CHAPTER 2

HYDROLOGIC PLANNING AND IMPLEMENTATION

Implementation of the Vernalis Adaptive Management Plan (VAMP) is guided by the framework provided in the San Joaquin River Agreement (SJRA) and recognition of the hydrologic conditions within the watershed. The Hydrology Group of the San Joaquin River Technical Committee (SJRTC) was established for the purpose of forecasting hydrologic conditions and for planning, coordinating, scheduling and implementing the flows required to meet the test flow target in the San Joaquin River near Vernalis. The Hydrology Group is also charged with exchanging information relevant to the forecasted flows, and coordinating with others in the SJRTC, in particular the Biology Group, whose responsibility is to plan and implement 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 water to meet a target flow. In 2010, the agencies belonging to the Hydrology Group included: Merced Irrigation District (MeID), Turlock Irrigation District (TID), Modesto Irrigation District (MID), Oakdale Irrigation District (OID), South San Joaquin Irrigation District (SSJID), San Joaquin River Exchange Contractors (SJRECWA), and the U.S. Bureau of Reclamation (USBR). Though not a water provider, the California Department of Water Resources (DWR) was closely involved with the coordination of operations relating to the potential installation of the Head of Old River Barrier (HORB) and the planning and coordination with the USBR on Delta exports consistent with the VAMP.

VAMP Background and Description

The VAMP provides for a steady 31-day pulse flow (target flow) at the Vernalis gage on the San Joaquin River (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 target flow period absent the VAMP (Existing Flow) as shown in Table 2-1. The Existing Flow is defined in the SJRA as "the forecasted flows in the San Joaquin River at Vernalis during the Pulse Flow Period that would exist absent the VAMP or water acquisitions," including such flows as minimum in-stream flows, water quality or scheduled fishery releases from New Melones Reservoir on the Stanislaus River, 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 as Defined in the San Joaquin River Agreement (SJRA)

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 SJRTC had identified a level of variation in San Joaquin River flow and SWP/CVP export rate thought to be within an acceptable range for specific VAMP test conditions. In developing the criteria, the SJRTC examined both the ability to effectively monitor and manage flows and exports within various ranges (e.g., the ability to accurately manage and regulate export rates is substantially greater than the ability to manage San Joaquin River flows) and the flow and

export differences among VAMP targets (Table 2-1). Through these discussions, the SJRTC agreed that SWP/CVP export rates would be managed to a level of plus or minus 2.5% of a given export rate target. Furthermore, the technical committees agreed that, to the extent possible, it would be desirable that exports be allocated approximately evenly between SWP and CVP diversion facilities.

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

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

The target flow of 2,000 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 2,000 cfs, the target flow will be 2,000 cfs and the USBR, in accordance with the SJRA, shall act to purchase additional water from willing sellers to fulfill the requirements of existing biological opinions.

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

Based upon hydrologic conditions, the target flow in a given year could either be increased to the next higher value (double-step) or the supplemental water requirement could be eliminated entirely (sequential dry-year relaxation). These potential adjustments to the target flow are dependent on the hydrologic year type as defined by the 60-20-20 Index, which is given a numerical indicator as shown in Table 2-2 to make this determination. A double-step flow year occurs when the sum of the numerical indicators for the previous year's year-type and current year's forecasted 90 percent exceedence year-type is seven (7) or greater, a general recognition of either abundant reservoir storage levels or a high probability of abundant runoff. A sequential dry-year relaxation 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 Classification Numerical Indicators Used in VAMP as Defined in the San Joaquin River Agreement (SJRA)

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

Under the SJRA, the maximum amount of supplemental water to be provided to meet VAMP target flows in any given year is 110,000 acre-feet. In a double-step year, the quantity of supplemental water required may be as high as 157,000 acre-feet. In any year in which more

than 110,000 acre-feet of supplemental water is needed, the USBR will attempt to acquire the needed additional water on a willing seller basis. In accordance with the SJRA, the SJRGA has agreed to extend a "favored purchaser" offer to the USBR through each current year's VAMP period.

2010 VAMP Year

The hydrologic conditions for the Water Year 2010[1] winter were very close to average in the San Joaquin River watershed, with seasonal precipitation in the San Joaquin Hydrologic Region (Cosumnes, Mokelumne, Stanislaus, Tuolumne, Merced and San Joaquin Rivers) measuring 100% of average on April 1, 2010[2]. The forecasted April-July runoff as of April 1st in the four basins above Vernalis (Stanislaus, Tuolumne, Merced and San Joaquin) ranged from 93% to 107% of average[2]. The April 1st-90% probability of exceedence forecast of the San Joaquin Valley Water Year Type Index (60-20-20 Index) is used to define the current year's numerical indicator for use in determining whether a "double-step", "single-step" or "sequential dry-year relaxation" condition exists. For this April 1st forecast, Water Year 2010 was classified as "below normal" with a numerical indicator of 3. The numerical indicators for 2008 and 2009 were 1 ("critical") and 2 ("dry"), respectively (Table 2-3). The sum of the 2009 and 2010 numerical indicators was 5 so the "double step" condition, which occurs when that sum is 7 or greater, was not in effect. Conversely, the sum of the 2008, 2009 and 2010 numerical indicators was 6 so the "sequential dry-year relaxation" condition, which occurs when that sum is 4 or less, was not in effect. Therefore, the "single-step" condition was in effect of the 2010 VAMP operation.

The planning process for the VAMP operation differed from that of prior VAMP years due to the introduction of the following factors:

1. The National Marine Fisheries Service (NMFS) Reasonable and Prudent Alternatives (RPAs) for the Stanislaus and San Joaquin Rivers. The RPAs specified required flows on the Stanislaus and San Joaquin Rivers depending on time of year and hydrologic conditions. Both of these flow requirements would be met through additional releases of flow from New Melones Reservoir on the Stanislaus River.

2. The one-year extension of the SJRA. Under this extension agreement the VAMP supplemental water and accompanying operation would be determined prior to the VAMP period and no adjustments to the supplemental water or operation would be made during the VAMP period. The agreement specifies that the Existing Flow for the Stanislaus River would be determined for VAMP planning purposes as if the New Melones Interim Plan of Operation were in effect. The consequence of this is that if the NMFS RPAs require more flow than is required for the VAMP operation, the flow in the San Joaquin River at Vernalis would likely exceed the VAMP flow target.

Table 2-3
Prior Year San Joaquin Valley Water Year Hydrologic Classifications Numerical Indicators Used in VAMP Planning

Year	60-20-20 Water Year Hydrologic Classification	VAMP Numerical Indicator
2000	Above Normal	4
2001	Dry	2
2002	Dry	2
2003	Below Normal	3
2004	Dry	2
2005	Wet	5
2006	Wet	5
2007	Critical	1
2008	Critical	1
2009	Dry	2
2010	Above Normal [a]	4

[a] Final Determination of the 60-20-20 Water Year Classification is not determined until July 1st of each year, after the VAMP period and may differ from the classification used during the April 1st, 90% exceedence forecast used for VAMP flow planning. The final determination of the 60-20-20 Water Year Clasificatiion will be used in next year's planning of VAMP flows.

An additional factor for 2010 that was not present previously was the San Joaquin River Restoration Program (Restoration Program). The Restoration Program requires additional releases from Millerton Lake to restore flows and salmon fishery between Millerton Lake and the Merced River. The initial releases under this program commenced in October 2009. The effect of the Restoration Program on the VAMP operation is to potentially reduce the uncertainty associated with the estimate of flow in the San Joaquin River at the Merced River. There was still some uncertainty with regard to how much of the Restoration Program flows would reach the Merced River in this initial year of the program, but the information gathered this year should prove helpful for future VAMP planning.

[1] *Water Year 2010 is October 2009 through September 2010.*

[2] *Water Conditions in California, California Cooperative Snow Surveys Bulletin 120, Report 3, April 1, 2010. California Department of Water Resources.*

Hydrologic Planning for 2010 VAMP

The SJRTC Hydrology Group held its initial meeting for the 2010 VAMP planning on February 24, 2010. The SJRTC Hydrology Group met two additional times in combination with the SJRTC Biology Group on March 17th and April 13th. At these meetings, forecasts of hydrologic and operational conditions on the San Joaquin River and its tributaries were discussed and refined. A telephone conference of the SJRTC was held on April 16, 2010 to finalize the VAMP period daily operation plan.

Initial Monthly Operation Forecast

As part of the initial planning efforts in February, a monthly operation forecast was developed by the Hydrology Group to provide an initial estimate of the Existing Flow and VAMP Target Flow. Inflows to the tributary reservoirs used in these forecasts were based on February 1st-DWR Bulletin 120 runoff forecasts. The monthly operation forecasts used the 90 percent and 50 percent probability of exceedence runoff forecasts to provide a range of estimates. The initial monthly operation forecast was presented at the February 24th SJRTC Hydrology Group meeting. The 90 percent probability of exceedence forecast indicated a VAMP target flow of 2,000 cfs and the 50 percent probability of exceedence forecast indicated a VAMP target flow of 3,200 cfs.

Daily Operation Plan Development

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

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

Flow Travel Times

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

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

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

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

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

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 immediately downstream of the Merced River confluence with the San Joaquin River at the San Joaquin River at Newman (NEW) gage and the gage on the Merced River near Stevinson (MST) which is immediately upstream of the Merced River inflow to the San Joaquin River).

A review of historical ungaged flows was made when the VAMP experiment was initially being developed 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. However, the review did indicate that the amount of ungaged flow at the beginning of the VAMP target flow period is a reasonable estimate of the average ungaged flow for target flow period. It is impossible to forecast day-to-day fluctuations of the ungaged flow, so the daily operation plan is developed assuming a constant ungaged flow throughout the target flow period essentially equal to the value entering the target flow period.

Table 2-4
Summary of Daily Operation Plans for the 2010 VAMP

Phase	VAMP Forecast Date	DWR Runoff Forecast Date	VAMP Target Flow Period	Single or Double Step	Assumed Ungaged Flow at Vernalis (cfs)	Existing Flow (cfs)	VAMP Target Flow (cfs)	SJRGA Supplemental Water Requirement (acre-feet)
Planning	3/16/10	3/9/10	April 25 - May 25	Single	600	2,870	3,200	20,480
					100	2,220	3,200	60,110
	4/12/10	3/23/10	April 25 - May 25	Single	300	3,020	3,200	11,010
Final	4/16/10	4/12/10	April 25 - May 25	Single	500	4,100	4,450	21,840

The VAMP 31-day target flow period can occur anytime between April 1st and May 31st. Factors that are considered in the determination of the timing of the VAMP target flow period include installation of HORB, availability of salmon smolt at the Merced River Hatchery (MRH), and manpower and equipment availability for salmon releases and tracking. Until a specific start date is defined, a default target flow period of April 15th to May 15th is used for the VAMP operation planning. Prior to the March Hydrology Group meeting the SJRTC had defined a VAMP target flow period of April 25th to May 25th for 2010 to allow the test salmon smolts to mature to the desirable size.

The initial daily operation plan was prepared on March 16th for the March 17th Hydrology Group meeting. Two versions of this plan were developed to account for hydrologic uncertainty, one considering wetter conditions and one considering drier conditions. Both conditions forecasted a VAMP Target Flow of 3,200 cfs with supplemental water requirements of about 20,500 acre-feet for the wetter condition and 60,000 acre-feet for the drier condition.

A second daily operation plan was prepared on April 12th. The DWR April 1st run-off forecast was not yet available when this plan was prepared, so it was based on the March 23rd interim runoff forecast. A single plan was developed at this time since the hydrologic condition uncertainty was much less due to the nearness of the VAMP flow period. The April 12th operation plan forecasted a VAMP Target Flow of 3,200 cfs, no change from the March 16th operation plan, but with a reduced supplemental water requirement of about 11,000 acre-feet.

The final daily operation plan was prepared on April 16th. As a result of cool and wet conditions in late March and early April and a corresponding increase in the run-off volume from the March 23rd forecast to the April 1st forecast the VAMP Target Flow increased to 4,450 cfs with a supplemental water requirement of 21,840 acre-feet. As stipulated by the SJRA Division Agreement the 21,840 acre-feet of supplemental water would be provided by Merced Irrigation District.

A key factor in the increased target flow from the April 12th operation plan to the April 16th operation plan was the need for increased flood control releases on the Tuolumne River. The uncertainty associated with flood control operations increased the uncertainty of achieving a stable flow for 31 days at Vernalis.

Table 2-4 provides a summary of the daily operation plans developed during the VAMP planning process. The daily operation plans are provided in their entirety in Appendix A, Tables 1 through 4.

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.

Implementation

Since the one year SJRA extension agreement stipulated that no changes to the proposed VAMP operation plan would be made once the VAMP operation commenced, the implementation phase of the VAMP hydrologic operation consisted mainly of monitoring the flow conditions during the VAMP period.

Table 2-5
Real-time Mean Daily Flow Data Sources Used in the 2010 VAMP

Measurement Location	Data Source
San Joaquin River near Vernalis	USGS, station 11303500 (http://waterdata.usgs.gov/ca/nwis/dv?cb_00060=on&format=html&begin_date=2010-01-01&end_date=&site_no=11303500&referred_module=sw)
Stanislaus River below Goodwin Dam	USBR, Goodwin Dam Daily Operation Report (http://www.usbr.gov/mp/cvo/vungvari/gdwdop.pdf)
Tuolumne River below LaGrange Dam	USGS, station 11289650 (http://waterdata.usgs.gov/ca/nwis/dv?cb_00060=on&format=html&begin_date=2010-01-01&end_date=&site_no=11289650&referred_module=sw)
Merced River at Cressey	CDEC, station CRS (http://cdec.water.ca.gov/cgi-progs/queryDgroups?s=fw2)
Merced River near Stevinson	CDEC, station MST (http://cdec.water.ca.gov/cgi-progs/queryDgroups?s=fw2)
San Joaquin River at Newman	USGS, station 11274000 (http://waterdata.usgs.gov/ca/nwis/dv?cb_00060=on&format=html&begin_date=2010-01-01&end_date=&site_no=11274000&referred_module=sw)

Table 2-6
Summary of USGS Flow Measurements at the San Joaquin River near Vernalis (VNS) Gage During the 2010 VAMP

Date	Time	Gage Height (ft.)	Measured Flow (cfs)	Rating Curve Shift (ft.)
2/11/10	10:58	10.63	2,560	-0.08
4/19/10	12:29	12.80	4,460	-0.34
4/26/10	11:29	13.82	5,530	-0.34
5/18/10	12:22	12.55	4,410	-0.31
7/13/10	12:18	9.13	1,530	+0.10

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 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. Arrangements were made with the USGS to measure the flow at Vernalis on a weekly basis during the VAMP target flow period in order to minimize the potential for these sudden and significant changes in the reported real-time flow. The results of these measurements are summarized in Table 2-6. There were no significant rating curve shifts experienced during the 2010 VAMP target flow period.

Results of Operations

The final record of flows during the VAMP period is based on the provisional mean daily flow data available from USGS, DWR and USBR as of October 1, 2010. 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, Figures 1 through 6, 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 5,140 cfs during the VAMP target flow period (April 25th – May 25th). Figure 2-2 shows the observed flows at Vernalis and at each of the tributary measurement points. The mean daily flow at Vernalis varied between 4,210 cfs and 5,890 cfs during the target flow period. A tabulation of the observed mean daily flows during and around the VAMP target flow period is provided in Table 2-7. The primary reason for the deviation of the observed flow from the target flow was the flood control operations on the Tuolumne River, which required higher releases from Don Pedro Reservoir than anticipated during the development of the VAMP daily operation plan. Additionally, flows in the San Joaquin River upstream of the Merced River were

generally higher than expected, possibly the result of less loss from the restoration flows than expected.

Merced Irrigation District provided 23,980 acre-feet of supplemental water during the VAMP flow period. The deviation from the forecasted supplemental water contribution of 21,840 acre-feet is likely due to operational limitations and error and uncertainty in real-time gage flow data.

The mean daily ungaged flow at Vernalis averaged 190 cfs during the VAMP period, ranging from a minimum of -312 cfs to a maximum of 667 cfs. A plot of the ungaged flow is provided in Figure 2-3.

The combined CVP and SWP Delta export rate target during the VAMP period was 1,500 cfs. The observed exports during this period, shown in Figure 2-4, averaged 1,520 cfs and ranged from 1,320 cfs to 1,560 cfs.

Hydrologic Impacts

The MeID 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, especially in below normal or dry years. Reservoir storage impacts are reduced or eliminated when the reservoirs make flood control releases.

If it is assumed that Merced ID diversions from the Merced River are the same as they would have been without the SJRA, then the storage impact on Lake McClure entering the 2010 VAMP operation was -104,610 acre-feet, as shown in Figure 2-5. 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 2-5. The impact of the Merced ID SJRA related conservation measures on Merced River diversions have not yet been quantified. Following the 2010 VAMP flow period flood control releases from Lake McClure were required resulting in the elimination of the aforementioned hypothetical storage deficit. 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 ten years of VAMP operation as shown in Appendix B, Figure 3.

The cumulative storage impact to Don Pedro Reservoir entering into 2010 was -19,650 acre-feet (Figure 2-6). This storage deficit was eliminated by the flood control operations made in 2010.

Summary of Historical VAMP Operations

The year 2010 marks the eleventh year of VAMP operation in compliance with State Water Board Decision 1641 (D-1641). A summary of the VAMP target flows for these first eleven years is provided in Table 2-8. A summary of the SJRGA supplemental water contributions is provided in Table 2-9. 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 eleven years of VAMP operation are provided in Appendix B, Figures 1 through 4.

Over the eleven 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.

State Water Board D-1641 Reservoir Refill

Reservoir refill, or replenishment, is noted in three places in D-1641:

The first description of reservoir refill or replenishment is noted in condition 7 on page 168 of D-1641 which states that:

IT IS FURTHER ORDERED that Licenses 990, 2684, 2685, 6047, 11395, and 11396 (Applications 1221, 1222, 1224, 10572, 16186, and 16187, respectively) of the Merced Irrigation District, Licenses 7856 and 7860 (Applications 10872 and 13310, respectively) of the Oakdale and South San Joaquin Irrigation Districts, and Licenses 5417 and 11058 (Applications 1233 and 14127, respectively) of the Turlock and Modesto Irrigation Districts shall be amended

by adding the following conditions which shall expire on December 31, 2011 or at such time as the San Joaquin River Agreement (SJRA) is terminated, whichever occurs first.

Condition 7 specifically states that (bold emphasis added for those related to reservoir refill):

(7.) Annually, Licensees shall submit an operations report to the Executive Director of the SWRCB by January 30 of the year following each year of operation under the SJRA. The report shall identify (a) the source and quantity of water released from storage, or storage and direct diversions foregone to meet the April-May pulse flow objective in the San Joaquin River at Airport Way Bridge in Vernalis; (b) the time period when this water was released from storage, or not diverted; ***(c) a monthly accounting of reservoir operations to refill reservoir storage;*** *(d) the source and quantity of water transferred to the USBR pursuant to the terms of the SJRA; (e) the quantity, timing, and location of groundwater extractions made to maintain water supply deliveries due to the SJRA; (f) the time period in which water sold to the USBR was released from storage or not diverted; and* ***(g) an analysis showing that all storage releases, storage and direct diversions foregone, and replenishment operations listed above were performed within the limits, terms and conditions of these licenses.***

The second description of reservoir refill or replenishment is noted in condition 3 on page 169 of D-1641 which states that:

IT IS FURTHER ORDERED that Licenses 990, 2684, 2685, 6047, 11395, and 11396 (Applications 1221, 1222, 1224, 10572, 16186, and 16187, respectively) of the Merced Irrigation District be amended by adding the following conditions which shall expire on December 31, 2011 or at such time as the San Joaquin River Agreement (SJRA) is terminated, whichever occurs first.

Condition 3 specifically states that:

(3.) At times when the USBR is releasing water from New Melones Reservoir for the purpose of meeting the Vernalis salinity objective, or when Standard Permit Term 93 is in effect, or when salinity objectives at Vernalis are not being met, Licensee shall not replenish (1) stored water or foregone diversions provided for the April-May pulse flow or the October target flow at Vernalis, or (2) water transferred to the USBR pursuant to the SJRA. The Executive Director of the SWRCB is delegated authority to ensure that this condition is not used by the USBR to increase the obligation of Licensee.

The third description of reservoir refill or replenishment is noted on page 170 of D-1641 which states that:

IT IS FURTHER ORDERED that Licenses 5417 and 11058 (Applications 1233 and 14127, respectively) of the Modesto and Turlock Irrigation Districts shall be amended by adding the following conditions which shall expire on December 31, 2011 or at such time as the San Joaquin River Agreement (SJRA) is terminated, whichever occurs first.

At times when the USBR is releasing water from New Melones Reservoir for the purpose of meeting the Vernalis salinity objective, or when Standard Permit Term 93 is in effect, or when salinity objectives at Vernalis are not being met, Licensees shall not replenish (1) stored water or foregone diversions provided for the April/May pulse flow at Vernalis, or (2) water transferred to the USBR pursuant to the San Joaquin River Agreement. The Executive Director of the SWRCB is delegated authority to ensure that this condition is not used by the USBR to increase the obligation of Licensee.

Tables 2-10 and 2-11 summarize when supplemental water was provided and when the storage was theoretically replenished for Lake McClure and Don Pedro Reservoir (refill), respectively. It should be noted that, contrary to the implication in the D-1641 conditions noted above, one does not choose when to replenish or refill. Refill occurs when reservoir releases under the hypothetical "without D-1641" scenario would be less than those that actually occur. There are two conditions that would cause this: 1) when the reservoir fills (i.e. when storage reaches the top of the allowable conservation storage), and 2) when the reservoir empties.

Another factor that would affect the size of the "hole" in the reservoir that would eventually be refilled is conservation by the irrigation districts that reduces diversions from the rivers downstream of the reservoirs that is a direct result of the SJRA. In other words, if a district provides 10,000 ac-ft of supplemental water from storage and subsequently has no changes in diversions from the river downstream of the reservoir, then the "hole" in the reservoir would be 10,000 ac-ft. However, if the district were paid for providing that supplemental water and used those funds to improve their efficiency (as is the case with the SJRA) which in turn results in reduced diversions from the river, which would back up the amount of reduction into the reservoir, reducing the "hole" that would need to be refilled. Since the effects of SJRA related conservation have not yet been quantified, the refill analysis presented herein assumes that demands on the rivers are the same both with and without D-1641.

As shown in Tables 2-10 and 2-11, even without accounting for the reduced river diversions due to SJRA-related conservation projects, reservoir refill has not

occurred during times when *"the USBR is releasing water from New Melones Reservoir for the purpose of meeting the Vernalis salinity objective or when Standard Permit Term 93 is in effect, or when salinity objectives at Vernalis are not being met."*

Plots comparing the theoretical without D-1641 storage and release for Lake McClure and Don Pedro Reservoir with the observed, or with D-1641, storage and release for the reservoir refill periods are provided in Appendix C, Figures 1 through 8. These plots illustrate the determination of the refill periods. Plots showing the Vernalis water quality condition during the refill periods and the corresponding Stanislaus River flow are provided in Appendix D, Figures 1 through 8. These plots provide the support for determining whether or not *"the USBR is releasing water from New Melones Reservoir for the purpose of meeting the Vernalis salinity objective, or when Standard Permit Term 93 is in effect, or when salinity objectives at Vernalis are not being met"*.

Table 2-7
2010 Vernalis Adaptive Management Plan (VAMP)
Final Flows and Accounting of Supplemental Water Contributions
VAMP Target Flow Period: April 25th – May 25th · Target Flow: 4,450 cfs

Date	Merced R. at Cressey				Tuolumne R. blw LaGrange Dam			Stanislaus R. blw Goodwin Dam			San Joaquin R. above Merced R. Flow [2] (cfs)	Ungaged Flow at Vernalis (cfs)	San Joaquin River at Vernalis		
	(3 day Travel Time to Vernalis) Existing Flow [1] (cfs)	Observed Flow (cfs)	Merced ID Supplemental Flow (cfs)	Exchange Contractors Supplemental Flow (cfs)	(2 day Travel Time to Vernalis) Existing Flow [1] (cfs)	Observed Flow (cfs)	MID/TID Supplemental Flow (cfs)	(2 day Travel Time to Vernalis) Existing Flow [1] (cfs)	Observed Flow (cfs)	OID/SSJID Supplemental Flow (cfs)			Existing Flow [1] (cfs)	Observed Flow (cfs)	VAMP Supplemental Water (cfs)
04/01/10	232	232			480	480		1,274	1,274		882	360	1,920	1,920	
04/02/10	189	189			634	634		1,354	1,354		853	377	2,040	2,040	
04/03/10	171	171			652	652		1,355	1,355		847	(171)	2,700	2,700	
04/04/10	163	163			652	652		1,359	1,359		861	(33)	3,040	3,040	
04/05/10	213	213			651	651		1,365	1,365		897	307	3,350	3,350	
04/06/10	203	203			653	653		1,353	1,353		952	457	3,500	3,500	
04/07/10	194	194			652	652		1,356	1,356		1,052	494	3,570	3,570	
04/08/10	198	198			652	652		1,358	1,358		1,101	459	3,630	3,630	
04/09/10	188	188			707	707		1,170	1,170		1,075	297	3,560	3,560	
04/10/10	178	178			759	759		1,005	1,005		1,068	195	3,500	3,500	
04/11/10	206	206			760	760		1,006	1,006		1,050	290	3,440	3,440	
04/12/10	227	227			1,080	1,080		1,014	1,014		1,079	610	3,630	3,630	
04/13/10	268	268			1,270	1,270		1,006	1,006		1,108	696	3,690	3,690	
04/14/10	251	251			1,260	1,260		999	999		1,136	691	4,070	4,070	
04/15/10	231	231			1,330	1,330		1,007	1,007		1,246	569	4,180	4,180	
04/16/10	218	218			1,580	1,580		1,022	1,022		1,291	567	4,230	4,230	
04/17/10	200	200			1,770	1,770		1,006	1,006		1,235	526	4,360	4,360	
04/18/10	205	205			1,950	1,950		1,008	1,008		1,146	366	4,490	4,490	
04/19/10	211	211			1,980	1,980		1,007	1,007		1,091	291	4,520	4,520	
04/20/10	221	221			2,140	2,140		1,010	1,010		1,074	366	4,670	4,670	
04/21/10	267	267			2,150	2,150		1,004	1,004		1,055	717	5,000	5,000	
04/22/10	250	567	317	0	2,130	2,130		1,000	1,000		1,087	595	5,030	5,030	
04/23/10	250	728	478	0	2,160	2,160	0	1,006	1,006	0	1,110	660	5,090	5,090	
04/24/10	250	907	657	0	1,990	1,990	0	1,007	1,007	0	1,190	826	5,310	5,310	
04/25/10	250	965	715	0	1,770	1,770	0	1,008	1,008	0	1,190	667	5,193	5,510	317
04/26/10	250	965	715	0	1,750	1,750	0	1,004	1,004	0	1,140	635	5,072	5,550	478
04/27/10	250	965	715	0	1,750	1,750	0	1,003	1,003	0	1,100	605	4,823	5,480	657
04/28/10	250	961	711	0	1,740	1,740	0	1,003	1,003	0	1,040	501	4,645	5,360	715
04/29/10	250	725	475	0	1,770	1,770	0	1,005	1,005	0	1,010	472	4,575	5,290	715
04/30/10	250	493	243	0	2,090	2,090	0	1,003	1,003	0	1,023	342	4,375	5,090	715
05/01/10	250	416	166	0	2,350	2,350	0	1,005	1,005	0	1,027	224	4,259	4,970	711
05/02/10	250	427	177	0	2,340	2,340	0	1,001	1,001	0	963	159	4,525	5,000	475
05/03/10	250	414	164	0	2,560	2,560	0	1,005	1,005	0	938	105	4,737	4,980	243
05/04/10	250	503	253	0	3,300	3,300	0	1,015	1,015	0	942	40	4,594	4,760	166
05/05/10	250	786	536	0	3,280	3,280	0	1,005	1,005	0	895	210	4,963	5,140	177
05/06/10	250	776	526	0	3,280	3,280	0	1,012	1,012	0	831	(161)	5,346	5,510	164
05/07/10	250	773	523	0	3,290	3,290	0	1,025	1,025	0	905	(63)	5,367	5,620	253
05/08/10	250	768	518	0	3,290	3,290	0	1,017	1,017	0	924	(289)	5,084	5,620	536
05/09/10	250	582	332	0	3,280	3,280	0	1,018	1,018	0	878	(276)	5,194	5,720	526
05/10/10	250	412	162	0	3,290	3,290	0	1,015	1,015	0	919	(114)	5,367	5,890	523
05/11/10	250	364	114	0	3,300	3,300	0	1,025	1,025	0	924	(164)	5,262	5,780	518
05/12/10	250	356	106	0	3,120	3,120	0	1,011	1,011	0	877	(216)	5,258	5,590	332
05/13/10	250	344	94	0	2,680	2,680	0	1,028	1,028	0	790	(241)	5,258	5,420	162
05/14/10	250	470	220	0	2,580	2,580	0	1,017	1,017	0	667	(312)	4,946	5,060	114
05/15/10	250	641	391	0	2,440	2,440	0	1,016	1,016	0	547	(134)	4,614	4,720	106
05/16/10	250	650	400	0	2,230	2,230	0	876	876	0	448	112	4,626	4,720	94
05/17/10	250	655	405	0	2,160	2,160	0	790	790	0	473	87	4,340	4,560	220
05/18/10	250	646	396	0	2,160	2,160	0	818	818		478	95	3,899	4,290	391
05/19/10	250	662	412	0	2,150	2,150	0	824	824		476	137	3,810	4,210	400
05/20/10	250	647	397	0	2,140	2,140	0	811	811		504	99	3,805	4,210	405
05/21/10	250	635	385	0	2,150	2,150	0	806	806		441	184	3,884	4,280	396
05/22/10	250	632	382	0	3,060	3,060	0	814	814		413	133	3,838	4,250	412
05/23/10	417	417			3,140	3,140	0	688	688		428	566	4,213	4,610	397
05/24/10	342	342			3,150	3,150		384	384		468	148	4,685	5,070	385
05/25/10	343	343			3,140	3,140		206	206		520	42	4,548	4,930	382
05/26/10	335	335			3,160	3,160		209	209		536	341	4,760	4,760	
05/27/10	350	350			2,610	2,610		214	214		555	532	4,740	4,740	
05/28/10	351	351			2,250	2,250		206	206		663	362	4,610	4,610	
05/29/10	339	339			2,050	2,050		203	203		745	676	4,390	4,390	
05/30/10	345	345			2,040	2,040		204	204		816	721	4,190	4,190	
05/31/10	346	346			2,040	2,040		202	202		854	741	4,090	4,090	
VAMP Period															
Average (cfs):	244	557	388	0	2,449	2,449	0	999	999	0	950	190	4,831	5,144	389
Supplemental Water (ac-ft):			23,980	0			0			0					23,980

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, 9/14/10

Merced River near Stevinson (CA DWR B05125): California DWR, USDAY V71 Output 8/25/10

Tuolumne River below LaGrange Dam near LaGrange (USGS 11289650): USGS, provisional data as of 9/14/10

Stanislaus River below Goodwin Dam: USBR, Goodwin Reservoir Daily Operations Report - OID/SSJID/Tri-Dams, 5/1/10 (April report) and 6/1/10 (May report)

San Joaquin River near Vernalis (USGS 11303500): USGS, provisional data as of 9/14/10

San Joaquin River at Newman (USGS 11274000): USGS, provisional data as of 9/14/10

Table 2-8
Summary of VAMP Flows, 2000-2010

Year	VAMP Target Flow Period	VAMP Target Flow Condition	VAMP Target Flow (cfs)	Observed VAMP Period Mean Flow (cfs)	Existing Flow (cfs)	VAMP Supplemental Water (acre-feet)	Delta Export Target (cfs)	Observed Delta Exports (cfs)
2000	4/15 - 5/15	Double-step	5,700	5,869	4,800	77,680	2,250	2,155
2001	4/20 - 5/20	Single-step	4,450	4,224	2,909	78,650	1,500	1,420
2002	4/15 - 5/15	Single-step	3,200	3,301	2,757	33,430	1,500	1,430
2003	4/15 - 5/15	Single-step	3,200	3,235	2,290	58,065	1,500	1,446
2004	4/15 - 5/15	Single-step	3,200	3,155	2,088	65,591	1,500	1,331
2005	5/1 - 5/31	na [a]	>7,000	10,390	10,390	0	2,250	2,986 [b]
2006	5/1 - 5/31	na [a]	>7,000	26,220/24,262 [c]	26,020	0	1,500/6,000	1,559/5,748 [c]
2007	4/22 - 5/22	Single-step	3,200	3,263	2,721	33,330	1,500	1,486
2008	4/22 - 5/22	Single-step	3,200	3,163	1,939	75,250	1,500	1,520
2009	4/19 - 5/19	Off-ramp	na	2,260	2,260	0	na	1,990
2010	4/25 - 5/25	Single-step	4,450	5,140	4,830	23,980	1,500	1,515

[a] Existing flow greater than maximum VAMP Target Flow of 7,000 cfs
[b] 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.
[c] "First fish release-recapture period"/"Second fish release-recapture period"

Table 2-9
Summary of VAMP Supplemental Water Contributions, 2000 - 2010

Year	VAMP Supplemental Water (acre-feet)		Supplemental Water (acre-feet) Merced ID	Oakdale ID	South San Joaquin ID	SJRECWA	Modesto ID	Turlock ID
2000	77,680	Observed:	42,770	7,300 [a]	7,300 [b]	8,280	5,580	6,450
		Division Agreement:	41,180	7,300	7,300	7,300	7,300	7,300
		Deviation:	+ 1590			+ 980	- 1,720	- 850
2001	78,650	Observed:	42,120	7,365	7,365	7,740	7,030	7,030
		Division Agreement:	42,150	7,300	7,300	7,300	7,300	7,300
		Deviation:	- 30	+ 65	+ 65	+ 440	- 270	- 270
2002	33,430	Observed:	25,840	3,795	3,795	0	0	0
		Division Agreement:	25,000	4,215	4,215	0	0	0
		Deviation:	+ 840	- 420	- 420	0	0	0
2003	58,065	Observed:	33,257	5,039	5,039	5,000 [c]	4,865	4,865
		Division Agreement:	33,065	5,000	5,000	5,000	5,000	5,000
		Deviation:	+ 192	+ 39	+ 39		- 135	- 135
2004	65,591	Observed:	37,680	5,880	5,880	5,000 [c]	5,576	5,576
		Division Agreement:	36,500	7,045.5	7,045.5	5,000	5,000	5,000
		Deviation:	+ 1,180	- 1165.5	- 1165.5		+ 576	+ 576
2005	0 [e]	Observed:	0	0	0	0	0	0
		Division Agreement:	0	0	0	0	0	0
		Deviation:	0	0	0	0	0	0
2006	0 [e]	Observed:	0	0	0	0	0	0
		Division Agreement:	0	0	0	0	0	0
		Deviation:	0	0	0	0	0	0
2007	33,330	Observed:	28,960	2,185 [d]	2,185 [d]	0	0	0
		Division Agreement:	25,000	4,165	4,165	0	0	0
		Deviation:	+ 3,960	- 1,980	- 1,980	0	0	0
2008	75,250	Observed:	38,150	7,260	7,260	7300 [c]	7,640	7,640
		Division Agreement:	38,750	7,300	7,300	7,300	7,300	7,300
		Deviation:	- 600	- 40	- 40	0	+ 340	+ 340
2009	0 [f]	Observed:	0	0	0	0	0	0
		Division Agreement:	0	0	0	0	0	0
		Deviation:	0	0	0	0	0	0
2010	23,980	Observed:	23,980	0	0	0	0	0
		Division Agreement:	23,980	0	0	0	0	0
		Deviation:	0	0	0	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
[e] Existing Flow greater than 7,000 cfs.
[f] Sequential dry-year relaxation.

Table 2-10
Summary of When Supplemental Water Was Provided and When Storage Was Theoretically Replenished for Lake McClure on the Merced River as Required Under D-1641

Date Range	D-1641 Supplemental Water [SJRA year] (ac-ft)	Reservoir Refill (ac-ft)	Storage Impact (ac-ft)	Vernalis Status [1]
4/18/00 - 5/11/00	46,750 [2000]		-46,750	
5/13/00 - 5/29/00		46,750	0	N
10/15/00 - 12/31/00	12,500 [2000]		-12,500	
4/17/01 - 5/19/01	42,120 [2001]		-54,620	
11/12/01 - 12/31/01	12,500 [2001]		-67,120	
4/13/02 - 5/15/02	25,840 [2002]		-92,960	
10/15/02 - 10/31/02	12,470 [2002]		-105,430	
4/11/03 - 5/16/03	38,260 [2003]		-143,690	
10/1/03 - 10/27/03	12,500 [2003]		-156,190	
4/12/04 - 5/13/04	42,680 [2004]		-198,870	
10/1/04 - 10/26/04	12,500 [2004]		-211,370	
1/25/05 - 3/23/05		211,370	0	N
8/26/05 - 9/3/05		12,500	12,500	N
10/1/05 - 10/26/05	12,500 [2005]		0	
10/8/06 - 10/28/06	12,500 [2006]		-12,500	
4/19/07 - 5/19/07	28,960 [2007]		-41,460	
11/6/07 - 12/17/07	12,500 [2007]		-53,960	
4/22/08 - 5/19/08	38,150 [2008]		-92,110	
10/1/08 - 10/24/08	12,500 [2008]		-104,610	
10/1/09 - 10/31/09	12,500 [2009]		-117,110	
4/22/10 - 5/22/10	23,970 [2010]		-141,080	
4/13/10 - 5/23/10		141,080	0	N
10/15/10 - 11/8/10	12,500 [2010]		-12,500	
11/27/10 - 12/8/10		12,500	0	N

[1] Y = USBR releasing water from New Melones Reservoir for Vernalis WQ
N = USBR not releasing water from New Melones Reservoir for Vernalis WQ

Table 2-11
Summary of When Supplemental Water Was Provided and When Storage Was Theoretically Replenished for Don Pedro Reservoir on the Tuolumne River as Required Under D-1641

Date Range	(ac-ft)	Reservoir Refill (ac-ft)	Storage Impact (ac-ft)	Vernalis Status [1]
4/13/00 - 5/12/00	22,650 [2000]		-22,650	
9/27/00 - 10/7/00		14,950	-7,700	N
3/23/01 - 3/28/01		4,610	-3,090	N
4/18/01 - 5/18/01	14,060 [2001]		-17,150	
4/13/03 - 5/13/03	9,730 [2003]		-26,880	
3/10/04 - 3/16/04		12,590	-14,290	N
3/27/04 - 4/1/04		14,290	0	N
4/13/04 - 5/13/04	11,150 [2004]		-11,150	
3/21/05 - 3/24/05		11,150	0	N
4/20/07 - 5/6/07	4,370 [2007]		-4,370	
4/20/08 - 5/20/08	15,280 [2008]		-19,650	
4/8/10 - 4/17/10		19,650	0	N

[1]
Y = USBR releasing water from New Melones Reservoir for Vernalis WQ
N = USBR not releasing water from New Melones Reservoir for Vernalis WQ

Figure 2-2
Recorded Flows during the 2010 VAMP on the San Joaquin River at Vernalis (VNS) and the Three Tributaries (Stanislaus, Tuolumne and Merced Rivers) Inflowing into the San Joaquin River above Vernalis

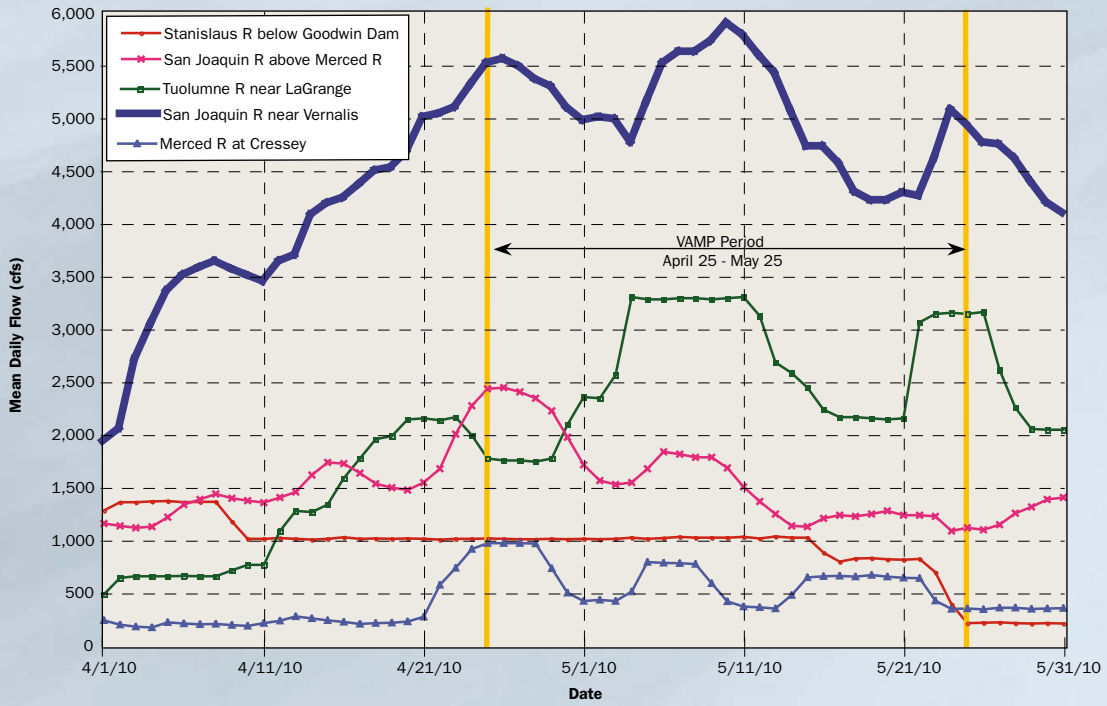

Figure 2-3
Ungaged Flow in the San Joaquin River at Vernalis (VNS) during the 2010 VAMP

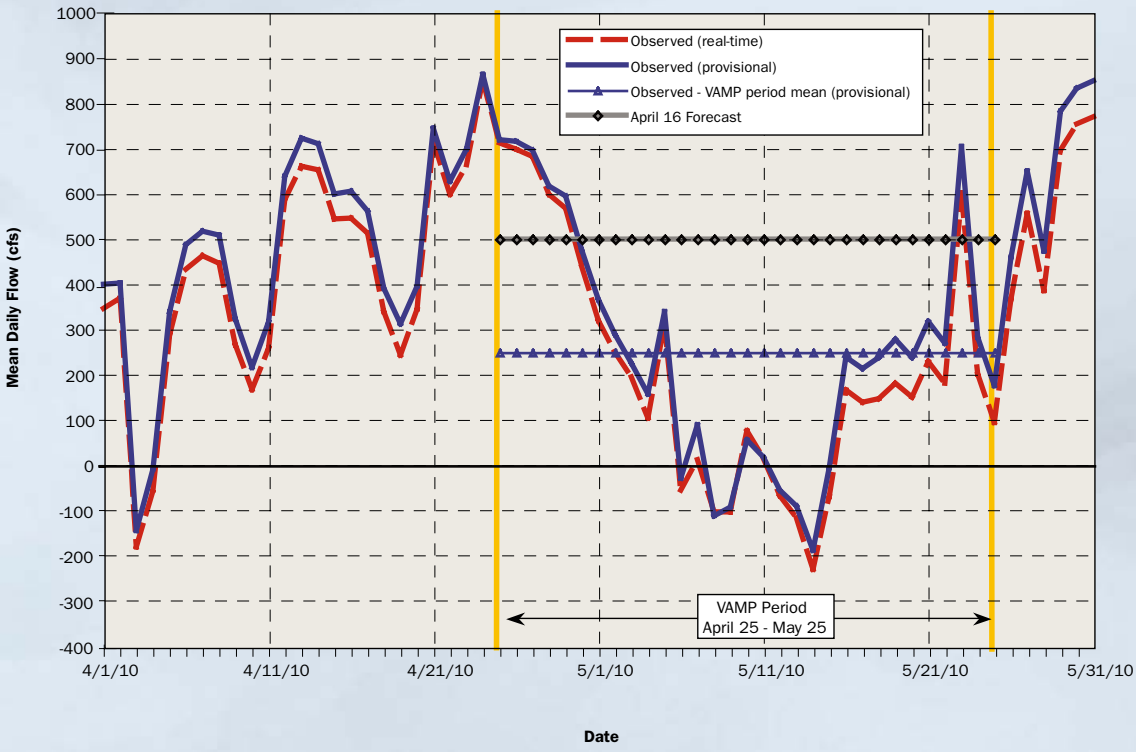

Figure 2-4
Federal and State Delta Exports during the 2010 VAMP

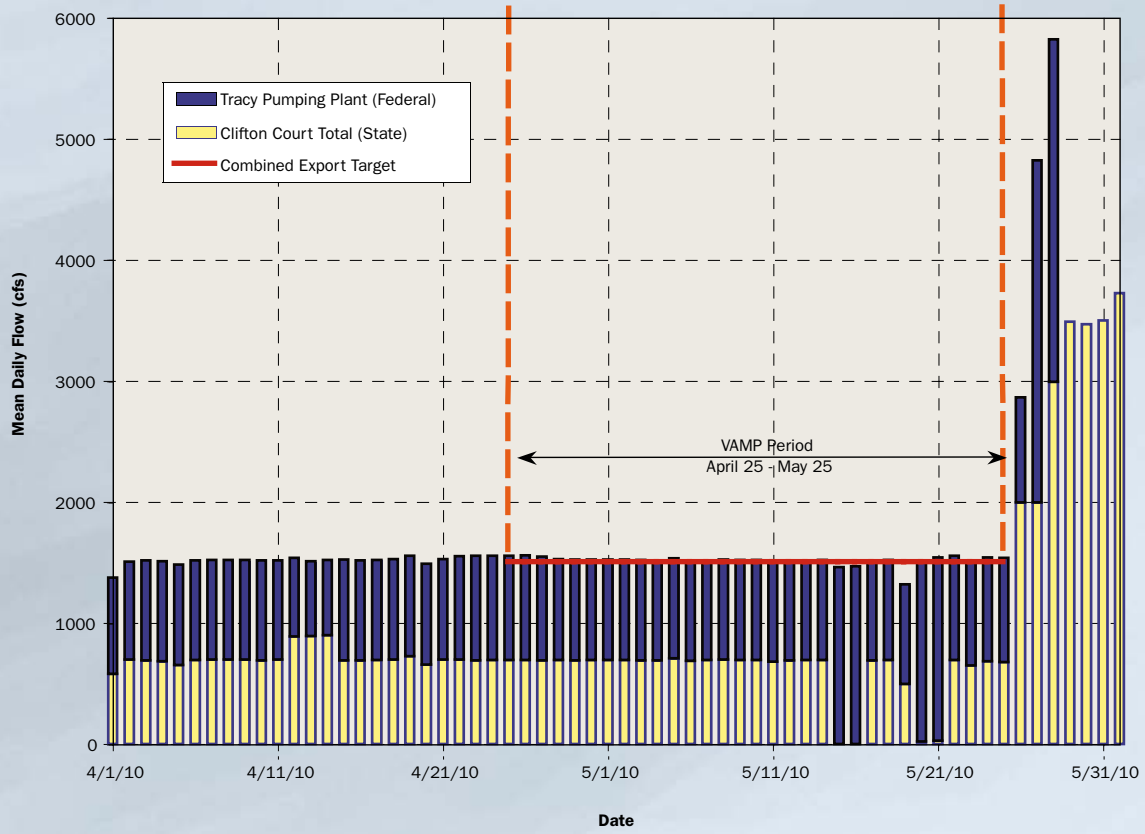

Figure 2-5
San Joaquin River Agreement (SJRA) Storage and Flow Impacts
Merced River – Lake McClure Storage and Release - 2010

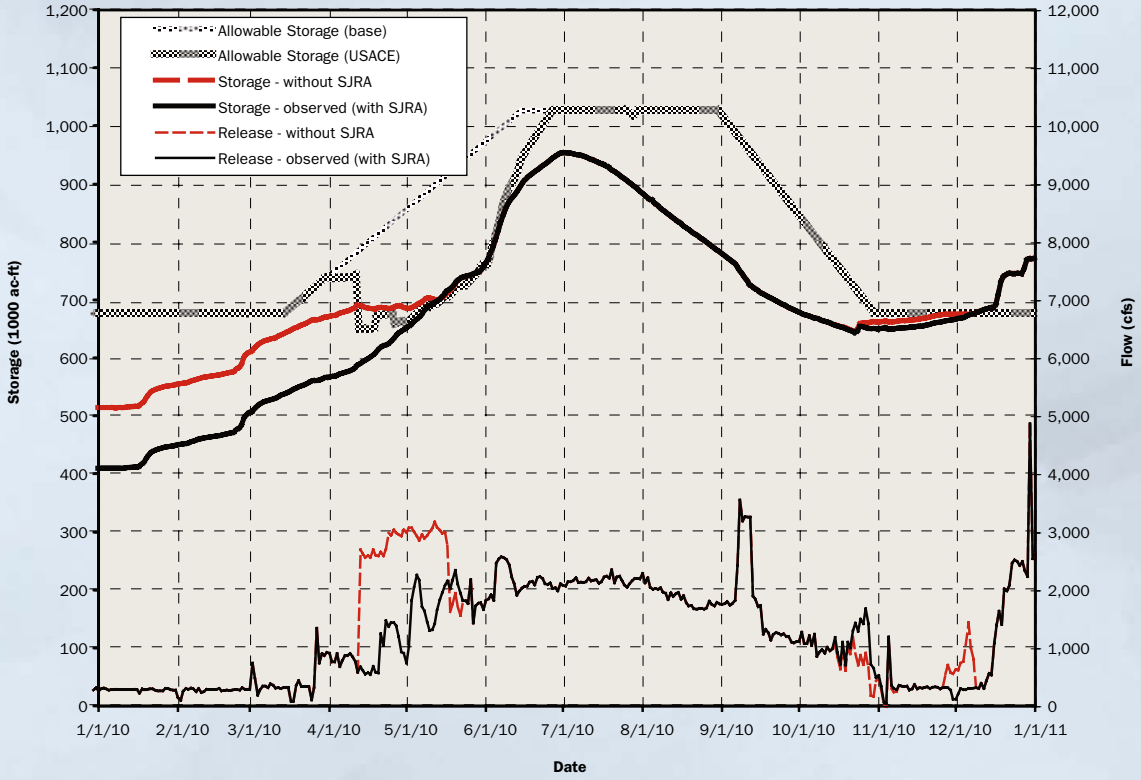

Figure 2-6
San Joaquin River Agreement (SJRA) Storage and Flow Impacts on the Tuolumne River – New Don Pedro Reservoir Storage and Release - 2010