2,200	0	2,200	1,500	T	May 03
	4,732	2,268	92	7,000	474	1,000	250	696	946	100	2,200	2,200	800	3,000	1,500	T	May 04
	5,422	1,578	95	7,000	454	1,000	250	713	963	100	2,200	2,200	800	3,000	1,500	T	May 05
	5,424	1,576	98	7,000	437	1,000	250	747	997	100	2,200	2,200	800	3,000	1,500	T	May 06
	5,404	1,596	101	7,000	403	1,000	250	724	974	100	2,200	2,200	800	3,000	1,500	T	May 07
	5,387	1,613	104	7,000	426	1,000	250	630	880	200	2,200	2,200	800	3,000	1,500	T	May 08
	5,353	1,647	108	7,000	420	1,000	250	639	889	200	2,200	2,200	800	3,000	1,500	T	May 09
	5,376	1,624	111	7,000	411	1,000	250	524	774	300	2,000	2,000	1,000	3,000	1,500	T	May 10
	5,370	1,630	114	7,000	426	1,000	250	509	759	300	2,000	2,000	1,000	3,000	1,500		May 11
	5,161	1,839	118	7,000	441	1,000	250	521	771	300	2,000	2,000	1,000	3,000	1,500		May 12
	5,176	1,824	121	7,000	429	1,000	250		250		1,900	1,900	1,100	3,000	1,500		May 13
	5,191	1,809	125	7,000	422	1,000	250		250		500	500		500	1,500		May 14
	5,079	1,921	129	7,000	447	1,000	250		250		500	500		500	1,500		May 15
	3,672	0		3,672	443	1,000	250		250		300	300		300	1,500		May 16
	3,697	0		3,697	442	1,000	250		250		300	300		300	1,500		May 17
	3,493	0		3,493	431	1,000	250		250		300	300		300	1,500		May 18
	3,492	0		3,492	431	1,000	250		250		300	300		300	1,500		May 19
	3,481	0		3,481	414	1,000	250		250		300	300		300	1,500		May 20
	3,481	0		3,481	395	1,000	250		250		300	300		300	1,500		May 21
	3,464	0		3,464	393	1,000	250		250		300	300		300	1,500		May 22
	3,445	0		3,445	372	1,000	250		250		300	300		300	1,500		May 23
	3,443	0		3,443	389	1,000	250		250		300	300		300	1,500		May 24
	3,422	0		3,422	397	1,000	250		250		300	300		300	1,500		May 25
	3,439	0		3,439	398	1,000	250		250		300	300		300	1,500		May 26
	3,447	0		3,447	365	1,000	250		250		300	300		300	1,500		May 27
	3,448	0		3,448	326	1,000	250		250		300	300		300	1,500		May 28
	3,415	0		3,415	337	1,000	250		250		300	300		300	1,500		May 29
	3,376	0		3,376	343	1,000	250		250		300	300		300	1,500		May 30
	3,387	0		3,387	332	1,000	250		250		300	300		300	1,500		May 31
	VAMP 31-day period *																
Mean (cfs)	4,949	2,095		7,044				1,076	1,326	177		1,694	842	2,535	1,500		
total (KAF)		128.8						66.2		10.9			51.8				

Construction period for the Old River Barrier.

Pulse flow period and tributary flow to meet the pulse flow.

Tuolumne FERC volume (TAF) = 91.2   91.2

* April 15 – May 15 Adjusted for lag time

VAMP 2000 SAN JOAQUIN RIVER TECHNICAL COMMITTEE HYDROLOGY GROUP

DAILY OPERATION PLAN, APRIL 11

Pulse Period: April 15-May 15 · Flow Target: 7,000cfs

	SJR nr Vernalis Existing	VAMP Suppl. flow at Vernalis	VAMP Cum. Suppl. Flow	SJR nr Vernalis w/VAMP	SJR above Merced R. (2-day lag)	Vernalis Accretion	Merced R. at Cressey Existing	Merced R. at Cressey Suppl.	Merced R. at Cressey w/VAMP (3-day lag)	Exchange Contractors Suppl. (3-day lag)	Tuolumne R. at LaGrange FERC pulse Desired	Tuolumne R. at LaGrange FERC pulse "Modified"	Tuolumne R. at LaGrange Suppl.	Tuolumne R. at LaGrange w/VAMP (2-day lag)	Stan. R. blw Goodwin (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol.
	[calc]	[calc]	[calc]	[calc]				[calc]	[calc]					[calc]		
	cfs	cfs		cfs	cfs	cfs		cfs	cfs	cfs		cfs	cfs	cfs	cfs	
Mar 29							660		660		2,519	2,519		2,519	846	
Mar 30							636		636		2,628	2,628		2,628	846	
Mar 31							606		606		2,039	2,039		2,039	846	
Apr 01	6,145			6,145	894	2,011	588		588		1,567	1,567		1,567	846	
Apr 02	5,745			5,745	843	2,224	599		599		1,126	1,126		1,126	846	
Apr 03	5,406			5,406	822	1,493	613		613		1,182	1,182		1,182	846	
Apr 04	5,181			5,181	839	1,778	601		601		738	738		738	851	
Apr 05	4,944			4,944	846	1,495	596		596		626	626		626	860	
Apr 06	4,738			4,738	937	1,697	376		376		616	616		616	831	
Apr 07	4,603			4,603	1,001	1,670	307		307		572	572		572	816	
Apr 08	4,598			4,598	977	1,618	309		309		406	406		406	826	
Apr 09	4,522			4,522	950	1,757	301		301		376	376		376	831	
Apr 10	4,315			4,315	925	1,799	304		304		396	396		396	878	
Apr 11	4,266			4,266	938	1,800	250		250		396	396		396	1,200	
Apr 12	4,300			4,300	861	1,800	250	0	250	0	396	396		396	1,500	M
Apr 13	4,638			4,638	779	1,800	250	0	250	0	2,300	2,300	1,500	3,800	1,500	T+M
Apr 14	4,807			4,807	724	1,800	250	0	250	0	2,300	2,300	1,500	3,800	1,500	T+M
Apr 15	5,829	1,500	3	7,329	669	1,000	250	0	250	0	2,300	2,300	1,500	3,800	1,500	T+M
Apr 16	5,774	1,500	6	7,274	659	1,000	250	0	250	0	2,300	2,300	1,500	3,800	1,500	T+M
Apr 17	5,719	1,500	9	7,219	620	1,000	250	0	250	0	2,300	2,300	1,500	3,800	1,500	T+M
Apr 18	5,709	1,500	12	7,209	595	1,000	250	0	250	0	2,300	2,300	1,500	3,800	1,500	T+M
Apr 19	5,670	1,500	15	7,170	581	1,000	250	779	1,029	100	2,300	2,300	1,500	3,800	1,500	T
Apr 20	5,645	1,500	18	7,145	571	1,000	250	1,791	2,041	200	1,100	1,000	1,800	2,800	1,500	T
Apr 21	5,631	1,500	21	7,131	559	1,000	250	1,812	2,062	250	600	600	1,100	1,700	1,500	
Apr 22	4,321	2,679	26	7,000	488	1,000	250	1,784	2,034	300	600	600	1,100	1,700	1,500	
Apr 23	3,909	3,091	32	7,000	466	1,000	250	1,772	2,022	300	600	600	1,100	1,700	1,500	
Apr 24	3,838	3,162	39	7,000	478	1,000	250	1,767	2,017	300	600	600	1,100	1,700	1,500	M
Apr 25	3,816	3,184	45	7,000	483	1,000	250	1,779	2,029	300	600	600	1,100	1,700	1,500	M
Apr 26	3,828	3,172	51	7,000	471	1,000	250	1,806	2,056	300	600	600	1,100	1,700	1,500	M
Apr 27	3,833	3,167	57	7,000	444	1,000	250	1,807	2,057	300	1,500	1,500	200	1,700	1,500	M
Apr 28	3,821	3,179	64	7,000	443	1,000	250	1,805	2,055	300	1,500	1,500	200	1,700	1,500	M
Apr 29	4,694	2,306	68	7,000	445	1,000	250	1,793	2,043	300	1,500	1,500	200	1,700	1,500	M
Apr 30	4,693	2,307	73	7,000	457	1,000	250	1,784	2,034	300	1,500	1,500	200	1,700	1,500	M
May 01	4,695	2,305	77	7,000	466	1,000	250	1,768	2,018	300	1,500	1,500	200	1,700	1,500	M
May 02	4,707	2,293	82	7,000	482	1,000	250	1,278	1,528	200	1,500	1,500	200	1,700	1,500	M
May 03	4,716	2,284	87	7,000	472	1,000	250	476	726	200	2,200	2,300	0	2,300	1,500	T
May 04	4,732	2,268	91	7,000	474	1,000	250	496	746	200	2,200	2,300	800	3,100	1,500	T
May 05	5,522	1,478	94	7,000	454	1,000	250	513	763	200	2,200	2,300	800	3,100	1,500	T
May 06	5,524	1,476	97	7,000	437	1,000	250	547	797	200	2,200	2,300	800	3,100	1,500	T
May 07	5,504	1,496	100	7,000	403	1,000	250	524	774	200	2,200	2,300	800	3,100	1,500	T
May 08	5,487	1,513	103	7,000	426	1,000	250	530	780	200	2,200	2,300	800	3,100	1,500	T
May 09	5,453	1,547	106	7,000	420	1,000	250	539	789	200	2,200	2,300	800	3,100	1,500	T
May 10	5,476	1,524	109	7,000	411	1,000	250	1,024	1,274	300	2,200	2,300	800	3,100	1,500	T
May 11	5,470	1,530	112	7,000	426	1,000	250	1,009	1,259	300	1,900	2,200	300	2,500	1,500	
May 12	5,461	1,539	115	7,000	441	1,000	250	1,021	1,271	300	1,800	2,200	300	2,500	1,500	
May 13	5,376	1,624	118	7,000	429	1,000	250		250		1,800	2,150	350	2,500	1,500	
May 14	5,391	1,609	121	7,000	422	1,000	250		250		1,550	300		300	1,500	
May 15	5,329	1,671	125	7,000	447	1,000	250		250		800	300		300	1,500	
May 16	3,472	0		3,472	443	1,000	250		250		300	300		300	1,500	
May 17	3,497	0		3,497	442	1,000	250		250		300	300		300	1,500	
May 18	3,493	0		3,493	431	1,000	250		250		300	300		300	1,500	
May 19	3,492	0		3,492	431	1,000	250		250		300	300		300	1,500	
May 20	3,481	0		3,481	414	1,000	250		250		300	300		300	1,500	
May 21	3,481	0		3,481	395	1,000	250		250		300	300		300	1,500	
May 22	3,464	0		3,464	393	1,000	250		250		300	300		300	1,500	
May 23	3,445	0		3,445	372	1,000	250		250		300	300		300	1,500	
May 24	3,443	0		3,443	389	1,000	250		250		300	300		300	1,500	
May 25	3,422	0		3,422	397	1,000	250		250		300	300		300	1,500	
May 26	3,439	0		3,439	398	1,000	250		250		300	300		300	1,500	
May 27	3,447	0		3,447	365	1,000	250		250		300	300		300	1,500	
May 28	3,448	0		3,448	326	1,000	250		250		300	300		300	1,500	
May 29	3,415	0		3,415	337	1,000	250		250		300	300		300	1,500	
May 30	3,376	0		3,376	343	1,000	250		250		300	300		300	1,500	
May 31	3,387	0		3,387	332	1,000	250		250		300	300		300	1,500	
	VAMP 31-day period*															
Mean (cfs)	5,018	2,029		7,048				974	1,224	195		1,763	860	2,623	1,500	
total (KAF)		125						59.9		12.0			52.9			

Actual Value

Barrier Construction

Stability Target

Tuolumne FERC volume (TAF) = 89.95 (33 days) 89.95 (31 days)

* April 15 – May 15 Adjusted for lag time

DAILY OPERATION PLAN, APRIL 13

Pulse Period: April 15-May 15 · Flow Target: 7,000cfs

Date	SJR nr Vernalis Existing	VAMP Suppl. flow at Vernalis	VAMP Cum. Suppl. Flow	SJR nr Vernalis w/VAMP	SJR above Merced R. (2-day lag)	Vernalis Accretion	Merced R. at Cressey Existing	Merced R. at Cressey Suppl.	Merced R. at Cressey w/VAMP (3-day lag)	Exchange Contractors Suppl. (3-day lag)	Tuolumne R. at LaGrange FERC pulse Desired	Tuolumne R. at LaGrange FERC pulse Existing	Tuolumne R. at LaGrange Suppl.	Tuolumne R. at LaGrange w/VAMP (2-day lag)	Stan. R. blw Goodwin (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol.
	[calc]	[calc]	[calc]	[calc]				[calc]	[calc]					[calc]		
	cfs	cfs		cfs	cfs	cfs		cfs	cfs	cfs		cfs	cfs	cfs	cfs	
Mar 29							660		660		2,519	2,519		2,519	846	
Mar 30							636		636		2,628	2,628		2,628	846	
Mar 31							606		606		2,039	2,039		2,039	846	
Apr 01	4,438			4,438	894	304	588		588		1,567	1,567		1,567	846	
Apr 02	4,055			4,055	843	534	599		599		1,126	1,126		1,126	846	
Apr 03	4,653			4,653	822	740	613		613		1,182	1,182		1,182	846	
Apr 04	4,403			4,403	839	1,000	601		601		738	738		738	851	
Apr 05	4,177			4,177	846	728	596		596		626	626		626	860	
Apr 06	3,985			3,985	937	944	376		376		616	616		616	831	
Apr 07	3,838			3,838	1,001	905	307		307		572	572		572	816	
Apr 08	3,828			3,828	985	848	309		309		406	406		406	826	
Apr 09	3,533			3,533	955	768	301		301		376	376		376	831	
Apr 10	3,256			3,256	925	732	304		304		396	396		396	878	
Apr 11	3,065			3,065	581	594	302		302		395	395		395	1,071	
Apr 12	3,049			3,049	459	549	423	0	423	0	737	737		737	1,200	M
Apr 13	3,186			3,186	418	835	326	0	326	0	2,300	2,300	1,479	3,779	1,275	T+M
Apr 14	3,398			3,398	451	700	250	0	250	0	2,300	2,300	1,500	3,800	1,500	T+M
Apr 15	5,116	1,479	3	6,595	447	700	250	0	250	0	2,300	2,300	1,500	3,800	1,200	T+M
Apr 16	5,277	1,500	6	6,777	443	700	250	0	250	0	2,300	2,300	1,400	3,700	1,100	T+M
Apr 17	4,897	1,500	9	6,397	439	700	250	0	250	0	2,300	2,300	1,300	3,600	1,100	T+M
Apr 18	4,643	1,400	12	6,043	436	550	250	768	1,018	0	2,300	2,300	1,300	3,600	1,100	T+M
Apr 19	4,639	1,300	14	5,939	432	550	250	772	1,022	100	2,300	2,300	300	2,600	1,100	T
Apr 20	4,636	1,300	17	5,936	428	550	250	1,476	1,726	200	1,100	1,000	1,100	2,100	1,500	T
Apr 21	4,632	1,068	19	5,700	424	550	250	1,680	1,930	200	600	600	700	1,300	1,500	
Apr 22	3,728	1,972	23	5,700	420	550	250	1,684	1,934	200	600	600	500	1,100	1,500	
Apr 23	3,324	2,376	28	5,700	416	550	250	1,588	1,838	300	600	600	500	1,100	1,500	
Apr 24	3,320	2,380	32	5,700	412	550	250	1,592	1,842	300	600	600	500	1,100	1,500	M
Apr 25	3,316	2,384	37	5,700	408	550	250	1,596	1,846	300	600	600	500	1,100	1,500	M
Apr 26	3,312	2,388	42	5,700	404	550	250	1,500	1,750	0	600	600	500	1,100	1,500	M
Apr 27	3,308	2,392	46	5,700	400	550	250	1,504	1,754	0	1,500	1,500	0	1,500	1,500	M
Apr 28	3,304	2,396	51	5,700	396	550	250	1,507	1,757	0	1,500	1,500	0	1,500	1,500	M
Apr 29	4,200	1,500	54	5,700	393	550	250	1,511	1,761	0	1,500	1,500	0	1,500	1,500	M
Apr 30	4,196	1,504	57	5,700	389	550	250	1,515	1,765	0	1,500	1,500	0	1,500	1,500	M
May 01	4,193	1,507	60	5,700	385	550	250	1,519	1,769	0	1,500	1,500	0	1,500	1,500	M
May 02	4,189	1,511	63	5,700	381	550	250	723	973		1,500	1,500	0	1,500	1,500	M
May 03	4,185	1,515	66	5,700	377	550	250	527	777	100	2,200	2,300		2,300	1,500	T
May 04	4,181	1,519	69	5,700	373	550	250	431	681	200	2,200	2,300	100	2,400	1,500	T
May 05	4,977	723	71	5,700	369	550	250	335	585	300	2,200	2,300	100	2,400	1,500	T
May 06	4,973	727	72	5,700	365	550	250	339	589	300	2,200	2,300	100	2,400	1,500	T
May 07	4,969	731	74	5,700	361	550	250	343	593	300	2,200	2,300	100	2,400	1,500	T
May 08	4,965	735	75	5,700	357	550	250	347	597	300	2,200	2,300	100	2,400	1,500	T
May 09	4,961	739	76	5,700	353	550	250	350	600	300	2,200	2,300	100	2,400	1,500	T
May 10	4,957	743	78	5,700	350	550	250	354	604	300	2,200	2,300	100	2,400	1,500	T
May 11	4,953	747	79	5,700	346	550	250	358	608	300	1,900	2,200	200	2,400	1,500	
May 12	4,950	750	81	5,700	342	550	250	362	612	300	1,800	2,200	200	2,400	1,500	
May 13	4,846	854	83	5,700	338	550	250		250		1,800	2,150	250	2,400	1,500	
May 14	4,842	858	84	5,700	334	550	250		250		1,550	300		300	1,500	
May 15	4,788	912	86	5,700	330	550	250		250		800	300		300	1,500	
May 16	2,934	0		2,934	443	550	250		250		300	300		300	1,500	
May 17	2,930	0		2,930	442	550	250		250		300	300		300	1,500	
May 18	3,043	0		3,043	431	550	250		250		300	300		300	1,500	
May 19	3,042	0		3,042	431	550	250		250		300	300		300	1,500	
May 20	3,031	0		3,031	414	550	250		250		300	300		300	1,500	
May 21	3,031	0		3,031	395	550	250		250		300	300		300	1,500	
May 22	3,014	0		3,014	393	550	250		250		300	300		300	1,500	
May 23	2,995	0		2,995	372	550	250		250		300	300		300	1,500	
May 24	2,993	0		2,993	389	550	250		250		300	300		300	1,500	
May 25	2,972	0		2,972	397	550	250		250		300	300		300	1,500	
May 26	2,989	0		2,989	398	550	250		250		300	300		300	1,500	
May 27	2,997	0		2,997	365	550	250		250		300	300		300	1,500	
May 28	2,998	0		2,998	326	550	250		250		300	300		300	1,500	
May 29	2,965	0		2,965	337	550	250		250		300	300		300	1,500	
May 30	2,926	0		2,926	343	550	250		250		300	300		300	1,500	
May 31	2,937	0		2,937	332	550	250		250		300	300		300	1,500	
VAMP 31-day period *																
Mean (cfs)	4,412	1,400		5,813				796	1,054	143		1,763	481	2,228	1,439	
total (KAF)		86						49.0		8.8			29.6			

Actual Value

Barrier Construction

Stability Target

Tuolumne FERC volume (TAF) = 89.95 (33 days) 89.95 (31 days)

* April 15 – May 15 Adjusted for lag time

DAILY OPERATION PLAN, APRIL 14

Pulse Period: April 15-May 15 · Flow Target: 7,000cfs

	SJR nr Vernalis Existing	VAMP Suppl. flow at Vernalis	VAMP Cum. Suppl. Flow	SJR nr Vernalis w/VAMP	SJR above Merced R. (2-day lag)	Vernalis Accretion	Merced R. at Cressey Existing	Merced R. at Cressey Suppl.	Merced R. at Cressey w/VAMP (3-day lag)	Exchange Contractors Suppl. (3-day lag)	Tuolumne R. at LaGrange FERC pulse Desired	Tuolumne R. at LaGrange FERC pulse Existing	Tuolumne R. at LaGrange Suppl.	Tuolumne R. at LaGrange w/VAMP (2-day lag)	Stan. R. blw Goodwin (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol.
	[calc]	[calc]	[calc]	[calc]				[calc]	[calc]					[calc]		
	cfs	cfs	TAF	cfs	cfs	cfs		cfs	cfs	cfs		cfs	cfs	cfs	cfs	
Apr 01					894	304	300		300		1,567	1,567		1,567	846	
Apr 02					843	534	300		300		1,126	1,126		1,126	846	
Apr 03					822	740	300		300		1,182	1,182		1,182	846	
Apr 04	4,122			4,122	839	1,007	300		300		738	738		738	851	
Apr 05	3,885			3,885	846	735	300		300		626	626		626	860	
Apr 06	3,678			3,678	937	950	300		300		616	616		616	831	
Apr 07	3,543			3,543	1,001	911	307		307		572	572		572	816	
Apr 08	3,523			3,523	985	839	309		309		416	416		416	819	
Apr 09	3,385			3,385	955	696	301		301		407	407		407	853	
Apr 10	3,246			3,246	925	719	304		304		397	397		397	878	
Apr 11	3,085	0		3,085	581	561	302	0	302		395	395		395	1,071	
Apr 12	3,040	0		3,040	459	539	317	0	317	0	737	737		737	1,200	M
Apr 13	3,191	0		3,191	418		326	0	326	0	2,300	2,300	1,480	3,780	1,275	T+M
Apr 14	3,998	0	0	3,998	414	1,300	250	0	250	0	2,300	2,300	1,500	3,800	1,500	T+M
Apr 15	4,810	1,480	3	6,290	411	500	250	0	250	0	2,300	2,300	1,500	3,800	1,100	T+M
Apr 16	5,040	1,500	5.9	6,540	407	500	250	0	250	0	2,300	2,300	1,400	3,700	1,100	T+M
Apr 17	4,561	1,500	8.9	6,061	403	500	250	0	250	0	2,300	2,300	1,300	3,600	1,100	T+M
Apr 18	4,557	1,400	11.7	5,957	400	500	250	154	404	100	2,300	2,300	1,300	3,600	1,100	T+M
Apr 19	4,553	1,300	14.2	5,853	396	500	250	858	1,108	100	2,300	2,300	500	2,800	1,500	T
Apr 20	4,550	1,300	16.8	5,850	392	500	250	1,562	1,812	200	1,100	1,400	700	2,100	1,500	T
Apr 21	4,946	754	18.3	5,700	389	500	250	1,765	2,015	200	600	800	500	1,300	1,500	
Apr 22	4,042	1,658	21.6	5,700	385	500	250	1,869	2,119	200	600	800	300	1,100	1,500	
Apr 23	3,439	2,262	26.1	5,700	381	500	250	1,823	2,073	250	600	800	200	1,000	1,500	
Apr 24	3,435	2,265	30.6	5,700	377	500	250	1,476	1,726	300	600	800	200	1,000	1,500	M
Apr 25	3,431	2,269	35.1	5,700	374	500	250	1,480	1,730	300	600	800	500	1,300	1,500	M
Apr 26	3,427	2,273	39.6	5,700	370	500	250	1,484	1,734	0	600	800	500	1,300	1,500	M
Apr 27	3,424	2,276	44.1	5,700	366	500	250	1,487	1,737	0	1,500	1,500	100	1,600	1,500	M
Apr 28	3,420	2,280	48.6	5,700	363	500	250	1,491	1,741	0	1,500	1,500	100	1,600	1,500	M
Apr 29	4,116	1,584	51.8	5,700	359	500	250	1,495	1,745	0	1,500	1,500	100	1,600	1,500	M
Apr 30	4,113	1,587	54.9	5,700	355	500	250	1,498	1,748	0	1,500	1,500	100	1,600	1,500	M
May 01	4,109	1,591	58.1	5,700	352	500	250	1,502	1,752	0	1,500	1,500	100	1,600	1,500	M
May 02	4,105	1,595	61.2	5,700	348	500	250	706	956	0	1,500	1,500	100	1,600	1,500	M
May 03	4,102	1,598	64.4	5,700	344	500	250	309	559	200	2,200	2,400	0	2,400	1,500	T
May 04	4,098	1,602	67.6	5,700	341	500	250	313	563	200	2,200	2,400	200	2,600	1,500	T
May 05	4,994	706	69.0	5,700	337	500	250	217	467	300	2,200	2,400	200	2,600	1,500	T
May 06	4,991	709	70.4	5,700	333	500	250	221	471	300	2,200	2,400	200	2,600	1,500	T
May 07	4,987	713	71.8	5,700	330	500	250	224	474	300	2,200	2,400	200	2,600	1,500	T
May 08	4,983	717	73.2	5,700	326	500	250	228	478	300	2,200	2,400	200	2,600	1,500	T
May 09	4,980	721	74.7	5,700	322	500	250	232	482	300	2,200	2,400	200	2,600	1,500	T
May 10	4,976	724	76.1	5,700	318	500	250	635	885	300	2,200	2,400	200	2,600	1,500	T
May 11	4,972	728	77.5	5,700	315	500	250	1,039	1,289	300	1,900	1,900	300	2,200	1,500	
May 12	4,968	732	79.0	5,700	311	500	250	1,143	1,393	400	1,800	1,400	400	1,800	1,500	
May 13	4,465	1,235	81.4	5,700	307	500	250	500	750		1,800	800	800	1,600	1,500	
May 14	3,961	1,739	84.9	5,700	304	500	250		250		1,550	300	500	800	1,500	
May 15	3,357	2,343	89.5	5,700	300	500	250		250		800	300		300	1,500	
May 16	2,854	1,000		3,854		500	250		250		300	300		300	1,500	
May 17	2,850	0		2,850		500	250		250		300	300		300	1,500	
May 18	2,550	0		2,550		500	250		250		300	300		300	1,500	
May 19	2,550	0		2,550		500	250		250		300	300		300	1,500	
May 20	2,550	0		2,550		500	250		250		300	300		300	1,500	
May 21	2,550	0		2,550		500	250		250		300	300		300	1,500	
May 22	2,550	0		2,550		500	250		250		300	300		300	1,500	
May 23	2,550	0		2,550		500	250		250		300	300		300	1,500	
May 24	2,550	0		2,550		500	250		250		300	300		300	1,500	
May 25	2,550	0		2,550		500	250		250		300	300		300	1,500	
May 26	2,550	0		2,550		500	250		250		300	300		300	1,500	
May 27	2,550	0		2,550		500	250		250		300	300		300	1,500	
May 28	2,550	0		2,550		500	250		250		300	300		300	1,500	
May 29	2,550	0		2,550		500	250		250		300	300		300	1,500	
May 30	2,550	0		2,550		500	250		250		300	300		300	1,500	
May 31	2,550	0		2,550		500	250		250		300	300		300	1,500	
	VAMP 31-day period *															
Mean (cfs)	4,320	1,456		5,776				813	1,068	147		1,761	496	2,257	1,441	
total (KAF)		89.5						50.0		9.0			30.5			

Pulse flow period

Tributary test flow periods

Green Type — *Actual flow*

DAILY OPERATION PLAN, APRIL 17

PULSE PERIOD: APRIL 15-MAY 15 · FLOW TARGET: 7,000CFS

SJR nr Vernalis Existing	VAMP Suppl. flow at Vernalis	VAMP Cum. Suppl. Flow	SJR nr Vernalis w/VAMP	SJR above Merced R. (2-day lag)	Vernalis Accretion	Merced R. at Cressey Existing	Merced R. at Cressey Suppl.	Merced R. at Cressey w/VAMP (3-day lag)	Exchange Contractors Suppl. (3-day lag)	Tuolumne R. at LaGrange FERC pulse Desired	Tuolumne R. at LaGrange FERC pulse Existing	Tuolumne R. at LaGrange Suppl.	Tuolumne R. at LaGrange w/VAMP (2-day lag)	Stan. R. blw Goodwin (2-day lag)	Maintain Priority Flow Level M=Merced T=Tuol.	
[calc]	[calc]	[calc]	[calc]				[calc]	[calc]					[calc]			
cfs	cfs	TAF	cfs	cfs	cfs		cfs	cfs	cfs		cfs	cfs	cfs	cfs		
				894	304	300		300		1,567	1,567		1,567	846		Apr 01
				843	534	300		300		1,126	1,126		1,126	846		Apr 02
				822	740	300		300		1,182	1,182		1,182	846		Apr 03
4,122			4,122	839	1,007	300		300		738	738		738	851		Apr 04
3,885			3,885	846	735	300		300		626	626		626	860		Apr 05
3,678			3,678	937	950	300		300		616	616		616	831		Apr 06
3,543			3,543	1,001	911	307		307		572	572		572	816		Apr 07
3,523			3,523	985	839	309		309		416	416		416	819		Apr 08
3,385			3,385	955	696	301		301		407	407		407	853		Apr 09
3,246			3,246	925	719	304		304		397	397		397	878		Apr 10
3,085	0		3,085	581	561	302	0	302		395	395		395	1,071		Apr 11
3,040	0		3,040	459	539	317	0	317	0	737	737		737	1,200	M	Apr 12
3,191	0		3,191	418	840	326	0	326	0	2,300	2,300	1,480	3,780	1,275	T+M	Apr 13
4,195	0	0	4,195	389	1,497	331	0	331	0	2,300	2,300	1,543	3,843	1,434	T+M	Apr 14
3,852	1,480	3	5,332	417	-458	339	0	339	0	2,300	2,300	1,503	3,803	1,109	T+M	Apr 15
3,969	1,543	6.0	5,512	454	-480	353	0	353	0	2,300	2,300	1,385	3,685	1,104	T+M	Apr 16
4,657	1,503	9.0	6,160	403	500	250	0	250	0	2,300	2,300	1,300	3,600	1,100	T+M	Apr 17
4,697	1,385	11.7	6,082	400	500	250	150	400	100	2,300	2,300	1,300	3,600	1,100	T+M	Apr 18
4,656	1,300	14.3	5,956	396	500	250	860	1,110	200	2,300	2,300	500	2,800	1,500	T	Apr 19
4,550	1,300	16.9	5,850	392	500	250	1,560	1,810	200	1,100	1,400	700	2,100	1,500	T	Apr 20
4,946	750	18.4	5,696	389	500	250	1,770	2,020	250	600	800	500	1,300	1,500		Apr 21
4,042	1,760	21.9	5,802	385	500	250	1,870	2,120	300	600	800	250	1,050	1,500		Apr 22
3,439	2,260	26.3	5,699	381	500	250	1,820	2,070	300	600	800	200	1,000	1,500		Apr 23
3,435	2,270	30.8	5,705	377	500	250	1,480	1,730	300	600	800	200	1,000	1,500	M	Apr 24
3,431	2,370	35.5	5,801	374	500	250	1,480	1,730	200	600	800	500	1,300	1,500	M	Apr 25
3,427	2,320	40.1	5,747	370	500	250	1,480	1,730	100	600	800	500	1,300	1,500	M	Apr 26
3,424	2,280	44.7	5,704	366	500	250	1,490	1,740	0	1,500	1,500	100	1,600	1,500	M	Apr 27
3,420	2,180	49.0	5,600	363	500	250	1,490	1,740	0	1,500	1,500	100	1,600	1,500	M	Apr 28
4,116	1,680	52.3	5,796	359	500	250	1,490	1,740	0	1,500	1,500	100	1,600	1,500	M	Apr 29
4,113	1,590	55.5	5,703	355	500	250	1,500	1,750	0	1,500	1,500	100	1,600	1,500	M	Apr 30
4,109	1,590	58.6	5,699	352	500	250	1,500	1,750	0	1,500	1,500	100	1,600	1,500	M	May 01
4,105	1,590	61.8	5,695	348	500	250	710	960	0	1,500	1,500	100	1,600	1,500	M	May 02
4,102	1,600	65.0	5,702	344	500	250	310	560	100	2,200	2,400	0	2,400	1,500	T	May 03
4,098	1,600	68.1	5,698	341	500	250	310	560	200	2,200	2,400	200	2,600	1,500	T	May 04
4,994	710	69.5	5,704	337	500	250	220	470	300	2,200	2,400	200	2,600	1,500	T	May 05
4,991	610	70.8	5,601	333	500	250	220	470	300	2,200	2,400	200	2,600	1,500	T	May 06
4,987	710	72.2	5,697	330	500	250	220	470	300	2,200	2,400	200	2,600	1,500	T	May 07
4,983	720	73.6	5,703	326	500	250	230	480	300	2,200	2,400	200	2,600	1,500	T	May 08
4,980	720	75.0	5,700	322	500	250	230	480	300	2,200	2,400	200	2,600	1,500	T	May 09
4,976	720	76.4	5,696	318	500	250	640	890	300	2,200	2,400	200	2,600	1,500	T	May 10
4,972	730	77.9	5,702	315	500	250	1,040	1,290	300	1,900	1,900	300	2,200	1,500		May 11
4,968	730	79.3	5,698	311	500	250	1,140	1,390	200	1,800	1,400	400	1,800	1,500		May 12
4,465	1,240	81.8	5,705	307	500	250	500	750		1,800	800	800	1,600	1,500		May 13
3,961	1,740	85.3	5,701	304	500	250		250		1,550	300	500	800	1,500		May 14
3,357	2,140	89.5	5,497	300	500	250		250		800	300		300	1,500		May 15
2,854	1,000		3,854		500	250		250		300	300		300	1,500		May 16
2,850	0		2,850		500	250		250		300	300		300	1,500		May 17
2,550	0		2,550		500	250		250		300	300		300	1,500		May 18
2,550	0		2,550		500	250		250		300	300		300	1,500		May 19
2,550	0		2,550		500	250		250		300	300		300	1,500		May 20
2,550	0		2,550		500	250		250		300	300		300	1,500		May 21
2,550	0		2,550		500	250		250		300	300		300	1,500		May 22
2,550	0		2,550		500	250		250		300	300		300	1,500		May 23
2,550	0		2,550		500	250		250		300	300		300	1,500		May 24
2,550	0		2,550		500	250		250		300	300		300	1,500		May 25
2,550	0		2,550		500	250		250		300	300		300	1,500		May 26
2,550	0		2,550		500	250		250		300	300		300	1,500		May 27
2,550	0		2,550		500	250		250		300	300		300	1,500		May 28
2,550	0		2,550		500	250		250		300	300		300	1,500		May 29
2,550	0		2,550		500	250		250		300	300		300	1,500		May 30
2,550	0		2,550		500	250		250		300	300		300	1,500		May 31

VAMP 31-day period *

	SJR nr Vernalis Existing	VAMP Suppl. flow at Vernalis	VAMP Cum. Suppl. Flow	SJR nr Vernalis w/VAMP	SJR above Merced R.	Vernalis Accretion	Merced R. at Cressey Existing	Merced R. at Cressey Suppl.	Merced R. at Cressey w/VAMP	Exchange Contractors Suppl.	Tuolumne R. FERC pulse Desired	Tuolumne R. FERC pulse Existing	Tuolumne R. Suppl.	Tuolumne R. w/VAMP	Stan. R. blw Goodwin	Maintain Priority
Mean (cfs)	4,265	1,456		5,721				813	1,077	147		1,761	496	2,257	1,439	
total (KAF)		89.5						50.0		9.0			30.5			

Pulse flow period

Tributary test flow periods

Green Type — *Actual flow*

VERNALIS ADAPTIVE MANAGEMENT PLAN (VAMP)

	Merced R. at Cressey (3-day log)									Tuolumne R. Near LaGrange (2-day log)									Stanislaus R. blw Goodwin Dam (2-day log)							
	SCHEDULED				OBSERVED					SCHEDULED				OBSERVED					SCHEDULED				OBSERVED			
	Existing	Suppl.	Total Flow	Cum. Suppl.	Existing	Ramping	Suppl.	Total Flow	Cum. Suppl.	Existing	Suppl.	Total Flow	Cum. Suppl.	Existing	Ramping	Suppl.	Total Flow	Cum. Suppl.	Existing	Suppl.	Total Flow	Cum. Suppl.	Existing	Suppl.	Total Flow	Cum. Suppl.
	(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(TAF)	(cfs)		(cfs)	(cfs)	(AF)	(cfs)	(cfs)	(cfs)	(AF)	(cfs)	(cfs)	(cfs)	(AF)
Apr 01	250	0	250		300	0	0	300		1,567	0	1,567		1,570	0	0	1,570		846	0	800		850	0	850	
Apr 02	250	0	250	0.0	300	0	0	300	0	1,126	0	1,126	0.0	1,130	0	0	1,130	0.0	846	0	800	0	850	0	850	0
Apr 03	250	0	250	0.0	300	0	0	300	0	1,182	0	1,182	0.0	1,180	0	0	1,180	0.0	846	0	800	0	850	0	850	0
Apr 04	250	0	250	0.0	300	0	0	300	0	738	0	738	0.0	740	0	0	740	0.0	851	0	800	0	850	0	850	0
Apr 05	250	0	250	0.0	300	0	0	300	0	626	0	626	0.0	630	0	0	630	0.0	860	0	800	0	860	0	860	0
Apr 06	250	0	250	0.0	300	0	0	300	0	616	0	616	0.0	620	0	0	620	0.0	831	0	800	0	830	0	830	0
Apr 07	250	0	250	0.0	310	0	0	310	0	572	0	572	0.0	570	0	0	570	0.0	816	0	800	0	820	0	820	0
Apr 08	250	0	250	0.0	310	0	0	310	0	416	0	416	0.0	420	0	0	420	0.0	819	0	800	0	820	0	820	0
Apr 09	250	0	250	0.0	310	0	0	310	0.0	407	0	407	0.0	410	0	0	410	0.0	853	0	800	0	860	0	860	0
Apr 10	250	0	250	0.0	300	0	0	300	0.0	397	0	397	0.0	400	0	0	400	0.0	878	0	800	0	890	0	890	0
Apr 11	250	0	250	0.0	300	0	0	300	0.0	395	0	395	0.0	400	0	0	400	0.0	1,071	0	1,000	0	1,070	0	1,070	0
Apr 12	250	0	250	0.0	290		0	290	0.0	737	0	737	0.0	740	440	0	740	0.0	1,200	0	1,200	0	1,200	0	1,200	0
Apr 13	250	0	250	0.0	300		0	300	0.0	2,300	1,480	3,780	2.9	2,300		1,480	3,780	2.9	1,275	0	1,500	0	1,280	0	1,280	0
Apr 14	250	0	250	0.0	310		0	310	0.0	2,300	1,500	3,800	5.9	2,300		1,540	3,840	6.0	1,500	0	1,500	0	1,430	0	1,430	0
Apr 15	250	0	250	0.0	310		0	310	0.0	2,300	1,500	3,800	8.9	2,300		1,500	3,800	9.0	1,100	0	1,100	0	1,110	0	1,110	0
Apr 16	250	0	250	0.0	330		0	330	0.0	2,300	1,400	3,700	11.7	2,300		1,390	3,690	11.7	1,100	0	1,100	0	1,100	0	1,100	0
Apr 17	250	0	250	0.0	380		0	380	0.0	2,300	1,300	3,600	14.2	2,300		1,310	3,610	14.3	1,100	0	1,100	0	1,120	0	1,120	0
Apr 18	250	150	400	0.3	250		290	540	0.6	2,300	1,300	3,600	16.8	2,300		990	3,290	16.3	1,100	0	1,100	0	1,080	0	1,080	0
Apr 19	250	1,550	1,800	3.4	250		1,470	1,720	3.5	2,300	200	2,500	17.2	2,300		70	2,370	16.4	950	0	950	0	870	0	870	0
Apr 20	250	1,550	1,800	6.4	250		1,650	1,900	6.8	1,400	100	1,500	17.4	1,400		0	1,370	16.4	1,250	0	1,250	0	1,170	0	1,170	0
Apr 21	250	1,550	1,800	9.5	250		1,590	1,840	9.9	800	300	1,100	18.0	800		260	1,060	16.9	1,500	0	1,500	0	1,500	0	1,500	0
Apr 22	250	1,550	1,800	12.6	250		1,570	1,820	13.0	800	300	1,100	18.6	800		320	1,120	17.6	1,500	0	1,500	0	1,490	0	1,490	0
Apr 23	250	1,480	1,730	15.5	250		1,550	1,800	16.1	800	300	1,100	19.2	800		330	1,130	18.2	1,500	0	1,500	0	1,490	0	1,490	0
Apr 24	250	1,480	1,730	18.5	250		1,560	1,810	19.2	800	300	1,100	19.8	800		330	1,130	18.9	1,500	0	1,500	0	1,480	0	1,480	0
Apr 25	250	1,480	1,730	21.4	250		1,470	1,720	22.1	800	300	1,100	20.4	800		290	1,090	19.5	1,500	0	1,500	0	1,510	0	1,510	0
Apr 26	250	1,490	1,740	24.4	250					800	300	1,100	21.0	800					1,500	0	1,500	0		0		0
Apr 27	250	1,490	1,740	27.3	250					1,500	0	1,500	21.0	1,500					1,500	0	1,500	0		0		0
Apr 28	250	1,490	1,740	30.3	250					1,500	0	1,500	21.0	1,500					1,500	0	1,500	0		0		0
Apr 29	250	1,500	1,750	33.2	250					1,500	0	1,500	21.0	1,500					1,500	0	1,500	0		0		0
Apr 30	250	1,500	1,750	36.2	250					1,500	0	1,500	21.0	1,500					1,500	0	1,500	0		0		0
May 01	250	710	960	37.6	250					1,500	0	1,500	21.0	1,500					1,500	0	1,500	0		0		0
May 02	250	200	450	38.0	250					1,500	500	2,000	22.0	1,500					1,500	0	1,500	0		0		0
May 03	250	0	250	38.0	250					2,400	0	2,400	22.0	2,400					1,500	0	1,500	0		0		0
May 04	250	0	250	38.0	250					2,400	50	2,450	22.1	2,400					1,500	0	1,500	0		0		0
May 05	250	0	250	38.0	250					2,400	50	2,450	22.2	2,400					1,500	0	1,500	0		0		0
May 06	250	0	250	38.0	250					2,400	50	2,450	22.3	2,400					1,500	0	1,500	0		0		0
May 07	250	0	250	38.0	250					2,400	50	2,450	22.4	2,400					1,500	0	1,500	0		0		0
May 08	250	0	250	38.0	250					2,400	50	2,450	22.5	2,400					1,500	0	1,500	0		0		0
May 09	250	50	300	38.1	250					2,400	50	2,450	22.6	2,400					1,500	0	1,500	0		0		0
May 10	250	250	500	38.6	250					2,400	0	2,400	22.6	2,400					1,500	0	1,500	0		0		0
May 11	250	450	700	39.5	250					1,900	300	2,200	23.2	1,900					1,500	0	1,500	0		0		0
May 12	250	800	1,050	41.1	250					1,400	700	2,100	24.6	1,400					1,500	0	1,500	0		0		0
May 13	250	400	650	41.9	250					800	900	1,700	26.3	800					1,500	0	1,500	0		0		0
May 14	250	0	250	41.9	250					300	500	800	27.3	300					1,500	0	1,500	0		0		0
May 15	250	0	250	41.9	250					300	0	300	27.3	300					1,500	0	1,500	0		0		0
May 16	250	0	250	41.9	250					300	0	300	27.3	300					1,500	0	1,500	0		0		0
May 17	250	0	250	41.9	250					300	0	300	27.3	300					1,500	0	1,500	0		0		0
May 18	250	0	250	41.9	250					300	0	300	27.3	300					1,500	0	1,500	0		0		0
May 19	250	0	250	41.9	250					300	0	300	27.3	300					1,500	0	1,500	0		0		0
May 20	250	0	250	41.9	250					300	0	300	27.3	300					1,500	0	1,500	0		0		0
May 21	250	0	250	41.9	250					300	0	300	27.3	300					1,500	0	1,500	0		0		0
May 22	250	0	250	41.9	250					300	0	300	27.3	300					1,500	0	1,500	0		0		0
May 23	250	0	250	41.9	250					300	0	300	27.3	300					1,500	0	1,500	0		0		0
May 24	250	0	250	41.9	250					300	0	300	27.3	300					1,500	0	1,500	0		0		0
May 25	250	0	250	41.9	250					300	0	300	27.3	300					1,500	0	1,500	0		0		0
May 26	250	0	250	41.9	250					300	0	300	27.3	300					1,500	0	1,500	0		0		0
May 27	250	0	250	41.9	250					300	0	300	27.3	300					1,500	0	1,500	0		0		0
May 28	250	0	250	41.9	250					300	0	300	27.3	300					1,500	0	1,500	0		0		0
May 29	250	0	250	41.9	250					300	0	300	27.3	300					1,500	0	1,500	0		0		0
May 30	250	0	250	41.9	250					300	0	300	27.3	300					1,500	0	1,500	0		0		0
May 31	250	0	250	41.9	250					300	0	300	27.3	300					1,500	0	1,500	0		0		0

TRACKING OF SPRING PULSE FLOW 2000

	Exchange Contractors (3-day log)				Upper SJR		SJR Accretions		San Joaquin R. at Vernalis									
	SUPPLEMENTAL								SCHEDULED					OBSERVED				
Date	Scheduled	Cum. Scheduled	Observed	Cum. Observed	Forecast	Observed	Forecast	Observed	Existing	Suppl.	Total	Target	Cum. Suppl.	Existing	Ramping	Suppl.	Total	Cum. Suppl.
	(cfs)	(TAF)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(TAF)	(cfs)	(cfs)	(cfs)	(cfs)	(AF)
Apr 01	0		0		894	900	304	300						5,090			5,090	
Apr 02	0	0.0	0	0.0	843	840	534	530						4,690			4,690	
Apr 03	0	0.0	0	0.0	822	820	740	730						4,350			4,350	
Apr 04	0	0.0	0	0.0	839	840	1,007	1,000	4,072	0	4,072			4,120	0	0	4,120	
Apr 05	0	0.0	0	0.0	846	850	735	730	3,835	0	3,835		0.0	3,880	0	0	3,880	0
Apr 06	0	0.0	0	0.0	937	940	950	950	3,628	0	3,628		0.0	3,680	0	0	3,680	0.0
Apr 07	0	0.0	0	0.0	1,001	1,000	911	900	3,493	0	3,493		0.0	3,540	0	0	3,540	0.0
Apr 08	0	0.0	0	0.0	985	980	839	830	3,473	0	3,473		0.0	3,520	0	0	3,520	0.0
Apr 09	0	0.0	0	0.0	955	950	696	700	3,335	0	3,335		0.0	3,390	0	0	3,390	0.0
Apr 10	0	0.0	0	0.0	925	930	719	720	3,189	0	3,189		0.0	3,250	0	0	3,250	0.0
Apr 11	0	0.0	0	0.0	581	580	561	600	3,026	0	3,026		0.0	3,130	0	0	3,130	0.0
Apr 12	0	0.0	0	0.0	459	460	539	580	2,989	0	2,989		0.0	3,110	0	0	3,110	0.0
Apr 13	0	0.0	0	0.0	418	420	840	850	3,137	0	3,137		0.0	3,200	0	0	3,200	0.0
Apr 14	0	0.0	0	0.0	414	390	1,300	1,590	3,946	0	3,946		0.0	3,850	440	0	4,290	0.0
Apr 15	0	0.0	0	0.0	411	420	500	-210	4,743	1,480	6,223	5,700	2.9	4,080		1,480	5,560	2.9
Apr 16	0	0.0	0	0.0	407	460	500	-70	4,964	1,500	6,464	5,700	5.9	4,350		1,540	5,890	6.0
Apr 17	0	0.0	0	0.0	403	490	500	680	4,561	1,500	6,061	5,700	8.9	4,820		1,500	6,320	9.0
Apr 18	100	0.2	100	0.2	400	550	500	1,490	4,557	1,400	5,957	5,700	11.7	5,660		1,390	7,050	11.7
Apr 19	200	0.6	200	0.6	500	570	1,400	1,380	5,453	1,300	6,753	5,700	14.2	5,620		1,310	6,930	14.3
Apr 20	200	1.0	200	1.0	392	660	1,300	830	5,350	1,300	6,650	5,700	16.8	5,240		990	6,230	16.3
Apr 21	200	1.4	200	1.4	646	780	1,500	1,700	5,500	450	5,950	5,700	17.7	5,790		460	6,250	17.2
Apr 22	200	1.8	200	1.8	636	750	1,100	1,160	4,392	1,850	6,242	5,700	21.4	4,610		1,670	6,280	20.5
Apr 23	200	2.2	200	2.2	625	640	1,000	830	4,196	2,050	6,246	5,700	25.4	4,160		2,110	6,270	24.7
Apr 24	200	2.6	200	2.6	615	600	900	860	4,086	2,050	6,136	5,700	29.5	4,150		2,110	6,260	28.9
Apr 25	200	3.0	200	3.0	605	570	800	790	3,975	2,050	6,025	5,700	33.6	3,970		2,100	6,070	33.0
Apr 26	100	3.2			595		800		3,965	1,980	5,945	5,700	37.5					
Apr 27	0	3.2			584		800		3,955	1,980	5,935	5,700	41.4					
Apr 28	0	3.2			574		800		3,945	1,980	5,925	5,700	45.4					
Apr 29	0	3.2			564		800		4,634	1,590	6,224	5,700	48.5					
Apr 30	0	3.2			554		800		4,624	1,490	6,114	5,700	51.5					
May 01	0	3.2			543		800		4,614	1,490	6,104	5,700	54.4					
May 02	100	3.4			533		800		4,604	1,500	6,104	5,700	57.4					
May 03	200	3.8			523		800		4,593	1,500	6,093	5,700	60.4					
May 04	200	4.2			513		800		4,583	1,210	5,793	5,700	62.8					
May 05	200	4.6			502		800		5,473	300	5,773	5,700	63.4					
May 06	200	5.0			492		800		5,463	250	5,713	5,700	63.9					
May 07	200	5.4			482		800		5,452	250	5,702	5,700	64.4					
May 08	200	5.8			472		800		5,442	250	5,692	5,700	64.9					
May 09	200	6.1			461		800		5,432	250	5,682	5,700	65.4					
May 10	300	6.7			451		800		5,422	250	5,672	5,700	65.9					
May 11	200	7.1			441		800		5,411	250	5,661	5,700	66.3					
May 12	100	7.3			431		800		5,401	250	5,651	5,700	66.8					
May 13	0	7.3			420		800		4,891	850	5,741	5,700	68.5					
May 14	0	7.3			410		800		4,381	1,350	5,731	5,700	71.2					
May 15	0	7.3			400		800		3,770	1,800	5,570	5,700	74.8					
May 16	0	7.3			0		500		2,960	0	2,960		74.8		0			
May 17	0	7.3			0		500		2,950	0	2,950		74.8		0			
May 18	0	7.3			0		500		2,550	0	2,550		74.8		0			
May 19	0	7.3			0		500		2,550	0	2,550		74.8		0			
May 20	0	7.3			0		500		2,550	0	2,550		74.8		0			
May 21	0	7.3			0		500		2,550	0	2,550		74.8		0			
May 22	0	7.3			0		500		2,550	0	2,550		74.8		0			
May 23	0	7.3			0		500		2,550	0	2,550		74.8		0			
May 24	0	7.3			0		500		2,550	0	2,550		74.8		0			
May 25	0	7.3			0		500		2,550	0	2,550		74.8		0			
May 26	0	7.3			0		500		2,550	0	2,550		74.8		0			
May 27	0	7.3			0		500		2,550	0	2,550		74.8		0			
May 28	0	7.3			0		500		2,550	0	2,550		74.8		0			
May 29	0	7.3			0		500		2,550	0	2,550		74.8		0			
May 30	0	7.3			0		500		2,550	0	2,550		74.8		0			
May 31	0	7.3			0		500		2,550	0	2,550				0			

*Pulse period average: 6406.6667

COMPARISON OF "REAL-TIME" AND PROVISIONAL FLOWS

Merced River Near Cressey

Merced River Near Stevinson

"Real-Time" (CDEC)
Provisional (DWR)

COMPARISON OF “REAL-TIME” AND PROVISIONAL FLOWS

San Joaquin River Near Newman

San Joaquin River Above Merced River

“Real-Time” (CDEC)
Provisional (DWR)

COMPARISON OF "REAL-TIME" AND PROVISIONAL FLOWS

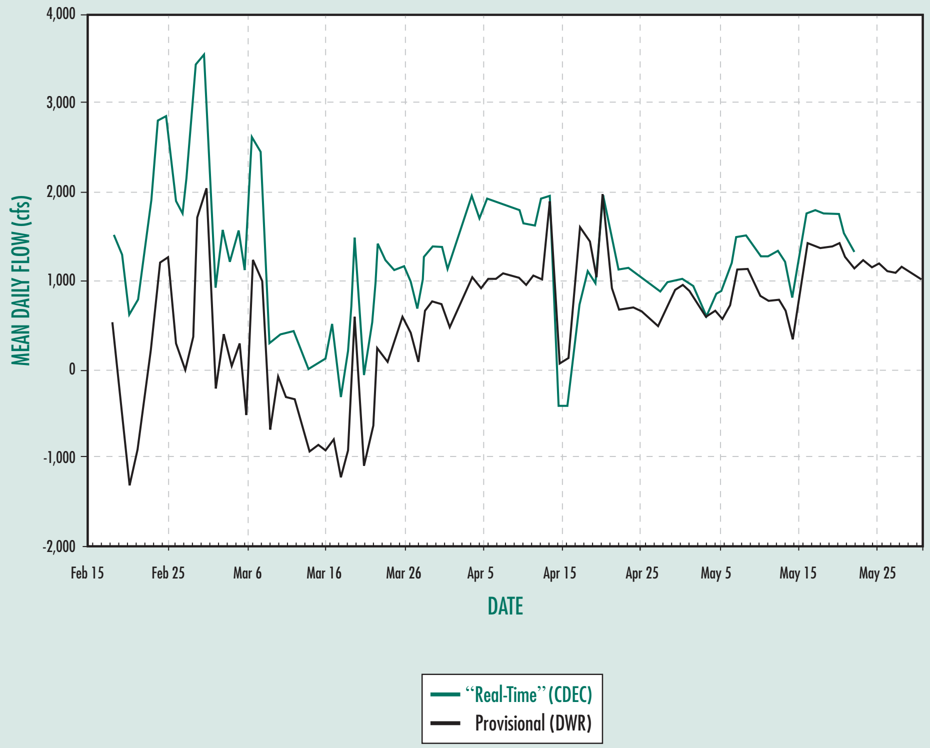
Tuolumne River Near LaGrange

Stanislaus River At Blossom Ridge

COMPARISON OF "REAL-TIME" AND PROVISIONAL FLOWS

San Joaquin River Near Vernalis

Ungaged Flow At San Joaquin River Near Vernalis



ACCOUNTING OF SUPPLEMENTAL WATER CONTRIBUTIONS

HYDROLOGY SUBGROUP OF THE SAN JOAQUIN RIVER TECHNICAL COMMITTEE · PULSE FLOW PERIOD: APRIL 15-MAY 15

	Merced R. at Cressey (3 day Travel Time to Vernalis)				Tuolumne R. blw LaGrange Dam (2 day Travel Time to Vernalis)				Stanislaus R. at Orange Blossom Br. (2 day Travel Time to Vernalis)				Exch. Contractors (3 day Travel Time)		San Joaquin R. at Vernalis			
Date	Existing Flow (cfs)	Observed Flow (cfs)	Supplemental Water (cfs)	Supplemental Water (TAF)	Existing Flow (cfs)	Observed Flow (cfs)	Supplemental Water (cfs)	Supplemental Water (TAF)	Existing Flow (cfs)	Observed Flow (cfs)	Supplementa Water (cfs)	Supplementa Water (TAF)	Supplemental Water (cfs)	Supplemental Water (TAF)	Existing Flow (cfs)	Observed Flow (cfs)	Supplemental Water (cfs)	Supplemental Water (TAF)
Apr 01	342	342			1,580	1,580			1,500	800					5,050	5,050		
Apr 02	340	340			1,200	1,200			1,500	796					4,580	4,580		
Apr 03	342	342			1,110	1,110			1,500	791					4,200	4,200		
Apr 04	328	328			768	768			1,500	788					3,940	3,940		
Apr 05	322	322			626	626			1,500	796					3,700	3,700		
Apr 06	306	306			616	616			1,500	807					3,490	3,490		
Apr 07	297	297			575	575			1,500	820					3,340	3,340		
Apr 08	297	297			404	403			1,500	830					3,340	3,340		
Apr 09	288	288			390	387			1,500	835					3,260	3,260		
Apr 10	288	288			393	390			1,500	885					3,050	3,050		
Apr 11	284	284			391	388			1,500	1,080					2,960	2,960		
Apr 12	297	297	0	0.00	688	683			1,500	1,210			0	0.00	3,050	3,050		
Apr 13	303	303	0	0.00	2,300	3,780	1,480	2.94	1,500	1,290	0	0	0	0.00	3,180	3,180		
Apr 14	306	306	0	0.00	2,300	3,830	1,530	3.03	1,500	1,440	0	0	0	0.00	4,460	4,460		
Apr 15	310	310	0	0.00	2,300	3,800	1,500	2.98	1,500	1,120	0	0	0	0.00	4,480	5,750	1,480	2.94
Apr 16	323	323	0	0.00	2,300	3,670	1,370	2.72	1,500	1,120	0	0	0	0.00	4,500	5,970	1,530	3.03
Apr 17	377	377	0	0.00	2,300	3,580	1,280	2.54	1,500	1,130	0	0	0	0.00	5,230	6,350	1,500	2.98
Apr 18	250	556	306	0.61	2,300	3,290	990	1.96	1,500	1,090	0	0	100	0.20	6,070	7,060	1,370	2.72
Apr 19	250	1,780	1,530	3.03	2,300	2,360	60	0.12	1,500	800	0	0	199	0.39	6,010	6,920	1,280	2.54
Apr 20	250	1,910	1,660	3.29	1,100	1,380	280	0.56	1,500	1,190	0	0	200	0.40	5,710	6,290	990	1.96
Apr 21	250	1,870	1,620	3.21	800	1,040	240	0.48	1,500	1,500	0	0	200	0.40	6,524	6,290	466	0.92
Apr 22	250	1,830	1,580	3.13	800	1,110	310	0.61	1,490	1,490	0	0	236	0.47	4,620	6,320	2,009	3.98
Apr 23	250	1,780	1,530	3.03	800	1,120	320	0.63	1,490	1,490	0	0	251	0.50	4,210	6,310	2,100	4.17
Apr 24	250	1,750	1,500	2.98	800	1,110	310	0.61	1,490	1,490	0	0	245	0.49	4,170	6,300	2,130	4.22
Apr 25	250	1,660	1,410	2.80	800	1,120	320	0.63	1,520	1,520	0	0	236	0.47	4,020	6,120	2,136	4.24
Apr 26	250	1,600	1,350	2.68	800	1,120	320	0.63	1,510	1,510	0	0	138	0.27	3,910	5,950	2,091	4.15
Apr 27	250	1,570	1,320	2.62	1,300	1,250	0	0.00	1,510	1,510	0	0	0	0.00	3,810	5,830	2,065	4.10
Apr 28	250	1,590	1,340	2.66	1,300	1,370	70	0.14	1,510	1,510	0	0	0	0.00	3,700	5,630	1,966	3.90
Apr 29	250	1,640	1,390	2.76	1,300	1,350	50	0.10	1,510	1,510	0	0	0	0.00	4,360	5,760	1,488	2.95
Apr 30	250	1,660	1,410	2.80	1,300	1,320	20	0.04	1,520	1,520	0	0	0	0.00	4,400	5,790	1,390	2.76
May 01	250	1,570	1,320	2.62	1,300	1,320	20	0.04	1,510	1,510	0	0	0	0.00	4,380	5,770	1,390	2.76
May 02	250	857	607	1.20	1,300	1,410	110	0.22	1,510	1,510	0	0	129	0.26	4,260	5,670	1,410	2.80
May 03	250	744	494	0.98	2,200	2,210	10	0.02	1,520	1,520	0	0	178	0.35	4,090	5,520	1,430	2.84
May 04	250	611	361	0.72	2,200	2,330	130	0.26	1,520	1,520	0	0	249	0.49	4,030	5,460	1,430	2.84
May 05	250	582	332	0.66	2,200	2,330	130	0.26	1,520	1,520	0	0	234	0.46	4,943	5,660	746	1.48
May 06	250	586	336	0.67	2,200	2,330	130	0.26	1,530	1,530	0	0	231	0.46	4,796	5,620	802	1.59
May 07	250	646	396	0.79	2,200	2,290	90	0.18	1,540	1,540	0	0	266	0.53	5,029	5,720	740	1.47
May 08	250	678	428	0.85	2,200	2,220	20	0.04	1,540	1,540	0	0	273	0.54	5,388	6,050	696	1.38
May 09	250	629	379	0.75	2,200	2,230	30	0.06	1,540	1,540	0	0	247	0.49	5,384	6,010	657	1.30
May 10	250	648	398	0.79	2,200	2,220	20	0.04	1,550	1,550	0	0	241	0.48	5,264	5,880	682	1.35
May 11	250	821	571	1.13	1,900	2,040	140	0.28	1,540	1,540	0	0	202	0.40	5,212	5,870	731	1.45
May 12	1,362	971	0	0.00	1,800	1,940	140	0.28	1,550	1,550			119	0.24	5,201	5,800	646	1.28
May 13	1,716	522			1,800	1,770	0	0.00	1,540	1,540					4,832	5,670	779	1.55
May 14	1,930	406			1,550	1,330			1,550	1,550					4,709	5,620	913	1.81
May 15	1,833	399			800	785			1,560	1,560					5,551	5,230	119	0.24
May 16	1,398	409			300	527			1,570	1,570					4,870	4,870		
May 17	1,416	377			300	312			1,540	1,540					4,590	4,590		
May 18	1,600	382			300	307			1,540	1,540					4,280	4,280		
May 19	1,690	371			300	419			1,520	1,520					4,050	4,050		
May 20	1,702	338			300	570			1,500	1,500					4,020	4,020		
May 21	1,692	345			300	570			1,510	1,510					4,210	4,210		
May 22	635	354			300	566			1,490	1,490					4,190	4,190		
May 23	391	356			300	568			1,480	1,480					4,050	4,050		
May 24	250	346			300	570			1,480	1,480					4,110	4,110		
May 25	346	346			300	572			1,470	1,470					4,040	4,040		
May 26	326	326			300	543			1,460	1,460					4,020	4,020		
May 27	263	263			300	319			1,460	1,460					3,870	3,870		
May 28	250	248			300	323			1,450	1,450					3,770	3,770		
May 29	250	238			300	323			1,450	1,450					3,610	3,610		
May 30	250	231			300	322			1,430	1,430					3,480	3,480		
May 31	250	229			300	319			1,420	1,420					3,400	3,400		
Total Supplemental Water (TAF):				46.75				22.65				0.0		8.28				77.68
													Pulse period average:		4,815	5,869		

Observed Flow Sources: Merced River at Cressey (CA DWR B05155): DWR San Joaquin District, provisional data received 6/13/00
Tuolumne River below LaGrange Dam near LaGrange (USGS 11289650): USGS, provisional data dated 6/9/00
San Joaquin River near Vernalis (USGS 11303500): USGS, provisional data dated 6/9/00
Stanislaus River at Orange Blossom Bridge (CA DWR B03175): DWR San Joaquin District, provisional data received 6/13/00

APPENDIX B

FALL WATER TRANSFER AND DELIVERY INFORMATION

INITIAL DAILY SCHEDULE, OCTOBER 19

(October 1–November 16) · SJRA and Fall 2000 Transfer Water Schedule

	SJRA Transfer Water			Fall 2000 Transfer Water					
	Shaffer Br/Cressey Base Flow for SJRA Transfer Water	SJRA Transfer Water Schedule	SJRA Transfer Water	Shaffer Br/Cressey Base Flow for Fall 2000 Transfer Water [1] + [2]	Fall 2000 Transfer Water Schedule – RIVER	Shaffer Br/Cressey Target Flow [4] + [5]	Fall 2000 Transfer Water Schedule – BYPASS	Fall 2000 Transfer Water [5] + [7]	Fall 2000 Transfer Balance
	(cfs)	(cfs)	(acre-ft)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(acre-ft)
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]
Oct 01	0	0	30	0	30	0	0	0	0
Oct 02	30	0	0	30	0	30	0	0	0
Oct 03	30	0	0	30	0	30	0	0	0
Oct 04	30	0	0	30	0	30	0	0	0
Oct 05	30	0	0	30	0	30	0	0	0
Oct 06	30	0	0	30	0	30	0	0	0
Oct 07	30	0	0	30	0	30	0	0	0
Oct 08	30	0	0	30	0	30	0	0	0
Oct 09	30	0	0	30	0	30	0	0	0
Oct 10	30	0	0	30	0	30	0	0	0
Oct 11	30	0	0	30	0	30	0	0	0
Oct 12	30	0	0	30	0	30	0	0	0
Oct 13	30	0	0	30	0	30	0	0	0
Oct 14	30	0	0	30	0	30	0	0	0
Oct 15	30	397	787	427	0	427	0	0	0
Oct 16	85	760	2,295	845	0	845	0	0	0
Oct 17	85	760	3,802	845	0	845	0	0	0
Oct 18	85	760	5,310	845	0	845	0	0	0
Oct 19	85	500	6,301	585	0	585	0	0	0
Oct 20	85	380	7,055	465	0	465	0	0	0
Oct 21	85	265	7,581	350	235	585	0	235	466
Oct 22	85	0	7,581	85	915	1,000	0	915	2,281
Oct 23	85	0	7,581	85	915	1,000	0	915	4,096
Oct 24	85	0	7,581	85	915	1,000	0	915	5,911
Oct 25	85	0	7,581	85	915	1,000	0	915	7,726
Oct 26	85	0	7,581	85	915	1,000	0	915	9,540
Oct 27	85	0	7,581	85	800	885	0	800	11,127
Oct 28	85	0	7,581	85	605	690	0	605	12,327
Oct 29	85	0	7,581	85	400	485	0	400	13,121
Oct 30	85	0	7,581	85	300	385	0	300	13,716
Oct 31	85	0	7,581	85	300	385	0	300	14,311
Nov 01	220	0	7,581	220	155	375	50	205	14,717
Nov 02	220	0	7,581	220	155	375	50	205	15,124
Nov 03	220	0	7,581	220	155	375	50	205	15,531
Nov 04	220	0	7,581	220	155	375	50	205	15,937
Nov 05	220	0	7,581	220	155	375	50	205	16,344
Nov 06	220	0	7,581	220	155	375	50	205	16,750
Nov 07	220	0	7,581	220	155	375	50	205	17,157
Nov 08	220	0	7,581	220	155	375	50	205	17,564
Nov 09	220	0	7,581	220	150	370	50	200	17,960
Nov 10	220	0	7,581	220	150	370	50	200	18,357
Nov 11	220	0	7,581	220	150	370	50	200	18,754
Nov 12	220	0	7,581	220	150	370	50	200	19,150
Nov 13	220	0	7,581	220	150	370	50	200	19,547
Nov 14	220	0	7,581	220	150	370	50	200	19,944
Nov 15	220	0	7,581	220	150	370	50	200	20,340
Nov 16	220	0	7,581	220	100	320	100	200	20,737

INITIAL DAILY SCHEDULE, OCTOBER 19

(November 17–December 31) · SJRA and Fall 2000 Transfer Water Schedule

	SJRA Transfer Water			Fall 2000 Transfer Water					
	Shaffer Br/Cressey Base Flow for SJRA Transfer Water	SJRA Transfer Water Schedule	SJRA Transfer Water	Shaffer Br/Cressey Base Flow for Fall 2000 Transfer Water [1] + [2]	Fall 2000 Transfer Water Schedule – RIVER	Shaffer Br/Cressey Target Flow [4] + [5]	Fall 2000 Transfer Water Schedule – BYPASS	Fall 2000 Transfer Water [5] + [7]	Fall 2000 Transfer Balance
	(cfs)	(cfs)	(acre-ft)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(acre-ft)
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]
Nov 17	220	0	7,581	220	100	320	100	200	21,134
Nov 18	220	0	7,581	220	100	320	100	200	21,531
Nov 19	220	0	7,581	220	100	320	100	200	21,927
Nov 20	220	0	7,581	220	100	320	100	200	22,324
Nov 21	220	0	7,581	220	100	320	100	200	22,721
Nov 22	220	0	7,581	220	100	320	100	200	23,117
Nov 23	220	0	7,581	220	100	320	100	200	23,514
Nov 24	220	0	7,581	220	100	320	50	150	23,812
Nov 25	220	0	7,581	220	100	320	0	100	24,010
Nov 26	220	0	7,581	220	100	320	0	100	24,208
Nov 27	220	0	7,581	220	100	320	0	100	24,407
Nov 28	220	0	7,581	220	100	320	0	100	24,605
Nov 29	220	0	7,581	220	100	320	0	100	24,803
Nov 30	220	0	7,581	220	100	320	0	100	25,002
Dec 01	220	80	7,739	300	0	300	0	0	25,002
Dec 02	220	80	7,898	300	0	300	0	0	25,002
Dec 03	220	80	8,057	300	0	300	0	0	25,002
Dec 04	220	80	8,216	300	0	300	0	0	25,002
Dec 05	220	80	8,374	300	0	300	0	0	25,002
Dec 06	220	80	8,533	300	0	300	0	0	25,002
Dec 07	220	80	8,692	300	0	300	0	0	25,002
Dec 08	220	80	8,850	300	0	300	0	0	25,002
Dec 09	220	80	9,009	300	0	300	0	0	25,002
Dec 10	220	80	9,168	300	0	300	0	0	25,002
Dec 11	220	80	9,326	300	0	300	0	0	25,002
Dec 12	220	80	9,485	300	0	300	0	0	25,002
Dec 13	220	80	9,644	300	0	300	0	0	25,002
Dec 14	220	80	9,802	300	0	300	0	0	25,002
Dec 15	220	80	9,961	300	0	300	0	0	25,002
Dec 16	220	80	10,120	300	0	300	0	0	25,002
Dec 17	220	80	10,278	300	0	300	0	0	25,002
Dec 18	220	80	10,437	300	0	300	0	0	25,002
Dec 19	220	80	10,596	300	0	300	0	0	25,002
Dec 20	220	80	10,754	300	0	300	0	0	25,002
Dec 21	220	80	10,913	300	0	300	0	0	25,002
Dec 22	220	80	11,072	300	0	300	0	0	25,002
Dec 23	220	80	11,230	300	0	300	0	0	25,002
Dec 24	220	80	11,389	300	0	300	0	0	25,002
Dec 25	220	80	11,548	300	0	300	0	0	25,002
Dec 26	220	80	11,706	300	0	300	0	0	25,002
Dec 27	220	80	11,865	300	0	300	0	0	25,002
Dec 28	220	80	12,024	300	0	300	0	0	25,002
Dec 29	220	80	12,182	300	0	300	0	0	25,002
Dec 30	220	80	12,341	300	0	300	0	0	25,002
Dec 31	220	80	12,500	300	0	300	0	0	25,002

	Oct	Nov	Dec	Total
SJRA Transfer Water (TAF):	7.58	0.00	4.92	12.50
Fall 2000 Transfer Water (TAF):	14.31	10.69	0	25.00

REVISED SCHEDULE #1, OCTOBER 31

(October 1–November 16) · SJRA and Fall 2000 Transfer Water Schedule

	SJRA Transfer Water			Fall 2000 Transfer Water					
	Shaffer Br/Cressey Base Flow for SJRA Transfer Water	SJRA Transfer Water Schedule	SJRA Transfer Water	Shaffer Br/Cressey Base Flow for Fall 2000 Transfer Water [1] + [2]	Fall 2000 Transfer Water Schedule – RIVER	Shaffer Br/Cressey Target Flow [4] + [5]	Fall 2000 Transfer Water Schedule – BYPASS	Fall 2000 Transfer Water [5] + [7]	Fall 2000 Transfer Balance
	(cfs)	(cfs)	(acre-ft)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(acre-ft)
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]
Oct 01	30	0	0	30	0	30	0	0	0
Oct 02	30	0	0	30	0	30	0	0	0
Oct 03	30	0	0	30	0	30	0	0	0
Oct 04	30	0	0	30	0	30	0	0	0
Oct 05	30	0	0	30	0	30	0	0	0
Oct 06	30	0	0	30	0	30	0	0	0
Oct 07	30	0	0	30	0	30	0	0	0
Oct 08	30	0	0	30	0	30	0	0	0
Oct 09	30	0	0	30	0	30	0	0	0
Oct 10	30	0	0	30	0	30	0	0	0
Oct 11	30	0	0	30	0	30	0	0	0
Oct 12	30	0	0	30	0	30	0	0	0
Oct 13	30	0	0	30	0	30	0	0	0
Oct 14	30	0	0	30	0	30	0	0	0
Oct 15	30	397	787	427	0	427	0	0	0
Oct 16	85	760	2,295	845	0	845	0	0	0
Oct 17	85	760	3,802	845	0	845	0	0	0
Oct 18	85	760	5,310	845	0	845	0	0	0
Oct 19	85	500	6,301	585	0	585	0	0	0
Oct 20	85	380	7,055	465	0	465	0	0	0
Oct 21	85	265	7,581	350	235	585	0	235	466
Oct 22	85	0	7,581	85	915	1,000	0	915	2,281
Oct 23	85	0	7,581	85	915	1,000	0	915	4,096
Oct 24	85	0	7,581	85	915	1,000	0	915	5,911
Oct 25	85	0	7,581	85	915	1,000	0	915	7,726
Oct 26	85	0	7,581	85	915	1,000	0	915	9,540
Oct 27	85	0	7,581	85	800	885	0	800	11,127
Oct 28	85	0	7,581	85	605	690	0	605	12,327
Oct 29	85	0	7,581	85	400	485	0	400	13,121
Oct 30	85	300	8,176	385	0	385	0	0	13,121
Oct 31	85	300	8,771	385	0	385	0	0	13,121
Nov 01	220	155	9,078	375	0	375	0	0	13,121
Nov 02	220	125	9,326	345	0	345	0	0	13,121
Nov 03	220	100	9,525	320	0	320	0	0	13,121
Nov 04	220	75	9,673	295	0	295	0	0	13,121
Nov 05	220	75	9,822	295	0	295	0	0	13,121
Nov 06	220	75	9,971	295	0	295	0	0	13,121
Nov 07	220	75	10,120	295	0	295	0	0	13,121
Nov 08	220	75	10,268	295	0	295	0	0	13,121
Nov 09	220	75	10,417	295	0	295	0	0	13,121
Nov 10	220	75	10,566	295	0	295	0	0	13,121
Nov 11	220	75	10,715	295	0	295	0	0	13,121
Nov 12	220	75	10,863	295	0	295	0	0	13,121
Nov 13	220	75	11,012	295	0	295	0	0	13,121
Nov 14	220	75	11,161	295	0	295	0	0	13,121
Nov 15	220	75	11,310	295	0	295	0	0	13,121
Nov 16	220	40	11,389	260	0	260	0	0	13,121

REVISED SCHEDULE #1, OCTOBER 31

(November 17–December 31) · SJRA and Fall 2000 Transfer Water Schedule

	SJRA Transfer Water			Fall 2000 Transfer Water					
	Shaffer Br/Cressey Base Flow for SJRA Transfer Water	SJRA Transfer Water Schedule	SJRA Transfer Water	Shaffer Br/Cressey Base Flow for Fall 2000 Transfer Water [1] + [2]	Fall 2000 Transfer Water Schedule – RIVER	Shaffer Br/Cressey Target Flow [4] + [5]	Fall 2000 Transfer Water Schedule – BYPASS	Fall 2000 Transfer Water [5] + [7]	Fall 2000 Transfer Balance
	(cfs)	(cfs)	(acre-ft)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(acre-ft)
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]
Nov 17	220	40	11,468	260	0	260	0	0	13,121
Nov 18	220	40	11,548	260	0	260	0	0	13,121
Nov 19	220	40	11,627	260	0	260	0	0	13,121
Nov 20	220	40	11,706	260	0	260	0	0	13,121
Nov 21	220	40	11,786	260	0	260	0	0	13,121
Nov 22	220	40	11,865	260	0	260	0	0	13,121
Nov 23	220	40	11,944	260	0	260	0	0	13,121
Nov 24	220	40	12,024	260	0	260	0	0	13,121
Nov 25	220	40	12,103	260	0	260	0	0	13,121
Nov 26	220	40	12,182	260	0	260	0	0	13,121
Nov 27	220	40	12,262	260	0	260	0	0	13,121
Nov 28	220	40	12,341	260	0	260	0	0	13,121
Nov 29	220	40	12,420	260	0	260	0	0	13,121
Nov 30	220	40	12,500	260	0	260	0	0	13,121
Dec 01	220	0	12,500	220	0	220	0	0	13,121
Dec 02	220	0	12,500	220	0	220	0	0	13,121
Dec 03	220	0	12,500	220	0	220	0	0	13,121
Dec 04	220	0	12,500	220	0	220	0	0	13,121
Dec 05	220	0	12,500	220	0	220	0	0	13,121
Dec 06	220	0	12,500	220	0	220	0	0	13,121
Dec 07	220	0	12,500	220	0	220	0	0	13,121
Dec 08	220	0	12,500	220	0	220	0	0	13,121
Dec 09	220	0	12,500	220	0	220	0	0	13,121
Dec 10	220	0	12,500	220	0	220	0	0	13,121
Dec 11	220	0	12,500	220	0	220	0	0	13,121
Dec 12	220	0	12,500	220	0	220	0	0	13,121
Dec 13	220	0	12,500	220	0	220	0	0	13,121
Dec 14	220	0	12,500	220	0	220	0	0	13,121
Dec 15	220	0	12,500	220	0	220	0	0	13,121
Dec 16	220	0	12,500	220	0	220	0	0	13,121
Dec 17	220	0	12,500	220	0	220	0	0	13,121
Dec 18	220	0	12,500	220	0	220	0	0	13,121
Dec 19	220	0	12,500	220	0	220	0	0	13,121
Dec 20	220	0	12,500	220	0	220	0	0	13,121
Dec 21	220	0	12,500	220	0	220	0	0	13,121
Dec 22	220	0	12,500	220	0	220	0	0	13,121
Dec 23	220	0	12,500	220	0	220	0	0	13,121
Dec 24	220	0	12,500	220	0	220	0	0	13,121
Dec 25	220	0	12,500	220	0	220	0	0	13,121
Dec 26	220	0	12,500	220	0	220	0	0	13,121
Dec 27	220	0	12,500	220	0	220	0	0	13,121
Dec 28	220	0	12,500	220	0	220	0	0	13,121
Dec 29	220	0	12,500	220	0	220	0	0	13,121
Dec 30	220	0	12,500	220	0	220	0	0	13,121
Dec 31	220	0	12,500	220	0	220	0	0	13,121

	Oct	Nov	Dec	Total
SJRA Transfer Water (TAF):	7.58	0.00	4.92	12.50
Fall 2000 Transfer Water (TAF):	14.31	10.69	0	25.00

REVISED SCHEDULE #2, NOVEMBER 3

(October 1–November 16) · SJRA and Fall 2000 Transfer Water Schedule

	SJRA Transfer Water			Fall 2000 Transfer Water					
	Shaffer Br/Cressey Base Flow for SJRA Transfer Water	SJRA Transfer Water Schedule	SJRA Transfer Water	Shaffer Br/Cressey Base Flow for Fall 2000 Transfer Water [1] + [2]	Fall 2000 Transfer Water Schedule – RIVER	Shaffer Br/Cressey Target Flow [4] + [5]	Fall 2000 Transfer Water Schedule – BYPASS	Fall 2000 Transfer Water [5] + [7]	Fall 2000 Transfer Balance
	(cfs)	(cfs)	(acre-ft)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(acre-ft)
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]
Oct 01	30	0	0	30	0	30	0	0	0
Oct 02	30	0	0	30	0	30	0	0	0
Oct 03	30	0	0	30	0	30	0	0	0
Oct 04	30	0	0	30	0	30	0	0	0
Oct 05	30	0	0	30	0	30	0	0	0
Oct 06	30	0	0	30	0	30	0	0	0
Oct 07	30	0	0	30	0	30	0	0	0
Oct 08	30	0	0	30	0	30	0	0	0
Oct 09	30	0	0	30	0	30	0	0	0
Oct 10	30	0	0	30	0	30	0	0	0
Oct 11	30	0	0	30	0	30	0	0	0
Oct 12	30	0	0	30	0	30	0	0	0
Oct 13	30	0	0	30	0	30	0	0	0
Oct 14	30	0	0	30	0	30	0	0	0
Oct 15	30	397	787	427	0	427	0	0	0
Oct 16	85	760	2,295	845	0	845	0	0	0
Oct 17	85	760	3,802	845	0	845	0	0	0
Oct 18	85	760	5,310	845	0	845	0	0	0
Oct 19	85	500	6,301	585	0	585	0	0	0
Oct 20	85	380	7,055	465	0	465	0	0	0
Oct 21	85	265	7,581	350	235	585	0	235	466
Oct 22	85	0	7,581	85	915	1,000	0	915	2,281
Oct 23	85	0	7,581	85	915	1,000	0	915	4,096
Oct 24	85	0	7,581	85	915	1,000	0	915	5,911
Oct 25	85	0	7,581	85	915	1,000	0	915	7,726
Oct 26	85	0	7,581	85	915	1,000	0	915	9,540
Oct 27	85	0	7,581	85	800	885	0	800	11,127
Oct 28	85	0	7,581	85	605	690	0	605	12,327
Oct 29	85	0	7,581	85	400	485	0	400	13,121
Oct 30	85	300	8,176	385	0	385	0	0	13,121
Oct 31	85	300	8,771	385	0	385	0	0	13,121
Nov 01	220	155	9,078	375	0	375	0	0	13,121
Nov 02	220	125	9,326	345	0	345	0	0	13,121
Nov 03	220	100	9,525	320	0	320	0	0	13,121
Nov 04	220	0	9,525	220	125	345	0	125	13,369
Nov 05	220	0	9,525	220	125	345	0	125	13,617
Nov 06	220	0	9,525	220	125	345	100	225	14,063
Nov 07	220	0	9,525	220	125	345	100	225	14,509
Nov 08	220	0	9,525	220	125	345	100	225	14,955
Nov 09	220	0	9,525	220	125	345	100	225	15,402
Nov 10	220	0	9,525	220	125	345	100	225	15,848
Nov 11	220	0	9,525	220	125	345	100	225	16,294
Nov 12	220	0	9,525	220	125	345	100	225	16,740
Nov 13	220	0	9,525	220	125	345	100	225	17,187
Nov 14	220	0	9,525	220	125	345	100	225	17,633
Nov 15	220	0	9,525	220	125	345	100	225	18,079
Nov 16	220	0	9,525	220	125	345	100	225	18,526

REVISED SCHEDULE #2, NOVEMBER 3

(November 17–December 31) · SJRA and Fall 2000 Transfer Water Schedule

	SJRA Transfer Water			Fall 2000 Transfer Water					
	Shaffer Br/Cressey Base Flow for SJRA Transfer Water	SJRA Transfer Water Schedule	SJRA Transfer Water	Shaffer Br/Cressey Base Flow for Fall 2000 Transfer Water [1] + [2]	Fall 2000 Transfer Water Schedule – RIVER	Shaffer Br/Cressey Target Flow [4] + [5]	Fall 2000 Transfer Water Schedule – BYPASS	Fall 2000 Transfer Water [5] + [7]	Fall 2000 Transfer Balance
	(cfs)	(cfs)	(acre-ft)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(acre-ft)
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]
Nov 17	220	0	9,525	220	125	345	100	225	18,972
Nov 18	220	0	9,525	220	125	345	100	225	19,418
Nov 19	220	0	9,525	220	125	345	100	225	19,864
Nov 20	220	0	9,525	220	125	345	100	225	20,311
Nov 21	220	0	9,525	220	125	345	100	225	20,757
Nov 22	220	0	9,525	220	125	345	100	225	21,203
Nov 23	220	0	9,525	220	125	345	100	225	21,650
Nov 24	220	0	9,525	220	125	345	100	225	22,096
Nov 25	220	0	9,525	220	125	345	100	225	22,542
Nov 26	220	0	9,525	220	125	345	100	225	22,988
Nov 27	220	0	9,525	220	125	345	100	225	23,435
Nov 28	220	0	9,525	220	125	345	100	225	23,881
Nov 29	220	0	9,525	220	125	345	100	225	24,327
Nov 30	220	0	9,525	220	125	345	100	225	24,774
Dec 01	220	50	9,624	270	0	270	0	0	24,774
Dec 02	220	50	9,723	270	0	270	0	0	24,774
Dec 03	220	50	9,822	270	0	270	0	0	24,774
Dec 04	220	50	9,921	270	0	270	0	0	24,774
Dec 05	220	50	10,020	270	0	270	0	0	24,774
Dec 06	220	50	10,120	270	0	270	0	0	24,774
Dec 07	220	50	10,219	270	0	270	0	0	24,774
Dec 08	220	50	10,318	270	0	270	0	0	24,774
Dec 09	220	50	10,417	270	0	270	0	0	24,774
Dec 10	220	50	10,516	270	0	270	0	0	24,774
Dec 11	220	50	10,616	270	0	270	0	0	24,774
Dec 12	220	50	10,715	270	0	270	0	0	24,774
Dec 13	220	50	10,814	270	0	270	0	0	24,774
Dec 14	220	50	10,913	270	0	270	0	0	24,774
Dec 15	220	50	11,012	270	0	270	0	0	24,774
Dec 16	220	50	11,111	270	0	270	0	0	24,774
Dec 17	220	50	11,211	270	0	270	0	0	24,774
Dec 18	220	50	11,310	270	0	270	0	0	24,774
Dec 19	220	50	11,409	270	0	270	0	0	24,774
Dec 20	220	50	11,508	270	0	270	0	0	24,774
Dec 21	220	50	11,607	270	0	270	0	0	24,774
Dec 22	220	50	11,706	270	0	270	0	0	24,774
Dec 23	220	50	11,806	270	0	270	0	0	24,774
Dec 24	220	50	11,905	270	0	270	0	0	24,774
Dec 25	220	50	12,004	270	0	270	0	0	24,774
Dec 26	220	50	12,103	270	0	270	0	0	24,774
Dec 27	220	50	12,202	270	0	270	0	0	24,774
Dec 28	220	50	12,301	270	0	270	0	0	24,774
Dec 29	220	50	12,401	270	0	270	0	0	24,774
Dec 30	220	25	12,450	245	0	245	0	0	24,774
Dec 31	220	25	12,500	245	0	245	0	0	24,774

	Oct	Nov	Dec	Total
SJRA Transfer Water (TAF):	7.58	0.00	4.92	12.50
Fall 2000 Transfer Water (TAF):	14.31	10.69	0	25.00

SJRA AND FALL 2000 WATER TRANSFER MONITORING (THROUGH DECEMBER 20)

(OCTOBER 1–NOVEMBER 16) · TRANSFER SCHEDULE REVISED NOVEMBER 3

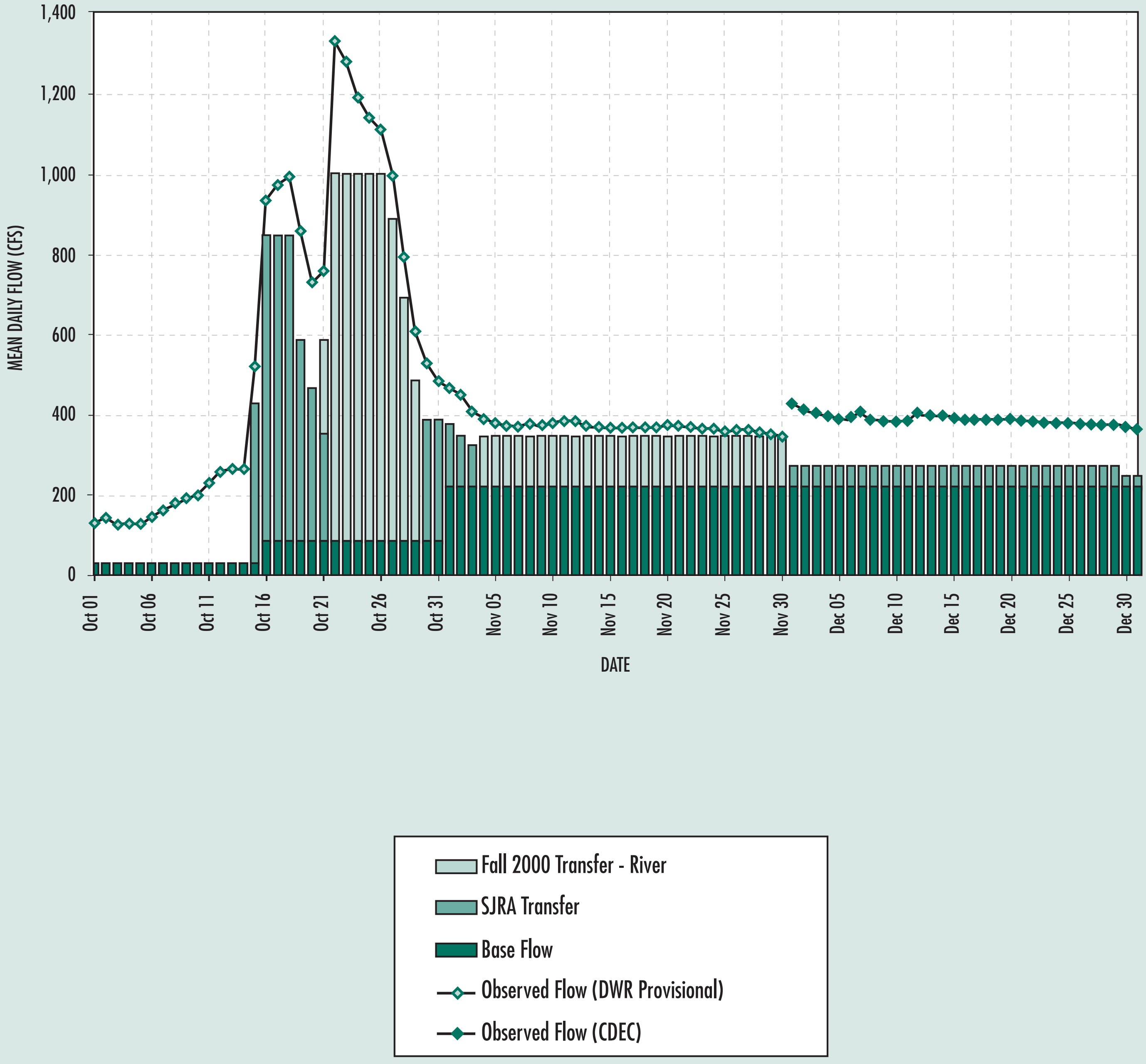
			SJRA Transfer Water			Fall 2000 Transfer Water					
	Shaffer Br/Cressey Base FLow for SJRA Transfer Water	Observed Flow at Cressey	Scheduled SJRA Transfer Water	Observed SJRA Transfer Water	SJRA Transfer Water Cumulative Volume	Scheduled Fall 2000 Transfer Water	Observed Fall 2000 Transfer Water	Scheduled Fall 2000 Transfer Water	Observed Livingston Spill	Observed Fall 2000 Transfer Water	Fall 2000 Transfer Balance
		DWR/CDEC				RIVER		BYPASS			
	cfs	cfs	cfs	cfs	ac-ft	cfs	cfs	cfs	cfs	cfs	acre-ft
Oct 01	30	132	0	0	0	0	0	0		0	0
Oct 02	30	145	0	0	0	0	0	0		0	0
Oct 03	30	130	0	0	0	0	0	0		0	0
Oct 04	30	132	0	0	0	0	0	0		0	0
Oct 05	30	131	0	0	0	0	0	0		0	0
Oct 06	30	149	0	0	0	0	0	0		0	0
Oct 07	30	165	0	0	0	0	0	0		0	0
Oct 08	30	182	0	0	0	0	0	0		0	0
Oct 09	30	195	0	0	0	0	0	0		0	0
Oct 10	30	201	0	0	0	0	0	0		0	0
Oct 11	30	232	0	0	0	0	0	0		0	0
Oct 12	30	257	0	0	0	0	0	0		0	0
Oct 13	30	267	0	0	0	0	0	0		0	0
Oct 14	30	266	0	0	0	0	0	0		0	0
Oct 15	30	521	397	397	787	0	0	0		0	0
Oct 16	85	934	760	760	2,295	0	0	0		0	0
Oct 17	85	972	760	760	3,802	0	0	0		0	0
Oct 18	85	993	760	760	5,310	0	0	0		0	0
Oct 19	85	859	500	500	6,301	0	0	0		0	0
Oct 20	85	731	380	380	7,055	0	0	0		0	0
Oct 21	85	759	265	265	7,581	235	235	0		0	466
Oct 22	85	1,330	0	0	7,581	915	915	0		0	2,281
Oct 23	85	1,280	0	0	7,581	915	915	0		0	4,096
Oct 24	85	1,190	0	0	7,581	915	915	0		0	5,911
Oct 25	85	1,140	0	0	7,581	915	915	0		0	7,726
Oct 26	85	1,110	0	0	7,581	915	915	0		0	9,540
Oct 27	85	995	0	0	7,581	800	800	0		0	11,127
Oct 28	85	793	0	0	7,581	605	605	0		0	12,327
Oct 29	85	609	0	0	7,581	400	400	0		0	13,121
Oct 30	85	529	300	300	8,176	0	0	0		0	13,121
Oct 31	85	485	300	300	8,771	0	0	0		0	13,121
Nov 01	220	462	155	155	9,078	0	0	0	51	0	13,121
Nov 02	220	451	125	125	9,326	0	0	0	34	0	13,121
Nov 03	220	408	100	100	9,525	0	0	0	10	0	13,121
Nov 04	220	393	0	0	9,525	125	125	0	6	0	13,369
Nov 05	220	383	0	0	9,525	125	125	0	73	0	13,617
Nov 06	220	379	0	0	9,525	125	125	100	94	94	14,051
Nov 07	220	376	0	0	9,525	125	125	100	123	100	14,497
Nov 08	220	382	0	0	9,525	125	125	100	122	100	14,943
Nov 09	220	383	0	0	9,525	125	125	100	115	100	15,390
Nov 10	220	385	0	0	9,525	125	125	100	113	100	15,836
Nov 11	220	392	0	0	9,525	125	125	100	114	100	16,282
Nov 12	220	394	0	0	9,525	125	125	100	113	100	16,729
Nov 13	220	380	0	0	9,525	125	125	100	111	100	17,175
Nov 14	220	368	0	0	9,525	125	125	100	111	100	17,621
Nov 15	220	363	0	0	9,525	125	125	100	110	100	18,067
Nov 16	220	363	0	0	9,525	125	125	100	111	100	18,514

SJRA AND FALL 2000 WATER TRANSFER MONITORING (THROUGH DECEMBER 20)

(November 17–December 31) • Transfer Schedule Revised November 3

			SJRA Transfer Water			Fall 2000 Transfer Water					
	Shaffer Br/Cressey Base Flow for SJRA Transfer Water	Observed Flow at Cressey	Scheduled SJRA Transfer Water	Observed SJRA Transfer Water	SJRA Transfer Water Cumulative Volume	Scheduled Fall 2000 Transfer Water	Observed Fall 2000 Transfer Water	Scheduled Fall 2000 Transfer Water	Observed Livingston Spill	Observed Fall 2000 Transfer Water	Fall 2000 Transfer Balance
		DWR/CDEC				RIVER		BYPASS			
	cfs	cfs	cfs	cfs	ac-ft	cfs	cfs	cfs	cfs	cfs	acre-ft
Nov 17	220	363	0	0	9,525	125	125	100	112	100	18,960
Nov 18	220	360	0	0	9,525	125	125	100	110	100	19,406
Nov 19	220	360	0	0	9,525	125	125	100	111	100	19,853
Nov 20	220	365	0	0	9,525	125	125	100	111	100	20,299
Nov 21	220	363	0	0	9,525	125	125	100	111	100	20,745
Nov 22	220	360	0	0	9,525	125	125	100	111	100	21,191
Nov 23	220	363	0	0	9,525	125	125	100	111	100	21,638
Nov 24	220	362	0	0	9,525	125	125	100	111	100	22,084
Nov 25	220	354	0	0	9,525	125	125	100	113	100	22,530
Nov 26	220	358	0	0	9,525	125	125	100	114	100	22,977
Nov 27	220	356	0	0	9,525	125	125	100	111	100	23,423
Nov 28	220	349	0	0	9,525	125	125	100	111	100	23,869
Nov 29	220	346	0	0	9,525	125	125	100	112	100	24,315
Nov 30	220	338	0	0	9,525	125	118	100	112	100	24,748
Dec 01	220	416	50	50	9,624						
Dec 02	220	400	50	50	9,723						
Dec 03	220	393	50	50	9,822						
Dec 04	220	389	50	50	9,921						
Dec 05	220	382	50	50	10,020						
Dec 06	220	383	50	50	10,120						
Dec 07	220	408	50	50	10,219						
Dec 08	220	394	50	50	10,318						
Dec 09	220	387	50	50	10,417						
Dec 10	220	380	50	50	10,516						
Dec 11	220	381	50	50	10,616						
Dec 12	220	400	50	50	10,715						
Dec 13	220	393	50	50	10,814						
Dec 14	220	398	50	50	10,913						
Dec 15	220	390	50	50	11,012						
Dec 16	220	382	50	50	11,111						
Dec 17	220	380	50	50	11,211						
Dec 18	220	380	50	50	11,310						
Dec 19	220	381	50	50	11,409						
Dec 20	220	377	50	50	11,508						
Dec 21	220	372	50								
Dec 22	220	371	50								
Dec 23	220	370	50								
Dec 24	220	370	50								
Dec 25	220	370	50								
Dec 26	220	367	50								
Dec 27	220	369	50								
Dec 28	220	369	50								
Dec 29	220	370	50								
Dec 30	220	359	25								
Dec 31	220	351	25								

SJRA AND FALL 2000
WATER TRANSFER MONITORING (THROUGH NOVEMBER 30)
MERCED RIVER AT CRESSEY



APPENDIX C

CHINOOK SALMON SURVIVAL INVESTIGATIONS

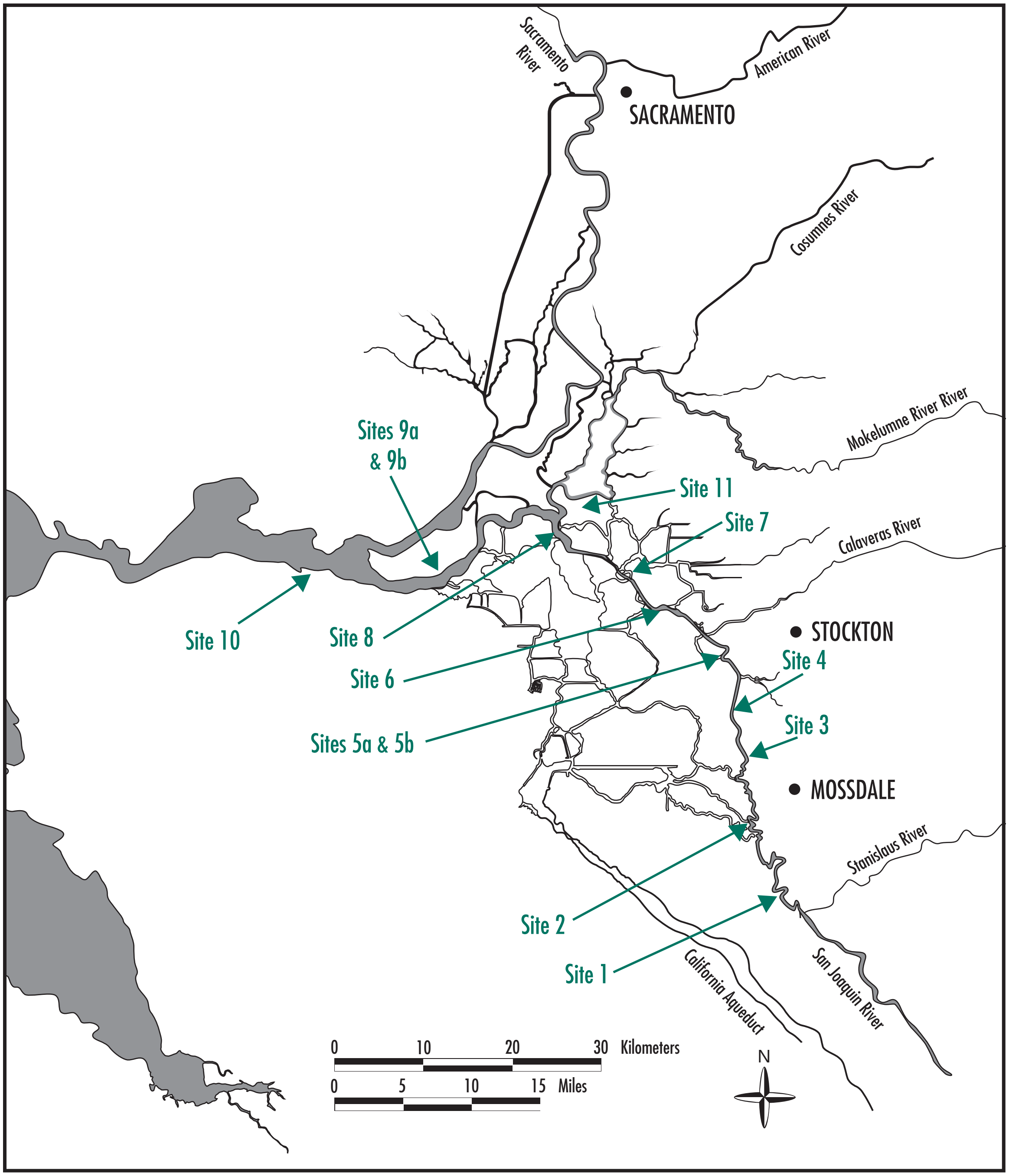


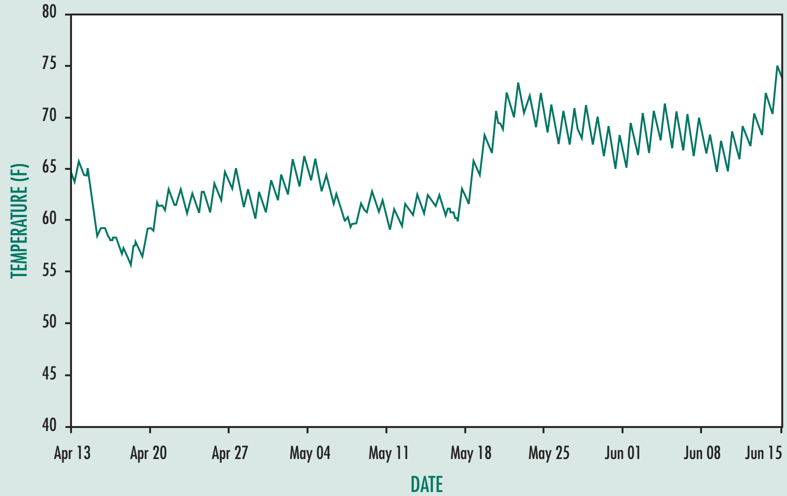
Figure C-1. Water temperature monitoring locations during the VAMP 2000 experiment.

VAMP 2000 WATER TEMPERATURE MONITORING

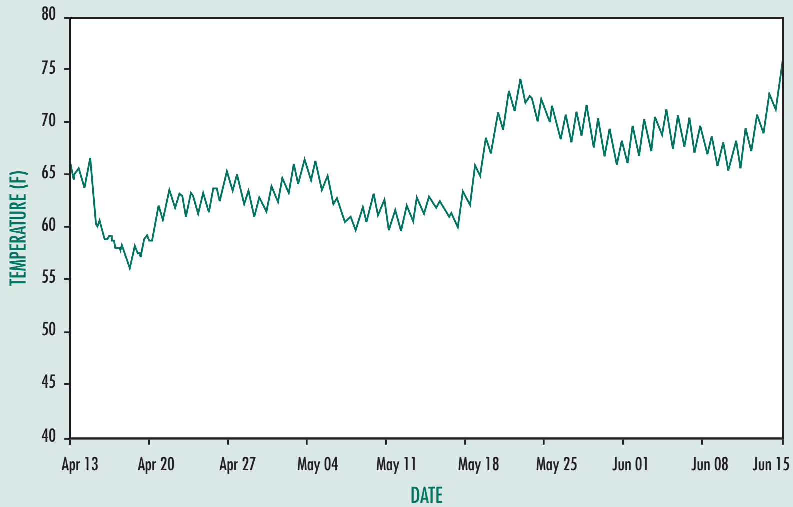
Site no.	Monitoring Location	Latitude	Longitude	Distance from Durham Ferry (mi)	Date Deployed	Date Retrieved	Notes
	Mokelumne River Hatchery			n/a	March 18	April 23	In river Apr 21
	Merced River Hatchery			n/a	March 25	April 19	In river Apr 17
1	Durham Ferry	N 37 41.381	W 121 15657	n/a	April 12	June 22	In 3′ of water, casing was filled with mud
2	Mossdale	N 37 47.180	W 121 18.425	11.2	April 12	August 5	Recorder dewatered
3	Dos Reis	N 37 49.808	W 121 18.665	16.4	April 12		Recorder lost
4	DWR Monitoring Station	N 37 51.869	W 121 19.376	19.4	April 12	August 5	In 2½′ of water
5a	Confluence – Top	N 37 56.818	W 121 20.285	26.5	April 12	August 5	In 2′ of water
5b	Confluence – Bottom	N 37 56.818	W 121 20.285	26.5	April 12	August 5	On bottom in 4½′ of water in mud
6	Downstream of Channel Marker 30	N 37 59.611	W 121 25.805	33.3	April 12	August 5	In 3′ of water
7	½ mile Upstream of Channel Marker 13	N 38 01.940	W 121 28.769	37.3	April 12	August 5	Retrieved
8	Downstream of Channel Marker 36	N 38 04.522	W 121 34.413	44.7	April 12	August 5	In 4′ of water
9a	Jersey Point USGS Gauging Station - top	N 38 03.172	W121 41.637	56.0	April 12	August 5	Retrieved, recorder not operating-data lost
9b	Jersey Point USGS Gauging Station – bottom	N 38 03.172	W121 41.637	56.0	April 12		Recorder lost – stuck & unable to dislodge
10	Chipps Island	N 38 03.084	W 121 55.463	71.5	April 17	September 16	
11	Lighthouse Restaurant Pier	N 38 06.332	W 121 34.209	47.0	April 12	August 5	Under pier in 3′ of water

WATER TEMPERATURE MONITORING

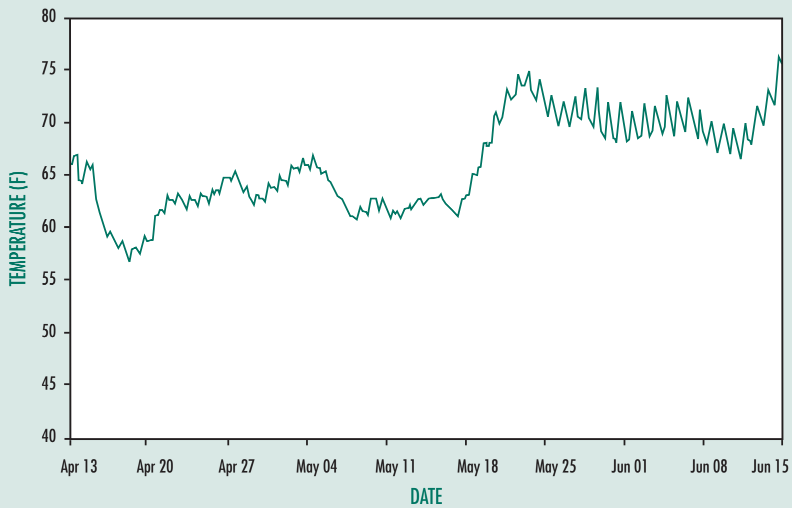
Station 1 · Durham Ferry



Station 2 · Mossdale

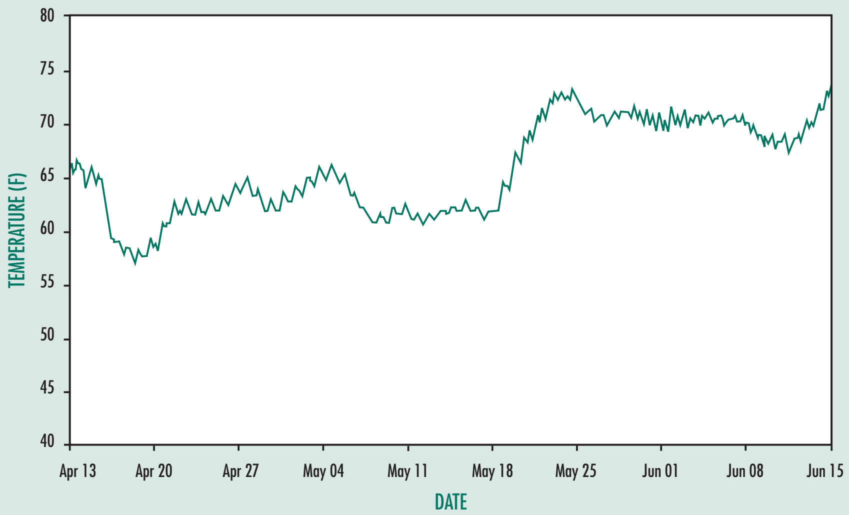


Station 4 · DWR Gauge

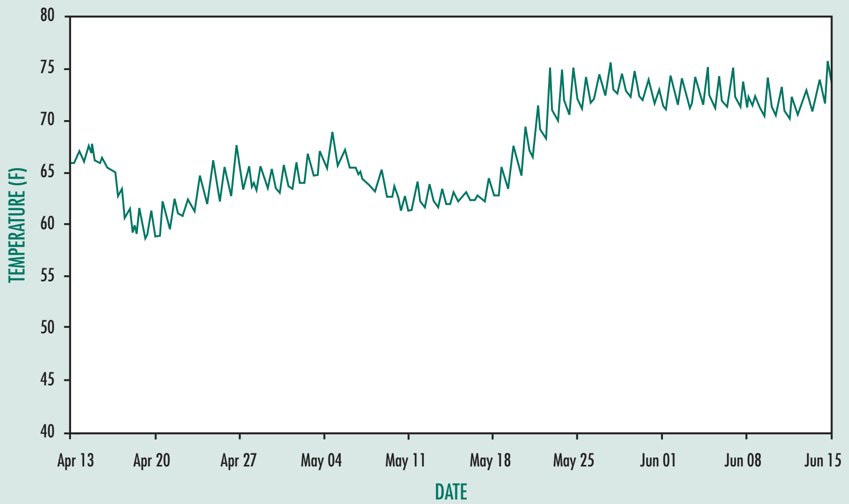


WATER TEMPERATURE MONITORING

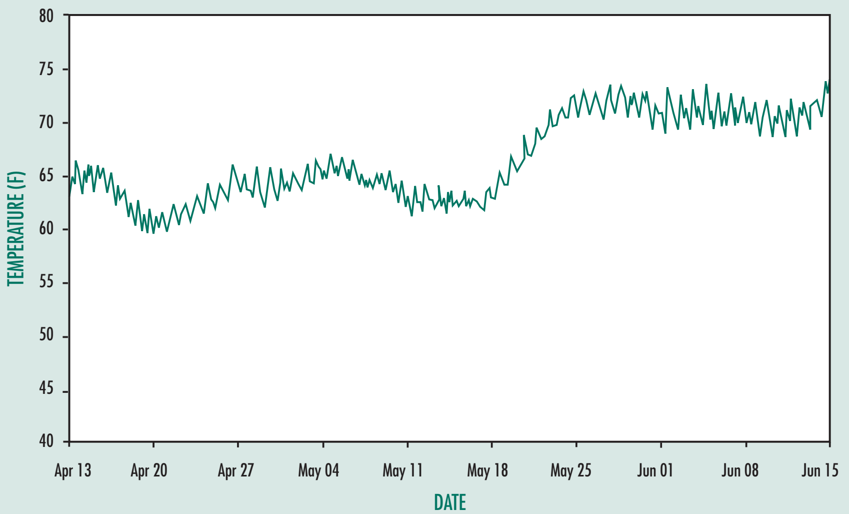
Station 5b · Bottom of Confluence



Station 6 · Downstream of Marker 30

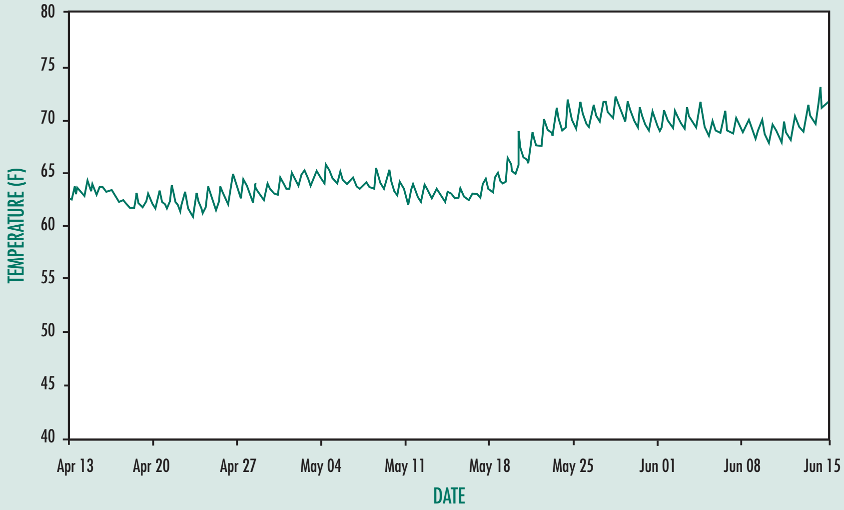


Station 7 · Upstream of Marker 13

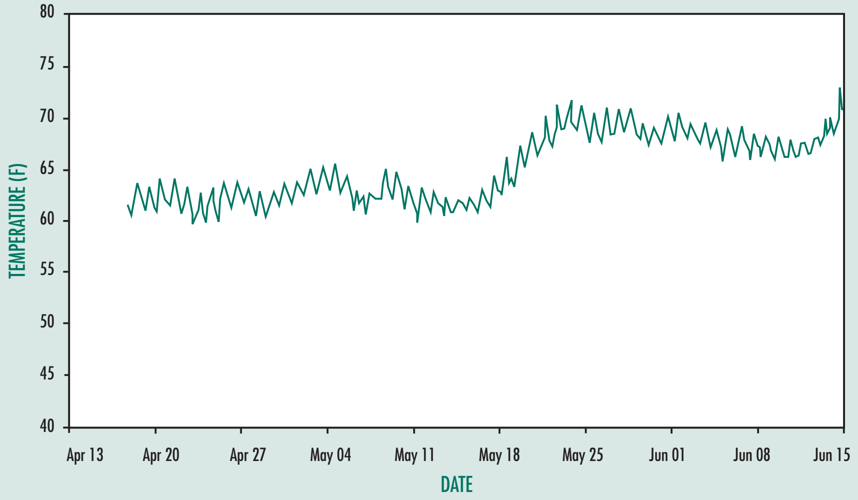


WATER TEMPERATURE MONITORING

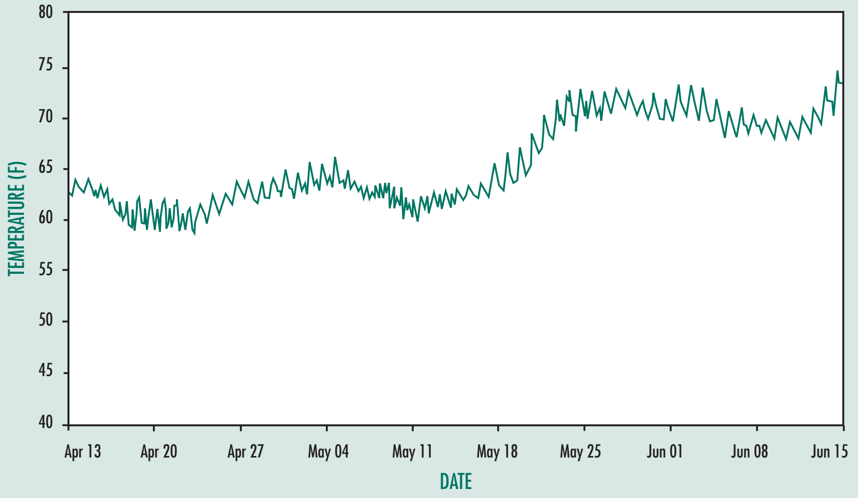
Station 8 · Downstream of Channel Marker 36



Station 10 · Chipps Island

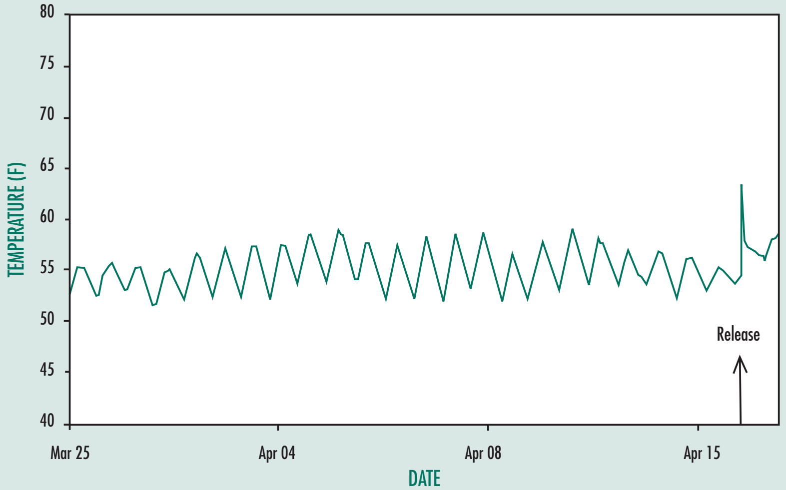


Station 11 · Mokelumne River

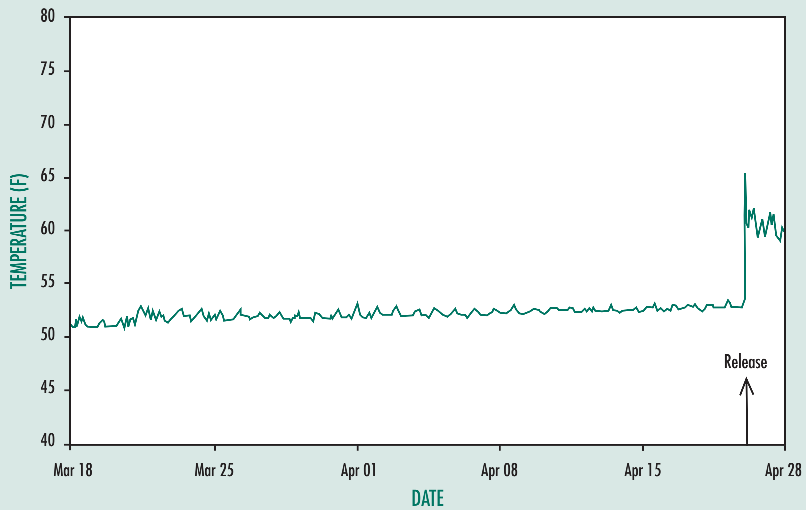


WATER TEMPERATURE MONITORING

Merced River Hatchery



Mokelumne River Hatchery



RESULTS OF NET PEN SAMPLING CONDUCTED IMMEDIATELY AFTER RELEASE AS PART OF THE VAMP STUDIES IN 2000.

Release location, release date, tag code, number in sample	Mean fork length (and range) in millimeters	Mean weight (and range) in grams	Mean percent (and range) of scale loss	Color	Fin hemorrhaging	Eyes	Gill color	Ad clips, comments
Durham Ferry Apr 17 06-04-02, 24 at release	82.9 (73-92)	6.4 (4.6-9.4)	8 (3-15)	Normal	1 with fin	Normal hemorrhaging	Normal	All with ad clip/ 1 with deformed caudal fin; 1 with smashed eye
Durham Ferry, Apr 17 06-04-01, 25 at release	82.6 (69-91)	6.4 (2.6-9.1)	5 (2-13)	Normal	None	Normal	Normal	All with ad clip/ 2 with pink on pelvic and anal fin; 1 with top of caudal gone
Durham Ferry, Apr 17 06-45-63, 25 at release	80.3 (72-87)	5.8 (3.6-7.5)	7 (3-15)	Normal	None	Normal color	1 with faded gill	All with ad clip/1 with deformed caudal fin
Mossdale, Apr 18 06-44-01, 25 at release	82.6 (72-91)	6.6 (4.5-8.8)	6 (1-13)	Normal	None	Normal	Normal	All with ad clip
Mossdale, Apr 18 06-44-02, 26 at release	82.1 (60-92)	6.4 (2.0-11.1)	5 (2-9)	1 with dark color	None	1 with bugged eyes	Normal	1 with no clip
Jersey Point, Apr 20 06-44-04, 25 at release	83.4 (75-90)	6.6 (4.2-8.1)	4 (1-10)	Normal	None	Normal	Normal	2 with poor ad clip
Jersey Point, Apr 20 06-44-03, 25 at release	82.3 (74-90)	6.5 (4.4 –10.0)	4 (1-10)	Normal	None	Normal	Normal	1 with no ad clip
Durham Ferry, Apr 28 06-01-0-6-09-15, 25 at release	77.2 (67-92)	5.1 (3.3- 8.2)	2 (0-5)	Normal	None	Normal	Normal	1 bad ad clip
Durham Ferry, Apr 28 06-01-11-08-14, 25 at release	75.7 (65-86)	4.8 (3.1-7.4)	3 (1-6)	Normal	None	Normal	Normal	1 not clipped, 1 with deformed operculum
Durham Ferry, Apr 28 06-01-11-09-14, 25 at release	78.2 (66-87)	5.2 (3.2 –9.4)	4 (1-20)	Normal	None	Normal	Normal	1 poor clip, 1 with large patch of scales missing
Jersey Point, May 1 06-01-06-10-02, 25 at release	82.9 (74-97)	6.6 (5.5 – 10.4)	2 (0-5)	Normal	None	Normal	Normal	All ad clipped
Jersey Point, May 1 06-01-06-10-01, 25 at release	78.5 (69-94)	5.7 (3.7 – 10.3)	2 (0-4)	Normal	None	Normal	Normal	All ad clipped

RESULTS OF NET PEN SAMPLING AFTER FISH WERE HELD FOR 48 HOURS, CONDUCTED AS PART OF THE VAMP STUDIES IN 2000.

Release location, release date, tag code, number processed	Mean Fork Length (and range) in millimeters	Mean Weight (and range) in grams	Mean (and range) of percent scale loss	Color	Fin Hemorrhaging	Eyes	Gill color	Ad Clips/Comments
Durham Ferry Apr 17 06-04-02								Fish escaped. No data available
Durham Ferry Apr 17 06-04-01								Fish escaped. No data available
Durham Ferry Apr 17 06-45-63								Fish escaped. No data available
Mossdale Apr 18, 06-44-01, 55 processed	82.4 (72-94)	6.0 (3.7-8.1)	1 (0-4)	Normal	None	Normal	Normal	2 with poor ad clip
Mossdale Apr 18, 06-44-02, 55 processed	84.1 (72-92)	6.4 (4.0-8.6)	2 (0-4)	Normal	None	Normal	Normal	3 with poor ad clip
Jersey Point Apr 20, 06-44-04, 86 processed	83.8 (72-94)	6.6 (3.6-8.4)	3 (1-8)	Normal	None	Normal	Normal	All ad clipped
Jersey Point Apr 20, 06-44-03, 123 processed	84.1 (76-94)	6.2 (4.1 –8.2)	2 (1-6)	Normal	None	Normal	Normal	1 with no ad clip
Durham Ferry Apr 28, 06-01-06-09-15, 89 processed	76 (64-90)	4.7 (2.8- 7.7)	2 (0-3)	Normal	None	Normal	Normal	2 with no ad clip
Durham Ferry Apr 28, 06-01-11-08-14, 149 processed	75.4 (59-91)	4.6 (2.3-8.2)	2 (0-5)	Normal	None	Normal	Normal	7 poor ad clipped, 1 with no clip, 4 with partial operculum, 1 dead
Durham Ferry Apr 28, 06-01-11-09-14, 101 processed	78.1 (65-89)	5.0 (2.7 –7.4)	2 (0-5)	Normal	None	Normal	Normal	7 poor clip, 2 with no clip, 1 with deformed caudal, 1escapee
Jersey Point May 1 06-01-06-10-02 200 processed	82.6 (70-97)	6.1 (3.4 – 9.8)	1 (0-3)	Normal	None	Normal	Normal	All ad clipped
Jersey Point May 1, 06-01-06-10-01, 125 processed	77.2 (63-95)	5.7 (2.7 – 10.2)	3 (0-8)	Normal	None	Normal	Normal	1 not clipped

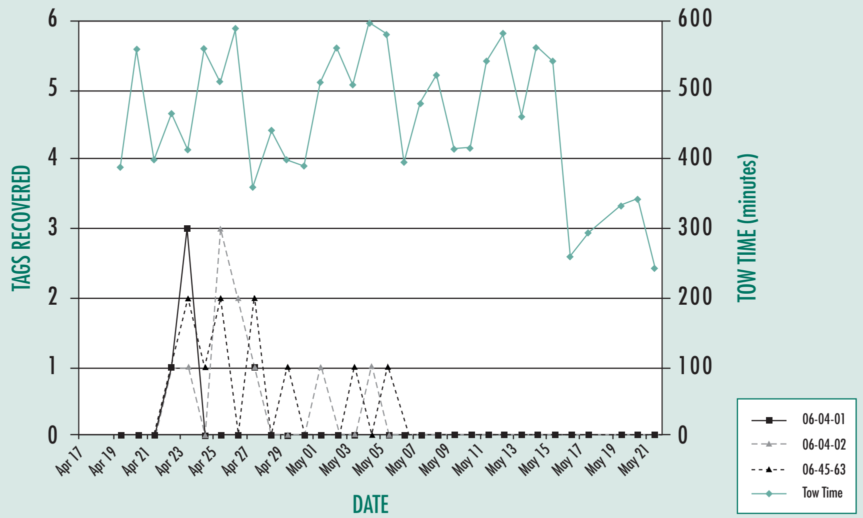
2000 CODED WIRE TAG RECOVERY INFORMATION

at Antioch and Chipps Island for Marked Fish Release as part of the Vernalis Adaptive Management Program

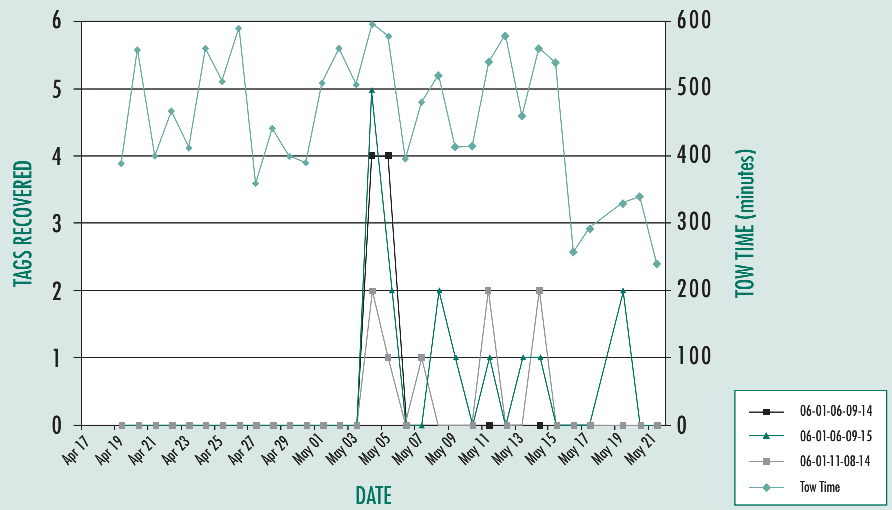
Tag Code	Release Site/Stock	Date	First Day Recovered	Last Day Recovered	Number Recovered	Minutes Fished	Survival Index	Group Survival	First Day Recovered	Last Day Recovered	Number Recovered	Minutes Fished	Survival Index	Group Survival
			Antioch Recovery Information						Chipps Island Recovery Information					
06-04-01	Durham Ferry (MRFF)		Apr 22	May 04	6	6,310	0.054		Apr 22	Apr 29	7	3,000	0.149	
06-04-02	Durham Ferry (MRFF)		Apr 22	May 04	10	6,310	0.088		Apr 23	May 19	10	10,135	0.206	
06-45-63	Durham Ferry (MRFF)		Apr 22	May 05	11	6,890	0.095		Apr 24	May 05	11	4,480	0.226	
	Total	Apr 17	Apr 22	May 05	27	6,890		0.079	Apr 22	May 19	28	10,535		0.193
06-01-06-09-14	Durham Ferry (MRFF)		May 04	May 05	8	1,177	0.059		May 04	May 14	7	4,055	0.150	
06-01-06-09-15	Durham Ferry (MRFF)		May 04	May 19	15	7,219	0.129		May 03	May 12	5	3,655	0.096	
06-01-11-08-14	Durham Ferry (MRFF)		May 04	May 14	8	5,540	0.069		May 04	May 21	10	6,855	0.206	
	Total	Apr 28	May 04	May 19	31	7,219		0.096	May 03	May 21	22	7,155		0.147
06-44-03	Jersey Point (MRFF)		Apr 21	Apr 28	50	3,746	0.434		Apr 22	May 02	24	4,180	0.463	
06-44-04	Jersey Point (MRFF)		Apr 21	May 03	47	6,113	0.401		Apr 22	May 02	41	4,180	0.782	
	Total	Apr 20	Apr 22	May 03	97	6,113		0.416	Apr 22	May 02	65	4,180		0.623
06-01-06-10-01	Jersey Point (MRFF)		May 02	May 14	76	6,607	0.606		May 03	May 17	48	5,555	0.949	
06-01-06-10-02	Jersey Point (MRFF)		May 02	May 20	76	8,626	0.704		May 02	May 14	30	4,755	0.623	
	Total	May 01	May 02	May 20	152	8,626		0.692	May 02	May 17	78	5,955		0.782
06-02-53	Jersey Point (MOK)		May 2	May 15	106	7,147	0.427		May 03	May 14	95	4,355	0.971	
06-02-54	Jersey Point (MOK)		May 2	May 14	110	6,607	0.439		May 02	May 12	74	4,055	0.734	
	Total	May 01	May 2	May 15	216	7,147		0.431	May 02	May 14	169	4,755		0.851
06-44-01	Mossdale (MRFF)		Apr 22	Apr 28	14	3,346	0.129		Apr 23	May 04	9	4,480	0.192	
06-44-02	Mossdale (MRFF)		Apr 23	May 14	16	10,785	0.149		Apr 23	Apr 29	9	2,600	0.199	
	Total	Apr 18	Apr 22	May 14	30	11,253		0.137	Apr 23	May 04	18	4,480		0.195
06-44-05	Mossdale (MRFF)	Apr 19 May 03	Apr 25	May 12	9	8,790	0.082		Apr 29	May 11	7	4,835	0.151	

MRFF denotes Merced River Fish Hatchery

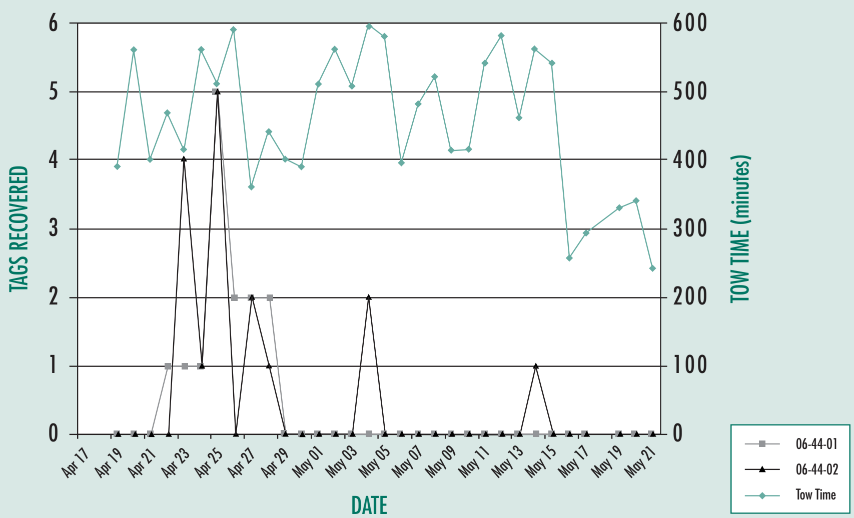
April 17th Durham Ferry Release Recovered at Antioch



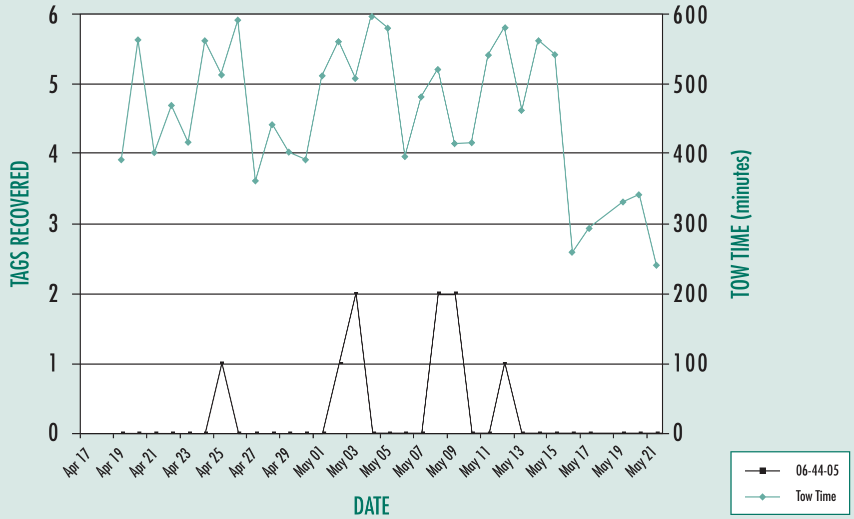
April 28th Durham Ferry Release Recovered at Antioch



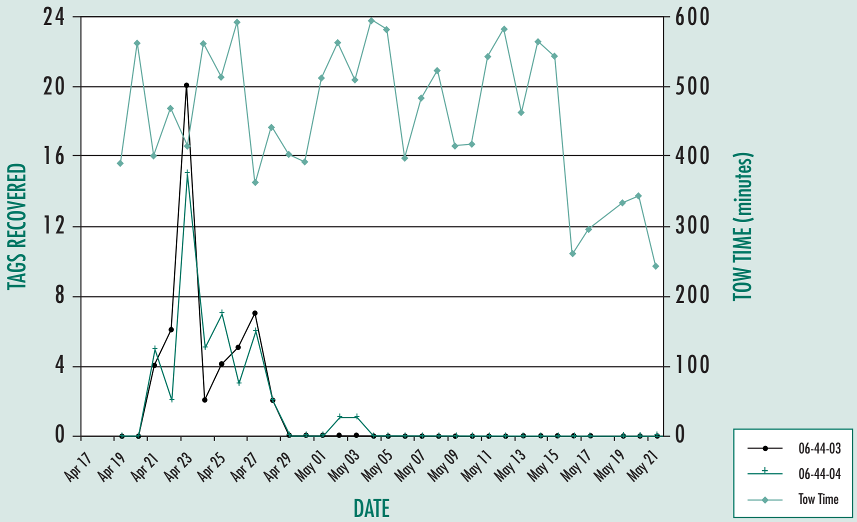
April 18th Mossdale Release Recovered at Antioch



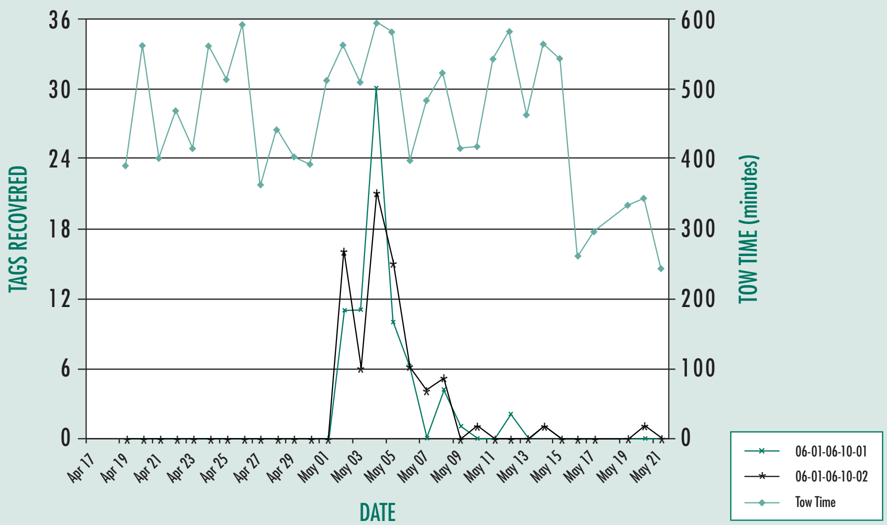
April 19th through May 3rd Mossdale Release Recovered at Antioch



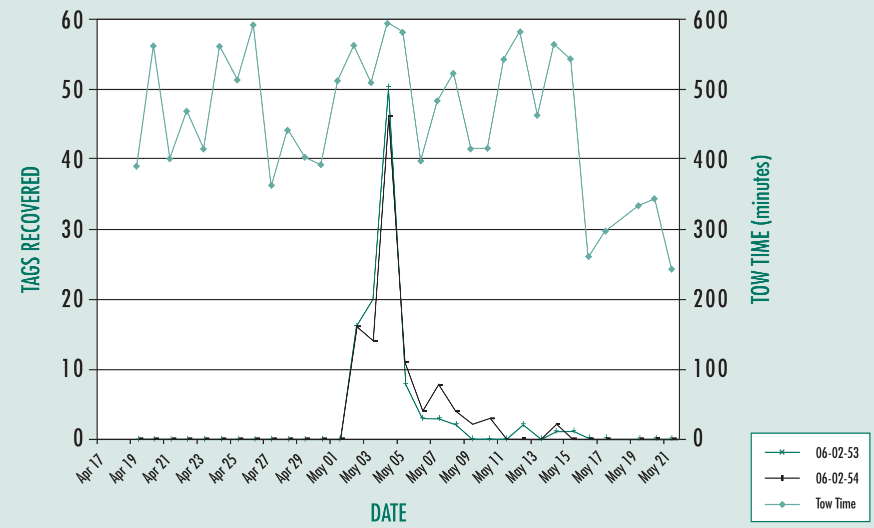
April 20th Jersey Point Release Recovered at Antioch



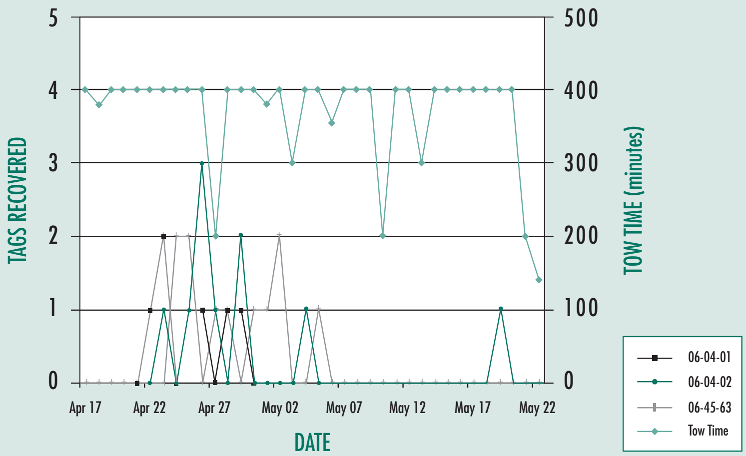
May 1st Jersey Point Release Recovered at Antioch



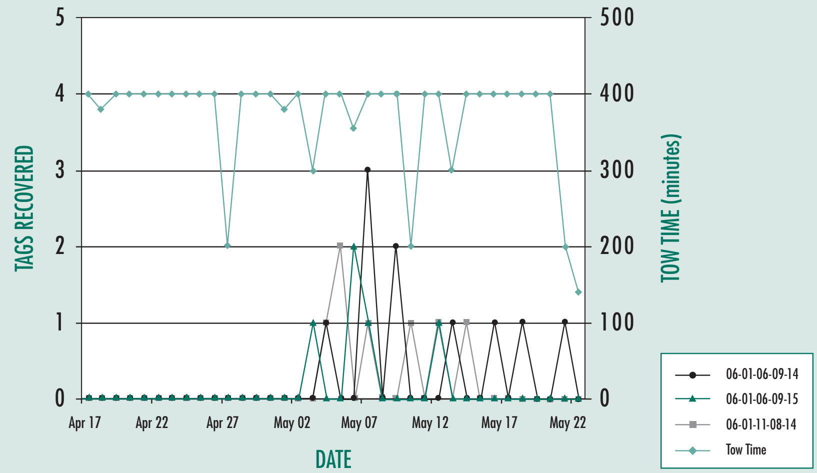
May 1st Jersey Point Release (Mokelumne Stock) Recovered at Antioch



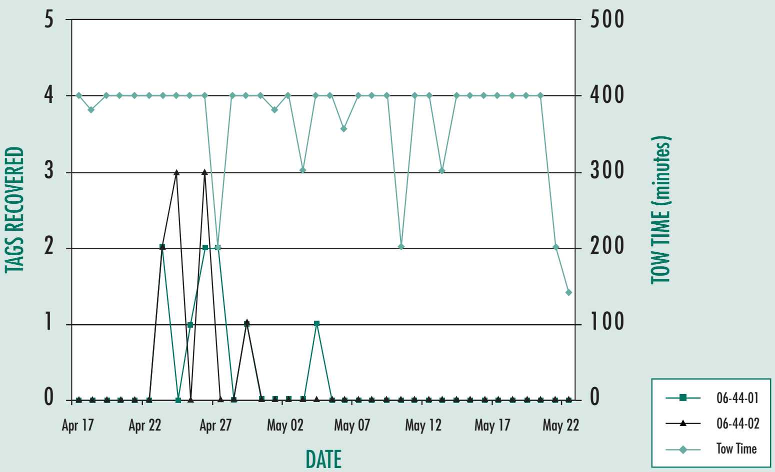
April 17th Durham Ferry Release Recovered at Chipps Island



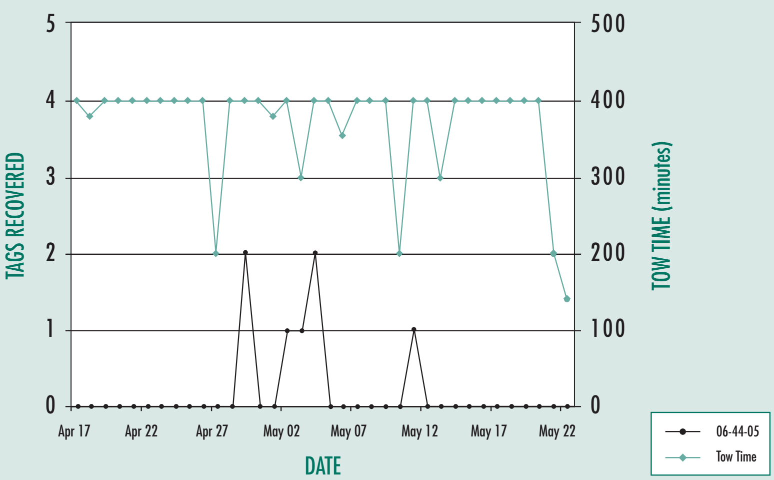
April 28th Durham Ferry Release Recovered at Chipps Island



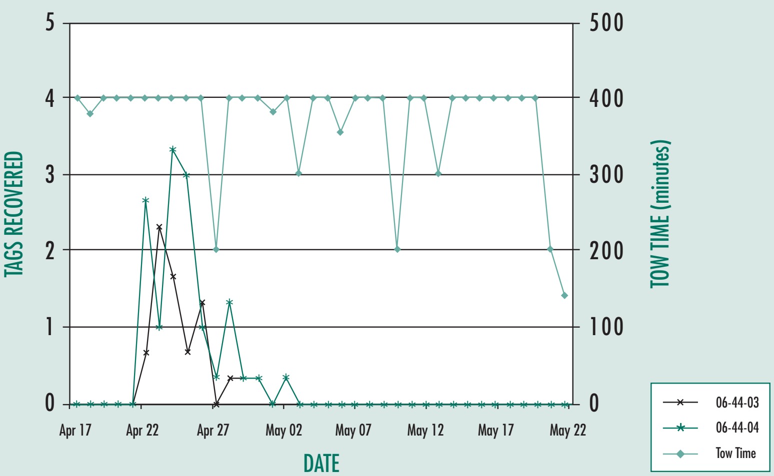
April 18th Mossdale Release Recovered at Chipps Island



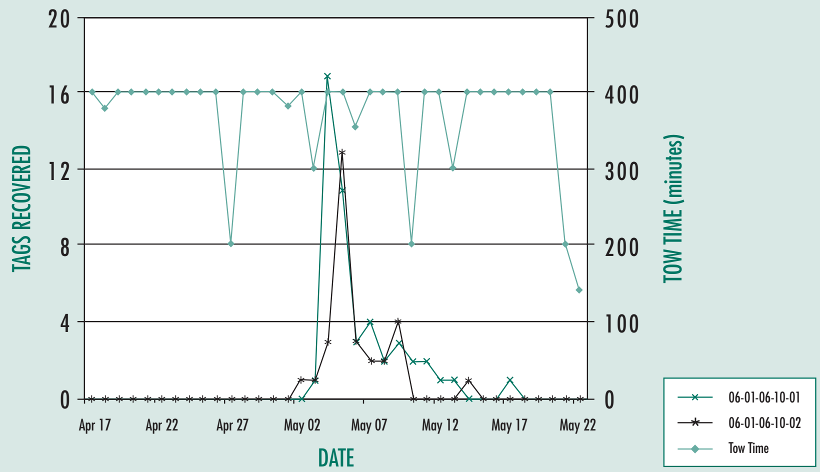
April 19th through May 3rd Mossdale Release Recovered at Chipps Island



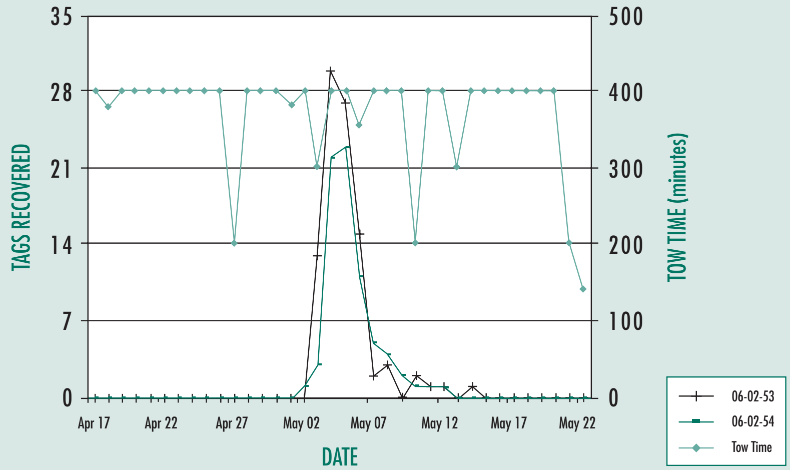
April 20th Jersey Point Release Recovered at Chipps Island



May 1st Jersey Point Release Recovered at Chipps Island



May 1st Jersey Point Release (Mokelumne Stock) Recovered at Chipps Island



2000 CODED WIRE TAG RELEASE
AND ANTIOCH, CHIPPS ISLAND, CENTRAL VALEY PROJECT (CVP) AND STATE WATER PROJECT (SWP) FISH FACILITY RECOVERY INFORMATION FOR SAN JOAQUIN TRIBUTARY RELEASES

Tag Code	Release Site/Stock	Date	Truck Temp	Release Temp	No. Released	Average Size (mm)	No. Recovered at Antioch	Percent Sampled at Antioch	Survival Index at Antioch	Group Survival at Antioch	No. Recovered at Chipps	Percent Sampled at Chipps	Survival Index at Chipps	Group Survival at Chipps	Expanded Salvage CVP	Expanded Salvage SWP
06-45-39	Upper Merced @ MRFF				25,313	78	2	0.33	0.017		5	0.261	0.098		0	20
06-45-40	Upper Merced @ MRFF				25,507	78	9	0.331	0.077		3	0.243	0.063		0	51
06-45-41	Upper Merced @ MRFF				25,318	78	2	0.383	0.015		4	0.278	0.074		12	41
06-45-42	Upper Merced @ MRFF				25,395	78	2	0.344	0.016		5	0.258	0.099		12	47
Total		Apr 12			101,533		15	0.325		0.033	17	0.262		0.083		
06-45-43	Hatfield State Park (MRFF)		12.2	20	24,525	76	8	0.336	0.07		5	0.258	0.103		12	146
06-45-44	Hatfield State Park (MRFF)		12.2	20	24,490	76	9	0.329	0.08		6	0.278	0.115		0	128
06-45-45	Hatfield State Park (MRFF)		12.2	20	24,432	76	8	0.322	0.07		2	0.278	0.038		12	127
Total		Apr 13			73,447		25	0.329		0.074	13	0.26		0.088		
06-45-49	Upper Merced @ MRFF				25,433	76	3	0.414	0.02		5	0.261	0.098		0	9
06-45-50	Upper Merced @ MRFF				27,042	76	2	0.414	0.013		6	0.263	0.11		36	12
06-45-51	Upper Merced @ MRFF				24,378	76	8	0.346	0.068		1	0.278	0.019		0	24
06-45-52	Upper Merced @ MRFF				25,293	76	7	0.346	0.058		4	0.264	0.078		12	0
Total		Apr 24			102,146		20	0.346	0.041	0.041	16	0.264		0.077		
06-45-53	Hatfield State Park (MRFF)				25,794	81	13	0.338	0.107		5	0.253	0.099		0	57
06-45-54	Hatfield State Park (MRFF)				26,189	81	5	0.35	0.039		4	0.243	0.082		12	90
06-45-55	Hatfield State Park (MRFF)				25,444	81	10	0.334	0.085		6	0.256	0.12		24	78
Total		Apr 27			77,427		28	0.341		0.076	15	0.256		0.098		
Tuolumne River																
06-45-56	La Grange (MRFF)	Apr 13	13.3	11.1	23,603	74	5	0.329	0.046		6	0.261	0.127		12	59
06-45-57	La Grange (MRFF)		13.3	11.1	22,096	74	2	0.336	0.019		1	0.278	0.021		24	22
06-45-58	La Grange (MRFF)		12.2	10.6	21,952	80	3	0.342	0.028		5	0.262	0.113		0	59
Total		Apr 15			44,048		5			0.024	6	0.262		0.067		
Mainstem San Joaquin																
06-45-60	Old Fisherman's Club (MRFF)	Apr 14	12.2	15.6	21,698	75	10	0.344	0.096		5	0.25	0.12		12	95
06-45-59	Old Fisherman's Club (MRFF)	Apr 16	12.2	13.3	23,071	73	12	0.32	0.117		4	0.261	0.086		12	116
Stanislaus River																
06-44-08	Knights Ferry (MRFF)		13.3	12.2	25,786	84	0				1	0.139	0.036		144	144
06-44-09	Knights Ferry (MRFF)		12.8	11.4	26,140	84	0				0				156	117
Total		May 18			51,926		0				1	0.139		0.018		
06-44-07	Knights Ferry (MRFF)	May 19	12.8	12.2	25,511	83	0				3	0.119	0.129		204	99
06-44-10	Two Rivers (MRFF)		14.4	20.6	25,712	85	0				4	0.164	0.123		276	471
06-44-11	Two Rivers (MRFF)		17.8	20.6	24,835	84	0				0				144	219
Total		May 20			50,547		0				4	0.164		0.063		

MRFF denotes Merced River Fish Hatchery

SMOLT SURVIVAL DATA
FOR SMOLTS RELEASED AT MOSSDALE, DURHAM FERRY (DF) AND JERSEY POINT BETWEEN 1994 AND 2000.

Year	Survival Index	No. of Fish Recovered	Release Temp	Size at Release	Survival Index	No. of Fish Recovered	Release Temp	Size at Release	Hatchery Stock	Ratio	Flow at Stockton	Flow at Vernalis	CVP & SWP Exports	Barrier Status
	Mossdale				Jersey Point									
1994	0	0	63	74	0.18	10	64	72	FRH	0.00	437	1387	1268	no barrier
1994	0.04	2	60	77	0.28	16	63	78	FRH	0.13	2468	2468	1671	barrier
1995	0.19	20	57	70	0.48	26	60	70	FRH	0.40	7363	18450	3666	no barrier
1996	0.02	2	59.5	78	0.5	25	62	78	FRH	0.04	2631	6673	1651	no barrier
1996	0.01	1	64	81	0.45	24	64	87	FRH	0.02	2475	6269	1517	no barrier
1997	0.19	10	60	100	1.03	55	63	99	FRH	0.18	5605	5905	2302	barrier (with 2 culverts)
1998	0.1	7	66	84	0.63	40	66	78	FRH	0.16	7692	18850	2004	no barrier
1998	0.56	88	57	86	1.84	187	62	89	MRFF	0.30	9140	22220	1616	no barrier
1999	0.28	36	62	79	0.73	59	63	81	MRFF	0.38	3161	6762	3161	no barrier
2000	0.19	18	56	79	0.62	65	64	82	MRFF	0.31	5936	6196	2332	barrier (with 2 open culverts)
2000	0.19 (DF)	28	57	80	0.62	65	64	82	MRFF	0.31	6077	6339	2335	barrier (with 2 open culverts)
2000	0.15(DF)	22	62	77	0.78	78	63	77	MRFF	0.19	4959	5702	1964	barrier (with 4 open culverts)

FRH denotes Feather River Hatchery

2000 CODED WIRE TAG RECOVERY INFORMATION

AT ANTIOCH AND CHIPPS ISLAND FOR MARKED FISH RELEASE AS PART OF THE VERNALIS ADAPTIVE MANAGEMENT PROGRAM

Tag Code	Release Site/Stock	Date	First Day Recovered	Last Day Recovered	Number Recovered	Minutes Fished	Survival Index	Group Survival	First Day Recovered	Last Day Recovered	Number Recovered	Minutes Fished	Survival Index	Group Survival
			Antioch Recovery Information						Chipps Island Recovery Information					
Merced River														
06-45-39	Upper Merced @ MRFF		Apr 26	Apr 27	2	950	0.017		Apr 25	May 09	5	5,635	0.098	
06-45-40	Upper Merced @ MRFF		Apr 24	Apr 29	9	2,863	0.077		Apr 25	Apr 28	3	1,400	0.063	
06-45-41	Upper Merced @ MRFF		Apr 25	Apr 26	2	1,103	0.015		Apr 24	Apr 26	4	1,200	0.074	
06-45-42	Upper Merced @ MRFF		Apr 23	Apr 25	2	1,488	0.016		Apr 25	May 07	5	4,835	0.099	
	Total	Apr 12	Apr 23	Apr 29	15	3,278		0.033	Apr 24	May 09	17	6,035		0.083
06-45-43	Hatfield State Park (MRFF)		Apr 22	Apr 27	8	2,906	0.070		Apr 22	Apr 28	5	2,600	0.103	
06-45-44	Hatfield State Park (MRFF)		Apr 23	May 02	9	4,738	0.080		Apr 21	Apr 26	6	2,400	0.115	
06-45-45	Hatfield State Park (MRFF)		Apr 20	Apr 30	8	5,096	0.073		Apr 23	Apr 24	2	800	0.038	
	Total	Apr 13	Apr 20	May 02	25	6,166		0.074	Apr 21	Apr 28	13	3,000		0.088
06-45-49	Upper Merced @ MRFF		May 04	May 04	3	597	0.020		May 06	May 19	5	5,255	0.098	
06-45-50	Upper Merced @ MRFF		May 04	May 04	2	597	0.013		May 04	May 19	6	6,055	0.110	
06-45-51	Upper Merced @ MRFF		May 04	May 13	8	4,980	0.068		May 05	May 05	1	400	0.019	
06-45-52	Upper Merced @ MRFF		May 04	May 13	7	4,980	0.058		May 04	May 20	4	6,455	0.078	
	Total	Apr 24	May 04	May 13	20	4,980		0.041	May 04	May 20	16	6,455		0.077
06-45-53	Hatfield State Park (MRFF)		Apr 25	May 13	13	9,250	0.107		May 06	May 12	5	2,555	0.099	
06-45-54	Hatfield State Park (MRFF)		May 04	May 14	5	5,540	0.039		May 08	May 11	4	1,400	0.082	
06-45-55	Hatfield State Park (MRFF)		Apr 27	May 12	10	7,687	0.085		May 05	May 15	6	4,055	0.120	
	Total	Apr 27	Apr 25	May 14	28	9,810		0.076	May 05	May 15	15	4,055		0.098
Tuolumne River														
06-45-56	La Grange (MRFF)	Apr 13	Apr 23	May 02	5	4,738	0.046		Apr 29	May 17	6	7,135	0.127	
06-45-57	La Grange (MRFF)		Apr 23	May 09	2	8,230	0.019		Apr 28	Apr 28	1	400	0.021	
06-45-58	La Grange (MRFF)		Apr 24	May 04	3	5,427	0.029		Apr 24	May 23	5	11,335	0.113	
	Total	Apr 15	Apr 23	May 09	5	8,230		0.024	Apr 24	May 23	6	11,335		0.067
Mainstem San Joaquin River														
06-45-60	Old Fisherman's Club (MRFF)	Apr 14	Apr 25	May 02	10	5,447	0.096		Apr 26	Apr 30	5	1,800	0.120	
06-45-59	Old Fisherman's Club (MRFF)	Apr 16	Apr 23	May 19	12	12,464	0.117		Apr 23	May 01	4	3,380	0.086	
Stanislaus River														
06-44-08	Knights Ferry (MRFF)				0				May 31	May 31	1	200	0.036	
06-44-09	Knights Ferry (MRFF)				0						0			
	Total	May 18							May 31	May 31	1	200		0.018
06-44-07	Knights Ferry (MRFF)	May 19			0				May 29	June 06	3	1,540	0.129	
06-44-10	Two Rivers (MRFF)				0				May 24	May 28	4	1,180	0.123	
06-44-11	Two Rivers (MRFF)				0						0		0.000	
	Total	May 20							May 24	May 28	4	1,180		0.063

MRFF denotes Merced River Fish Hatchery