



# 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<sup>1</sup> 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.

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

<sup>1</sup>Water Year 2007 is October 2006 through September 2007.

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 (SJRGAA) 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 SJRGAA 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.

<b>60-20-20 Water Year Classification</b>	<b>VAMP Numerical Indicator</b>
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)	SJRG 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	
					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:

$$\text{Ungaged flow at Vernalis} = \text{VNS} - \text{GDW}_{\text{lag}} - \text{LGN}_{\text{lag}} - \text{CRS}_{\text{lag}} - \text{USJR}_{\text{lag}}$$

Where:

VNS = San Joaquin River near Vernalis

GDW = Stanislaus River below Goodwin Dam lagged 2 days

LGN<sub>lag</sub> = Tuolumne River below LaGrange Dam lagged 2 days

CRS<sub>lag</sub> = Merced River at Cressey lagged 3 days

USJR<sub>lag</sub> = 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 ( <a href="http://waterdata.usgs.gov/ca/nwis/dv?format=pre&amp;period=31&amp;site_no=11303500">http://waterdata.usgs.gov/ca/nwis/dv?format=pre&amp;period=31&amp;site_no=11303500</a> )
Stanislaus River below Goodwin Dam	USBR, Goodwin Dam Daily Operation Report ( <a href="http://www.usbr.gov/mp/cvo/vungvari/gdwdop.pdf">http://www.usbr.gov/mp/cvo/vungvari/gdwdop.pdf</a> )
Tuolumne River below LaGrange Dam	USGS, station 11289650 ( <a href="http://waterdata.usgs.gov/ca/nwis/dv?format=pre&amp;period=31&amp;site_no=11289650">http://waterdata.usgs.gov/ca/nwis/dv?format=pre&amp;period=31&amp;site_no=11289650</a> )
Merced River at Cressey	CDEC, station CRS ( <a href="http://cdec.water.ca.gov/cgi-progs/queryDgroups?s=fw2">http://cdec.water.ca.gov/cgi-progs/queryDgroups?s=fw2</a> )
Merced River near Stevenson	CDEC, station MST ( <a href="http://cdec.water.ca.gov/cgi-progs/queryDgroups?s=fw2">http://cdec.water.ca.gov/cgi-progs/queryDgroups?s=fw2</a> )
San Joaquin River at Newman	USGS, station 11274000 ( <a href="http://waterdata.usgs.gov/ca/nwis/dv?format=pre&amp;period=31&amp;site_no=11274000">http://waterdata.usgs.gov/ca/nwis/dv?format=pre&amp;period=31&amp;site_no=11274000</a> )

**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.

## 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 May 15, 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

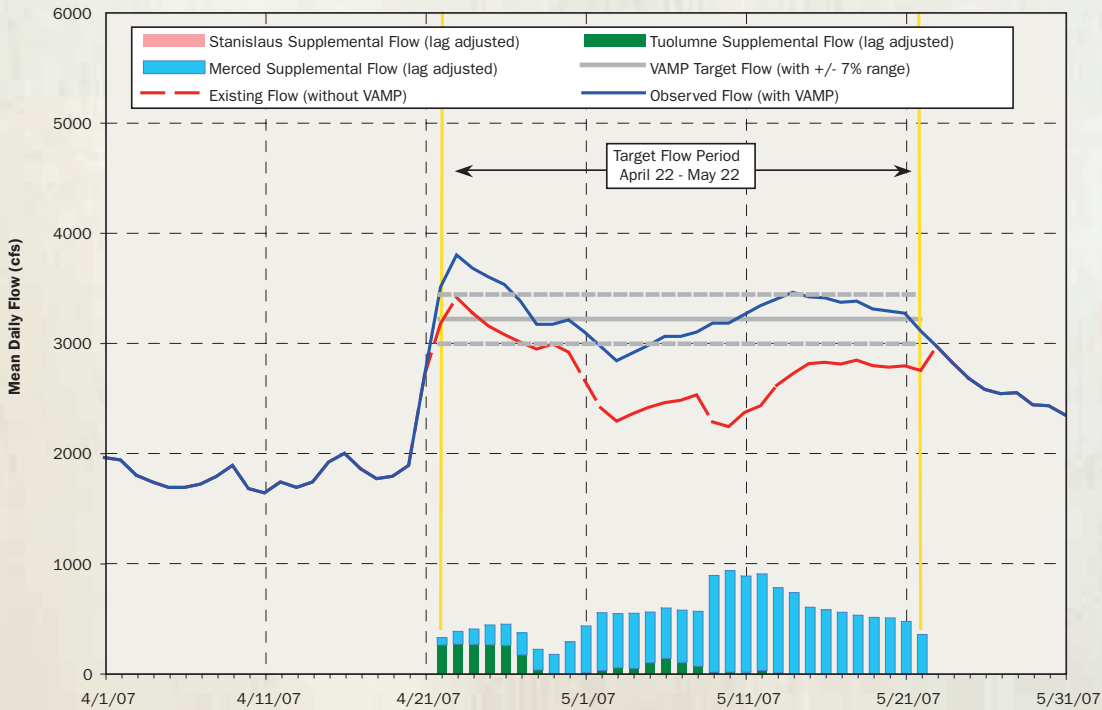
2007 marks the eighth year of VAMP operation in compliance with D-1641. A summary of the VAMP target flows for these first eight years is provided in Table 2-7. A summary of the SJRGA supplemental water contributions is provided in Table 2-8. The SJRTC Hydrology Group monitors the cumulative impact of 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

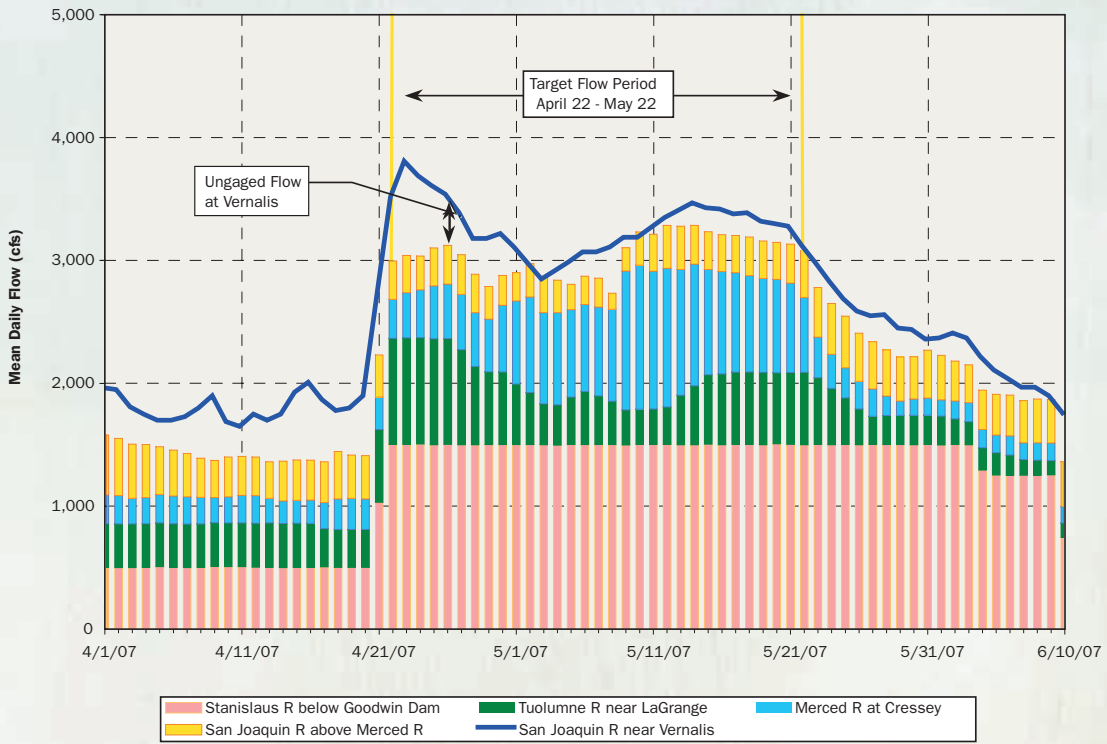


**Figure 2-3**  
2007 VAMP - San Joaquin River near Vernalis with and without VAMP

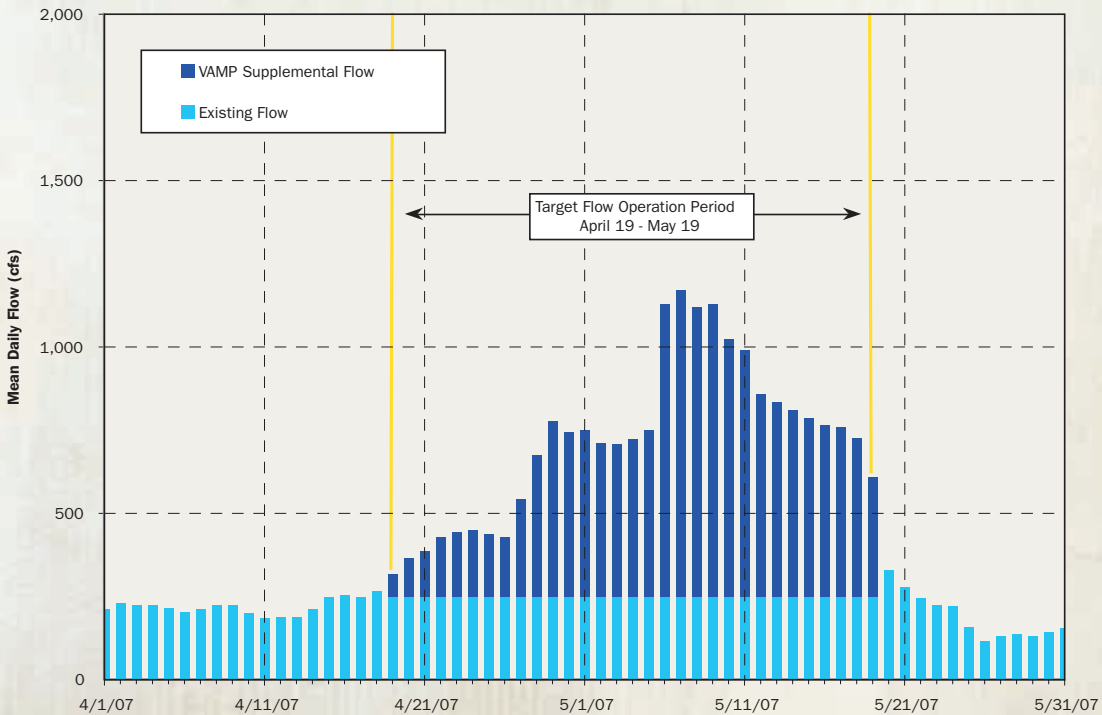




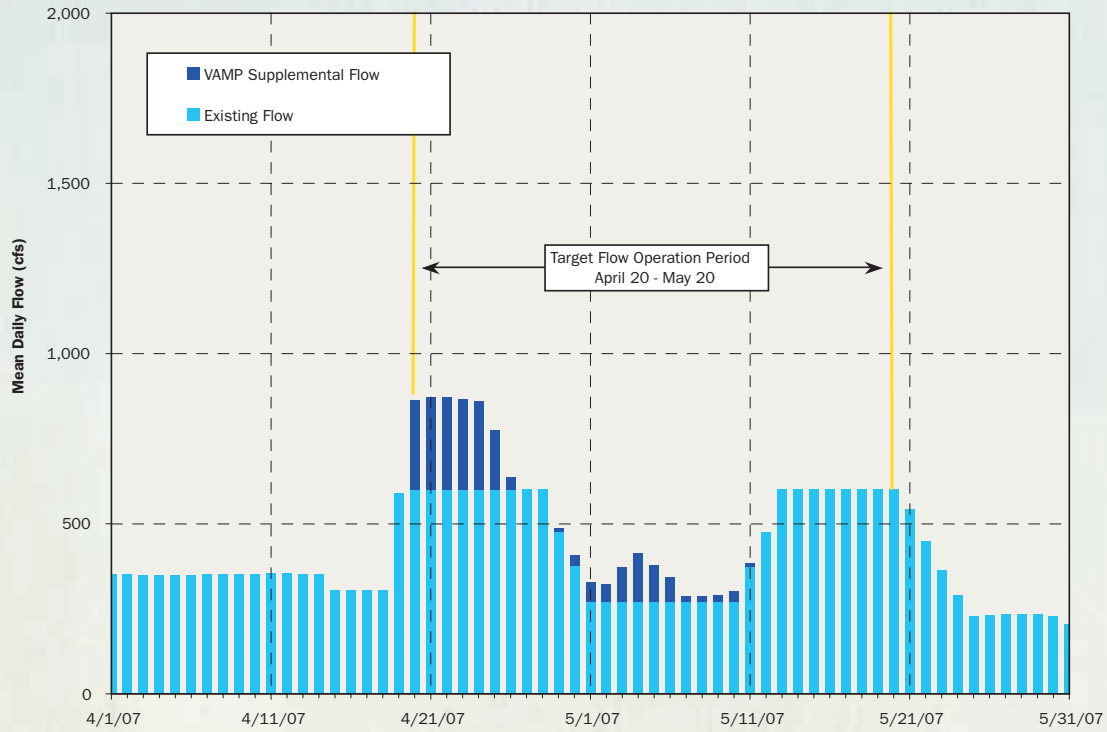
**Figure 2-4**  
 2007 VAMP: San Joaquin River near Vernalis  
 With Lagged Contributions from Primary Sources



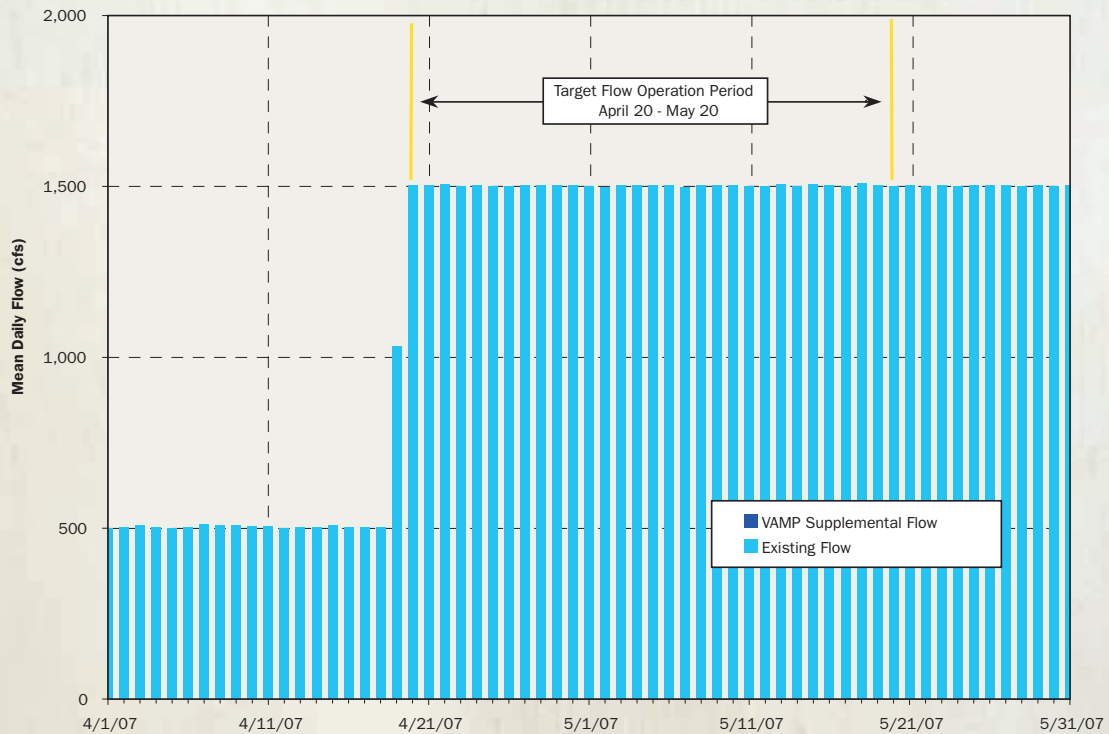
**Figure 2-5**  
 2007 VAMP - Merced River at Cressey with and without VAMP



**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

Date	Merced R. at Cressey (3 day Travel Time to Vernalis)			Tuolumne R. blw LaGrange Dam (2 day Travel Time to Vernalis)			Stanislaus R. blw Goodwin Dam (2 day Travel Time to Vernalis)			Upper SJR [2]	Vernalis Ungaged	San Joaquin River at Vernalis		
	Existing Flow [1] (cfs)	Observed Flow (cfs)	VAMP Supplemental Water (cfs)	Existing Flow [1] (cfs)	Observed Flow (cfs)	VAMP Supplemental Water (cfs)	Existing Flow [1] (cfs)	Observed Flow (cfs)	VAMP Supplemental Water (cfs)	Observed Flow (cfs)	Observed Flow (cfs)	Existing Flow [1] (cfs)	Observed Flow (cfs)	VAMP Supplemental 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	
<b>VAMP Period</b>														
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 occurred 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 in conjunction 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

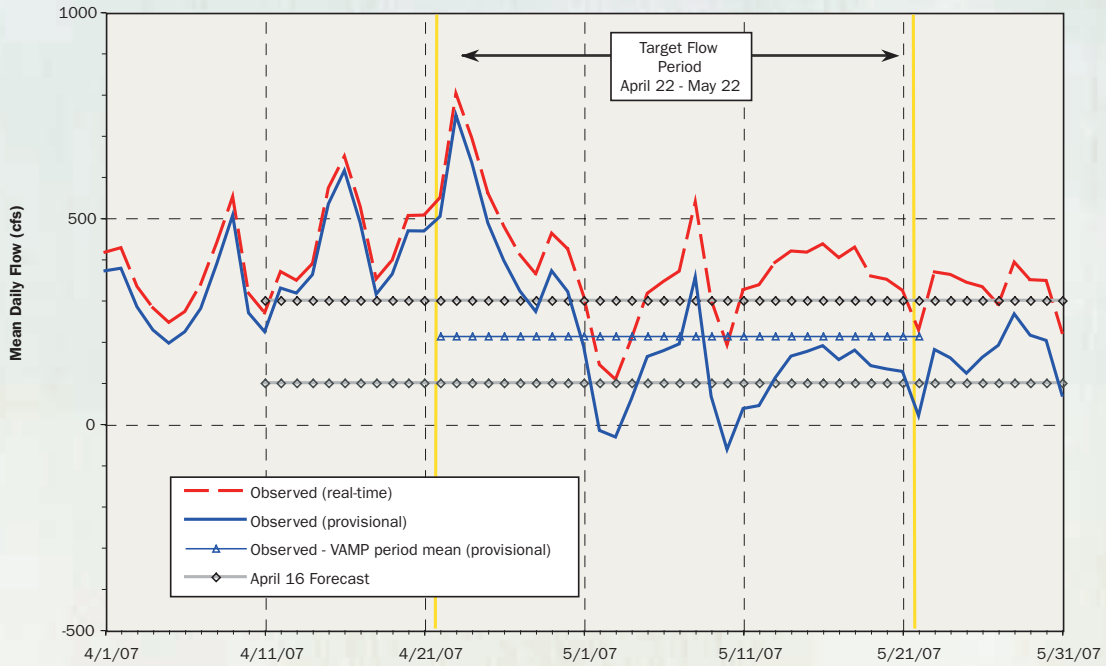
[b] Provided by Merced ID (54.55%), Oakdale ID (15.91%), Modesto ID (15.91%) and Turlock ID (13.64%)

[c] Provided by Merced ID

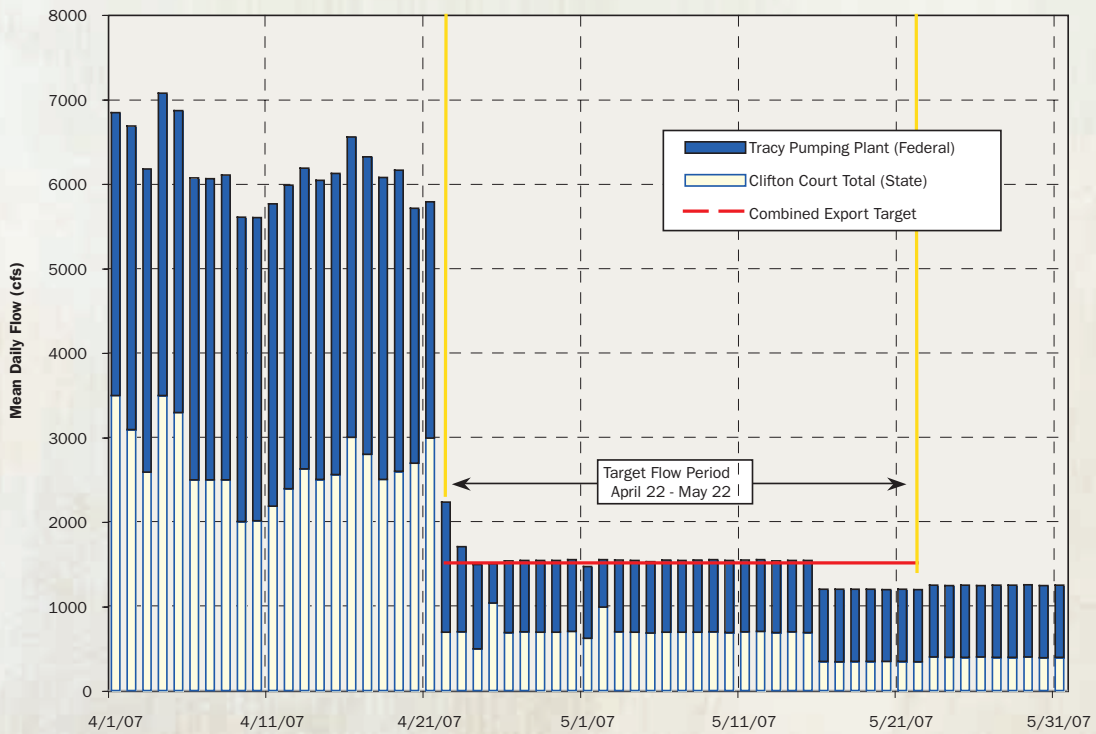
[d] Provided by Modesto ID/Turlock ID on the Tuolumne River due to flow constraints on the Stanislaus River



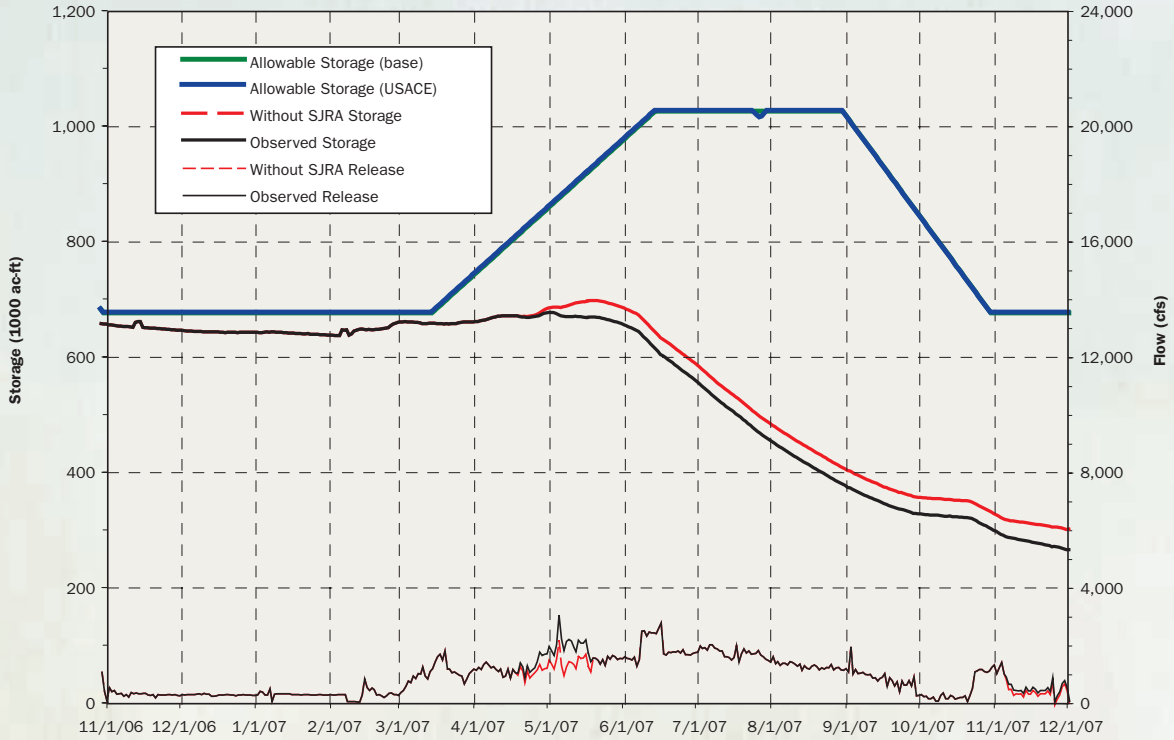
**Figure 2-8**  
2007 VAMP - Ungaged Flow in San Joaquin River at Vernalis



**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**

