San Joaquin River diversion data assimilation, drainage estimation and installation of diversion monitoring stations

CALFED Project #: ERP-01-N61-02

Principal Investigators

Nigel W.T. Quinn. PhD, P.E.
Alice Tulloch, P.E.

Tulloch Engineering
7202 Hites Cove Road
Mariposa, CA 95338

Report to

CALFED Bay-Delta Program
Sacramento, CA 95814

September 15, 2002

Executive Summary

This report was prepared to document existing data on river diversions and drainage return flows to the San Joaquin River between Mendota Pool and Channel Point on the San Joaquin River Deep Water Ship Channel. The report is divided into two main sections. The first section concentrates on the lower San Joaquin River from Mendota Pool to Vernalis. This section of the San Joaquin River receives inflow from a variety of sources including east-side tributaries, (dominated by reservoir releases), west-side tributaries (dominated by agricultural return flows), groundwater recharge and discharges from wetlands and publicly owned waste treatment plants. River diversions can remove a significant amount of San Joaquin River flow, especially in dry years. This reach of the San Joaquin River is also not typically affected by tidal flows, being sufficiently upstream. The second section of the report deals with the tidally influenced reach of the San Joaquin River Delta between Vernalis and Channel Point. There are no major tributary inflows in this reach - the most signicant inflows are irrigation return flows from adjacent agricultural lands pumped over the levee into the River. The major diversion of San Joaquin River water occurs at the junction with Old River, where, depending on Delta hydraulics up to 50% of the River flows may be diverted when hydraulic barriers are not in place.

One of the difficulties that had to be overcome in completing this project is the dearth of measured data to allow an accurate mass balance of flow and mass loads of constituents. Where monitoring data was lacking estimates based on judgement and similar year hydrology were used. The basis for these estimates is provided in the report.

Several public-domain surface water simulation models were utilized in the development of the diversion and drainage estimates for the San Joaquin River. The SWRCB's San Joaquin River Input-Output model (SJRIO-2) (Grober 1989) was run and the model data parsed into a small number of stream segments for which mass balances of flow to and from the San Joaquin River were made. The current SJRIO-2 model is an outgrowth of the SJRIO model (Kratzer et al., 1987) which was the result of a significant data collection and monitoring program begun in 1985. Investment in the model declined after 1991 with a corresponding reduction in data collection. A daily version of the SJRIO-2 model (SJRIODAY) was developed by the San Joaquin River Management Program's Water Quality Subcommittee (SJRMP-WQS) in the late 1990's to assist with the forecasting of San Joaquin River assimilative capacity for salt at Vernalis. Water quality objectives for electrical conductivity (EC) at Vernalis and the 30-day running average EC determine the magnitude of releases made from New Melones Reservoir for water quality compliance.

The Department of Water Resources (DWR) Delta Simulation Model (DSM-2) was used to estimate diversions and drainage flows between Vernalis of the SJR and the Deep Water Ship Channel (DWSC). A sub-model known as the Delta Island Consumptive Use Model (DICU) provides estimates of Delta consumptive use by crop depending on water year type and estimated monthly evaporation, which is used by DSM-2 to resolve the hydrodynamics of Delta channels.

These modeling analyses have been supplemented with estimates made using the results of a synoptic survey of riparian pumps and Drains made during April 2001, land use estimates using the USBR detailed San Joaquin River aerial photography (USBR, 1993) and the SWRCB database of riparian and appropriative water rights holders.

The US Bureau of Reclamation's WESTSIM preliminary groundwater – surface water model was used to estimate monthly groundwater fluxes between the regional groundwater aquifer and the SJR. This model is currently under calibration. These estimates are contrasted with estimates made within the SJRIO-2 model and made independently by the USGS in 1991?) and most recently by the CRWQCB (2001).

The report also summarizes data from the largest irrigation diverters along the main stem of the San Joaquin River. As part of this project the installation of a Accoustic Velocity Meter (AVM) and an electrical conductivity sensor was completed at the West Stanislaus Irrigation District, the largest riparian diverter on the San Joaquin River. Continuous flow and EC data collected at this station is accessible through a phone modem and is currently posted at weekly intervals to a web site, hosted by the University of California, Berkeley. The flow data reported shows an interesting trend starting in early August whereby District diversions diminish from a high of 200 cfs to between 10 and 50 cfs from late September to mid November, after which they cease. This reduction in pumping occurs at the same time as the low dissolved problems are manifested in the Deep Water Ship Channel. Significant reductions in San Joaquin River pumpage allow the uninterrupted passage of algal load from the upper watershed to the ship channel potentially doubling the algal loads in the space of 50 days, if diversions from the river at this time of year are as great at 50% of the unimpaired flow. This problem is obviously much worse in dry years during which riparian and appropriative diversions can remove much of flow from the river and less severe in wet years when these diversions have a much smaller impact on flow to the Deep Water Ship Channel.

A second installation is near completion at the Patterson Irrigation District, the second largest riparian diverter from the San Joaquin River. A cooperative agreement with the Patterson Irrigation District will routinely provide flow and electrical conductivity information from their SCADA real-time monitoring network once the sensor has interfaced with the District's existing system. The advantage with this arrangement is that it greatly reduces ongoing maintenance costs of the station.

Executive Summary – Key Questions Addressed

1. Lower San Joaquin River : Mendota Pool to Vernalis

1. How do agricultural diversions above Vernalis potentially affect DO in the Deep Water Ship Channel?

   As shown in the monitoring at West Stanislaus Irrigation District during 2001, irrigation diversions decline rapidly in mid-August and are at 10% of their mid-summer volumes by the end of September. This reduction in diversion volume while allowing more flow to the reach of the River below Vernalis also reduces the loading of algal biomass removed from the River. Greater flows through the Deep Water Ship Channel decrease residence time and the opportunity for settling of algae loads. Greater algal loads however result in increased oxygen demand.

2. How important are irrigation return flows and how do these vary within the watershed?

   Irrigation return flows to the San Joaquin River can be either surface water returns or groundwater accretions. As shown by data in the report the San Joaquin River mostly loses water to the adjacent groundwater aquifer in the reach between Bear Creek (the upstream modeling boundary) and Newman. Between Newman and Vernalis the river is a gaining stream for most of the year. Between Lander Avenue and Vernalis groundwater accounts for approximately 5% of the total flow in the river and is responsible for about 20% of the salt load in the River. Surface return flows along the San Joaquin River account for 13% of the flow and about 16% of the salt load. From Mud and Salt Sloughs, westside agriculture contributes 4% of the flow and 21 % of the salt load. The algal load from these surface water sources will increase with residence time in the channels. The flow path from point of irrigation application to the River is much shorter for water districts north of Newman than those to the south discharging to Mud and Salt Sloughs. Their contribution to River algal load is therefore likely less.

3. How do wetland operations affect potentially affect nutrient and algal loads in the San Joaquin River ?

   Wetland water quality data has been provided by Stringfellow and Quinn that shows that wetland return flows, generated during the flooding of seasonal wetlands in the fall, provides BOD and both dissolved and particulate carbon loads to the San Joaquin River. Increases in water supply, brought about through the passage of the CVPIA, have allowed wetland managers to practice more of a flow-through operation, freshening the wetlands and increasing their productivity. Organic-rich sediments, oxidized and mineralized during the hot summer months release nutrients to the flood water which is carrried into the San Joaquin River through Mud and Salt Sloughs. Particulate organic matter increases turbidity and lowesr light penetration potentially inhibiting algae growth. On the other hand, some of the dissolved nutrients may act to stimulate algae growth.

2. San Joaquin River Delta : Vernalis to Channel Point (DWSC)

1. To what extent are return flows from irrigation adding to the river load or diluting the river load at Channel Point?

   Return flows are ungaged in this reach and were estimated using survey data and interviews with South Delta farmers. Return flows are estimated to be less than 10% of the river's flow at 1,000 cfs in the reach between Vernalis and Channel Point, but would be a more significant contribution at lower flows.

2. To what extent does the diversion of flows below Vernalis by riparian diverters account for the reduction of BOD load at Channel Point?

Riparian irrigation diversions were estimated by delineating the irrigated acreage adjacent to the San Joaquin River based on land ownership records. Using average water use per acre and accounting for groundwater pumping the total diversion was estimated to be at least 300 cfs during the summer months. This may represent as much as 30% of the flow at 1000 cfs and account for a 30% reduction in algal biomass loading compared to algal loads measured at the San Joaquin River at Vernalis.

3. What is the significance of POTW discharges to the San Joaquin River.

   During the summer months, up to October 1, municipal POTW discharges are small in volume equivalent to about 1% of river flow and 2-3% of the loading of oxygen demanding substances measured at Vernalis.

Executive Summary – Summary Diversion Flows 1999-2001

For the project synthesis report the primary data requested of the project was accurate information on channel diversions along the San Joaquin River channel between Mendota Pool and Channel Point in Stockton. Riparian and appropriative pumping from the San Joaquin River is restricted according to individual water rights issued by the State Water Resources Control Board. There is very little government enforcement of these pumping regulations and the system is largely peer regulated and policed. An upstream riparian or appropriate diverter who used in excess of his water right in a dry year might be reported to the SWRCB. In addition it is unlikely that a riparian or appropriate diverter would over-design his pumping plant without calling attention to the fact since most pumping plants are clearly visible along the banks of the San Joaquin River.

Tables A and B (overleaf) provide monthly volumes of river diversions for the four major diverters along the San Joaquin River which include West Stanislaus Irrigation District, Patterson Irrigation District, El Solyo Water District and Banta Carbona Irrigation District.

Summary Table A : Major San Joaquin River Diversions (acre-ft)

Patterson Irrigation District
San Joaquin River Diversions
(Ac-Ft.)

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	TOTALS	ERROR EST.
1999	0	0	941	4640	7952	7957	8030	7707	5289	910	0	0	43426	+/- 2%
2000	0	0	350	6460	7860	7581	8150	7479	2982	419	0	0	41281	+/- 2%
2001	0	0	861	4668	8929	8180	8620	7479	2982	419	0	0	42137	+/- 2%
occurrence avg.	0	0	717	5256	8247	7906	8267	7555	3751	583	0	0	42282	

West Stanislaus Irrigation District
San Joaquin River Diversions
(Ac-Ft.)

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	TOTALS	ERROR EST.
1999	400	89	2819	4863	9732	9584	11013	8638	3789	925	1188	1984	55024	+/- 5%
2000	1501	0	587	7040	8098	8655	9686	6421	3339	903	539	627	47396	+/- 5%
2001	481	376	787	5320	9456	8116	9203	7561	3268	653	374	125	45720	+/- 2%
occurrence avg.	794	155	1398	5741	9095	8785	9967	7540	3465	827	700	912	49380	

* West Stanislaus ID upgraded flow and EC monitoring in 2001 with assistance from CALFED and SJR-DO project

El-Solyo Water District
San Joaquin River Diversions
(Ac-Ft.)

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	TOTALS	ERROR EST.
1999	0	0	191	715	2024	1997	4654	3320	1191	233	236	75	14636	+/- 5-10%
2000	37	0	94	1739	1639	2951	3713	2697	821	192	0	0	13883	+/- 5-10%
2001	0	0	167	1746	1559	1938	2718	2189	944	521	0	0	11782	+/- 5-10%
occurrence avg.	12	0	151	1400	1741	2295	3695	2735	985	315	79	25	13434	

Banta Carbona Irrigation District
San Joaquin River Diversions
(Ac-Ft.)

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	TOTALS	ERROR EST.
1999	0	0	148	2183	11819	10444	12798	9417	2994	1231	0	0	51035	+/- 5%
2000	1128	0	134	6099	9518	10753	12248	7492	2795	802	0	0	50967	+/- 5%
2001	0	0	1446	6347	11133	9972	7293	7516	2718	1474	311	0	48210	+/- 5%
occurrence avg.	376	0	576	4876	10824	10389	10780	8142	2836	1169	104	0	50071	

Summary Table B : Major San Joaquin River Diversions (cfs)

Patterson Irrigation District
San Joaquin River Diversions
(cfs.)

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	ERROR EST.
1999	0	0	16	79	135	136	137	131	90	16	0	0	+/- 2%
2000	0	0	6	110	134	129	139	127	51	7	0	0	+/- 2%
2001	0	0	15	80	152	139	147	127	51	7	0	0	+/- 2%
occurrence avg.	0	0	12	90	140	135	141	129	64	10	0	0	

West Stanislaus Irrigation District
San Joaquin River Diversions
(cfs)

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	ERROR EST.
1999	7	2	48	83	166	163	188	147	65	16	20	34	+/- 5%
2000	26	0	10	120	138	147	165	109	57	15	9	11	+/- 5%
2001	8	6	13	91	161	138	157	129	56	11	6	2	+/- 2%
occurrence avg.	14	3	24	98	155	150	170	128	59	14	12	16	

El-Solyo Water District
San Joaquin River Diversions
(cfs)

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	ERROR EST.
1999	0	0	3	12	34	34	79	57	20	4	4	1	+/- 5-10%
2000	1	0	2	30	28	50	63	46	14	3	0	0	+/- 5-10%
2001	0	0	3	30	27	33	46	37	16	9	0	0	+/- 5-10%
occurrence avg.	0	0	3	24	30	39	63	47	17	5	1	0	

Banta Carbona Water District
San Joaquin River Diversions
(cfs)

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	ERROR EST.
1999	0	0	3	37	201	178	218	160	51	21	0	0	+/- 5%
2000	19	0	2	104	162	183	209	128	48	14	0	0	+/- 5%
2001	0	0	25	108	190	170	124	128	46	25	5	0	+/- 5%
occurrence avg.	6	0	10	83	184	177	184	139	48	20	2	0	

Table of Contents

List of Figures

List of Tables

.

List of Acronyms, Abbreviations and Definitions

GBP	Grasslands Bypass Project
DSM2	Delta Simulation Model
DSM2-SJR	San Joaquin River extension to DSM-2
DWSC	Deep Water Ship Channel
LBNL	Lawrence Berkeley National Laboratory
SJR	San Joaquin River
SJRMP-WQS	San Joaquin River Management Program–Water Quality Subcommittee
SJRIO-2	San Joaquin River Input-Output Model
SJRIODAY	Daily version of SJRIO-2
SJR	San Joaquin River
WESTSIM	Westside Groundwater-Surface Water Similation Model

Introduction

The project purpose is to gather existing information from all sources to improve understanding of the role of seasonal San Joaquin River diversions and return flows on the load of dissolved oxygen demanding substances that reach the San Joaquin River Deep Water Ship Channel. The geographic scope of this project is limited to the San Joaquin River from Mendota Pool, a regulating and holding reservoir near the town of Mendota to Channel Point, the map location where the San Joaquin River enters the San Joaquin River Deep Water Ship Channel.on the main stem of the San Joaquin River.

The report is divided into two main sections. The first section concentrates on the lower San Joaquin River from Mendota Pool to Vernalis. This section of the San Joaquin River receives inflow from a variety of sources including east-side tributaries, dominated by reservoir releases; west-side tributaries, dominated by agricultural return flows; groundwater recharge; and discharegs from wetlands and publicly owned waste treatment plants. River diversions can remove a significant amount of San Joaquin River flow, especially in dry years. This reach of the San Joaquin River is also not typically affected by tidal flows, being sufficiently upstream. The second section of the report delas with the tidally influenced reach of the San Joaquin River between Vernalis and Channel Point. There are no major tributary inflows in this reach - the most signicant inflows are irrigation return flows from adjacent agricultural lands pumped over the levee into the River. The major diversion of San Joaquin River water occurs at the junction with Old River, where, depending on Delta hydraulics up to 50% of the River flows may be diverted when hydraulic barriers are not in place.

Hypothesis testing of various conceptual models of algae growth, nutrient assimilation and removal on the San Joaquin River and its tributaries requires accurate data on basin hydrology. Hydrologic data is available for the main stem of the river and for the major east and west-side tributaries. River diversions, both riparian and appropriative and smaller river accretions are not measured directly and, except for the four largest riparian diverters, West Stanislaus Irrigation District (WSID), Patterson Irrigation District (PWD), El Solyo Water District (ESWD) and Banta Carbona Irrigation District (located between Vernalis and Mossdale) there is no available data. River diversions can remove large volumes of algae biomass from the San Joaquin River, filtering the algal cells as the water is conveyed along canals to field turnouts and percolates through the soil. Return flows generated within these agricultural areas have been found by other researchers to account for a relatively small percentage of algal BOD (Kratzer, personal communication, 2001), however this depend on the transit time from drain to river and the flow path. In water districts where drainage water may be ponded for several days before release, algal loads can equal or even exceed those in the diverted water.

Extensive use was made of a number of surface water models to estimate river diversions and return flows. These models include SJRIO-2, DSM2-SJR (the San Joaquin extension of DSM-2) and the full DSM-2 model, as well as project reports that describe and accompany these models. The first two models SJRIO-2 and DSM2-SJR contain the same basic data, DSM2-SJR was extended into the San Joaquin Basin by making use of the time series data already contained within the SJRIO-2 model. The DSM-2 model is a full hydrodynamic model with more system specific data requirements for bathymetry and bed slope. The SJRIO-2 model is an updated, more mechanistic version of the SWRCB's SJRIO model. A daily version of the SJRIO-2 model (SJRIODAY) was developed by the San Joaquin River Management Program's Water Quality Subcommittee (SJRMP-WQS) in the late 1990's to assist with the forecasting of San Joaquin River assimilative capacity for salt at Vernalis. Water quality objectives for electrical conductivity (EC) at Vernalis and the 30-day running average EC determine the magnitude of releases made from New Melones Reservoir for water quality compliance. The DWR Delta Simulation Model (DSM2-SJR) was used to estimate diversions and drainage flows between Vernalis of the SJR and the Deep Water Ship Channel (DWSC). A sub-model known as the Delta Island Consumptive Use Model (DICU) provides estimates of Delta consumptive use by crop depending on water year type and estimated monthly evaporation, which is used by DSM-2 to resolve the hydrodynamics of Delta channels.

The WESTSIM model, currently under development at the US Bureau of Reclamation (USBR) is used to estimate groundwater fluxes along the San Joaquin River between Mendota pool and the DWSC. The full WESTSIM model simulates westside groundwater flow for the entire west-side of the San Joaquin Basin from Tracy in the north to Kettleman City in the south. The San Joaquin River is typically dry in the reach between Mendota Pool and Bear Creek except during wet years and during flood flows. East-side flows along the middle SJR are intercepted by the Chowchilla and Eastside bypasses, the remainder flows into the Mendota Pool. Diversions are made from the Pool to the lift canals of the Firebaugh Canal Water District and to the Main and Outside lift canals. These canals formed the distribution system of the original Miller and Lux lands which were reclaimed in the late 19th century.

PART 1 - San Joaquin River : Mendota Pool to Vernalis

San Joaquin River Basin Hydrology

The San Joaquin River Basin drains the San Joaquin Valley and has a drainage area of approximately 7400 square miles. The River flows west from its headwaters in the Sierra National Forest, through Millerton Reservoir and then bifurcates close to the Valley trough in a manner whereby the main flow passes along a series of bypasses until it reaches the main stem of the lower San Joaquin River and a smaller volume travels westward, often disappearing into the streambed before reaching Mendota Pool. The main stem of the flowing river from Bear Creek to Vernalis is joined by major eastside tributaries and by a larger number of west-side ephemeral streams, which convey surface runoff from the Coast Range during winter and contain mostly agricultural surface drainage during the summer months (Figures 1 and 2). Vernalis is often chosen as the boundary with the Sacramento – San Joaquin Delta since it the lowest monitoring station on the river not subject to tidal influence. The major east-side tributaries convey spring snowmelt with some rainfall runoff and agricultural drainage from the lower reaches. The water quality of these sources is generally good, with an electrical conductivity of less than 100 uS/cm.

To understand the dynamics and hydrochemistry of the San Joaquin River it is necessary to gain an appreciation of the relative importance of the east-side components of flow compared to those flows originating from the west-side (Table 1). The percentages shown in Table 1 can vary markedly between wet and dry years – hence the numbers shown are for a 10-year mean calculated from 1985 to 1994 (Grober, 2001).

Table 1. San Joaquin River sources of flow and salt.
(mean annual load in tons)

Source	Discharge (acre-feet X 1000)	Percent	TDS Load (tons X 1000)	Percent
East-side tributaries	1,323	70%	148	16%
Groundwater	90	5%	191	20%
West side agriculture	68	4%	201	21%
Grassland wetlands	60	3%	74	8%
Groundwater inflow	11	1%	77	8%
West-side surface returns	70	4%	57	6%
Subsurface return flows (main stem SJR)	11	1%	25	3%
Surface return flows (main stem SJR)	250	13%	150	16%
Municipal & Industrial	15	1%	14	2%
Total	1,899	100%	938	100%

Data based on mean values for water years 1985 to 1994 (Grober - CRWQCB)

Figure 1. San Joaquin River Basin showing major surface water monitoring sites between Mendota Pool and Channel Point. The reach between Mendota Pool and Lander Avenue is mostly dry. Hence Lander Avenue (Stevinson), located downstream from the confluence of Bear Creek, is considered to be the upper San Joaquin River flow boundary (source : DWR)

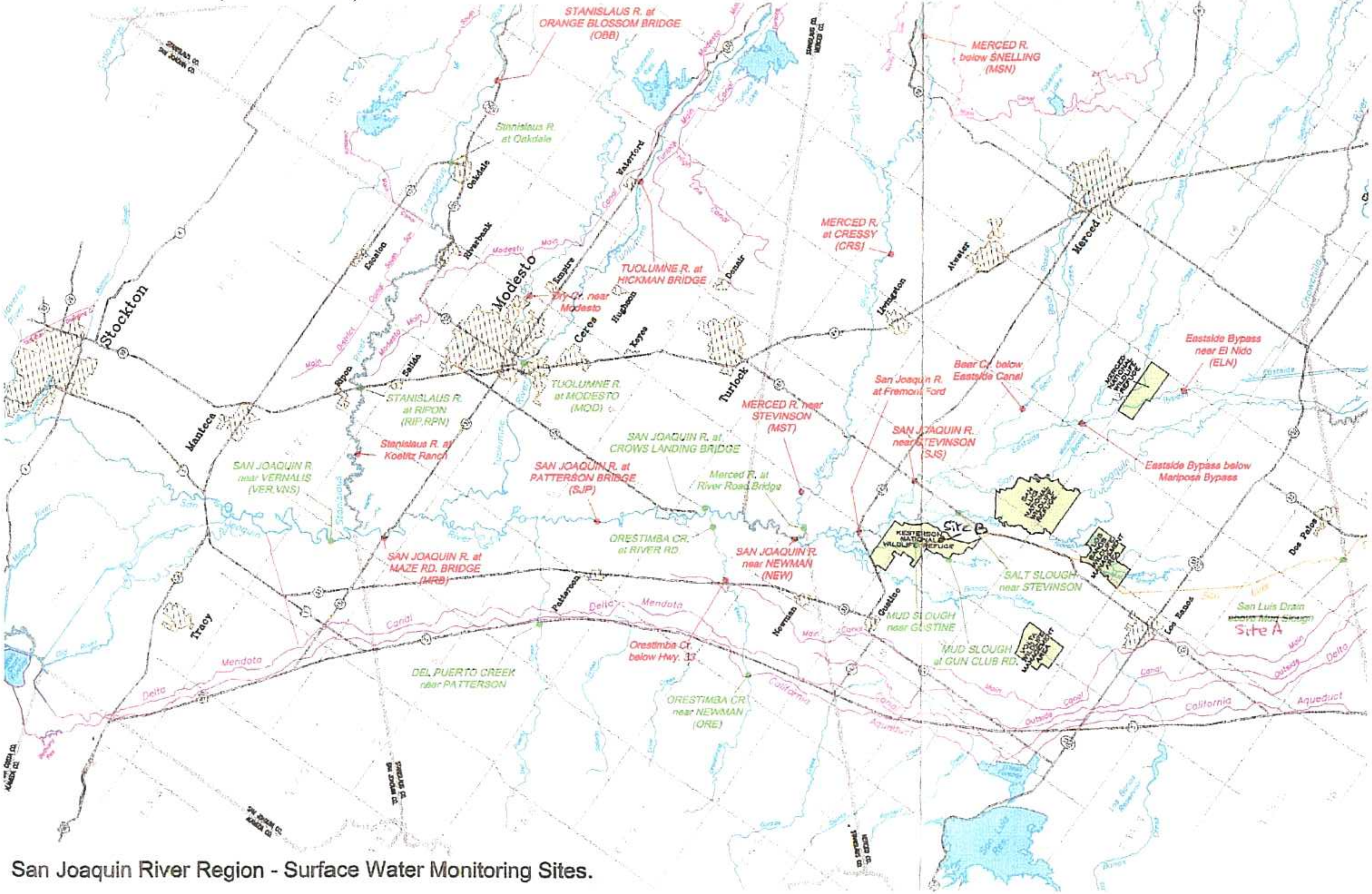
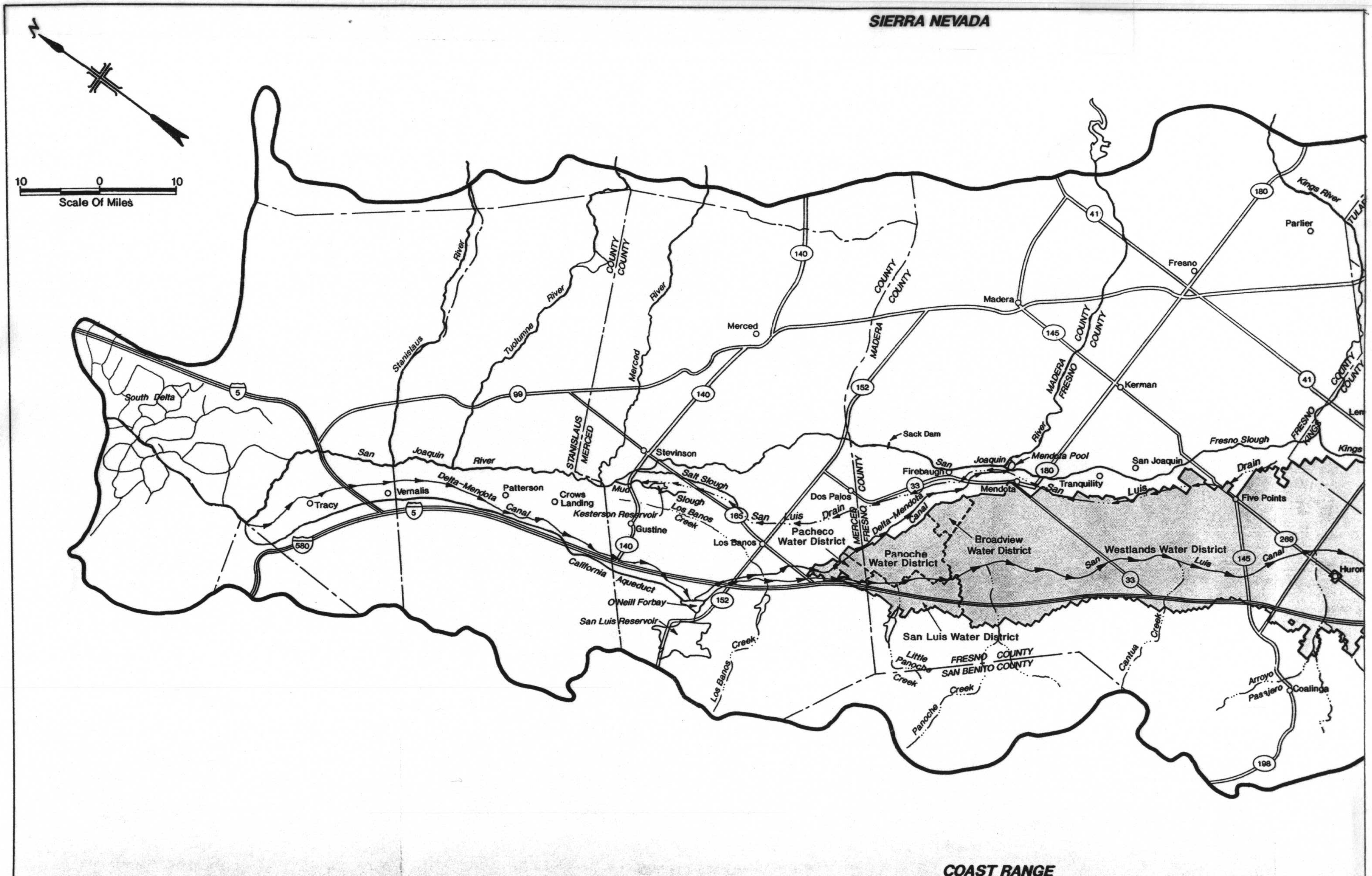


Figure 2. Simplified map of the San Joaquin River Basin showing San Luis Drain and major canal networks.



Since the east-side tributaries originate in the granitic Sierra Nevada the quality of these flows is generally excellent, the gravels formed by the weathered rock are largely insoluble

Snow-melt provides a large component of the east-side flow volume. West-side hydrology, on the other hand is dominated by return flows from agriculture and wetlands. Occasionally, severe and prolonged winter and spring storm events produce significant volumes of runoff along the major west-side ephemeral stream water courses, resulting in widespread flooding on the valley floor. These large flows are associated with high mass loadings of various salts including boron and selenium which are readily mobilized from the cretaceous shale deposits of the Moreno and Kreyenhagen formations. Although the salinity of water is not directly related to algal growth in the upper watersheds - salinity and the concentrations of particular salts such as boron, selenium, molybdenum and arsenic can help to discriminate the source of the salts. Nutrients such as nitrate and phosphorus also add to the salt load discharged from a watershed. Nitrate and phosphorus are typically in abundance and are not thought to limit algal growth in the watershed. The species of algae that grows in channels within the watershed and that is transported downstream in the San Joaquin River and into the Deep Water Ship Channel in Stockton may be affected by salinity. In this report flow information is presented with occasional reference to salinity and water quality.

East-side tributaries and return flows

The major east-side tributaries in the San Joaquin Basin are the San Joaquin, Merced, Tuolomne and Stanislaus Rivers which join the Lower San Joaquin River upstream of

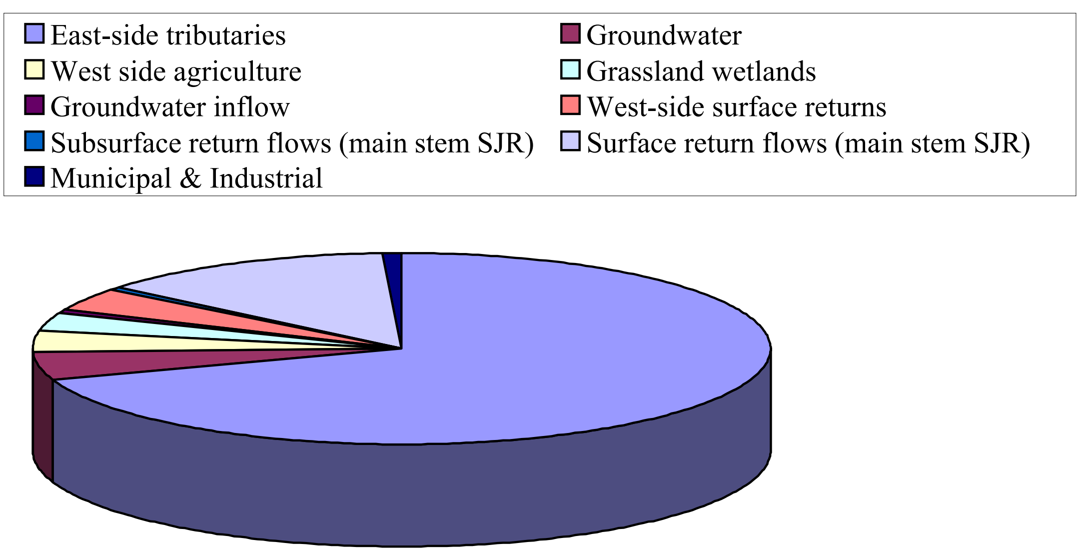


Figure 3. Flow contribution to the SJR

Vernalis. There are three minor east-side tribuatries in the Basin, Bear Creek, the east-side Bypass and the Mariposa Bypass. Within the Delta, downstream of Vernalis, in the reach between Vernalis and Channel Point only French Camp Slough and Walthall Slough provide measureable surface inflow. The east-side tributaries and the locations of real-time flow and water quality monitoring stations along each tributary were shown in Figure 1.

The mean flow from the east-side tributaries is 1,323,000 acre-ft per year which accounts for about 70% of the total flow measured at Vernalis. This figure includes reservoir releases from east-side tributaries as well as irrigation return flows from east-side water districts discharged into one of the tributaries above the lowest monitoring station.

East-side agricultural discharges

Agricultural soils on the east-side are derived from the granitic Sierra Nevada and are almost completely lacking in natural salts. Water percolating through these soils pick up little salinity with the result that return flows from agriculture have relatively low electrical conductivities. On the east-side water supplies are most often diversions from one of the three major tributaries with some supplemental groundwater pumping. Return flows from these areas are often returned to the same river from which they were diverted or to drain laterals which discharge directly to the San Joaquin River. Whereas salts from the west-side are mostly derived from natural sources, salts from east-side agriculture are often dominated by salts from fertilizer and soil amendments.

Two large irrigation districts supply water to eastside agriculture. Modesto Irrigation District (MID) services the area bounded by the Stanislaus Tuolumne and San Joaquin (Figure 4). The area between the Tuolumne, Merced and San Joaquin Rivers is serviced by Turlock Irrigation District (TID). Both of these districts receive irrigation water from offstrearn storage sources upstream of the gages on the Stanislaus and Tuolumne Rivers, respectively. Operational spills and agricultural tail-waters from each district are collected and conveyed by canals to point sources on the SJR, TUO, and STA.

Modesto Irrigation District has approximately 10 canals that combine and discharge to three discrete points and one spreading basin within the study boundaries (Pate, 2001):

Lateral No. 4 (MID#4) spills to the SJR.
Lateral No. 5 (MID#5) spills to a slough adjacent to the TUO near the SJR confluence and downstream of the MOD gauging station. This flow was assumed to reach the TUO.
Lateral No. 6 (MID#6) spills to the STA above Koetitz Ranch and downstream of the RIP gauging station.

Modesto Main Drain (MMAIN) conveys spills from Lateral No. 3 and 7 to Miller Lake. Miller Lake has the ability to spill into the STA. However, no records of Miller Lake flows into the STA have been found. MMAIN spills are assumed to reach the STA by seepage, thus no time adjustments were made to the data set.

Turlock Irrigation District has approximately six canals that discharge to six discrete points within the study boundaries (Figures 4 and 5):

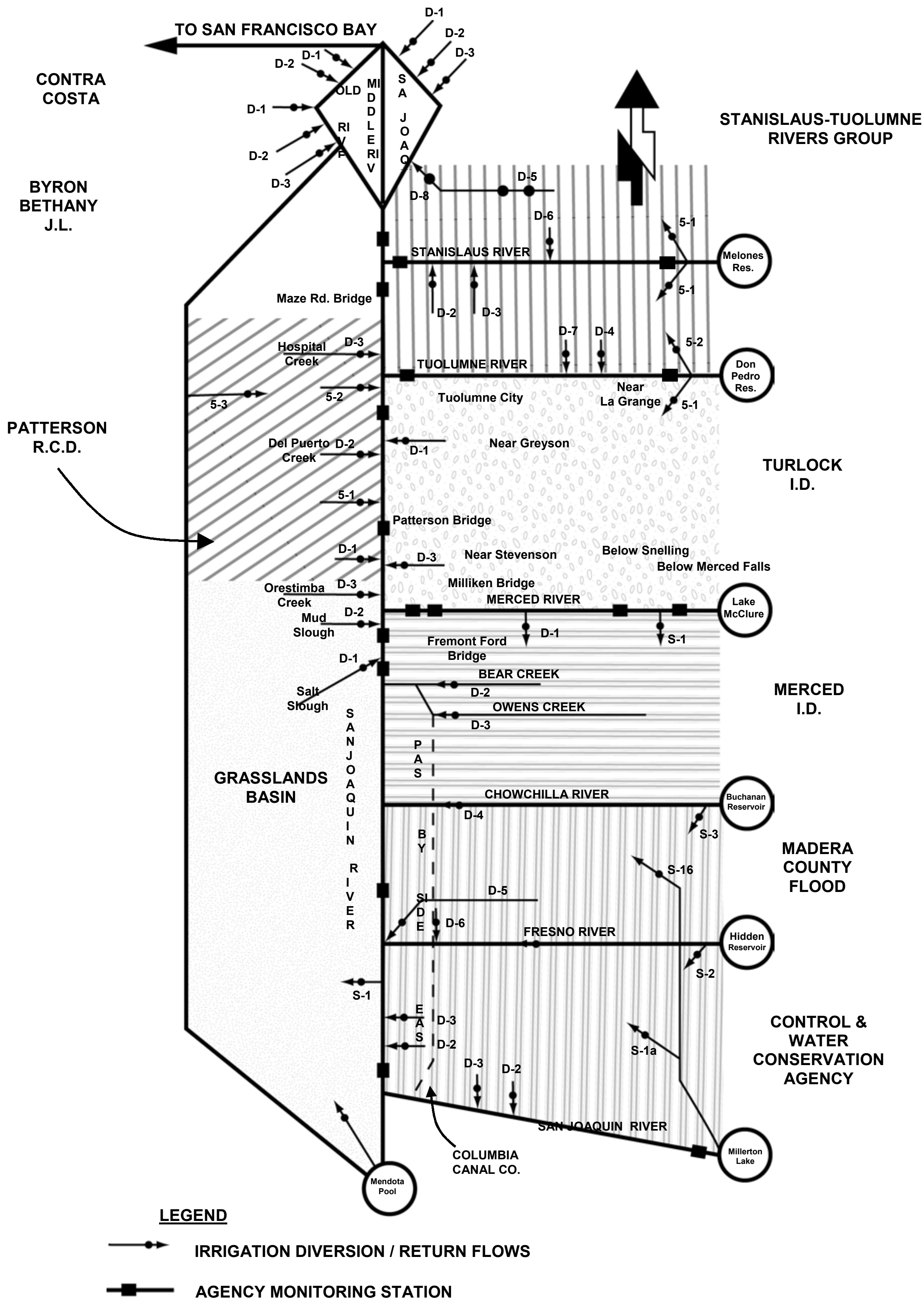


Figure 4. Map of tributaries, diversion locations and west-side return flows for the San Joaquin Basin (source : CWRCB).

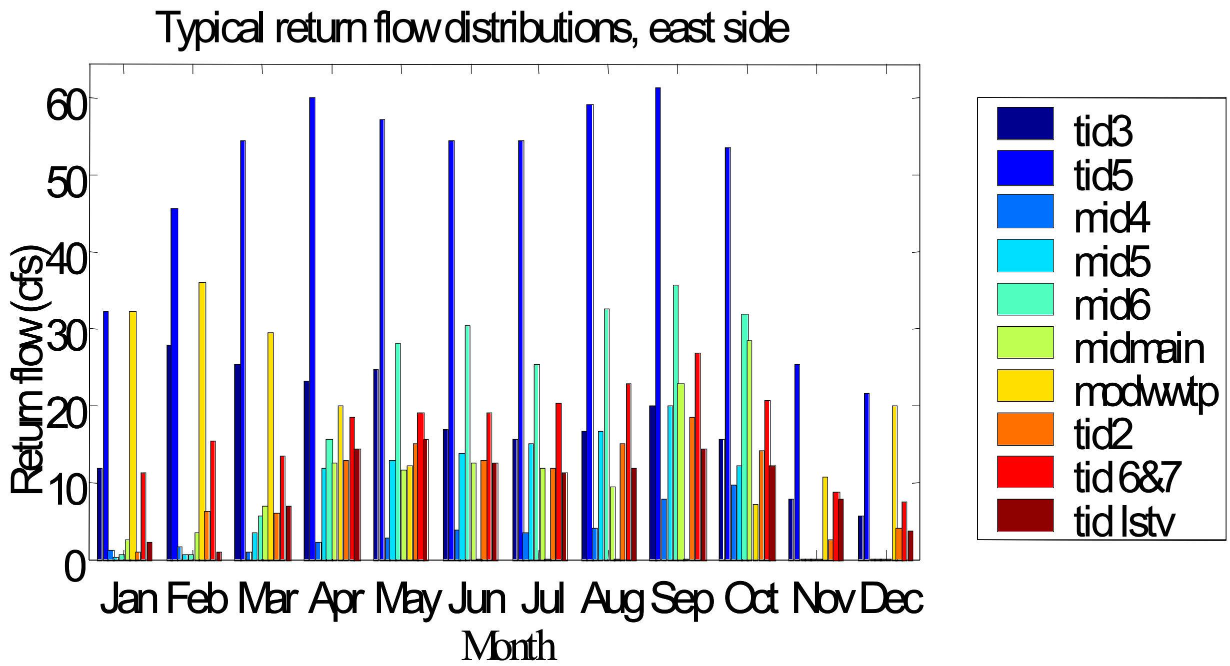


Figure 5. East-side return flow distribution from various drainage facilities in Turlock and Modesto Irrigation Districts.

Lateral No. I Spill (TID#I) spills to the TUO downstream of the MOD gauging station Lower Lateral No. 2 Spill (TID#2) spills to the SJR
Lateral No. 3 Drain (TID#3), a.k.a. Westport Drain, discharges to the SJR
Lateral No.5 Drain (TID#5), a.k.a. Carpenter Drain, discharges to the SJR
Lateral No. 6 and 7 Spills (TID6&7) combine and spill to the SJR Lower Stevinson Spill (TID_LSTV) spills to the MER downstream of the MST gauging station

These six canals accumulate drainage from seven other canals in the TID network:
• TID#3 combines drainage from Lower Laterals (LL) #2.5 and #3
• TID#5 combines drainage from Lower Lateral Spills (LL) #4, #4.5 and #5.5
• Lateral Spills (L) #5 and #5.5. The TWWTP also discharges treated wastewater into L#5

This information was initially obtained from the CRWQCB SJRIO-2 model and was used in the development of the DSM2-SJR model to reconstruct portions of incomplete data sets at some discharge points when possible (Pate, 2001). The east-side districts maintain monthly total flow records relatively close to the release points. Flow data are not available for TID#1.

Irrigation return flows shown in Figure 5 range from less than 5 cfs to over 50 cfs. East-side return flows are greatest in volume during the summer months. However certain east-side drains show flows during the entire year. These return flows are mostly un-gauged. Flows in DSM-2 are based on measurements taken for the SRWCB 1987 report (Kratzer et al., 1987).

West-side tributaries and return flows

There are nine significant streams and conveyances that drain the west-side of the San Joaquin Basin and that are tributaries to the San Joaquin River (Figure 4). Many of the streams in this list are ephemeral conveying rainfall runoff during the winter season agricultural runoff and drainage return flows during the summer months. Some of the coast range watersheds are extensive and during extended winter storms can yield large volumes of water. The San Luis Drain (SLD) is a concrete-lined conveyance that once formed part of a Valley Master Drain system providing drainage relief for the entire west-side of the Basin. Today 28 miles of the Drain service five agricultural water districts and convey subsurface drainage water into Mud Slough, six miles upstream of the confluence with the San Joaquin River. Because of its importance to the hydrology of the River the SLD is listed under west-side tributaries.

West-side tributaries along the main steam of the SJR account for 16% of the total flow at Vernalis – about 250,000 acre-ft/year.

Chlorophyll and turbidity data collected from the watershed as part of the San Joaquin River Dissolved Oxygen TMDL Project supports the hypothesis that these west-side streams and conveyances are responsible for much of the seed algal biomass entering the San Joaquin River. In the southern half of the Basin where the Valley floor widens and the distance between the Coast Range Mountains and the River increases – residence time in surface drainage conveyances tends to increase. These are favorable conditions for algae growth.

The following list of west-side tributaries is organized from south to north in terms of their discharge into the San Joaquin River. Each tributary is described in detail and available recent data is summarized if available :

Panoche-Silver Creek
San Luis Drain
Salt Slough
Mud Slough
Spanish Grant Drain
Orestimba Creek
Hospital Creek
Ingram Creek
Del Puerto Creek

Panoche –Silver Creek (PSC)

The Panoche-Silver Creek watershed lies on the southern boundary of the San Joaquin Basin and provides drainage for over 350 square miles of the Coast Range mountains. During and after sustained precipitation such as occurred in 1995 and 1997 considerable runoff is generated within the watershed - flood flows move east along Belmont Avenue into the town of Mendota, discharging directly into Mendota Pool. In some instances flood flows breach the water delivery canals and the flood wave moves north and south along the canal alignment. The Panoche-Silver Creek watershed delivers considerable sediment to the alluvial fan during these flooding episodes.

For the San Joaquin River Dissolved Oxygen TMDL Panoche and Silver Creeks are not a significant problem source since, as shown in Figure 5, most of the flows generated by the watershed occur during the winter months, when temperature and daylight hours inhibit algae growth and accumulation of algal biomass. The sediment associated with the occasional flood flows from the watershed are unlikely to contain the same levels of adsorbed phosphate, that may help to stimulate algae growth later in the season, owing to the types of land uses in the watershed.

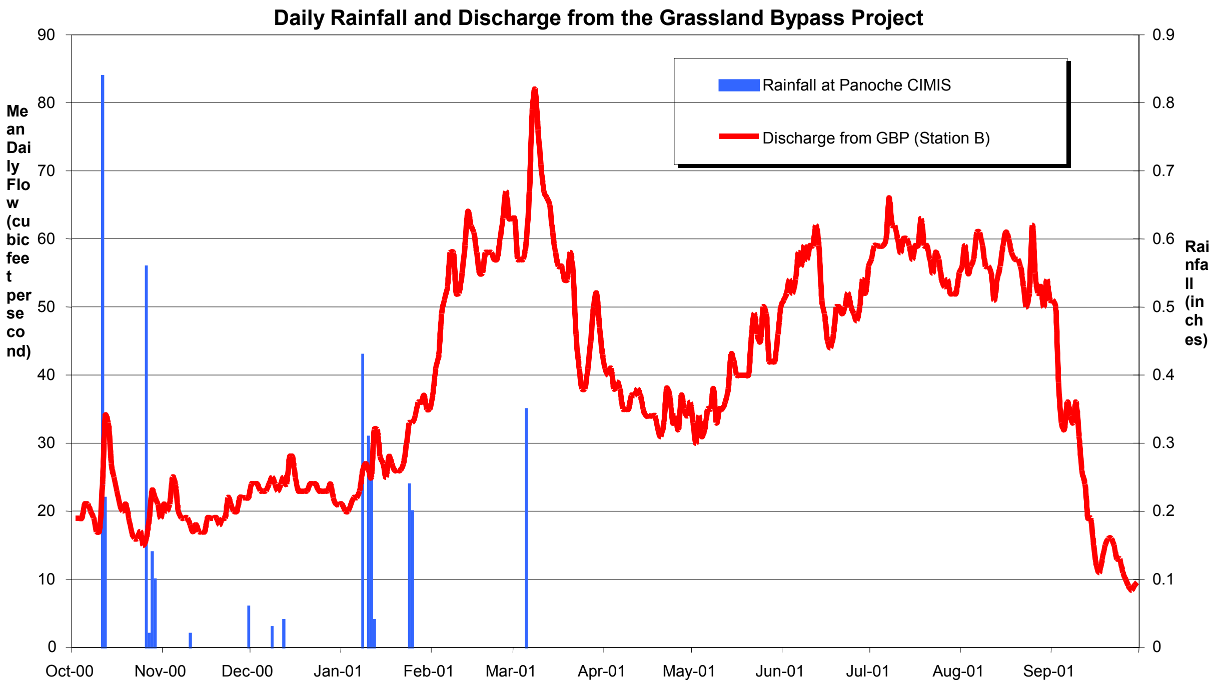


Figure 6. Daily rainfall and drainage flow measured at Site B for 2001 (Oct – Sept).

San Luis Drain

The San Luis Drain (Figure 1) was originally constructed by the US Bureau of Reclamation to convey west-side agricultural drainage for disposal in the Delta. Only 85 miles of the 170 mile Drain were constructed and between 1980 and 1985 the Drain conveyed drainage from a 5200 acre area of Westlands Water District to a holding reservoir located within the Kesterson National Wildlife Refuge. Kesterson Reservoir was originally designed as a regulating reservoir but became a terminal reservoir on account of budget difficulties and funding delays in completing the project. The discovery of selenium teratogenesis in wildfowl embryos halted the project and led to the closure of the Reservoir and San Luis Drain and the plugging of tile drainage connections with the facility within the Westlands Water District. In 1996, the US Bureau of Reclamation, in partnership with other resource agencies, environmental agencies and interest groups initiated the Grasslands Bypass Project which took selenium-laden agricultural drainage out of Grassland Water District supply channels and re-routed it along 28 miles of the San Luis Drain.

Monitoring of the agricultural drainage from the Grasslands Bypass Project area occurs at a number of stations, labelled A through N. Sites A and B are located one mile north of the inlet to the Drain and two miles south of the outlet from the Drain respectively. Since the Drain is concrete lined and intensively monitored for flow, electrical conductivity and selenium concentrations it provides a useful laboratory for studying ecological dynamics such as algae growth and nutrient fluxes. Stringfellow and Quinn (2002), in a separate report to the San Joaquin River DO TMDL project, provide some insight into the potential use of the San Luis Drain as a physical and chemical model of the San Joaquin River.

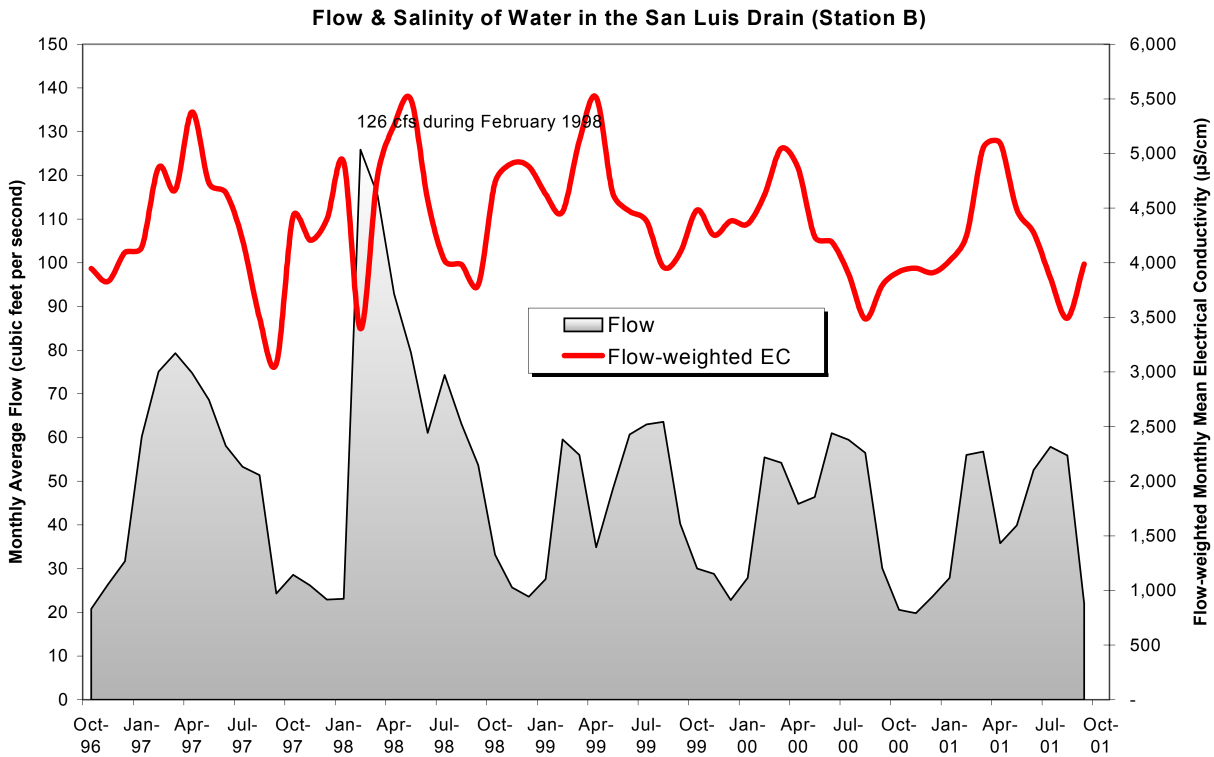


Figure 7. Flow at Site B for years 1996-2001. Site B is the compliance monitoring point for the Grassland Bypass Project

Flow monitoring data, collected for the past 5 years at Sites B in the San Luis Drain, is presented in Figure 7 (USBR, 2002). The graph show high flows in the first two El-Nino years of the project followed by three years of consistent flow data for water years 1999, 2000 and 2001. Groundwater accretions between Site A and B occur through weep valves in the invert of the Drain. These flows are shown to dilute the EC of the drainage water in the months of October through late February each year. These months correspond to the schedule of seasonal wetland flooding in the adjacent marshes. These groundwater accretions may contain considerable nitrate but will be strained of any algae precursors.

Mud Slough

Agricultural drainage flows from the selenium affected area of the Grasslands Basin are discharged into Mud Slough from the San Luis Drain at a point about 6 miles upstream of the confluence of Mud Slough and the San Joaquin River. Site C was established on Mud Slough upstream of the Drain discharge point and represents mostly wetland return flows and wetland water quality from the North Grassland Water District (Figure 8). The Grassland Water District supplies water to private duck clubs and cattle grazing properties north and south of the City of Los Banos. Figure 8 shows the combined agricultural and wetland flows for the period 1996 – 2001. Comparison of Figure 8 and 9 shows how the hydrology of Mud Slough is dominated by the wetlands – the hydrographs are very similar.

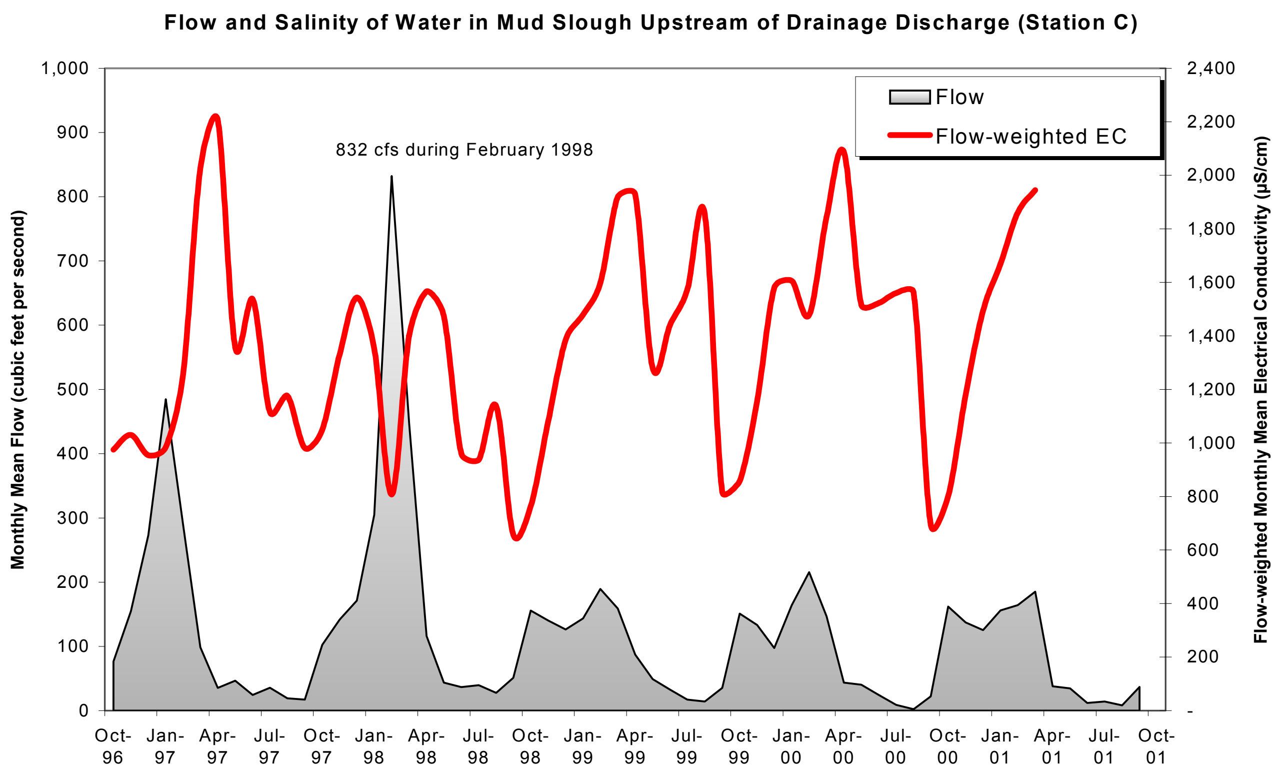


Figure 8. Flow at Site C in Mud Slough upstream on the confluence with the San Luis Drain

Flow from Mud Slough (north) into the San Joaquin River occasionally contained drainage from the Grasslands agricultural area prior to 1997 although most agricultural drainage was diverted through the Blake-Porter Bypass into Salt Slough. After September 27 1996 agricultural drainage from the Grasslands agricultural area was all diverted into the San Luis Drain and a connector channel built to connect the terminus of the San Luis Drain with Mud Slough. Hence from this date Mud Slough has conveyed all the flow from the Grasslands agricultural area – an increase in average monthly flow of about 50 cfs.

Salt Slough

Salt Slough conveys a mix of agricultural drainage and wetland return flows from the eastern half of the Grasslands watershed to the San Joaquin River. Agricultural lands draining into Salt Slough are outside the margins of the west-side alluvial fans and hence do not export selenium drainage at concentrations above the CRWQCB concentration objective of 5 ppb.

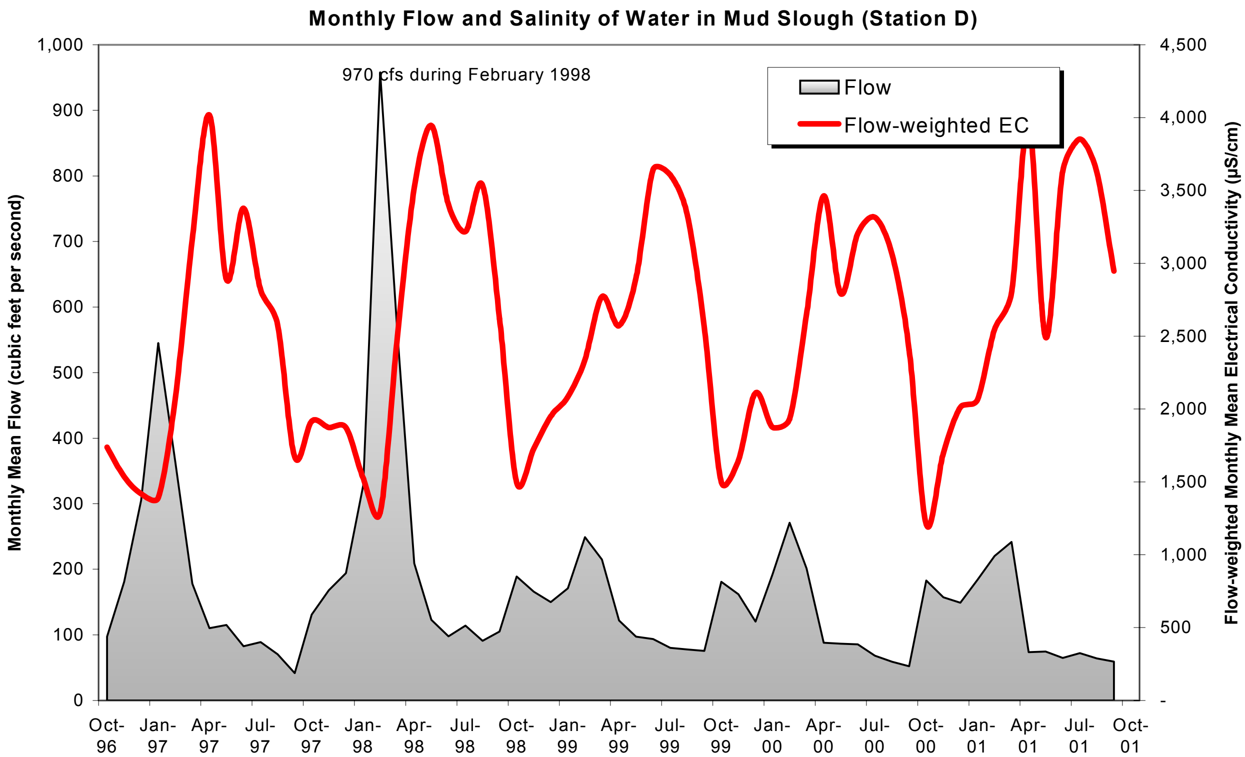


Figure 9. Flow in Mud Slough below the San Luis Drain confluence for 1996-2001. Mud Slough is the primary source of algal loading from the Grassland Watershed.

Between 1985 and 1996 Salt Slough conveyed selenium contaminated flows from the Grasslands Basin. Drainage flows from Panoche, Pacheco, Widren, Broadview and Firebaugh Water Districts were combined in the Main Drain, a conveyance that runs parallel to the Main Canal, and then siphoned under the Main Canal to either Camp 13 or Agatha Canals. The combined drainage flows ran into Mud Slough (South) before being diverted into the Blake-Porter Bypass and hence into Salt Slough. After the initiation of the Grassland Bypass project in 1996, local (non-seleniferous) agricultural drainage and wetland drainage make up the majority of flow in Salt Slough. Because of the changes in contributing areas to the hydrology of Salt Slough data prior to 1997 is of little value in developing mean monthly flow volumes. Figure 10 shows flow in Salt Slough for 1996-2001.

Although the agricultural and wetland areas contributing to Salt Slough are not subject to the Grasslands Bypass Use Agreement developed for use of the San Luis Drain, Figure 10 shows a very similar inter-annual hydrological variation as the previous graphs. This comparison demonstrates the importance of water year type in dictating the flows discharged to the San Joaquin River. This should also serve as a warning to the San Joaquin River DO TMDL project that algal loads and the importance of upstream sources of BOD loading to the

DWSC can vary significantly from year to year. This calls for the study of algal load impacts under a wide range of climate conditions.

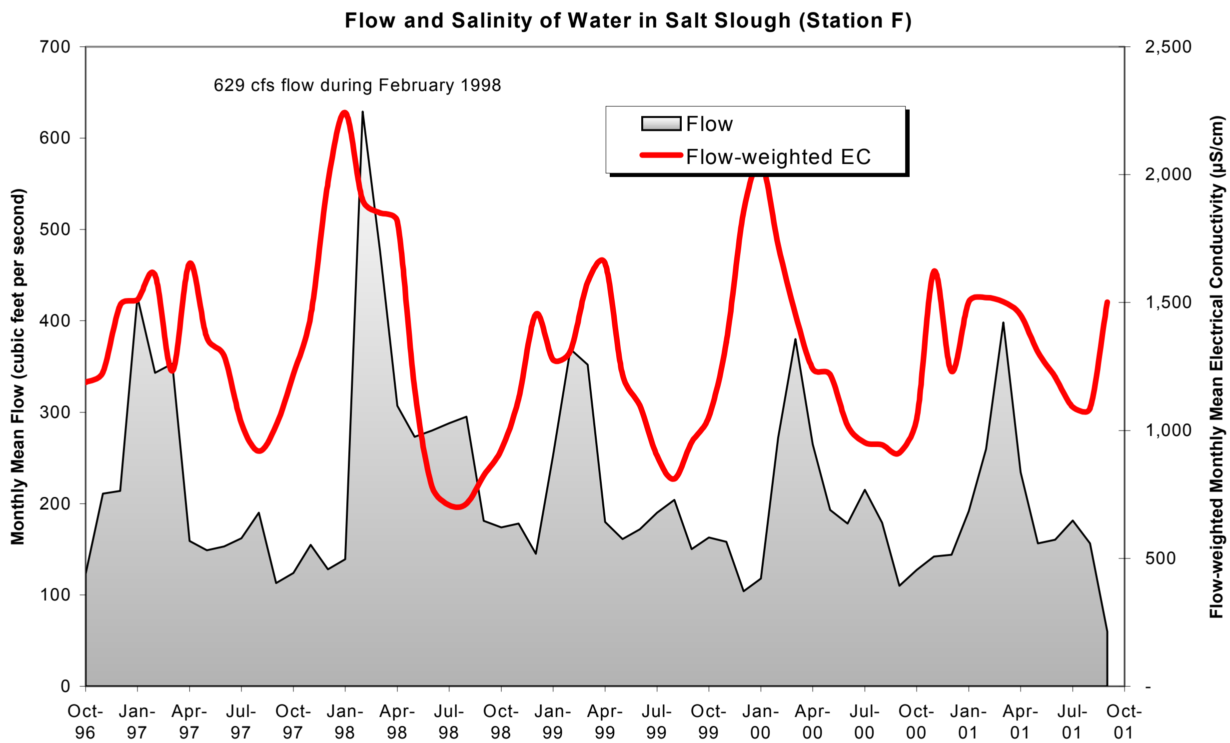


Figure 10. Flow in Salt Slough at Highway 165 for years 1996 - 2001. Salt Slough contains a combination of wetland flows from State and Federal refuges and private duck clubs and agriculture outside the seleniferous area defined by the Grassland Bypass Project.

.

Crows Landing Compliance Monitoring Station

The San Joaquin River monitoring station at Crows Landing was installed in 1996 to serve the Grassland Bypass Project as the first SJR location from the discharge point of the Grassland Bypass Project. Crows Landing had served as the CRWCB compliance monitoring station for selenium and boron since 1985. Although the SJR Newman Bridge station is closer to the Mud Slough discharge point the proximity of this station to the confluence of the Merced River made the station unreliable for water quality sampling. In general Newman flows, when added to flows from Orestimba Creek, correspond to flows measured at Crows Landing Bridge. Crows Landing is approximately 6 miles north of Newman. Figure 11 shows the flows measured at Crows Landing since October 1996.

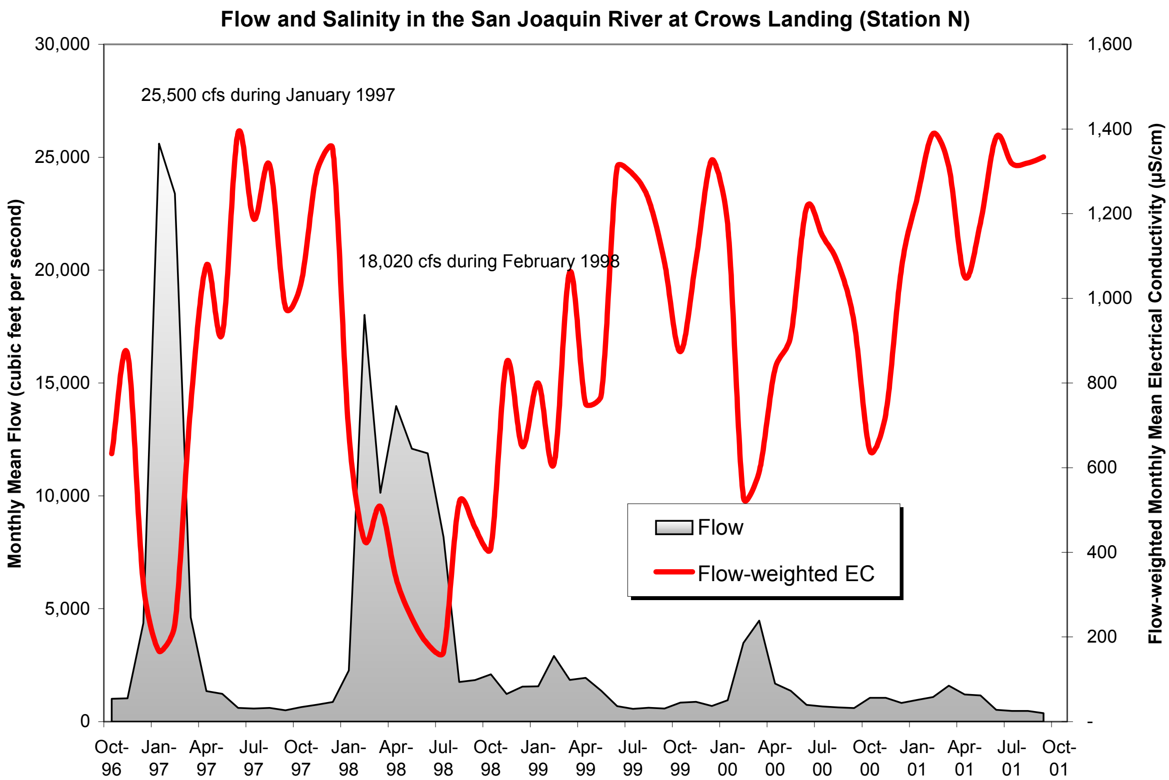


Figure 11. Flows in the San Joaquin River measured at the CRWQCB compliance station at Crows Landing for years 1996-2001. Note the significant flow events during 1997 and 1998 which dominate the hydrology of the flow record.

Spanish Grant Drain

The Spanish Grant Drain is located at River Mile 105 (see table in Appendix D) about 4 miles north of Orestimba Creek. The Drain collects mostly return flows from riparian pump diversions along a short reach of the San Joaquin River. A small volume of return flow from the Central California Irrigation District also is conveyed to the River through this Drain. Unlike Orestimba Creek, Del Puerto Creek, Hospital and Ingram Creeks this Drain does not extend into the west-side Coast Range. Hence the Drain flows mostly during the summer. Figure 12 shows 3 synoptic flow measurements taken by the USGS during 2001 in June, July and August. Flows in Spanish Grant Drain range from 12 to 29 cfs.

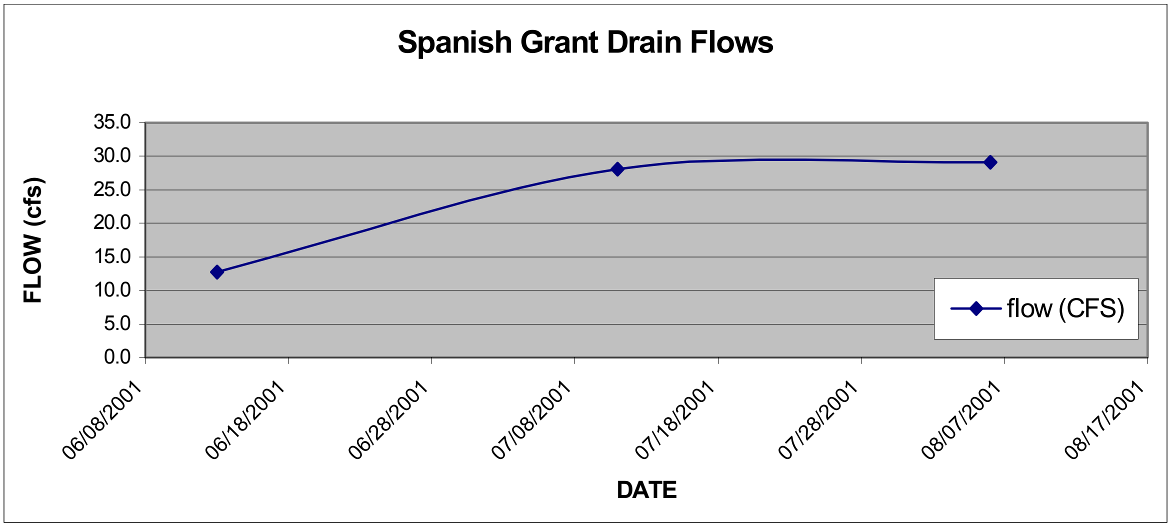


Figure 12. Flow in Spanish Grant Drain during summer 2001.

Hospital Creek / Ingram Creek

Hospital Creek and Ingram Creeks combine to the east of Highway 33 and hence are usually considered to be one conveyance. Hospital and Ingram Creeks are in an ungaged watershed and run through the West Stanislaus Irrigation District prior to discharge to the San Joaquin River at River mile 80 (Appendix D). In the CRWQCB's SJRIO2 model, flow hydrology is calculated as a percentage of Orestimba Creek flows based on watershed size (approximately 64 percent). Hospital / Ingram Creeks are also assumed to have the same return flow salinity due to geographic similarities. Figure 13 shows the flow, measured by the USGS, in Hospital Creek during June, July and August 2001. Flows fall in the range of 15 – 30 cfs during these summer months.

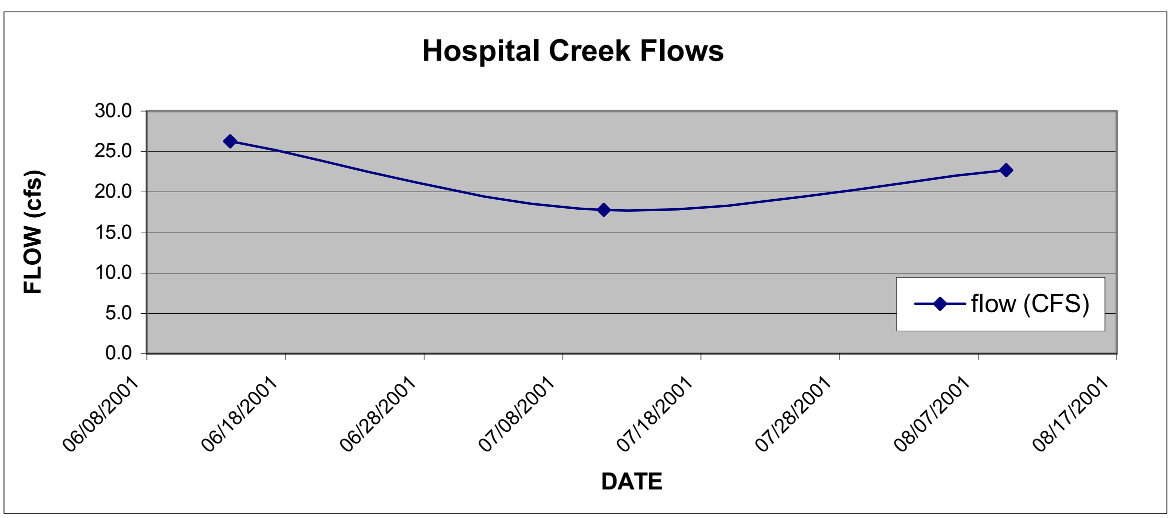


Figure 13. Flow in Hospital Creek during summer 2001.

Del Puerto Creek

Del Puerto Creek runs through the southern quarter of the West Stanislaus Irrigation District between the towns of Patterson and Westley. Like the other west-side creeks it conveys rainfall runoff during the winter months and agricultural drainage during the summer. The Creek discharges to the San Joaquin River at River Mile 93 (Appendix D). The relatively short path from the west-side of the watershed to the River reduces the opportunity for this Creek and Hospital/Ingram Creek to accumulate any significant algal load – this has been confirmed by preliminary results of 2001 monitoring, presented by the USGS (Kratzer, 2001 :

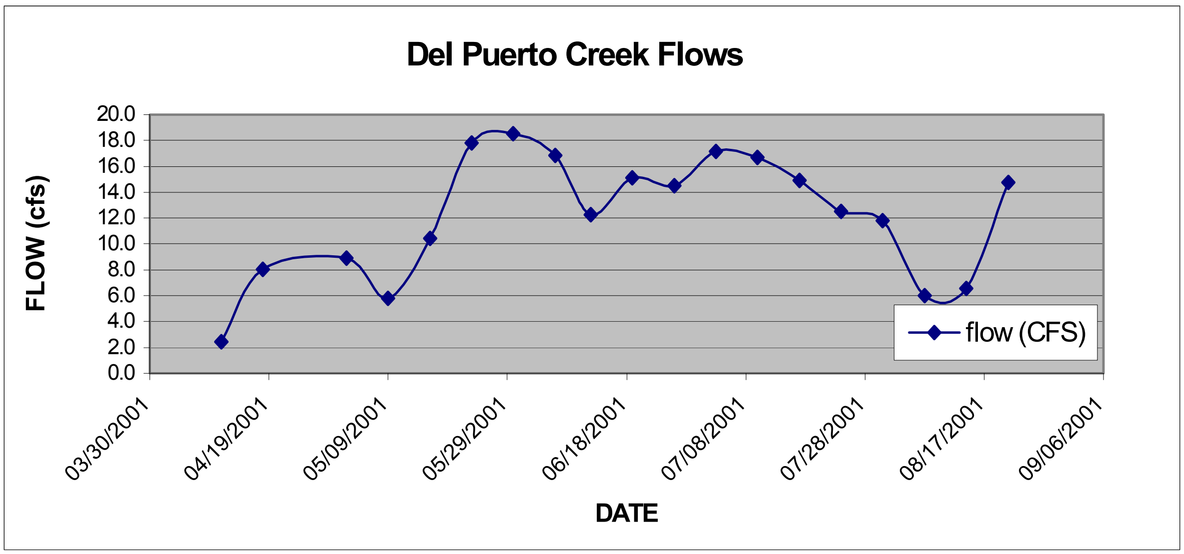


Figure 14. Flow in Del Puerto Creek during summer 2001.

personal communication). Figure 14 shows flow data, collected by the USGS every two weeks during the irrigation season between March and September. The flows peak in early June at about 19 cfs and verage about 15 cfs during the late spring and summer months of May, June and July.

Orestimba Creek

Orestimba Creek is the dominant west-side tributary in the Basin, north of Little Panoche Creek, and discharges to the San Joaquin River at river mile 109 (Appendix D). Orestimba Creek drains a medium sized watershed in the Coast Range and hence can produce substantial flood flows during and after substantial and prolonged precipitation. Figure 15 shows a time series plot of measured and synthetic flows for Orestimba Creek. As shown in the plot 1998 produced the highest flows on record of about 24 m^3/sec (approximately 850 cfs). The large spikes are as a result of large rainfall-runoff events – the more consistent flows below 2 m^3/sec are the result of irrigation season return flows.

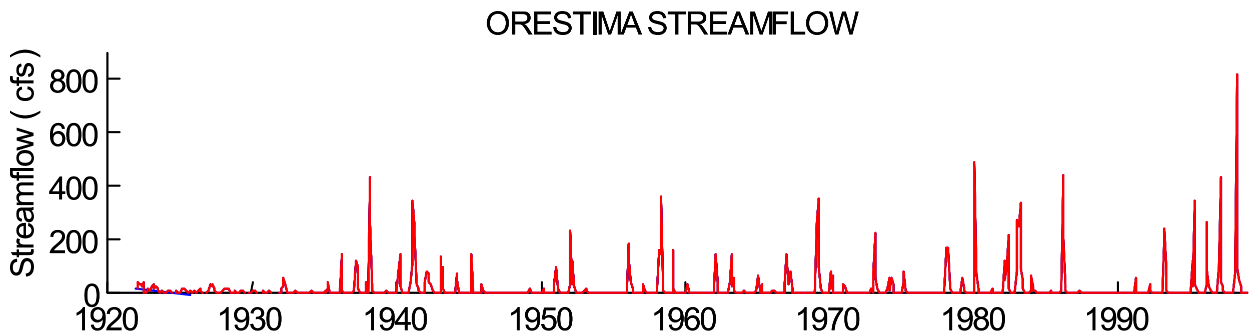


Figure 15. Time series plot for Orestimba Creek located between Crows Landing and Newman on the San Joaquin River. Orestimba Creek cariies flood flows from the Coast Range during the winter season and irrigation return flows during the summer. Orestimba Creek is used as an index site for all west-side creeks

In Figure 16 regressions are shown of Orestimba Creek versus Hospital / Ingram Creeks, Del Puerto Creek , Mud Slough and Salt Slough. The gradient of the best-fit line is similar for both Hospital / Ingram and Del Puerto Creeks but quite different for both Mud and Salt

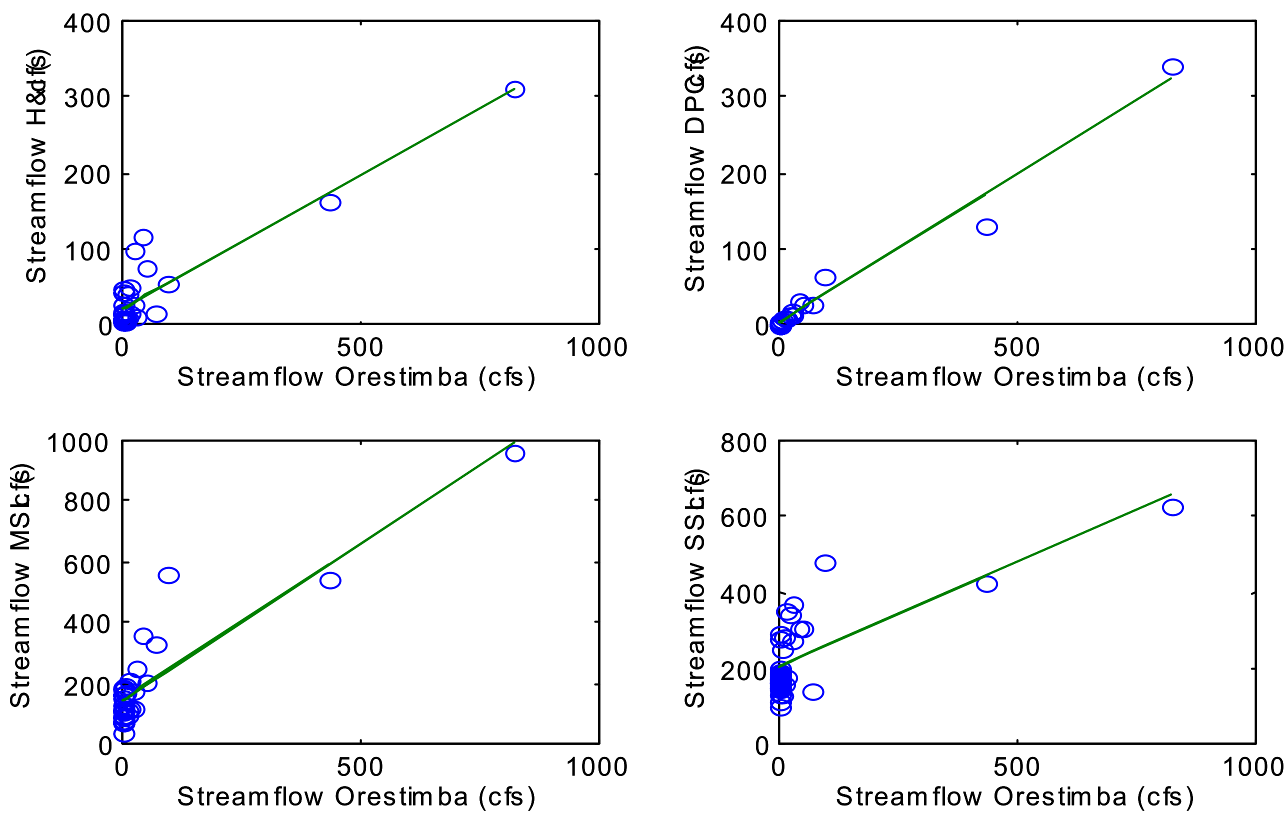


Figure 16. Regressions on Orestimba Creek for Hospital/Ingram Creek, Del Puerto Creek and Mud and Salt Sloughs. Only Orestimba Creek is gauged (+/- 10% accuracy).

Sloughs. This infers that Orsetimba Creek is a good index site for estimating the former two creeks but a poor estimator for Mud and Salt Sloughs. Given the diverse land use in the Grassland watershed – this is expected.

West-side diversions

There are several sources of water used for irrigation on the westside: SJR diversions, Central Valley Project (CVP) direct deliveries from the San Luis Canal or Delta Mendota Canal, CVP deliveries obtained under contract with one of the Exchange Contractors and delivered using private ly owned canals such as the Main Canal; and pumped groundwater. Records of CVP deliveries are maintained by the San Luis and Delta Mendota Water Authority, individual water districts and the US Bureau of Reclamation. Data on total monthly diversions from the SJR are maintained by ESWD, WSID, and PWD and reported annually to the CRWQCB. These three districts account for approximately 50% of the total estimated diversion from the San Joaquin River between Lander Avenue and Vernalis.

Diversion data obtained from the largest three diverters for the past 3 years is reported to the CRWQCB. Other districts' diversions are estimated by river mile using a relationship developed for SJRIO-2 (Kratzer et al. 1987). This formulation was based on applying monthly average usage to maximum allowable diversion ratios of the largest three diverters. In addition to the five appropriative diverters, there are also riparian diverters whose diversion rights precede formal agreements. These diversions are ungaged and were estimated by river mile in the SWRCB analysis from assumed acreage, crop type, and crop water demand per SJRIO (Kratzer et al. 1987). The crops for the riparian users were assumed to be almonds, corn, and pasture. Cropping patterns were assumed to remain the same throughout the calibration period. Agricultural return flows were estimated by applying an efficiency factor to all of the sources of irrigation water by river mile. Return flows were estimated to be 30 percent of the water supplied per source. The return flow calculation has four components contributing to return flows per SJRIO (Kratzer et al. 1987). These components include (a). CVP deliveries to appropriative water right holders; (b) water returned from the largest three SJR diversions; (c). return flows from all other SJR diversions, and (d). groundwater pumped from shallow aquifers.

The SWRCB analysis was performed in the mid 1980's and there has been no comparable effort since to characterize the hydrology of the lower San Joaquin River. However, given the changes in water supply availability and programs such as the Grassland Bypass Project to control contaminant discharges to the San Joaquin River, the assumption of 30% is unlikely to be valid. Water districts such as Patterson Irrigation District and Banta Carbona Irrigation District have taken actions to curtail discharges to the San Joaquin River in the past decade and have invested in on-farm reuse measures which return surface drainage collected in tailwater ponds to the head of the distribution laterals for blending. Recent announcement by the CRWQCB of a salinity and boron TMDL for the watershed has created more interest in these types of on-farm drainage discharge reduction facilities.

Figure 17 compares the annual diversions to West Stanislaus Irrigation District, Patterson Irrigation District and El Solyo Water District. These diversions are shown for the five water year types described by the San Joaquin River Index (Appendix E). In most cases irrigation

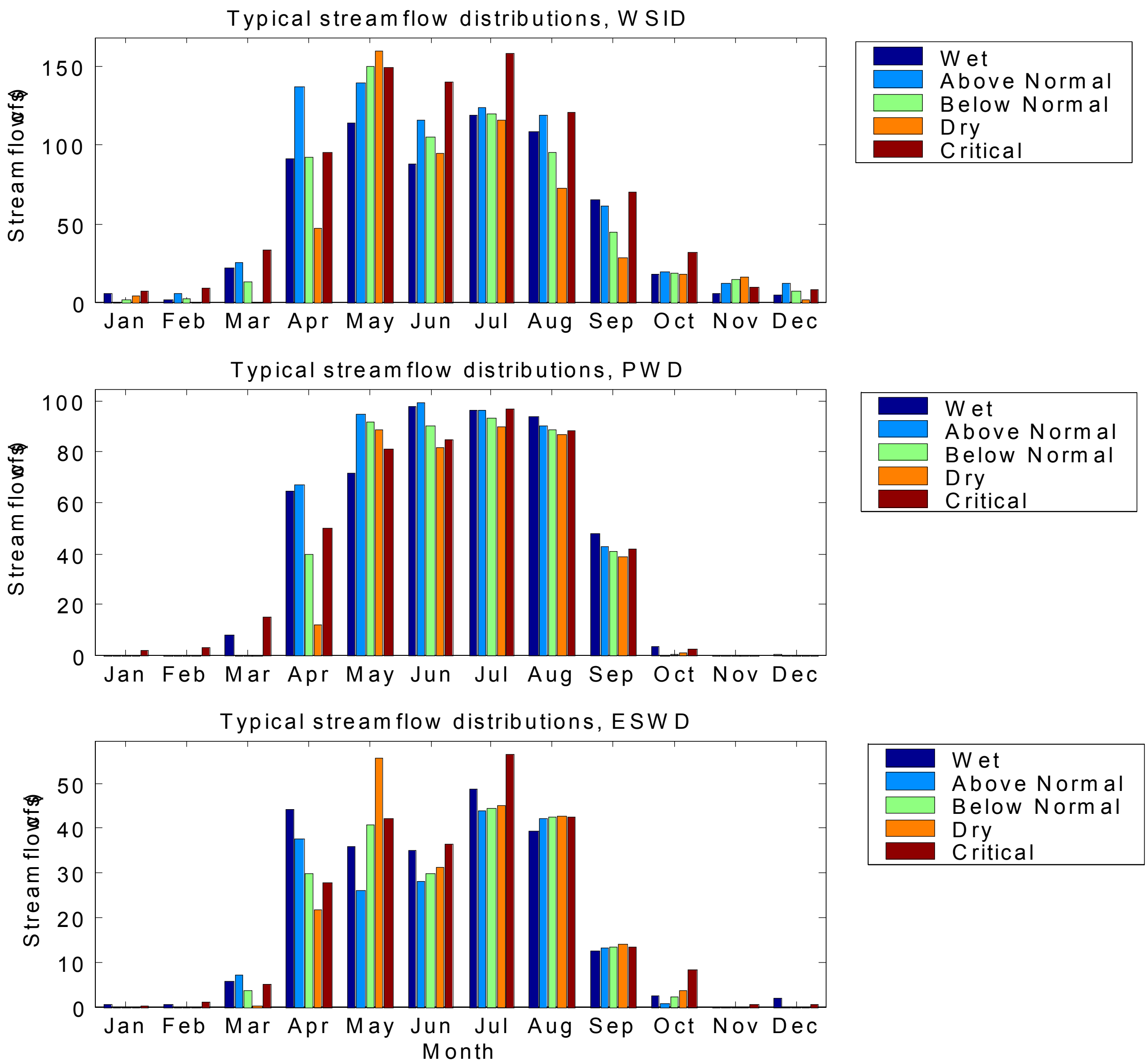


Figure 17. Typical monthly diversions for West Stanislaus ID (WSID), Patterson WD (PWD) and El Solyo Water District (ESWD) for various water year types.

diversions from the San Joaquin River increase rapidly towards the end of March and drop sharply in late August. Some districts such as West Stanislaus Irrigation District appears to divert water in some years throughout the year.

Figures 18, 19 and 20 are taken from the DSM2-SJR model and show by river reach the monthly diversions from all riparian diverters for prototypical critically dry, wet and dry years. The DSM2-SJR model is calibrated for years 1985 through 1993. These reaches are defined in Appendix D and in Table 2 below. Appendix D also describes the model node labels for the DSM2-SJR model.

Table 2. River reach definitions used to summarize DSM-2 flow diversion data. Note that the greatest party of SJR water diverted is from Reaches 1 and 2. Appendix D provides a graphical representation of this table.

RIVER REACH NUMBER	UPSTREAM BOUNDARY	DOWNSTREAM BOUNDARY
1	Tuolomne River	Vernalis
2	Del Puerto Creek	Tuolomne River
3	Orestimba Creek	Del Puerto Creek
4	Merced River	Orestimba Creek
5	Mud Slough	Merced River
6	Salt Slough	Mud Slough
7	Bear Creek	Salt Slough

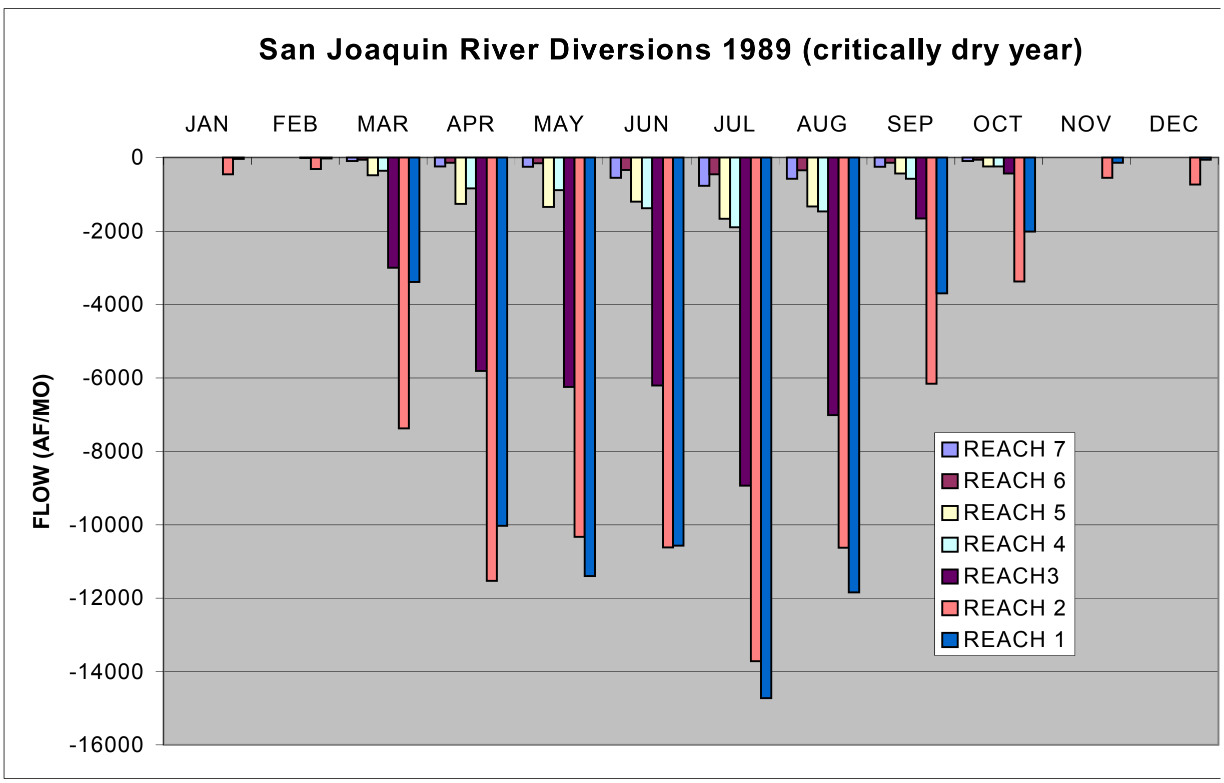


Figure 18. San Joaquin River diversions by model reach for 1989 (typical of the critically dry water year type condition.

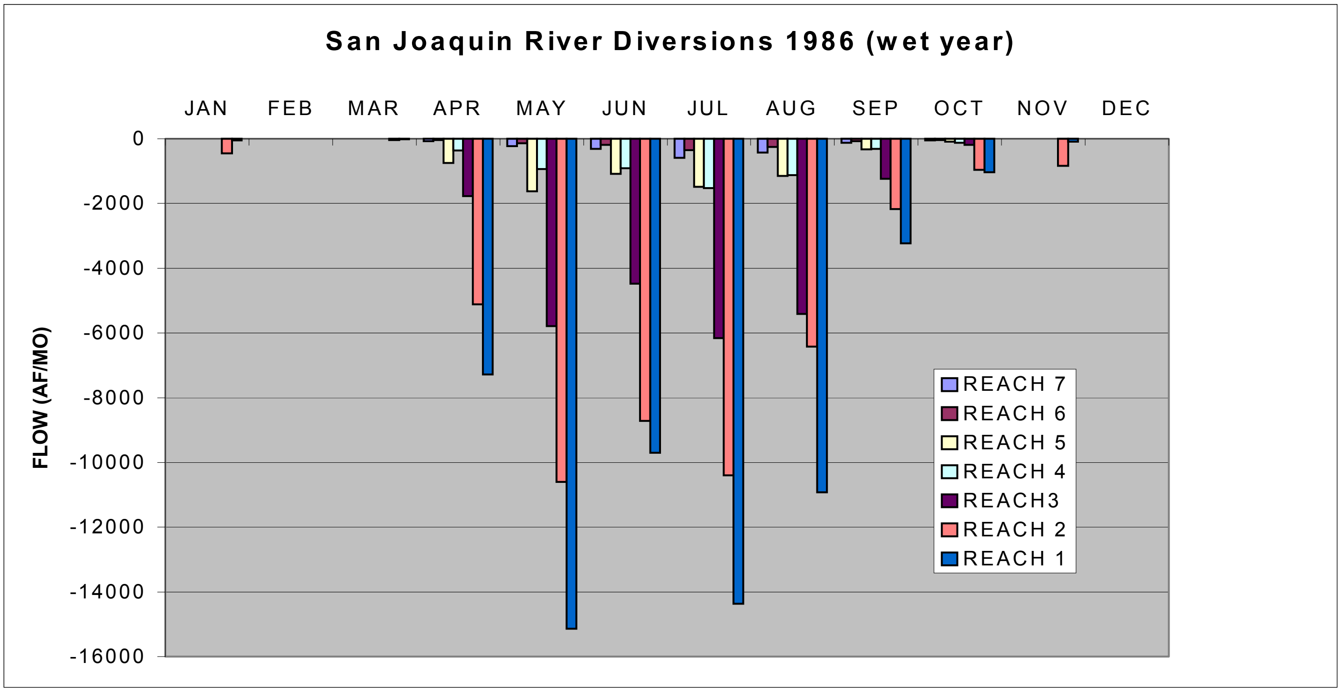


Figure 19. San Joaquin River diversions by model reach for 1986 (an extreme wet water year type condition)

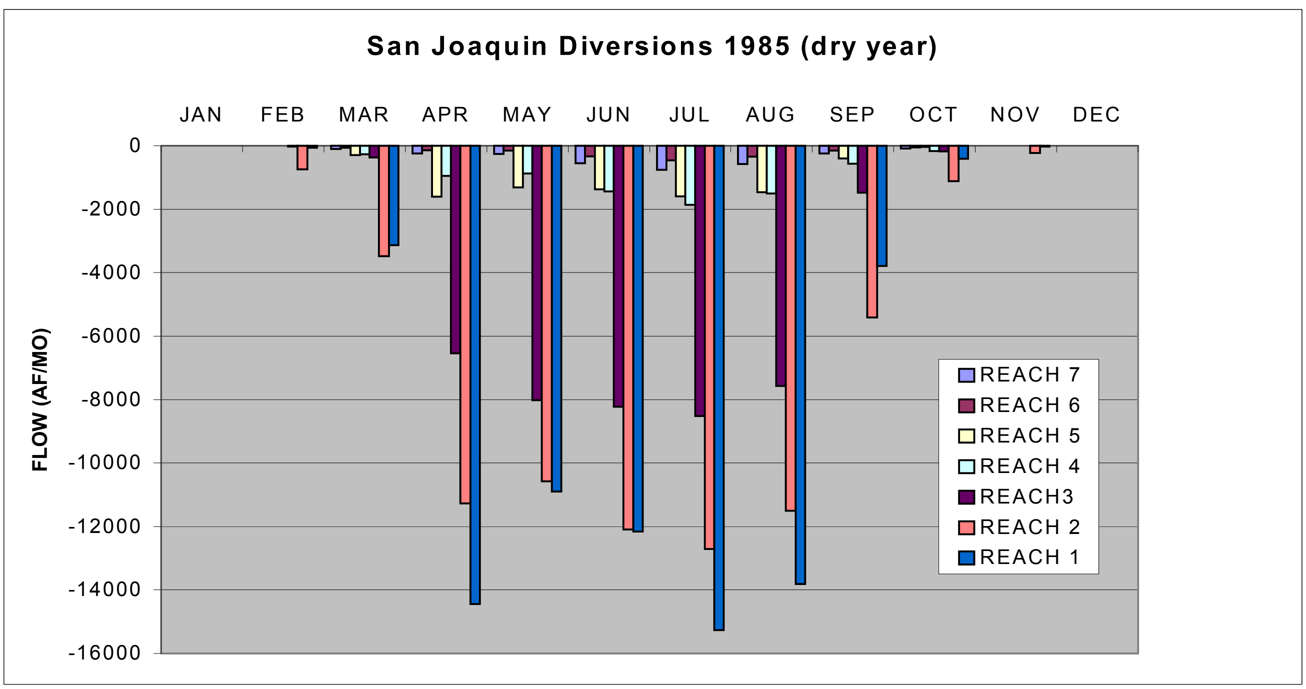


Figure 20. San Joaquin River diversions by model reach for 1985 (an average dry water year type condition)

These plots give a consistent result showing a sharp drop off in diversions in late August. In these plots the three years chosen to represent critically dry years, wet years and dry years are 1989, 1986 and 1985. The CRWQCB has not calibrated the current SJRIO-2 model past 1993. Since this model database was used in the development of the DSM2-SJR model – the DSM2-SJR model has the same limitation. It is interesting to note that in all but severe drought years riparian diverters continue to remove their water right allotments from the river – 1989 the total volume removed from the River appears larger. During wet years there appears to be some curtailment of diverted River flow in the spring months.

West Stanislaus Irrigation District – flow diversion monitor installation

One of the tasks under the 2001 Directed Action Project involved the installation of an accoustic doppler sensor and electrical conducity sensor in the first lift canal of the West Stanislaus Irrigation District. This task was funded with the intent that any dissolved oxygen TMDL for the San Joaquin River would require real-time data on river diversions. Diversions remove algal biomass from the River and with this biomass part of the oxygen demand associated with it upon entering the Deep Water Ship Channel. It was envisaged that real-time monitoring would go hand-in-hand with real-time dissolved oxygen modeling of the lower San Joaquin River. Some background on the Irrigation District is provided below together with field data collected from the installed monitoring station during 2001.

The West Stanislaus Irrigation District (WSID) was formed in 1920 to provide diverted San Joaquin River water to local farmers. The District secured a water right for 262.15 cfs from January 1 to December 31 each year. The irrigated acreage under this licence is 21,660 acres. The District also diverts water for the White Lake Mutual water Company equal to a continuous flow of 45 cfs. The area irrigated by the Water Company is 2202 acres.

The development of the Central Valley Project in the 1960's to prevent further overdraft of aquifers in the San Joaquin Basin led to the construction of Friant Dam and the diversion of San Joaquin River water to the Friant-Kern subregion. The USBR entered into a contract with the WSID to replace some of the water supply no longer pumpable from the San Joaquin River with water pumped from the Delta through the Delta Mendota Canal. The initial contract was signed for an amount of 20,000 acre-ft which was subsequently increased to 50,000 acre-ft in 1976. Droughts and water restrictions brought about with the passage of the Central Valley Project Improvement Act have placed constraints on the amount of water the USBR can deliver through its CVP contract. In 1990 and 1993 the District received a 50% supply, in 1991 and 1992 the supply was cut further to 25%.

The District owns four wells that have been located along the District Main Lift Canal. These pumps produce approximately 30 cfs and are operated during the peak irrrigation season for a minimum of 45 days per year. The approximate annual pumpage of the District-owned wells is 4,000 acre-ft /year. There are a larger number of private groundwater wells in the water district. The water from these wells must be blended with DMC water owing to its high salinity.

Given the over-commitment of San Joaquin Basin water resources it is probable that, save for periods of inactivity due to pump maintenance, that the District will attempt to use its full allocation of San Joaquin River water annually. This diversion and other like diversions can have a significant implication for the San Joaquin River Dissolved Oxygen TMDL since removal of river water also removes suspended particulates such as algae and dissolved ions from the San Joaquin River. Algae will be filtered from the percolating water and some salts may be consumed by crops while the water passes through the crop root zone or adsorbed to soil. A small proportion of the particulates and a larger proportion of the dissolved ions are likely returmed to the San Joaquin by way of the major and minor surface drains.

Estimation of water diversions along the San Joaquin River has been one of the most difficult aspects of flow and water quality simulation modeling in the San Joaquin River (Pate, 2001, personal communication). The desire of the Technical Advisory Committee of the SJR Dissolved Oxygen TMDL project to move from historical simulation modeling to a more dynamic forecasting type of operation creates an even greater need for reliable river diversion data. Hence the TAC requested that a real-time flow and electrical conductivity monitoring station be installed and maintained as part of the year 2001 Directed Action Project. The advantage of stations of this type is that they can easily accommodate other sensors should there be an interest in other water quality parameters. Turbidity, dissolved oxygen, chlorophyll, pH and certain specific ion sensors can be interfaced with the existing stage, flow and electrical conductivity sensors at the site.

West Stanislaus Irrigation District diversion monitoring

The San Joaquin River Management Program Water Quality Subcommittee provided an datalogger, electrical conductivity and stage sensor which was deployed at a newly constructed gauge house on the first lift canal of the WSID on May 9, 2001. An accoustic velocity meter was initially installed at the site, on loan from SONTEK Inc. and removed in mid-June 2001. A new MGD Inc. accoustic velocity meter was purchased by the Water District in late June, 2001, installed and interfaced with the datalogger, electrical conductivity sensor and telemetry system on July 4, 2001 with funding from the San Joaquin River Dissolved Oxygen project. The site has been maintained using Quality Assurance procedures published by the Grasslands Bypass Project since this installation date.

Flow, electrical conductivity and temperature data for the diversion monitoring station at West Stanislaus Irrigation District is provided in Figures 21, 22 and 23. The flow data shows diversions of between 150 cfs and 200 cfs for the majority of the irrigation season starting on May 15, 2001 (Julian Day 135) through August 10, 2001 (Julian Day 222). After August 10 a slow downward trend can be observed until September 27 (Julian Day 270) to a steady-state pumping rate of between 10 and 50 cfs which diminishes to zero on November 14 (Julian Day 318). The period of rapid reduction in pumping may be significant for the San Joaquin River Dissolved Oxygen TMDL project, especially if this trend is replicated in the other riparian diverters including Patterson Irrigation District, El Solyo Water District and Banta Carbona Irrigation District. This reduction in pumping occurs at the same time as the low dissolved problems are manifested in the Deep Water Ship Channel. Significant reductions in San Joaquin River pumpage allow the uninterrupted passage of algal load from the upper watershed to the ship channel potentially doubling the algal loads in the space of 50 days, if diversions from the river at this time of year are as great at 50% of the unimpaired flow. This problem is obviously much worse in dry years during which riparian and appropriative diversions can remove much of the flow from the river and less severe in wet years when these diversions have a much smaller impact on flow to the Deep Water Ship Channel

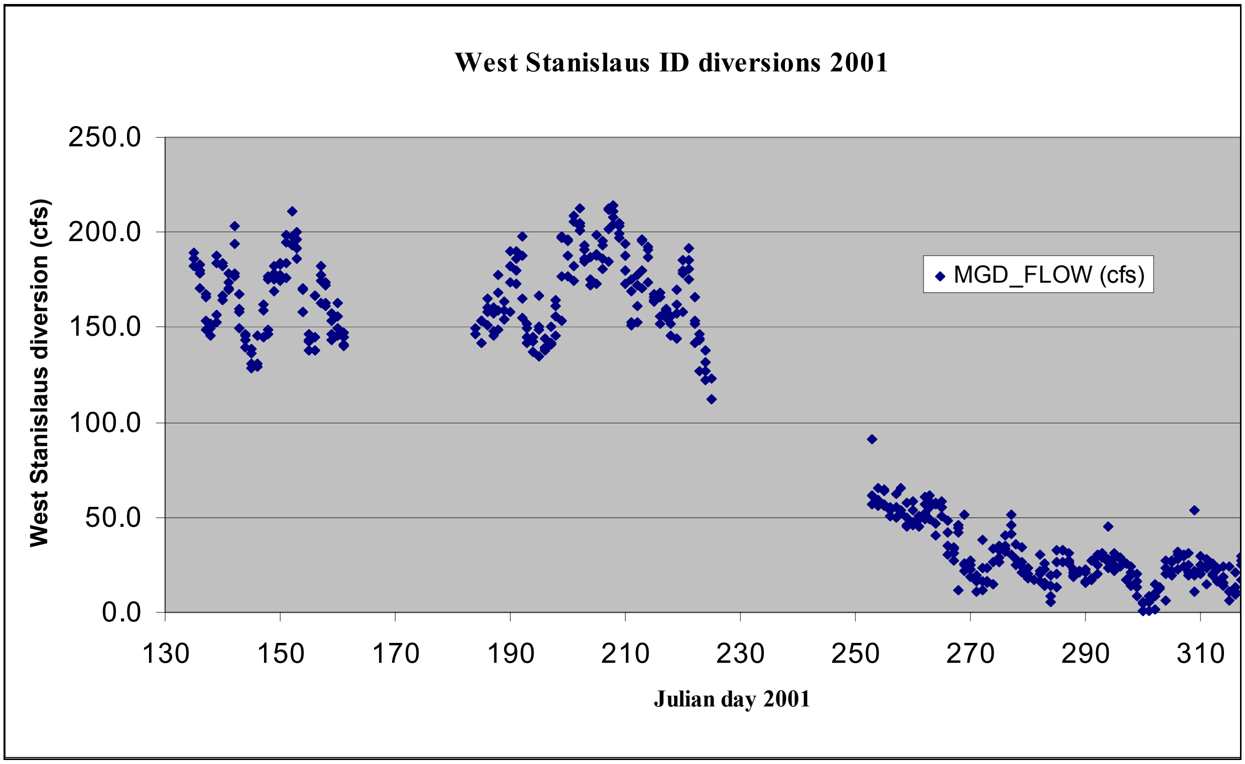


Figure 21. Measured SJR diversion by West Stanislaus Irrigation District during 2001.

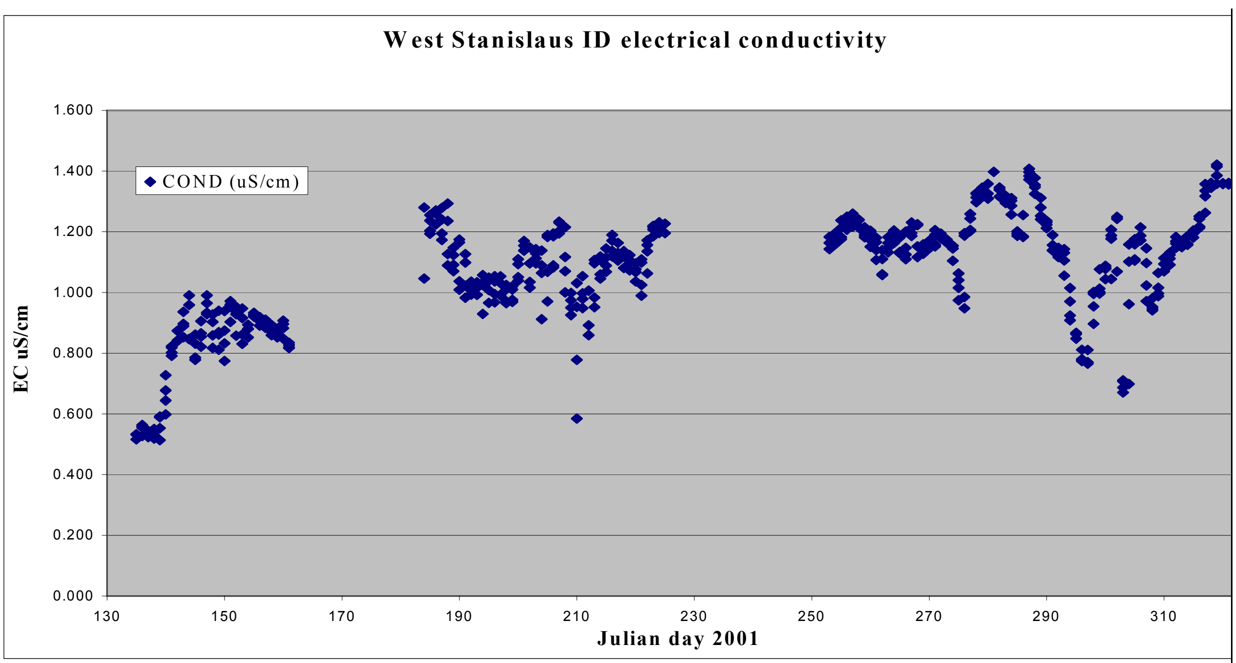


Figure 22. Salinity of West Stanislaus Irrigation District diversion during 2001.

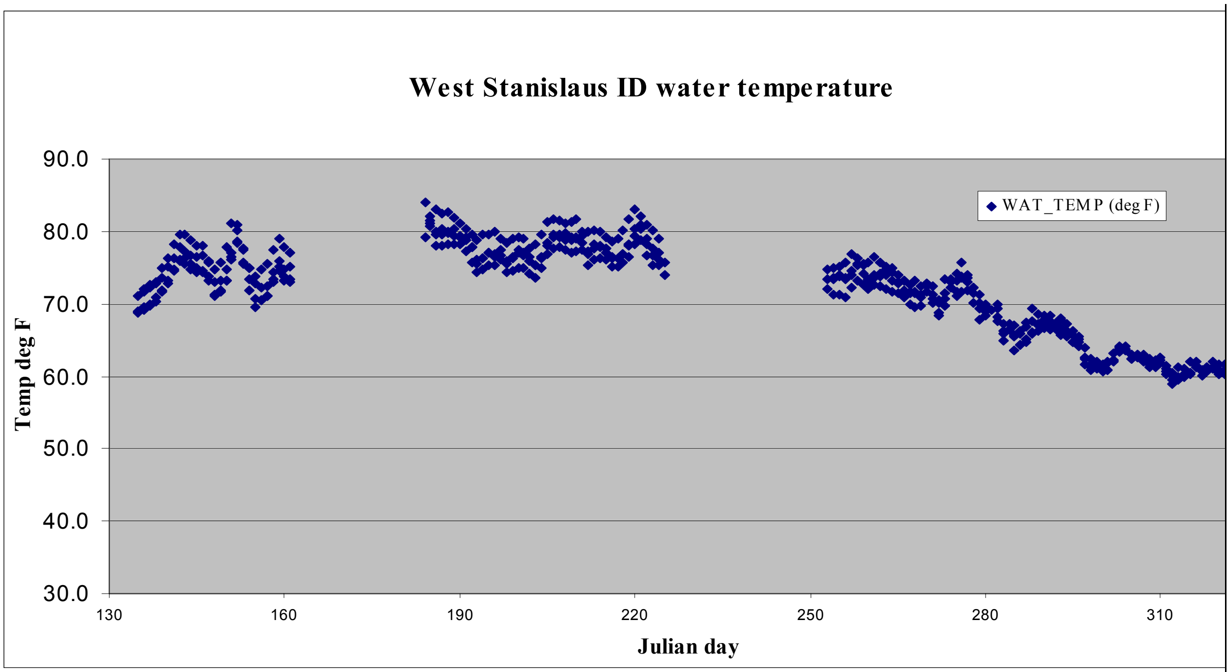


Figure 23. Temperature of West Stanislaus Irrigation District diversion during 2001

A web site has been created for easy dissemination of data from the West Stanislaus Irrigation District monitoring station. The web address is :
http://socrates.berkeley.edu/~nwquinn/Grassland_Realtime/Quinn-Grass/
Figures 24 and 25 show the web page for the District and current real-time data. Pumping has ceased for the season – hence the current salt flow and calculated salt load are zero.

Patterson Irrigation District diversion - flow monitoring data access

Patterson Irrigation District has a water right for 38,000 acre-ft/year and is the second largest riparian diverter on the lower San Joaquin River. The District has developed a state-of-the-art SCADA system for their irrigation supply system which provides real-time information of every turnout in the District.

An agreement has been brokered with the Patterson Irrigation District to allow access to their river diversion information without the need for construction of a full gauging station, initially determined to be necessary for the current project. An electrical conductivity sensor and analog signal converter was purchased for the site and tied into Patterson Irrigation District's existing monitoring system. The Water District is developing a system that will allow diversion, electrical conductivity and temperature data to be accessed weekly via a web site or ftp server for use by the San Joaquin River DO TAC.

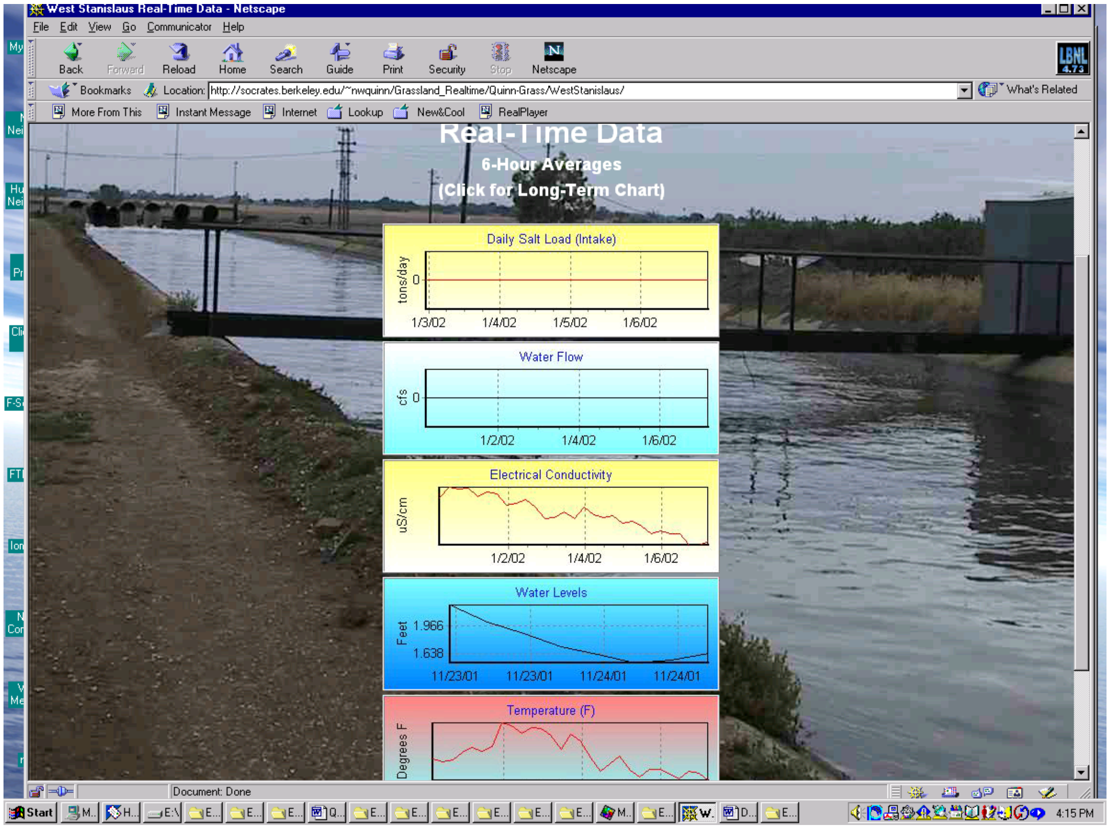


Figure 24. Real-time stage, flow and electrical conductivity data for the West Stanislaus monitoring site for the week of January 2, 2002.

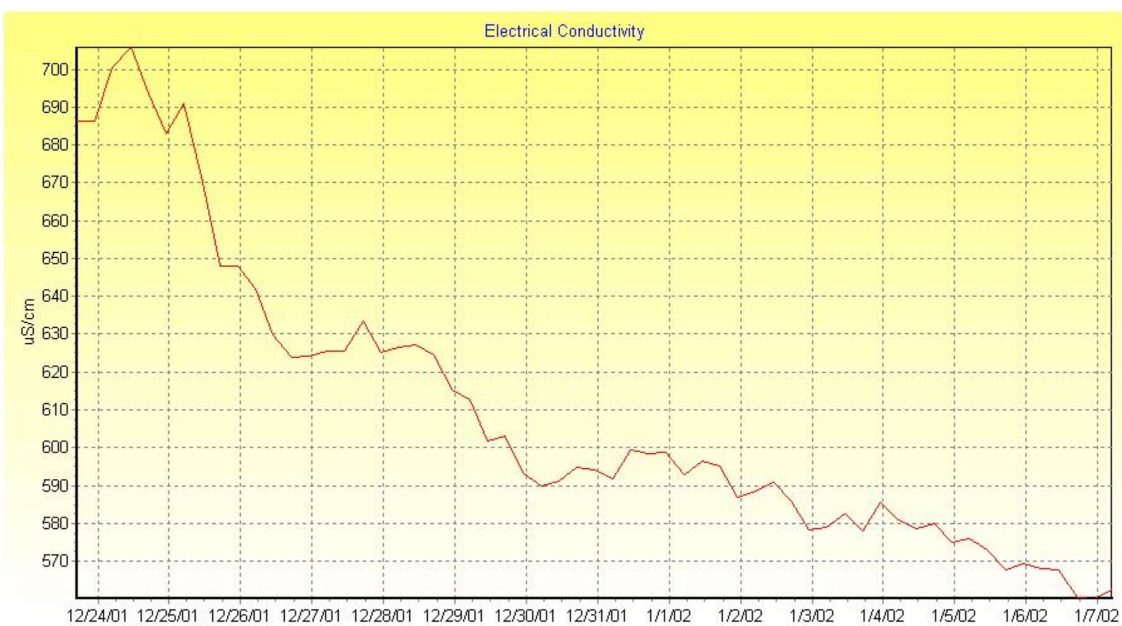


Figure 25. Detailed electrical conductivity data obtained by double-clicking on EC image on real-time SJR DO project website for the West Stanislaus monitoring station.

El Solyo Water District diversions

The El Solyo Water District (ESWD) has a right to 13,000 acre-ft per year of San Joaquin River water. Unlike Patterson Irrigation District or West Stanislaus Irrigation District the El Solyo Water District has no contract for Delta water from the US Bureau of Reclamation. Instead it relies on San Joaquin River water and groundwater pumping for its full supply. The Waer District is small in area – roughly one quarter the size of the Patterson Irrigation District.

Banta Carbona Irrigation District diversions

The Banta Carbona Irrigation District is located in the Delta downstream of Vernalis. The District uses about 59,000 acre-ft during a typical year about half of which is pumped from the San Joaquin River. The US Bureau of Reclamation provides the District with up to 25,000 acre-ft per year as an exchange for San Joaquin River water diverted to the Friant-Kern service area. The District currently operates a pumping plant off Kasson Road in the South Delta, north of Vernalis, which is capable of delivering 200 cfs when all pumps are operational.

Del Puerto Water District diversions

The USBR maintains records of CVP deliveries to all districts that are Federal contractors. The CVP component was originally based on 10 appropriative districts; however, the Del Puerto Water District (DPWD) acquired six of the 10 in 1995. For modeling purposes the DPWD deliveries must now be synthetically redistributed to maintain the original assumption of 10 districts and preserve the historical record.

Central California Irrigation District diversions

The Central California Irrigation District (CCID) supplies its customers through the Main Canal. Land within the CCID may have riparian or appropriative rights to San Joaquin River water. The database of water rights holders will be investigated and reported on in the final version of this report.

Municipal discharges

There are four major identified municipal discharges to the main stem of the San Joaquin River (Pate, 2001). These are :

1. Newman Wastewater Treatment Plant
2. Turlock Wastewater Treatment Plant
3. Modesto Wastewater Treatment Plant
4. Los Banos Wastewater Treatment Plant (via Los Banos Creek)

The City of Modesto is the only municipality that discharges directly to the SJR. The Modesto Wastewater Treatment Plant (MWWTP) maintains total monthly discharge records. The City of Turlock Wastewater Treatment Plant (TWWTP) discharges indirectly to the SJR and is accounted for later. The City of Newman Wastewater Treatment Plant (NWWTP) uses a system of retention, evaporation, and land disposal. The NWWTP only discharges to the SJR during the rainy season when the disposal site is saturated and unable to assimilate the effluent. The NWWTP flow and salinity contributions to the SJR are assumed negligible (Kratzer et al. 1987). No significant industrial discharges have been identified (Kratzer et al. 1987).

Figure 5 previously showed both the current mean return flow data from east-side drains and the Modesto Waste Water Treatment Plant.

Groundwater accretions

Gains from or losses to local groundwater aquifers cannot be measured directly except by difference where other flow components are accurately gauged. Hence most estimates of groundwater flux into and out of the river is obtained by modeling. A number of studies have been made of groundwater within the San Joaquin River basin, the most recent of which was prepared by Cooley (CRWWCB, 2001). Cooley provides a good summary of the results of past studies. The results of these studies report that the San Joaquin River is mostly a gaining stream – estimates of the magnitude of these gains range from 4.6 cfs/mile to 6.7 cfs/mile.Cooley's independent estimates show that in the upper reach of the flowing section of the River the river may be losing up to ½ cfs/mile. For the majority of reaches below the losing reach gains were of the order of 6 cfs/mile.

Table 2. CRWQCB estimate of groundwater accretion data by reach

REACH	Length (miles)	Annual net gain (cfs/mile)	July-Dec (cfs/mile)	Jan – June (cfs/mile)
1. Stevinson to Newman	14.3	3.8	1.8	5.8
2. Newman to Crows Landing	15.2	6.1	4.6	7.7
3. Crows Landing to Patterson	9.5	28.0	28.9	27.2
4. Patterson to Vernalis	30.8	6.1	4.7	7.4

The analysis above is most clearly demonstrated graphically. Figures 27 through 33 for 2001, produced by DWR Fresno, are results from the CALFED-sponsored real time water quality management program developed by the SJRMP Water Quality Subcommittee (Quinn, et. al, 1997; Quinn and Karkoski, 1998). This project has developed a water quality forecasting system to help coordinate reservoir operations and west-side saline discharges to the San Joaquin River. The Committee has developed a real-time network of monitoring stations along the San Joaquin River and in its major west-side triibutaries (Figure 26).

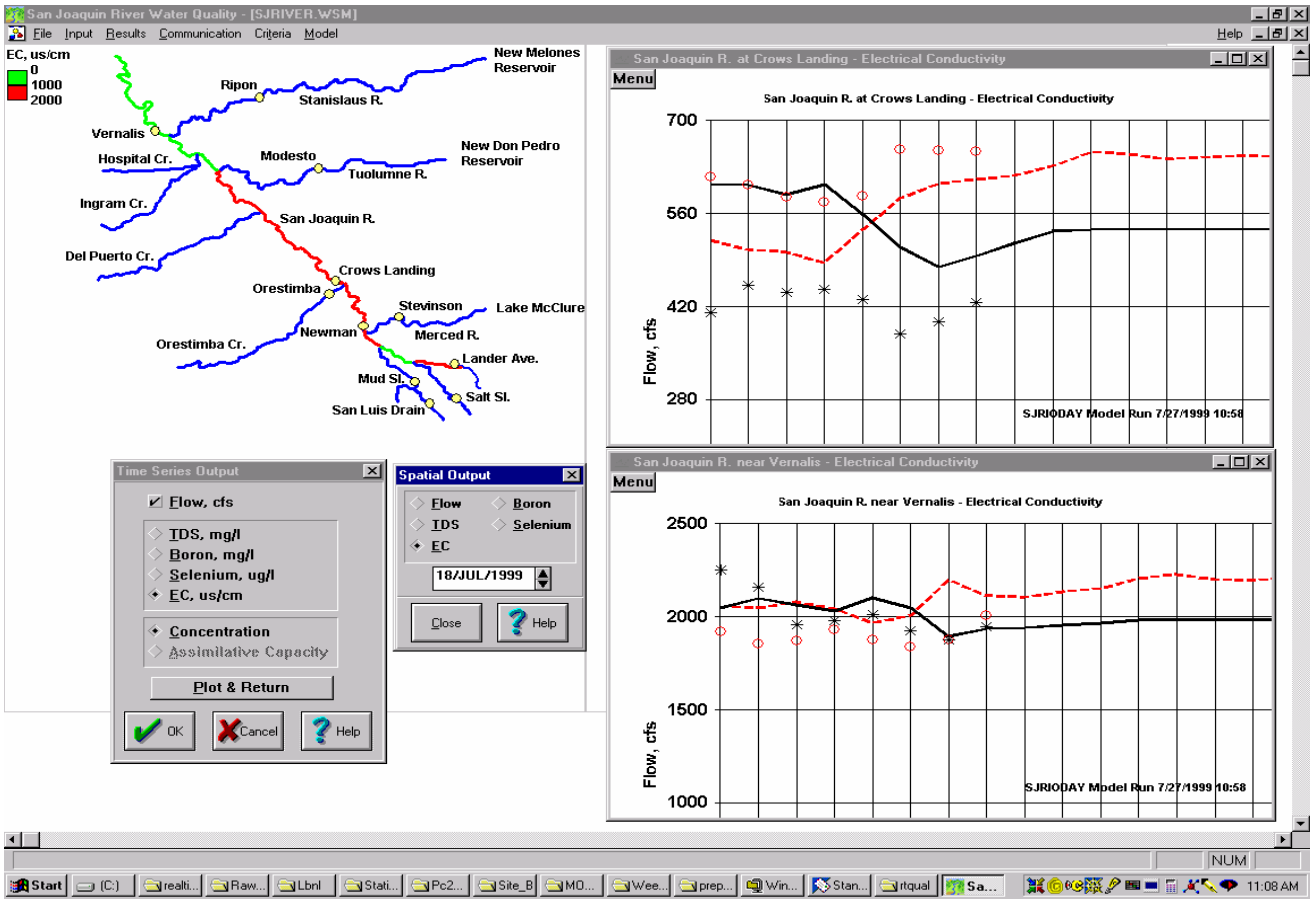


Figure 26. Real-time water quality modeling and forecasting system used weekly to assess San Joaquin River assimilative capacity for salt loading.

Figure 27 shows the flow measured at various River monitoring stations for 2001. The Vernalis Adapative Management Program (VAMP) between April 15 and May 15 are notable in the graph. Flows increase as one moves downstream as more of the east-side tributaries are included in the main stem flows. Figure 28 shows gains and losses for the whole river for 2001. This plot provides evidence for the assertion that between Lander Avenue and Vernalis the river is a gaining stream. Brief excursions below the zero line are most likely noise in the data than any real reversal in groundwater accretions.

Figure 29 shows flow measured at Stevinson (Lander Avenue). This gauge station is probably the poorest in the monitoring network for measuring flow. The hydrograph shows spikes in late January, mid and late February and in early March. These are most likely releases from Friant Dam via the Chowchilla Bypass or releases along other east-side tributaries such as Bear Creek.

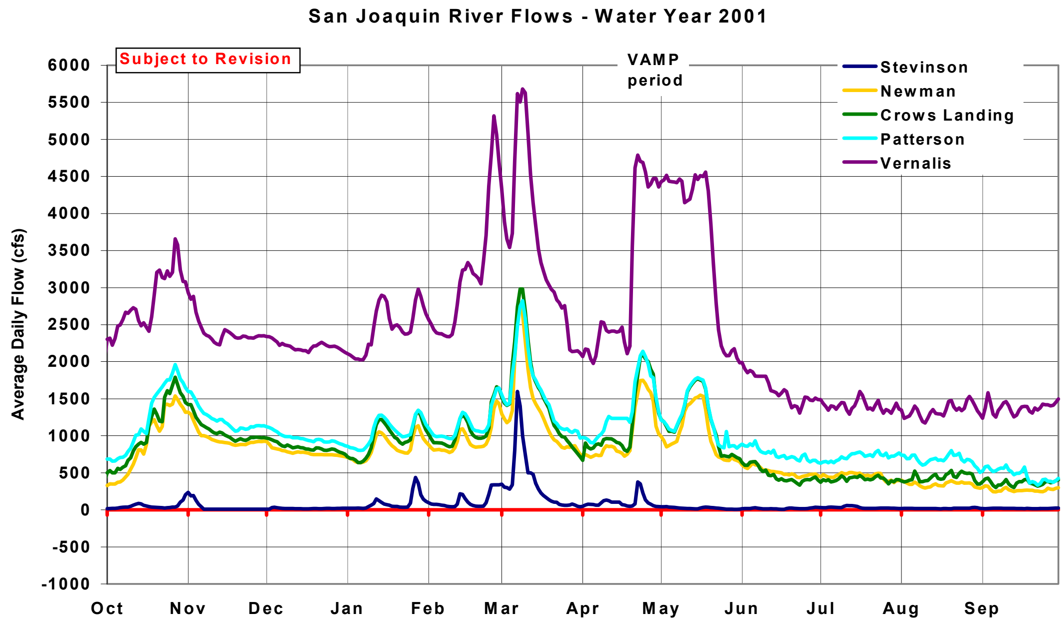


Figure 27. Flows measured at various bridge monitoring stations along the SJR during 2001 (SJRMP Water Quality Subcommittee, 2001)

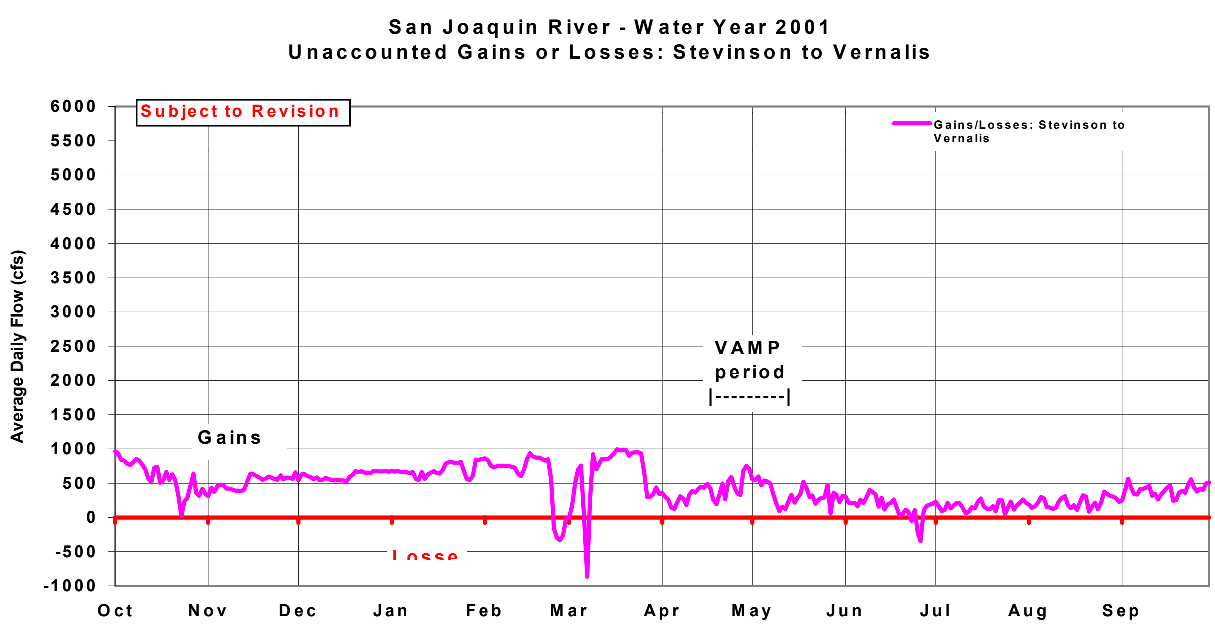


Figure 28. Unaccounted gains and losses between Lander Avenue and Vernalis for 2001. (Source : SJRMP-WQS, 2001)

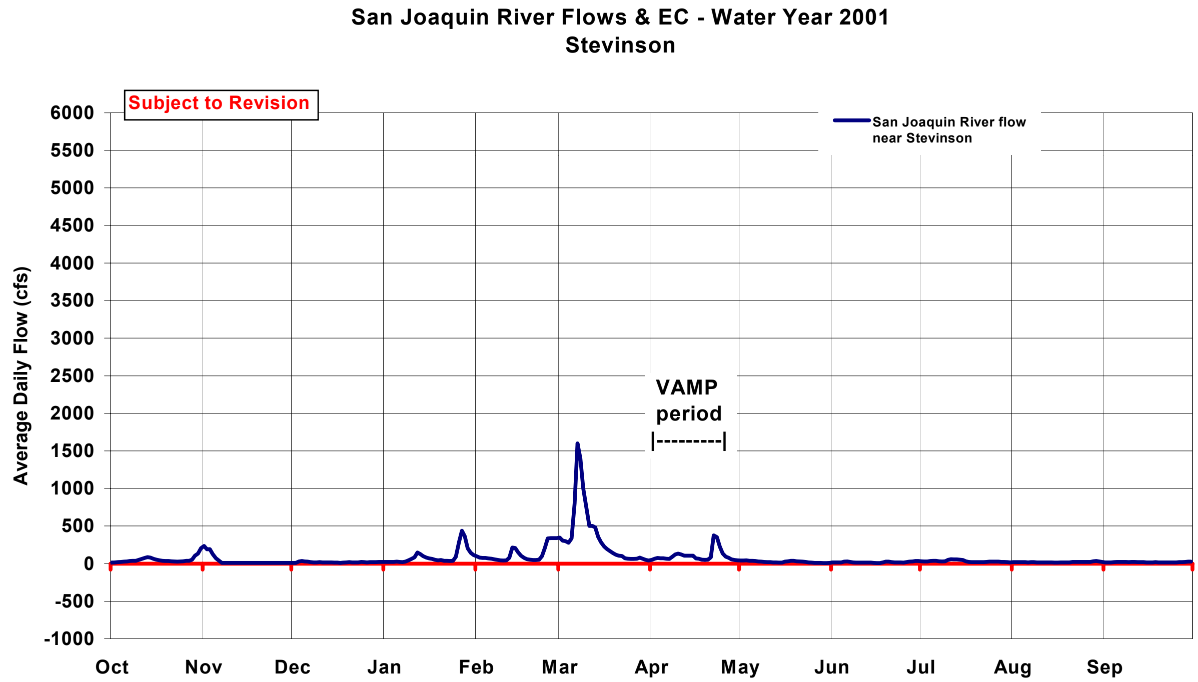


Figure 29. San Joaquin River flows at Lander Avenue (Stevinson) during 2001. Lander Avenue is the uppermost flow monitoring station in the real-time monitoring network. (Source : SJRMP-WQS, 2001)

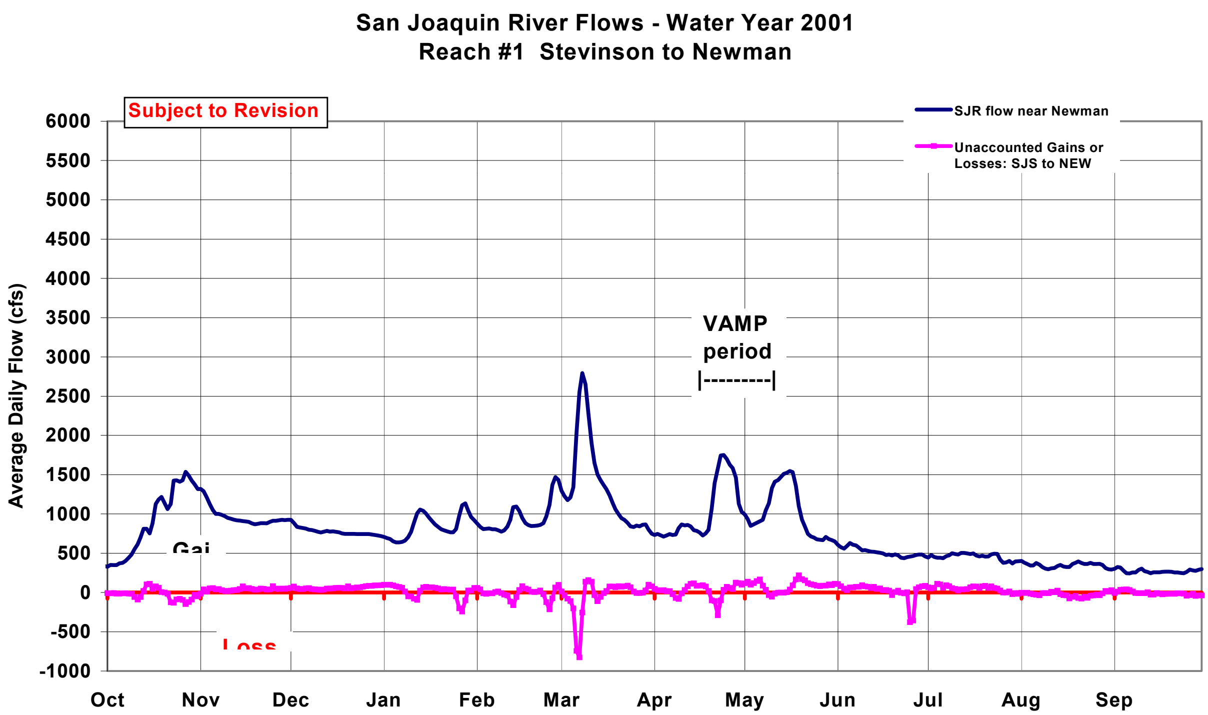


Figure 30. San Joaquin River flows at Newman and losses from river between Lander Avenue and Newman during 2001. (Source : SJRMP-WQS, 2001)

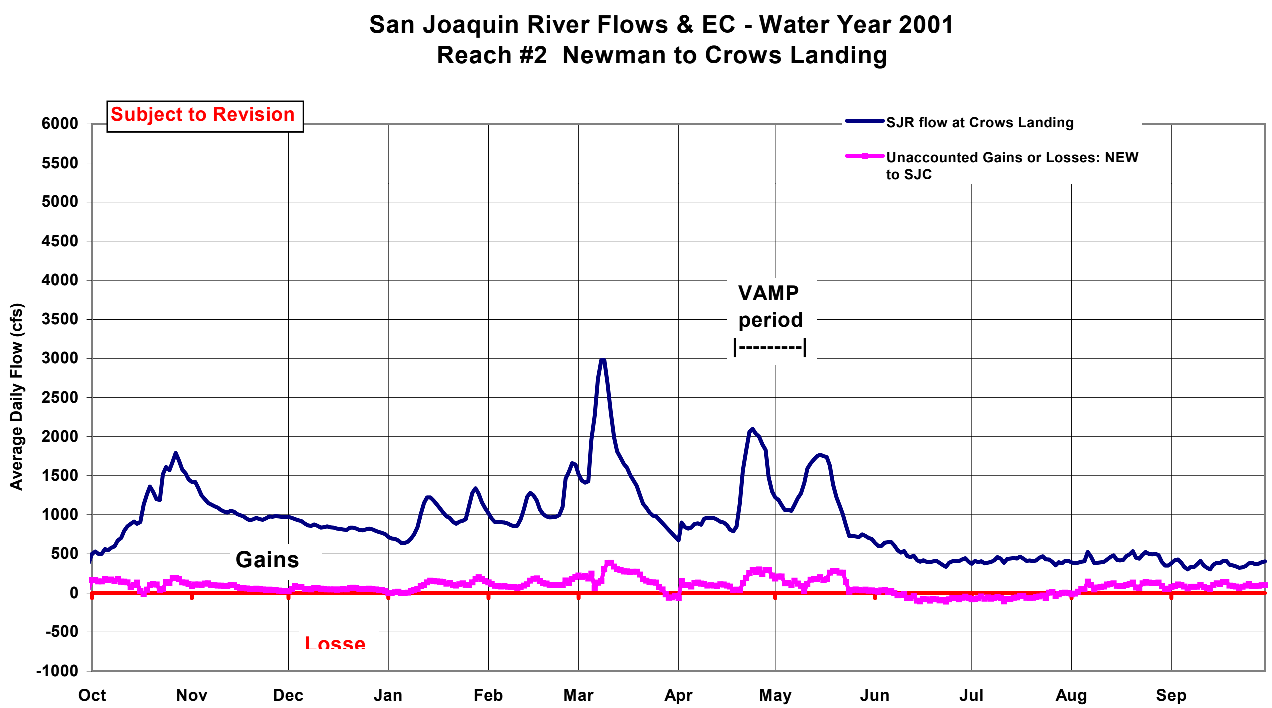


Figure 31. San Joaquin River flows at Newman and losses from river between Lander Avenue and Newman during 2001. (Source : SJRMP-WQS, 2001)

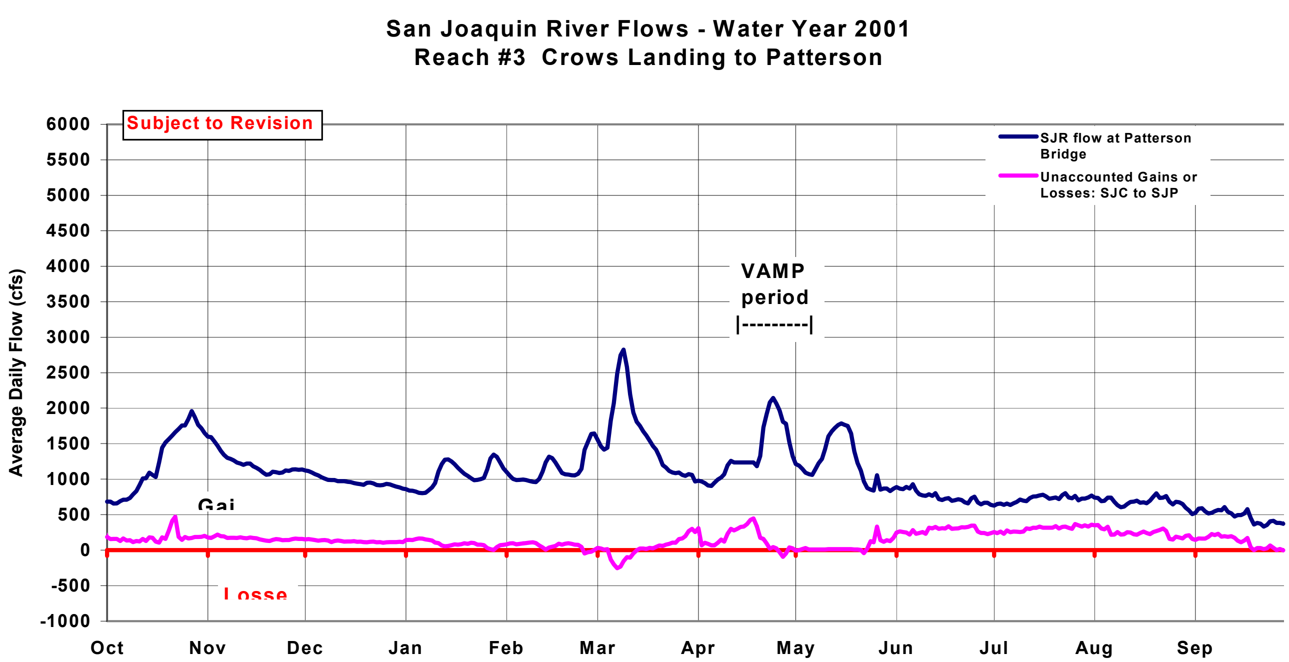


Figure 32. San Joaquin River flows at Patterson and losses from river between Crows Landing and Patterson during 2001. (Source : SJRMP-WQS, 2001)

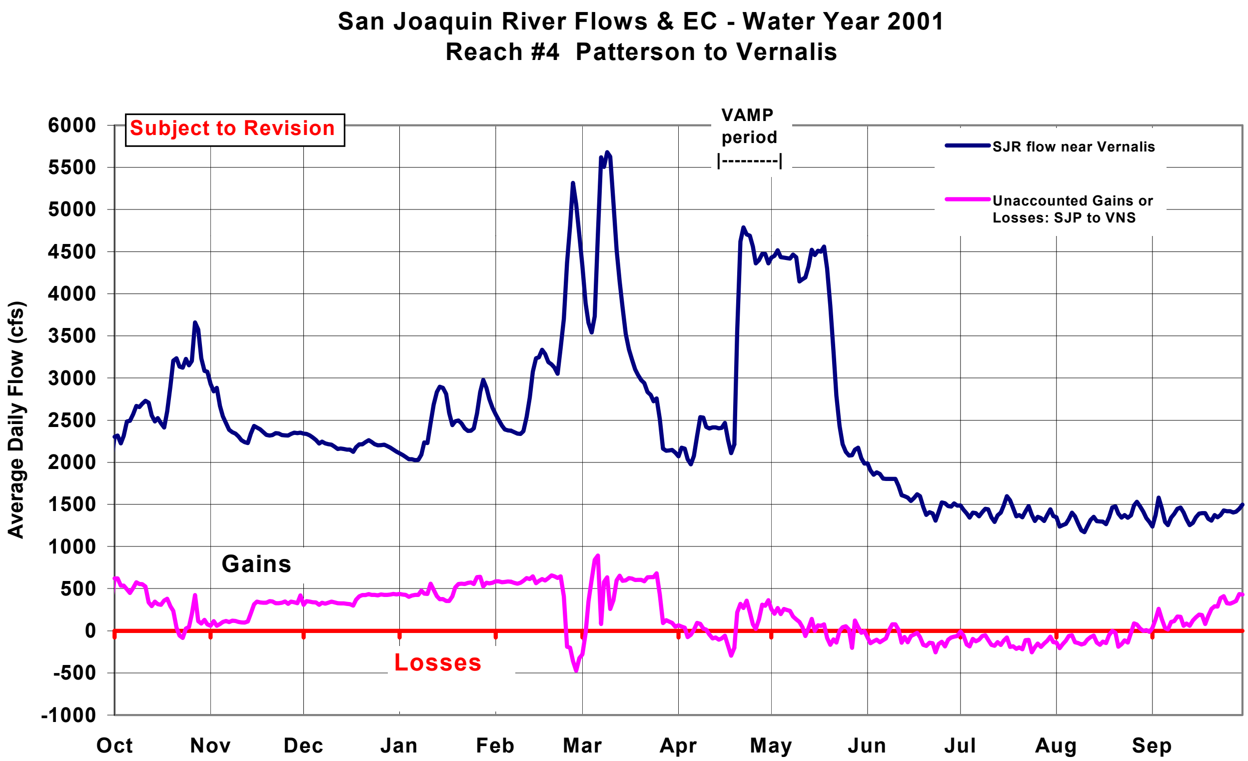


Figure 33. San Joaquin River flows at Vernalis and losses from river between Patterson and Vernalis during 2001. (Source : SJRMP-WQS, 2001)

Flows into Mendota Pool are rarely transported downstream except when of significant magnitude. Figures 30 through 33 show gains and losses for the river by month for the four reaches described above together with the river flows along each reach. Accretions appear highest for the fourth reach from Patterson to Vernalis in the months from November through March. These are months when groundwater pumping from private wells in the vicinity of the River may be lowest. This sort of response would indicate more pumping than most current groundwater models of the system currently show. Figure 34 compares the gains and losses for the reach from Lander Avenue to Vernalis for years 1999, 2000 and 2001.

Figure 35 compares the San Joaquin River hydrologies of the past 3 years. Water year 2001 is remarkable for its low annual flow volume in comparison to the other 2 years.

Groundwater modeling

In the SJRIO and DSM2-SJR modeling efforts groundwater pumping is estimated as a residual in the hydrologic mass balance. Annual groundwater pumped for the 13 townships along the SJR in the project area for water years 1961 to 1977 was originally based on consumptive use of water and power consumption records (Kratzer et al. 1987). The average of each of the four water year types: critically dry, dry, normal, and wet, were used in DSM2-SJR based on the simulation year type.

In the original SJRIO model groundwater accretions and depletions were calculated using a steady-state, 1-dimensional deterministic model based on the Dupuit-Forchheimer assumptions.

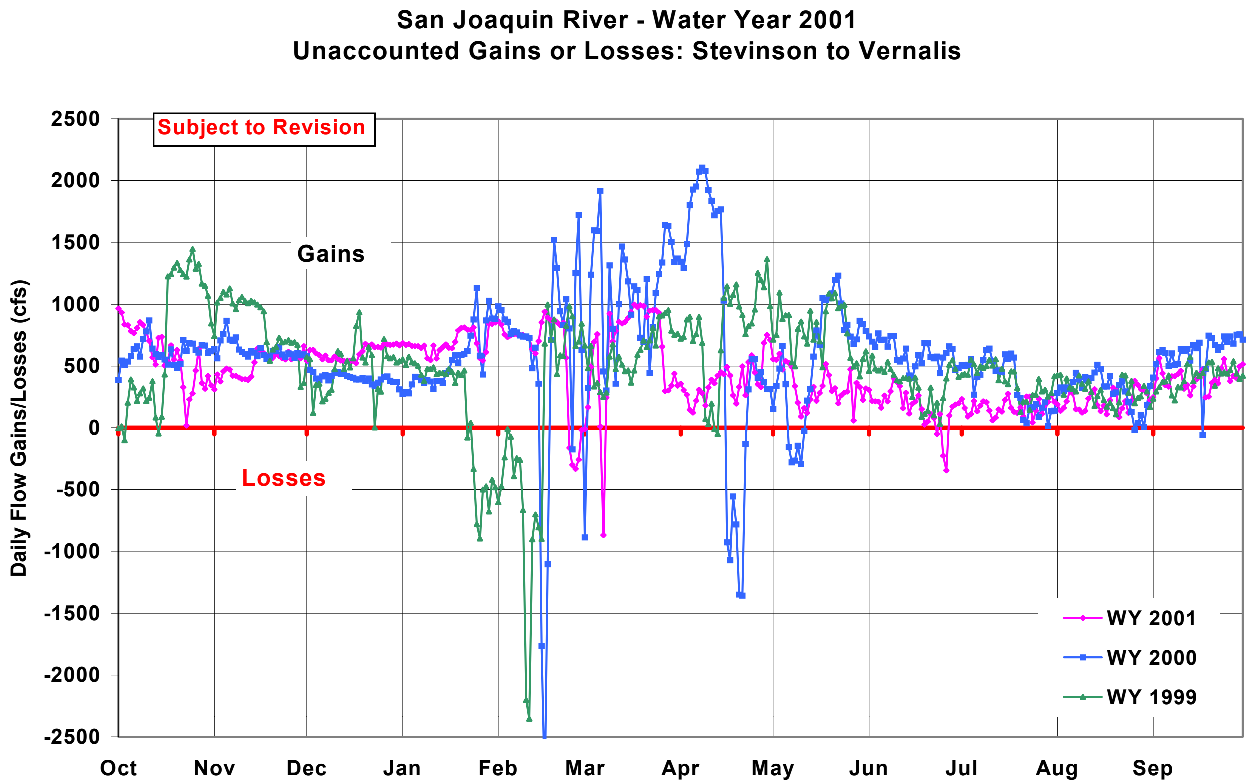


Figure 34. Comparison of years 1999, 2000 and 2001 with regard to monthly gains and losses in the reach from Lander Avenue to Vernalis.(Source: SJRMP-WQS, 2001)

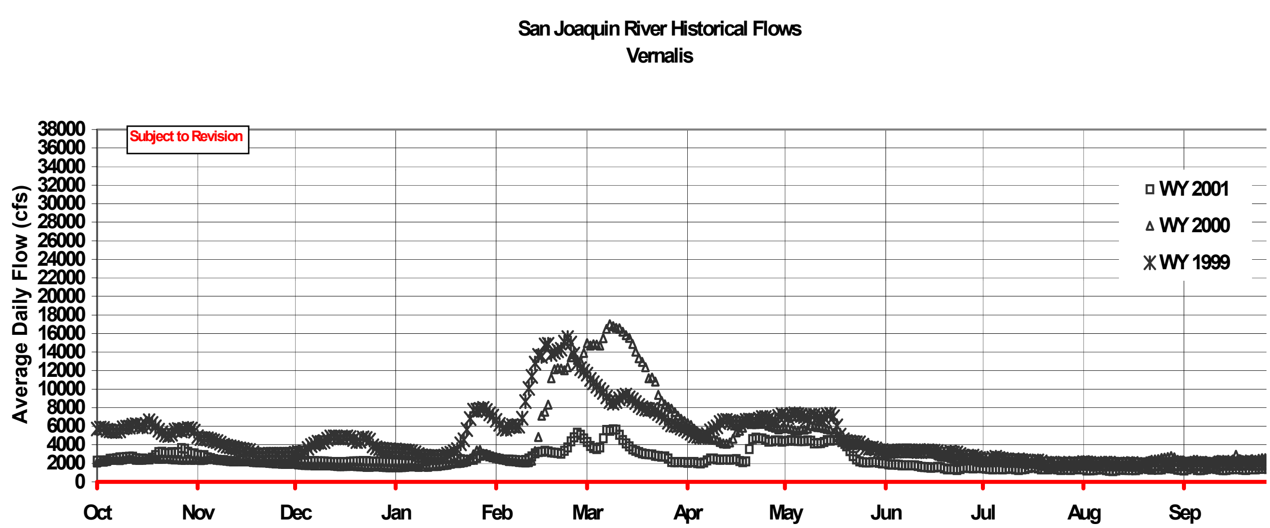


Figure 35. Comparison of years (a) 1999, 2000 and 2001 with regard to monthly flows at Vernalis. (Source : SJRMP-WQS, 2001)

Groundwater flows to the SJR were calculated monthly per river mile for water years 1979, 1981, 1982, 1984, and 1985. Flows to the eastside tributaries were calculated monthly for the entire reach below the gauging stations to their confluence with the SJR. The details of the groundwater model are described in Kratzer et al., 1987. The results of the groundwater model are given as monthly and annual flow summaries. The mean monthly groundwater flows were used to create static annual set of monthly distribution ratios. The distribution ratios are then used to distribute the annual groundwater flows to the SJR per river mile.

WESTSIM model development

The US Bureau of Reclamation, in conjuction with Berkeley National Laboratory and Montgomery-Watson-Harza is developing an integrated groundwater-surface model based on the Integrated Groundwater Surface Water Model (IGSM) (Montgomery Watson, 1990; Quinn et al., 2001). The model has a land-use package which integrates information on land use, cropping practices, irrigation diversions, crop transpiration and groundwater pumping to create a much more detailed account of water balance within the watershed than has been possible to date. Figure 36 is a map of the regions currently represented in the model and of the model dimensions. WESTSIM uses a one mile finite element mesh to capture the water district boundaries on the west-side of the Basin and divides the aquifer into 6 layers, five above and one below the Corcoran Clay, a thick clay aquitard that underlies much of the southern half of the San Joaquin Basin and which has a significant effect on groundwater aquifer hydrology. Figure 37 shows the region where the majority of river diversions occur on the San Joaquin River – the river reaches 18, 19 and 20.

Figures 38 and 39 are hydrographs produced by the current incompletely calibrated WESTSIM model for reaches 19 and 20 respectively. Each of these graphs show annual estimates of surface water returns (irrigation return flows), runoff and SJR diversions. Reach 19 in WESTSIM corresponds to Reach 1 in Appendix D-1 and is the river segment between the Tuolomne River and Stanislaus River tributaries. This is a reach of the river with some of the highest diversions. Reach 20 extends from the Stanislaus River tributary on the SJR, downstream of Vernalis, to a point immediately upstream of the Banta Carbona Irrigation District intake and the bifurcation point with Old River. The model shows diversions of approximately equivalent magnitudes for the three reaches.

Diversions in Reach 19 range from 22,000 to 41,000 acre-ft per year. This is equivalent to a daily removal of 50 – 90 cfs at the pumps for the March through October period (8 months). Diversions in Reach 20 were between 21,000 and 42,000 acre-ft per year. The diversions in this reach are similar to those in Reach 19 – between 50 and 90 cfs daily. The estimate of surface water returned to the River is much higher in Reach 19 sometimes exceeding River diversions. Although some water districts in this reach receive up to a 50% Federal water supply these return flows appear high – the model data will require further attention.

Appendix B contains output from the stream budget package for an initial calibration run of the model. This is provided mostly for illustrative purposes since this work is in progress and it is envisaged that the reach by reach river budgets will change as calibration proceeds. Appendix D contains two tables which show the relationship between the WESTSIM nodes and reaches and river miles and reaches along the San Joaquin River.

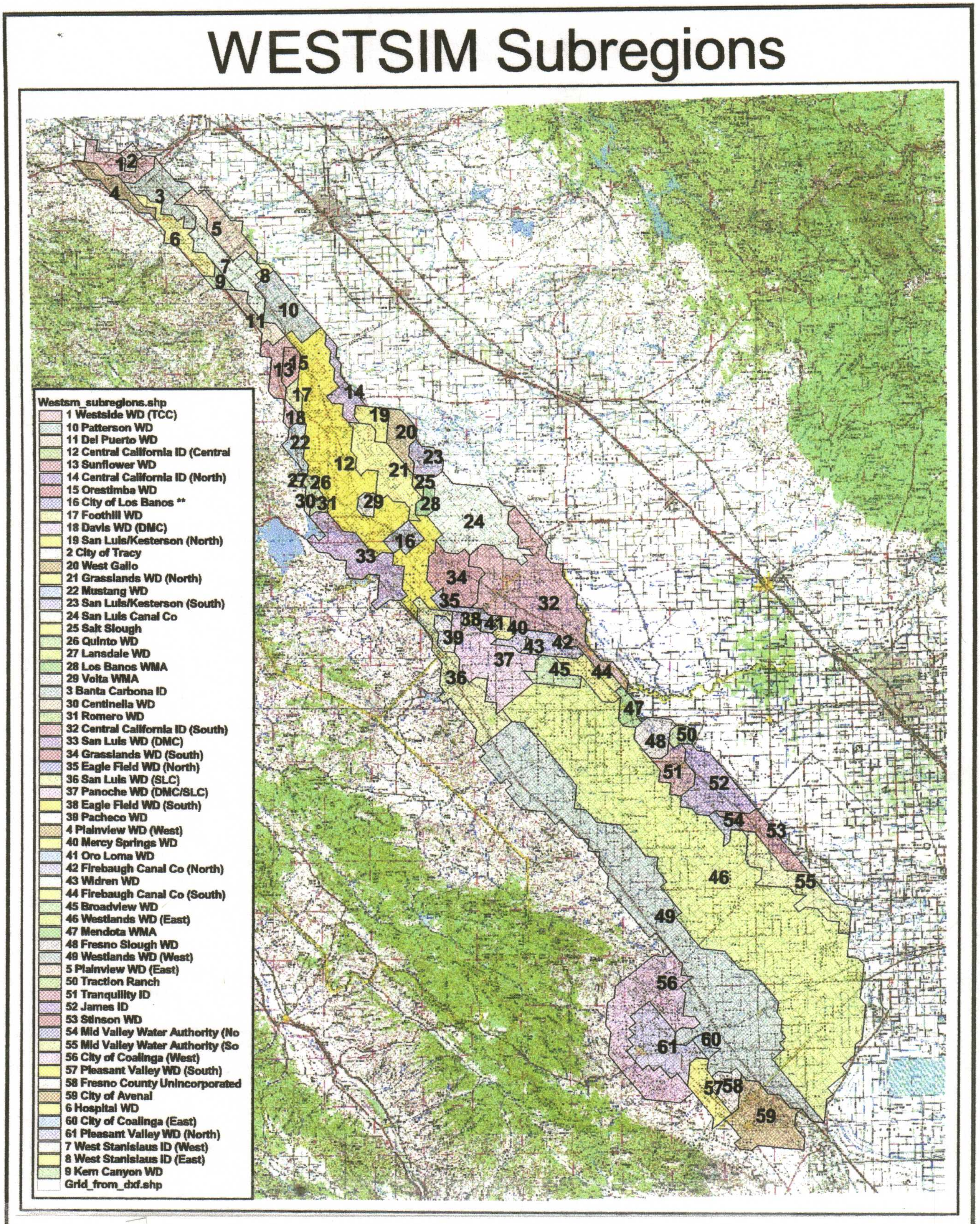


Figure 36 Areal extent of the WESTSIM groundwater-surface water model under development within the US Bureau of Reclamation (Quinn, 2001).

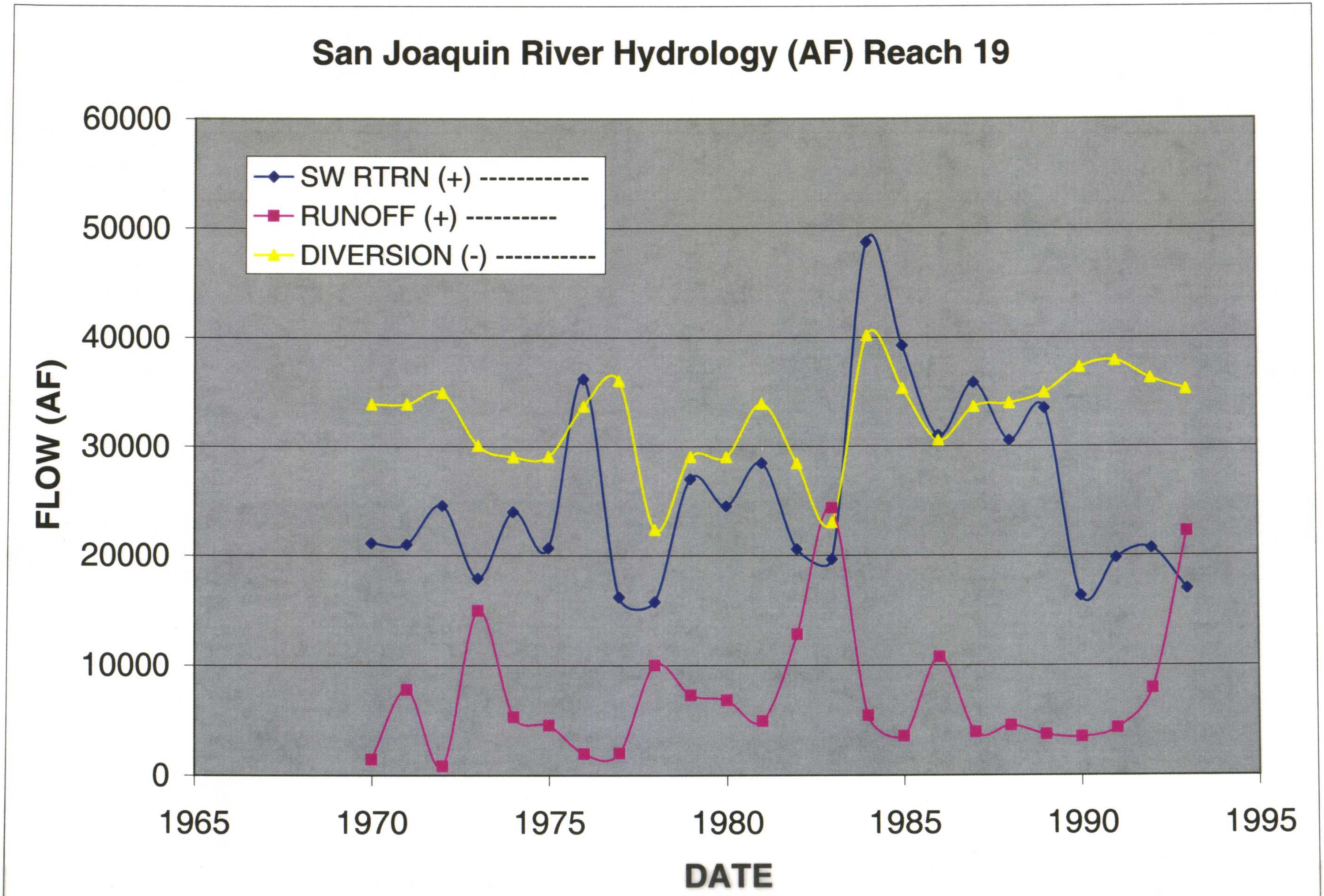


Figure 38. Diversions, surface water returns and runoff for WESTSIM San Joaquin River Reach 19 (Tuolomne River confluence to Stanislaus River confluence). This corresponds to Reach 1 in Appendix D-1.

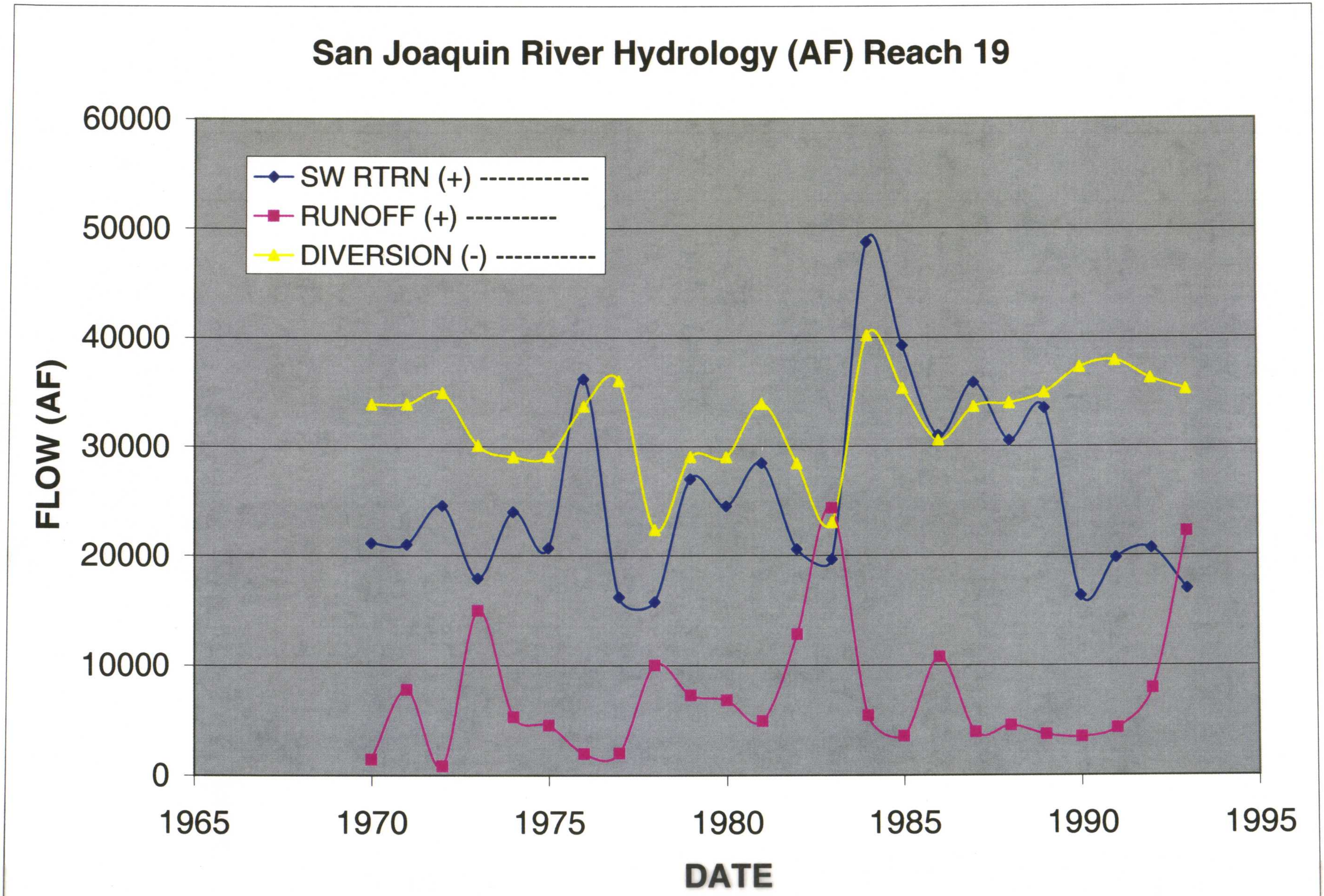


Figure 38. Diversions, surface water returns and runoff for WESTSIM San Joaquin River Reach 19 (Tuolomne River confluence to Stanislaus River confluence). This corresponds to Reach 1 in Appendix D-1.

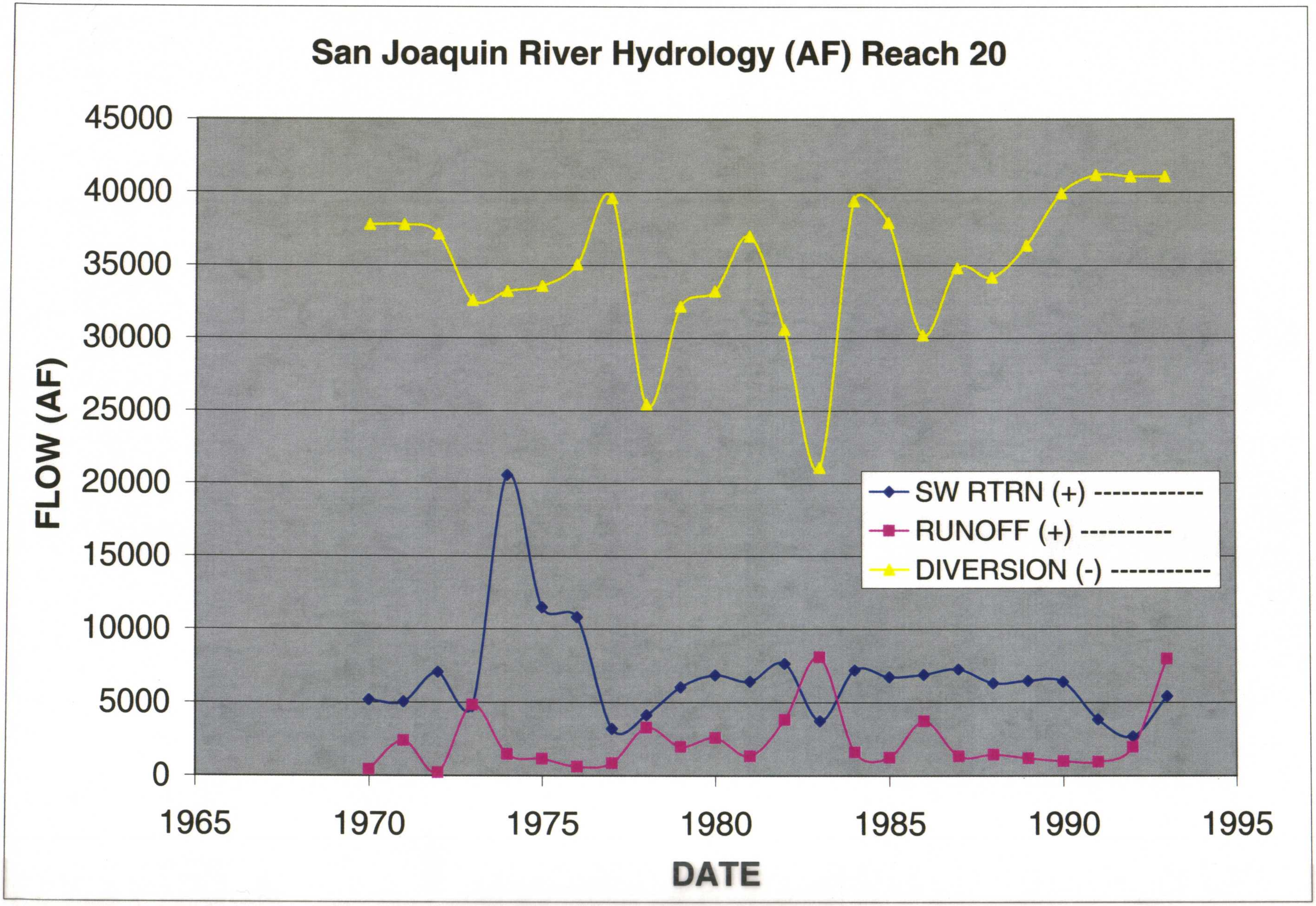


Figure 39. Diversions, surface water returns and runoff for WESTSIM San Joaquin River Reach 20 (below Stanislaus confluence near Vernalis). This reach is outside the DSM2-SJR model boundary in Appendix D-1.

Table 3. WESTSIM model estimate of river gain by reach

SJR RIVER REACH WESTSIM	MEAN ANNUAL SJR GAIN (AF/year)	MEAN DAILY GAIN (cfs/reach)	GAIN/RIVER MILE (cfs/mile)
18 Del Puerto Creek to Tuolomne River	6733	18.4	3.3
19 Tuolomne River to Stanislaus River	12352	33.8	2.9
20 Stanislaus River to New Jerusalem Drain	13316	36.4	2.1

PART 2 - San Joaquin River Delta : Vernalis to Channel Point

Background

The San Joaquin River Delta can be distinguished from the lower San Joaquin River above Vernalis by the following means:

1. Tidal influence
2. Agricultural drainage needs to be pumped over levees into the River.
3. There are no major tributary inflows.
4. There is a channel bifurcation at Old River.
5. River access and ability to monitor diversions and discharges is considerably impeded.
6. The river is navigable and more traffic from recreational boaters occurs.

Old River

Flow diversions associated with the operation of barriers at each end of Old River create a number of river conditions which can effect the loading of algae and BOD to the DWSC as well as effecting the assimilative capacity of the DWSC. Alex Hildebrand provided an overview of the various operating modes at Old River.

At the head of Old River, the Department of Water Resources installs a rock and culvert barrier in spring from April 15 to May 15 (dates of installation and removal may vary by 1-2 weeks) and again in October and November. The purpose of this barrier in the spring is to minimize the number of out-migrating anadromous fish being swept into the export pumps at Clifton Court. This barrier has been in operation for about three years under an agreement among the Department of Water Resources, the Corps of Engineers and the fish agencies. Installation of the barrier in the fall is to facilitate upstream fish migration and helps to maintain dissolved oxygen in the DWSC. The installation of the rock barrier at the head of Old River tends to dewater the Old River channel, causing difficulties for irrigation diversions in this reach.

To mitigate the dewatering problem in Old River, temporary barriers have been in use in of Old River, Grant Line canal and Middle River. Permanent operable barriers are under development. These barriers will be operated to trap tidal flows in the South Delta, in order to provide adequate water depth for irrigation pumps to riparian diverters in Old River, Middle River and Grantline Canal. The CVP and HHWP diversions above and within the Delta, and man-made sources of salts within the San Joaquin watershed contribute to a high salinity problem in the South Delta. The purpose of the permanent barriers are to provide directional flow and eliminate null zones in the South Delta with salt concentrations near 1500 ppm. Salt concentrations in the San Joaquin River near Vernalis can exceed 1200 ppm at times. Irrigation water needs to be less than 500 ppm to avoid crop damage for the most sensitive crops.

The permanent barriers will close on the out-going tide and reopen on the in-coming tide. The amount of trapped tidal water will be greater than needed for irrigation diversions, in order to provide adequate suction head for pumps. Some of the excess water will flow in a counter direction to natural flow, easterly to the head of Old River and then down the DWSC during low Vernalis flow periods. This will provide a small amount of oxygenation in Old River, preventing stagnation during barrier closure. The potential exists that the counter flow through Old River will have a lower concentration of oxygen demand than the SJR flow coming from Vernalis. The Old River counter flow will include dilution of Sacramento River flow, from the cross Delta flow at Grant Line canal.

The installation of the permanent barriers is apparently still a concern to the US Fish and Wildlife Service. It is uncertain how the barriers will work together with respect to fish migration. The Delta Keeper has also expressed concern that the operation of permanent barriers will pull outflow from the lower end of the DWSC into the bottom of Old River, causing a recirculation of San Joaquin River water with its BOD load from Grant Line back to the head of Old River and through the DWSC. These two concepts merit additional study to better characterize the interaction of flow and loading as a result of the barriers. The water quality model would need to be expanded to address the diurnal flow regimes and water quality reactions around the loop of Old River, and the DWSC.

While in place during the spring and fall, the rock barrier at the head of Old River decreases the amount of San Joaquin River flow and BOD loading leaving the main channel. The result is that most of the Vernalis flow goes through the DWSC. Since the concentration of BOD is not changed by the head of Old River barrier, the corresponding amount of load continues with the flow increment to the DWSC.

Two wastewater treatment plants will have an effect on the water quality and loading in Old River. Tracy's POTW currently discharges to Old River. Mountain House CSD is considering discharging in this area as well, presumably during the same period. Operation of the barriers needs to be coordinated with the POTW discharges to provide adequate flushing.

South Delta Hydrologic Factors and Changes

The occurrence of leakage form the Delta Mendota Canal and distribution canals in the South Delta has contributed to a rising ground water table in some areas west of the SJR. In one of these areas, the New Jerusalem Drainage District operates along the San Joaquin River to lower water tables and flush salt. Stormwater accumulations are also pumped to the river in some areas during the rainy season. This phenomenon does not occur every year, and does not last very long when it occurs. This event would not have a significant effect on the DWSC DO problem during the summer.

Diversions Downstream of Vernalis

The lands in most of the South Delta are above mean tide level. Riparian land owners along the lower San Joaquin River often have both riparian and appropriative water rights. Many of them participate in small irrigation districts. These districts do not ordinarily maintain records of the quantity of river flow pumped. Flows reported by irrigation districts to the DWR are probably estimated from pump run times rather than flow metering. Farmers in the South Delta do not generally use groundwater for irrigation due to the high salt content of the groundwater.

Average return flows from riparian and appropriative users is estimated at 20-25% of diversions. (Hildebrand, 2001, p.c.) However, the actual return flows may vary widely, depending on soil and crop types, and season. From late June to August, some riparian farmers may run their irrigation pumps almost full time to keep up with their crop's needs. In the South Delta, farmers typically irrigate almost every month except January, for a variety of purposes.

The prospect of rolling power outages, due to California's energy shortage, may have an impact on irrigation and thereby an impact on DO in the DWSC. If a pump shuts off due to a blackout, the hundreds of siphons used to irrigated have to be reset. Incompletely irrigated fields would receive twice as much water as needed at the near end of the field in order to completely irrigate the far end after a black out.

Analysis of Usage

Riparian Irrigation Usage

Riparian irrigation usage was estimated based on the product of the probable riparian acreage and typical irrigated agriculture water usage in the region. The total irrigated area in the South Delta has been estimated at 122,000 acres (Hildebrand, 2001 – personal communication). Hildebrand has estimated the average July diversions for the entire South Delta to be between 1200 and 1300 cfs during a typical year. Then the total usage was allocated over a four month core growing period. Irrigation use can occur during almost any month of the year. A four month core period will provide a conservative estimate of the diversion rate for riparian uses during the DO deficit period.

County Assessor's information was used to calculate an order-of-magnitude estimate of the seasonal irrigation diversions by riparian diverters. Table 3 summarizes the acreages and land uses for the properties most probably riparian to the San Joaquin River between Vernalis (River mile 77) and Channel Point (River Mile 40). Appendices F and G provide the property information use in this analysis. Due to the data extraction method, this estimate is more likely to understate the acreage entitled to riparian water rights. Furthermore, the actual usage will also vary depending on individual appropriative rights established on riparian lands.

San Joaquin County and Stanislaus County property data was analyzed to assess the probable irrigated riparian acreage between RM 40 and RM 77. Property under a Williamson Act contract is assumed to be fully irrigated. Non-taxable property included city, county, port and state properties. Many of these are under land uses that are not irrigated from the river, such as schools, the port, wastewater ponds, levees, drainage district facilities, or wildlife areas. Assessor records provided no classification for a number of the riparian properties. Unclassified properties under 10 acres were excluded from the irrigated total, on the assumption that these represent small residential holdings. Commercial land uses were also excluded from the irrigated acreage. These assumptions on the acreage to be included in the total are preliminary, and subject to further field verification if the modeling of the DO behavior in this reach warrants it.

Table 4
SJR Riparian Acreage

Vernalis to Channel Point

	Land Designation	**Gross Acres**	**Probable % Irrigated**	**Estimated Irrigated Acres**	**Average Parcel Size, Ac**
Westside					
	Williamson Act (Ag)	6,653	100%	6,653	158
	Non-Taxable	4,292	0%	0	429
	Unclassified	4,246	75%	3,185	137
		15,191		**9,838**	
Eastside					
	Williamson Act (Ag)	4,983	100%	4,983	135
	Non-Taxable	1,663	11.5%	190	43
	Unclassified	3,905	75%	2,929	64
		10,551		**8,102**	
Total Both Sides		25,742		**17,940**	

Riparian irrigation application rates are not typically metered by individual water users. Riparian diverters may have pump run time or power usage information, but this is not public information. Irrigation application rates are commonly estimated at 3-4 feet per year in the San Joaquin Valley.

The core irrigation season in the south Delta was assumed to be 4 months long, from mid-April to mid-August. Irrigation can occur during almost any month of the year for various purposes. Irrigation during the core summer season is reported to be a continuous rotation among fields. Diversion pumps can run continuously. Then irrigation is reduced significantly to mature field crops or after orchard crops are harvested

The gross diversion rate for riparian users is estimated by:

$$Q = \frac{17{,}940 \text{ acres} \times 4 \text{ feet/acre} \times 43{,}560}{4 \text{ months} \times 30\text{d} \times 24\text{hr} \times 60^2} = 300 \text{ cfs}$$

The following assumptions were used to estimate the order-of-magnitude of flows and loading for riparian diversions. Jones & Stokes presented the 2000 data for Stockton and the lower San Joaquin River. Typical June to September river flows averaged 2,300 cfs at Vernalis, 1,000 cfs at Stockton. BOD at Vernalis was assumed to average 2.6 ppm, TSS was 8 ppm. BOD at Stockton was assumed to average 2.5 ppm, TSS was 6 ppm.

At an assumed BOD5 concentration of 2.6 ppm at Vernalis, this riparian diversion would contain about 4,200 lb/day of BOD removed from the SJR. Estimated TSS removal is 13,000 lb/day. 300 cfs out of a river flow of 1000 to 2000 cfs is a significant diversion of both flow and load from this reach of the river. This assumption should be tested against the computer models to determine to what extent the loading reduction represents the unaccounted for reduction between Vernalis and Channel Point.

These are order-of-magnitude estimates of comparable flow and loading. They are not intended for exact predictive purposes, but to assess the merit of investigating the riparian diversions in more detail, both as to water quality, flow rates and timing. From these comparisons, it appears that riparian diversions have a significant influence on the flow and loading through the DWSC.

The maximum return flow in this area during summer is estimated at less than 25% of this amount, or 75 cfs. However, the schedule and amount of return flows is even more uncertain than the riparian diversions. Factors for which no data is available include high ground water pumping, pre-planting irrigation return flows and post-production salinity leaching. As part of an order-of-magnitude estimate of riparian diversions and returns during the DO deficit period, these variations are assessed to be minor factors.

Riparian Pumping Capacity

Data from the June 5 boat survey was used to estimate the available pumping capacity observed. This was used to compare the estimated riparian diversion rates to the available pumping capacity. Table 4 summarizes this tally of pumping capacity. Actual pump curves for the many different types of pumps were not available, so a flow velocity of 14 fps was assumed through the observed suction piping sizes. This number was selected based on an assumed 15 feet head and agricultural pump catalog curves.

Table 5
Estimated Riparian Pumping Capacity RM 40 to RM 77

Suction Size	# of Pumps	Estimated Capacity / Pump, cfs	Total Capacity, cfs
6-inch	11	2.8	31
8-inch	10	4.9	49
10-inch	21	7.7	162
12-inch	31	11.1	344
14-inch	24	15.0	360
16-inch	13	19.6	255
18-inch	2	24.8	50
20-inch	3	30.5	92
Total			1,342

The estimated pumping capacity of 1,300 cfs greatly exceeds the theoretical diversion rate of 300 cfs calculated above. The reasons for this difference are not known, but point to an unknown factor that may have a significant impact on the DO behavior in this reach of the river.

Use of Delta Simulation Model (DSM-2)

The Department of Water Resources developed a Delta Island Consumptive Use Model (DICU) to estimate Delta island diversions and return flows for the entire Delta region (DWR, 1995). The model was specifically developed to estimate salinity and total organic carbon loading to the Delta from agricultural activities in these islands. The Department of Water Resources did extensive validation of the model by focusing on Twitchell Island and developing water and salinity balances for this tract of the Delta. The model was shown to be very sensitive to irrigation efficiency and evapotranspiration estimates which control the quanity of both diversions and return flows from March to September each year. Leaching water estimates can have a large impactson diversion estimates during the month it is applied (October through December) and on the months when drainage occurs (January through April) (DWR, 1995). Precipitation is an important effect on return flow estimates during the winter months.

A map of the approximate locations of Delta island diversion pumps and drains is shown in Figure 40.

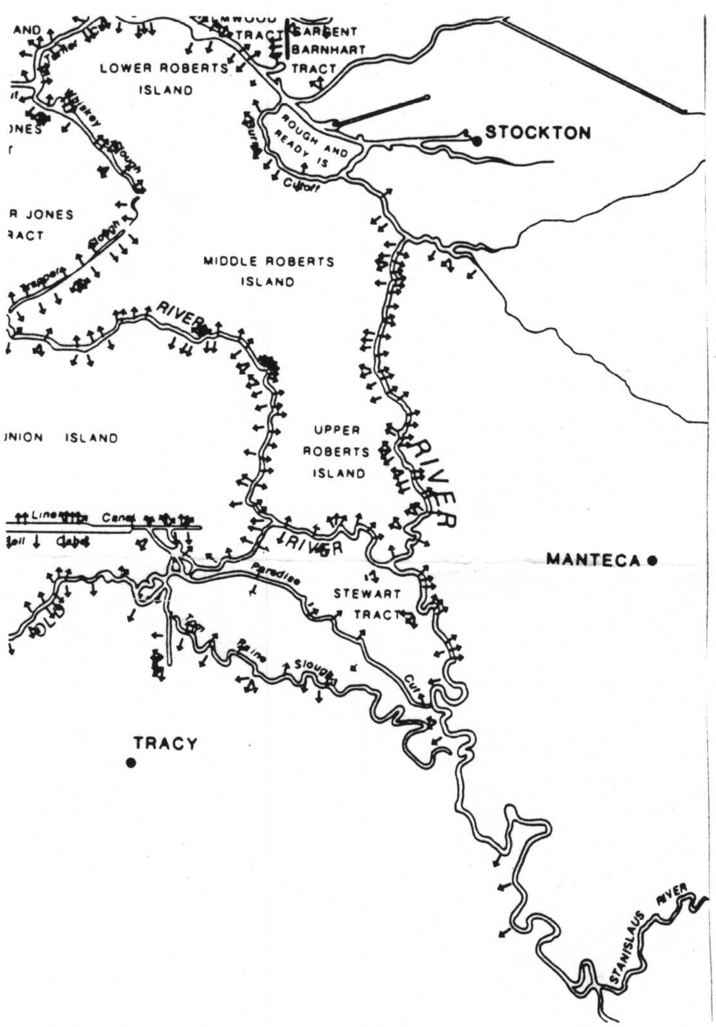
Wastewater Treatment Plant Flows and Water Quality Merced River to Channel Point

Four municipal wastewater treatment plants hold NPDES permits to discharge directly to the San Joaquin River between Los Banos and Channel Point. The City of Stockton's RWCF discharge information has already been presented by Jones & Stokes (2000). The other municipal POTWs with permitted river discharges are Manteca, Modesto and Turlock. All the other POTWs in the San Joaquin Valley below Los Banos depend on land application of their treated wastewater. Tracy discharges to Old River.

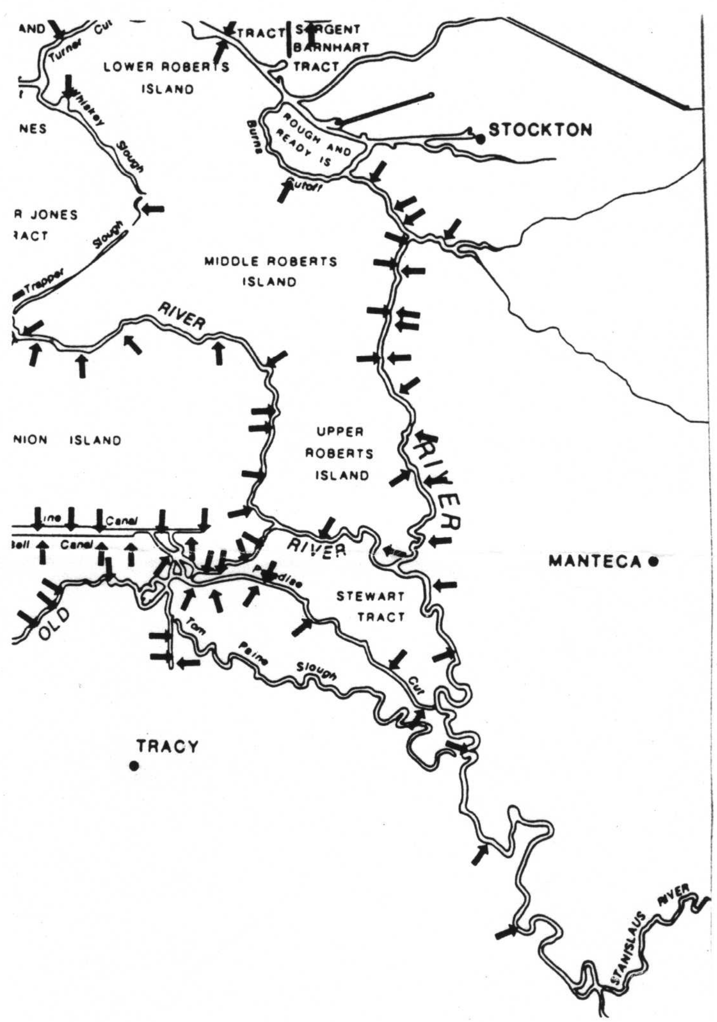
The City of Manteca's POTW discharges an average of 6 MGD to the San Joaquin River. They also reclaim a significant amount of this flow for irrigation on private and public lands. So, discharge to the river can vary from zero to full flow from day to day depending on irrigation needs. Although their permit allows 20 ppm of BOD and 20 ppm of SS, their typical discharge contains approximately 15 ppm of BOD or SS. Their discharge point to the San Joaquin River is located one mile south of the Mossdale boat ramp near Oakwood Lake, approximately at RM 57. Manteca is evaluating advanced waste treatment in order to expand both their river discharge and their wastewater reclamation facilities for future needs.

The City of Modesto operates a secondary treatment plant with extensive treated water storage and reclamation facilities at their Jennings Road ranch facility. Modesto's NPDES permit allows them to discharge to the San Joaquin River immediately upstream of the Westport Drain, but only between October 1 and May 1, if a 20:1 dilution ratio can be maintained with the river flow. The NPDES permits discharge at 30 ppm BOD5 and 30 ppm

SAN JOAQUIN RIVER – VERNALIS TO STOCKTON*



DIVERSIONS



RETURNS

Figure 40. Map showing the approximate locations of Delta island diversions and return flows for the San Joaquin River between Vernalis and Stockton and for the South Delta.

* From Delta Atlas, California Department of Water Resources, Sacramento, 1993

SS. However, in order to meet this water quality standard, Modesto typically does not commence river discharge until after November 1. In 2001, discharge did not begin until December. Average discharge rates are about 27 MGD during the winter discharge period. Actual BOD concentration is in the range of 10 ppm, TSS of 20 ppm. In order to meet the river dilution ratio, the discharge rate at Modesto can be quite variable. Modesto recycles up to 30,000 AF in reclaimed water irrigation on the City owned ranch. Modesto's Wastewater Master Plan anticipates that the City will discontinue river discharge when a favorable full reclamation project can be developed, or when the economics of meeting river discharge standards become too costly.

The City of Turlock operates a secondary treatment plant that discharges an annual average of 10.4 MGD to TID Lateral #5 and the Harding Drain, which discharges to the San Joaquin River downstream of Orestimba Creek. The Turlock WWTP discharges all year. Peak flow rates are not significantly different than the average annual rate. The NPDES permit allows discharge at 30 ppm BOD5 and 30 ppm Suspended Solids. However, the average discharge contains 12 ppm BOD5 and 22 ppm SS. In response to a variety of upcoming regulatory requirements, the Turlock WWTP will be constructing tertiary wastewater treatment and conveyance facilities to move towards full reclamation of their wastewater in the short term. They expect to eliminate all river discharge within 10 years.

The City of Turlock has been conducting expanded monitoring since 1999, to collect data relevant to the dissolved oxygen question. A review of the data showed that it would be difficult and unrepresentative to summarize the flow and loading data for this report. Samples have been tested for ammonia, TSS, BOD, and CBOD, but not for TKN or chlorophyll a. Samples have been collected weekly of the effluent and of the river at points upstream and downstream of the wastewater effluent's discharge point in the San Joaquin River near TID Lateral #5. Table 5 shows some of the data available from the Turlock data set.

Table 6
Turlock Water Quality Sampling Examples
July 1 to October 1

	1999	2000
Average Ammonia conc., mg/l		
Upstream	0.5	0.6
Effluent	8.8	6.6
Downstream	0.6	0.6
Seasonal Trend of Effluent Conc.	Decreasing	Rising
River Dilution Ratio		
Average	84:1	77:1
Minimum	61:1	66:1

The City of Turlock is constructing additional ammonia treatment facilities, and so the water quality of its effluent and effluent flow rates are expected to differ significantly from past data. Similar data for the cities of Modesto, Manteca and Tracy is not available. To the extent that detailed time-sensitive water quality and flow data for the treatment plant discharges is necessary for the predictive reliability of the river model, it is recommended that a focused monitoring program be developed.

Table 6 describes the main stem SJR municipal discharges upstream of Vernalis. This table indicates that the flow contributed by POTWs to the San Joaquin River during the June 1 to September 30 DO deficit period is in the range of 16-24 cfs. During this period, flows passing Vernalis are approximately 2,000 cfs. The POTW flows represent less than 1% of the SJR flow passing Vernalis before October 1. After Modesto begins discharging after October 1, the POTW flow contribution can increase to 58-67 cfs, or about 3%, depending on the river's flow conditions.

Table 7
SJR POTW Discharges
Between Los Banos and Vernalis

POTW	Discharge Season	SJR River Mile	Average Daily Flow, cfs	[BOD5] ppm	# BOD/day	[TSS] ppm	# SS/day
Manteca	Year Round, intermittent on a daily basis	57	9	15	750	15	750
Modesto	After October 1, 3-5 mo/yr		42	10	2250	20	4500
Turlock	Year Round		16	12	1040	22	1900

The loading contribution of the POTWs during the June 1 to September 30 period is estimated at 1,800 pounds of BOD5 per day, 2,700 pounds of SS per day. After Modesto begins discharging in November or December, the load can increase to about 4,000 pounds of BOD5/day and 7,000 pounds of SS/day. During summer, POTW loads contribute approximately 6 % of the BOD load and 3% of the SS load passing Vernalis (BOD: 32,000 lb/d; SS: 100,000 lb/day).

Cities are expected to grow, and the demand for wastewater treatment capacity will increase. It is not correct to assume that increased demand will translate to increased discharges of treated effluent to the San Joaquin River. Several of the cities contacted are evaluated the economic benefits of recycling their wastewater to higher uses such as irrigation or industrial use. Due to the increasing value of water in California, it is not unlikely that the wastewater flows now entering the San Joaquin River may decrease in the future. It is too soon to tell what impact new reclaimed wastewater uses might have on the flow and loading of oxygen demanding substances in the San Joaquin River, but certainly the modeling and implementation planning should include elements that can assist in assessing such changes in the river's behavior.

Mobile Home Parks Below Mossdale

Two mobile home parks were observed on the river, which may be a source of nutrients, depending on the condition and operation of their sewage disposal systems. Heaven Acres is located at a few miles downstream of Mossdale. Mossdale Mobile Home Park is located at Mossdale. If these residential communities are served by septic systems, these systems may be a source of nutrient loading to the river. Further investigations would be needed to determine the relative size of this potential source of nutrients. Other mobile home parks or septic systems may be located upstream of Mossdale and may be a source of nutrients.

Stormwater Discharges

It was not within the scope of this project to assess the contribution of discharges from stormwater systems to the dissolved oxygen deficit. Non-stormwater discharges can occur from municipal stormwater systems during the period of concern, June 1 to November 1. Stormwater discharges begin with the first rains in the fall. First flush of the system during the storm can send elevated concentrations of pollutants and nutrients into the receiving streams. An assessment is needed to determine the relative magnitude of flow and loading from these intermittent discharges, to determine whether they may be a significant factor in the behavior of dissolved oxygen in the DWSC.

Groundwater Discharges

It was not within the scope of this project to assess the contribution of groundwater discharges to the flow and loading of the San Joaquin River. A project to evaluate this possible source was not funded in the current CALFED Directed Action. Kratzer (1987), demonstrated that groundwater can contain elevated concentrations of nitrates. Further information is needed on the levels and locations of nutrients entering the river. Evidence is available from wastewater treatment plant monitoring which quantifies the nutrients being applied to reclaimed wastewater land application sites. Further work is needed though to characterize the fate of the surface loading once it reaches the river by groundwater flow.

Discussion

This survey of irrigation diversions and return flows will benefit from more direct contact with individual water districts and riparian diverters, and with progress anticipated within the next 3 months on the WESTSIM groundwater surface water model. The project includes the installation of a diversion monitoring station at Patterson Irrigation District. This station and another monitoring station destined for Salt Slough should be available for the year 2002 San Joaquin River DO TMDL studies.

Section 2 presents order-of-magnitude estimates of comparable flow and loading. They are not intended for exact predictive purposes, but to assess the merit of investigating the riparian diversions and municipal discharges in more detail, both as to water quality, flow rates and timing. The analysis provides a high and low estimate of river diversion pumping ranging from 300 cfs to 1342 cfs. Obviously the higher number could exceed the mean daily flow in the San Joaquin River at Vernalis during the summer and early fall months that are of concern to River water quality regulators – and would imply that the entire flow of the River would be captured by the pumps during periods of peak irrigation demand. Hydrodynamic data available from the Department of Water Resources and the US Geological Survey would imply that there is a net outflow from the San Joaquin River through the Deep Water Ship Channel during all months of the year. This suggests that the lower estimate may be more realistic.

Additional Studies Needed

- Loading reductions through diversion, based on actual amount of riparian pumping.
- Water quality changes from return flows, from various soils and crops.
- Diurnal flow modeling and water quality reactor around the loop of Old River, SJR, DWSC, to quantify effect of recirculation on DWSC DO.
- Mass and flow balance between Vernalis and Channel Point using a similar approach to WESTSIM and through use of the Delta Island Consumptive Use Model (DICU) within DSM-2.
- Assessment of the condition and operation of septic or sanitary systems serving mobile home parks located on the banks of the San Joaquin River..
- Continuing and expanded monitoring of time-sensitive water quality and flow data for the four wastewater treatment plant dischargers, to the extent that this data would be necessary and effective in the modeling of the time-distance relationship between upstream loading and the DWSC's dissolved oxygen.
- Assess the importance of stormwater system discharges on the dissolved oxygen behavior of the DWSC.
- Assess the importance of nutrients in groundwater from various irrigation and land application practices make to the dissolved oxygen behavior of the DWSC.

Acknowledgements

The authors gratefully acknowledge the assistance provided by Mary Hildebrand and Alex Hildebrand to better understand operations within the Delta; Ernie Taylor, (DWR, Fresno) for providing the latest spreadsheet on the results of the CALFED Real-Time Water Quality Management Project; Chris Eacock (USBR, Fresno) for summarizing data from the Grasslands Bypass Project; to the Cities of Atwater, Ceres, Escalon, Gustine, Hughson, Lathrop, Livingston, Los Banos, Manteca, Merced, Modesto, Newman, Oakdale, Patterson, Ripon, Riverbank, Salida, Tracy, Turlock, and Waterford for information on their wastewater plants, to the Turlock and Modesto Irrigation Districts, and to the San Joaquin River Dissolved Oxygen TAC and Steering Committee for supporting this study.

The authors would also like to thank the internal peer reviewers for their helpful comments: Alex Hildebrand, Dr. G. Fred Lee, Paul Hutton, and Dr Chris Foe.

Literature Cited

Cooley W. 2001. Groundwater flow net analysis for lower San Joaquin River Basin. Draft memo to CRWQCB Aug 8, 2001.

Department of Public Works. Report of Sacramento-San Joaquin Water Supervision. Bulletin 23 Series.

Department of Water Resources (2001). San Joaquin River Management Program, Water Quality Subcommittee Annual Report to CALFED on Real-Time Water Quality Management of the San Joaquin River. Ernie Taylor, DWR Fresno, Chair.

Department of Water Resources (1995). Estimation of Delta Island Diversions and Return Flows. Division of Planning, Sacramento, CA. February.

Department of Water Resources (1965). Sacramento-San Joaquin Delta Area. Land use Survey data. Office Report, Sacramento, CA.

Department of Water Resources. (1993) Sacramento-San Joaquin Delta Atlas.

Grober L.C. (1989). Data refinements and modeling results for the lower San Joaquin River Basin. A report to the State Water Resources Control Board. University of California, Davis. June 1989.

Kratzer, C.R., P.J. Pickett, E.A. Rashmawi, C.L. Cross, and K.D. Bergeron. (1987). *An InputOutput Model of the San Joaquin Riverfrom the Lander Avenue Bridge to the Airport Way Bridge.* Technical Committee Report No. W.Q. 85-1. California State Water Resources Control Board.

Kratzer, C.R. Personal communication. US Geological Survey, San Joaquin NAQWA Division, Sacramento, CA.

Jones & Stokes 2000. Data Summary Report for San Joaquin River Dissolved Oxygen TMDL, CALFED 2000 Grant", October 5, 2001

Pate T. (2001). DSM-2 Boundary extension. Draft Report on documentation of the DSM-2 San Joaquin River extension. Department of Water Resources, 2001.

Pate, T. (2001). Personal communication. Department of Water Resources, Delta Modeling Section, Sacramento, CA

Quinn N.W.T, C.W. Chen, L.F. Grober, J. Kipps and E. Cummings. 1997. Computer model improves real-time management of water quality. California Agriculture, Vol 51, No. 5.

Quinn N.W.T. and J. Karkoski. 1998. Potential for real-time management of water quality in the San Joaquin Basin, California. Journal of the American Water Resources Association, Vol 34, No. 6.

Quinn N.W.T. 2001. Powerpoint presentation made to USBR Groundwater Coinference, Port Angeles, 2001.

San Joaquin County Assessor's Rolls

US Bureau of Reclamation (2002). Preliminary Draft Annual Report, Grassland Bypass Project. Authors Eacock M.C. and Quinn N.W.T. Sections on (a) Flow and Electrical Conductivity Monitoring and (b) Impacts on the San Joaquin River.

US Geological Survey Quad maps:
Stockton West 1987
Vernalis, 1991
Lathrop, 1994
Ripon, 1987

APPENDIX A : **Boat survey of San Joaquin River diversions and drainage between the Deep Water Ship Channel and Mossdale.**

Date : June 5, 2001
Time : 8:25 a.m. to 3:00 p.m

San Joaquin River Diversions – Stockton DWSC to Mossdale, June 5, 2001
Field Survey commenced at 8:25 AM PDT, during apparent high tide, from the DeltaKeeper boat ramp on the Calaveras River, 37º 57.82'N, 121º 20.32'W. All diversions or returns observed were in operational condition unless otherwise noted. Wind speeds were still in the morning, increasing to 15-25 mph from the west by mid-day. Lat/Lon. is plus or minus 100 yds. Field survey ended at 3:00 PM at the starting point.

Landmark #	Diversion or Return? Which bank?	Latitude, Longitude[1]	Approximate river mile[2]	Description	Comments
1	Div	37º 57.22' N 121º 20.50' W	39.5	10" Ø suction	Below Channel Pt.
2	2 Div	37º 56.97' 121º 20.22'	39.8	2 10" Ø suctions	Inactive
3	Div	37º 56.82 121º 20.35'	40.1	10" Ø suction	
4	2 Ret Left	37º 56.29' 121º 20.13		Est. 2 – 3' Ø submerged discharge lines	**Stockton WWTP**
5	Ret Right	37º 56.29' 121º 20.13		__" Ø pipe	**Port of Stockton**
6	Ret Right	37º 55.89' 121º 19.69'		Broken pipe	Abandoned
7	Div & Gage right	37º 56.10' 121º 19.81'		WWTP Gage house and 2 10" Ø suctions	
8	Div	37º 55.68' 121º 19.64'		8" Ø suction and pump	Near Highway 4 bridge
9	Return	37º 55.55' 121º 19.50'		8" Ø pipe	Possible storm drain?
10	2 Div	37º 55.55' 121º 19.50'		2 - 12" Ø suctions	
11	Div	37º 55.45' 121º 19.43'		6" Ø suction	
12	Div	37º 55.38' 121º 19.39'		6" Ø suction	
13	Div	37º 55.32' 121º 19.33'		10" Ø suction	

[1] Magellan Trailblazer XL GPS Unit
[2] From USGS topographic maps, Stockton West and Lathrop quads

Landmark #	Diversion or Return? Which bank?	Latitude, Longitude	Approximate River Mile	Description	Comments
14	Div	37º 55.30' N 121º 19.29' W		8" Ø suction	
15	Uncertain	37º 55.30' 121º 19.29'		8" Ø pipe	Inactive
16	Div	37º 55.23' 121º 19.24'	43	12" Ø suction	
--	--	37º 55.14' 121º 19.13'		French Camp Slough	
17	Div Left	37º 54.98' 121º 19.30'		12" Ø suction	
18	Div. Left	37º 54.96' 121º 19.31'		14" Ø suction	
19	Div Left	37º 54.81' 121º 19.44'	43.5	14" Ø suction	
20	Div Left	37º 54.48' 121º 19.51'		12" Ø suction	Very old centrifugal pump, running
21	6 Returns right	37º 54.38' 121º 19.45'		6 24" Ø flap gates	Possible Weston Ranch stormwater discharges
22	Div & Ret right	37º 54.38' 121º 19.45'		12" Ø suction, 12" Ø return	
23	Div & Ret Left	37º 54.25' 121º 19.47'		16" Ø suction, 16" Ø return	Running
24	Div & Ret Left	37º 54.17' 121º 19.53'		14" Ø suction, 10" Ø return	
25	Div right	37º 54.12' 121º 19.54'		8" Ø suction	
26	Div Left	37º 54.08' 121º 19.54'		6" Ø suction	
27	2 Div right	37º 54.05' 121º 19.55'		12" Ø and 6" Ø suctions	River depth 12 ft.

Landmark #	Diversion or Return? Which bank?	Latitude, Longitude	Approximate River Mile	Description	Comments
28	Div Left	37º 53.97’ N 121º 19.58’ W		8” Ø suction	
29	2 Div & Ret Right	37º 53.89’ 121º 19.61’		12” Ø and 14” Ø suctions, 8” Ø return	Running
30	Div & Ret right	37º 53.89’ 121º 19.61’		14” Ø suction, __” Ø return	
31	Div left	37º 53.97’ 121º 19.74’		10” Ø suction	Near old brick tower, labeled S B Co., 1893
32	Div right	37º 53.97’ 121º 19.74’		10” Ø suction	
33	Div & Ret left	37º 53.37’ 121º 19.91’		14” Ø suction, 12” Ø return	
34	Div & Ret right	37º 53.36’ 121º 19.83’		14” Ø suction, 14” Ø return	
35	Div right	37º 53.27’ 121º 19.84’		20” Ø suction	
36	Div left	37º 53.27’ 121º 19.84’		6” Ø suction	
37	Div & Ret left	37º 53.10’ 121º 19.91’		12” Ø suction, __” return	
38	3 Div right	37º 52.90’ 121º 19.96’	46	3 pipes: 12”, 10”, and 10”	Near high voltage power lines
39	2 Ret left	37º 52.85’ 121º 19.98’		2 12” Ø pipes	
40	Div right	37º 52.86’ 121º 19.97’		10” Ø suction	
41	Div left	37º 52.79’ 121º 19.97’		12” Ø suction	Near Matthews Road bridge
42	Div Left	37º 52.68’ 121º 19.91’		18” Ø suction	New

Landmark #	Diversion or Return? Which bank?	Latitude, Longitude	Approximate River Mile	Description	Comments
43	Div Right	37º 52.68' 121º 19.90'		12" Ø suction	
44	2 Div right	37º 52.60' 121º 19.93'		10" and 8" Ø suctions	
45	Div left	37º 52.56' 121º 19.92'		14" Ø suction	
46	Div Right	37º 52.51' 121º 20.00'		12" Ø suction	
47	Div left	37º 52.37' 121º 19.90'		12" Ø suction	
48	Div & Ret right	37º 52.32' 121º 19.87'		16" Ø suction	Running
49	Div Left	37º 52.32' 121º 19.87'		10" Ø suction	
50	Div Left	37º 52.37' 121º 19.90'		12 "Ø suction	
51	2 Div Left	37º 52.30' 121º 19.85'		12" and 10" Ø suctions	
52	Div right	37º 52.14' 121º 19.72'		10" Ø suction	
53	Div right	37º 52.06' 121º 19.67'		10" ? Ø suction	
54	Div Left	37º 51.99' 121º 19.67'		16" Ø suction	Running and discharging to river
55	Unknown left	37º 51.85' 121º 19.59'		Top of buried 14" gate valve observed on levee	
56	Gage right	37º 51.87' 121º 19.40'		Tide gage station?	DWR?
57	Div Right	37º 51.82' 121º 19.28'		8" Ø suction	Running
58	Div Right	37º 51.65' 121º 19.23'		8" Ø suction	

Landmark #	Diversion or Return? Which bank?	Latitude, Longitude	Approximate River Mile	Description	Comments
59	Div Right	37º 51.46' N 121º 19.14' W		14" Ø suction	
60	Div Left	37º 51.44' 121º 19.17'		20" Ø suction	
61	Div Right	37º 51.33' 121º 19.22'		10" Ø suction	
62	Div Right	37º 51.29' 121º 19.21'		14" Ø suction	
63	Div Left	37º 51.27' 121º 19.40'		16" Ø suction	
64	-- right	37º 51.07' 121º 19.32'	49	Heaven Acres mobile home community	Septic Tanks? Observed one 6" drainage pipe to the edge of the river. Access by way of Manila Road, off Roth Rd exit, I-5.
65	Div Left	37º 50.91' 121º 19.45'		12" Ø suction	Running
66	Div & Ret Left	37º 50.90' 121º 19.47'		18" Ø suction, 10" Ø return	
67	Div Right	37º 50.80' 121º 19.43'		6" Ø suction	
68	Unknown Left	37º 50.78' 121º 19.39'		8" Ø suction	
69	Div Left	37º 50.72' 121º 19.33'		14" Ø suction	
70	Div & Ret? right	37º 50.68" 121º 19.33'		14" Ø suction or casing, 12" Ø return?	
71	Div Right	37º 50.36' 121º 19.07'		14" Ø suction	
72	Div & Ret Left	37º 50.31' 121º 19.04'		16" Ø suction, 12" Ø return	
73	Div Left	37º 50.19' 121º 18.99'		14" Ø suction	9: 45 AM, water depth 9 ft, river width about 80 ft.

Landmark #	**Diversion or Return? Which bank?**	**Latitude, Longitude**	**Approximate River Mile**	**Description**	**Comments**
74	Div Left	37º 50.06' N 121º 18.87' W		14" Ø suction	
75	Div & 2 Ret Right	37º 50.03' 121º 18.85'		16" Ø suction, 10" and 6" Ø returns	
76	Div Right	37º 50.02' 121º 18.84'		12" Ø suction	Running
77	Div Right	37º 49.99' 121º 18.81'	50.7	6" Ø suction	Near Dos Rios Park & boat ramp
78	Div Right	37º 49.84' 121º 18.72'		12" Ø suction	
79	Ret Right	37º 49.84' 121º 18.72'		8" Ø return	
80	Div Right	37º 49.59' 121º 18.61'		14" Ø suction	
81	2 Div & Ret right	37º 49.58' 121º 18.61'		16" and 14" Ø suctions, __" Ø return	Both pumps running
82	2 Div Left	37º 49.48' 121º 18.80'		16" Ø inactive 12" Ø suction	One pipe inactive
83	2 Div left	37º 49.48' 121º 18.82'		2 14" Ø suctions	
84	Ret Left	37º 49.26' 121º 19.20'		14" Ø pipe	
85	Div Left	37º 49.26' 121º 19.21'	52	10" Ø suction	
86	Div Right	37º 49.08' 121º 18.89'		14" Ø suction	
87	2 Div Right	37º 49.08' 121º 18.89'		12" and 10" Ø suctions	
88	Div Right	37º 48.93' 121º 18.83'		8" Ø suction	

Landmark #	Diversion or Return? Which bank?	Latitude, Longitude	Approximate River Mile	Description	Comments
89	Div Left	37º 48.66' N 121º 19.38' W	53	12" Ø suction	Running w/ discharge to river
90	--	37º 48.52' 121º 19.64'	53.5	**Head of Old River**	Pulling remains of Old River barrier out. Channel had been open since the weekend before. Goat herd resident on right bank. Lots of trash, due to public access on left bank. 10:10 AM
91	Div & Ret Right	37º 48.17' 121º 18.77'		14" Ø suction, __ " Ø return	Running
92	Div Right	37º 48.11' 121º 18.75'		12" Ø suction	
93	2 Div Right	37º 47.94' 121º 18.91'		2 - 6" Ø suctions	Abandoned and inactive
94	3 Div & 2 Ret Left	37º 47.72' 121º 18.92'		3 pumps w/ 2 – 16" and 1 – 12" Ø suctions, 2 – 12" Ø returns	
95	Div Right	37º 47.72' 121º 18.47'		6" Ø suction	
96	Ret Right	37º 47.66' 121º 18.44'		16" Ø suction	
97	3 Div	37º 47.48' 121º 18.47'		8", 6" and 4" Ø suctions	
98	--	37º 47.32' 121º 18.49'		SPRR Bridge at Mossdale	Water depth 13.5 ft
99	Div Left	37º 47.24' 121º 18.48'		14" Ø suction	
100	--	37º 47.21' 121º 18.40'	56	Continuous monitoring station	On balascule bridge at I-5 crossing
101	--	37º 47.04' 121º 17.95'		Mossdale mobil home community	Septic tanks? Water depth 5-8 ft.

Landmark #	Diversion or Return? Which bank?	Latitude, Longitude	Approximate River Mile	Description	Comments
102	Div Left	37º 46.81' N 121º 18.05' W		12" Ø suction	Near UPRR bridge
103	2 Div right	37º 46.86' 121º 18.19'		2 – 16" Ø suctions	
104	2 Ret right	37º 46.86' 121º 18.19'		14" and 6" Ø flap gates	
105	-- right	37º 46.73' 121º 18.04'	57	Walthall Slough	Oakwood Park and Weatherbee Lake are directly upstream in the slough. Residential area adjancent.
106	Div Right	37º 45.81' 121º 18.55'		10" Ø suction	
107	Div Left	37º 45.81' 121º 18.55'		12" Ø suction	
108	Div Left	37º 45.68' 121º 18.55'		20" Ø suction	
109	--	37º 45.22' 121º 18.27'	60	Paradise Cut dam	
110	3 Div Left	37º 45.08' 121º 18.22'		3 pumps: 16", 14", and 12" Ø suctions	All 3 running
111	Div Left	37º 45.06' 121º 17.81'		12" Ø suction	
112	Div & Ret Right	37º 45.09' 121º 17.77'		12" Ø suction, 14" Ø return	10:45 AM. Boat grounded on sandbar. Water depth quite variable,up to 18 ft. Maximum extent of survey upstream.

Note: CDFG was observed sampling for salmon smolts above the head of Old River, 37º 48.28' N, 121º 18.81' W

San Joaquin River Water Quality Sampling, 6/5/01

Sampling began about 11:30 AM, after tide had been going out for some time. Observed tidal difference was at least 2 feet at French Camp Slough. Second letter on sample number indicates sampling units used: Q = Quanta, H = Hydrolab Scout 2[3]

Sample number	Latitude/ Longitude[4]	River Mile[5]	Location	Water Depth	Sample Depth	Temp, ºC	EC, mS/cm	DO, mg/l
A-Q	37º 45.10' N 121º 17.72' W	60	Above Paradise Cut dam.		1 ft.	20.25	702	10.14
A-H	37º 45.10' 121º 17.72'	60	"		1 ft.	20.26	795	6.6
B-Q	37º 45.28' 121º 18.27'	59			1 ft.	20.3	702	9.97
B-H	37º 45.28' 121º 18.27'	59			1 ft.	20.3	793	6.7
C-Q	37º 46.03' 121º 18.50'	58		14 ft.	1 ft.	20.4	697	10.3
C-H	37º 46.03' 121º 18.50'	58		"	1 ft.	20.4	787	8.44
D-Q	37º 46.27' 121º 18.12'	57.5	At mouth of ox bow	5 – 12 ft Quite variable	1 ft	20.5	695	10.4
D-H	37º 46.27' 121º 18.12'	57.5	"	"	1 ft.	20.5	785	8.8
E-Q	37º 46.72' 121º 18.00'	56.5	Below Walthall Slough	10-17 ft.	1 ft.	20.7	695	10.2
E-H	37º 46.72' 121º 18.00'	56.5	"	"	1 ft.	20.7	786	8.8
F-Q	37º 47.08' 121º 18.31'	56.2	Under Mossdale I-5 bridge	8 ft.	1 ft.	20.4	697	10.3
F-H	37º 47.08' 121º 18.31'	56.2	"	"	1 ft.	20.9	787	9.4

[3] The probe membrane on the Hydrolab unit was possibly dried out, and exhibited DO drift over sampling period.
[4] Magellan Trailblazer XL GPS unit.
[5] From USGS topographic maps, Stockton West and Lathrop quadrangles, and SJR Stockton to Merced River Aerial Atlas, USCE, April 1984.

Sample number	Latitude/ Longitude	River Mile	Location	Water Depth	Sample Depth	Temp, ºC	EC, mS/cm	DO, mg/l
G-Q	37º 48.31' N 121º 19.37' W	54	Above Old River[6]	13 ft.	1 ft.	21.2	708	10.5
G-H	37º 48.31' 121º 19.37'	54	"	"	1 ft.	21.4	799	9.8
H-Q	37º 48.55' 121º 19.60'	53.5	Below Old River	16 ft	L ft.	21.4	708	10.4
H-H	37º 48.55' 121º 19.60'	53.5	"	"	1 ft.	21.4	799	9.6
I-Q	37º 49.72' 121º 18.68'	50.7	Dos Rios boat ramp	9 ft.	1 ft.	21.0	689	10.9
I-H	37º 49.72' 121º 18.68'	50.7	"	"	1 ft.	21.1	778	10.2
J-Q	37º 50.87' 121º 19.46'	49.2	Above Heaven Acres	11 - 20 ft.	1 ft.	21.6	693	10.8
J-H	37º 50.87' 121º 19.46'	49.2	"	"	1 ft.	21.6	783	10.5
K-Q	37º 50.87' 121º 19.46'	49.2	"	"	3 m, near bottom	21.5	693	11.0
L-Q	37º 51.06' 121º 19.35'	48.9	Below Heaven Acres	11 ft.	1 ft.	21.6	693	10.7
L-H	37º 51.06' 121º 19.35'	48.9	"	"	1 ft.	21.6	783	9.8
M-Q	37º 52.63' 121º 19.90'	46.3	At Matthews Road bridge and power lines	12 ft	1 ft.	21.5	705	10.5
M-H	37º 52.63' 121º 19.90'	46.3	"	"	1 ft.	21.9	797	9.8

[6] An estimated 2/3rds of SJR flow was going down Old River.

Sample number	Latitude/ Longitude	River Mile	Location	Water Depth	Sample Depth	Temp, ºC	EC, mS/cm	DO, mg/l
N-Q	37º 54.67' N 121º 19.46' W	43.5	Above French Camp Slough	10 ft.	1 ft.	22.1	691	9.38
N-H	37º 54.67' 121º 19.46'	43.5	"	"	1 ft.	22.1	781	8.9
O-Q	37º 55.20' 121º 19.11'	42.8	Mouth of French Camp Slough	8 ft.	1 ft.	21.8	197	7.0
O-H	37º 55.20' 121º 19.11'	42.8	"	"	1 ft.	21.9	225	7.14
P-Q	37º 54.95' 121º 18.30'	--	About ¾ mile up French Camp Slough[7]	0-8 ft.	1ft.	22.7	166	6.6
P-H	37º 54.95' 121º 19.11'	--	"	"	1 ft.	22.6	186	6.8
Q-Q	37º 55.69' 121º 19.70'	42.1	At Garwood Bridge, above Stockton WWTP	15 ft.	1 ft.	22.2	575	8.3
Q-H	37º 55.69' 121º 19.70'	42.1	"	"	1 ft.	22.2	700	7.82
R-Q	37º 56.35' 121º 20.53	41	Below Stockton WWTP discharge point.	12 ft.	1 ft.	22.3	585	8.48
R-H	37º 56.35' 121º 20.53'	41	"	"	1 ft.	22.3	661	7.97
S-Q	37º 57.09' 121º 20.18'	39.5	At Channel Point, near shore. Channel marker 48	15 ft.	1 ft.	23.8	618	6.23
S-H	37º 57.09' 121º 20.18'	39.5	"	"	1 ft.	23.8	698	6.53

[7] Turbidity was noticeably higher in French Camp Slough. Stream bed was shallow mud flats, with quite variable depth, high organic content fine soils.

Sample number	Latitude/ Longitude	River Mile	Location	Water Depth	Sample Depth	Temp, ºC	EC, mS/cm	DO, mg/l
T-Q	37º 57.09' N 121º 20.18' W	39.5	Channel Point, mid channel. Channel marker 48.	40 ft.	Bottom	22.8	610	7.1
U-Q	37º 57.09' 121º 20.18'	39.5	"	"	8 m	22.9	612	6.9
V-Q	37º 57.09' 121º 20.18'	39.5	"	"	4 m	22.3	613	6.6
W-Q	37º 57.09' 121º 20.18'	39.5	"	"	1 m	22.2	613	6.5
X-Q	37º57.92' 121º 22.03'	38	Opposite mouth of Calaveras River, mid channel[8]	37 ft.	Bottom	22.9	625	4.69
Y-Q	37º 57.92' 121º 22.03'		"	"	8 m	23.1	634	4.86
Z-Q	37º 57.92' 121º 22.03'		"	"	4 m	23.2	635	4.89
AA-Q	37º 57.92' 121º 22.03'		"	"	1 m	24.3	635	5.28
BB-Q	37º 58.08 121º 21.73'	--	About ½ mile up the Calaveras River	6 ft.	1 ft.	25.2	457	5.65
BB-H	37º 58.08' 121º 21.73'	--	"	"	1 ft.	25.1	516	6.14

Sampling Team: Nigel Quinn, Alice Tulloch, Bill Johnston, Fred Lee
Boat and crew provided courtesy of the DeltaKeeper and Bill Jennings.

[8] Opposite the lower end of Burns Cut and Rough and Ready Island, near the continuous monitoring station.

Additional comments from Bill Jennings on sources and diversions on the SJR below Mossdale:

1. Weston Ranch storm water system discharges can occur at any time. In summer, nuisance water from landscape overirrigation is automatically pumped from their ponds to the SJR.
2. The outfall opposite the Stockton WWTP discharge point is surface water drainage from about 90% of the Port property.
3. There is a hog ranch above Channel Point. He doesn’t know where the waste is going.
4. Duell correctional facility operates a dairy near Mossdale.
5. He described suspected past incidents of improper sewage disposal at Heaven Acres or Mossdale mobile home parks.

APPENDIX B : Output from the stream budget analysis package of the WESTSIM integrated groundwater-surface water model, currently under development by the US Bureau of Reclamation.

Note : These are preliminary calibration results and some of the groundwater gains/losses numbers will likely change with improved model calibration.

STREAM BUDGET (AF)
WESTSIM MODEL REACH-1

TIME	UPSTRM (+)	TRIB (+)	SW RTRN (+)	RUNOFF (+)	GW GAIN (+)	BYPASS (-)	DIVERSION (-)	STORAGE (-)	DWNSTRM (=)
1970	0	88955	0	0	1318	0	0	0	90273
1971	0	12513	0	0	-169	0	0	0	12344
1972	0	660	0	0	294	0	0	0	954
1973	0	20697	0	0	-18	0	0	0	20680
1974	0	138025	0	0	-3465	0	0	0	134560
1975	0	21915	0	0	-400	0	0	0	21516
1976	0	1682	0	0	244	0	0	0	1926
1977	0	0	0	0	3	0	0	0	3
1978	0	667148	0	0	-15176	0	0	0	651971
1979	0	62877	0	0	-775	0	0	0	62103
1980	0	672071	0	0	-16541	0	0	0	655530
1981	0	28328	0	0	337	0	0	0	28665
1982	0	521773	0	0	2988	0	0	0	524761
1983	0	2365480	0	0	-33806	0	0	0	2331674
1984	0	648158	0	0	-15074	0	0	0	633084
1985	0	26155	0	0	65	0	0	0	26220
1986	0	723868	0	0	-1050	0	0	0	722818
1987	0	17253	0	0	-3556	0	0	0	13697
1988	0	1502	0	0	5	0	0	0	1507
1989	0	0	0	0	1	0	0	0	1
1990	0	0	0	0	0	0	0	0	0
1991	0	99	0	0	-1	0	0	0	98
1992	0	0	0	0	1	0	0	0	1
1993	0	45847	0	0	-246	0	0	0	45601
AVG.	0	252709	0	0	-3543	0	0	0	249166

STREAM BUDGET (AF)
WESTSIM MODEL REACH 2

TIME	UPSTRM (+)	TRIB (+)	SW RTRN (+)	RUNOFF (+)	GW GAIN (+)	BYPASS (-)	DIVERSION (-)	STORAGE (-)	DWNSTRM (=)
1970	90273	0	127	13	1121	0	0	0	91534
1971	12344	0	118	16	563	0	0	0	13041
1972	954	0	138	6	1362	0	0	0	2460
1973	20680	0	123	1371	809	0	0	0	22983
1974	134560	0	122	257	-5816	0	0	0	129123
1975	21516	0	109	115	786	0	0	0	22525
1976	1926	0	107	91	2314	0	0	0	4439
1977	3	0	114	11	1301	0	0	0	1428
1978	651971	0	109	3085	-38571	0	0	0	616594
1979	62103	0	40	35	-9270	0	0	0	52908
1980	655530	0	123	559	-52733	0	0	0	603479
1981	28665	0	118	14	3299	0	0	0	32096
1982	524761	0	106	224	-25979	0	0	0	499112
1983	2331674	0	111	1604	-82323	0	0	0	2251065
1984	633084	0	132	8	-27968	0	0	0	605256
1985	26220	0	124	19	995	0	0	0	27358
1986	722818	0	120	303	-23719	0	0	0	699522
1987	13697	0	90	29	-1160	0	0	0	12656
1988	1507	0	95	38	3948	0	0	0	5589
1989	1	0	163	13	1458	0	0	0	1635
1990	0	0	162	14	1193	0	0	0	1369
1991	98	0	156	466	2278	0	0	0	2998
1992	1	0	159	461	2534	0	0	0	3156
1993	45601	0	156	883	2324	0	0	0	48964
AVG.	249166	0	122	401	-10052	0	0	0	239637

STREAM BUDGET (AF)
WESTSIM MODEL REACH-3

TIME	UPSTRM (+)	TRIB (+)	SW RTRN (+)	RUNOFF (+)	GW GAIN (+)	BYPASS (-)	DIVERSION (-)	STORAGE (-)	DWNSTRM (=)
1970	0	0	2037	2452	-1330	0	0	0	3160
1971	0	0	3779	4484	-2580	0	0	0	5683
1972	0	0	3009	2517	-1610	0	0	0	3916
1973	0	0	2834	32351	-9523	0	0	0	25661
1974	0	0	3669	18105	-4445	0	0	0	17330
1975	0	0	4360	8801	-4089	0	0	0	9072
1976	0	0	4281	17366	-6614	0	0	0	15033
1977	0	0	3276	1151	-1198	0	0	0	3229
1978	0	0	2951	81371	-11996	0	0	0	72326
1979	0	0	3659	11050	-3951	0	0	0	10758
1980	0	0	4418	53682	-7350	0	0	0	50750
1981	0	0	4871	9937	-4138	0	0	0	10670
1982	0	0	4688	27530	-4761	0	0	0	27457
1983	0	0	4311	64598	1276	0	0	0	70185
1984	0	0	5140	5575	-1315	0	0	0	9399
1985	0	0	5159	13209	-4160	0	0	0	14209
1986	0	0	5129	26564	-2662	0	0	0	29031
1987	0	0	3844	10682	-4077	0	0	0	10449
1988	0	0	4786	19307	-5191	0	0	0	18902
1989	0	0	4489	4581	-2436	0	0	0	6634
1990	0	0	3839	2782	-1794	0	0	0	4827
1991	0	0	2952	50971	-3896	0	0	0	50028
1992	0	0	4041	20958	-5402	0	0	0	19597
1993	0	0	4175	41407	-6788	0	0	0	38793
AVG.	0	0	3987	22143	-4168	0	0	0	21963

STREAM BUDGET(AF)
WESTSIM MODEL REACH-4

TIME	UPSTRM (+)	TRIB (+)	SW RTRN (+)	RUNOFF (+)	GW GAIN (+)	BYPASS (-)	DIVERSION (-)	STORAGE (-)	DWNSTRM (=)
1970	94694	0	345	355	10620	0	0	0	106013
1971	18724	0	351	476	-19551	0	0	0	0
1972	6375	0	383	168	-6926	0	0	0	0
1973	48645	0	305	3444	-51071	0	0	0	1322
1974	146453	0	347	1763	-31127	0	0	0	117436
1975	31598	0	342	851	-32778	0	0	0	13
1976	19472	0	332	1802	-21394	0	0	0	213
1977	4657	0	270	176	-5103	0	0	0	0
1978	688920	0	279	4864	-816	0	0	0	693246
1979	63666	0	356	572	-39167	0	0	0	25427
1980	654229	0	363	3554	-11863	0	0	0	646283
1981	42766	0	363	498	-26911	0	0	0	16716
1982	526570	0	332	1553	-1956	0	0	0	526499
1983	2321250	0	256	3590	-40040	0	0	0	2285056
1984	614655	0	364	231	4006	0	0	0	619255
1985	41567	0	656	575	-4161	0	0	0	38638
1986	728553	0	435	2068	17694	0	0	0	748751
1987	23105	0	472	1227	-24804	0	0	0	0
1988	24491	0	452	1405	10858	0	0	0	37206
1989	8269	0	482	424	-6362	0	0	0	2813
1990	6197	0	402	236	-6835	0	0	0	1
1991	53025	0	343	2878	29390	0	0	0	85637
1992	22753	0	326	2925	-22662	0	0	0	3342
1993	87757	0	330	3381	-5371	0	0	0	86098
AVG.	261600	0	370	1626	-11930	0	0	0	251665

STREAM BUDGET(AF)
WESTSIM MODEL REACH-5

TIME	UPSTRM (+)	TRIB (+)	SW RTRN (+)	RUNOFF (+)	GW GAIN (+)	BYPASS (-)	DIVERSION (-)	STORAGE (-)	DWNSTRM (=)
1970	106013	171251	0	0	-24763	0	0	0	252502
1971	0	89247	0	0	-40386	0	0	0	48861
1972	0	110019	0	0	-41497	0	0	0	68522
1973	1322	381161	0	0	-59417	0	0	0	323066
1974	117436	211344	0	0	-57090	0	0	0	271689
1975	13	165586	0	0	-61267	0	0	0	104331
1976	213	176370	0	0	-69053	0	0	0	107530
1977	0	144517	0	0	-62736	0	0	0	81781
1978	693246	757188	0	0	-71611	0	0	0	1378823
1979	25427	179382	0	0	-67264	0	0	0	137545
1980	646283	574828	0	0	-58419	0	0	0	1162693
1981	16716	172603	0	0	-44689	0	0	0	144630
1982	526499	445237	0	0	-28399	0	0	0	943337
1983	2285056	2040746	0	0	-57484	0	0	0	4268318
1984	619255	651972	0	0	-26867	0	0	0	1244360
1985	38638	186475	0	0	-35327	0	0	0	189786
1986	748750	656392	0	0	-27193	0	0	0	1377949
1987	0	180878	0	0	-34400	0	0	0	146478
1988	37206	185258	0	0	-22894	0	0	0	199571
1989	2813	193118	0	0	-28608	0	0	0	167323
1990	1	193732	0	0	-22025	0	0	0	171707
1991	85637	167929	0	0	-19492	0	0	0	234074
1992	3342	163938	0	0	-25596	0	0	0	141684
1993	86098	197761	0	0	-28025	0	0	0	255834
AVG.	251665	349872	0	0	-42271	0	0	0	559266

STREAM BUDGET(AF)
WESTSIM MODEL REACH-6

TIME	UPSTRM (+)	TRIB (+)	. SW RTRN (+)	RUNOFF (+)	GW GAIN (+)	BYPASS (-)	DIVERSION (-)	STORAGE (-)	DWNSTRM (=)
1970	252502	0	0	0	-5277	0	0	0	247225
1971	48861	0	0	0	-10589	0	0	0	38272
1972	68522	0	0	0	-10026	0	0	0	58496
1973	323066	0	0	0	-15682	0	0	0	307383
1974	271689	0	0	0	-20876	0	0	0	250813
1975	104331	0	0	0	-25324	0	0	0	79007
1976	107530	0	0	0	-30801	0	0	0	76729
1977	81781	0	0	0	-24961	0	0	0	56820
1978	1378823	0	0	0	-35844	0	0	0	1342980
1979	137545	0	0	0	-29851	0	0	0	107695
1980	1162693	0	0	0	-28209	0	0	0	1134484
1981	144630	0	0	0	-16675	0	0	0	127956
1982	943337	0	0	0	-11253	0	0	0	932084
1983	4268318	0	0	0	-26171	0	0	0	4242147
1984	1244360	0	0	0	-4310	0	0	0	1240051
1985	189786	0	0	0	-12436	0	0	0	177350
1986	1377949	0	0	0	-8973	0	0	0	1368976
1987	146478	0	0	0	-12600	0	0	0	133878
1988	199571	0	0	0	-11113	0	0	0	188457
1989	167323	0	0	0	-13595	0	0	0	153728
1990	171707	0	0	0	-8938	0	0	0	162769
1991	234074	0	0	0	-9829	0	0	0	224245
1992	141684	0	0	0	-9602	0	0	0	132081
1993	255834	0	0	0	-15098	0	0	0	240736
AVG.	559266	0	0	0	-16585	0	0	0	542682

STREAM BUDGET (AF)
WESTSIM MODEL REACH-7

TIME	UPSTRM (+)	TRIB (+)	. SW RTRN (+)	RUNOFF (+)	GW GAIN (+)	BYPASS (-)	DIVERSION (-)	STORAGE (-)	DWNSTRM (=)
1970	247225	0	0	0	54465	0	0	0	301690
1971	38272	0	0	0	20270	0	0	0	58543
1972	58496	0	0	0	30985	0	0	0	89481
1973	307383	0	0	0	46060	0	0	0	353443
1974	250813	0	0	0	33255	0	0	0	284068
1975	79007	0	0	0	-3810	0	0	0	75197
1976	76729	0	0	0	1514	0	0	0	78243
1977	56820	0	0	0	29990	0	0	0	86810
1978	1342980	0	0	0	27558	0	0	0	1370537
1979	107695	0	0	0	23780	0	0	0	131474
1980	1134484	0	0	0	8098	0	0	0	1142582
1981	127956	0	0	0	26093	0	0	0	154048
1982	932084	0	0	0	13826	0	0	0	945910
1983	4242147	0	0	0	-22856	0	0	0	4219291
1984	1240051	0	0	0	41847	0	0	0	1281898
1985	177350	0	0	0	-413	0	0	0	176937
1986	1368976	0	0	0	34951	0	0	0	1403927
1987	133878	0	0	0	19580	0	0	0	153458
1988	188457	0	0	0	12923	0	0	0	201380
1989	153728	0	0	0	-11469	0	0	0	142259
1990	162769	0	0	0	54810	0	0	0	217579
1991	224245	0	0	0	-3537	0	0	0	220708
1992	132081	0	0	0	29462	0	0	0	161544
1993	240736	0	0	0	11442	0	0	0	252178
AVG.	542682	0	0	0	19951	0	0	0	562633

STREAM BUDGET(AF)
WESTSIM MODEL REACH-8

TIME	UPSTRM (+)	TRIB (+)	SW RTRN (+)	RUNOFF (+)	GW GAIN (+)	BYPASS (-)	DIVERSION (-)	STORAGE (-)	DWNSTRM (=)
1970	301690	32310	0	1	57668	0	2403	0	389266
1971	58543	22705	0	4	-8381	0	2403	0	70467
1972	89481	17668	0	0	7923	0	2277	0	112796
1973	353443	41348	0	154	75343	0	1950	0	468338
1974	284068	28501	0	11	-20330	0	1707	0	290543
1975	75197	29010	0	23	13953	0	1833	0	116350
1976	78243	21059	0	0	3433	0	2396	0	100339
1977	86810	17087	0	0	3464	0	2261	0	105100
1978	1370537	104973	0	115	34697	0	1550	0	1508772
1979	131474	30562	0	56	-7855	0	1950	0	152288
1980	1142582	89758	0	69	66080	0	1709	0	1296781
1981	154048	24641	0	15	14818	0	2403	0	191119
1982	945910	97688	0	100	19210	0	1681	0	1061228
1983	4219291	297080	0	320	40552	0	2236	0	4555007
1984	1281898	81115	0	2	-329	0	2848	0	1359838
1985	176937	29737	0	0	-2189	0	2890	0	201596
1986	1403927	84694	0	127	42130	0	1963	0	1528915
1987	153458	19354	0	11	4313	0	2522	0	174614
1988	201380	6227	0	7	20761	0	2335	0	226040
1989	142259	7374	0	1	16346	0	2871	0	163109
1990	217579	3831	0	0	39720	0	2747	0	258383
1991	220708	9329	0	11	7533	0	2871	0	234711
1992	161544	11054	0	52	47224	0	2090	0	217784
1993	252178	46485	0	272	-19245	0	2216	0	277473
AVG.	562633	48066	0	56	19035	0	2255	0	627536

STREAM BUDGET (AF)
WESTSIM MODEL REACH-9

TIME	UPSTRM (+)	TRIB (+)	SW RTRN (+)	RUNOFF (+)	GW GAIN (+)	BYPASS (-)	DIVERSION (-)	STORAGE (-)	DWNSTRM (=)
1970	0	0	116064	11745	-8773	0	0	0	119036
1971	0	0	59268	17150	-16286	0	0	0	60131
1972	0	0	89101	4246	-17395	0	0	0	75952
1973	0	0	85344	53060	-25444	0	0	0	112959
1974	0	0	55997	17824	-25662	0	0	0	48160
1975	0	0	92334	18921	-27090	0	0	0	84166
1976	0	0	116528	7637	-22856	0	0	0	101308
1977	0	0	95858	3008	-12659	0	0	0	86207
1978	0	0	92874	85929	-24094	0	0	0	154709
1979	0	0	70638	31852	-22985	0	0	0	79505
1980	0	0	154177	44021	-33965	0	0	0	164233
1981	0	0	196688	16305	-29367	0	0	0	183627
1982	0	0	146248	40825	-29313	0	0	0	157760
1983	0	0	141543	77073	-28562	0	0	0	190054
1984	0	0	322539	17542	-30645	0	0	0	309436
1985	0	0	123316	14185	-21413	0	0	0	116089
1986	0	0	159853	49486	-27203	0	0	0	182136
1987	0	0	119470	23205	-24785	0	0	0	117890
1988	0	0	181745	20474	-32361	0	0	0	169859
1989	0	0	121063	13795	-26950	0	0	0	107908
1990	0	0	128810	5874	-19589	0	0	0	115095
1991	0	0	98466	18531	-25410	0	0	0	91587
1992	0	0	67912	32201	-20342	0	0	0	79771
1993	0	0	105658	66119	-34627	0	0	0	137150
AVG.	0	0	122562	28792	-24491	0	0	0	126864

STREAM BUDGET(AF)
WESTSIM MODEL REACH-1 10

TIME	UPSTRM (+)	TRIB (+)	SW RTRN (+)	RUNOFF (+)	GW GAIN (+)	BYPASS (-)	DIVERSION (-)	STORAGE (-)	DWNSTRM (=)
1970	508302	0	0	614	159920	0	1511	0	667325
1971	130598	0	0	1224	-11013	0	1511	0	119298
1972	188748	0	0	120	7813	0	2045	0	194636
1973	581297	0	0	3112	73052	0	1240	0	656221
1974	338702	0	0	816	-17725	0	1704	0	320090
1975	200516	0	0	674	54353	0	1170	0	254374
1976	201647	0	0	23	6651	0	1693	0	206628
1977	191307	0	0	61	16418	0	1426	0	206361
1978	1663482	0	0	1714	33170	0	2231	0	1696135
1979	231793	0	0	1183	15628	0	1240	0	247364
1980	1461014	0	0	1193	61958	0	2359	0	1521806
1981	374745	0	0	548	34425	0	1511	0	408208
1982	1218989	0	0	1733	-10027	0	1356	0	1209338
1983	4745061	0	0	4652	63550	0	1412	0	4811851
1984	1669274	0	0	764	20990	0	2354	0	1688675
1985	317684	0	12513	565	53593	0	1793	0	382563
1986	1711050	0	2005	2104	31033	0	1050	0	1745142
1987	292504	0	3518	686	40606	0	1583	0	335732
1988	395899	0	4086	855	1607	0	1657	0	400790
1989	271017	0	5583	563	58190	0	1792	0	333560
1990	373479	0	6925	471	-15792	0	2981	0	362101
1991	326298	0	14796	639	68435	0	1792	0	408376
1992	297555	0	6568	1525	598	0	1933	0	304314
1993	414624	0	9891	4851	61269	0	1399	0	489235
AVG.	754399	0	2745	1279	33696	0	1698	0	790422

STREAM BUDGET(AF)
WESTSIM MODEL REACH -11

TIME	UPSTRM (+)	TRIB (+)	.SW RTRN (+)	RUNOFF (+)	GW GAIN (+)	BYPASS (-)	DIVERSION (-)	STORAGE (-)	DWNSTRM (=)
1970	0	0	70148	9892	-4672	0	0	0	75369
1971	0	0	96206	11152	-19578	0	0	0	87779
1972	0	0	110603	2072	-19235	0	0	0	93439
1973	0	0	92916	40861	-19160	0	0	0	114617
1974	0	0	120255	12609	-22244	0	0	0	110621
1975	0	0	146979	17811	-22487	0	0	0	142304
1976	0	0	136093	3754	-17369	0	0	0	122478
1977	0	0	71981	2248	-15745	0	0	0	58484
1978	0	0	94036	52299	-18867	0	0	0	127467
1979	0	0	103944	20580	-17174	0	0	0	107350
1980	0	0	109891	22704	-17644	0	0	0	114951
1981	0	0	87376	10042	-20898	0	0	0	76520
1982	0	0	93907	19647	-19475	0	0	0	94079
1983	0	0	91989	45199	-20622	0	0	0	116567
1984	0	0	70879	10979	-17272	0	0	0	64586
1985	0	0	105117	6902	-17206	0	0	0	94812
1986	0	0	95682	26825	-17914	0	0	0	104594
1987	0	0	94236	16200	-19101	0	0	0	91335
1988	0	0	91904	12870	-16251	0	0	0	88523
1989	0	0	95697	8302	-17930	0	0	0	86069
1990	0	0	62330	3445	-14409	0	0	0	51367
1991	0	0	58741	11104	-15233	0	0	0	54611
1992	0	0	47735	16365	-15613	0	0	0	48487
1993	0	0	76499	35730	-20807	0	0	0	91422
AVG.	0	0	92714	17483	-17788	0	0	0	92410

STREAM BUDGET(AF)
WESTSIM MODEL REACH-12

TIME	UPSTRM (+)	TRIB (+)	.SW RTRN (+)	RUNOFF (+)	GW GAIN (+)	BYPASS (-)	DIVERSION (-)	STORAGE (-)	DWNSTRM (=)
1970	0	0	95812	6905	-7880	0	0	0	94837
1971	0	0	91836	24249	-28182	0	0	0	87903
1972	0	0	98615	3328	-35944	0	0	0	65999
1973	0	0	90227	61474	-50905	0	0	0	100795
1974	0	0	63217	18785	-43912	0	0	0	38090
1975	0	0	57077	23350	-45242	0	0	0	35185
1976	0	0	61311	3864	-41298	0	0	0	23877
1977	0	0	33934	1853	-27167	0	0	0	8620
1978	0	0	42934	63149	-44660	0	0	0	61424
1979	0	0	51815	25574	-41244	0	0	0	36145
1980	0	0	212949	26960	-46889	0	0	0	193020
1981	0	0	243592	12320	-43341	0	0	0	212571
1982	0	0	168632	35150	-41810	0	0	0	161972
1983	0	0	185452	73184	-44173	0	0	0	214463
1984	0	0	513624	13334	-42838	0	0	0	484120
1985	0	0	177966	10172	-37123	0	0	0	151016
1986	0	0	172396	35507	-35359	0	0	0	172544
1987	0	0	109143	15050	-33980	0	0	0	90213
1988	0	0	217290	14596	-35508	0	0	0	196377
1989	0	0	99411	9078	-29574	0	0	0	78915
1990	0	0	162856	5123	-29074	0	0	0	138905
1991	0	0	116027	12198	-29371	0	0	0	98854
1992	0	0	98246	21844	-31396	0	0	0	88694
1993	0	0	118343	59992	-32800	0	0	0	145536
AVG.	0	0	136779	24043	-36653	0	0	0	124170

STREAM BUDGET(AF)
WESTSIM MODEL REACH-13

TIME	UPSTRM (+)	TRIB (+)	SW RTRN (+)	RUNOFF (+)	GW GAIN (+)	BYPASS (-)	DIVERSION (-)	STORAGE (-)	DWNSTRM (=)
1970	837531	0	27192	871	35446	0	0	0	901041
1971	294981	0	148	2033	-16650	0	0	0	280511
1972	354075	0	12349	810	10483	0	0	0	377716
1973	871633	0	7975	6613	7633	0	0	0	893855
1974	468800	0	6995	3393	-13688	0	0	0	465501
1975	431863	0	10880	2790	-108	0	0	0	445425
1976	352983	0	9222	1156	7243	0	0	0	370603
1977	273466	0	5057	1543	-11929	0	0	0	268137
1978	1885026	0	12493	4652	7184	0	0	0	1909355
1979	390859	0	13395	3251	-8346	0	0	0	399159
1980	1829777	0	18523	3967	5338	0	0	0	1857605
1981	697298	0	31384	2001	4291	0	0	0	734974
1982	1465389	0	14155	5161	3565	0	0	0	1488270
1983	5142881	0	12757	9734	22153	0	0	0	5187525
1984	2237381	0	44363	2877	5422	0	0	0	2290044
1985	628391	0	13052	2340	-6819	0	0	0	636964
1986	2022279	0	16304	4728	1682	0	0	0	2044994
1987	517280	0	14723	1843	-8926	0	0	0	524919
1988	685690	0	22036	2806	12381	0	0	0	722913
1989	498545	0	11271	1896	-5540	0	0	0	506171
1990	552373	0	25309	1262	-9860	0	0	0	569084
1991	561842	0	9021	1545	2602	0	0	0	575010
1992	441495	0	11926	3820	-4940	0	0	0	452300
1993	726193	0	14926	8912	4875	0	0	0	754906
AVG.	1007001	0	15227	3334	1812	0	0	0	1027374

STREAM BUDGET(AF)
WESTSIM MODEL REACH-14

TIME	UPSTRM (+)	TRIB (+)	SW RTRN (+)	RUNOFF (+)	GW GAIN (+)	BYPASS (-)	DIVERSION (-)	STORAGE (-)	DWNSTRM (=)
1970	901041	488562	0	0	64285	0	14692	0	1439196
1971	280511	200620	0	0	-20006	0	14692	0	446434
1972	377716	253405	0	0	7374	0	14470	0	624025
1973	893855	237555	0	0	23763	0	12269	0	1142904
1974	465501	474712	0	0	7336	0	12231	0	935318
1975	445425	528468	0	0	-18494	0	12455	0	942944
1976	370603	226530	0	0	16197	0	13685	0	599645
1977	268137	64823	0	0	-9058	0	15555	0	308347
1978	1909355	550921	0	0	52648	0	9648	0	2503276
1979	399159	552537	0	0	-32137	0	12268	0	907291
1980	1857605	994751	0	0	-2559	0	12292	0	2837505
1981	734974	246088	0	0	5560	0	14844	0	971779
1982	1488270	998493	0	0	26482	0	11272	0	2501972
1983	5187525	2277454	0	0	66205	0	9574	0	7521610
1984	2290044	802045	0	0	7124	0	15713	0	3083500
1985	636964	299988	0	0	-2922	0	15222	0	918808
1986	2044994	624935	0	0	-16719	0	11322	0	2641888
1987	524919	159369	0	0	20351	0	13944	0	690695
1988	722914	110660	0	0	8923	0	13370	0	829127
1989	506171	99370	0	0	-5627	0	14958	0	584957
1990	569084	88708	0	0	-2283	0	15771	0	639738
1991	575010	73954	0	0	36040	0	16258	0	668747
1992	452300	104423	0	0	-7855	0	14752	0	534116
1993	754906	362670	0	0	-6531	0	15255	0	1095790
AVG.	1027374	450877	0	0	9087	0	13605	0	1473734

STREAM BUDGET(AF)
WESTSIM MODEL REACH-15

TIME	UPSTRM (+)	TRIB (+)	SW RTRN (+)	RUNOFF (+)	GW GAIN (+)	BYPASS (-)	DIVERSION (-)	STORAGE (-)	DWNSTRM (=)
1970	0	9350	10291	342	-4478	0	0	0	15505
1971	0	3536	12207	2358	-9596	0	0	0	8505
1972	0	0	13475	142	-5198	0	0	0	8419
1973	0	21237	6235	4304	-13109	0	0	0	18667
1974	0	10145	13376	2021	-14523	0	0	0	11019
1975	0	7287	9762	1353	-8903	0	0	0	9500
1976	0	0	14753	544	-6253	0	0	0	9045
1977	0	0	3330	717	-2167	0	0	0	1879
1978	0	30992	5150	2509	-12294	0	0	0	26356
1979	0	4017	7832	1469	-7117	0	0	0	6201
1980	0	39056	9764	1908	-15307	0	0	0	35421
1981	0	1003	10902	1337	-5355	0	0	0	7887
1982	0	29219	8297	3800	-16173	0	0	0	25143
1983	0	64917	6251	7412	-18598	0	0	0	59981
1984	0	6981	9910	1564	-6801	0	0	0	11654
1985	0	452	11872	1104	-4182	0	0	0	9247
1986	0	38313	8101	3197	-13473	0	0	0	36138
1987	0	419	8800	1108	-3801	0	0	0	6526
1988	0	0	11949	1764	-5154	0	0	0	8559
1989	0	0	7978	1135	-2475	0	0	0	6638
1990	0	0	5595	823	-1750	0	0	0	4668
1991	0	3646	4521	965	-2531	0	0	0	6601
1992	0	2338	4180	2309	-2336	0	0	0	6492
1993	0	32191	5973	5875	-15190	0	0	0	28849
AVG.	0	12712	8771	2086	-8198	0	0	0	15371

STREAM BUDGET(AF)
WESTSIM MODEL REACH-16

TIME	UPSTRM (+)	TRIB (+)	SW RTRN (+)	RUNOFF (+)	GW GAIN (+)	BYPASS (-)	DIVERSION (-)	STORAGE (-)	DWNSTRM (=)
1970	1454702	0	28532	1787	106654	0	50035	0	1541639
1971	454939	0	29572	8714	-3613	0	50035	0	439576
1972	632444	0	38542	968	54715	0	50035	0	676634
1973	1161571	0	22881	14462	39182	0	49874	0	1188222
1974	946337	0	37789	6015	47457	0	44131	0	993466
1975	952444	0	23585	4036	-22711	0	44131	0	913223
1976	608690	0	24625	1931	11291	0	32314	0	614223
1977	310226	0	19090	2305	-32120	0	59188	0	240314
1978	2529632	0	16061	10550	115607	0	34188	0	2637662
1979	913492	0	21388	6916	-53345	0	49862	0	838589
1980	2872926	0	20426	7648	81549	0	44131	0	2938418
1981	979665	0	27722	4519	24559	0	50035	0	986430
1982	2527115	0	46300	9192	-296	0	43417	0	2538894
1983	7581591	0	20609	21673	65205	0	21401	0	7667677
1984	3095153	0	49844	4930	26178	0	39500	0	3136604
1985	928055	0	43478	2810	-19437	0	39740	0	915166
1986	2678026	0	24174	9099	30589	0	23973	0	2717915
1987	697221	0	32606	3178	-7746	0	32314	0	692945
1988	837686	0	33902	4258	41929	0	30502	0	887273
1989	591595	0	36498	2643	25272	0	37937	0	618071
1990	644406	0	43094	2332	-12130	0	48046	0	629656
1991	675347	0	44826	2225	12796	0	53581	0	681613
1992	540608	0	42733	5718	-5748	0	52659	0	530652
1993	1124639	0	46440	19703	42305	0	52659	0	1180428
AVG.	1489105	0	32280	6567	23673	0	43070	0	1508554

STREAM BUDGET(AF)
WESTSIM MODEL REACH- 17

TIME	UPSTRM (+)	TRIB (+)	SW RTRN (+)	RUNOFF (+)	GW GAIN (+)	BYPASS (-)	DIVERSION (-)	STORAGE (-)	DWNSTRM (=)
1970	0	2929	0	0	525	0	0	0	3453
1971	0	1810	0	0	-1589	0	0	0	222
1972	0	188	0	0	977	0	0	0	1165
1973	0	8419	0	0	-3010	0	0	0	5409
1974	0	2879	0	0	192	0	0	0	3070
1975	0	3044	0	0	-485	0	0	0	2559
1976	0	100	0	0	999	0	0	0	1098
1977	0	10	0	0	-9	0	0	0	1
1978	0	8010	0	0	-1939	0	0	0	6070
1979	0	2173	0	0	260	0	0	0	2434
1980	0	10950	0	0	-2222	0	0	0	8728
1981	0	1006	0	0	2068	0	0	0	3074
1982	0	8806	0	0	-3738	0	0	0	5068
1983	0	33931	0	0	-7938	0	0	0	25993
1984	0	3937	0	0	1059	0	0	0	4996
1985	0	919	0	0	1176	0	0	0	2095
1986	0	11282	0	0	-3130	0	0	0	8152
1987	0	786	0	0	1290	0	0	0	2075
1988	0	412	0	0	1605	0	0	0	2017
1989	0	79	0	0	914	0	0	0	993
1990	0	631	0	0	434	0	0	0	1065
1991	0	1740	0	0	583	0	0	0	2324
1992	0	1856	0	0	-1449	0	0	0	407
1993	0	12813	0	0	-3885	0	0	0	8928
AVG.	0	4946	0	0	-721	0	0	0	4225

STREAM BUDGET(AF)
WESTSIM MODEL REACH-18

TIME	UPSTRM (+)	TRIB (+)	.SW RTRN (+)	RUNOFF (+)	GW GAIN (+)	BYPASS (-)	DIVERSION (-)	STORAGE (-)	DWNSTRM (=)
1970	1545092	0	3153	109	50289	0	52747	0	1545896
1971	439798	0	4479	1235	-4792	0	52747	0	387974
1972	677799	0	4864	88	50048	0	54252	0	678547
1973	1193631	0	3484	1802	2618	0	37208	0	1164327
1974	996537	0	3530	629	19907	0	46797	0	973806
1975	915782	0	2871	651	-11354	0	50100	0	857849
1976	615321	0	4843	197	42290	0	58013	0	604639
1977	240315	0	1398	239	-3684	0	42815	0	195454
1978	2643732	0	2045	1182	79476	0	41293	0	2685142
1979	841023	0	2565	723	-26137	0	35986	0	782189
1980	2947146	0	2820	903	3611	0	46797	0	2907683
1981	989504	0	3823	492	142	0	56050	0	937911
1982	2543963	0	3203	1444	78345	0	37865	0	2589090
1983	7693670	0	2006	2790	708	0	33307	0	7665867
1984	3141600	0	4090	626	-6352	0	57188	0	3082777
1985	917261	0	4369	408	24386	0	70118	0	876305
1986	2726067	0	2495	1242	-12481	0	45293	0	2672029
1987	695020	0	3205	400	649	0	55286	0	643989
1988	889290	0	2955	532	6478	0	57458	0	841797
1989	619064	0	3592	392	25496	0	64529	0	584016
1990	630721	0	2983	377	24711	0	64266	0	594526
1991	683937	0	2633	382	7436	0	63752	0	630636
1992	531059	0	2131	843	-7891	0	60230	0	465912
1993	1189357	0	1698	2642	19294	0	60230	0	1152761
AVG.	1512779	0	3135	847	15133	0	51847	0	1480047

STREAM BUDGET(AF)
WESTSIM MODEL REACH-19

TIME	UPSTRM (+)	TRIB (+)	SW RTRN (+)	RUNOFF (+)	GW GAIN (+)	BYPASS (-)	DIVERSION (-)	STORAGE (-)	DWNSTRM (=)
1970	1545896	969323	21112	1431	34090	0	33857	0	2537994
1971	387974	517198	20999	7761	2365	0	33857	0	902440
1972	678547	311174	24543	839	22948	0	34908	0	1003143
1973	1164327	380875	17906	14948	9536	0	30075	0	1557516
1974	973806	600042	23983	5286	18105	0	29003	0	1592220
1975	857849	908089	20663	4542	6339	0	29051	0	1768430
1976	604639	661207	36161	1946	2160	0	33691	0	1272422
1977	195454	153309	16170	1998	6741	0	36008	0	337664
1978	2685142	472865	15743	9987	43986	0	22355	0	3205367
1979	782189	950072	27006	7261	-20911	0	29026	0	1716591
1980	2907683	1775166	24516	6815	17918	0	29003	0	4703095
1981	937911	716911	28460	4922	9751	0	33905	0	1664050
1982	2589090	2003745	20564	12792	16282	0	28424	0	4614050
1983	7665867	3995223	19642	24346	22971	0	23034	0	11705016
1984	3082777	1683538	48730	5423	855	0	40180	0	4781143
1985	876305	592590	39252	3567	1275	0	35313	0	1477676
1986	2672029	1329047	30993	10737	15513	0	30536	0	4027784
1987	643989	525239	35841	3934	6582	0	33650	0	1181935
1988	841797	156397	30525	4526	15083	0	33961	0	1014366
1989	584016	133683	33488	3713	11353	0	34925	0	731328
1990	594526	156836	16293	3494	8204	0	37245	0	742109
1991	630636	152776	19779	4312	15420	0	37863	0	785059
1992	465912	152977	20651	7894	-7986	0	36234	0	603215
1993	1152761	355868	16938	22189	32539	0	35232	0	1545062
AVG.	1480047	818923	25415	7278	12130	0	32556	0	2311237

STREAM BUDGET(AF)
WESTSIM MODEL REACH- 20

TIME	UPSTRM (+)	TRIB (+)	SW RTRN (+)	RUNOFF (+)	GW GAIN (+)	BYPASS (-)	DIVERSION (-)	STORAGE (-)	DWNSTRM (=)
1970	2537994	892069	5153	418	24953	0	37770	0	3422817
1971	902440	548414	5017	2389	1288	0	37770	0	1421778
1972	1003143	284669	7042	215	7009	0	37133	0	1264946
1973	1557516	809408	4718	4821	2482	0	32592	0	2346354
1974	1592220	1048014	20556	1466	2385	0	33212	0	2631429
1975	1768430	765608	11468	1140	5381	0	33562	0	2518466
1976	1272422	187374	10790	613	1234	0	35046	0	1437388
1977	337664	32530	3187	856	3035	0	39588	0	337684
1978	3205367	922731	4120	3269	13253	0	25417	0	4123324
1979	1716591	515490	6027	1979	-2401	0	32175	0	2205511
1980	4703096	1201310	6846	2592	13720	0	33212	0	5894351
1981	1664050	282522	6411	1337	262	0	36988	0	1917594
1982	4614050	644626	7628	3828	11816	0	30587	0	5251361
1983	11705017	1851200	3720	8082	1930	0	21061	0	13548886
1984	4781143	1268384	7183	1606	22123	0	39395	0	6041045
1985	1477676	569957	6716	1232	1139	0	37917	0	2018802
1986	4027784	966613	6871	3724	-497	0	30192	0	4974304
1987	1181935	531757	7246	1340	5216	0	34804	0	1692690
1988	1014366	437107	6301	1448	5377	0	34168	0	1430431
1989	731328	449850	6459	1188	-863	0	36369	0	1151593
1990	742109	315138	6382	996	11679	0	39930	0	1036374
1991	785059	192221	3829	940	-3786	0	41197	0	937067
1992	603215	222528	2675	1965	-2068	0	41093	0	787222
1993	1545062	339482	5407	7979	14413	0	41093	0	1871250
AVG.	2311237	636625	6740	2309	5795	0	35095	0	2927612

STREAM BUDGET(AF)
WESTSIM MODEL REACH- 21

TIME	UPSTRM (+)	TRIB (+)	SW RTRN (+)	RUNOFF (+)	GW GAIN (+)	BYPASS (-)	DIVERSION (-)	STORAGE (-)	DWNSTRM (=)
1970	0	0	0	0	1	0	0	0	1
1971	0	0	0	0	0	0	0	0	0
1972	0	0	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0	0	0
1975	0	0	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0	0	0
1979	0	0	0	0	0	0	0	0	0
1980	0	0	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0	0	0
AVG.	0	0	0	0	0	0	0	0	0

STREAM BUDGET(AF)
WESTSIM MODEL REACH-22

TIME	UPSTRM (+)	TRIB (+)	SW RTRN (+)	RUNOFF (+)	GW GAIN (+)	BYPASS (-)	DIVERSION (-)	STORAGE (-)	DWNSTRM (=)
1970	0	0	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	0	0	0
1972	0	0	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0	0	0
1975	0	0	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0	0	0
1979	0	0	0	0	0	0	0	0	0
1980	0	0	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0	0	0
AVG.	0	0	0	0	0	0	0	0	0

STREAM BUDGET(AF)
WESTSIM MODEL REACH- 23

TIME	UPSTRM (+)	TRIB (+)	SW RTRN (+)	RUNOFF (+)	GW GAIN (+)	BYPASS (-)	DIVERSION (-)	STORAGE (-)	DWNSTRM (=)
1970	0	814	1807	382	-787	0	0	0	2217
1971	0	583	2619	457	-563	0	0	0	3095
1972	0	70	2182	183	-68	0	0	0	2368
1973	0	3147	1963	14260	-3002	0	0	0	16367
1974	0	915	2215	5328	-885	0	0	0	7574
1975	0	1243	2380	3162	-1206	0	0	0	5579
1976	0	79	2296	8363	-76	0	0	0	10661
1977	0	51	1888	328	-49	0	0	0	2218
1978	0	5278	1725	23879	-4854	0	0	0	26029
1979	0	1896	2035	2189	-1837	0	0	0	4283
1980	0	2983	2246	15693	-2871	0	0	0	18051
1981	0	683	2407	1510	-660	0	0	0	3940
1982	0	1154	2292	6259	-1115	0	0	0	8591
1983	0	13580	2230	16557	-9112	0	0	0	23255
1984	0	1504	2528	1066	-1451	0	0	0	3647
1985	0	139	2573	1989	-134	0	0	0	4567
1986	0	3525	2588	5723	-3239	0	0	0	8597
1987	0	479	1843	832	-463	0	0	0	2691
1988	0	321	2397	3190	-310	0	0	0	5598
1989	0	0	2332	446	0	0	0	0	2778
1990	0	141	2133	320	-136	0	0	0	2458
1991	0	1484	1757	14372	-1365	0	0	0	16248
1992	0	1278	1663	3832	-1239	0	0	0	5534
1993	0	7269	1744	6939	-6006	0	0	0	9947
AVG.	0	2026	2160	5719	-1726	0	0	0	8179

STREAM BUDGET(AF)
WESTSIM MODEL REACH-24

TIME	UPSTRM (+)	TRIB (+)	SW RTRN (+)	RUNOFF (+)	GW GAIN (+)	BYPASS (-)	DIVERSION (-)	STORAGE (-)	DWNSTRM (=)
1970	0	2747	69	194	-3005	0	0	0	4
1971	0	1751	66	231	-2043	0	0	0	5
1972	0	152	77	85	-311	0	0	0	2
1973	0	5426	63	2389	-7487	0	0	0	391
1974	0	2674	67	391	-3125	0	0	0	8
1975	0	1776	47	299	-2116	0	0	0	7
1976	0	91	48	437	-569	0	0	0	8
1977	0	501	59	154	-710	0	0	0	3
1978	0	28480	145	7272	-29492	0	0	0	6406
1979	0	3767	162	300	-4223	0	0	0	5
1980	0	6700	61	1807	-8309	0	0	0	260
1981	0	1122	52	199	-1371	0	0	0	4
1982	0	2291	70	351	-2706	0	0	0	6
1983	0	31481	71	2960	-32056	0	0	0	2456
1984	0	6239	109	119	-6465	0	0	0	2
1985	0	333	98	293	-719	0	0	0	5
1986	0	8515	75	594	-9168	0	0	0	15
1987	0	405	96	397	-891	0	0	0	6
1988	0	130	71	570	-765	0	0	0	7
1989	0	0	67	174	-238	0	0	0	3
1990	0	0	127	378	-362	0	0	0	143
1991	0	2032	105	1298	-3034	0	0	0	402
1992	0	1809	106	1859	-3122	0	0	0	652
1993	0	16751	107	4097	-19756	0	0	0	1199
AVG.	0	5216	84	1119	-5918	0	0	0	500

APPENDIX C : Lookup table to convert Julian day numbers to the day of year calendar. Note that during leap years 1 day is added to all dates after and including March 1.

ERROR CODES

3 Program Table full
4 Intermediate Storage full
5 Final Storage Area 2 not allocated
8 CR10X was reset by watch dog timer
9 Insufficient Input Storage
10 Low battery voltage
11 Attempt to allocate unavailable storage
12 Duplicate *4 ID
20 Subroutine encountered before END of previous subroutine
21 END without IF, LOOP, or SUBROUTINE
22 Missing END
23 Non-existent SUBROUTINE
24 ELSE in SUBROUTINE without IF
25 ELSE without IF
26 EXIT LOOP without LOOP
27 IF CASE without BEGIN CASE
30 IFs and/or LOOPS nested too deep
31 SUBROUTINES nested too deep
32 Instruction 3 and interrupt subroutine use same port
33 Cannot use control port 6 as counter with Instruction 15 or SDM
40 Instruction does not exist
41 Incorrect Execution Interval
60 Insufficient Input Storage
61 Burst Measurement Scan Rate too Short
62 N<2 in FFT

***D Mode Errors**
94 Program storage area full
95 Flash program does not exist
96 Addressed device not connected
97 Data not received within 30 seconds
98 Uncorrectable errors detected
99 Wrong file type or editor error

DAY OF YEAR CALENDAR

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
JAN	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
FEB	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60		
MAR	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90
APR	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	
MAY	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151
JUN	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	
JUL	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	209	210	211	212
AUG	213	214	215	216	217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241	242	243
SEP	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272	273	
OCT	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300	301	302	303	304
NOV	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320	321	322	323	324	325	326	327	328	329	330	331	332	333	334	
DEC	335	336	337	338	339	340	341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	358	359	360	361	362	363	364	365

Add 1 to unshaded values during leap years.

CAMPBELL SCIENTIFIC, INC.
815 W. 1800 N. • Logan, Utah 84321-1784 • (435) 753-2342 • FAX (435) 750-9540
Offices also located in: Australia • Brazil • Canada • England • France • South Africa

DSM2-Reach	Node	Description	RM	CDEC,USGS
	17	Current DSM2 Boundary		WQCB
601	601	Stanislaus River, MID #6, Modesto Main Canal	75	SJRIO
602	602	RM 76	76	LOCAL
603	603	El Soyo Main Canal, Sub-ELS, Hwy132 Bridge	77+	**REACH**
604	604	Maze Rd. Gage Station	78.5	**1**
605	605	Hospital/Ingram Creek, Sub-H/I	80	
606	606	MID #4, RM 81	81	
607	607	Finnegan Cut	83-	
608	608	Tuolumne River, MID #5	84-	
609	609	W. Stanislaus Main Canal	84	
610	610	Reclamation Dist. 2092 Drain #2	85+	
611	611	Reclamation Dist. 2092 Drain #3	86+	
612	612	Old Grayson Channel	87	**2**
613	613	Laird Slough	88	
614	614	Westley Wasteway	89	
615	615	TID #2	90+	
616	616	Richie Slough, Sub-RSL	91.5	
617	617	Del Puerto Creek	93-	
618	618	TID #3 (Westport) & Loquat Ave. Drains	93+	
619	619	Magnolia Ave. Drain	94+	
620	620	Modesto Sewage Outfall	95	
621	621	Eucalyptus & Lemon Ave. Drains	96	
622	622	Patterson Sewage Outfall & Olive Ave. Drains, ~Sub-PAT	97-	
623	623	Patterson Pumphouse/Main Canal	98-	**3**
624	624	Lake Ramona, Sub-RLK	99+	
625	625	Reclamation Dist. 1602 Overflow Drain	101+	
626	626	Paradise Ave. Slough & Gomes Lake Discharge Pumps	102+	
627	627	TID Lateral #5 Drain	103+	
628	628	Spanish Grant Drain	105	
629	629		106+	
630	630	Crows Landing Bridge	107.5	
631	631	Orestimba Creek	109+	
632	632		110+	
633	633	~TID #6&7, Alhem Tile & Reclamation Dist. 2063 Drains	112-	
634	634	Gonsalves Tailwater Drain	112.5	**4**
635	635	Villa Manucha & Freitas Rd. Drains	113+	
636	636		114+	
637	637	Allen Serpa Pumps and Drain	116-	
638	638	RM 117	117	
639	639	Merced River, TID Lower Stevinson	118+	
640	640	Newman Slough	119	**5**
641	641	Newman Wasteway& Orestimba Rancho Drain	119.5	
642	642	Mud Slough	121+	
643	643	RM 123	123	
644	644	Mud Slough	124+	**6**
645	645	Fremont Ford Bridge	125	
646	646	Stevinson Op. Spills #1 & #2	126-	
647	647	Stevinson Op. Spill #3	127-	
648	648	Salt Slough	129.5	
649	649		130+	
650	650		132-	**7**
651	651	Tail Water Drain	133-	
652	652	Field Drain	134-	
653	653	Bear Creek (CURRENT BOUNDARY)	136-	

Appendix D-2 : Relationship between WESTSIM stream nodes and San Joaquin River mile markers. WESTSIM stream node numbers range from 57 to 156 .

WESTSIM STREAM NODE #	ATLAS 84 RIV MILE	RAS STATION RIVER MILE		WESTSIM STREAM NODE #	ATLAS 84 RIV MILE	RAS STATION RIVER MILE	
57	205.2	203.5		107	140.2	138.0	
58	205.2	203.5		108	139.6	137.4	
59	204.4	202.7		109	137.0	134.8	
60	203.8	202.1		110	135.8	133.6	
61	202.0	200.2		111	135.8	133.6	
62	201.0	199.2		112	132.9	130.6	Stevinson
63	199.2	197.4		113	131.0	128.7	
64	197.3	195.5		114	128.6	126.3	Salt Slough
65	196.2	194.4		115	128.6	126.3	
66	195.0	193.2		116	126.5	124.2	
67	193.4	191.6		117	125.2	122.9	Fremont Ford
68	192.0	190.2		118	122.8	120.5	
69	191.3	189.5		119	119.8	117.4	
70	190.4	188.6		120	119.8	117.4	
71	189.1	187.3		121	118.8	116.4	
72	187.6	185.7		122	118.2	115.8	
73	186.2	184.3		123	118.2	115.8	Hills Ferry
74	185.5	183.6		124	116.0	113.6	
75	184.9	183.0		125	114.0	111.6	
76	183.8	181.9		126	111.2	108.8	
77	182.6	180.7		127	109.3	106.9	
78	181.4	179.5		128	109.3	106.9	
79	181.4	179.5		129	107.2	104.8	Crows Landing
80	179.9	178.0		130	105.2	102.7	
81	179.4	177.5		131	104.3	101.8	
82	178.2	176.3		132	103.0	100.5	
83	177.0	175.1		133	101.0	98.5	
84	175.2	173.2		134	99.8	97.3	
85	173.8	171.8	Highway 152	135	98.8	96.3	
86	172.6	170.6		136	97.5	95.0	
87	171.6	169.6		137	95.5	93.0	
88	170.4	168.4		138	94.0	91.5	
89	168.8	166.8		139	93.0	90.4	
90	167.3	165.3		140	93.0	90.4	
91	167.3	165.3		141	92.0	89.4	
92	165.5	163.5		142	89.0	86.4	
93	163.8	161.8		143	87.0	84.4	
94	162.5	160.5		144	86.5	83.9	
95	161.4	159.3		145	84.2	81.6	
96	159.6	157.5		146	83.8	81.2	Tuolumne
97	157.2	155.1		147	83.8	81.2	
98	156.3	154.2		148	80.8	78.2	
99	154.8	152.7		149	79.5	76.9	
100	151.8	149.7		150	77.0	74.3	
101	149.8	147.7		151	75.6	72.9	
102	148.0	145.9		152	74.9	72.2	Stanislaus
103	146.5	144.3		153	74.9	72.2	
104	143.8	141.6		154	72.5	69.8	Vernalis
105	142.4	140.2		155	71.5	68.8	
106	141.0	138.8		156	71.0	68.3	

Appendix D-3 : WESTSIM model input data file for stream reaches. Stream reaches are numbered relative to WESTSIM stream node numbers and are not the same reaches described in Appendix D-1. Note that Figures 38 and 39 refer to stream reaches 19 and 20.Reach 19 (Appendix D-3) is Reach 1 (Appendix D-1) located between the Tuolomne and Stanislaus Rivers and Reach 20 (Appendix D-3) is downstream of Vernalis and the current DSM-2 model.

```
C***************************************************************************
***
C
C        INTEGRATED GROUND AND SURFACE WATER MODEL  (IGSM)
C
C---------------------------------------------------------------------------
---
C
C                       STREAM GEOMETRY DATA FILE
C
C---------------------------------------------------------------------------
---
C
*              Project:  Westsim Model, US Bureau of Reclamation
*                        Western San Joaquin Valley,  California
*              Filename: ws_strm.dat 01/26 Los Banos Creek 5/15 Added
C                        Note: Los Banos Creek joins to SJ River in model to
avoid
C                             re-numbering stream nodes (N. Quinn)
C***************************************************************************
***
C                             File Description:
C
C   This data file contains all of the stream node and stream geometry data
C   used in the model. Each reach of a stream/river is listed by the stream
node
C   and corresponding  groundwater nodes. Also, a rating table  is listed for
C   each  stream node.
C***************************************************************************
***
C                       Number of Diversion and Stream Reaches
C
C   NR;  Number of stream reaches modeled
C   NRTB;  Number of data points in stream rating tables
C
C---------------------------------------------------------------------------
---
C   VALUE                     DESCRIPTION
C---------------------------------------------------------------------------
---
    24                        / NR
     7                        / NRTB
C***************************************************************************
***
C                          Stream reach descriptions
C
C   The following lists the stream nodes and corresponding groundwater
C   nodes for each stream reach modeled.
C
C   ID;    Reach number
C   IBUR;  First upstream stream node of reach
C   IBDR;  Last downstream node of reach
C   IDWN;  Stream node into which reach flows into
C
C   In addition, for each stream node within the reach the corresponding
C   groundwater node and subregion number is listed.
```

```
C
C   IRV;    Stream node
C   IGW;    Corresponding groundwater node
C   IRGST;  Corresponding subregion number
C
C---------------------------------------------------------------------------
---
C     REACH  1  -  FRESNO SLOUGH @ S.F. KINGS RIVER - STINSON WEIR
C   Reach  Upstream  Downstream  Outflow
C            Node       Node       Node
C   ID       IBUR       IBDR       IDWN
C---------------------------------------------------------------------------
---
     1        1          9         10
C---------------------------------------------------------------------------
---
C   Stream   Groundwater   Subregion
C   node       node        number
C   IRV        IGW         IRGST
C---------------------------------------------------------------------------
---
    1        2198         55
    2        2140         55
    3        2118         55
    4        2094         55
    5        2044         55
    6        2025         55
    7        1992         55
    8        1943         55
    9        1923         53
C---------------------------------------------------------------------------
---
C     REACH  2  -  FRESNO SLOUGH @ STINSON WEIR>JAMES BYPASS - FRESNO SLOUGH
C   Reach  Upstream  Downstream  Outflow
C            Node       Node       Node
C   ID       IBUR       IBDR       IDWN
C---------------------------------------------------------------------------
---
     2       10         32         48
C---------------------------------------------------------------------------
---
C   Stream   Groundwater   Subregion
C   node       node        number
C   IRV        IGW         IRGST
C---------------------------------------------------------------------------
---
    10       1923         53
    11       1895         53
    12       1856         53
    13       1834         53
    14       1807         53
    15       1787         53
    16       1766         53
    17       1734         53
    18       1722         53
    19       1703         53
    20       1669         52
    21       1661         52
    22       1640         52
    23       1612         52
    24       1598         52
    25       1578         52
    26       1557         52
    27       1538         52
    28       1519         52
    29       1495         52
    30       1481         52
    31       1452         52
```

```
    32       1451         51
C----------------------------------------------------------------------
---
C     REACH  3  -  FRESNO SLOUGH - JAMES BYPASS
C    Reach  Upstream  Downstream  Outflow
C             Node       Node       Node
C    ID       IBUR       IBDR       IDWN
C----------------------------------------------------------------------
---
     3        33          47         48
C----------------------------------------------------------------------
---
C    Stream  Groundwater  Subregion
C    node       node      number
C    IRV        IGW       IRGST
C----------------------------------------------------------------------
---
     33       1745        53
     34       1720        53
     35       1701        53
     36       1668        53
     37       1658        53
     38       1623        53
     39       1609        52
     40       1594        52
     41       1575        52
     42       1553        52
     43       1535        52
     44       1518        52
     45       1494        52
     46       1480        52
     47       1451        51
C----------------------------------------------------------------------
---
C     REACH  4  -  FRESNO SLOUGH - SJ RIVER
C    Reach  Upstream  Downstream  Outflow
C             Node       Node       Node
C    ID       IBUR       IBDR       IDWN
C----------------------------------------------------------------------
---
     4        48          57         58
C----------------------------------------------------------------------
---
C    Stream  Groundwater  Subregion
C    node       node      number
C    IRV        IGW       IRGST
C----------------------------------------------------------------------
---
     48       1451        51
     49       1439        50
     50       1420        48
     51       1401        48
     52       1380        48
     53       1347        48
     54       1339        47
     55       1325        47
     56       1305        47
     57       1279        47
C----------------------------------------------------------------------
---
C     REACH  5  -  SJ RIVER - SACK DAM
C    Reach  Upstream  Downstream  Outflow
C             Node       Node       Node
C    ID       IBUR       IBDR       IDWN
C----------------------------------------------------------------------
---
     5        58          78         79
C----------------------------------------------------------------------
```

```
---
C   Stream   Groundwater   Subregion
C   node       node        number
C   IRV        IGW         IRGST
C-----------------------------------------------------------------------------
---
    58        1279          47
    59        1265          32
    60        1245          32
    61        1233          32
    62        1222          32
    63        1202          32
    64        1181          32
    65        1158          32
    66        1128          32
    67        1117          32
    68        1104          32
    69        1105          32
    70        1085          32
    71        1086          32
    72        1066          32
    73        1027          32
    74        1012          32
    75        1013          32
    76        1001          32
    77        982           32
    78        961           32
C-----------------------------------------------------------------------------
---
C     REACH   6   - SJR SACK DAM - SAND SLOUGH CNTRL
C    Reach  Upstream  Downstream  Outflow
C             Node       Node       Node
C    ID       IBUR       IBDR       IDWN
C-----------------------------------------------------------------------------
---
      6        79         90         91
C-----------------------------------------------------------------------------
---
C   Stream   Groundwater   Subregion
C   node       node        number
C   IRV        IGW         IRGST
C-----------------------------------------------------------------------------
---
    79        961           32
    80        940           32
    81        941           32
    82        921           32
    83        902           32
    84        883           32
    85        864           32
    86        842           32
    87        826           32
    88        807           32
    89        783           32
    90        769           32
C-----------------------------------------------------------------------------
---
C     REACH   7   -   SJR @ SAND SLOUGH - BEAR CREEK
C    Reach  Upstream  Downstream  Outflow
C             Node       Node       Node
C    ID       IBUR       IBDR       IDWN
C-----------------------------------------------------------------------------
---
      7        91         110        111
C-----------------------------------------------------------------------------
---
C   Stream   Groundwater   Subregion
C   node       node        number
```

```
C   IRV        IGW          IRGST
C-----------------------------------------------------------------------------
---
    91       769          24
    92       741          24
    93       729          24
    94       708          24
    95       689          24
    96       669          24
    97       668          24
    98       639          24
    99       633          24
    100      615          24
    101      598          24
    102      573          23
    103      561          23
    104      530          23
    105      520          23
    106      502          23
    107      474          20
    108      475          20
    109      467          20
    110      449          20
C-----------------------------------------------------------------------------
---
C     REACH  8  -  SJR @ BEAR CK - SALT SLOUGH
C   Reach  Upstream  Downstream  Outflow
C            Node       Node      Node
C   ID       IBUR       IBDR      IDWN
C-----------------------------------------------------------------------------
---
     8        111         114        115
C-----------------------------------------------------------------------------
---
C   Stream  Groundwater  Subregion
C   node      node       number
C   IRV       IGW        IRGST
C-----------------------------------------------------------------------------
---
    111      449          20
    112      432          20
    113      416          20
    114      388          20
C-----------------------------------------------------------------------------
---
C     REACH  9 -  SALT SLOUGH - SJR
C   Reach  Upstream  Downstream  Outflow
C            Node       Node      Node
C   ID       IBUR       IBDR      IDWN
C-----------------------------------------------------------------------------
---
     9        157         173        115
C-----------------------------------------------------------------------------
---
C   Stream  Groundwater  Subregion
C   node      node       number
C   IRV       IGW        IRGST
C-----------------------------------------------------------------------------
---
    157      667          24
    158      652          24
    159      627          24
    160      626          24
    161      613          24
    162      596          24
    163      579          24
    164      559          23
    165      528          23
```

```
    166        518          20
    167        501          23
    168        485          20
    169        465          20
    170        435          20
    171        425          20
    172        415          20
    173        388          20
C-----------------------------------------------------------------------------
---
C      REACH 10   -   SJR @ SALT SLOUGH - SJR @ MUD SLOUGH
C    Reach  Upstream  Downstream  Outflow
C             Node       Node       Node
C    ID       IBUR       IBDR       IDWN
C-----------------------------------------------------------------------------
---
      10      115        119        120
C-----------------------------------------------------------------------------
---
C    Stream   Groundwater   Subregion
C    node       node          number
C    IRV        IGW           IRGST
C-----------------------------------------------------------------------------
---
    115        388          19
    116        383          19
    117        373          14
    118        353          14
    119        347          14
C-----------------------------------------------------------------------------
---
C      REACH  11 -  MUD SLOUGH - SJR
C    Reach  Upstream  Downstream  Outflow
C             Node       Node       Node
C    ID       IBUR       IBDR       IDWN
C-----------------------------------------------------------------------------
---
      11       174       185        120
C-----------------------------------------------------------------------------
---
C    Stream   Groundwater   Subregion
C    node       node          number
C    IRV        IGW           IRGST
C-----------------------------------------------------------------------------
---
    174        498          21
    175        484          21
    176        462          21
    177        434          21
    178        423          21
    179        424          21
    180        413          21
    181        399          19
    182        382          19
    183        372          19
    184        361          14
    185        347          14
C-----------------------------------------------------------------------------
---
C      REACH  12 -  LOS BANOS CREEK TO SJ RIVER
C    Reach  Upstream  Downstream  Outflow
C             Node       Node       Node
C    ID       IBUR       IBDR       IDWN
C-----------------------------------------------------------------------------
---
      12       252       278        120
C-----------------------------------------------------------------------------
---
```

```
C   Stream   Groundwater   Subregion
C   node       node         number
C   IRV        IGW          IRGST
C-----------------------------------------------------------------------------
---
    252        654          33
    253        670          33
    254        655          33
    255        656          33
    256        644          33
    257        620          12
    258        621          12
    259        605          12
    260        606          12
    261        592          12
    262        567          12
    263        553          21
    264        538          21
    265        514          21
    266        515          21
    267        496          21
    268        471          21
    269        460          21
    270        444          21
    271        422          21
    272        411          21
    273        387          21
    274        381          14
    275        371          14
    276        360          14
    277        346          14
    278        347          14
C-----------------------------------------------------------------------------
---
C      REACH  13 -   SJR @ MUD SLOUGH - SJR @ MERCED R
C    Reach  Upstream  Downstream  Outflow
C             Node        Node       Node
C    ID       IBUR        IBDR       IDWN
C-----------------------------------------------------------------------------
---
     13        120         122        123
C-----------------------------------------------------------------------------
---
C   Stream   Groundwater   Subregion
C   node       node         number
C   IRV        IGW          IRGST
C-----------------------------------------------------------------------------
---
    120        347          14
    121        337          14
    122        323          14
C-----------------------------------------------------------------------------
---
C      REACH  14 -   SJR @ MERCED - ORESTIMBA CREEK                TUOLUMNE R
C    Reach  Upstream  Downstream  Outflow
C             Node        Node       Node
C    ID       IBUR        IBDR       IDWN
C-----------------------------------------------------------------------------
---
     14        123         127        128
C-----------------------------------------------------------------------------
---
C   Stream   Groundwater   Subregion
C   node       node         number
C   IRV        IGW          IRGST
C-----------------------------------------------------------------------------
---
    123        323          14
```

```
    124     317          14
    125     307          14
    126     294          14
    127     287          14
C-----------------------------------------------------------------------
---
C     REACH  15 -  ORESTIMBA CREEK - SJ RIVER
C    Reach  Upstream  Downstream  Outflow
C           Node       Node       Node
C    ID     IBUR       IBDR       IDWN
C-----------------------------------------------------------------------
---
     15       234        244       128
C-----------------------------------------------------------------------
---
C    Stream  Groundwater  Subregion
C    node       node      number
C    IRV        IGW       IRGST
C-----------------------------------------------------------------------
---
     234       295         13
     235       288         13
     236       289         13
     237       296         15
     238       290         15
     239       291         12
     240       283         12
     241       284         12
     242       285         12
     243       286         12
     244       287         14
C-----------------------------------------------------------------------
---
C     REACH  16 -  SJR @ ORESTIMBA CREEK-DEL PUERTO CREEK
C    Reach  Upstream  Downstream  Outflow
C           Node       Node       Node
C    ID     IBUR       IBDR       IDWN
C-----------------------------------------------------------------------
---
     16       128        139       140
C-----------------------------------------------------------------------
---
C    Stream  Groundwater  Subregion
C    node       node      number
C    IRV        IGW       IRGST
C-----------------------------------------------------------------------
---
     128     287         14
     129     276         14
     130     263         12
     131     257         10
     132     249         10
     133     238         10
     134     232         10
     135     225         10
     136     218         10
     137     211         10
     138     204         10
     139     196         10
C-----------------------------------------------------------------------
---
C     REACH  17 - DEL PUERTO CREEK - SJ RIVER   TUOLUMNE R
C    Reach  Upstream  Downstream  Outflow
C           Node       Node       Node
C    ID     IBUR       IBDR       IDWN
C-----------------------------------------------------------------------
---
     17       245        251       140
```

```
C-----------------------------------------------------------------------
---
C   Stream   Groundwater   Subregion
C   node       node        number
C   IRV        IGW         IRGST
C-----------------------------------------------------------------------
---
     245        197          11
     246        191          11
     247        202           7
     248        203           7
     249        194          10
     250        195          10
     251        196          10
C-----------------------------------------------------------------------
---
C     REACH  18 -  SJR @ DEL PUERTO CREEK - TUOLUMNE R
C   Reach  Upstream  Downstream  Outflow
C            Node       Node       Node
C   ID       IBUR       IBDR       IDWN
C-----------------------------------------------------------------------
---
     18        140         146      147
C-----------------------------------------------------------------------
---
C   Stream   Groundwater   Subregion
C   node       node        number
C   IRV        IGW         IRGST
C-----------------------------------------------------------------------
---
    140      196          8
    141      186          8
    142      183          8
    143      177          5
    144      164          5
    145      158          5
    146      153          5
C-----------------------------------------------------------------------
---
C     REACH  19 -  SJR @ TUOL - STANISLAUS R
C   Reach  Upstream  Downstream  Outflow
C            Node       Node       Node
C   ID       IBUR       IBDR       IDWN
C-----------------------------------------------------------------------
---
     19        147         152      153
C-----------------------------------------------------------------------
---
C   Stream   Groundwater   Subregion
C   node       node        number
C   IRV        IGW         IRGST
C-----------------------------------------------------------------------
---
    147      153          5
    148      145          5
    149      136          5
    150      128          5
    151      120          5
    152      112          5
C-----------------------------------------------------------------------
---
C     REACH  20 -  SJR @ STANISLAUS R - OUT
C   Reach  Upstream  Downstream  Outflow
C            Node       Node       Node
C   ID       IBUR       IBDR       IDWN
C-----------------------------------------------------------------------
---
     20        153         156        0
```

```
C-----------------------------------------------------------------------
---
C    Stream   Groundwater   Subregion
C    node       node        number
C    IRV        IGW         IRGST
C-----------------------------------------------------------------------
---
     153      112          5
     154      102          5
     155      103          5
     156      95           5
C-----------------------------------------------------------------------
---
C      REACH  21 -  LITTLE PANOCHE CREEK
C    Reach  Upstream  Downstream  Outflow
C             Node        Node       Node
C    ID       IBUR        IBDR       IDWN
C-----------------------------------------------------------------------
---
      21        186       192          0
C-----------------------------------------------------------------------
---
C    Stream   Groundwater   Subregion
C    node       node        number
C    IRV        IGW         IRGST
C-----------------------------------------------------------------------
---
    186        1002         36
    187        984          36
    188        985          36
    189        986          36
    190        987          37
    191        988          37
    192        1019         37
C-----------------------------------------------------------------------
---
C      REACH  22 -  PANOCHE CREEK
C    Reach  Upstream  Downstream  Outflow
C             Node        Node       Node
C    ID       IBUR        IBDR       IDWN
C-----------------------------------------------------------------------
---
      22        193       205          0
C-----------------------------------------------------------------------
---
C    Stream   Groundwater   Subregion
C    node       node        number
C    IRV        IGW         IRGST
C-----------------------------------------------------------------------
---
     193       1234         49
     194       1235         49
     195       1224         49
     196       1236         49
     197       1237         49
     198       1225         49
     199       1238         49
     200       1209         49
     201       1223         49
     202       1210         46
     203       1211         46
     204       1212         46
     205       1213         46
C-----------------------------------------------------------------------
---
C      REACH  23 -  CANTUNA CREEK
C    Reach  Upstream  Downstream  Outflow
C             Node        Node       Node
```

```
C   ID        IBUR        IBDR        IDWN
C-------------------------------------------------------------------------
---
     23        206        212          0
C-------------------------------------------------------------------------
---
C   Stream  Groundwater  Subregion
C   node       node       number
C   IRV        IGW        IRGST
C-------------------------------------------------------------------------
---
    206       1641         49
    207       1642         49
    208       1643         49
    209       1672         49
    210       1673         49
    211       1663         49
    212       1674         49
C-------------------------------------------------------------------------
---
C     REACH  24 -  LOS GATOS CREEK
C   Reach  Upstream  Downstream  Outflow
C            Node       Node       Node
C   ID       IBUR       IBDR       IDWN
C-------------------------------------------------------------------------
---
     24        213        233          0
C-------------------------------------------------------------------------
---
C   Stream  Groundwater  Subregion
C   node       node       number
C   IRV        IGW        IRGST
C-------------------------------------------------------------------------
---
    213       1874         56
    214       1897         56
    215       1945         56
    216       1965         56
    217       1997         56
    218       2048         61
    219       2065         61
    220       2120         61
    221       2130         61
    222       2146         61
    223       2173         61
    224       2174         61
    225       2175         49
    226       2230         49
    227       2248         49
    228       2249         49
    229       2231         49
    230       2209         49
    231       2210         49
    232       2232         49
    233       2211         49
```

San Joaquin River Index
Water Year Hydrologic Classification

Water Year	Unimpaired Runoff (1,000 A.F.) April - July	Oct. - Mar.	0.2x PYI*	Index	Classification	
1970					Above Normal	
1971					Below Normal	
1972					Dry	
1973					Above Normal	
1974					Wet	
1975					Wet	
1976					Critical	
1977					Critical	
1978					Wet	
1979					Above Normal	
1980					Wet	
1981					Dry	
1982					Wet	
1983					Wet	
1984					Above Normal	
1985					Dry	
1986					Wet	
1987					Critical	
1988					Critical	
1989					Critical	
1990				1,514	Critical	
1991	2,360	553	303	1,829	Critical	
1992	1,870	855	366	1,659	Critical	
1993	5,560	2,495	332	4,167	Wet	Regional Board says AN
1994	1,830	665	833	2,064	Critical	
1995	7,450	3,665	413	5,616	Wet	
1996	4,440	2,570	900	4,078	Wet	
1997	3,930	5,715	816	4,317	Wet	
1998	5,820	2,825	863	4,920	Wet	
1999	3,550	1,900	900	3,410	Above Normal	
2000	December 1, 1999 Estimate 75% Exceedence			2,200	Dry	
2000	January 1, 2000 Estimate 75% Exceedence			1,800	Critical	
2000	January 18, 2000 Estimate 75% Exceedence			1,900	Critical	
2000	February 1, 2000 Estimate 75% Exceedence			2,300	Dry	
2000	February 15, 2000 Estimate 75% Exceedence			2,600	Below Normal	
2000	March 1, 2000 Estimate 75% Exceedence			3,300	Above Normal	
2000	April 1, 2000 Estimate 75% Exceedence			3,100	Below Normal	
2000	May 1, 2000 Estimate 90% Exceedence			3,430	Above Normal	
2000	May 9, 2000 Estimate 90% Exceedence			3,570	Above Normal	

* - A cap of 4.5 MAF is placed on the previous years index to account for required flood control reservoir releases during wet years. (Changed from .9 to 4.5 per CDEC)

The San Joaquin River Index includes the Stanislaus, Tuolumne, Merced, and San Joaquin Rivers.

Index Classification Runoff (1000 af)	
0 to </=2100	Critical
>2100 to </=2500	Dry
>2500 to </=3100	Below Normal
>3100 to <3800	Above Normal
>/= 3800	Wet

Forecast Available: http://cdec.water.ca.gov/cgi-progs/iodir/WSI

Source: McGahan, written comm., 2000; WYINDEX.WB2, Regional Board 1994.

APPENDIX F : **Property information for potential appropriative and riparian diverters on the East side of the San Joaquin River.**

Appendix F

Riparian Properties on Eastside of San Joaquin River

1/15/02

River Mile	APN	Acres	Land Use	County	Owner	Latitude 37 deg./min.	Longitude 121 deg./min.
39.70	145-020-04	162.28	NT	SJ	Stockton Port District	57.10	20.00
39.90	145-020-13			SJ	Joan Devon Brown Tr	57.00	20.20
40.00	145-020-07	9.32	NT	SJ	Stockton Port District	56.80	20.20
40.10	145-020-14		NT	SJ	Stockton Port District	56.80	20.30
40.30	145-020-08	107.18	NT	SJ	Stockton Port District	56.70	20.40
41.20	145-030-09	247.37	NT	SJ	Stockton Port District	56.30	20.10
41.30	163-330-01		NT	SJ	BNSF RR	56.20	20.00
41.30	163-330-02	8.65	NT	SJ	BNSF RR	56.20	20.00
41.60	163-330-03	46.68	NT	SJ	City of Stockton	56.10	19.70
41.80	163-340-09	27.56		SJ	Heitman Holdings	56.00	19.60
42.00	163-340-10	0.00		SJ	Heitman Holdings	55.80	19.60
42.20	163-020-33	5.91	NT	SJ	City of Stockton Econ Dev	55.70	19.50
42.80	163-070-35	77.72		SJ	Forward Inc.	55.30	19.20
42.80	163-070-36	192.71	NT	SJ	City of Stockton Golf	55.30	19.20
43.10	164-020-01	84.00		SJ	Kristin McFall et al	55.10	19.20
43.20	164-020-03	36.08		SJ	Kristin McFall et al	55.00	19.20
43.40	164-060-65	2.45		SJ	LBL L-Suncal Western LLC	54.90	19.30
43.50	164-040-49	0.00		SJ	LBL L-Suncal Western LLC	54.80	19.40
43.70	164-030-03	54.54		SJ	Pleasant Valley Investments	54.70	19.50
44.00	166-340-54	0.00	NT	SJ	City of Stockton	54.40	19.30
44.20	166-030-23	29.44		SJ	Home Builders Inc	54.20	19.40
44.30	166-030-05	43.66	A	SJ	Fumiko Asano	54.10	19.50
44.40	166-030-28	60.48		SJ	Schuler Homes of CA	54.00	19.50
44.80	166-020-01	106.95	A	SJ	William Long et al	53.80	19.60
45.20	166-020-05	178.25	A	SJ	Marguerite Calcagno	53.50	19.60
45.50	166-020-04	337.25	A	SJ	Marguerite Calcagno	53.30	19.80
45.70	191-300-01	32.90	A	SJ	Melvin Young	53.20	19.80
45.90	191-300-18	81.27	A	SJ	Raymond Calcagno et al	52.90	19.90
46.20	191-300-17	1.51	NT	SJ	San Joaquin County	52.80	19.90
46.30	191-300-16	73.06		SJ	William Long et al	52.70	19.90
47.00	191-290-01	362.78	A	SJ	Albert R. Muller	52.20	19.70
47.30	191-280-23	75.93	A	SJ	Cecil Rodgers et ux	52.00	19.60
47.40	191-280-22	2.86	A	SJ	Cecil Rodgers et ux	51.90	19.50
47.50	191-280-26	5.10		SJ	Dale Johnson et ux	51.90	19.40
47.60	191-280-16	1.60		SJ	Velma Jacopetti	51.80	19.30
47.65	191-280-15	0.70		SJ	Clinton Marshal et al	51.80	19.30
47.70	191-280-25	8.38		SJ	Pete Paulsen et ux	51.80	19.20
47.70	191-280-29	43.33		SJ	Clinton Marshall et al	51.80	19.20
47.70	191-280-13	1.45		SJ	Jerry Power et ux	51.80	19.20
48.00	191-280-11	40.49		SJ	Norma Quattrin et al	51.70	19.00
48.30	191-280-10	49.49	A	SJ	Rio Blanco Ranch	51.40	19.10
48.60	191-270-01	98.50		SJ	Larry Matlock et ux	51.20	19.20

Subtotal 2,697.83

River Mile	APN	Acres	Land Use	County	Owner	Latitude 37 deg./min.	Longitude 121 deg./min.
48.60	191-270-12	10.00		SJ	Harvey Lawrence et al	51.20	19.20
48.70	191-270-13	108.00	A	SJ	Harvey Lawrence et al	51.20	19.40
49.20	191-270-10	21.65		SJ	Jimmy Robinson	50.80	19.40
49.40	191-270-21	93.39	A	SJ	Monte McFall	50.70	19.20
50.20	191-220-04	99.10	A	SJ	Alice Widmer	50.30	18.90
50.40	191-220-06	15.20		SJ	Genoveva Leal	50.10	18.80
50.50	191-220-41	0.50	NT	SJ	San Joaquin County	50.00	18.70
50.50	191-220-22	5.00		SJ	S & F Aurelio et al	50.00	18.70
50.60	191-220-21	9.00	NT	SJ	State of Calif.	49.90	18.60
50.80	191-220-47	11.77		SJ	Carroll Stanley et al	49.80	18.60
51.20	191-210-04	130.01	A	SJ	Michael Robinson	49.50	18.60
51.60	191-210-05	272.27	A	SJ	Michael Robinson	49.30	19.00
52.30	191-200-01	231.83		SJ	Barbara Terry et al	49.00	18.80
52.50	191-200-02	39.41	A	SJ	J W Silveira et ux	48.90	19.00
53.50	191-190-01	190.59	A	SJ	J W Silveira	48.50	19.50
54.40	191-190-02	84.55		SJ	Barbara Terry et al	48.20	18.70
54.60	191-190-06	50.00		SJ	Mildred Tholke et al	48.00	18.70
54.70	191-190-03	5.79		SJ	Joel Tinker	47.90	18.70
54.80	191-190-05	20.49		SJ	Thomas Osborn et ux	47.80	18.70
54.80	191-190-16	10.35		SJ	Willaim Darden et ux	47.80	18.70
55.30	241-020-01	10.27		SJ	Lathrop Assoc.	47.70	18.50
55.40	241-020-09	26.31		SJ	Marie Vallentyne	47.80	18.40
55.45	241-020-08	0.25		SJ	LOF Glass Inc	47.70	18.30
55.70	241-020-22	30.21		SJ	Angie Queirolo	47.50	18.30
56.00	241-020-33	13.16		SJ	Anthony Queirolo et ux	47.40	18.40
56.10	241-020-34	3.39		SJ	Anthony Queirolo et ux	47.30	18.40
56.20	241-020-17	4.80	NT	SJ	San Joaquin County	47.20	18.30
56.40	241-020-11	62.70		SJ	Crossroads Crea Investors, Met. Life Ins. Co	47.00	18.20
56.80	241-030-03	161.42		SJ	Roorda & Cowart Farms	46.80	18.00
56.90	241-020-09	154.00		SJ	Vernalis Partners Ltd	46.70	18.00
57.00	241-030-10	117.66		SJ	Vernalis Partners Ltd	46.70	17.90
57.10	241-040-14	24.03		SJ	Vernalis Partners	46.60	18.00
57.30	241-040-13	34.00		SJ	National American Corp, Two River Resort	46.50	18.20
57.50	241-040-09	68.19	A	SJ	Mizuno Farms	46.30	18.10
58.50	241-060-02	304.21	A	SJ	Mizuno Farms	45.70	17.80
59.50	241-060-01	76.00		SJ	Mizuno Farms	45.80	18.40
60.60	241-070-01	417.31	A	SJ	Denis Babson et ux	45.10	18.10
61.30	241-070-03	18.60	A	SJ	Johnnie Ray Cardoza et al	45.00	17.50
61.40	241-070-06	60.06	A	SJ	Johnnie Ray Cardoza et al	44.90	17.50
61.70	241-080-06	138.77	A	SJ	Alexander Hildebrand	44.70	17.30
61.80	241-080-07	49.60	A	SJ	Mizuno Farms	44.60	17.20
61.90	241-080-04	138.36	A	SJ	Mizuno Farms	44.00	17.50
62.20	241-080-05	215.73		SJ	Eddy Jo Cardoza et al	44.40	17.80
62.70	241-090-02	105.70	A	SJ	Anthony Dutra	43.90	17.70

River Mile	APN	Acres	Land Use	County	Owner	Latitude 37 deg./min.	Longitude 121 deg./min.
63.20	241-090-06	91.09		SJ	Dutra Farms	43.60	17.90
	Subtotal	3,734.72					
63.30	241-090-08	14.00	NT	SJ	South Delta WD	43.50	17.80
63.40	241-090-07	4.50	NT	SJ	Banta Carbona ID	43.50	17.70
64.10	241-100-01	60.50	A	SJ	Dutra Farms	43.00	17.40
64.20	241-100-05	7.23	A	SJ	Dutra Farms	42.40	16.20
65.00	241-100-04	115.15	NT	SJ	Calif DFG	42.50	16.70
65.20	241-100-03	84.41	A	SJ	Dutra Farms	42.60	16.50
65.60	241-100-02	101.36	A	SJ	Dutra Farms	42.80	16.50
65.80	241-090-05	74.80	A	SJ	Dutra Farms	43.10	16.60
66.20	241-350-25	12.93		SJ	Paul Coit	43.20	16.30
67.00	241-360-03	360.62	A	SJ	Cardoza Home Ranch	43.20	15.60
68.10	241-200-11	26.28	NT	SJ	Recl. Dist. 2064	47.60	18.70
68.20	241-200-01	58.50		SJ	Eddy Cardoza et al	42.30	16.30
68.30	241-200-02	5.74		SJ	Eddy Cardoza et al	42.20	16.40
68.50	241-200-03	224.84	A	SJ	H. Stanley Mortensen et al	42.50	16.20
68.60	241-200-10	8.22	NT	SJ	Recl. Dist 2064	42.20	16.30
68.70	241-200-08	13.77	NT	SJ	Sac/SJ DD	42.10	16.40
68.80	241-190-02	1.62	NT	SJ	Sac/SJ DD	42.00	16.40
68.80	241-190-01	2.01	NT	SJ	Sac/SJ DD	42.00	16.40
68.90	241-190-03	15.22	NT	SJ	San Joaquin City Office Ed.	41.80	16.30
69.50	241-180-09	0.24	NT	SJ	Sac/SJ DD	41.40	16.20
69.60	241-180-13	1.80	NT	SJ	Sac/SJ DD	41.30	16.30
69.70	241-140-01	12.32		SJ	Bernice Riney	41.30	16.40
70.00	241-140-02	17.83	NT	SJ	San Joaquin County	41.10	16.50
70.10	241-140-05	0.00		SJ	Louis Shank et al	41.00	16.40
70.50	241-180-15	81.75	NT	SJ	San Joaquin City Off Ed	41.20	16.10
70.80	241-180-16	76.17	NT	SJ	San Joaquin City Off Ed	41.40	15.80
71.10	241-180-06	128.25	A	SJ	Donald Moretti	41.20	15.60
71.20	241-370-13	13.91		SJ	George Vierra	41.20	15.50
71.20	241-180-14	2.04	NT	SJ	Sac/SJ DD	41.20	15.50
71.20	241-370-01	6.24	NT	SJ	San Joaquin City Off Ed	41.20	15.50
71.30	241-370-12	8.11		SJ	George Vierra	41.10	15.40
71.30	241-370-15	30.64	NT	SJ	Sac/SJ DD	41.10	15.40
71.50	241-370-06	44.53		SJ	William Meagher et al	41.00	15.40
71.50	241-370-09	26.02	NT	SJ	Recl. Dist 2064	41.00	15.40
71.80	241-370-07	12.55		SJ	Manteca Sportsmen	40.90	15.70
72.40	257-070-18	2.02	NT	SJ	Sac/SJ DD	40.50	15.80
72.50	257-070-20	281.44	A	SJ	RJM Enterprises	40.40	15.70
73.40	257-070-21	12.88	NT	SJ	Sac/SJ DD	39.90	15.10
74.30	257-070-19	116.06	A	SJ	RJM Enterprises	40.40	14.60
74.50	257-090-13	5.00		SJ	Raymond Kamenichy	40.20	14.50
74.50	257-070-14	38.71	A	SJ	RJM Enterprises	40.20	14.50
74.60	257-090-22	31.08		SJ	Leroy Bernardo et ux	40.20	14.50
74.65	257-090-24	8.85	NT	SJ	River Junction Recl. Dist.	40.10	14.50

74.70	257-090-12	33.30		SJ	Leroy Bernardo et ux	40.00	14.50
74.80	257-090-19	1.65	NT	SJ	Sac/SJ DD	40.00	14.50
	Subtotal	2,185.09					

River Mile	APN	Acres	Land Use	County	Owner	Latitude 37 deg./min.	Longitude 121 deg./min.
74.80	257-090-11	8.35		SJ	George Turkmany	40.00	14.50
74.90	257-090-09	4.94		SJ	George Turkmany	39.90	14.40
76.50	12-45-03	1,383.97		Stan	Robert Gallo	39.00	13.50
77.00	12-45-04	61.13	NT	Stan	USA	38.70	13.50
77.70	12-45-05	66.19		Stan		38.30	13.30
78.30	12-46-01	4.20	NT	Stan	Hetch Hetchy Water/Power	38.20	12.90
78.50	12-46-02	122.40	NT	Stan	USA	38.00	12.80
80.10	12-45-06	10.70		Stan		0.00	0.00
80.70	12-46-18	27.87		Stan	Old Fishermans Club	38.20	11.40
81.40	12-46-19	65.88	NT	Stan	USA	0.00	0.00
83.20	12-46-17	144.67	NT	Stan	USA	0.00	0.00
	Subtotal	1,900.30					
	Total	10,517.94					

APPENDIX G : **Property information for potential appropriative and riparian diverters on the East side of the San Joaquin River.**

Appendix G
Riparian Properties on Westside of San Joaquin River

1/15/02

River Mile	APN	Acres	Land Use	County	Owner	Latitude 37 deg./min.	Longitude 121 deg./min.
39.30	162-030-03	8.46		SJ	Monte Vista Weber Bus. Park	57.2	20.5
40.20	162-030-01	1,351.03	NT	SJ	USA	56.7	20.4
41.50	162-140-01	504.59	NT	SJ	City of Stockton	56.5	20.3
42.20	162-150-01	1.99		SJ	Mario & Alison Jacques	55.7	19.6
42.40	162-150-02	67.88	A	SJ	Mabel Moitoso	0	0.0
42.60	162-150-03	46.10	A	SJ	Lindley Lehmann et ux	55.4	19.3
42.80	162-150-04	4.87	A	SJ	John Braas	55.3	19.1
42.90	162-150-07	23.45	A	SJ	Henry Muller	55.2	19.1
43.00	162-150-08	23.96	A	SJ	Henry Muller	55.1	19.1
43.30	162-150-10	7.24		SJ	Willard Collins	55	19.3
43.40	162-150-11	22.25		SJ	Willard Collins	55.1	19.4
43.70	162-160-01	125.84	A	SJ	Theodore Witt	54.6	19.5
43.90	162-160-02	16.02		SJ	Frederick Witt	54.4	19.5
44.20	162-160-04	31.00	A	SJ	Judith Balcao	54.3	19.5
44.50	162-160-03	60.00	A	SJ	Daniel Roza	54	19.6
44.60	162-110-07	59.56	A	SJ	Daniel Roza	53.9	19.6
44.80	162-110-09	35.76		SJ	Dante Nomellini	53.8	19.7
45.00	162-110-08	139.25	A	SJ	R G Ohm & B J Cotrs	53.6	19.7
45.30	162-100-01	103.23	A	SJ	R G Ohm & B J Cotrs	53.4	19.8
45.70	162-100-03	167.56		SJ	Thelma Saunders	53.2	19.8
46.10	191-110-04	50.61	A	SJ	Glenn Saunders	52.8	19.9
46.20	191-120-09	101.83	A	SJ	P G Ohm & R Vada	52.7	19.9
46.30	191-120-05	35.83	A	SJ	Ivan Cerri et al	52.7	19.8
46.40	191-120-06	35.93	A	SJ	Ivan Cerri et al	52.6	19.9
46.70	191-120-07	53.00		SJ	Ivan Cerri et al	52.4	19.9
47.30	191-140-01	251.90	A	SJ	Robinson Family	51.9	19.6
47.50	191-140-02	5.00		SJ		51.9	19.4
47.60	191-140-03	5.11		SJ		51.8	19.3
48.20	191-140-04	340.00	A	SJ	I N Robinson Jr	51.5	19.0
48.80	191-150-03	260.00	A	SJ	Ruth Axlund	51.2	19.3
49.50	191-150-04	166.00	A	SJ	RS Costa et al	50.7	19.2
49.80	191-150-05	99.08	A	SJ	R S Costa et al	50.5	19.1
50.00	191-160-02	173.00	A	SJ	Arnold Strecher et ux	50.3	19.0
50.30	191-160-03	205.00	A	SJ	Lynn Miller	50	18.8
50.50	191-170-03	187.28	A	SJ	Bernard Damele et al	49.9	18.7
50.70	191-170-07	54.78	A	SJ	Bernard Damele et al	49.8	18.6
51.50	191-180-03	70.05	A	SJ	J Braas et al	49.3	18.9
53.00	191-180-02	427.59		SJ	Jacquelyn Cordes et al	48.7	19.2
53.50	213-240-04	108.18	A	SJ	Califia LLC	48.5	19.5
53.50	213-240--01	70.77	A	SJ	Califia LLC	48.5	19.5
53.80	213-240-03	77.44	A	SJ	Califia LLC	48.4	19.2
53.80	213-240-02	193.08	A	SJ	Califia LLC	48.4	19.2
	Subtotal	5,771.50					

River Mile	APN	Acres	Land Use	County	Owner	Latitude 37 deg./min.	Longitude 121 deg./min.
54.50	213-310-01	354.84	A	SJ	Califia LLC	48	18.7
56.00	241-110-01	102.89	A	SJ	Mary Alegre	47.3	17.9
56.40	239-020-01	3.27		SJ	Mossdale Mobile Home Park	47	18.2
56.80	239-030-01	159.32		SJ	Mossdale Assoc PTP	46.8	18.0
57.50	239-030-05	10.00		SJ	Gail Hystad	46.3	18.2
57.70	239-030-09	92.30	A	SJ	Frank Alegre et ux	46.2	18.1
58.50	239-240-02	132.11		SJ	Mizuno Farms	45.6	17.8
59.00	239-240-01	36.72		SJ	Mizuno Farms	46.1	18.3
59.30	239-040-07	137.00		SJ	Thomas Pishos et al	46	18.5
59.50	239-040-02	2.78		SJ	Paradise Mutual Water Co.	45.8	18.5
60.30	239-130-03	616.91	A	SJ	Main Stone Corp (Pierre Perret)	45.3	18.3
60.60	239-140-05	598.40	A	SJ	Main Stone Corp (Pierre Perret)	45.1	18.2
61.00	239-140-06	63.90	A	SJ	John Eagle III et ux	45.1	17.8
61.80	239-140-03	49.20		SJ	John Eagle III et ux	44.6	17.5
62.10	239-140-04	71.60		SJ	Stephen Pellegri & Sons	44.4	17.7
62.30	239-160-09	102.40		SJ	Mary Silva et al	44.3	17.8
62.40	239-160-10	8.32	NT	SJ	Sac/SJ DD	44.2	17.8
62.50	239-160-11	17.80	NT	SJ	New Jerusalem DD	44.1	17.7
62.60	239-160-12	48.10		SJ	Maria Campass	44	17.7
63.20	239-160-18	209.64	A	SJ	Dorothy Applin et al	43.6	17.9
63.40	239-230-03	230.12	A	SJ	Union Safe Bank	43.5	17.7
63.60	239-230-06	9.25	NT	SJ	Banta Carbona ID	43.4	17.5
63.70	239-230-05	2.56	NT	SJ	Sac/SJ DD	43.3	17.5
64.50	241-380-02	444.68	A	SJ	Fred Douma et ux	42.8	17.0
66.00	241-380-08	32.10		SJ	SJ Open Space Fmld Tr, c/o Neumiller & I	43.2	16.4
66.50	241-380-07	318.80		SJ	F C Alegre et ux	43.3	16.0
68.20	241-380-05	23.20	NT	SJ	Sacramento/San Joaquin Drainage District	42.4	16.2
69.00	241-380-04	574.65	A	SJ	Marion McLeod et al	41.8	16.3
70.00	241-150-01	411.96		SJ	San Joaquin River Club	41	16.5
72.40	241-160-02	13.77		SJ	Amelia Fisk	40.5	15.8
72.50	241-160-04	27.63		SJ	Chemanoor Zachariah	40.4	15.7
72.90	241-170-06	66.26	A	SJ	William Ohm et ux	40.3	15.4
73.20	241-170-07	66.15	A	SJ	Steven Ohm et ux	40.1	15.2
73.50	241-170-08	66.37	A	SJ	Martin Fisk et al	39.9	15.0
74.00	241-170-03	86.00		AJ	Coddington Family	40.2	14.7
77.20	42372	919.32		Stan	William McCombs	39.1	13.9
77.30	42615	0.00		Stan	James Lopez	38.9	13.7
77.40	42634	156.80		Stan	Nasca Valley Inc.	38.8	13.7
78.30	13774	276.45	NT	Stan	USA	38.2	12.9
79.20	14504	363.50	NT	Stan	USA	37.7	12.7
80.50	12-46-03	776.70		Stan	J M Equip	38.3	11.6
83.00	42652	1,736.00	NT	Stan	USA	0	0.0
	Subtotal	9,419.77					
	Total	15,191.27					

APPENDIX H

Accuracy, operation and maintenance of Continuous Chlorophyll and Turbidity Sensors (SCUFA)

H.1 Objective

At the conclusion of the 2001 CALFED was anticipated that a more comprehensive watershed monitoring program addressing upstream algal would rely on continuous sensors rather than on weekly or monthly grab samples. In the fall of 2001 Peggy Lehman reported on the availability of a new instrument from Turner Designs Inc. named SCUFA, which provided the capability of continuous measurements of either chlorophyll-a or rhodamine, a built-in datalogger and a submersible battery pack allowing autonomous deployment. Until this innovation from Turner Designs Inc. the company offered a flow-through cell which attached to the 10-AU-005-CE Field Fluorometer. Although the 10AU is a rugged, field-portable instrument it is bulky and expensive – approximately $12,000 with standard options. The SCUFA is less than 50% of the price and offers the same optical sensor as the field instrument. The first objective of this series of experiments was to gain experience with the maintenance and deployment of these instruments and to test their accuracy against standard analytical techniques for chlorophyll-*a* analysis. The sensors were deployed near the inlet and outlet of the San Luis Drain (at stations approximately 26 miles apart). The second objective was to quantify changes in chlorophyll-*a* concentrations between these stations and from these data estimate algae growth rates.

H.2.1 Laboratory Methods

The SCUFA units were calibrated against chlorophyll-*a* concentrations in the laboratory. The method for chlorophyll extraction and quantification was adapted from Standard Methods 10200H by Jeremy Hanlon at LBNL :

2.1.1 Materials needed:

1. Vacuum filtration apparatus to hold 47mm GF/F Whatman glass fiber filters
2. Saturated magnesium carbonate and water solution in squirt bottle
3. Filter forceps (tweezers)
4. Containers (Plastic screw top Falcon vial) for holding and freezing filters
5. Freezer
6. Chilled water bath
7. Tissue grinder (Wheaton pt#358009) 15ml with modified Teflon pestle (see note below)
8. Variable speed hand drill with 3/8” chuck
9. Extraction solution: 90% acetone 10% sat. magnesium carbonate in water solution (in squirt bottle)

10. Graduated 15ml glass centrifuge tubes with caps
11. Benchtop centrifuge
12. Spectrophotometer (Perkin-Elmer UV-Vis) and two 1cm quartz cuvettes
13. 0.1N HCl
14. Pipettes for 1ml and 33 mls

2.1.2 Method: Filtration

1. Dim lights in work area or otherwise keep samples out of light
2. Place GF/F filters on support with the irregularly textured surface up and assemble apparatus
3. Resuspend sample in collection container by shaking before pouring into filter apparatus
4. Quantify volume filtered and try to get at least 500ml through (may take 10-30 minutes) keep filtration apparatus covered from dust and light.
5. Rinse down sides of apparatus with small amount of magnesium carbonate solution (stir before using to resuspend powder)
6. Remove filter from apparatus with forceps and place in labeled container, place container in freezer immediately

2.1.3 Method: Extraction

1. Pre-chill all glassware etc. which will come into contact with sample extract
2. Remove the filter from freezer tear into several pieces (using clean, gloved hands) and place in chilled tissue grinder, add 2 to 3 ml of acetone extraction solution
3. Place the chilled, modified Teflon pestle in the drill chuck , tighten with chuck key
4. Maintain cold temperature while grinding filter in the bottom of tube at top drill speed until no discernable pieces of filter remain. MAKE SURE TUBE DOES NOT BECOME WARM. If grinder starts to become warm; STOP! Place entire apparatus back into chilled water bath to re-cool.
5. Transfer the filter pulp to graduated centrifuge tube and rinse grinder with additional acetone solution into the centrifuge tube. The total volume in centrifuge tube after rinsings should be between 9 and 11 ml with 10 ml being the goal
6. Place capped and labeled centrifuge tube in refrigerator to steep for at least 4 hours but not more than 24 hours
7. After steeping, centrifuge filter extract using bench-top centrifuge at speed setting #4 for 15 to 20 minutes. It is helpful to chill the tube holders before centrifuging to help maintain cold temperature
8. After centrifuging, remove tubes and use foil covers to protect chlorophyll extract from light while at the spectrophotometer.

2.1.4 Method: spectrophotometric determination of chlorophyll content

1. Turn on the Perkin-Elmer spectrophotometer and start UVWinlab software from desktop icon
2. Choose the CHLAPPTN.MWP Method
3. Fill in sample list, first one being "blank" second one being the sample and third being the sample with acid (ie 1.blank 2.MDS 3.MDSacid) repeat sample and sample with acid for each extract to be analyzed
4. Using acetone extraction solution as a blank in both the front and rear cuvettes start the program method and click "OK" when prompted to enter the blank sample
5. Cover the top of rear cuvette with parafilm to avoid evaporation during analysis
6. Rinse front cuvette with sample extract once then pipette 1ml of extract and click "OK"
7. When prompted to place next sample in holder, remove cuvette and pipette in 33mls of 0.1N HCl, cover with parafilm and invert several times to mix
8. Place the cuvette back into spectrophotometer and wait 90 seconds before clicking the "OK" button
9. When prompted, remove the cuvette and rinse with DI water, shake out excess water and repeat steps 6 and 7 for remaining samples
10. Print out results and tape into a notebook
11. Clean both quartz cuvettes and turn off the spectrophotometer.

In the experimental protocol the teflon pestle should be modified to work with glass fiber filters. This requires that the radius of the pestle must be reduced to allow more room between it and the wall of the grinding tube. Sand paper should be used while spinning the pestle in the drill and a small amount of the Teflon material should be gently removed. Grinding was made much easier by adding light spiral grooves in the pestle with a file..

H 2.1 Field and Laboratory Methods

Field samples were collected in 1 liter glass Wheaton media bottles at various sample points in the Grasslands Basin on July 25, 2002 and were immediately put on ice and transported to the Lab. Upon arrival the samples were held at 4 degrees Celsius before starting the analyses. Sample chlorophyll-a and turbidity were measured in the lab using the SCUFA (Turner Designs) instrument using the flow-through cap provided with the unit and a peristaltic pump, using the protocol described in the instrument manual. For the chlorophyll extraction, the Standard Methods 10200H protocol was followed using Whatman GF/F filters and a 90% saturated magnesium carbonate acetone solution. The extracted chlorophyll-a was read in 1 cm quartz cuvettes on a Perkin Elmer UV/Vis spectrophotometer. Total organic carbon (TOC) analysis was performed using an Apollo 9000HS (Tekmar/Dorhman) on 30 ml samples in VOA vials while a stir bar provided constant agitation to the solution.

Calibration of the SCUFA unit was performed in the laboratory using algae grown in a small aquarium in water derived from the San Luis Drain. This was necessary in order to obtain the range of algae concentrations needed to develop a full calibration curve. The algal sample was transferred into a sample cup into which the SCUFA probe was inserted. Care was taken to exclude direct incident light. Serial dilutions were made of the algal sample to create a series of algal concentrations with which to compare the SCUFA readings.

H 2.2 Calibration Results

The data obtained from the calibration experiment is presented in Figure H2(a). The SCUFA units exhibits a linear response with a low error. The R^2 value for the regression of SCUFA fluorescence units and chlorophyll-a is 0.9972. On the basis of this strong correlation an experiment was designed to deploy the SCUFA units in the San Luis Drain.

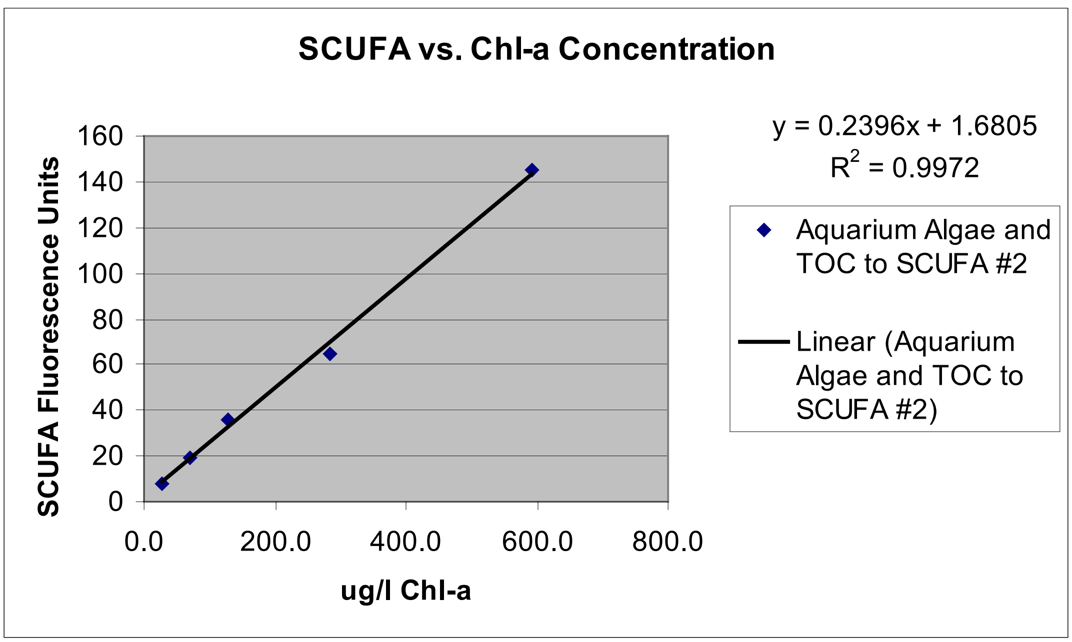


Figure H2(a) : SCUFA reading and chlorophyll-a concentration for a laboratory algae sample.

A second experiment was carried out to develop a relationship between total organic carbon concentration and chlorophyll concentration. Since algae cells have a high concentration of carbon it is expected that the correlation will be high between these parameters. The regression coefficient for the linear relationship between TOC and chlorophyll-a is 0.9935.

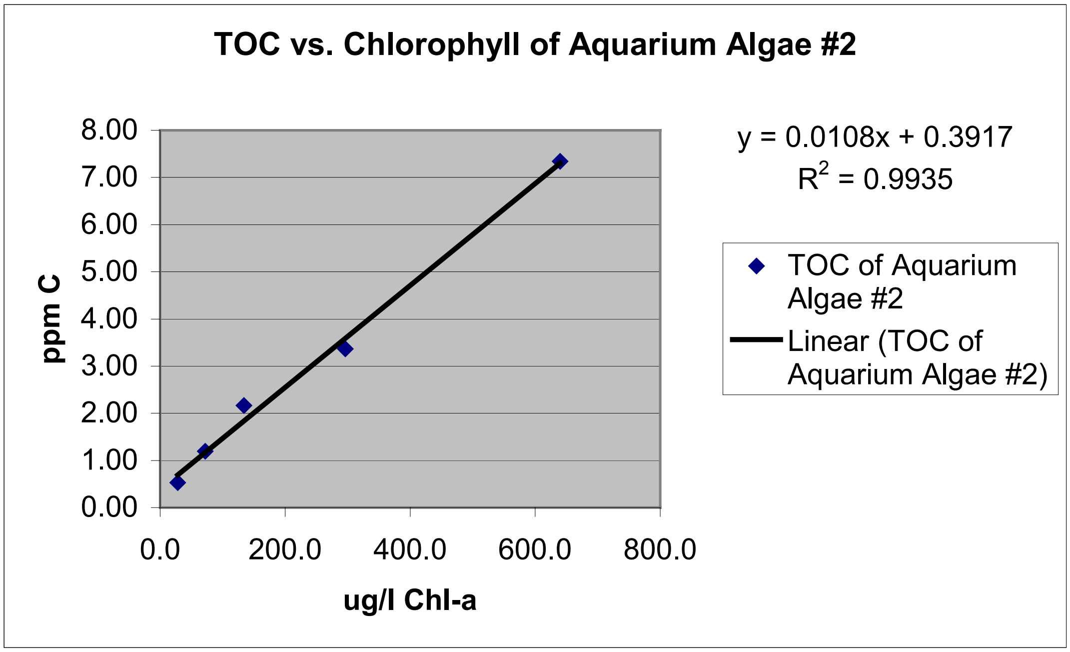


Figure H2(b) : Total organic carbon and chlorophyll-a concentration for a laboratory algae sample.

H 3.1 SCUFA Deployment

The SCUFA sondes were equipped with optional detachable batteries and internal data loggers to allow the instruments to be deployed autonomously. Attention to the connectors used to secure the detachable battery pack to the sonde showed them to be both insecure and prone to vandalism. Since each battery pack costs over $1,000 – loss of the battery pack is a significant cost together with the opportunity cost of the lost data. A secure housing was designed to eliminate this design-flaw and to make the instruments more secure in their deployment. The housing was constructed of ½ inch fiberglass tubing, cut to a length to leave three inches of the sonde body and the probe sensor housing protruding. A brass rod was machined and drilled to form a locking bolt which was inserted though a drilled hole in the fiberglass housing and the top flange on the sonde to secure the sonde in place. The gap between the sonde body and the internal diameter of the housing is less than ¾ inch – allowing no opportunity for a vandal to disconnect the sonde and battery pack.

The sondes were suspended on stout chains from bridges at upstream (Site A) and downstream (Site B) locations (Figure 4.1.b), along the San Luis Drain. The stability and the reliability of the fluorescent measurements recorded on the sondes were evaluated over a three month period. The SCUFA sondes successfully logged chlorophyll data for two weeks between maintenance visits. If the maintenance schedule was extended to longer than two weeks, sensor fouling proceeded rapidly resulting in signal degradation. The sensor maintained calibration against a chlorophyll-*a* standard for the entire three month test period, checked in the field using a solid calibration standard.

(a) SCUFA disassembled

(b) SCUFA in protective housing

Figure H3.1: Self-Contained Underwater Fluorescence Apparatus (SCUFA) shown disassembled (a) and assembled in protective housing (b). SCUFA sondes can be deployed independently or integrated into existing continuous flow monitoring infrastructure.

Data from a typical two-week deployment is presented in Figure H3.2. The data show that chlorophyll-*a* concentrations can vary by a factor of greater than two within a short time (hours) at Site B, but that Site A had less variability. This study illustrates that information collected with SCUFA sondes can help fill data gaps concerning the magnitude and frequency of algal blooms.

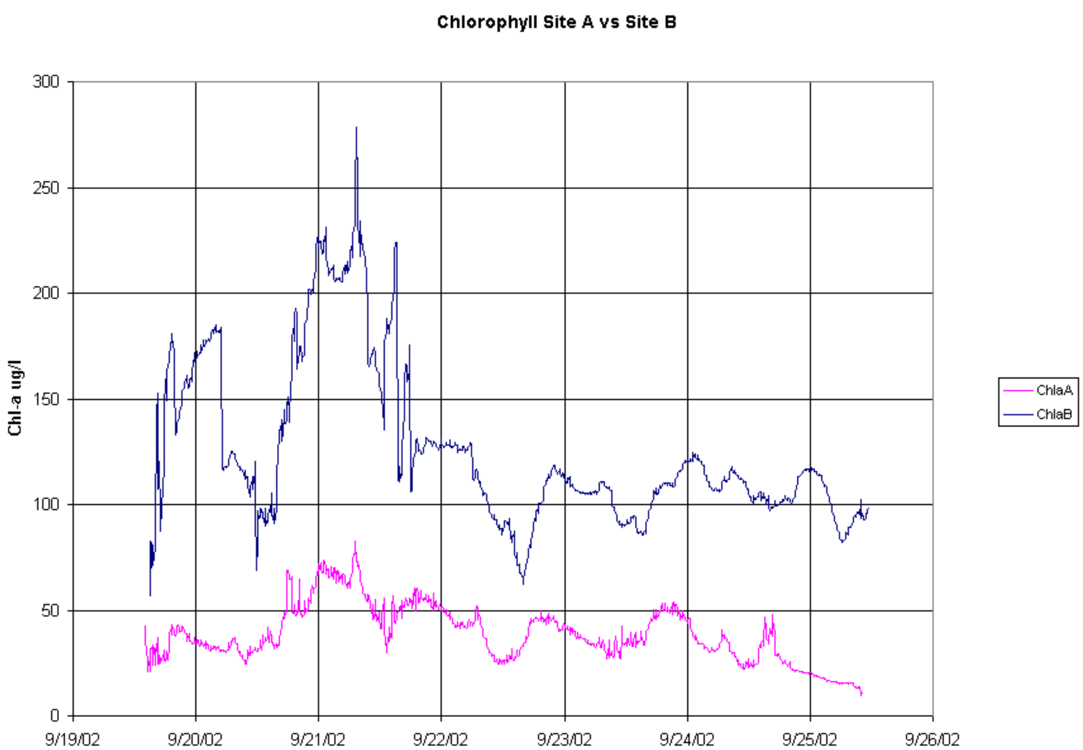
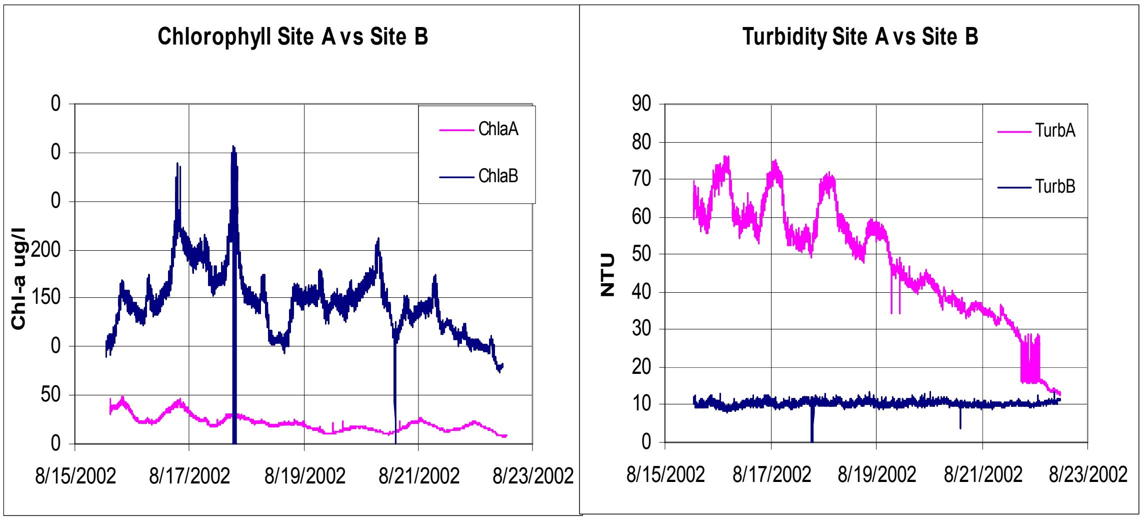


Figure H3.2 : Example of data from a two-week experimental deployment of a SCUFA sonde at the entrance and exit of the San Luis Drain. The data shows that algal chlorophyll concentration increases in the drain and that chlorophyll-a concentration can change significantly over short periods of time.

The next two sets of graphs plot chlorophyll-a and turbidity at Sites A and B for an earlier period between August 15, 2002 and August 23, 2002. Figure H3.3 shows a similar chlorophyll-a concentration increase between Sites A and B to that in Figure H3.2 – in which the chlorophyll-a concentration more than doubles along the 28 miles of channel. Figure H3.4 shows one of the factors that contributes to this increase which is a decrease in turbidity. Water that enter the drain at Site A contains a moderate sediment load as a result of the unlined earthern ditches the water flows through in transit to the San Luis Drain. Once in the San Luis Drain, the velocity diminishes as the flow cross-section expands and the flow gradient diminishes. The Drain cross-section increases again at about Check 19 further slowing flow velocity. Stokian sediment settling, which occurs as the drain water passes between Check structures, results in a decrease in drain sediment turbidity. As sediment settles out of the water column - light penetration increases resulting in greater potential algae growth per unit length of the drain channel. In Figure H3.4 the turbidity decreases dramatically after August 19 at Site A – however no corresponding increase shows up in the chlorophyll concentration at Site A in Figure H3.3. This would suggest that turbidity decreases due to sediment settling is a more important factor than any increase in turbidity due to enhanced algal growth at Site A.

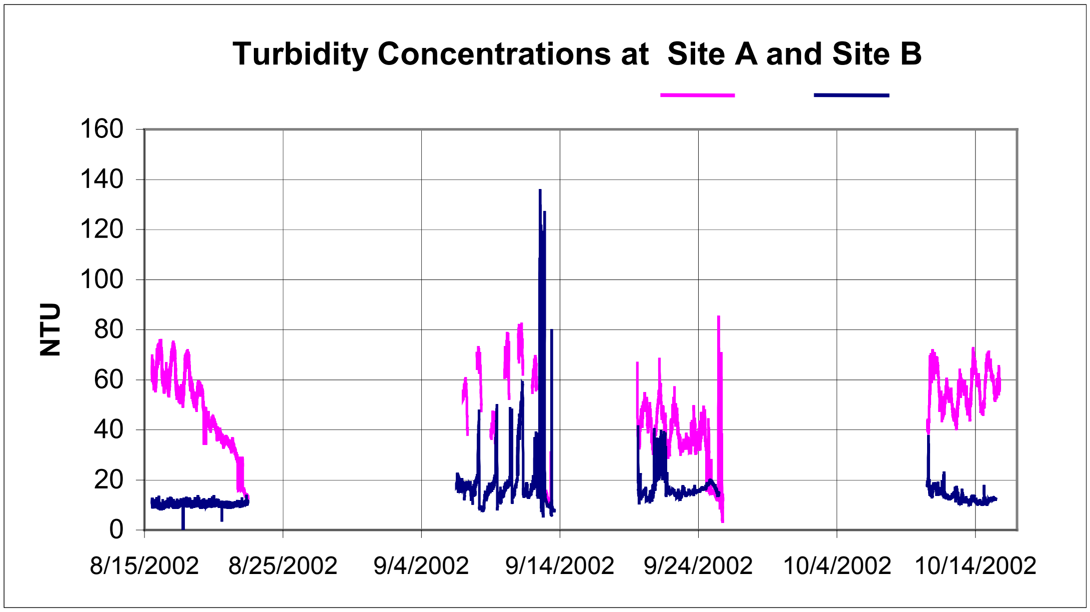


Figures H3.3 and H3.4. Comparison of Chlorophyll-a and turbidity concentrations at Sites A and B on the San Luis Drain.

The step decline in turbidity concentration shown in Figure H3.4 appears to somewhat of an anomaly. In Figure H3.5 a longer time series plot is shown for all the deployments of the SCUFA sonde in the San Luis Drain. Turbidity concentrations are shown to be quite variable and appear to show a similar range of high and low turbidity values during the period of deployment. Sediment fluctuations in the influent drain water at Site A is likely a result of various ditch cleaning operations within the Grasslands agricultural sub-Basin.

H 4. Analysis of diurnal trends in algal production

Given the apparent increase in algal biomass over the 1.5 to 3 day travel time (a function of flow) within the San Luis Drain, a question was raised as to whether a diurnal signal could be recognized in the time series data. If it is assumed that the Drain acts like a plug flow reactor with minimal horizontal dispersion and mixing the hypothesis can be advanced that photosynthetic diurnal growth in the Drain would show maximum concentrations during the mid-day to late afternoon period and minimum concentrations during the night. To test this hypothesis graphically, a plot has been made of chlorophyll-a concentration over time for a period between August 15 and August 20, 2002m indicating the noon to 6:00 p.m. time period which might be associated with periods of maximum algal growth.



Figures H3.5 Chlorophyll-a and turbidity concentrations at Sites A and B on the San Luis Drain for various deployments during 2002.

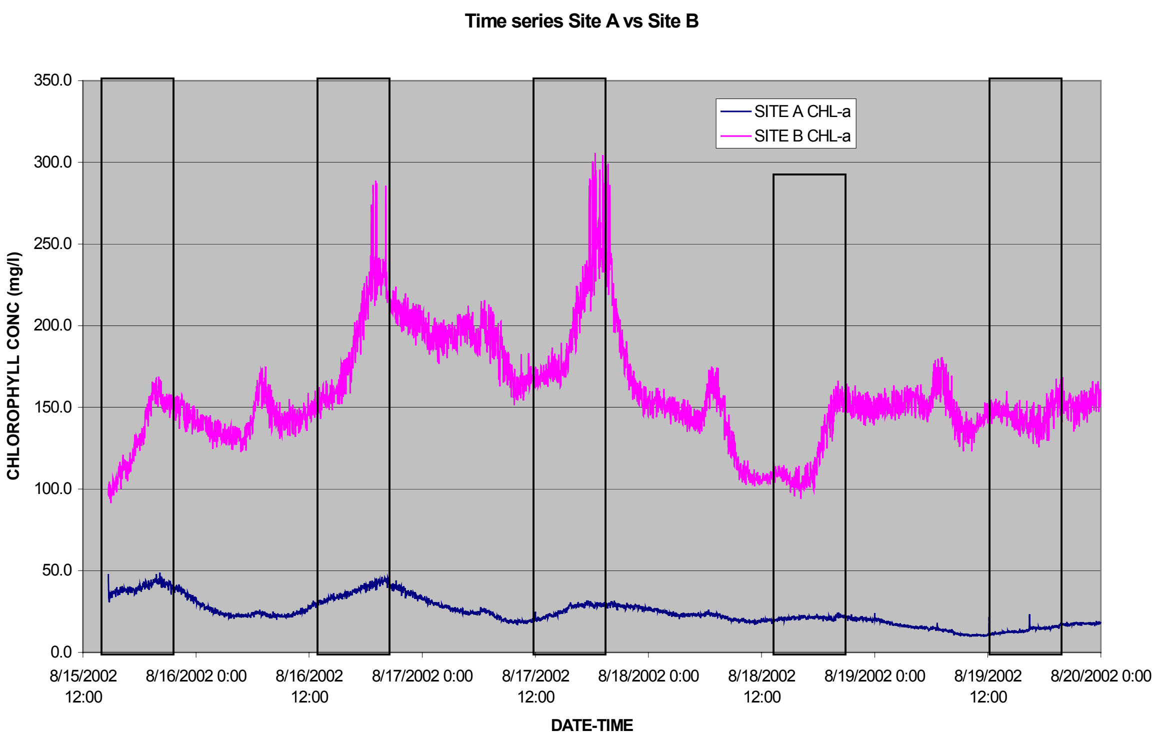


Figure 3.6. Time series of chlorophyll-a concentrations at Sites A and B on the San Luis Drain showing periods during which diurnal algal growth rates are expected to be at a maximum.

The highlighted areas do show positive gradients of algal production which might give weight to the hypothesis that there is a diurnal periodicity to algae growth.

However maximum chlorophyll concentrations appear to coincide with 8:00 p.m rather than 6:00 p.m, which is unexpected since the afternoon sun strikes the drainwater at an increasing acute angle as the hour approaches dusk – irradiating an uncreasingly smaller volume of drain water in the San Luis Drain. During August 16, algal growth rates remain high during the night hours.

The eighteen check structures and culverts that are encountered by the drain water in transit along the San Luis Drain tends to increase longitudinal dispersion. This phenomenon has been observed during several dye studies conducted in the early 1990's which plotted the shape of the dye plume as water passed between Sites A and B on its course between the Main Drain (upstream of Site A) to Crows Landing on the San Joaquin River.

H 5. Summary

The set of experiments, conducted in the San Luis Drain and described in this supplement to the Quinn and Tulloch Final Report on San Joaquin River diversions and drainage (Quinn and Tulloch, 2001), were primarily to assess the utility of the SCUFA sondes for the anticipated 2003 CALFED Directed Action study. The author's experience with these units has been positive and a number of SCUFA units have been recommended in the monitoring plan recommended to CALFED. Although initial deployment will be as autonomous units that are serviced every 2 weeks – a longer term objective is that these or similar units be integrated into the SCADA or real-time water quality monitoring systems of San Joaquin Basin water districts.

H 6. References

Quinn N.W.T and A. Tulloch. 2002. San Joaquin River diversion data assimilation, drainage estimation and installation of diversion monitoring stations. Final Report. CALFED Project #: ERP-01-N61-02

American Public Health Association. 1995. Standard Methods of the Examination of Water and Wastewater, 19th Edition. American Public Health Association, Washington, DC.

Stringfellow, W. T. and N. W. T. Quinn. 2002. Discriminating Between West-Side Sources of Nutrients and Organic Carbon Contributing to Algal Growth and Oxygen Demand in the San Joaquin River. CALFED Bay-Delta Program, Sacramento, CA. Ernest Orlando Lawrence Berkeley National Laboratory Formal Report No. LBNL-51166. Berkeley National Laboratory, Berkeley, CA.

APPENDIX I

San Joaquin River diversion data for 2002 :
Patterson Irrigation District and West Stanislaus Irrigation District

I.1 Objective

This report updates the diversion data in the Quinn and Tulloch Final Report (Quinn and Tulloch, 2002) to include all of the 2002 pumping data. This information was gathered from telemetered flow and water quality monitoring stations that were completed with partial support from the CALFED-sponsored San Joaquin River Low Dissolved Oxygen Project .

I.2 Background

In the Final Project Report to CALFED entitled "San Joaquin River diversion data assimilation, drainage estimation and installation of diversion monitoring stations, (Quinn and Tulloch, 2002)" the authors provided analysis which showed the importance of accurate estimation of river diversions to the development of a mass balance of algal loads from the upper watersheds. Algal loads are diverted from the San Joaquin River along with river water – only a small portion of this water is returned directly to the river. In some water districts such as Patterson Irrigation District, facilities have been completed to eliminate all surface water returns to the San Joaquin River. When diverted river water is applied to land to irrigate crops the algae is filtered by the soil and becomes an organic amendment to the soil. Deep percolating irrigation water may be intercepted by drainage ditches or become part of the regional groundwater system that flows towards the San Joaquin River. In the case of water intercepted directly by surface drainage ditches and of subsurface tile drains discharging to surface drainage ditches there is opportunity for algal growth depending on the length of time the drainage water remains in the channel. On the west side of the San Joaquin Valley between Highway 140 and Vernalis, the travel times between field and the SJR are typically short – as a result of the short flow paths to the river. As a consequence it is anticipated that river diversions in this reach of the river will have a greater impact on algal loading than drainage return flows.

There are approximately 41 riparian and appropriative diverters of San Joaquin River water between Lander Avenue and Vernalis. A boat survey conducted during 2001 produced a count of over 100 individual lift pumps along the levee in the reach of the River between Vernalis and the Stockton Deep Water Ship Channel (DWSC). The major river diverters in the reach between Lander Avenue and Vernalis are Patterson Irrigation District (PID), West Stanislaus Irrigation District (WSID)and El Solyo Water District (ESWD). As part of the 2001 CALFED study monitoring equipment was installed and maintained in the first lift Canals of both the PID and WSID. This monitoring equipment and the arrangements made with both these water districts for data access provided CALFED with real-time data for San Joaquin River diversions into these districts. This capability is crucial for future modeling purposes.

West Stanislaus Irrigation District was formed in 1920 – the first water deliveries to the District were made in 1929. Water deliveries have increased from 12,000 acre-feet the first year to a maximum of 113,000 acre-feet in 1984. Water from the San Joaquin River in conveyed through a mile-long unlined gravity canal to the first pumping plant where water is lifted 35 ft into the concrete lined main canal. A total of six pumping plants lift water to an elevation of 165 ft above sea level. Water is diverted from the main canal to laterals that run north and south. In 1929 all water supply to the District was diverted from the San Joaquin River. After the construction of Friant Dam and the diversion of San Joaquin River water to the southern San Joaquin Valley the quality of water diverted from the SJR declined. Litigation from west-side riparian water districts resulted in the provision of federal water deliveries from the Delta to offset these water quality problems. In 1953 the district signed a contract for 20,000 acre-feet of water – this was increased to 50,000 acre-feet in 1976. The Water District has diverted up to 66,000 acre-feet from turnouts at mile 31.31 and 38.13 along the Delta-Mentota Canal. The District irrigates approximately 22,500 acres of cropland through 84 miles of laterals and sublaterals. Although Delta water typically is of better quality than San Joaquin River water the District typically diverts its maximum allocation from the River, largely on account of the lower cost. This policy is true also for Patterson ID and Banta Carbona ID.

Figure I-1. Flow and water quality monitoring station at the West Stanislaus Irrigation District.

Patterson Irrigation District was organized much later than West Stanislaus Irrigation District, in 1955. The District has pre-1914 appropriative water rights that entitles it to pump water from the San Joaquin River from its inception as the Patterson Land Company in 1909. In 1967 the District entered into a long term contract with the Bureau of Reclamation for 22,500 acre-ft as compensation for the loss of high quality San Joaquin River water. The area of the water district is approximately 13,800 acres mostly divided into small hobby farms and ranchettes –which creates added challenges for water management. Water diversions from the river take place at a pumping plant located on the levee bank. Water passes into a concrete lined main canal and then through a number of pumping lift stations to the head of the canal. Delta Mendota Canal water can be blended with San Joaquin River water by simulyaneously diverting from the river and he Delta Mendota Canal.

Figure I-2. Flow measuring flume at the Patterson Irrigation District.

I.3 Data Development

Data have been downloaded from monitoring stations established in 2001 with partial funding from the CALFED San Joaquin River Low Dissolved Oxygen Project. Data is collected every 15 minutes at West Stanislaus Irrigation District and hourly at Patterson Irrigation District. Diversions typically start in late March, early April each year, depending on the weather. Pumps are shut down for the winter in October or November.

I.4 Results

The 2002 diversion data for both West Stanislaus Irrigation District and Patterson Irrigation District are shown graphically and in monthly tabular form in Figures I-3 and I-4 and in Tables I-1 and I-2. Both graphs show a significant decline in diversion flows during the month of October with flows declining approximately 150 cfs in West Stanislaus Irrigation District and 120 cfs in Patterson Irrigation District between October 1 and October 30.

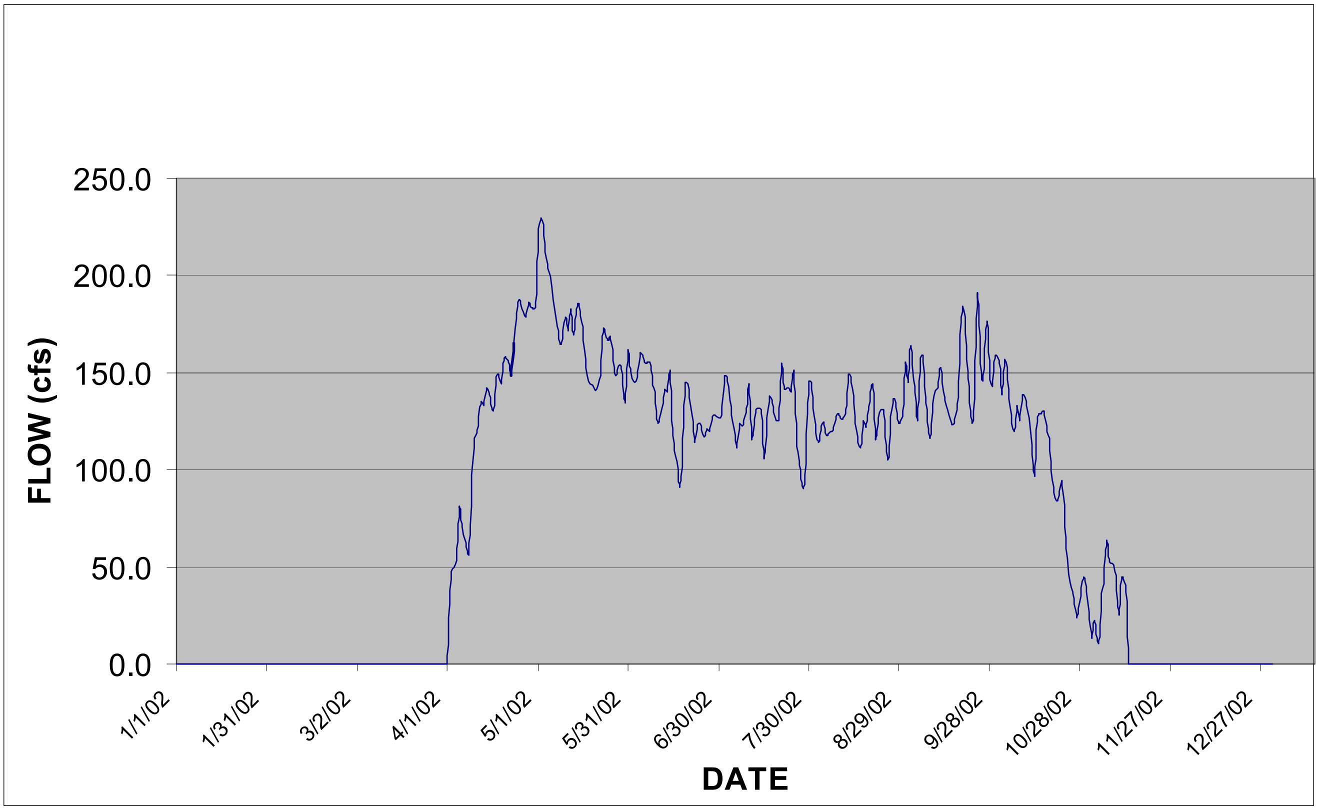


Figure I-3. San Joaquin River diversions to West Stanislaus Irrigation District in 2002.

West Stanislaus Irrigation District
San Joaquin River Diversions
(Ac-Ft.)

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	TOTALS	ERROR EST.
1999	400	89	2819	4863	9732	9584	11013	8638	3789	925	1188	1984	55024	+/- 5%
2000	1501	0	587	7040	8098	8655	9686	6421	3339	903	539	627	47396	+/- 5%
2001	481	376	787	5320	9456	8116	9203	7561	3268	653	374	125	45720	+/- 2%
2002	0	0	0	7480	10534	7903	7951	7844	8780	6094	882	0	57468	+/- 2%
occurrence avg.	596	116	1048	6176	9455	8564	9463	7616	4794	2144	746	684	51402	

* West Stanislaus ID upgraded flow and EC monitoring in 2001 with assistance from CALFED and SJR-DO project

Table I-1. Comparison of San Joaquin River diversions to West Stanislaus ID 1999-2002.

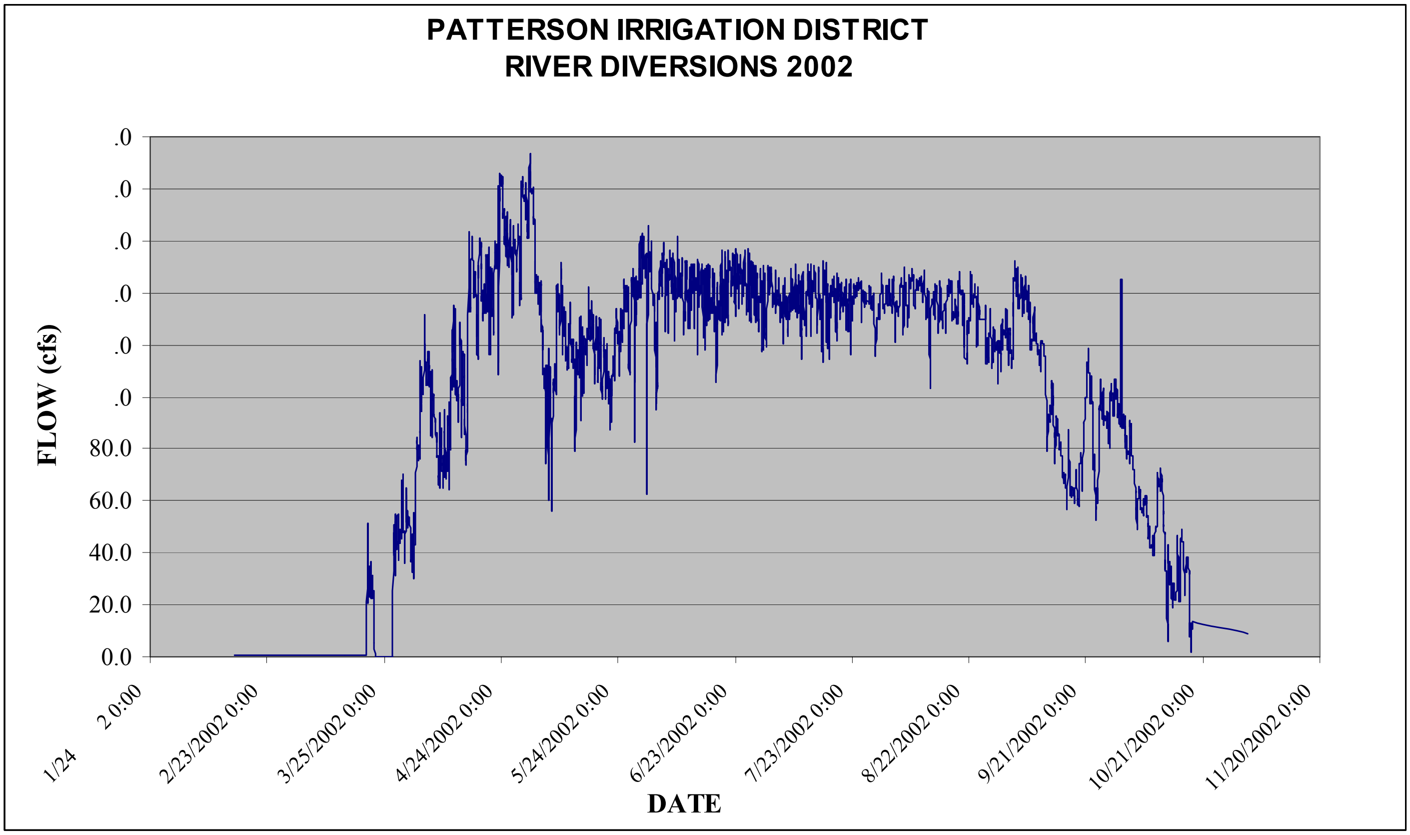


Figure I-4. San Joaquin River diversions to Patterson Irrigation District in 2002.

Patterson Irrigation District
San Joaquin River Diversions
(Ac-Ft.)

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	TOTALS	ERROR EST.
1999	0	0	941	4640	7952	7957	8030	7707	5289	910	0	0	43426	+/- 2%
2000	0	0	350	6460	7860	7581	8150	7479	2982	419	0	0	41281	+/- 2%
2001	0	0	861	4668	8929	8180	8620	7479	2982	419	0	0	42137	+/- 2%
2002	0	12	561	7186	7700	8402	8409	8185	5952	1674	2	0	48084	+/- 2%
occurrence avg.	0	3	678	5738	8110	8030	8302	7713	4301	856	1	0	43732	

Table I-2. Comparison of San Joaquin River diversions to Patterson ID 1999-2002.

The effect of this reduction in diversion at the two largest west-side agricultural diverters and other riparian water district that divert water on a similar schedule is shown in Figure I-5. The river flow at Vernalis increases by approximately 1,000 cfs from 1,200 cfs to over 2,200 cfs. If diversions into Old River were minimal during this period, Lee (2003), Chen (2002) and others have suggested that any dissolved oxygen deficit that has been shown to occur at flows of 1,000 cfs and lower would likely disappear at a flow of 2,000 cfs. Appendix D-7 of the Synthesis Report, Lee (2003) shows dissolved oxygen increasing from 4 mg/l to 8 mg/l between the beginning and end of October 2003.

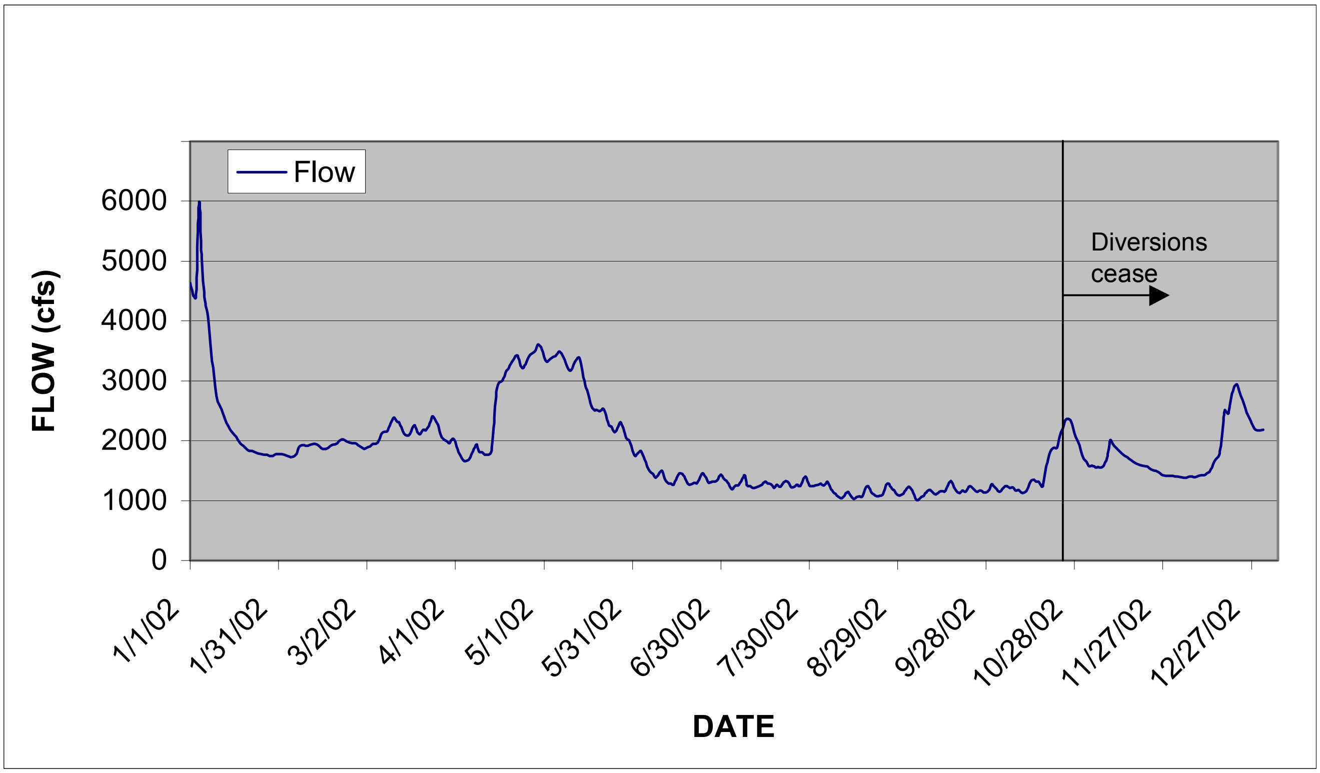


Figure I-5. Flows recorded at the Vernalis monitoring site during 2002.

I.5 References

Chen C.W. and Tsai W. 2002. Final Report : Improvements and Calibrations of Lower San Joaquin River DO Model. Report prepared for the San Joaquin River DO TMDL Sttering Committee. Systech Engineering, San Ramon, CA. March, 2002.

Grober L.C. (1989). Data refinements and modeling results for the lower San Joaquin River Basin. A report to the State Water Resources Control Board. University of California, Davis. June 1989.

Kratzer, C.R., P.J. Pickett, E.A. Rashmawi, C.L. Cross, and K.D. Bergeron. (1987). An InputOutput Model of the San Joaquin River from the Lander Avenue Bridge to the Airport

Way Bridge. Technical Committee Report No. W.Q. 85-1. California State Water Resources Control Board.

Lee, G.F. and A. Jones-Lee, 2003. Synthesis and Discussion of Findings on the Cuases and Factors Influencing Low DO in the San Joaquin River Deep Water Ship Channel near Stockton, CA: Including 2002 data.

Quinn N.W.T. and A. Tulloch, 2002 San Joaquin River diversion data assimilation, drainage estimation and installation of diversion monitoring stations CALFED Bay-Delta Program, Sacramento, CA 95814. September 15, 2002.

APPENDIX J

Annual variation in San Joaquin River diversions : Banta Carbona Irrigation District 1970-2002

J.1 Objective

This appendix to the Quinn and Tulloch, Final Report (2002) analyses the year to year variation in San Joaquin River flows diverted to the Banta Carbona Irrigation District. This analysis will help modeling of this reach of the river and may allow some simple heuristics to be developed for flow and algal load forecasting purposes.

J.2 Background

In the Final Project Report to CALFED entitled "San Joaquin River diversion data assimilation, drainage estimation and installation of diversion monitoring stations, (Quinn and Tulloch, 2002)" the authors provided data which showed the importance of accurate estimation of river diversions to the development of a mass balance of algal loads from the upper watersheds. In Appendix I flow diversion data from the two largest San Joaquin River riparians was presented for 2002. These water districts have the capacity to divert more than 350 cfs from the San Joaquin River – their patterns of diversion were shown to be quite similar.

The Banta Carbona Irrigation District extends from the City of Tracy to the San Joaquin-Stanislaus County line near the town of Vernalis. The District provides water to 17,900 acres of which 16,500 acres are irrigable. The original intake channel was designed to have a capacity of 200 cfs and pumping plants were designed and installed to be able to provide a minimum of 150 cfs. By 1969, increased salinity levels in the San Joaquin River and the ensuing litigation was resolved by the provision of Central Valley Project water from the US Burau of Reclamation's Delta Mendota Canal. A contract of 25,000 acre-feet was signed in 1969. For the period 1973 through 1981, except for critically dry years of 1976 and 1977, the District has withdrawn an average of 9,500 acre-feet of water from the Delta Mendota Canal. During normal water years approximately 50% of the District's supply is pumped from the San Joaquin River.

Like West Stanislaus Irrigation District and Patterson Irrigation District, Banta Carbona Irrigation District takes gravity flows from the Delta Mendota Canal on the west and pumps from the San Joaquin River through a state-of-the-art fish screen facility on the east – allowing the District to blend water supply. Figures 1-3 shows the Banta Carbona ID intake canal and fish screen facility, ¼ mile above the pumps at the first lift canal. Operational spills to the most part are returned to the Main Canal. Subsurface drainage flows are collected in a network of drains within the New Jerusalem Drainage District, a separate institution contained with Banta Carbona Irrigation District. These flows are combined in the New Jerusalem Drain which discharges to the San Joaquin River approximately ¼ mile downstream from the Banta Carbona Irrigation District intake canal.

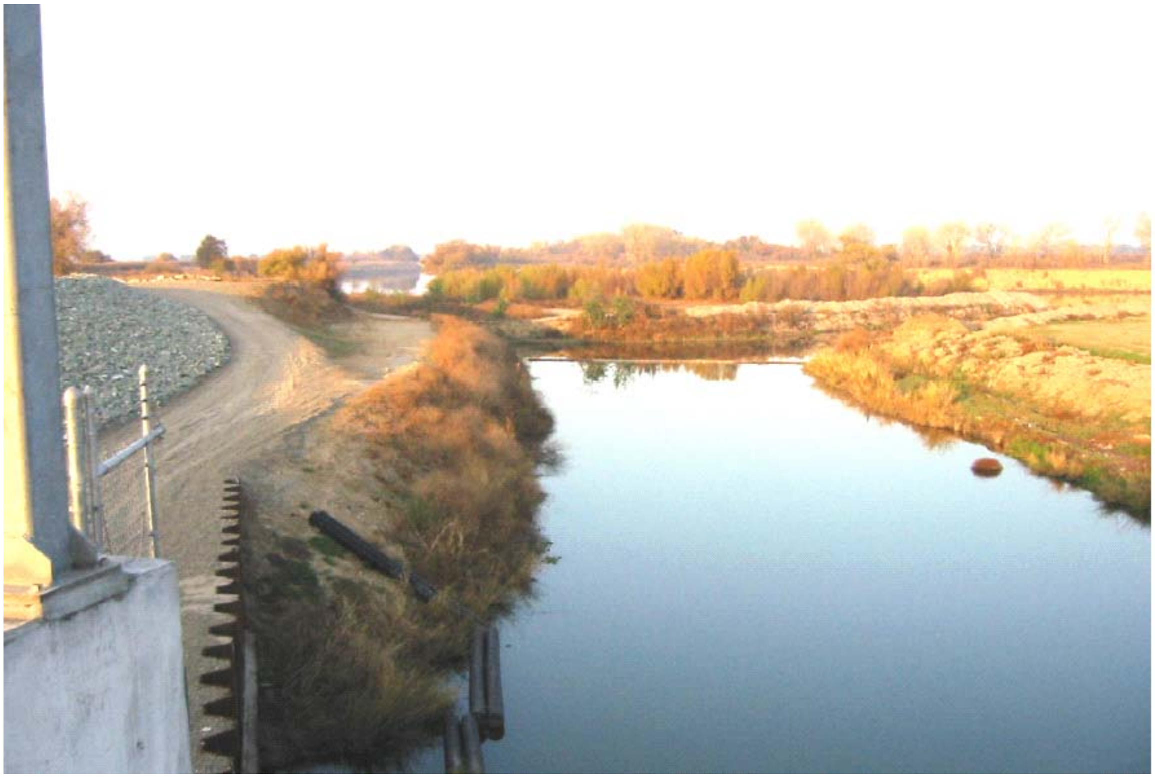


Figure J-1. Banta Carbona Irrigation District intake canal.

Figure J-2. Banta Carbona Irrigation District fish screen facility.

Figure J-3. Main intake canal showing first bank of lift pumps approximately 1/4 mile from the fish screen facility.

J.3 Data Development

The data used to perform the analysis of Banta Carbona ID pumping was obtained from hand notes in the daily Water Master handbooks for years 1972 to 2002. A man-day was required to record and analyze each year of record.

J.4 Results

The 1999-2002 diversion data for Banta Carbona Irrigation District is presented in monthly tabular form in Table J-1.

Banta Carbona Irrigation District
San Joaquin River Diversions
(Ac-Ft.)

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	TOTALS	ERROR EST.
1999	0	0	148	2183	11819	10444	12798	9417	2994	1231	0	0	51035	+/- 5%
2000	1128	0	134	6099	9518	10753	12248	7492	2795	802	0	0	50967	+/- 5%
2001	0	0	1446	6347	11133	9972	7293	7516	2718	1474	311	0	48210	+/- 5%
2002	0	0	667	5082	9335	9205	11182	8736	3306	1233	289	0	49034	+/- 5%
occurrence avg.	282	0	599	4928	10451	10093	10880	8290	2953	1185	150	0	49812	

Table J-1 Comparison of monthly San Joaquin River pumping for years 1999-2002.

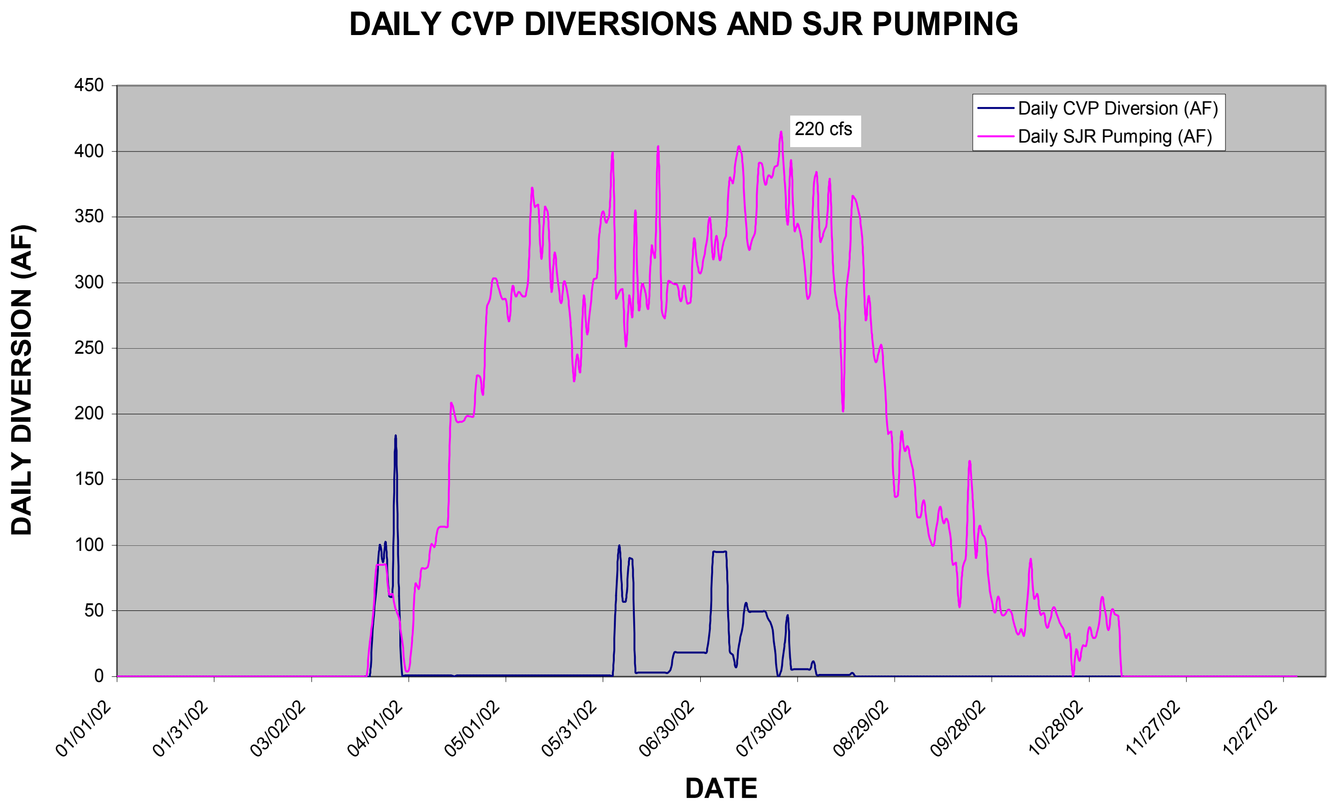


Figure J-4. Daily pumping from the San Joaquin River and estimated CVP diversions from totalizing meters on the Delta Mendota Canal for 2002.

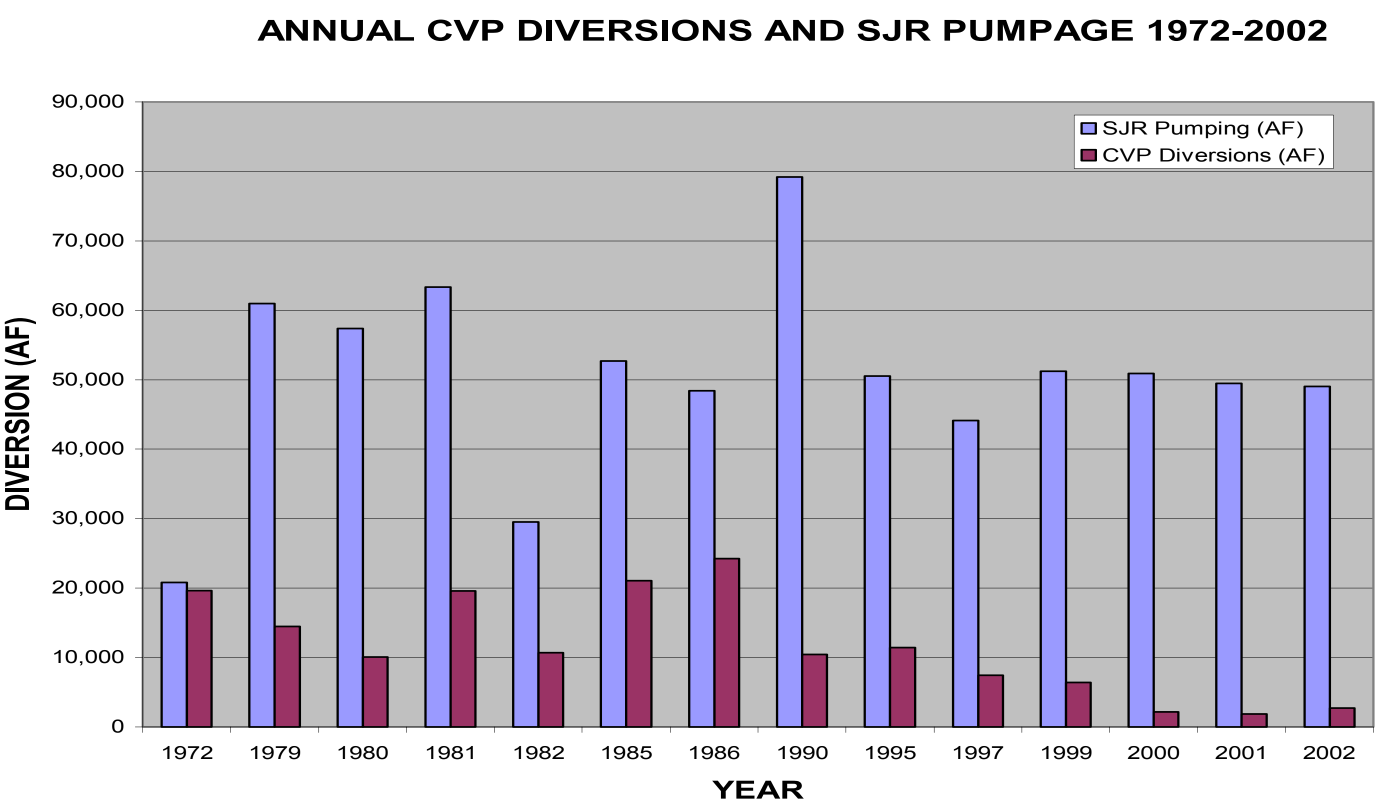


Figure J-4. Comparison of annual CVP diversions and SJR pumping for years 1972 - 2002.

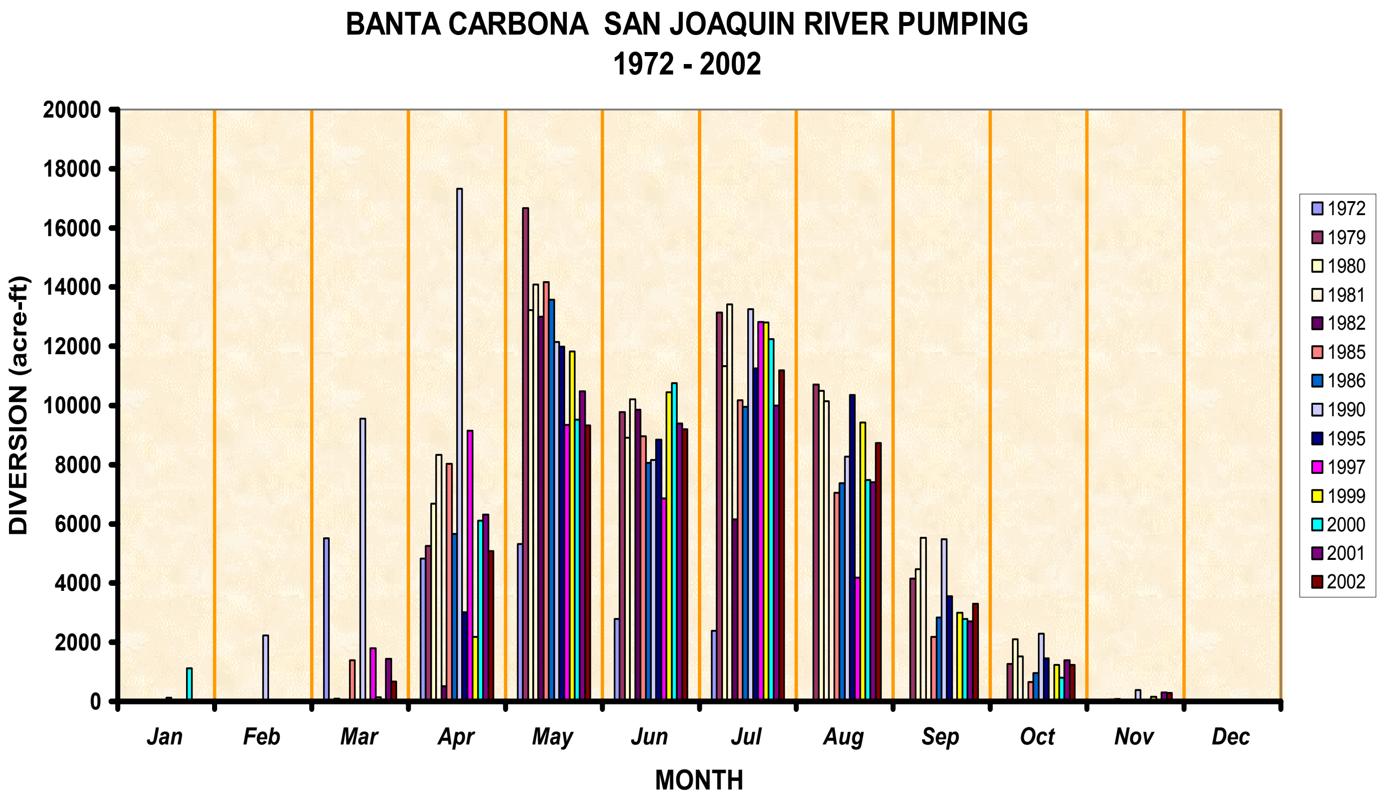


Figure J-5. Monthly pumping from the San Joaquin River for selected water years 1972-2002.

The data in Table J-1 shows very consistent river diversions between 2001 and 2002. In 2001 pumping was estimated at 48,210 acre-ft. In 2002 the total river pumping was 49,035 acre-feet. River pumping appears to end a little earlier in Banta Carbona Irrigation District than in Patterson or West Stanislaus Irrigation Districts as shown in Figure J-4. CVP water appears to be used in the District mainly as a supplemental supply. Very little CVP water was used in 2000, 2001 or 2002. The incentive to pump close to a full allocation of San Joaquin River water may relate to the cost of CVP water and the ability to sell surplus water outside the District. CVP diversions from the Delta Mendota Canal appear to have steadily decreased as a proportion of the District supply since 1986.

In Figure J-5 the monthly pumping from the San Joaquin River for selected years from 1972 to 2002 is shown. The Figure shows quite consistent river pumping in wet and dry years alike. The pumping rate drops off in mid-August and is close to zero most years in the month of November.

J5. Summary

The results of the analysis performed on Banta Carbona Irrigation District San Joaquin River pumping are significant for future forecasting of algal load removal rates in the reach from Vernalis to Mossdale Bridge and the Deep Water Ship Channel. Consistent removal rates make forecasting easier and reduce error. Real-time access to flows measured at the fish facility would help to quantify San Joaquin River diversions leading to improved estimation of remaining algal loads being passed into the Deep Water Ship Channel.

J.6 References

Banta Carbona Irrigation District : 1972-2002. Water Master field notebooks.

Quinn N.W.T. and A. Tulloch, 2002 San Joaquin River diversion data assimilation, drainage estimation and installation of diversion monitoring stations CALFED Bay-Delta Program, Sacramento, CA 95814. September 15, 2002.

APPENDIX K

Installation, operation, maintenance and data reporting at Salt Slough monitoring station at Wolfsen Road Bridge

K 1.0 Background

Mud Slough and Salt Slough are the main drainage arteries of the Grassland Watershed, a 370,000-acre area west of the SJR, covering portions of Merced and Fresno Counties (Figure 1). The watershed includes 197,000 acres of farmland referred to as the Grassland Drainage Area, and approximately 100,000 acres of wetland habitat (Chilcott *et al*. 2000). The wetland habitat includes duck clubs (private wetlands) and wildlife refuges. The majority of the surface water used for both irrigation and wetland management in the Grassland Watershed is imported from the Sacramento-San Joaquin Delta through the Delta-Mendota Canal.

Salt Slough is a slow moving, meandering west-side tributary to the San Joaquin River. The Slough contains mixed drainage primarily from agricultural and wetland sources. Prior to initiation of the Grassland Bypass Project in September 1996 most agricultural drainage from the Grassland Basin agricultural area (covering approximately 97,000 acres) was diverted to Salt Slough (Figure 1). Selenium laden drainage water would combine in the Main Drain and then be conveyed through the South Grassland Water District either via Agatha or Camp 13 Canals in a flip-flop conveyance arrangement. This allowed the canals to be used for drainage service and wetland water supply alternatively. The flow from these conveyances typically entered Santa Fe Canal, or if being used for wetland deliveries, into Mud Slough (south). Drainage water in Mud Slough South would drain directly into Salt Slough at the northern tip of the Los Banos Wildlife Management Area. Water conveyed in the Santa Fe Canal from the South Grassland Water District could be diverted into Salt Slough through the Blake Porter Bypass (Figure 1), a short canal linking the Santa-Fe Canal with Mud Slough (south) or alternatively, to Mud Slough (north) through the San Luis Canal and Fremont Canal. Monitoring conducted since 1985 shows the bulk of the salt load from the Grasslands Basin agricultural area being discharged to Salt Slough.

After September 1996, 28 miles of the San Luis Drain were utilized to convey selenium-laded agricultural drainage water around the Grassland Water District, with a new point of discharge established into Mud Slough at the terminus of the San Luis Drain. The discharge point is approximately 6.5 miles from the confluence of Mud Slough and the San Joaquin River. Removing agricultural drainage water from Salt Slough also removed a significant source of salt, boron and selenium – greatly improving the quality of the water in Salt Slough. Removal of agricultural drainage water has allowed the San Luis National Wildlife Refuge to exercise their historic water right to Salt Slough water since selenium levels are, since October 1996, consistently below the 2 ppb threshold for wetland water supply.

K 1.1 Flow and algal biomass mass balance

In the Stringfellow and Quinn proposal for the 2001 San Joaquin Low Dissolved Oxygen studies (Stringfellow and Quinn, 2002) mass balances were proposed at three paired locations in order to isolate the algal load contributions from : (a) agricultural areas; (b) private wetlands; and (c) a federal wildlife refuge. The hypothesis of the Stringfellow and Quinn project was that it is

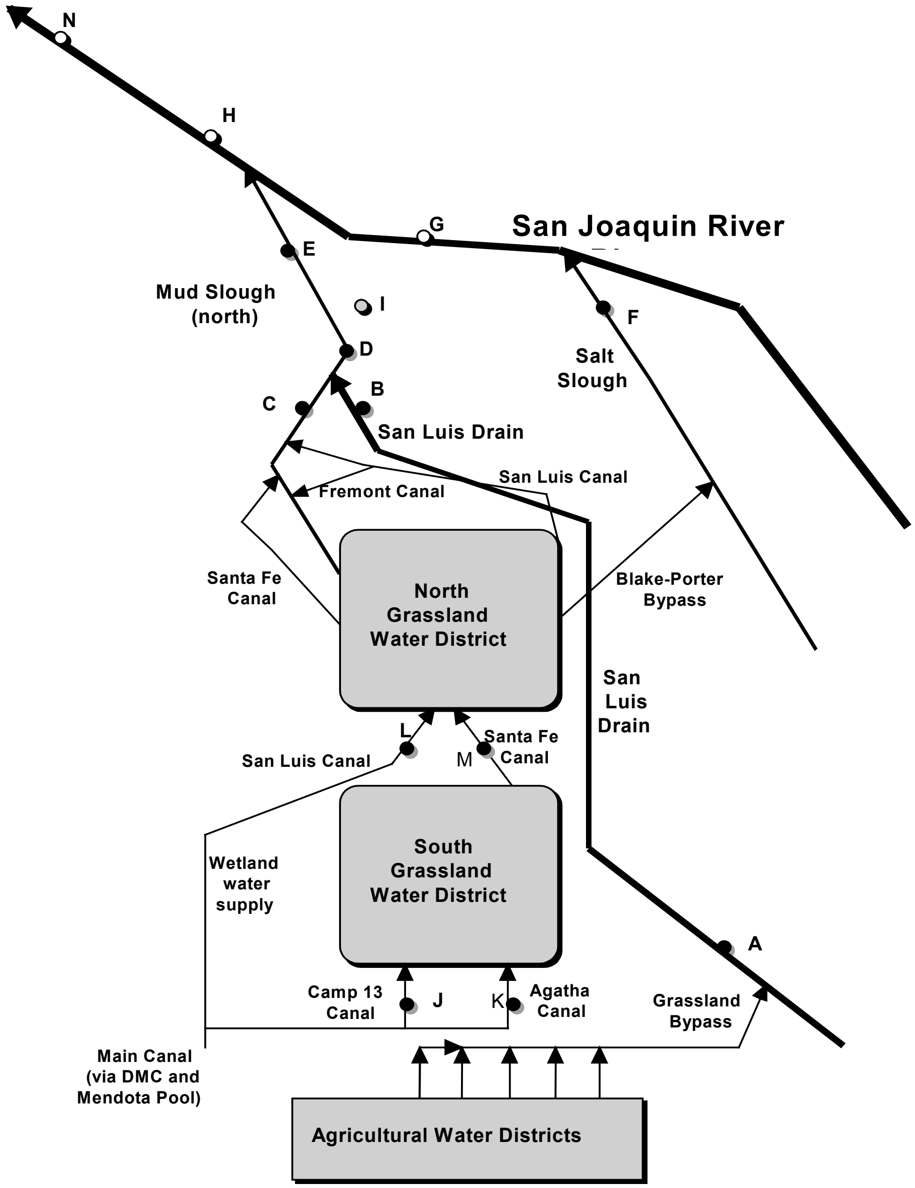


Figure 1. Schematic of canal system and flow of drainage in the Grasslands Basin.

possible to discriminate between wetland and agricultural sources of organic and inorganic nutrients entering the San Joaquin River. It was further hypothesized that if the relationship between water use practices (such as irrigation and flood-up) and water quality can be understood, then there will be management remedies to minimize the impact of discharges from the Grasslands on the SJR DO deficits.

The four sample points that were selected to isolate nutrient and carbon loading associated with public and private wetlands from those associated with agriculture (Figure 2) were the Volta Wasteway (inlet) and Mud Slough at Gun Club Road (outlet) for the private wetland contribution and Salt Slough at Wolfsen Road (upstream) and Salt Slough at Highway 165 (downstream) for the public refuge removal or discharges. The mass balance between Sites A and B on the San Luis Drain measured net algal growth during the 1.5 to 3 day travel time between these stations, 28 miles apart on the san Luis Drain. At each location, parameters were measured that had been previously identified by the SJR DO TAC as having potential impact on the Stockton DO deficit.

Water quality samples were collected from Salt Slough at Wolfsen Road Bridge and at Highway 165 however a complete mass balance was not possible without flow data at Wolfsen Road Road Bridge. Hence as part of the 2001 study proposal a new monitoring station was specified for construction at this location (Figures 2 and 3).

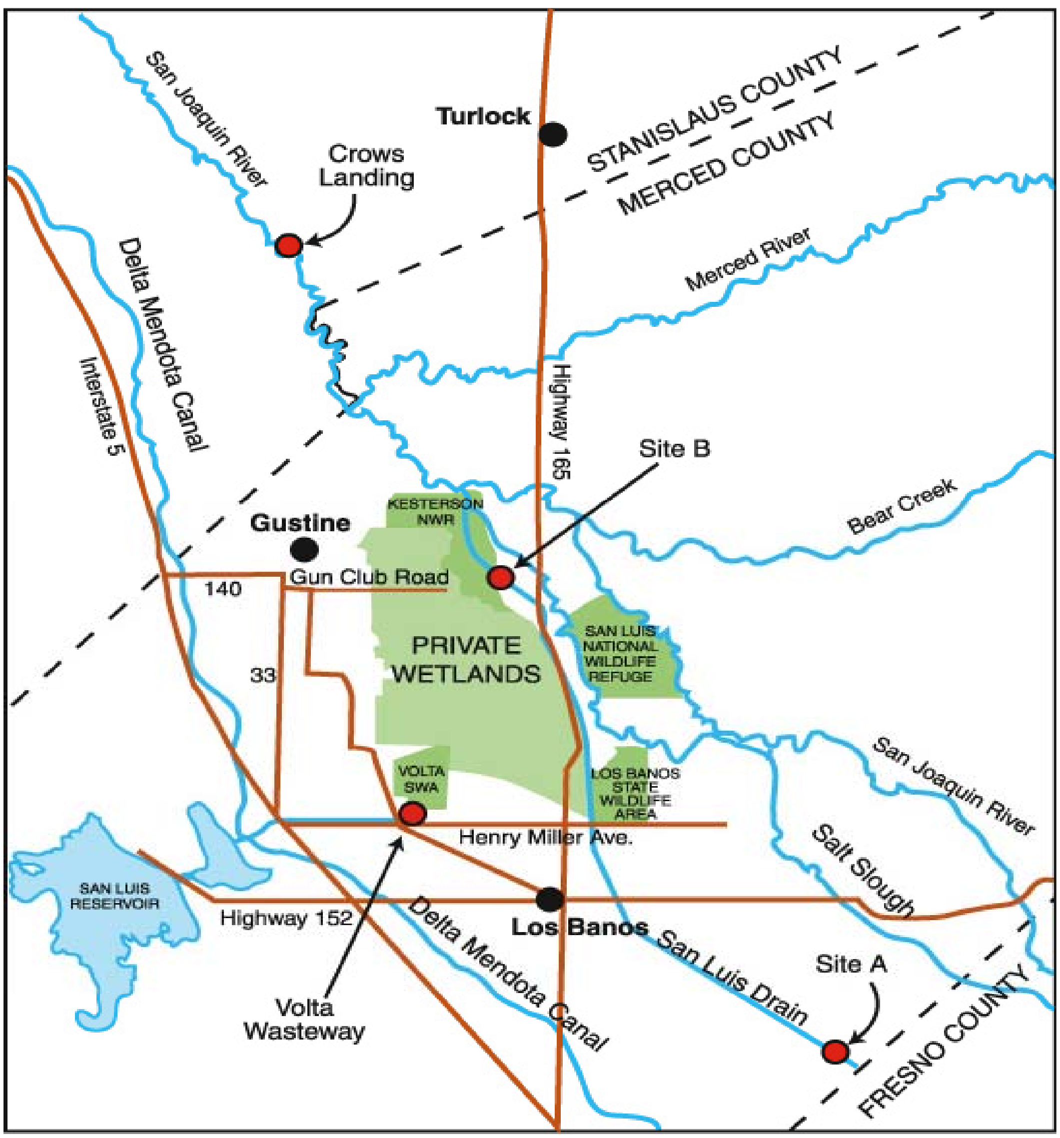


Figure 2. Wetland resource areas within the Grasslands Basin.

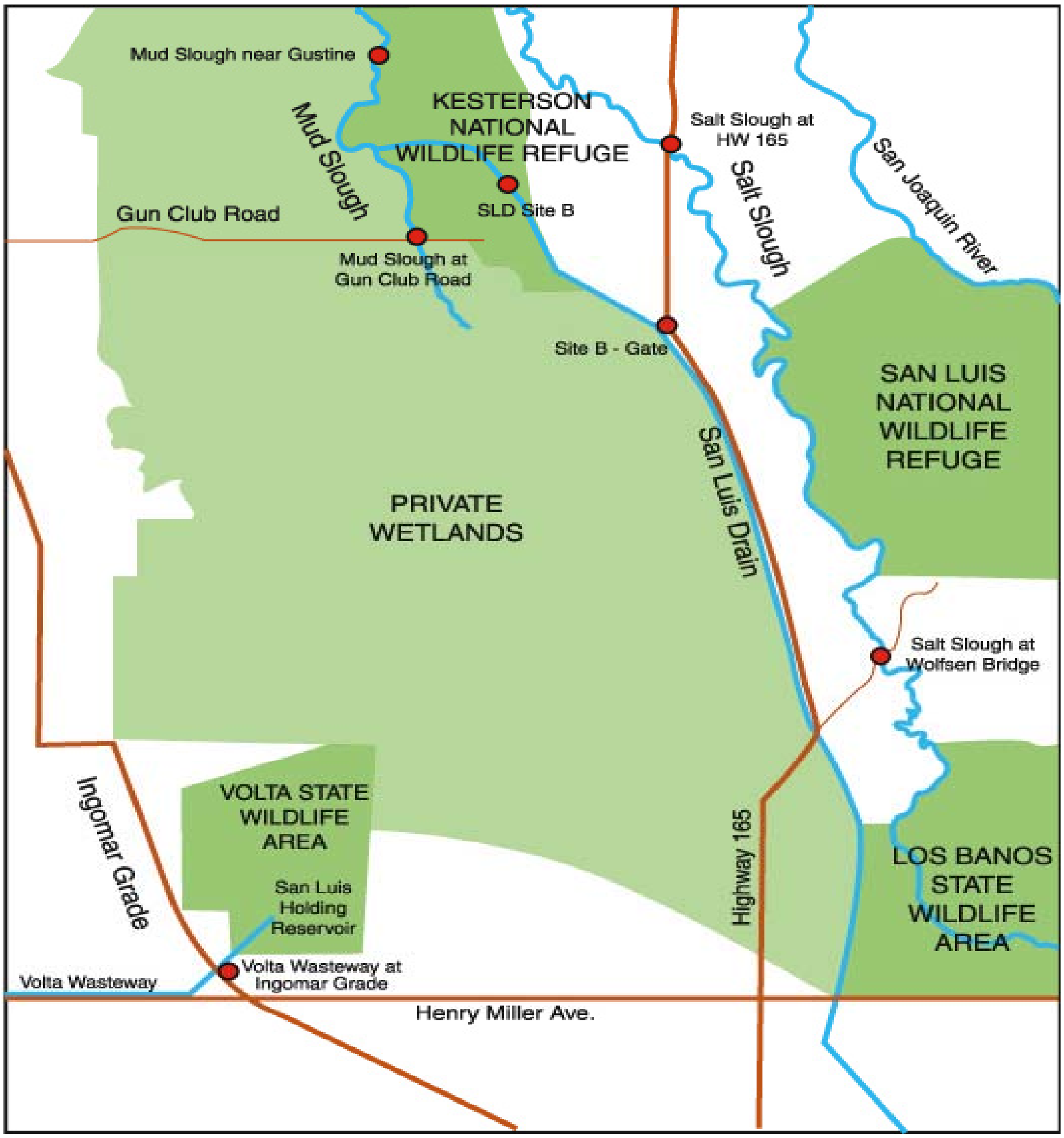


Figure 3. Detailed map of Salt Slough showing location of Wolfsen Road monitoring station.

Contracting difficulties with the LBNL contract were finally resolved by combining the Quinn/Tulloch and Stringfellow/Quinn studies under a single contract with Tulloch Engineering Inc. During this process Chris Foe at the Regional Water Quality Control Board questioned the wisdom of installing the new station at Wolfsen Road Bridge because the station would not be functional prior to the conclusion of the Stringfellow and Quinn algal source and mass balance study. Without the flow data from Wolfsen Road Bridge the algal load upstream of the return flows and diversions to the San Luis National Wildlife Refuge could not be properly accounted for. The Technical Advisory Committee however, after hearing arguments in favor of moving ahead with the station, voted to approve the installation. The Wolfsen Road Station was recognized as a critical monitoring station for a future upper watershed algal load assessment study – anticipated in 2003.

K 1.2 Construction of the Wolfsen Road Monitoring Station

Construction of the monitoring station began in early 2002. The site was located immediately downstream the Wolfsen Road bridge west bank of Salt Slough. The GPS coordinates of the Wolfsen Road Bridge site relative to the Salt Slough Hwy 165 site appear in Table 1. The site sits above an old USGS or DWR stilling well, long abandoned, that was previously used top measure stage. The major advantages of the site are that it is adjacent to living quarters owned by the Department of Fish and Game, which reduces the chance of vandalism, and access to the site is easy. The Department of Fish and Game graciously provided 100 volt power to the station as well as provided phone access. This has helped to reduce maintenance costs at the site.

Table 1: GPS locations of Salt Slough monitoring stations at Wolfsen Road Bridge and Hwy 165 (Lander Avenue)

Site Name	Latitude	Longitude	USGS Site Code
Salt Slough at Wolfsen Road	37^{o} 12.533’	120^{o} 48.775’	-------
Salt Slough at State Road 165	37^{o} 14.876’	120^{o} 51.116’	11261100

The monitoring equipment installed at the monitoring station include a SONTEK acoustic velocity sensor for measuring water stage and velocity and a combined electrical conductivity and temperature sensor from Campbell Scientific Inc. for measuring salinity. Data is recorded at 15 minute intervals on Campbell Scientific Inc. CR-10X datalogger which is accessible through a 1200 baud phone modem. Data is downloaded from the station each week and posted automatically to the following website at UC Berkeley : http://socrates.berkeley.edu/~nwquinn/Grassland_Realtime/Quinn-Grass/WolfsenRoad/wolfsen.html

Figure 4. Web posting of recent electrical conductivity and temperature data for the Wolfsen Road Bridge monitoring station. Water level data is suspect and SONTEK acoustic meter will need attention before 2003 studies commence.

H 1.3 Results

Table 2 displays the electrical conductivity, temperature, stage and flow data collected during 2002. Although the station was operational on May 16, 2002 – technical problems with the SONTEK acoustic velocity sensor, that were finally determined to be a problem with the sensor control software, prevented stage and flow data from coming on-line until August 3, 2002. There is currently no funding available to maintain the station.

Table 2. EC, temperature and flow data for 2002

Year	Julian Day	Time	EC	Temp	Stage	Flow
		Hr:Min	US/cm	F	Feet	cfs
2002	136	1245	1.288	71.7		
2002	137	1230	1.280	70.9		
2002	138	1215	1.193	71.6		
2002	139	1200	0.991	69.8		
2002	140	1145	0.946	67.3		
2002	141	1130	0.877	64.0		
2002	142	1015	0.983	65.0		
2002	143	1000	1.051	67.5		
2002	144	945	0.993	69.0		
2002	145	930	0.921	72.5		
2002	146	915	0.963	73.0		
2002	147	900	1.061	72.7		
2002	148	845	1.119	73.3		
2002	149	830	1.342	75.3		
2002	150	815	1.192	78.1		
2002	151	800	1.421	81.4		
2002	152	745	1.299	76.8		
2002	153	730	1.140	69.6		
2002	154	715	0.971	68.8		
2002	155	700	0.964	70.9		
2002	156	645	0.976	74.5		
2002	136	730	1.237	73.3		
2002	137	715	1.280	71.0		
2002	138	700	1.240	71.5		
2002	139	645	1.027	70.0		
2002	140	630	0.948	67.7		
2002	141	615	0.886	64.4		
2002	142	500	0.944	64.9		
2002	143	445	1.062	67.2		
2002	144	430	1.014	68.5		
2002	145	415	0.921	71.8		
2002	146	400	0.952	73.1		
2002	147	345	1.027	72.8		
2002	148	330	1.112	73.2		

2002	149	315	1.317	74.8		
2002	150	300	1.221	77.4		
2002	151	245	1.331	81.0		
2002	152	230	1.358	78.4		
2002	153	215	1.202	70.6		
2002	154	200	0.979	68.4		
2002	155	145	0.957	70.2		
2002	156	130	0.982	73.7		
2002	214	117	1.025	77.7		
2002	215	102	1.026	78.2	0.96	46
2002	216	47	1.138	76.0	0.91	44
2002	217	32	1.148	73.1	0.94	45
2002	218	17	1.012	74.2	1.59	77
2002	219	2	1.047	74.1	1.51	73
2002	220	2	1.046	74.0	1.44	70
2002	220	2347	1.015	74.9	1.76	86
2002	221	2332	1.016	77.1	1.29	63
2002	222	2317	0.958	78.4	1.36	66
2002	223	2302	0.997	78.3	1.15	56
2002	224	2247	1.059	77.7	1.08	52
2002	225	2232	1.089	78.6	0.94	46
2002	226	2217	1.068	78.6	0.92	45
2002	227	2202	1.032	78.8	1.06	51
2002	228	2147	1.093	78.0	0.96	46
2002	229	2132	1.047	76.6	1.18	57
2002	230	2117	1.019	75.3	1.36	66
2002	231	2102	1.002	74.4	1.70	82
2002	232	2047	0.993	72.4	1.86	90
2002	233	2032	1.079	72.5	1.29	63
2002	234	2017	1.094	72.1	1.04	50
2002	235	2002	1.134	70.9	0.94	46
2002	236	1947	1.207	71.7	0.95	46
2002	237	1932	1.129	73.1	1.13	55
2002	238	1917	1.148	73.9	1.33	64
2002	239	1902	1.132	74.6	0.93	45
2002	240	1847	1.228	75.9	0.68	33
2002	241	1832	1.299	73.7	0.63	31
2002	242	1817	1.418	74.5	0.90	44
2002	243	1802	1.401	76.0	0.95	46
2002	244	1747	1.253	77.5	0.93	45
2002	245	1732	1.240	78.2	0.92	45
2002	246	1717	1.130	78.7	0.88	43
2002	247	1702	1.139	75.7	0.84	41
2002	248	1647	1.055	73.1	0.84	41
2002	249	1632	1.055	71.1	0.91	44
2002	250	1617	1.053	70.2	0.93	45
2002	251	1602	1.026	69.6	0.99	48
2002	252	1547	1.006	70.5	0.91	44

2002	253	1532	1.050	72.4	0.90	44
2002	254	1517	1.209	73.7	0.99	48
2002	255	1502	1.269	74.4	1.08	52
2002	256	1447	1.256	74.1	1.11	54
2002	257	1432	1.214	73.7	1.04	50
2002	258	1417	1.191	73.9	1.01	49
2002	259	1402	1.236	72.0	1.05	51
2002	260	1347	1.215	71.8	1.05	51
2002	261	1332	1.311	72.1	1.03	50
2002	262	1317	1.134	72.3	0.99	48
2002	263	1302	1.051	74.2	0.39	19
2002	264	1247	1.021	75.3	0.80	39
2002	265	1232	1.023	74.9	1.07	52
2002	266	1217	0.978	74.6	0.97	47
2002	267	1202	1.009	74.6	0.99	48
2002	268	1147	1.038	75.0	1.04	51
2002	269	1132	1.037	73.2	0.96	47
2002	270	1117	1.055	70.6	0.94	45
2002	271	1102	1.176	66.6	0.81	39
2002	272	1047	1.172	66.7	0.92	45
2002	273	1032	1.065	67.8	0.87	42
2002	274	1017	1.066	66.8	0.81	39
2002	275	1002	1.159	61.5	0.77	37
2002	276	947	1.207	60.2	0.53	26
2002	277	932	1.223	62.6	0.41	20
2002	278	917	1.293	65.0	0.48	23
2002	279	902	1.311	67.0	0.92	44
2002	280	847	1.278	68.7	0.91	44
2002	281	832	1.198	69.7	0.88	42
2002	282	817	1.273	70.2	1.08	52
2002	283	802	1.314	70.3	1.07	52
2002	284	747	1.265	67.2	0.95	46
2002	285	732	1.216	65.6	0.83	40
2002	286	717	1.196	65.6	0.91	44
2002	287	702	1.209	66.2	0.92	45
2002	288	647	1.294	66.1	0.91	44
2002	289	632	1.319	65.0	0.99	48
2002	290	617	1.164	63.1	0.85	41
2002	291	602	1.208	63.2	0.85	41
2002	292	547	1.300	63.1	0.87	42
2002	293	532	1.297	63.7	0.83	40
2002	294	517	1.254	64.3	0.90	44
2002	295	502	1.210	64.3	0.91	44
2002	296	447	1.212	63.6	0.93	45
2002	297	432	1.078	62.1	1.06	51
2002	298	417	1.089	60.6	1.22	59
2002	299	402	1.111	60.7	1.21	59
2002	300	347	1.139	61.0	1.23	60

2002	301	332	1.162	60.9	1.53	74
2002	302	317	1.188	61.0	1.57	76
2002	303	302	1.253	60.7	1.29	63
2002	304	247	1.322	59.8	1.12	54
2002	305	232	1.361	58.4	0.98	48
2002	306	217	1.546	56.5	0.86	42
2002	307	202	1.615	55.5	0.88	43
2002	308	147	1.552	55.6	0.86	42
2002	309	132	1.435	55.7	0.84	41
2002	310	117	1.328	56.0	0.94	46
2002	311	102	1.278	56.2	0.97	47
2002	312	47	1.215	57.6	0.93	45
2002	313	32	1.086	59.2	1.33	65
2002	314	17	1.077	60.6	2.15	104
2002	315	2	1.143	60.1	2.36	114
2002	316	2	1.175	59.6	2.38	116
2002	316	2347	1.181	59.5	2.36	115
2002	317	2332	1.248	59.5	2.27	110
2002	318	2317	1.382	59.1	1.93	93
2002	319	2302	1.390	57.9	1.79	87
2002	320	2247	1.361	57.1	1.81	88
2002	321	2232	1.342	56.9	1.91	93
2002	322	2217	1.354	55.9	2.00	97
2002	323	2202	1.414	55.6	1.46	71
2002	324	2147	1.471	55.9	1.41	68
2002	325	2132	1.490	55.6	1.34	65
2002	326	2117	1.481	56.5	1.37	67
2002	327	2102	1.571	56.4	1.43	69
2002	328	2047	1.646	56.1	1.44	70
2002	329	2032	1.676	56.5	1.02	50
2002	330	2017	1.661	54.6	0.86	42
2002	331	2002	1.658	53.0	0.82	40
2002	332	1947	1.652	52.1	0.84	41
2002	333	1932	1.688	52.5	0.72	35
2002	334	1917	1.706	52.9	0.68	33
2002	335	1902	1.705	53.4	0.68	33
2002	336	1847	1.656	53.5	0.70	34
2002	337	1832	1.583	53.2	0.81	39
2002	338	1817	1.594	52.9	0.55	27
2002	339	1802	1.621	52.5	0.83	40
2002	340	1747	1.621	52.1	0.74	36
2002	341	1732	1.615	52.5	0.76	37
2002	342	1717	1.638	52.2	0.81	39
2002	343	1702	1.634	52.5	0.80	39
2002	344	1647	1.630	52.6	0.81	39
2002	345	1632	1.614	52.9	0.76	37
2002	346	1617	1.537	53.4	0.89	43
2002	347	1602	1.566	52.2	1.14	55

2002	348	1547	1.518	52.9	1.12	54
2002	349	1532	1.478	53.2	1.25	61
2002	350	1517	1.410	52.9	1.59	77
2002	351	1502	1.405	53.2	2.00	97
2002	352	1447	1.460	52.3	2.05	100
2002	353	1432	1.498	50.7	2.05	99
2002	354	1417	1.479	48.2	2.29	111
2002	355	1402	1.469	49.0	2.58	125
2002	356	1347	1.506	49.6	2.56	124
2002	357	1332	1.533	48.6	2.49	121
2002	358	1317	1.546	47.5	2.45	119
2002	359	1302	1.530	46.1	2.54	123
2002	360	1247	1.543	45.6	2.59	126
2002	361	1232	1.553	47.5	2.57	125
2002	362	1217	1.570	50.1	2.45	119
2002	363	1202	1.548	50.3	2.38	115
2002	364	1147	1.594	49.9	2.35	114
2002	365	1132	1.634	49.4	2.20	107

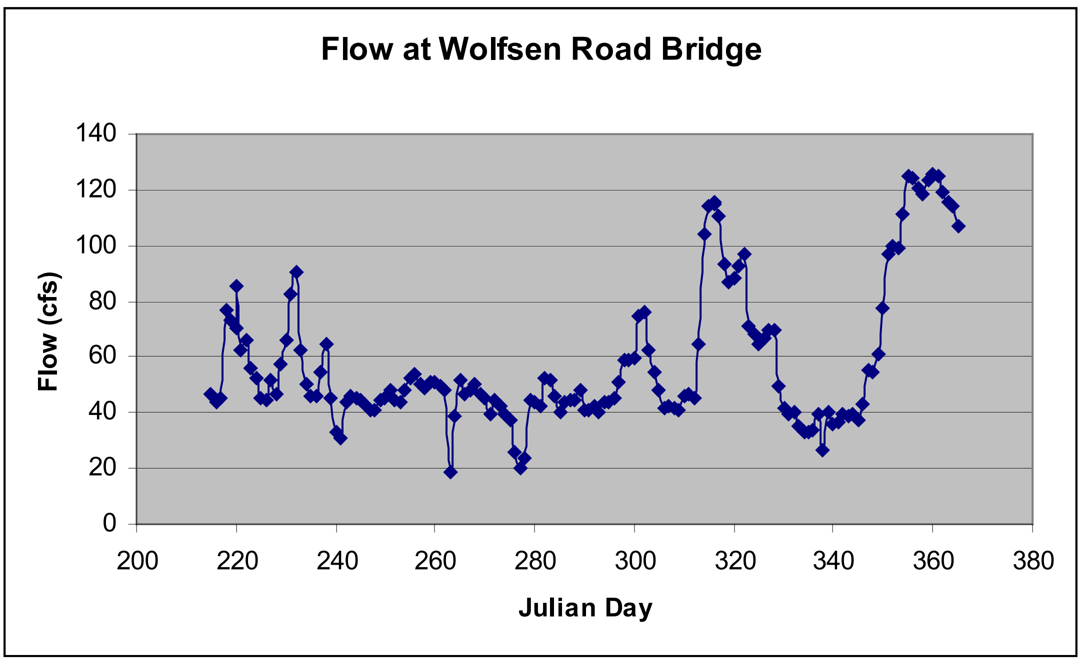


Figure 5. Flow record for 2002 at Wolfsen Road Bridge

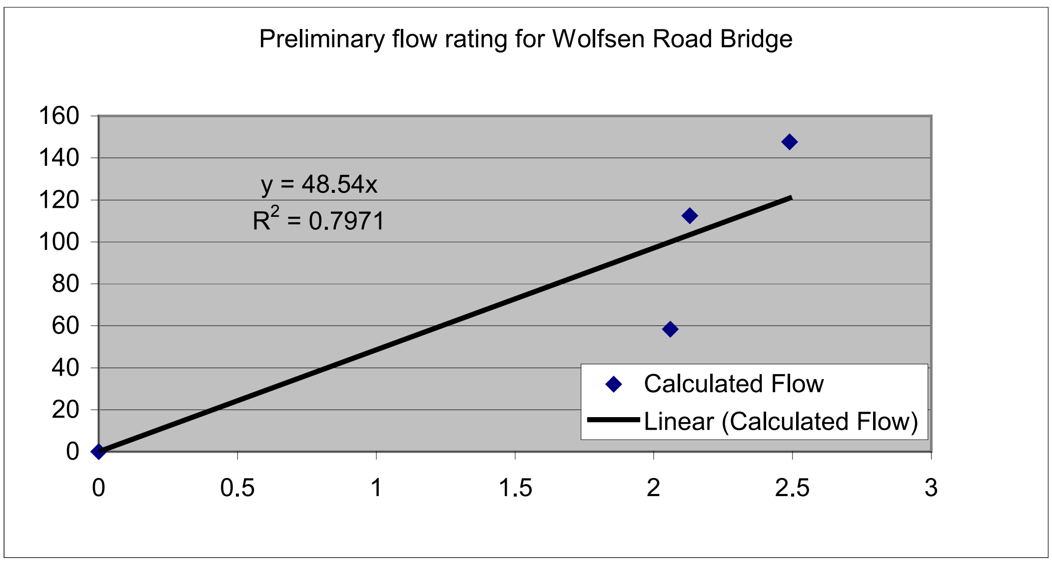
H 1.4 Site quality assurance and flow rating

Flow and electrical conductivity were checked monthly at the Wolfsen Road Station. The electrical conductivity sensor was removed from the water, cleaned, rinsed with deionized water and returned to the water. The readings after cleaning the sensor were compared to readings obtained from a Myron Ultrameter, which was calibrated in the laboratory one day prior to performing the site field quality assurance exercise. For the reporting period the electrical conductivity sensor remained within 5% of the Myron Ultrameter reading. Hence no correction needed to be made at the sensor.

One river bottom survey and three stage-discharge ratings were performed to develop a preliminary relationship between measured and actual discharge (Appendix K-1). These ratings are presented in Figure 6. The three data points shown do not fall on a straight line through the origin – the lower value may be an outlier. Several more rating experiments will need to be performed before a useable rating can be established. Flows reported in Table 2 were developed from this preliminary rating :

flow (cfs) = 48.54 * stage (feet).

Future work at the Wolfsen Road monitoring station will compare the measured discharge against the calculated discharge obtained using the stage-area relationship and the measured x-component of velocity obtained from the SONTEK acoustic velocity meter.



H 1.5. Summary

This report has documented work performed under Task 7- Installation of a New Monitoring Station at Wolfsen Rd. – as part of the directed action studies on low dissolved oxygen in the San Joaquin Deep Water Ship Channel : CALFED Project #: ERP-01-N61-02. This station will be essential to any continued work looking at algae sources within Salt Slough and will allow researchers to better understand the relative contribution of State and federal refuges to algal loading from the upper watershed.

H 6. References

Chilcott, J., L. Grober, A. Vargas, and J. Eppinger. 2000. Agricultural Drainage Contribution to Water Quality in the Grassland Watershed of Western Merced County, California: October 1997 - September 1998 (Water Year 1998). Staff Report of the California Environmental

Protection Agency, Regional Water Quality Control Board, Central Valley Region, Sacramento, CA.

Jones and Stokes Associates. 1998 (June). Potential Solutions for Achieving the San Joaquin River Dissolved Oxygen Objectives. Jones & Stokes Associates, Sacramento, CA.

Quinn N.W.T and A. Tulloch. 2002. San Joaquin River diversion data assimilation, drainage estimation and installation of diversion monitoring stations. Final Report. CALFED Project #: ERP-01-N61-02

Stringfellow, W. T. and N. W. T. Quinn. 2002. Discriminating Between West-Side Sources of Nutrients and Organic Carbon Contributing to Algal Growth and Oxygen Demand in the San Joaquin River. CALFED Bay-Delta Program, Sacramento, CA. Ernest Orlando Lawrence Berkeley National Laboratory Formal Report No. LBNL-51166. Berkeley National Laboratory, Berkeley, CA.

APPENDIX K-1

FLOW MONITORING WORKSHEET

SITE: Wolfsen road
NAME: Nigel, Jeremy
DATE: 8/15/2002
TIME: 1:30pm

Direction of Rating:

Note : The first and last flow increments are calculated using an area of A = x/2 * d. In table use the width increment immediately below the current line.

DISTANCE TO WATER ALONG CANAL LINING:
WATER DEPTH TO BED SEDIMENTS (CENTER):
CALCULATED SEDIMENT DEPTH:
GAGE HEIGHT (staff gage): 2.49

SLD dimensions
L =
D =
W =

EC Readings:
EC Readings:

HORIZ DIST (ft)	DEPTH (d) TO LINING (ft)	0.6 * DEPTH (ft) (TOP)	0.4 * DEPTH (ft) (BOT)	VEL 0.4 * D (ft/s)	VEL 0.6 * D (ft/s)	MEAN VEL (ft/s)	WIDTH INCR (x)	AREA (A = x * W)	INCREMENTAL DISCHARGE (q) q= A* MEAN (v)
0	0.00	0.00	0.00			0.000		0.00	0.00
							5		
5	0.18	0.14	0.04			0.340		0.90	0.31
							5		
10	0.75	0.60	0.15			0.560		3.75	2.10
							5		
15	0.55	0.44	0.11			0.790		2.75	2.17
							5		
20	1.34	1.07	0.27			0.960		6.70	6.43
							5		
25	1.46	1.17	0.29			1.080		7.30	7.88
							5		
30	1.93	1.54	0.39			0.920		9.65	8.88
							5		
35	1.36	1.09	0.27			0.460		6.80	3.13
							5		
40	2.01	1.61	0.40			1.420		10.05	14.27
							5		
45	2.26	1.81	0.45			1.310		11.30	14.80
							5		
50	2.54	2.03	0.51			1.380		12.70	17.53
							5		
55	2.06	1.65	0.41			1.240		10.30	12.77
							5		
60	2.73	2.18	0.55			1.630		13.65	22.25
							5		
65	3.14	2.51	0.63			1.220		15.70	19.15
							5		
70	3.03	2.42	0.61			0.780		15.15	11.82
							5		
75	1.92	1.54	0.38			0.360		9.60	3.46
							5		
80	0.85	0.68	0.17			0.150		4.25	0.64
							5		
85		0.00	0.00			0.000		0.00	0.00
							5		
90		0.00	0.00			0.000		0.00	0.00
							5		
95		0.00	0.00			0.000		0.00	0.00
							5		
100		0.00	0.00			0.000		0.00	0.00
							5		

Time

TOTAL DISCHARGE: 147.59

Discharge from AVM

MEAN - AVM: #DIV/0!

TOTAL DISCHARGE:

FLOW MONITORING WORKSHEET

SITE: Wolfsen road
NAME: Nigel, Jeremy
DATE: 8/25/2002
TIME: 12:00pm

Direction of Rating

Note : The first and last flow increments are calculated using an area of A = x/2 * d. In table use the width increment immediately below the current line.

DISTANCE TO WATER ALONG CANAL LINING:
WATER DEPTH TO BED SEDIMENTS (CENTER):
CALCULATED SEDIMENT DEPTH:
GAGE HEIGHT (staff gage): 2.13

SLD dimensions
L =
D =
W =

EC Readings:
EC Readings:

HORIZ DIST (ft)	DEPTH (d) TO LINING (ft)	0.6 * DEPTH (ft) (TOP)	0.4 * DEPTH (ft) (BOT)	VEL 0.4 * D (ft/s)	VEL 0.6 * D (ft/s)	MEAN VEL (ft/s)	WIDTH INCR (x)	AREA (A = x * W)	INCREMENTAL DISCHARGE (q) q= A* MEAN (v)
0	0.00	0.00	0.00			0.000		0.00	0.00
							5		
5	0.00	0.00	0.00			0.000		0.00	0.00
							5		
10	0.35	0.28	0.07			0.330		1.75	0.58
							5		
15	0.12	0.10	0.02			0.160		0.60	0.10
							5		
20	0.49	0.39	0.10			0.680		2.45	1.67
							5		
25	1.17	0.94	0.23			1.020		5.85	5.97
							5		
30	1.53	1.22	0.31			0.940		7.65	7.19
							5		
35	0.99	0.79	0.20			0.650		4.95	3.22
							5		
40	1.73	1.38	0.35			1.230		8.65	10.64
							5		
45	1.96	1.57	0.39			1.280		9.80	12.54
							5		
50	1.95	1.56	0.39			1.390		9.75	13.55
							5		
55	1.86	1.49	0.37			1.070		9.30	9.95
							5		
60	2.31	1.85	0.46			1.630		11.55	18.83
							5		
65	2.68	2.14	0.54			0.950		13.40	12.73
							5		
70	2.59	2.07	0.52			0.980		12.95	12.69
							5		
75	1.53	1.22	0.31			0.360		7.65	2.75
							5		
80	0.35	0.28	0.07			0.040		1.75	0.07
							5		
85		0.00	0.00			0.000		0.00	0.00
							5		
90		0.00	0.00			0.000		0.00	0.00
							5		
95		0.00	0.00			0.000		0.00	0.00
							5		
100		0.00	0.00			0.000		0.00	0.00
							5		

Time

TOTAL DISCHARGE: 112.47

Discharge from AVM

MEAN - AVM: #DIV/0!

TOTAL DISCHARGE:

FLOW MONITORING WORKSHEET

SITE: Salt Slough at Wolfson Rd.
NAME: Nigel, Jeremy
DATE: Oct. 2, 2002
TIME: 3:00pm

Direction of Rating:

Note : The first and last flow increments are calculated using an area of A = x/2 * d. In table use the width increment immediately below the current line.

DISTANCE TO WATER ALONG CANAL LINING:
WATER DEPTH TO BED SEDIMENTS (CENTER):
CALCULATED SEDIMENT DEPTH:
GAGE HEIGHT (staff gage): 2.06

SLD dimensions
L =
D =
W =

EC Readings:
EC Readings:

HORIZ DIST (ft)	DEPTH (d) TO LINING (ft)	0.6 * DEPTH (ft) (TOP)	0.4 * DEPTH (ft) (BOT)	VEL 0.6 * D (ft/s)	VEL 0.4 * D (ft/s)	MEAN VEL (ft/s)	WIDTH INCR (x)	AREA (A = x * W)	INCREMENTAL DISCHARGE (q) q= A* MEAN (v)
0	0.00	0.00	0.00		0.00	0.000			
							5		
5	0.00	0.00	0.00		0.00	0.000		0.00	0.00
							5		
10	0.15	0.09	0.06		0.06	0.060		0.75	0.05
							5		
15	0.15	0.09	0.06		0.06	0.060		0.75	0.05
							5		
20	0.84	0.50	0.34		0.33	0.330		4.20	1.39
							5		
25	1.09	0.65	0.44		0.41	0.410		5.45	2.23
							5		
30	1.48	0.89	0.59		0.56	0.560		7.40	4.14
							5		
35	0.89	0.53	0.36		0.35	0.350		4.45	1.56
							5		
40	1.51	0.91	0.60		0.60	0.600		7.55	4.53
							5		
45	1.75	1.05	0.70		0.70	0.700		8.75	6.13
							5		
50	1.58	0.95	0.63		0.65	0.650		7.90	5.14
							5		
55	1.39	0.83	0.56		0.56	0.560		6.95	3.89
							5		
60	1.85	1.11	0.74		0.72	0.720		9.25	6.66
							5		
65	2.23	1.34	0.89		0.88	0.880		11.15	9.81
							5		
70	2.09	1.25	0.84		0.83	0.830		10.45	8.67
							5		
75	1.42	0.85	0.57		0.56	0.560		7.10	3.98
							5		
80	0.20	0.12	0.08		0.08	0.080		1.00	0.08
							5		
85		0.00	0.00		0.00	0.000		0.00	0.00
							5		
90		0.00	0.00		0.00	0.000		0.00	0.00
							5		
95		0.00	0.00		0.00	0.000		0.00	0.00
							5		
100		0.00	0.00		0.00	0.000		0.00	0.00
							5		

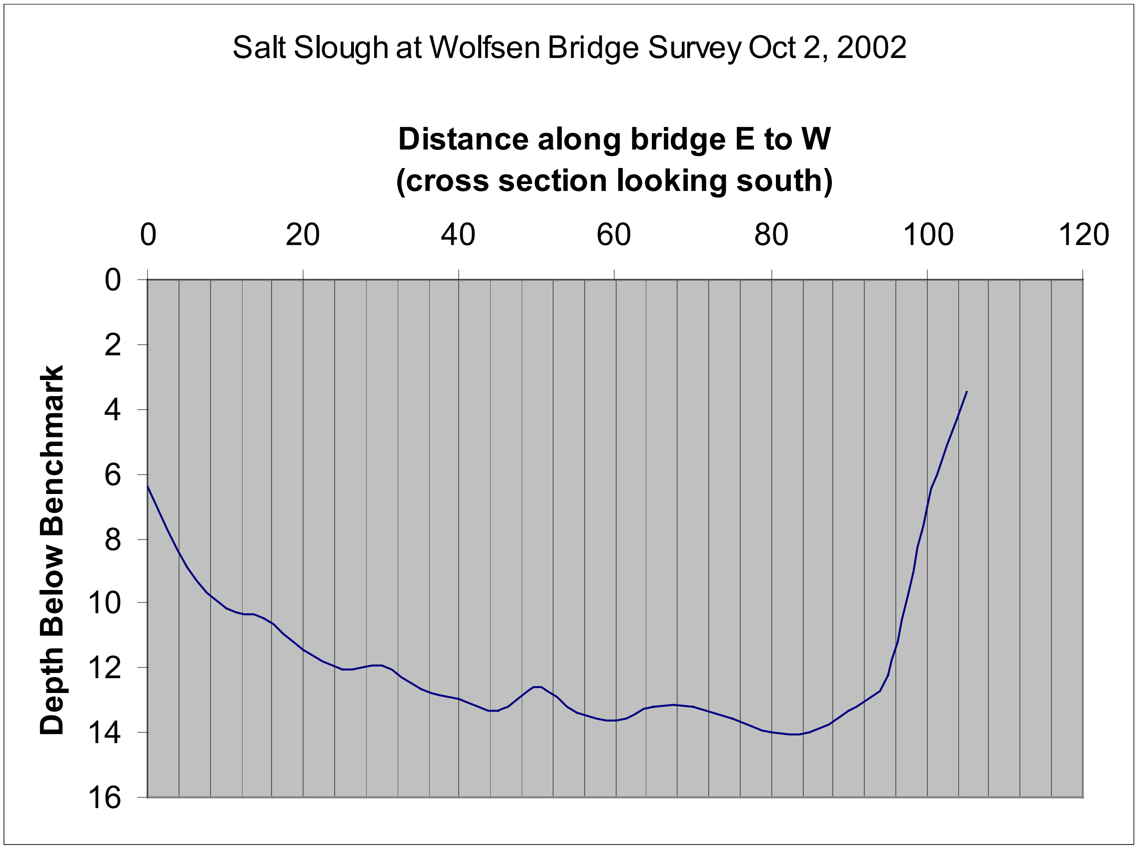
Time

TOTAL DISCHARGE: 58.30

Discharge from AVM

MEAN - AVM: #DIV/0!

TOTAL DISCHARGE:


Salt Slough at Wolfsen Bridge Survey Oct 2, 2002
Distance along bridge E to W
(cross section looking south)
0
20
40
60
80
100
120
Depth Below Benchmark
0
2
4
6
8
10
12
14
16