Title

San Joaquin River Up-Stream DO TMDL Project Task 4: Monitoring Study Interim Task Report

#3

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Task 4: Monitoring Study

Interim Task Report # 3

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List of Acronyms

Acronyms/Abbreviations	Description
Algal pigments	Chlorophyll-a and pheophytin
BOD	Biochemical oxygen demand
CBOD	Carbonaceous biochemical oxygen demand
CDEC	California Data Exchange Center
CEQA	California Environmental Quality Act
Chl-a	Chlorophyll-a
Chl-a by SM	Chlorophyll-a by spectrophotometric method
Chl-a by TC	Chlorophyll-a measured by the trichromatic method
CV	Coefficient of variation (%)
CVRWQCB	Central Valley Regional Water Quality Control Board
CWI	California Water Institute
DO	Dissolved oxygen
DOC	Dissolved organic carbon
DOM	Dissolved organic matter
DWR	California Department of Water Resources
DWSC	Deep water ship channel
EC	Specific conductance
EERP	Environmental Engineering Research Program
GPS	Global Positioning System
ID	Irrigation District
IEP	Interagency Ecological Program
Max	maximum value
Mean	Mean value or average
mg/L	Milligrams per liter
Min	Minimum value
MSS	Mineral suspended solids
MS	
N	Number of values
NBOD	Nitrogenous BOD
NEPA	National Environmental Policy Act
NH4-N	Ammonia nitrogen
NO3-N	Nitrate nitrogen
NPDES	National Pollutant Discharge Elimination System
NTU	Nephelometric turbidity units
ODS	Oxygen-depleting substance
oPO4-P	soluble reactive ortho-phosphate phosphorous
PI	Principal Investigator
POM	Particulate organic carbon
ppb	Parts per billion
PRR	Peer Review Recommendation
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
RWQCB	Regional Water Quality Control Board

Acronyms/Abbreviations	Description
SCADA	Supervisory Control and Data Acquisition
SCUFA	Self-Contained Underwater Fluorescence Apparatus
SJR	San Joaquin River
SJRGA	San Joaquin River Group Authority
SJVDA	San Joaquin Valley Drainage Authority
SM	Standard Method
Sonde Chl-a corr for TriC	Chlorophyll-a measured by sonde, calibrated to Chl-a by TC, considered the most reliable estimation of algal biomass
Spec Cond	Specific conductance
SR	Stakeholder Recommendation
Std Dev	Standard deviation
TAC	Technical Advisory Committee
T-Alk	Total alkalinity (pH 4.5)
TMDL	Total maximum daily load
TOC	Total organic carbon
Total-P	Total phosphorous
Tol P	
TP	
TSS	Total suspended solids
UCB	University of California, Berkeley
UCD	University of California, Davis
ug/L	micrograms per liter
μg/L	
UOP	University of the Pacific
USGS	U.S. Geological Survey
VSS	Volatile suspended solids
WWTP	Wastewater treatment plant

Chapter 1

INTRODUCTION & OVERVIEW OF TASK 4

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Introduction

The purpose of the Dissolved Oxygen Total Maximum Daily Load Project (DO TMDL Project) is to provide a comprehensive understanding of the sources and fate of oxygen-consuming materials in the San Joaquin River (SJR) watershed between Channel Point and Lander Avenue (upstream SJR). When completed, this study will provide the stakeholders an understanding of the baseline conditions of the basin, provide input for an allocation decision, and provide the stakeholders with a tool for measuring the impact of any water quality management program that may be implemented as part of the DO TMDL process.

Previous studies have identified algal biomass as the most significant oxygen-demanding substance in the DO TMDL Project study-area between of Channel Point and Lander Ave on the SJR. Other oxygen-demanding substances found in the upstream SJR include ammonia and organic carbon from sources other than algae. The DO TMDL Project study-area contains municipalities, dairies, wetlands, cattle ranching, irrigated agriculture, and industries that could potentially contribute biochemical oxygen demand (BOD) to the SJR. This study is designed to discriminate between algal BOD and other sources of BOD throughout the entire upstream SJR watershed. Algal biomass is not a conserved substance, but grows and decays in the SJR; hence, characterization of oxygen-demanding substances in the SJR is inherently complicated and requires an integrated effort of extensive monitoring, scientific study, and modeling.

In order to achieve project objectives, project activities were divided into a number of Tasks with specific goals and objectives. In this report, we present the results of monitoring and research conducted under Task 4 of the DO TMDL Project. The major objective of Task 4 is to collect sufficient hydrologic (flow) and water quality (WQ) data to characterize the loading of algae, other oxygen-demanding materials, and nutrients from individual tributaries and sub-watersheds of the upstream SJR between Mossdale and Lander Avenue. This data is specifically being collected to provide data for the Task 6 Modeling effort. Task 4 provides input and calibration data for flow and WQ modeling associated with the low DO problems in the SJR watershed, including modeling on the linkage among nutrients, algae, and low DO. Task 4 is providing a higher volume of high quality and coherent data to the modeling team than was available in the past for the upstream SJR. The monitoring and research activities under Task 4 are integrated with the Modeling effort (Task 6) and are not designed to be a stand alone program. Although, the majority of analysis of the Task 4 data is occurring as part of the Task 6 Modeling program, analysis of Task 4 data independently of the modeling effort is also an important component of the DO TMDL Project effort.

In this report, we present the results of monitoring and research conducted under Task 4. The major purposes of this report are to 1) document activities undertaken as part of the DO TMDL Project; 2) organize electronic data for delivery to State agencies, stakeholders and principal investigators (cooperators) on the DO TMDL Project; 3) provide a summary analysis of the data for reference and to assist stakeholders in planning watershed activities in response to the DO TMDL requirements; and 5) provide a preliminary scientific interpretation independently of the Task 6 Modeling effort. Due to the extensive scope of the Task 4 portion of the DO TMDL Project, the Task 4 March 2007 Interim Report is divided into a numbers of chapters and associated appendixes designed to be able to stand independently of each other. The purpose of this chapter is to provide an overview of Task 4 data collection and to explain the structure of the overall report.

Methods

The DO TMDL Project was developed under the auspices of CALFED Bay-Delta Program and was originally funded by the California Bay Delta Authority (CBDA) in a contract with the San Joaquin Valley Drainage Authority (SJVDA). In 2006, the project was moved from CBDA to the Department of Fish and Game (DFG). The project is administered by GCAP Services, Inc., which accepts deliverables on behalf of the State. SJVDA has subcontracted to the Environmental Engineering Research Program (EERP) at the University of the Pacific to be the lead scientific agency for the DO TMDL Project. Lawrence Berkeley National Laboratory (LBNL), University of California Davis (UCD), the San Joaquin River Group Authority (SJRGA) and SJVDA are cooperating participants on Task 4. This report and associated electronic files represent the major annual deliverable for Task 4.

Chapters 2, 3, and 8 and Appendixes D were written primarily to document programmatic progress under the Task 4 research effort. Chapter 2 describes the methods used for data collection and the results of the Task 4 quality assurance program. Chapter 3 and Appendix D describes and documents field research activities undertaken by the Environmental Engineering Research Program (EERP) at the University of the Pacific. Chapter 8 documents activities associated with the collection of continuous chlorophyll concentration data at critical locations on the SJR.

Chapters 1, 2, 4, and 5 and Appendixes A, B, C, E, F, and G were written to assist in the transfer of electronic data from the DO TMDL Program to cooperators on the project and to provide a summary analysis of the data for reference. These chapters and Appendixes also serve to document the extensive programmatic effort associated with Task 4.

Chapters 4, 5, 6, and 7 provide scientific analysis of the Task 4 data independently of the Task 6 Modeling effort. Other scientific analysis are in progress and will be included in subsequent reports. The Project plan is to collect three years of data (2005, 2006, and 2007) and to present a final scientific analysis in 2008. This report is a interim deliverable on the project and scientific analysis presented here is considered preliminary in nature.

The Task 4 data is being provided to the State contracting agency (GCAP) in electronic form. Electronic data is available to other cooperators as a data down-load from a FTP-site or will be provided on CD if requested. Additionally, the data will be provided to the Interagency Ecological Program (IEP) for entry in their database and dissemination to cooperators. The IEP is a cooperator on the DO TMDL Project.

Results and Discussion

In 2005 and 2006, WQ grab samples were collected at ninety-seven locations in the SJR valley (Table 1). The sites were selected from a potential list of 120 sites identified in an initial site survey conducted in 2002. Stations were selected based on their importance to the establishment of a sustainable monitoring program; sites useful for conducting a mass balance on algal, BOD and nutrients in the upstream SJR; sites included in other monitoring and research programs; sites included as part of watershed surveys and sites of importance and relevance to water quality modeling. All the sites include in 2005 sampling were upstream of tidal influences, with the exception of Mossdale Landing (DO-4) which is accepted as the upper limit of the tidal reach and was included to allow connection between riverine and tidal models being developed for the SJR.

Twenty sites were designated "core" sites these sites were sampled approximately every two weeks during the irrigation season and monthly during the winter season. These sites represent the main stem of the SJR, the major tributaries, and significant Drainages from both the east- and west-sides of the SJR. Figure 1 shows the location of the core sites.

Sampling at other sites was less frequent and was conducted with the objective of building a data base to allow statistical comparison between different Drainage areas or to conduct longitudinal studies in specific Drainages. A statistical comparison between Drainages is useful for optimizing the long-term monitoring plan and for resolving outstanding issues concerning the validity of modeling smaller tributaries based on WQ results from larger tributaries. The locations of the intermittent sites is shown in Figure 2.

Summary statistics for selected WQ parameters for data collected in 2005 and 2006 are presented in Appendix A. Measurements on additional parameters are included in the complete data set presented in the electronic data delivery (Appendix F). A complete list of all parameters measured and included in Appendix F is presented in Table 2. Table 2 lists the column headings of the data contained in Appendix F. All the WQ data presented in Appendixes A and F were collected under the Task 4 QA/QC program and are considered high quality data. Preliminary analysis of this data is presented in Chapters 4 and 5.

In addition to grab sample analysis, flow data was collected throughout the SJR in 2006. Summary statistics for all available flow data are presented in Table 3. Continuous flow data is organized into Excel files which include a report cover describing the flow station; QA/QC data (if available); raw data; and reviewed data that is considered the best available (Appendix G). The daily average flows for 2006 continuous monitoring stations are plotted and presented graphically in Appendix B. Ratings for flow stations maintained by EERP and cooperators are presented as Appendix C and these stations have known quality ratings. Data from sites not maintained by EERP were provided by cooperators or collected from CDEC and are of unknown quality. Specifically, backflow conditions existed at many tributaries for much of the spring and high flows reported for April at sites such as Salt Slough at Lander and Orestimba Creek at River Road (Appendix B, Figure 15 and 17) are questionable. For comparison, see flows reported for Salt Slough at Wolfsen Road (Appendix B, Figure 41) which is just up-stream of Salt Slough at Lander and is maintained by EERP.

In most locations where flow and WQ are monitored, specific conductance (EC) data are collected. Summary statistics for all available EC data are presented in Table 4. Supporting data for EC are presented in Appendixes A, C, F, and G. Although EC data is generally robust, the reporting of data for sites such as the Tuolumne River (Table 4) suggest that further refinement of the data is needed before the data is used in modeling. Further processing of the EC data will be conducted as part of Task 6.

In summary, the Task 4 effort has been very successful with the collection of a complete, well documented, and high quality data set. Scientific analysis of this data under both Task 4 and Task 6 is in progress and will be completed within the contract period (by 2008). Preliminary analysis indicates that the results of Task 4 will provide the information needed by the cooperators to implement a scientific TMDL. Tools to assist cooperators with the interpretation of Task 4 data are being proposed (Chapter 4) and will be evaluated further in the coming year.

Figure 1: Location of the water quality sampling stations included in the core sampling program.

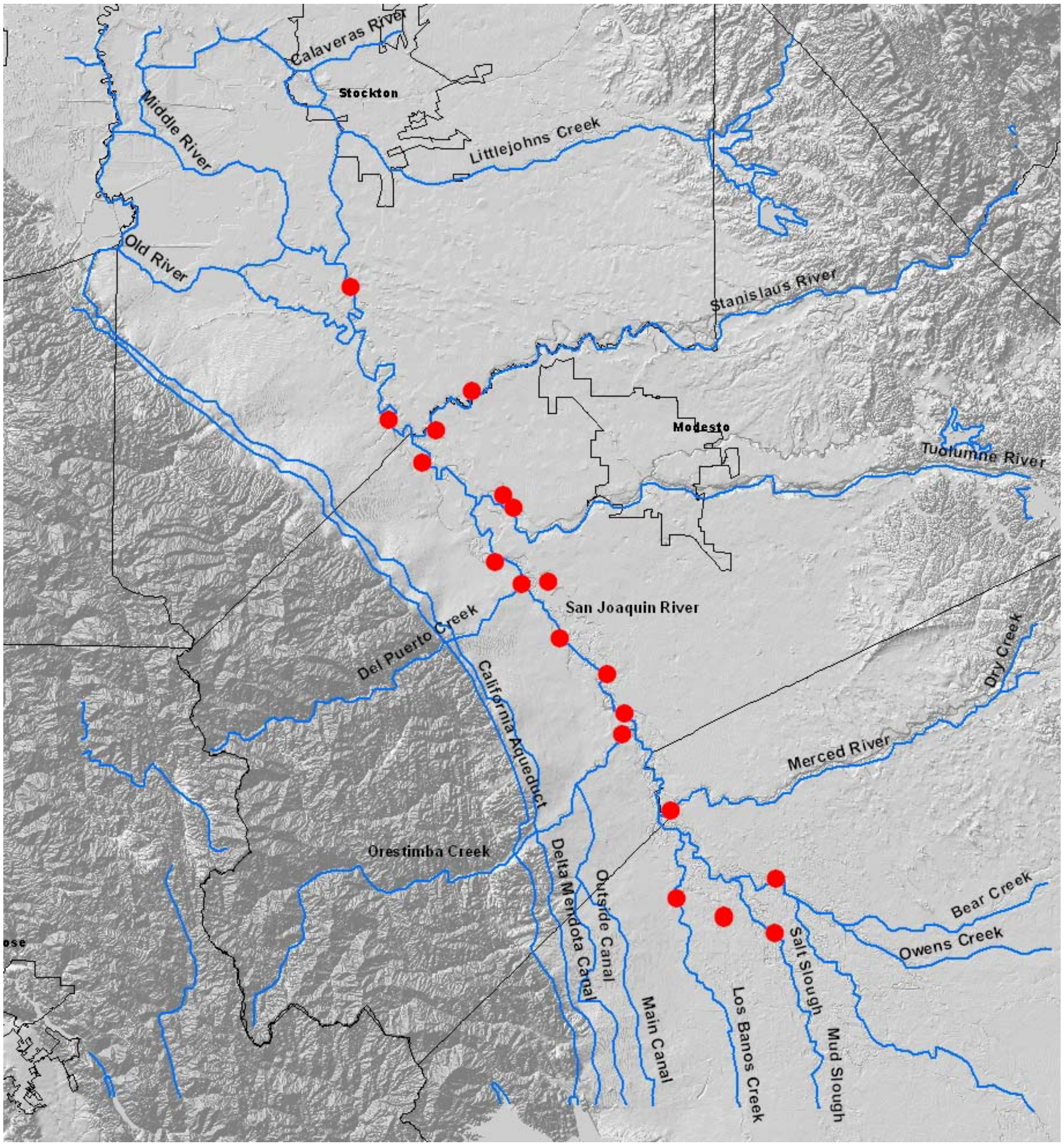

Figure 2: Location of the water quality sampling stations included in the intermittent sampling program.

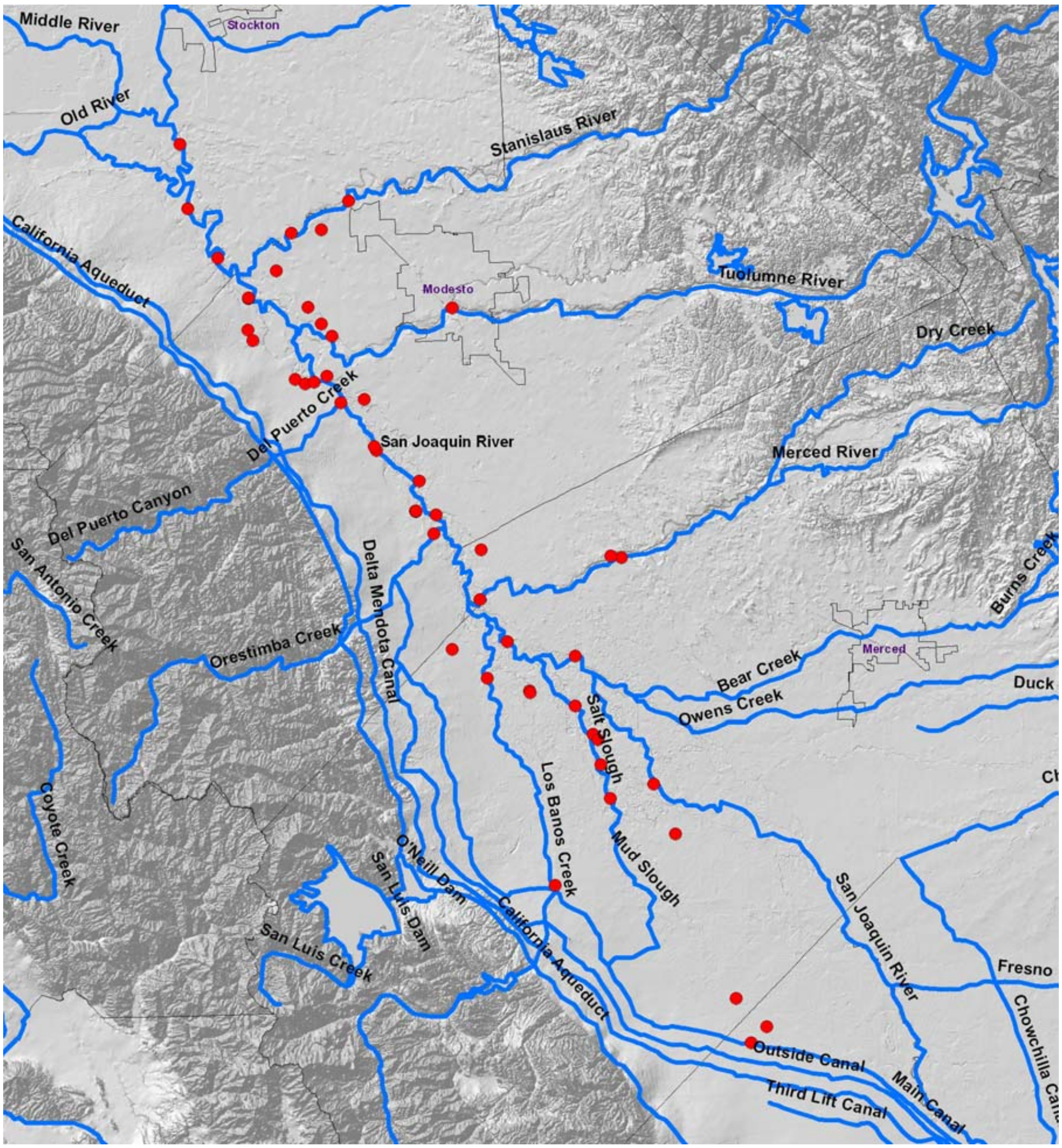

Table 1: List of sample sites included in the Task 4 water quality sampling activities for 2005 and 2006. Site degree indicates the relationship of the sample station to the San Joaquin River (SJR) and other sample stations. Measurements at primary (1^o) stations are presumed to connect to the river stations (0^o) without passing any other water quality measurement station. Sampling locations labeled as "2" and "3" degree convey water that passes through two or three other sampling locations before reaching the SJR. Sample locations of "4" degree are watershed sites four or more stations away from the SJR. Negative sites are diversions.

DO Site Number	Sample Station Name	Site Degree	Latitude	Longitude
1	**SJR at Channel Point**	0	37.95027	-121.33715
2	**SJR at Dos Reis Park**	0	37.83053	-121.31107
3	**SJR at Old River (DWR Lathrop)**	0	37.81082	-121.32392
4	**SJR at Mossdale**	0	37.78710	-121.30757
5	**SJR at Vernalis-McCune Station**	0	37.67936	-121.26504
6	**SJR at Maze**	0	37.64142	-121.22902
7	**SJR at Patterson**	0	37.49373	-121.08081
8	**SJR at Crows Landing**	0	37.43197	-121.01165
9	**SJR at Fremont Ford**	0	37.30985	-120.93055
10	**SJR at Lander Avenue**	0	37.29424	-120.85125
11	**French Camp Slough**	1	37.91613	-121.30447
12	**Stanislaus River at Caswell Park**	1	37.70160	-121.17719
13	**Stanislaus River at Ripon**	2	37.73113	-121.10811
14	**Tuolumne River at Shiloh Bridge**	1	37.60350	-121.13125
15	**Tuolumne River at Modesto**	2	37.62722	-120.98742
16	**Merced River at River Road**	1	37.35043	-120.96196
17	**Merced River near Stevinson**	2	37.38730	-120.79366
18	**Mud Slough near Gustine**	1	37.26250	-120.90555
19	**Salt Slough at Lander Avenue**	1	37.24795	-120.85194
20	**Los Banos Creek Flow Station**	1	37.27546	-120.95532
21	**Orestimba Creek at River Road**	1	37.41396	-121.01488
22	**Modesto ID Lateral 4 to SJR**	1	37.63057	-121.15888

DO Site Number	Sample Station Name	Site Degree	Latitude	Longitude
23	**Modesto ID Lateral 5**	1	37.61452	-121.14339
24	**Modesto ID Lateral 6**	1	37.70383	-121.14143
25	**Modesto ID Main Drain**	1	37.67026	-121.21904
26	**Turlock ID Highline Spill**	1	37.38921	-120.80568
27	**Turlock ID Lateral 2 to SJR**	1	37.56522	-121.13836
28	**Turlock ID Westport Drain**	1	37.54196	-121.09408
29	**Turlock ID Harding Drain**	1	37.46427	-121.03093
30	**Turlock ID Lateral 6 & 7 at Levee**	1	37.39782	-120.97225
31	**BCID - New Jerusalem Drain**	1	37.72669	-121.29963
32	**El Solyo WD - Grayson Drain**	1	37.58563	-121.17699
33	**Hospital Creek**	1	37.61029	-121.23082
34	**Ingram Creek**	1	37.60026	-121.22506
35	**Westley Wasteway Flow Station**	1	37.55818	-121.16375
36	**Del Puerto Creek Flow Station**	1	37.53947	-121.12206
38	**Marshall Road Drain**	1	37.43605	-121.03600
43	**El Solyo Water District Diversion**	-1	37.64011	-121.22949
44	**San Luis Drain End**	2	37.26090	-120.90520
45	**Volta Wasteway at Ingomar Grade**	3	37.10528	-120.93643
46	**Mud Slough at Gun Club Road**	2	37.23145	-120.89923
48	**FC-5 - Grassland Area Farmers**	4	36.92428	-120.65411
49	**PE-14 - Grasslands Area Farmers**	4	36.93884	-120.63555
50	**San Luis Drain Site A**	4	36.96660	-120.67060
52	**Salt Slough at Sand Dam**	4	37.12415	-120.73735
53	**Salt Slough at Wolfsen Road**	2	37.15937	-120.81292
54	**Los Banos Creek at Ingomar Grade**	2	37.07780	-120.88046
57	**Ramona Lake Drain**	1	37.47881	-121.06850
59	**SJR Laird Park**	0	37.55731	-121.15011
60	**Moffit 1 South**	2	37.22068	-120.83178

DO Site Number	Sample Station Name	Site Degree	Latitude	Longitude
61	**Deadmans Slough**	2	37.21531	-120.82629
62	**Mallard Slough**	2	37.19187	-120.82379
63	**Inlet C Canal**	3	37.17224	-120.7616
64	**Moran Drain**	1	37.43547	-121.03551
65	**Spanish Grant Drain**	1	37.43576	-121.03581
66	**ESWD Maze Blv. Drain**	1	37.64060	-121.22925
67	**Newman Wasteway at Brazo Road**	1	37.30378	-120.99632
68	**S-Lake Basin**	2	37.25326	-120.91793
69	**Santa Fe Canal**	3	37.24717	-120.91510
84	**SJR at Garwood Bridge**	0	37.92819	-121.32843
86	**Ramona Drain Apple Ave**	4	37.44474	-121.04405
87	**Ramona Drain Prune Ave**	4	37.45147	-121.04642
88	**Ramona Drain Apricot Ave**	4	37.46078	-121.06255
89	**Ramona Drain Pomelo Ave**	4	37.46547	-121.07030
90	**Ramona Drain Almond Ave**	4	37.47432	-121.06919
91	**Paradise Drain Prune Ave**	4	37.45533	121.04750
92	**Paradise Drain Apricot Ave**	4	37.46436	-121.05387
93	**Paradise Drain Pomelo Ave**	4	37.46900	-121.05387
94	**Paradise Drain Almond Ave**	4	37.47398	-121.06686
95	**Ramona Drain at Ramona Lake**	4	37.47398	-121.06686
96	**WPF-VD-1**	4	37.44346	-121.05474
97	**WPF-VD-2**	4	37.44430	-121.05282
98	**WPF-VD-3**	4	37.44515	-121.05099
101	**WPF-UD-IN**	4	37.44346	-121.05474
102	**WPF-UD-OUT**	4	37.44688	-121.04724
103	**SLD Check 18**	4	36.96013	-120.66275
104	**SLD Check 16**	4	36.98261	-120.69002
105	**SLD Check 15**	4	36.98901	-120.70459

DO Site Number	Sample Station Name	Site Degree	Latitude	Longitude
106	**SLD Check 14**	4	36.99981	-120.72400
107	**SLD Check 13**	4	37.00737	-120.73754
108	**SLD Check 12**	4	37.01070	-120.74387
109	**SLD Check 11**	4	37.03939	-120.77164
110	**SLD Check 10**	4	37.05537	-120.78780
111	**SLD Check 9**	4	37.07150	-120.80380
112	**SLD Check 8**	4	37.09966	-120.82168
113	**SLD Check 7**	4	37.10600	-120.82028
114	**SLD Check 6**	4	37.11795	-120.81778
115	**SLD Check 5**	4	37.14673	-120.82385
116	**SLD Check 4**	4	37.17693	-120.83313
117	**SLD Check 3**	4	37.20752	-120.84597
118	**SLD Check 2**	4	37.21507	-120.85081
119	**SLD Check 1**	4	37.23127	-120.87577
120	**South Marsh-1-Intermediary**	4	37.18234	-120.78642
121	**South Marsh-1-East**	4	37.18411	-120.79002
122	**South Marsh-1-West**	4	37.18261	-120.79272
123	**Ramona Lake NW Quad**	4	37.47697	-121.07071
124	**Ramona Lake NE Quad**	4	37.47750	-121.06954

End Table 1

Table 2: List of environmental and water quality parameters included in Appendix F and location of parameter columns Appendix F data file. Summary statistics for selected locations and selected parameters are presented in Appendix A.

Column Headings in Appendix F	Excel Column Location
Entry Number	A
DO site number	B
Sample ID	C
Site name	D
Day Number	E
Sample Date	F
Time -hour	G
River Mile (approximate)	H
Site relation to river (degree)	I
North (latitude)	J
West (longitude, negative value)	K
Flow-Number of measurements (n)	L
Flow- Average Daily (cfs) (<3.0 not reportable) (red is estimate)	M
Flow- Minimum Daily (cfs) (<3.0 not reportable)	N
Flow-Maximum Daily (cfs) (<3.0 not reportable)	O
Flow- Instantaneous (cfs) (<3.0 not reportable)	P
Flow- Standard Deviation	Q
Station EC- Number of measurements (n)	R
Station EC- Average Daily (uS/cm)	S
Station EC- Minimum Daily (uS/cm)	T
Station EC- Maximum Daily (uS/cm)	U
Station EC- Instantaneous (uS/cm)	V
Station EC-Standard Deviation	W
Stage- Number of measurements (n)	X
Stage- Average Daily (ft)	Y
Stage- Minimum Daily (ft)	Z

Column Headings in Appendix F	Excel Column Location	
Stage- Maximum Daily (ft)	A	A
Stage- Instantaneous (ft)	A	B
Stage- Standard Deviation	A	C
Temp C	A	D
Spec Cond mS/cm	A	E
TDS g/L	A	F
DO%	A	G
DO mg/L	A	H
DO Charge	A	I
Depth ft	A	J
pH	A	K
ORP mV	A	L
Sonde Turbidity NTU (values to 800 reported) or HACH	A	M
Sonde Fluorescence, %FS (values to 100 reported)	A	N
Sonde Chl-a corr for TriC (8.54) ug/L (red is TC value)	A	O
Sonde Chl-a corr for SM (7.73) ug/L (red is SM value)	A	P
PAR (Flat) Quantum Detector umole photons/sec/m2 (red calc from LUX)	A	Q
LUX (lumen /m2)	A	R
8.3 Alk, mg CaCO3/L (<2.0 not reportable)	A	S
4.5 Alk, mg CaCO3/L (<2.0 not reportable)	A	T
Total Organic Carbon, mg/L (<1.0 not reportable)	A	U
Dissolved Organic Carbon, mg/L (<1.0 not reportable)	A	V
UOP Total Nitrogen	A	W
UOP Dissolved Nitrogen	A	X
VSS + DOC mg/L	A	Y
VSS, mg/L (<5.0 not reportable)	A	Z
TSS, mg/L (<5.0 not reportable)	B	A
Mineral Solids mg/L (<5.0 not reportable)	B	B

Column Headings in Appendix F	**Excel Column Location**	
UoP Nitrate-N mg/L (<0.03 not reportable)	B	C
UoP Total Ammonia-N mg/L (<0.06 not reportable)	B	D
UoP Soluble Phosphate as P, (0.7 micron filter) mg/L (<0.03 not reportable)	B	E
UoP Total P mg/L	B	F
UoP Total Fe mg/L (<0.02 not reportable)	B	G
UC Davis Total-N mg/L (<0.05 not reportable)	B	H
UC Davis NH4-N, (0.2 micron filter) mg/L (<0.01 not reportable)	B	I
UC Davis NO3-N, (0.2 micron filter) mg/L (<0.02 not reportable)	B	J
UC Davis Total-P mg/L (<0.01 not reportable)	B	K
UC Davis PO4-P (0.2 micron filter) mg/L (<0.002 not reportable)	B	L
BOD by SM mg/L (<1.0 not reportable)	B	M
CBOD by SM mg/L (<1.0 not reportable)	B	N
NBOD by SM mg/L (<1.0 not reportable)	B	O
Total Protein- Unfiltered mg/L (<1.0 not reportable)	B	P
Soluble Protein- Filtered (0.7 micron Filter) mg/L (<1.0 not reportable)	B	Q
Parti-culate Protein mg/L	B	R
Chl-a SM ug/L (<1.2 not reportable)	B	S
Pheophyton SM ug/L (<1.2 not reportable)	B	T
Algal pigments SM ug/l (Chl + Pheo) (<1.2 not reportable)	B	U
Chl-a TriChrom ug/L (<1.0 not reportable)	B	V
Chl-b TriChrom ug/L (<1.3 not reportable)	B	W
Chl-c TriChrom ug/L (<1.5 not reportable)	B	X

End Table 2

Table 3: Summary statistics for available flow data for DO TMDL Project Sites. Additional flow data and supporting information are available in Appendixes B, C, and G.

DO Site	Site name	N flow	Mean flow (CFS)	Min flow (CFS)	Max flow (CFS)	Std Dev flow
1	**SJR at Channel Point**	21892	4625	-3562	16089	4673
2	**SJR at Dos Reis Park**	21892	4625	-3562	16089	4673
3	**SJR at Old River (DWR Lathrop)**	34674	-283	-12256	15010	8410
4	**SJR at Mossdale**	34654	9012	4	29425	7408
5	**SJR at Vernalis**	34605	10348	690	36098	9190
6	**SJR at Maze**	342	8423	1168	34077	8102
7	**SJR at Patterson**	34925	4936	675	27953	5857
8	**SJR at Crows Landing**	34172	4857	716	34300	5676
9	**SJR at Fremont Ford**	34201	2165	131	21600	3189
10	**SJR at Lander Avenue**	34411	2743	0	23438	4841
12	**Stanislaus River at Caswell Park**	34680	2198	453	6270	1466
13	**Stanislaus River at Ripon**	34680	2198	453	6270	1466
14	**Tuolumne River at Shiloh Bridge**	31003	3229	60	11400	2531
15	**Tuolumne River at Modesto**	31003	3229	60	11400	2531
16	**Merced River at River Road**	14578	2845	595	6045	1548
17	**Merced River near Stevinson**	14578	2845	595	6045	1548
18	**Mud Slough near Gustine**	34132	266	24	1140	213
19	**Salt Slough at Lander Avenue**	34655	440	40	2150	424
20	**Los Banos Creek at HW 140**	11440	49	3	131	25
21	**Orestimba Creek at River Road**	32218	64	0	3190	234
22	**MID Lateral 4 to SJR**	6139	14	0	90	17
23	**MID Lateral 5 to Tuolumne**	6140	24	0	113	20
24	**MID Lat 6 to Stanislaus River**	6140	42	0	125	24

DO Site	Site name	N flow	Mean flow (CFS)	Min flow (CFS)	Max flow (CFS)	Std Dev flow
25	**MID Main Drain to Stan. R. via Miller Lake**	3581	16	0	208	15
26	**TID Highline Spill**	365	14	0	67	18
27	**TID Lateral 2**	365	5	0	35	7
28	**TID Westport Drain Flow Station**	best est.	30	5	50	
29	**TID Harding Drain**	365	34	4	92	15
30	**TID Lateral 6 & 7 at Levee**	365	14	0	55	12
31	**BCID - New Jerusalem Drain**	12949	7	0	19	5
32	**El Solyo WD - Grayson Drain**	best est.	10	0	20	
33	**Hospital Creek**	35040	2	0	15	3
34	**Ingram Creek**	35040	6	0	31	7
35	**Westley Wasteway Flow Station**	9037	2	0	33	2
36	**Del Puerto Creek Flow Station**	23459	10	0	49	9
38	**Marshall Road Drain**	18258	4	0	48	3
40	**Patterson Irrigation District (diversions)**	3909	90	0	153	44
41	**West Stanislaus Irrigation District (diversions)**	183	92	0	192	52
42	**Banta Carbona Irrigation District (diversions)**	364	67	0	254	82
43	**El Solyo Pumping Station (diversions)**	12	16	0	50	19
44	**San Luis Drain End**	35902	36	11	179	13
45	**Volta Wasteway**	31650	82	1	492	81
46	**Mud Slough at Gun Club Road**	31911	34	-1	131	29
49	**PE-14 Grasslands Area Farmers**	35040	19	5	76	10
50	**San Luis Drain Site A (Check 18)**	34922	32	7	191	14
53	**Salt Slough at Wolfsen Road**	29957	203	19	452	91

DO Site	Site name	N flow	Mean flow (CFS)	Min flow (CFS)	Max flow (CFS)	Std Dev flow
54	**Los Banos Creek at Ingomar Grade**	best est.	5	0	10	
55	**Modesto WWTP**	NPDES	45			
56	**Turlock WWTP**	NPDES	20			
57	**Ramona Lake Drain**	best est.	20	0	30	
59	**SJR Laird Park**	342	5219	716	27255	5944
60	**Moffit 1 South**	8759	1	0	11	3
61	**Deadman's Slough**	8758	8	0	56	14
62	**Mallard Slough**	8759	8	0	49	10
63	**Inlet C Canal**	8568	22	0	113	22
64	**Moran Drain**	30792	2	0	20	3
65	**Spanish Grant Drain**	27658	9	0	53	10
66	**ESWD Maze Blv. Drain**	best est.	5	0	15	
67	**Newman Wasteway at Brazo Road**	best est.	5	0	30	
68	**S. Lake Basin**	32371	25	-1	232	24
84	**SJR at Garwood/HW 4**	21892	4625	-3562	16089	4673

End Table 3

Table 4: Summary statistics for available electrical conductivity data for DO TMDL Project Sites. Additional data and supporting information are available in Appendixes A, C, F, and G.

DO Site	Site name	N EC	Mean EC (uS/cm)	Min EC (uS/cm)	Max EC (uS/cm)	Std Dev EC
1	**SJR at Channel Point**	34,763	332	0	1,389	181
2	**SJR at Dos Reis Park**	1	511	511	511	
3	**SJR at Old River (DWR Lathrop)**	22,335	349	0	802	236
4	**SJR at Mossdale**	8,694	311	0	856	186
5	**SJR at Vernalis**	25	316	94	762	175
6	**SJR at Maze**	21	413	104	1,002	251
7	**SJR at Patterson**	8,725	570	0	2,099	366
8	**SJR at Crows Landing**	34,180	601	0	213,644	1,452
9	**SJR at Fremont Ford**	34,575	819	0	2,490	516
10	**SJR at Lander Avenue**	8,634	489	12	1,469	335
11	**French Camp slough**	3	483	99	736	338
12	**Stanislaus River at Caswell Park**	21	75	59	121	15
14	**Tuolumne River at Shiloh Bridge**	5,591	325	0	380,998	7,734
15	**Tuolumne River at Modesto**	5,591	325	0	380,998	7,734
16	**Merced River at River Road**	4,545	89	0	211	50
17	**Merced River near Stevinson**	4,545	89	0	211	50
18	**Mud Slough near Gustine**	34,132	2,286	33	5,226	810
19	**Salt Slough at Lander Avenue**	34,653	1,130	19	249,102	1,653
20	**Los Banos Creek at Highway 140**	6,713	934	577	1,468	222
21	**Orestimba Creek at River Road**	34,400	481	2	186,437	2,040
22	**MID Lateral 4 to SJR**	No Data	No Data			
23	**MID Lateral 5 to Tuolumne**	13	125	30	536	144

DO Site	Site name	N EC	Mean EC (uS/cm)	Min EC (uS/cm)	Max EC (uS/cm)	Std Dev EC
25	**MID Main Drain to Stan. R. via Miller Lake**	13	379	200	968	205
27	**TID Lateral 2**	1	54	54	54	
28	**TID Westport Drain Flow Station**	13	679	140	1,126	318
29	**TID Harding Drain**	22	682	363	1,227	230
30	**TID Lateral 6 & 7 at Levee**	11	660	431	974	184
31	**BCID - New Jerusalem Drain**	23,165	2,393	3	2,603	123
32	**El Solyo WD - Grayson Drain**	1	761	761	761	
33	**Hospital Creek**	35,040	478	0	1,966	405
34	**Ingram Creek**	35,040	966	178	2,057	548
35	**Westley Wasteway Flow Station**	21,789	443	2	1,177	225
36	**Del Puerto Creek Flow Station**	32,785	620	0	2,492	276
38	**Marshall Road Drain**	32,787	615	0	2,082	435
44	**San Luis Drain End**	35,902	4,634	2	6,999	637
45	**Volta Wasteway**	29,818	773	5	2,301	528
46	**Mud Slough at Gun Club Road**	31,911	1,388	5	3,314	637
49	**PE-14 Grasslands Area Farmers**	35,040	4,438	18	6,851	734
50	**San Luis Drain Site A (Check 18)**	34,920	4,990	5	13,160	775
53	**Salt Slough at Wolfsen Road**	32,894	1,138	486	2,378	385
54	**Los Banos Creek at Ingomar Grade**	1	680	680	680	
57	**Ramona Lake Drain**	12	1,145	957	1,502	159
59	**SJR Laird Park**	9	697	469	938	147
60	**Moffit 1 South**	8,759	524	5	1,638	603
61	**Deadman's Slough**	8,758	1,428	639	2,771	458
62	**Mallard Slough**	8,759	1,394	5	6,676	1,032
63	**Inlet C Canal**	8,759	685	5	3,146	432

DO Site	Site name	N EC	Mean EC (uS/cm)	Min EC (uS/cm)	Max EC (uS/cm)	Std Dev EC
64	**Moran Drain**	32,787	222	0	1,791	232
65	**Spanish Grant Drain**	32,787	1,152	3	4,138	902
66	**ESWD Maze Blv. Drain**	1	543	543	543	
67	**Newman Wasteway at Brazo Road**	1	930	930	930	
68	**S. Lake Basin**	32,371	1,794	5	4,476	780
80	**South Marsh 1 Inlet**	7	639	370	1,392	368
81	**South Marsh 1 Outlet**	10	687	379	1,346	284
82	**South Marsh 3 Inlet**	12	1,120	427	1,729	399
83	**South Marsh 3 Outlet**	12	1,182	721	1,839	350
84	**SJR at Garwood/HW 4**	1	513	513	513	

End Table 4

Chapter 2

METHODS, QUALITY ASSURANCE, AND QUALITY CONTROL

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Introduction

In 2005 and 2006, nearly 1200 water samples were collected along the San Joaquin and major tributaries by the University of the Pacific (UOP) field crew in support of the DO TMDL project. During sample collection field measurements were taken including flow, velocity, chlorophyll fluorescence, electrical conductivity, pH, dissolved oxygen and turbidity. Grab samplers were vertically integrated water samples were collected and brought to the UOP laboratory for immediate processing. Two sample teams were deployed so all sites were sampled during the same day to allow for consistent environmental conditions for all samples. At the UOP laboratory samples were filtered, analyzed, or preserved within 24 hours of sample collection. Samples were transported to University of California, Davis (UCD) on the sampling day and filtered in the lab within 24 hours.

The purpose of this report is to describe the performance of the analytical and field crew and the quality of the data set as defined in the DO TMDL Quality Assurance Project Plan (QAPP) (Stringfellow, 2005). For the purpose of this report, Quality Assurance (QA), as outlined in the QAPP, is the process in which the project data is evaluated and handled. Quality Control (QC) guidelines are the requirements specified in the QAPP to determine if the data is valid. The QAPP provides both a QA process and QC requirements for production of accurate and precise water quality from the laboratory and the field in support of the project objectives. The QAPP imposes several layers of quality review on the data. These include procedures established for data collection and processing by the laboratory analyst and the field personnel; oversight by the QA/QC manager; review by data analysts; and review by independent personnel. This iterative process has helped create a complete and high quality data set.

Methods

Data Quality Assurance and Quality Control

Each analytical group (UC Davis or UOP) have established Standard Operating Procedures (SOPs) (Borglin et al., 2005) for all routine analysis methods. The SOPs insure consistency in the analysis procedures, data reporting, and QC requirements. The SOP was prepared by experienced analysts in collaboration with the QA/QC manager. The SOPs were kept in the analysis area and a master copy was kept on file. Daily laboratory work at the bench level was carried out according these documents.

Data produced daily by analysts was recorded electronically and in a laboratory notebook. Electronic forms were used for entering data and calculation of results from the unknown samples and standards using calibration parameters. Preliminary review of data quality was completed by the analyst who confirmed that all standards and quality control samples met quality control guidelines. If the guidelines were not met, the analysis met with the QA/QC manager to identify the problem and the samples re-analyzed after remediation of any problems with analytical instrumentation, standards, calibration, or analysis procedures. Data that passed QC guidelines was then entered into the master spreadsheet.

Data in the master spreadsheet was subject to further review by applying simple linear regressions between correlated analyses to identify data outliers. This procedure was used to check for data entry or calculation errors. If problems were discovered during this process, the analyst was asked to recheck the data entry and quality of the sample analysis.

Quality control procedures for each laboratory analysis, discrete field sampling events, and continuous field monitoring data collection include calibration of instruments with certified standards. Quality control samples were run in conjunction with unknown samples and, depending on the analysis, could include all or some of the following: calibration check standards, laboratory control samples, sampling and analytical duplicates, matrix spikes, and analytical blanks (Table A). In addition, analyses of performance test standards were conducted at a minimum of once a year to verify the proper working order of equipment, quality of reagents, analytical technique, and analytical methods.

Sampling and Field Water Quality Measurements

Field sampling, which was performed by the field crew, consisted of collecting water samples, measuring water quality with a sonde, and recording of field conditions at DO sites within the study area. Prior to sampling, field equipment was calibrated and trip blanks were gathered and loaded into the sampling vehicles. Field sheets describing the sampling routine were disseminated before sampling to the sample crew and other pertinent individuals. Sampling was attempted at each DO site on the field sheets the day of sampling. At each site water and water quality measurements were collected. The samples were stored at 4°C after collection and returned to the lab for analysis.

The day before sample collection YSI 6600 Sonde connected to YSI 650 MDS handset were calibrated at UOP following procedures in the YSI 6-Series Environmental Monitoring Systems Handbook (YSI Inc., Yellow Springs, CO). The sonde has several probes which were calibrated independently. Dissolved oxygen and depth were calibrated using the wet-towel method where the sonde was placed in a tube with a wet-towel around the sensors and calibrated in a water-saturated air environment. Specific Conductivity, measured with an Electrical Conductivity probe (EC), was calibrated using a 0.01D KCL Conductivity standard with a value of 1408µS/cm (Radiometer Analytical SAS, Lyon, France). The pH probe was calibrated using standards of pH 4, pH 7, and pH 10 (VWR International, West Chester, PA). Oxidation-reduction potential (ORP) was calibrated with Zobell's solution (Ricca Chemical Company, Arlington, TX). The fluorescence probe output (for estimating chlorophyll) was recorded in Millipore water or 0 NTU water to account for drift. The turbidity probe was calibrated with three standards of 0 NTU or Millipore water, 40 NTU, and 200 NTU (HACH, Loveland, CO).

Each sampling day, the sonde was recalibrated for DO at the first site to account for local barometric pressure. At each sampling location, water quality data was collected for at least 2 minutes using a sonde deployed in the sample water and programmed to log a reading for every parameter every four seconds for at least two minutes, providing a statistically significant sample size ($n > 30$). The data from the sonde was also recorded in the field notebook. The parameters measured by the sonde at each site included time, temperature (°C), electrical conductivity (mS/cm), total dissolved solids (g/L), dissolved oxygen (DO) percent, DO concentration (mg/L), DO charge, depth (ft), pH, oxidation-reduction potential (mV), turbidity (NTU), chlorophyll content (μg/L), fluorescence, and barometric pressure (mmHg).

While the sonde logged water quality data, water samples were collected and incident sunlight and water velocity were measured to document current field conditions. During sampling in 2005, the Photosynthetically Active Radiation (PAR) was measured in triplicate in full sun mode using a LI-250A meter with the LI-192 underwater quantum sensor and LI-193 spherical quantum sensor (Li-cor, Lincoln, NE). Light measurements were also taken using a Model 3252 (LUX) Traceable® Dual-Display Light Meter (Control Company, Friendswood, TX). It was found that the readings between the model 3252 and the LI-192 were highly correlated in 2005 and only the LUX meter readings were taken in 2006. Velocity measurements were taken with a Marsh-McBirney Model 2000 Flo-Mate (Marsh-McBirney, Frederick, MD) with the flow sensor facing upstream and horizontal to the flow.

Water samples were collected in glass 1000 mL bottles (Wheaton Science Products, Millville, NJ), 1000 mL HDPE Trace-Clean narrow mouth plastic bottles (VWR International), or 250 mL HDPE Trace-Clean wide mouth plastic bottles (VWR International) in accordance with requirements for different lab analysis and volume requirements. Bottles were labeled with the appropriate sample number, site name and sample date. All bottles were rinsed with sample water prior to collection of a depth integrated sample. Some sites required a bucket to collect water because of sampling from a high bridge or platform. For these sites, the bucket was pre-rinsed with sample water and sample bottles were filled using a rinsed funnel. Care was taken to distribute the water evenly to all sample bottles (rather than sequentially). Samples were immediately stored at 4°C after sampling (cooler temperature was recorded in the lab upon delivery) and transported to the lab for analysis on the day of sampling. All bottle numbers, meter readings, and time in and out of the sample site were recorded in the field notebook.

Post field activities included cleaning and storing all field equipment and post-calibrating the sondes to account for drift during the sampling day. Post-calibration consisted of checking the sonde value to that of the standard value and was completed within twenty-four hours of the sampling event. After post-calibration sondes were cleaned and stored with a small amount of water in the calibration cup to prevent drying of the DO membrane.

Sample preparation and processing

Samples were received by the laboratory the same day they were sampled, logged in and inspected for damage, and stored at $4^{℃}$ until filtering and analysis. Samples were filtered and preserved if necessary within 24 hours of collection. Archive filtrate and unfiltered samples were saved from all sites for any needed re-analysis or additional analysis that may be determined necessary. Samples were analyzed at laboratories at UOP and UC Davis, and the procedures are described separately below.

Samples were collected, preserved, stored, and analyzed by methods outlined in *Standard Methods for the Analysis of Water and Wastewater*, (APHA, 2005, 1998) unless otherwise indicated. Certified standards, trace clean and certified sample bottles, reagent grade chemicals and high purity water produced by a Milli-Q gradient system (Millipore, Billerica, MA) were used for all analysis. Glassware that was reused was cleaned thoroughly with in warm water with Alconox detergent, rinsed with 10% HCl, and rinsed a minimum of 5 times with high purity water.

UC Davis

Samples for dissolved nitrate, ammonia, and phosphate (NO_3-N and Soluble NH_3-N and PO_4-P) were filtered through a pre-rinsed, 0.22 µm polycarbonate membrane (Millipore Isopore^{TM}). NO_3-N and Soluble NH_3-N were quantified simultaneously using an automated membrane diffusion/conductivity detection method (Carlson, 1978, 1986; Carlson et al., 1990). Total nitrogen was determined by the same method from unfiltered sample following persulfate oxidation (Yu et al., 1994) using a 1% persulfate oxidant concentration, a sample:oxidant ratio of 1:1 (V/V), and heating in an autoclave. The limit of detection for this method was 50 ppb N.

Ortho-phosphate (PO_4-P) was determined on the filtrate using the stannous chloride method. (SM 4500-P.D). The limit of detection for this method is approximately 3 ppb PO_4-P in clean water using a 1 cm cell for measurement. Total phosphorus (Tot P) was analyzed on unfiltered samples by the same method after digestion. To digest, 5.0 mL of each sample was aliquotted into trace clean 40mL glass vials (IChem, Rockwood, TN), 5.0 mL digestion reagent was added (10 g potassium persulfate, 6 g boric acid, and 3 g NaOH in 500 mL Millipore water) was added and then was autoclaved for 1 hour. After cooling, Tot P was determined using the stannous chloride as described above.

UOP

Filters were used in the analysis of chlorophyll pigments, particulate organic matter (samples sent to USGS), total suspended solids and volatile suspended solids (TSS/VSS), and phospholipid fatty acid analysis (PLFA). Samples were filtered through 47 mm Whatman GF/F filters (0.7 µm pore size) for the collection of filterable solids. Filters used for TSS/VSS analysis were pre-rinsed with high purity water (Milli-Q gradient, Millipore, Billerica, MA). All filters were pre-combusted for 6 hours at 550$^{\circ C}$ prior to filtering. Filtrate was used for analysis of dissolved nitrate, ammonia, and phosphate (NO_3-N and Soluble NH_4-N and PO_4-P), dissolved organic carbon, and dissolved total nitrogen. Sample bottles were shaken thoroughly before filtration and sample bottle weights were recorded before and after the sample was filtered and the difference was recorded as the filtered sample weight.

Unfiltered samples were analyzed for Biochemical oxygen demand (BOD) by Standard Method (SM) 5210 B (APHA, 2005) with a modification for measurement of oxygen demand at 10 days rather than 5 days. Previous studies in the SJR have used 10-day BOD analysis as a standard procedure and this data set will be consistent with prior studies. BOD was measured without seed, as in previous studies. Initial and final dissolved oxygen was measured using a calibrated YSI 5000 DO meter equipped with a YSI 5010 BOD probe (Yellow Springs, OH) and calibrated by Winkler titration according to SM 10200 H (APHA, 2005). Duplicate samples were prepared every 20 analyses and blanks consisted of BOD buffer solution prepared according to SM 5210 B. All samples were tested at both full concentration and diluted 100 mL of sample to 200 mL of BOD buffer solution to increase the number of reportable results. All BOD tests were initiated within 24 hours of sample collection. A standard curve was prepared for each sample set consisting of a BOD standard solution (HACH, Loveland, CO) containing glucose and glutamic acid at 1, 2, 3, and 4 mg/L in dilution buffer with 5 mL of seed from a randomly selected sample. In addition, Carbonaceous BOD (CBOD) was determined by adding 0.16 mg of nitrification inhibitor (N-serve, HACH, Loveland, CO) to a duplicate sample set. The resulting CBOD was subtracted from the total BOD to determine the Nitrogenous BOD (NBOD).

Total organic carbon (TOC) and total nitrogen (TN) were measured using unfiltered samples on a Teledyne-Tekmar Apollo 9000 with inline TN analyzer (Mason, OH) by high temperature combustion according to SM 5310 B (APHA, 2005). This machine was equipped with an auto-sampler that allows for continuous stirring of sample. Dissolved organic carbon (DOC) and dissolved nitrogen (DN) were measured using the sample filtrate by the same method. All samples were preserved < pH 2 with concentrated phosphoric acid and stored at 4°C until analysis. Samples were analyzed within 28 days of collection. The limits of detection for carbon (TOC and DOC) and nitrogen (TN and DN) were 1.00 mg/L C and 0.090 mg/L N.

Total suspended solids (TSS) and volatile suspended solids (VSS) were analyzed by SM 2540 D and E (APHA, 2005). Typically 1000 mL of sample was filtered on a pre-weighed pre-combusted Whatman GF/F filter. The filter was placed in an aluminum dish and dried at 105°C under vacuum to constant weight. After drying, the filter and dish were allowed to cool in a dessicator. The filters were weighed for TSS determination. The dried and weighted filters were then combusted at 550°C for 6 hours and reweighed for VSS determination. Mineral suspended solids (MSS) concentration was calculated by subtracting VSS from TSS.

Chlorophyll-a (chl-a) and pheophytin-a (pha-a) were extracted and analyzed using UV absorption as described in SM 10200 H (APHA, 2005). Both the trichromatic and the pha-a methods were used for quantification. At least 1000 mL of samples were filtered using a vacuum filtration onto a Whatman GF/F filter within 24 hours of sample collection. The sample was kept in the dark during storage and filtration. After the water was removed saturated $MgCO_3$ was applied to the sample on the filter and the filter was stored at -20°C for up to 14 days before analysis. Extraction was performed by grinding the filter with a Teflon tissue grinder in acetone saturated with 10% by weight $MgCO_3$. The extracted sample was centrifuged for 5 minutes at 3000 rpm and the chl-a and pha-a was quantified by measurement of the supernatant on a Perkin Elmer Lambda 35 spectrometer (PE spec) (Wellesley, MA).

For PLFA analysis, up to 1000 mL of water sample was filtered through a Whatman GF/F glass fiber filter within 24 hours of collection. After filtration, the filter was placed in a 25 mL glass tube and stored at -20°C until extraction. Total lipids and chlorophyll pigments were extracted from the filter with a modified Bligh-Dyer solution which consists of 5 mL of chloroform, 10 mL of methanol, and 4 mL of phosphate buffer. Chlorophyll pigments in the extract were quantified by measuring absorbance at 665 nm on the PE Spec. This measurement was compared to the measurements made by SM 10200H and served as a control for the grinding process, which can result in the loss of chlorophyll if frictional rises in temperature are not properly controlled. Phospholipids were quantified on Agilent Model 6250 (Santa Clara, CA) gas chromatograph equipped with both a flame ionization and Mass spectrometer as detectors.

Total protein was quantified in all the samples using the Lowry method (Pierce Biosciences, Rockford, IL). The analysis was scaled up from the standard kit so the analysis was performed on 1 mL samples and analyzed in cuvettes with a 5 cm path length. Standard curves were made using bovine albumin from Pierce Biosciences (Rockford, IL). Samples were frozen within 24 hours of collection and defrosted prior to analysis.

Alkalinity was measured on samples within 24 hours of sample collection by titration of a 50 mL sample with 0.02 N H_2SO_4 to an endpoint of pH 8.3 and 4.5. The samples were stirred continuously during titration. Quality control included analysis of two independent alkalinity standards, one from HACH (Loveland, CO) and the other from ERA (Arvada, CO), to insure proper preparation of the titrating solution and calibration of the pH probe.

Total Iron (Tot Fe) was measured using a reaction with phenanthroline according to SM 3500-Fe B using FerroVer reagents purchased from HACH (Loveland, CO). Within twenty-four hours of sample collection, 6 mL aliquots of unfiltered sample was placed in 15 mL disposal centrifuge tubes and stored at -20°C for later quantification of Tot Fe. Prior to analysis, the samples were defrosted and 1 mL of sample was removed and used to measure the background absorbance of the water sample at 510 nm on the PE Spec. Total Fe was measured on the remaining 5 mL of unfiltered sample by the addition of pre-made HACH FerroVer phenanthroline reagent and measurement at 510 nm. The background sample absorbance was subtracted from the sample absorbance with reagent added.

Total ammonia nitrogen (Tot NH_4-N) was quantified with the Nesslerization method (SM 4500-NH3 C, APHA, 1992) modified for use on SJR samples. The test was performed on unfiltered samples that were frozen within 24 hours of collection. After defrosting, 5 mL of sample was centrifuged at 3000 rpm for 5 minutes. Background interference from sample color was determined by measurement of 0.5 mL of the supernatant 425 nm prior to the addition of reagent. HACH Nessler reagent (Loveland, CO) was then added to the remaining sample; the sample was vortexed thoroughly and re-centrifuged (to remove interference from salts). Ammonia was quantified by subtracting the absorbance of the sample without reagent from the sample with reagent at 425 nm. The reportable limit for this method was 0.32 mg/L NH_4-N.

Dissolved ortho-phosphate (PO_4-P) was quantified in filtered samples by the ascorbic acid method (adapted from SM 4500-P-E) using HACH PhosVer3 packets (Loveland, CO) and measurement at 890 nm. The reportable limit for this method was 18 μg/L PO_4-P.

Combined nitrate (NO_3-N) and nitrite (NO_2-N) were analyzed by the cadmium reduction method (adapted from SM 4500-NO3-E) using HACH NitraVer (Loveland, CO) reagents. The reportable limit for this method was 0.5 mg/L NO_3-N.

Total phosphorus (Tot-P) was analyzed on 5.0 mL unfiltered samples by the stannous chloride method, SM 4500-P (APHA, 2005). Samples were digested by the addition of 5.0 mL digestion reagent (10 g potassium persulfate, 6 g boric acid, and 3 g sodium hydroxide in 500 mL Millipore water) and autoclaved for 30 minutes. The limit of detection for this analysis was 18 μg/L Tot-P.

Results

Summary of QC samples

Two major quantitative means were used to evaluate the performance of the laboratories and field crew. The first was routine measurement of QC samples, the second evaluation of independently prepared performance check samples.

The summary of the QC samples run in conjunction with sample collection does not address the actual values or trends in the samples collected. The QC data collected addresses the precision, accuracy and the overall confidence in the produced data set. For the 2006 sample year, the UC Davis and UOP laboratories had an overall QC sample pass rate of 97%. This included all the required QC samples: calibration checks, laboratory check samples, analytical and field duplicates, matrix spikes, and blanks run in conjunction with the unknown samples. Average for the QC sample pass rates for each individual analysis is shown in Table B for UOP and Table C for UCD.

Shown in Table C are the Field QC samples, including both the pre and post calibration standards. These numbers represent an average of 9 different sonde units used throughout 2005 and 2006. The overall passage of QC samples for the field was 97.5 %.

Outside blind check samples (Ultra Scientific, North Kingstown, RI; RTC, Laramie, WY) were purchased for an additional assessment of the laboratory capabilities. This allows the analyst to address any weaknesses and provides a quality check from an independent source. In 2005 and 2006, all of the proficiency check standards were analyzed within acceptable limits as defined by the supplier with the exception of one Total N sample from (see Table C and D). This sample was analyzed by both the UOP and UC Davis laboratories which produced 48.3 and 55.1 % recoveries, respectively. Upon investigation it was discovered that this standard was made from Glycine. Analysts at UOP prepared Glycine standards and confirmed that this compound is not efficiently analyzed by our techniques. Ongoing method development is addressing this issue.

Table A. Definition of Analytical Quality Control Samples used in Laboratory analysis at UOP

QC Type	Definition	Frequency	Used to Evaluate	Limits	Corrective Action
Calibration Check (CC)	Standard solution at a concentration in the center of the calibration curve.	Every analytical batch or at least every 20 samples.	Accuracy Comparability	80 –120%	Analysis can not proceed unless the CC passes.
Laboratory Control Sample (LCS)	Standard solution from a different vendor than that of the calibration standard spiked with compounds of interest into a clean water matrix.	Every analytical batch or at least every 40 samples.	Accuracy Comparability	80 –120%	Perform instrument maintenance and prepare new standard solution if necessary.
Matrix spike & Matrix spike duplicate (MS/MSD)	Standard solution with compounds of interest spiked into a representative sample matrix.	Every 40 samples.	Precision Accuracy Comparability	80 –120%	If LCS passes, result may reflect matrix interference and may be reported with qualification.
Surrogate	The addition of a non-occurring substituted compound to the sample matrix.	Inorganics: Not Applicable. Organics: every sample if available.	Precision Comparability	75 –125%	Rerun sample. If second result is not within limits, report with qualifier.
Instrument or Analytical Blank (IB or AB)	Clean water matrix, free of analyte. Analyzed in same manner as samples.	Every analytical batch or at least every 20 samples.	Accuracy	Below Method Detection Limit (MDL)	In some cases, target compound values may be subtracted out, in other analyses target compounds present in blank must be flagged as contamination and may not be subtracted out.

Table B: Summary of Quality Control samples for the UOP laboratory analysis.

QA Summary Report- UOP

	QA/QC type	Total Alkalinity	Ammonia-N	Nitrate-N	Phosphate-P	Total Iron-Fe	Total P
	PQL (mg/L)	2	0.32	0.5	0.18	0.18	0.18
% of QA passed	Total	100.00%	94.74%	97.44%	97.44%	87.18%	100.00%
	LabDup	100.00%	94.74%	97.44%	97.44%	87.18%	100.00%
	Dup	100.00%	97.50%	100.00%	95.00%	95.00%	100.00%
	MS	100.00%	94.87%	84.62%	100.00%	100.00%	100.00%
	MSD	100.00%	90.24%	82.93%	100.00%	100.00%	100.00%
	LCS	100.00%	97.56%	100.00%	100.00%	100.00%	100.00%
	CC	100.00%	97.44%	100.00%	100.00%	97.44%	100.00%
	TB (<PQL)	100.00%	97.44%	100.00%	100.00%	100.00%	100.00%

	QA/QC type	Total Organic Carbon (TOC)	Total Nitrogen (TN)	Dissolved Organic Carbon (DOC)	Dissolved Nitrogen (DN)	BOD	CBOD	NBOD	BOD Standard Curve
	PQL (mg/L)	1.0	0.2	1.0	0.2	1	1	1	R2>0.975
% of QA passed	Total	100.00%	99.19%	97.44%	98.42	94.59%	94.59%	86.49%	88.89%
	LabDup	100.00%	97.14%	97.44%	100.00%				
	Dup	97.44%	97.22%	100.00%	100.00%	94.74%	92.11%	78.95%	
	MS	94.87%	100.00%	100.00%	97.22%				
	MSD	95.12%	100.00%	100.00%	94.74%				
	LCS	100.00%	100.00%	100.00%	100.00%				
	CC	97.44%	100.00%	97.44%	97.22%				
	TB (<PQL)	86.84%	97.2%	92.31%	97.2%	94.44%	97.22%	94.44%	

	QA/QC type	Total Suspended Solids (TSS)	Volatile Suspended Solids (VSS)	Chl-a SM UV
	PQL (mg/L)	5 mg	5 mg	abs < 0.1
% of QA passed	Total	87.34%	97.47%	89.09%
	Dup	80.00%	95.00%	78.57%
	TB (<PQL)	94.87%	100.00%	100.00%

Table C: Summary of the Quality Control Samples for the UC Davis Laboratory Analysis

		Total N (ppm) PQL-0.05	NH4-N (ppm) PQL-0.01	NO3-N (ppm) PQL-0.01	Total P (ppm) PQL-0.005	PO4-P (ppm) PQL-0.003
% fo QA Passed	Total	97.22%	95.83%	97.22%	98.61%	97.22%
	Field Dup	97.22%	91.67%	94.44%	97.22%	97.22%
	TB <PQL	97.22%	100.00%	100.00%	100.00%	97.22%

Table D: Summary of the Quality Control Samples for the Field Analysis

Parameter	% Pass Pre-Deployment	% Pass Post-Deployment
Depth (ft)	99.7	98.2
DO %	100.0	90.3
DO (mg/L)	100.0	93.3
DO Charge	100.0	89.9
EC	98.2	99.7
pH 4.0	100.0	100.0
pH 7.0	100.0	100.0
pH 10.0	100.0	100.0
ORP	100.0	100.0
Turbidity 0 NTU	100.0	91.5
Turbidity 40 NTU	100.0	100.0
Turbidity 200 NTU	100.0	100.0
Chla	89.8	88.5
Flr	100.0	93.9

Table E: UOP Proficiency Check sample results for TSS, TOC, Conductivity, BOD, and CBOD.

TSS			
Expected concentration	Acceptable Range	UOP result	% recovery
mg/L	mg/L	mg/L	UOP
164	138-170	156.11	95.2
151	134-159	145.2	96.2
161	143-169	150.97	93.8
159	142-167	163.46	102.8
TOC			
Expected concentration	Acceptable Range	UOP result	% recovery
mg/L	mg/L	mg/L	UOP
35.3	31.0-39.7	37.11	105.1
35.3	31.0-39.7	35.44	100.4
28.2	25.0-31.2	25.2	89.4
14.1	11.6-16.6	15.054	106.8
47	41.8-51.8	51.9	110.4
Conductivity			% recovery
Expected concentration	Acceptable Range	UOP result	UOP
940	884-997	932	99.1
814	764-864	851	104.5
pH			
9.23	9.03-9.43	9.18	99.5
9.23	9.03-9.43	9.15	99.1
9.28	9.08-9.48	9.13	98.4
BOD			
Expected concentration	Acceptable Range	UOP result	% recovery
mg/L	mg/L	mg/L	UOP
22.2	10.9-33.4	28.75	129.5
CBOD			
Expected concentration	Acceptable Range	UOP result	
mg/L	mg/L	mg/L	
19.2	8.56-29.8	28.5	148.4

Table F: UOP and UC Davis Proficiency Check sample results for nutrient analysis

			% recovery		%recovery
mg/L NO3 - N			UOP		UCD
Expected concentration	Acceptable Range	UOP result		UCD result	
mg/L NO3 - N	mg/L NO3 - N	mg/L NO3 - N		mg/L NO3 - N	
3.81	3.43-4.19	4.34	113.9	5.595	
5.42	4.64 - 6.10			5.231	96.5
8.48	7.21-9.63	7.78	91.7		
38.8	33.3-43.5	33.91	87.4	37.34	96.2
6.92	6.23-7.61	6.57	94.9		
10.2	8.7-11.6	8.93	87.5		
34.6	29.8-38.8	29.41	85.0		
12.3	10.5-14.0	10.6	86.2	12.52	101.8
mg/L NH4 - N					
Expected concentration	Acceptable Range	UOP result	% recovery	UCD result	
mg/L NH4 - N	mg/L NH4 - N	mg/L NH4 - N	UOP	mg/L NH4 - N	
18.3	15.6-20.9	19.83	108.4	18.06	98.7
10.5	8.9-12.0	10.06	95.8		
13.1	10.8-15.2	14.31	109.2	15.72	120.0
mg/L PO4 - P					
Expected concentration	Acceptable Range	UOP result	% recovery	UCD result	
mg/L PO4 - P	mg/L PO4 - P	mg/L PO4 - P	UOP	mg/L PO4 - P	
4.71	4.26-5.20	4.91	104.2	5.079	107.8
1.18	1.01-1.37	1.24	105.1	1.147	97.2
ALKALINITY					
Expected concentration	Acceptable Range	UOP result	% recovery	UCD result	
mg CO3/L	mg CO3/L	mg CO3/L	UOP	mg CO3/L	
538	511-555	514	95.5		
352	327-363	328	93.2		
231	208-254	239	103.5		
249	224-274	234	94.0		
TOTAL P					
Expected concentration	Acceptable Range	UOP result	% recovery	UCD result	
mg/L P	mg/L P		UOP	mg/L P	
5.07	4.20-5.59			5.477	108.0
3.04	2.66-3.46			3.306	108.8
TOTAL N					
Expected concentration	Acceptable Range	UOP result	% recovery	UCD result	
mg/L N	mg/L N	mg/L N	UOP	mg/L N	
16.8	13.7-19.4			16.61	98.9
33.6	25.6-39.6	16.235	48.3	18.5	55.1
12.3	10.5-14.0	12.87	104.6	12.86	104.6
20	5.9-7.9			19.4	97.0

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Chapter 3

FIELD WORK DOCUMENTATION

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Introduction

The Environmental Engineering Research Program (EERP) at the University of the Pacific (UOP) is the lead scientific agency on several water quality and ecosystem restoration projects focused on understanding and improving water quality in the San Joaquin River (SJR). The largest project is the Dissolved Oxygen Total Maximum Daily Load Project (DOTMDL Project), which has as a primary objective the development of a mass balance on phytoplankton and oxygen demanding materials in the SJR between Lander Ave in the south and Channel Point in the north. Additional EERP projects include the evaluation of organic carbon sources and fate in the SJR, studies of wetland ecosystems, and studies examining the impact of current agricultural best management practices (BMPs) on water quality. For all of these projects, water quality and water flow must be measured at numerous locations throughout the watershed.

EERP works in cooperation with local, State, and Federal scientists and stakeholders to maintain a network of flow and water quality monitoring stations throughout our study region. The field research program effort includes water quality sampling (grab sampling), flow measurement, continuous flow monitoring station maintenance, quality assurance (QA), and flow rating events, as well as activities associated with directed scientific studies, such as deployment of continuous chlorophyll monitors to measure temporal variation in phytoplankton growth kinetics. Major objectives of the field research program are to support stakeholder flow monitoring efforts, maintain a high level of quality control on all flow and water quality monitoring activities, organize collected data for scientific and engineering analysis, and collect data in support of the DOTMDL Project modeling effort. The purpose of this report is to document EERP field activities for the 2006 field season.

Methods

Field notebooks were used to document all field activities. In Appendix D, field activity reports document field activities by day for 2006. Each field activity report includes a brief description of the work performed and the reason for going out. Each day was categorized and given an appropriate heading. Available photographs were included to provide further documentation. Any problems encountered in the field were documented in the field notebook and activity report. In Appendix D, each field day is categorized using headings of sampling, station maintenance and QA, extended deployment, or station upgrades, where applicable.

Equipment used in EERP field work is listed in Table 1. In 2006, sampling events were categorized into Core sampling, Intermittent sampling, Wetland sampling, BMP sampling, and Extended Deployment sampling. The designations correspond to specific sampling lists and schedules developed to assist EERP field teams in organizing their activities. Core sampling events included up to 25 sampling sites. Wetland sampling events included up to 20 samples. BMP sampling included up to 17 samples. The number of sites sampled on Extended Deployment sampling events and Intermittent sampling events varied to accommodate specific scientific objectives. See Table 2 for a comprehensive site list.

Sampling and Water Quality Measurements

At each location for each sampling event, water quality data was collected using a YSI 6600 multi-parameter sonde connected to a YSI 650 MDS handset (YSI Inc., Yellow Springs, CO). The sonde was deployed and programmed to log a reading for every parameter every four seconds for at least two minutes, providing a statistically significant sample size ($n > 30$). The parameters measured by the sonde at each site include time, temperature (°C), electrical conductivity (mS/cm), total dissolved solids (g/L), dissolved oxygen (DO) percent, DO concentration (mg/L), DO charge, depth (ft), pH, oxidation-reduction potential (mV), turbidity (NTU), chlorophyll content (ug/L), fluorescence, and barometric pressure (mmHg).

While the sonde logged water quality data, water samples were collected and incident sunlight and water-velocity were measured (to document current field conditions). Water samples were collected in three different types of bottles [glass 1 liter bottles (Wheaton Science Products, Millville, NJ), 1 liter Trace-Clean plastic bottles (VWR International, West Chester, PA), and 250 mL Trace-Clean plastic bottles (VWR International)] in accordance with requirements for different lab analysis. Samples were depth integrated and stored at 4°C after sampling. Light measurements were taken using a handheld LUX meter (VWR International). Velocity measurements were taken with a model 2000 flow-meter (Marsh-McBirney, Frederick, MD).

Station Maintenance and QA

Station maintenance included downloading data from the station logger, cleaning the EC probe, checking the bubbler line for leaks, clearing weir and instruments of debris, and inspecting equipment for damage. Oftentimes QA was performed at the same time as station maintenance. QA was performed on EC and flow.

For QA on the EC probe, the probe was cleaned with a small brush and the probe EC values were compared to an independently calibrated YSI sonde placed into the water adjacent to the other probe. If the EC probe showed more than 10% difference from the calibrated reference sensor, the probe was re-cleaned and basic maintenance performed, such as checking connections. If the probe continued to give inaccurate data, typically the only repair was to replace the faulty probe.

A QA value (rating measurement) for flow depended on the site being visited. If the site had a sharp crested weir structure, a weir stick (Cal Poly ITRC, San Luis Obispo, CA) measured flow and the flow measurement was entered into the QA and rating record. When the site did not have a sharp-crested weir, a cross-channel flow rating was taken by wading, using a handheld flow meter and measuring tape strung across the channel. Average water velocity was then taken at 60 percent depth from the bottom at set intervals across the stream channel, usually every foot but varied depending on the channel width. Flow was calculated by multiplying cross-sectional area of each section by the velocity for that section and adding sectional flows to obtain a total flow, or discharge, for the site. At all sites the staff gauge was recorded as the QA value and compared with in-situ stage measuring equipment. Discrepancies between manual ratings and continuous measurement were resolved by any number of means, up to and including replacing or moving the location of monitoring stations.

Extended Deployment

Extended deploy field events included taking sondes and leaving them at specific DO sites for an extended period of time, usually lasting two weeks. Extended deploy events were often in conjunction with a sampling event. This provided starting and ending water quality samples to compare with the extended deployment sonde values.

Sondes were calibrated the day before being placed in the field and modified with longer wiper brushes to better keep the sensors free of algae and debris. They were programmed to run unattended for the length of deployment. At the time of deployment sondes were put into black PVC housings protecting the equipment from damage while at the site. Sondes were attached with a cable and padlock to an anchor, such as a metal post or bridge pylon. Once deployed, sondes were left unattended for periods of approximately two weeks. Upon conclusion of the deployment sondes were retrieved and placed into coolers to keep the membranes moist until post-calibration could be performed. Post-calibration was completed within twenty-four hours of deployment. After being post-calibrated sondes were cleaned up with water, the DO membranes and batteries were changed, and the extended deploy wipers were removed.

Station Up-Grades

Activities performed during flow station upgrades depended on what was being done to the specific site. Upgrades often consisted of installing new equipment. A list of equipment used for flow measurement is listed in Table 1. Frequently upgraded equipment included bubbler units, doppler flow meters, EC probes, and weir boards. A list of equipment for each upgrade was compiled and measurements were made for any equipment lines, weir boards or other materials that needed to be added to the station. Materials and supplies were purchased and brought back to UOP allowing easier access to a wider range of tools that could not be brought out to the field. Work was completed at UOP and the materials were brought to the site often needing to be cut or bent into the shape. The equipment was installed and lines were run from the station house to the equipment.

Results

During the 2006 field season crews went into the field a total of 80 times. Of these 80 trips, 43 were sampling events, 16 were flow ratings, and the other 21 times consisted of station upgrades, training sessions, meetings, and station maintenance. Core sites were sampled 21 times, Wetland sites 12 times, Extended Deploy sites 4 times, BMP sites 3 times, Intermittent sites 2 times, and the San Luis Drain was sampled 1 time during the San Luis Drain study. Grasslands monitoring and QA was performed 6 times and Westside monitoring and QA was performed 10 times. All other field activities consisted of station maintenance, station upgrades, training sessions, and meetings with agencies and land owners.

Occasionally equipment failures were discovered during station maintenance events. Most equipment failures were fixed in the field, other times equipment had to be switched out and taken back to the Hydraulics Lab at UOP to be fixed. On January 9th the pressure transducer at DO-68 S-Lake Basin was non-functional. The cable for the pressure transducer was measured for a replacement sensor to be installed. January 31st DO-31 New Jerusalem Drain had a leaky bubbler line that was fixed by having the line removed and connections retightened. DO-35 Westley Wasteway Flow Station had a short circuit with the Starflow, due to a damaged cable, that made the logger freeze. The logger was removed on February 8th and reinstalled on February 14th and the Starflow cable was disconnected from the logger. On May 9th DO-38 Marshall Drain Road had a leaky bubbler that was fixed by removing the "T" valve. The Design Analysis (Logan, Utah) logger unit at DO-31 New Jerusalem Drain was reporting errors when downloading data on November 17th and December 8th. The logger was replaced on December 18th.

Sometimes natural events, such as storms, washed out a station. On January 9th the sensors and bridge at DO-20 Los Banos Creek Flow Station were found washed out. The bridge was replaced by Grasslands Water District in March and the bubbler installed September 5th and the Sontek installed October 31st. On Feb 2nd DO-45 Volta Wasteway at Ingomar Grade the staff gauge was remounted on a metal pole because the first (wood) fixture had rotted out. The station at DO-57 Ramona Lake was washed out in April floods, but was not fixed in 2006. Occasionally there were problems with the wiper that cleans the optic sensors on the sonde used for sampling and extended deployments causing the wiper to park over the sensor and present invalid readings. This happened on September 7th to one of the crews on a Core sampling event. On October 26th the sonde used for sampling had the DO sensor membrane punctured and had to be replaced in the field.

Discussion

All fieldwork activities for 2006 were documented. On average there was a crew in the field 1.5 times each week. There were 3.5 sampling trips on average each month. Core sites were sampled an average of 1.75 times a month. Field activities were documented with photographs. However, a picture was not taken on every field event. In the future photographs should be taken on each field outing.

The majority of continuous monitoring stations worked without major problems. Stations that were reliable in 2005 were reliable in 2006 with the exception of DO-20 Los Banos Creek and DO-57 Ramona Lake which were washed out by spring floods. DO-35 Westley Wasteway Flow Station was not reliable in 2005 (in part due to illegal dumping activities blocking structures) and this station was relocated and completely remodeled and upgraded in 2006. Occasionally leaks were found in the bubbler lines, but these were due to loose connections that were easily fixed.

Major equipment failures, such as the Starflow short circuit from DO-35 Westley Wasteway, were nearly all caused by outside factors. The short circuit in the Starflow was the result of a backhoe accidentally slicing the cable while clearing debris from the channel. At the end of the year, when data for December was downloaded from Westside monitoring stations, a faulty data collection card failed to retrieve data from loggers at the same time caused the loggers to stop recording data for the rest of December. This error was not discovered until January 2007.

Reliability of flow data for 2006 depended on the site in question. Any station that had consistency in structure, such as a weir system that is routinely cleared of debris, provided reliable flow and water quality data. Sites that had a bubbler line installed and a developed flow stage relationship supplied accurate flow data. However, if the weir was not kept clear of debris then the flow data was not reliable. Sites located in wetlands, such as DO-61 Deadmans Slough and DO-62 Mallard Slough, were subject to significant beaver activity and consistently had large amounts of debris (beaver dams) in front of the weir structures. This caused the water to back up behind the weir and gave inaccurate flow readings. Theses sites are being evaluated for up-grading to the use of Doppler flow meters that could be put at the outlet of the pipes and do not require a sharp-crested weir for accurate measurement and should be able to provide accurate flow measurement even in the presence of beaver activity.

Table 1: Equipment Descriptions

Device	*Description*
Campbell Logger (Campbell Scientific Inc., Logan, UT)	Logger put into continuous monitoring stations. Records and stores data from EC probe, flow device, and bubbler.
H-350XL Design Analysis Logger (Design Analysis Associates Inc., Logan, UT)	Logger put into continuous monitoring stations. Records and stores data from EC probe, flow device, and bubbler.
MACE Agriflo (MACE, Sydney, Australia)	Doppler device put near bottom of channel to measure flow. This device is better for defined structures such as pipes and weir structures. Often used at continuous monitoring stations.
Starflow (Unidata, O'Connor, Australia)	Doppler device put near bottom of channel to measure flow. This device is better for defined structures such as pipes and weir structures. Often used at continuous monitoring stations.
Sontek (Sontek/YSI Inc., San Diego, CA)	Doppler device put in channel to measure flow. MACE units measure flow by looking out into the channel and are better for open, or natural, channel situations. Often used at continuous monitoring stations.
H-350XL/355 Combo Bubbler (Design Analysis Associates Inc., Logan, UT)	A bubbler measures water level by detecting the pressure required to force air through a tube below the water level in the channel. In areas with a weir system a bubbler can be used to measure flow, as the height of water above the weir is proportional to the flow.
Staff Gauge (Wildlife Supply Company, Buffalo, NY)	A gauge put in a fixed location to observe water level. Often used to verify bubbler reading during QA visits.
Cal Poly ITRC Weir Stick (Cal Poly ITRC, San Luis Obispo, CA)	Scale mounted on a stick used to measure the height of the water above a weir structure. This value is then multiplied times the weir width to get flow.
EC Probe (YSI Inc., Yellow Springs, OH) (Campbell Scientific Inc., Logan, UT)	Sensor used to measure the Electrical Conductivity or Specific Conductivity of the water. Often deployed at continuous monitoring stations in the field
YSI Sonde (YSI Inc., Yellow Springs, OH)	Multi-parameter instrument used to measure water quality. Most often used during sampling events.
Lux light meter (VWR International, West Chester, PA)	Meter used to measure light intensity.
GPS Map 188C Sounder with sonar (Garmin Intl. Inc., Olathe KS)	Global Positioning System. Used to track location when using the boat and to map out sample sites.

Table 2: DOTMDL Site List

DO Number	*Site Name*	*Type*
1	**SJR at Channel Point**	Intermittent
2	**SJR at Dos Reis Park (Lathrop)**	Intermittent
3	**SJR at Old River**	Intermittent
4	**SJR at Mossdale**	Core sites
5	**SJR at Vernalis-McCune Station (River Club)**	Core sites
6	**SJR at Maze**	Core sites
7	**SJR at Patterson**	Core sites
8	**SJR at Crows Landing**	Core sites
9	**SJR at Fremont Ford**	Intermittent
10	**SJR at Lander Avenue**	Core sites
11	**French Camp Slough**	Intermittent
12	**Stanislaus River at Caswell Park**	Core sites
13	**Stanislaus River at Ripon**	Intermittent
14	**Tuolumne River at Shiloh Bridge**	Core sites
15	**Tuolumne River at Modesto**	Intermittent
16	**Merced River at River Road**	Core sites
17	**Merced River near Stevinson**	Intermittent
18	**Mud Slough near Gustine**	Core sites, Wetland
19	**Salt Slough at Lander Avenue**	Core sites, Wetland
20	**Los Banos Creek Flow Station**	Core sites, Wetland
21	**Orestimba Creek at River Road**	Core sites
22	**Modesto ID Lateral 4 to SJR**	Intermittent
23	**Modesto ID Lateral 5 to Tuolumne**	Core sites
24	**Modesto ID Lateral 6 to Stanislaus River**	Intermittent
25	**Modesto ID Main Drain to Stan. R. via Miller Lake**	Core sites
26	**Turlock ID Highline Spill**	Intermittent
27	**Turlock ID Lateral 2 to SJR**	Intermittent
28	**Turlock ID Westport Drain Flow station**	Core sites
29	**Turlock ID Harding Drain**	Core sites
30	**Turlock ID Lateral 6 & 7 at Levee**	Core sites
31	**BCID - New Jerusalem Drain**	Intermittent
32	**El Solyo WD - Grayson Drain**	Intermittent
33	**Hospital Creek**	Core sites
34	**Ingram Creek**	Core sites
35	**Westley Wasteway Flow Station**	Intermittent
36	**Del Puerto Creek Flow Station**	Core sites
37	**Newman Wasteway at SJR**	Intermittent
38	**Marshall Road Drain**	Intermittent
39	**Salado Creek Flow Station**	Intermittent
40	**Patterson Irrigation District Diversion**	Diversion
41	**West Stanislaus Irrigation District Diversion**	Diversion
42	**Banta Carbona Irrigation District Diversion**	Diversion
43	**El Solyo Water District Diversion**	Diversion
44	**San Luis Drain End**	Core sites
45	**Volta Wasteway at Ingomar Grade**	Intermittent
46	**Mud Slough at Gun Club Road**	Intermittent, Wetland
47	**Delta-Mendota Canal inlet to the Mendota Pool**	Intermittent
48	**San Luis Drain Site A**	Intermittent
49	**FC-5 - Grassland Area Farmers**	Intermittent
50	**PE-14 - Grasslands Area Farmers**	Intermittent
51	**Arroyo Canal**	Intermittent
52	**Salt Slough at Sand Dam**	Intermittent
53	**Salt Slough at Wolfsen Road**	Wetland

DO Number	Site Name	Type
54	**Los Banos Creek at Ingomar Grade**	Intermittent
55	**Modesto WWTP**	NPDS
56	**Turlock WWTP**	NPDS
57	**Ramona Lake Drain**	Core sites
58	**San Luis Drain Site B**	Intermittent
59	**SJR Laird Park**	Core sites
60	**Moffit 1 South**	Wetland
61	**Deadmans Slough**	Wetland
62	**Mallard Slough**	Wetland
63	**Inlet C Canal**	Wetland
64	**Moran Drain**	Intermittent
65	**Spanish Grant Drain**	Intermittent
66	**ESWD Maze Blv. Drain**	Intermittent
67	**Newman Wasteway at Brazo Road**	Intermittent
68	**S-Lake Basin**	Intermittent
69	**Santa Fe Canal**	Intermittent
80	**South Marsh-1-Inlet**	Wetland
81	**South Marsh-1-Outlet**	Wetland
82	**South Marsh-3-Inlet**	Wetland
83	**South Marsh-3-Outlet**	Wetland
84	**SJR at Highway 4 (Garwood Bridge Charter Way)**	Intermittent
85	**SJR Hills Ferry**	Intermittent
86	**Ramona drain Apple Ave**	BMP
87	**Ramona drain Prune Ave**	BMP
88	**Ramona drain Apricot Ave**	BMP
89	**Ramona drain Pomelo Ave**	BMP
90	**Ramona drain Almond Ave**	BMP
91	**Paradise drain Prune Ave**	BMP
92	**Paradise drain Apricot Ave**	BMP
93	**Paradise drain Pomelo Ave**	BMP
94	**Paradise drain Almond Ave**	BMP
95	**Ramona drain at Ramona Lake**	BMP, Intermittent
96	**WPF-VD-1**	BMP
97	**WPF-VD-2**	BMP
98	**WPF-VD-3**	BMP
99	**WPF-VD-4**	BMP
100	**WPF-VD-5**	BMP
101	**WPF-UD-IN**	BMP
102	**WPF-UD-OUT**	BMP
103	**SLD Check 18**	Intermittent
104	**SLD Check 16**	Intermittent
105	**SLD Check 15**	Intermittent
106	**SLD Check 14**	Intermittent
107	**SLD Check 13**	Intermittent
108	**SLD Check 12**	Intermittent
109	**SLD Check 11**	Intermittent
110	**SLD Check 10**	Intermittent
111	**SLD Check 9**	Intermittent
112	**SLD Check 8**	Intermittent
113	**SLD Check 7**	Intermittent
114	**SLD Check 6**	Intermittent
115	**SLD Check 5**	Intermittent
116	**SLD Check 4**	Intermittent
117	**SLD Check 3**	Intermittent

DO Number	*Site Name*	*Type*
118	**SLD Check 2**	Intermittent
119	**SLD Check 1**	Intermittent
120	**South Marsh-1-Intermediary**	Wetland
121	**South Marsh-1-East**	Wetland
122	**South Marsh-1-West**	Wetland
123	**Ramona Lake NW Quad**	Intermittent
124	**Ramona Lake NE Quad**	Intermittent
125	**Ramona Lake SW Quad**	Intermittent
126	**Ramona Lake SE Quad**	Intermittent
127	**SJR at Brant Bridge**	Intermittent
128	**SJR Brickyard Site**	Intermittent

End Table 2

Chapter 4

RANKING OF SAN JOAQUIN RIVER TRIBUTARIES BY LOAD AND WATER QUALITY

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Introduction

One objective of the DO TMDL Project is to collect baseline data on water quality and flow conditions in the SJR and to provide that information to interested stakeholders in a way that facilitates stakeholder-lead management actions necessary to meet TMDL requirements and improve beneficial uses. Development of any action plan requires the setting of priorities and goals.

One approach to setting priorities is to establish numeric standards for water quality and determine which sites are better or worse than the numeric standard. There are numerous drawbacks to this approach, including the scientific uncertainty of how to establish numeric goals and the lack of numeric standards for many water quality constituents of concern. When numeric standard do exist, the use of standards set for one purpose in the development of priorities for unrelated purposes is questionable. For example, optimization of fish habitat is unlikely to be achieved by setting goals based on drinking water standards. There are other questions concerning numeric standards. How applicable are numeric standards set on a state or national level to individual local conditions? How are numeric standards are useful for setting priorities if all watersheds under scrutiny fail to achieve minimum standards? Finally, there is often lack of agreement among stakeholders and regulators as to what the numeric goals should be and that any actual improvement in environmental conditions may be delayed until final numeric goals are established.

An alternative method for setting remediation or restoration priorities is to rank locations within a watershed in relation to each other. If parties can agree on the simple premise than water quality in a watershed needs improvement, then it follows that taking action toward improvement would be advisable, even if there was not agreement as to what the final level of improvement needs to be reached. By ranking locations in the watershed to each other, priorities for action can be set in the absence of specific regulatory targets. Ranking is obviously a useful tool for the TMDL process.

There are numerous ways to rank water quality between locations and ranks can further be combined into indexes to differentiate locations from each other. The most common ranking techniques involve the calculation of a arithmetic means (averages) and associated parametric measures of variance and then applying methods such as means-testing or analysis of variance (ANOVA) to differentiate locations from each other. The drawback to this approach is that water quality monitoring data are typically not normally distributed and a normal distribution is a requirement for the valid application of parametric statistical methods. Various transformations can be applied, such as log-transformations, but in some cases these transformations do not yield normally distributed data. The calculation of parametric means on non-normal data has little statistical significance. The non-normal distribution of water quality data strongly effects the resulting means, which can be skewed by outlying measurements, particularly in the case where there are a limited number of values are recorded. In addition, non-detect results are often ignored when parametric methods are applied, particularly if data are log-transformed before analysis, biasing against locations with only transient poor water quality events.

An alternative approach to ranking and indexing water quality data is to use nonparametric methods. Although less widely utilized than parametric statistics, nonparametric methods are accepted as statistically valid and are simple in concept (Lehmann, 2006; Sokal and Rohlf, 1995). In nonparametric analysis, scores (1, 2, 3, ... *n*) are substituted for actual numeric data and comparisons are made using sums of score (rankings) rather than the measurements themselves. Nonparametric methods are less biased by outlying data and are applicable to data that is not normally distributed (Lehmann, 2006; Sokal and Rohlf, 1995).

In this report, water quality and loads between tributary locations on the SJR were examined using both parametric and nonparametric methods. The use of parametric means to compare locations was questioned due to the non-normal distribution of the SJR data. Wilcoxon ranking procedures were applied to SJR data and normalized rank-means (NRMs) were calculated for each sampling location (Lehmann, 2006; Wilcoxon, 1945). The NRMs were used to compare load and water quality between locations and are believed to be more reliable and statistically valid. NRMs are also used to calculate water quality indexes that allow the simultaneous comparison of multiple water quality parameters by location. Unsupervised pattern recognition methods (cluster analysis) were used to help visualize results and assist stakeholders in synthesizing monitoring results. In this Chapter we are presenting the results of water quality and load data collected in 2005 and 2006 from the primary tributaries of the SJR between Mossdale and Lander Ave.

Methods

Sample collection and measurement of water quality parameters followed procedures described in Chapters 2 and 3.

Data from 2005 and 2006 were compiled and analyzed using both parametric and nonparametric statistical methods (Lehmann, 2006; Sokal and Rohlf, 1995; Zar, 1999). The one-way analysis of variance (ANOVA) and Tukey-Kramer HSD (honestly significant difference) test were applied as parametric means difference tests. The Wilcoxon mean rank test was applied to generate normalized rank-means (NRMs) used to compare water quality and load between locations. For NRM analysis, the water quality and load data for each parameter for all locations to be compared were pooled and assigned a rank according the method of Wilcoxon (Lehmann, 2006; SAS Institute Inc., 2007; Wilcoxon, 1945). For each location, the expected rank under the null hypothesis (that all locations have equal rank) was subtracted from the actual rank sum of that location and the result divided by the standard deviation of pooled data, yielding a NRM expressed in units of standard deviation.

$$\text{NRM} = (R_j - R_o)/(\text{SD})$$

where R_j is the actual rank-sum of water quality at location *j*; R_o is the expected rank sum for a location under the null hypothesis (that all locations are equal); and SD is the standard deviation for the polled ranks. The NRM is similar to the ‘C’ or ‘z’ Wilcoxon statistic (Sokal and Rohlf, 1995; Zar, 1999). Parametric and nonparametric calculations were preformed using JMP statistical software (SAS Institute, Research Triangle Park, NC).

For the calculation of an overall "water quality" ranking for each location, the average of the NRMs for electrical conductivity (EC), chlorophyll-a (chl-a), total organic carbon (TOC), volatile suspended solids (VSS), mineral suspended solids (MSS), ammonia (NH4-N), nitrate (NO3-N), soluble reactive phosphate (oPO4), and biochemical oxygen demand (BOD) was calculated. For an overall "algae" ranking for each location the average of the NRMs for chl-a, NO3-N, NH4-N, and oPO4 was calculated. The parameters used in the calculation of the "algae" ranking were previously shown to have a positive correspondence to phytoplankton growth in this system (Stringfellow et al., 2006).

Unsupervised pattern recognition or cluster analysis (CA) was used to organize NRM results and indexes into three groups based on natural divisions as determined by Ward's minimum-variance method (SAS Institute Inc., 2007). In Wards minimum-variance method, the distance between two clusters is the ANOVA sum of squares between the two clusters. At each generation, the within-cluster sum of squares is minimized over all partitions obtainable by merging two clusters from the previous generation (SAS Institute Inc., 2007). *In this application, cluster analysis is used as a visualization tool only. Members of each group are more alike to each other than the other groups, but there is no attempt to measure the significance of the grouping in this report*. The assignment of locations to three groups, as apposed to five or any other number, is arbitrary and three groups were selected for simplicity of presentation and understanding. The assignment of colors and markers is for visual effect only and has no inherent meaning.

Results

The parametric means (averages) and associated coefficients of variation (CV) are presented in Appendix A for selected water quality parameters by tributary location. Averages are strongly influenced by outlying or extreme values and this effect is pronounced in cases were the number of samples is small, as demonstrated by the high CV values for many locations (Appendix A).

Water quality data collected in the San Joaquin Valley between March 2005 and December 2006 was tested for a normal distribution, both before and after transformation (log, power, and Weibull). Distributions were tested for pooled data and data by individual locations. For pooled data and most sample locations, water quality data was not normally distributed, a requisite for the application of most parametric statistical methods used to compare means (Sokal and Rohlf, 1995). Some parametric methods are robust enough that they are often applied to data that are not normally distributed and these methods (ANOVA and means testing) were applied to determine if they could be used to rank and distinguish sampling locations one from another (Sokal and Rohlf, 1995; Zar, 1999). The ANOVA test determined that locations did differ from each other, but means-testing did not organize the results in a meaningful manner (see Table 1 for example). The high variance of the water quality data at many locations obscured differences between locations. Based on the non-normal distribution and the high variance of the data, it was concluded that the use of parametric means was not an effective way to compare and organize water quality information between different tributary locations in the San Joaquin Valley.

The use of Wilcoxon ranks, a nonparametric method, was tested as a method for comparing locations. The Wilcoxon-rank method is applicable to data that is not normally distributed. NRM were calculated from the Wilcoxon rankings and NRMs were combined to create water quality and algae indexes as described in the methods section. NRM results are presented graphically in Figures 1 to 19. Figures 1 to 10 present the results of NRM calculated from concentration data and Figures 11 to 19 present NRMs calculated for loading results.

The results of the NRM analysis suggest that NRMs are a useful tool for the organization and comparison of large sets of water quality data, such as have been collected in by the DO TMDL Project. For example, individual NRM calculations allow locations with high concentrations of phosphate (Figure 3) or sediments (Figure 4) to be easily differentiated from locations with high concentrations of algal biomass (Figure 1). since NRMs for different constituents are all expressed in common units of standard deviations from the mean, NRM results for different load or water quality parameters can be combined to create water quality and load indexes, allowing several parameters to be evaluated simultaneously. for example, in Figure 9 and 18, significant sources of nutrients and algal biomass are grouped together, since both nutrients and biomass are independently needed to stimulate excess phytoplankton production in the SJR. In all cases, NRM analysis correctly assigns a favorable rank to the Tuolumne, Stanislaus, and Merced Rivers for water quality, but because of the relatively high flows on these tributaries, assigns a low ranking to those same locations for load (Figures 1 to 19). This ranking is consistent with assignments that would be made other methods.

The results of the NRM analysis are consistent with previous studies identifying sources of nutrients and algal biomass in the DO TMDL Project study area (Kratzer and Shelton, 1998; Kratzer et al., 2004; Stringfellow and Quinn, 2002). Additionally, new information is apparent from this analysis. For example, the apparent importance of Los Banos Creek to water quality in the region was not previously recognized (Figures 10).

In summary, nonparametric methods are useful for organizing the data collected as part of the DO TMDL Project. Combining NRM analysis with CA allows the simple presentation of complex data sets will little apparent loss of information. The combining of NRM results into water quality and load indexes is a useful tool for examining different parameters simultaneously. The use of NRM analysis and the application of nonparametric statistical techniques to the analysis of DO TMDL Project data will continue for the duration of the project.

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Figure 1: Normalized rank means (NRMs) of San Joaquin River tributaries in relation to each other for the water quality parameter chlorophyll-*a* (phytoplankton biomass). Cluster analysis (CA) was used to visually display NRM results from lowest to highest rankings. In this application, CA is used as a visualization tool only and there is no attempt to measure the significance of the grouping. The assignment of colors and markers is for visual effect only and has no inherent significance.

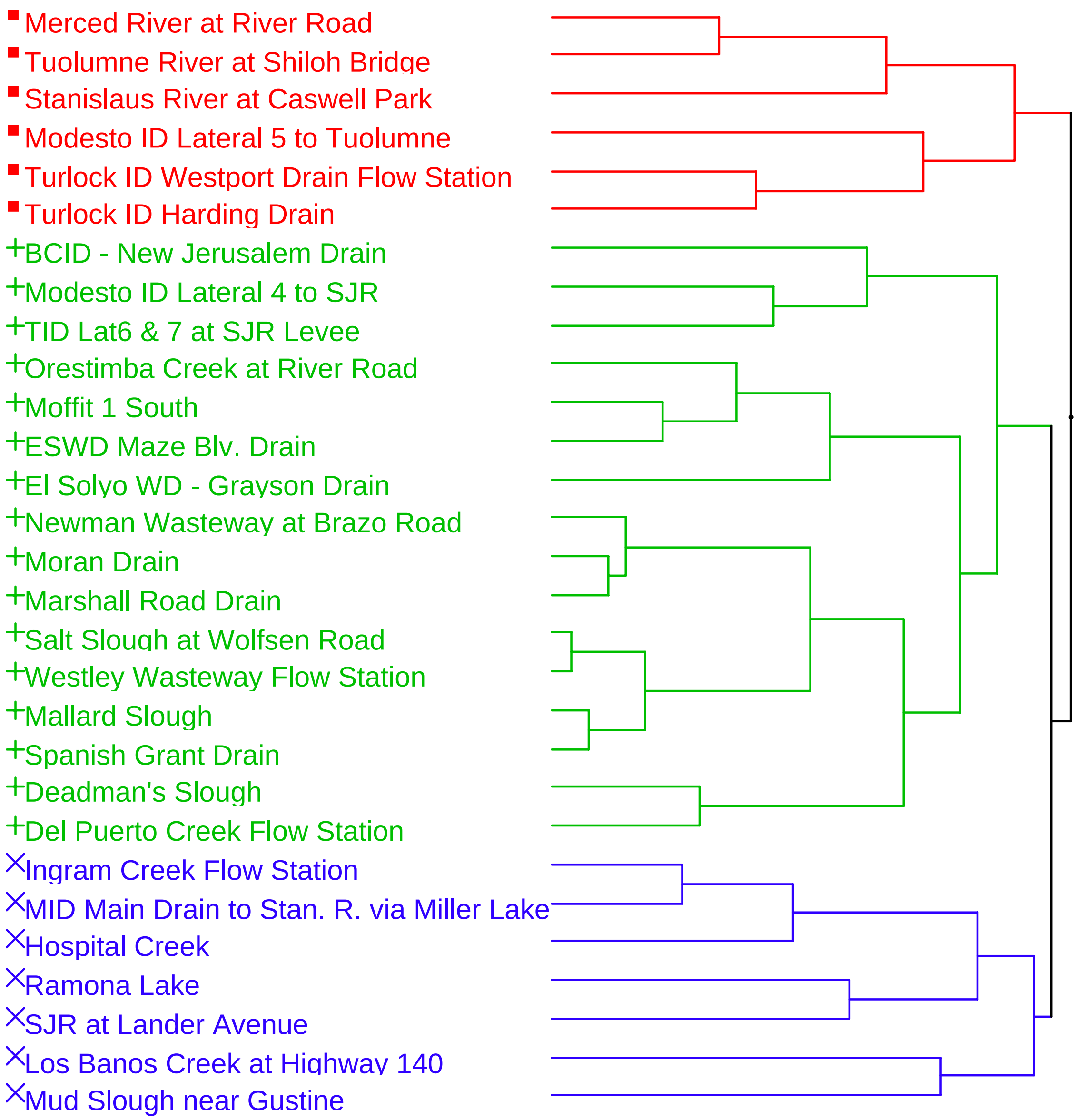

Figure 2: Normalized rank means (NRMs) of San Joaquin River tributaries in relation to each other for the water quality parameter nitrate-nitrogen (NO3-N). Cluster analysis (CA) was used to visually display NRM results from lowest to highest rankings. In this application, CA is used as a visualization tool only and there is no attempt to measure the significance of the grouping. The assignment of colors and markers is for visual effect only and has no inherent significance.

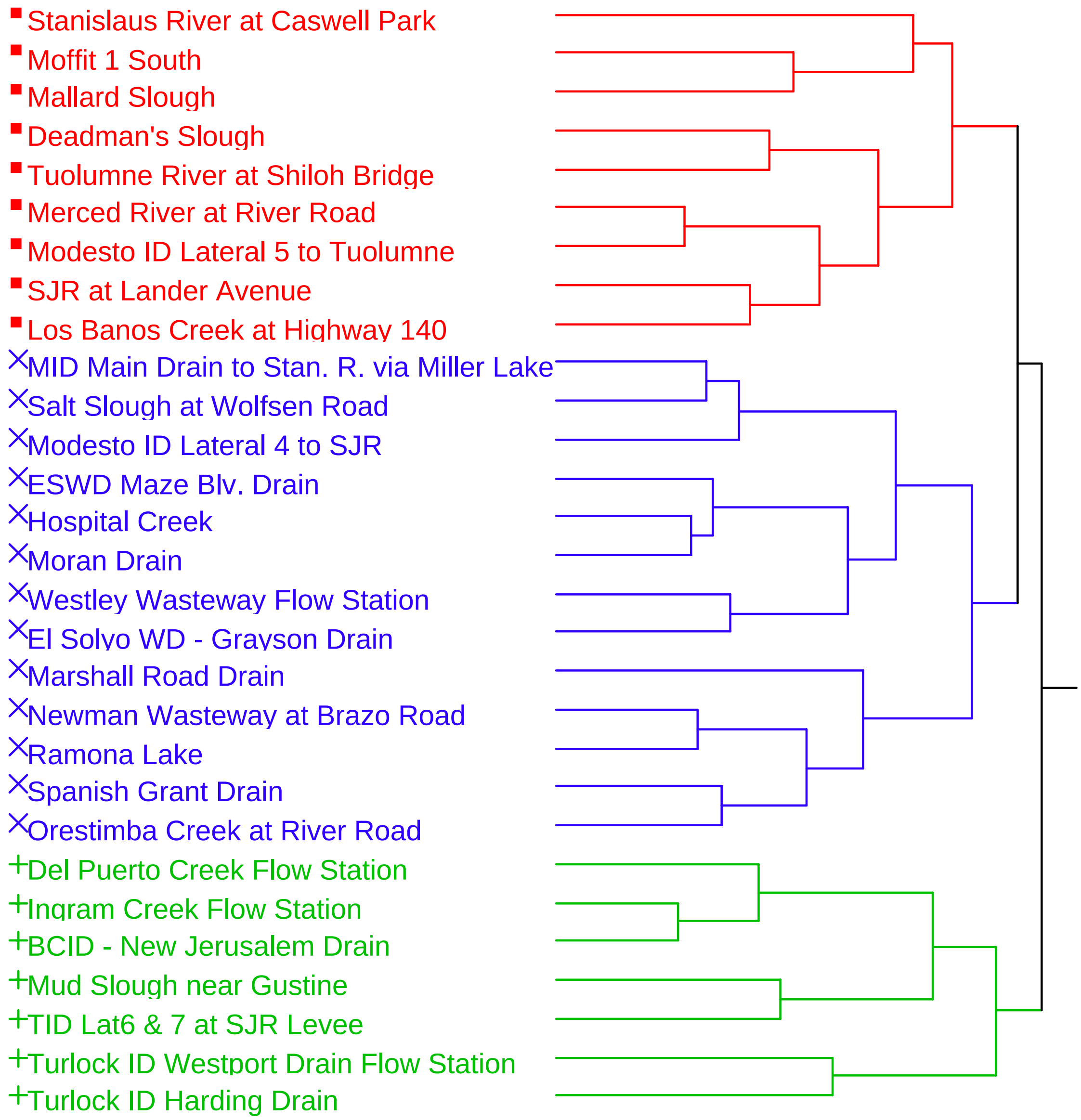

Figure 3: Normalized rank means (NRMs) of San Joaquin River tributaries in relation to each other for the water quality parameter soluble reactive phosphate phosphorous (oPO4-P). Cluster analysis (CA) was used to visually display NRM results from lowest to highest rankings. In this application, CA is used as a visualization tool only and there is no attempt to measure the significance of the grouping. The assignment of colors and markers is for visual effect only and has no inherent significance.

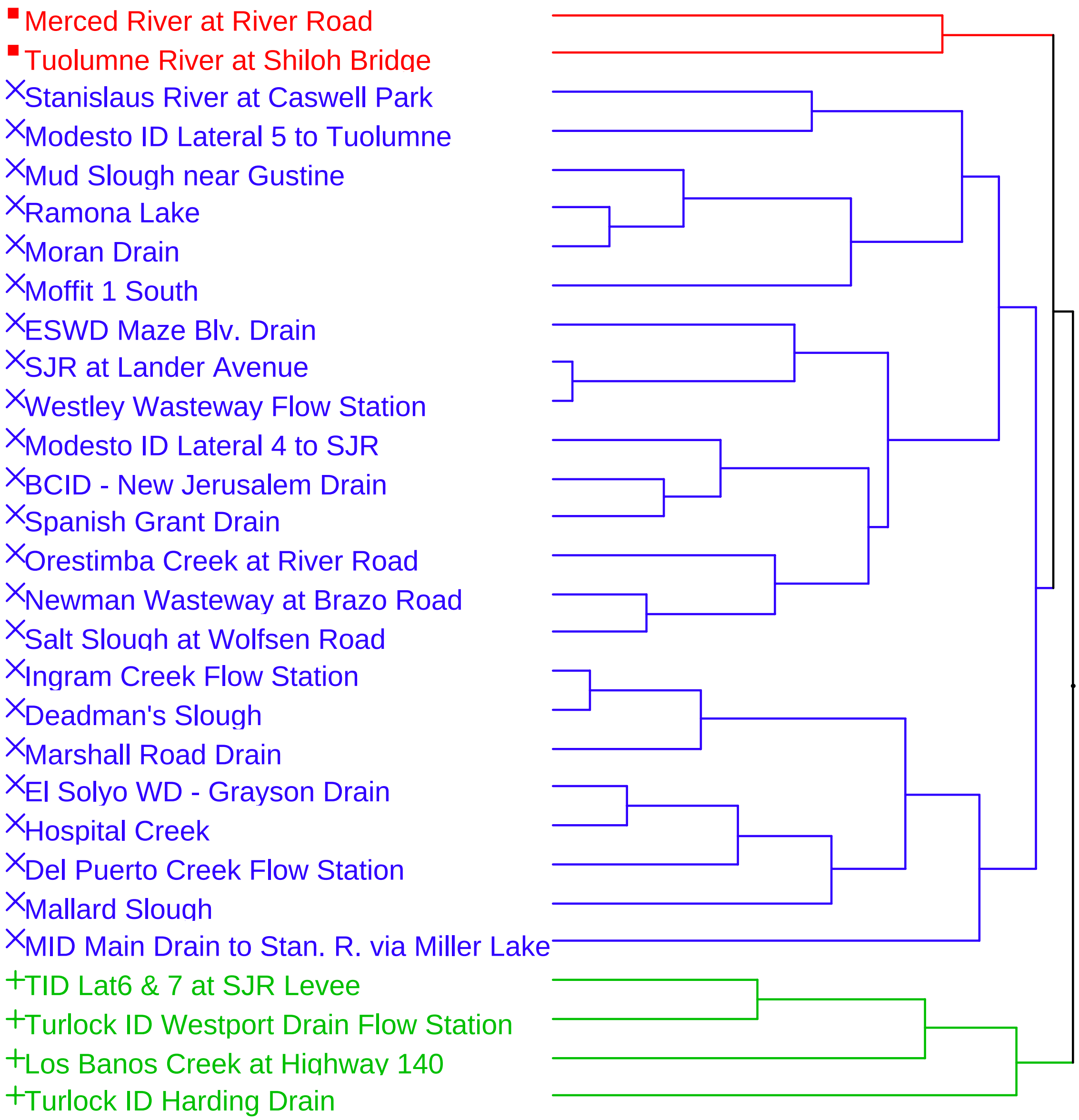

Figure 4: Normalized rank means (NRMs) of San Joaquin River tributaries in relation to each other for the water quality parameter mineral suspended solids (MSS). Cluster analysis (CA) was used to visually display NRM results from lowest to highest rankings. In this application, CA is used as a visualization tool only and there is no attempt to measure the significance of the grouping. The assignment of colors and markers is for visual effect only and has no inherent significance.

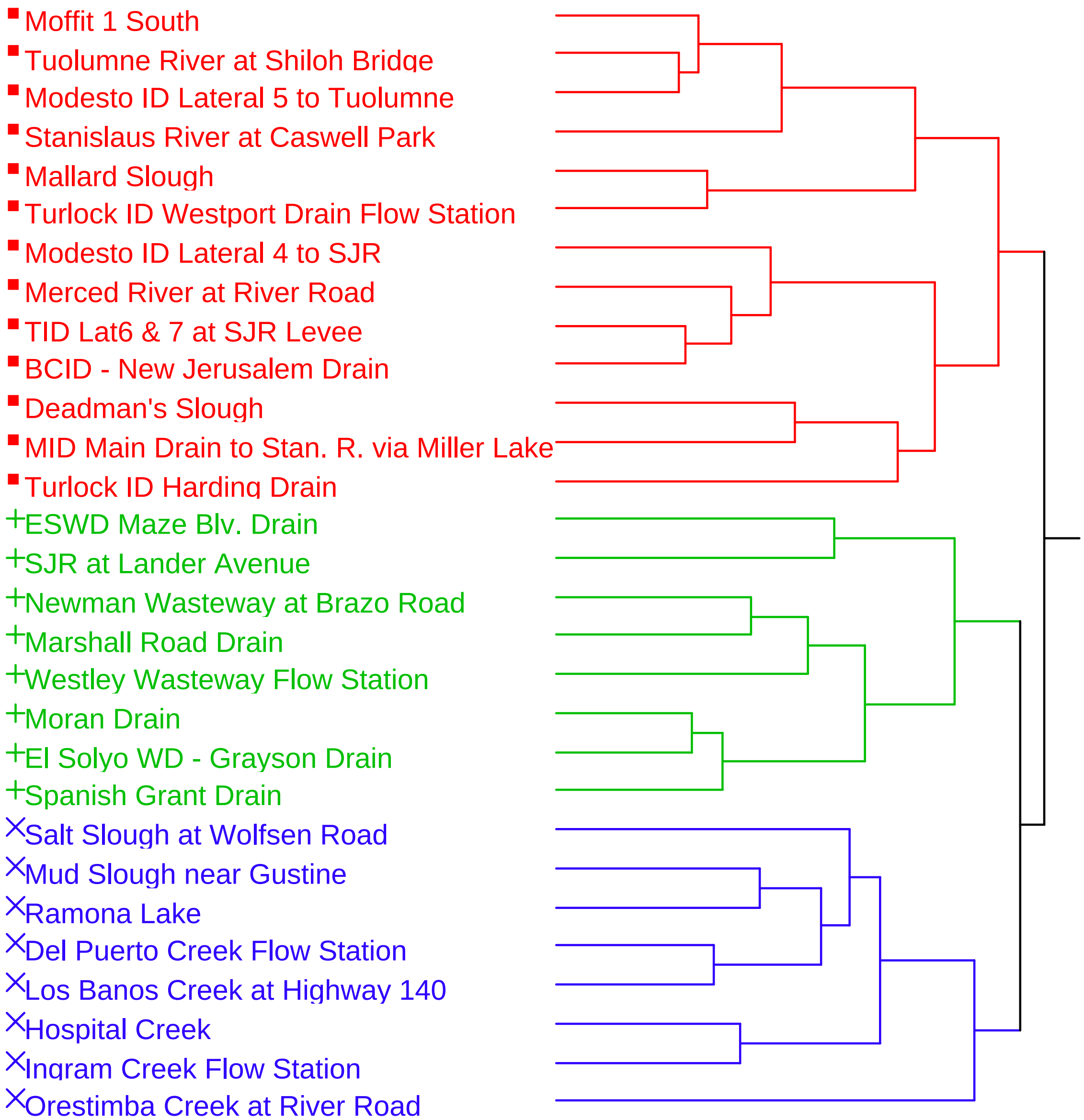

Figure 5: Normalized rank means (NRMs) of San Joaquin River tributaries in relation to each other for the water quality parameter biochemical oxygen demand (BOD). Cluster analysis (CA) was used to visually display NRM results from lowest to highest rankings. In this application, CA is used as a visualization tool only and there is no attempt to measure the significance of the grouping. The assignment of colors and markers is for visual effect only and has no inherent significance.

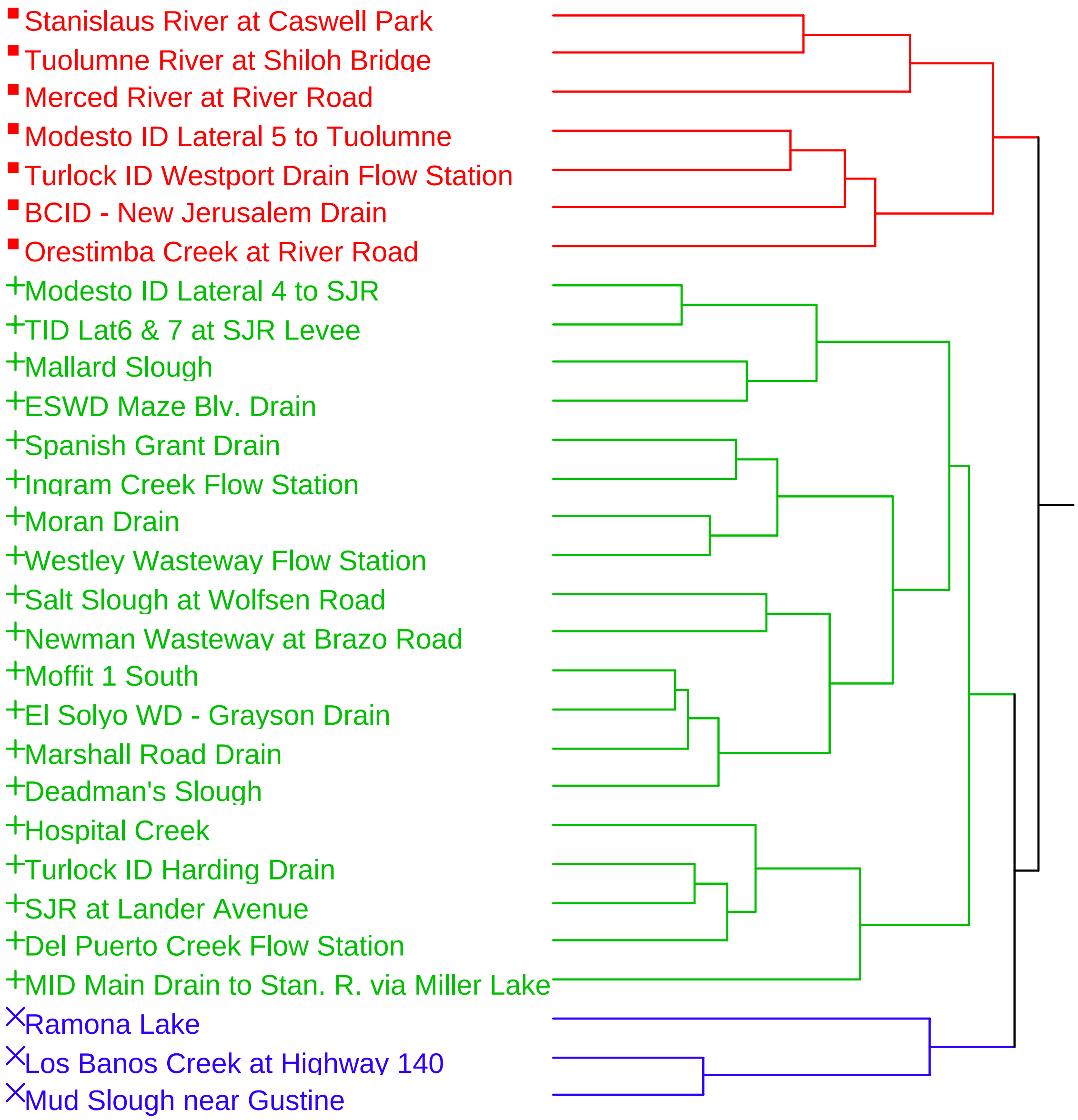

Figure 6: Normalized rank means (NRMs) of San Joaquin River tributaries in relation to each other for the water quality parameter ammonia-nitrogen (NH4-N). Cluster analysis (CA) was used to visually display NRM results from lowest to highest rankings. In this application, CA is used as a visualization tool only and there is no attempt to measure the significance of the grouping. The assignment of colors and markers is for visual effect only and has no inherent significance.

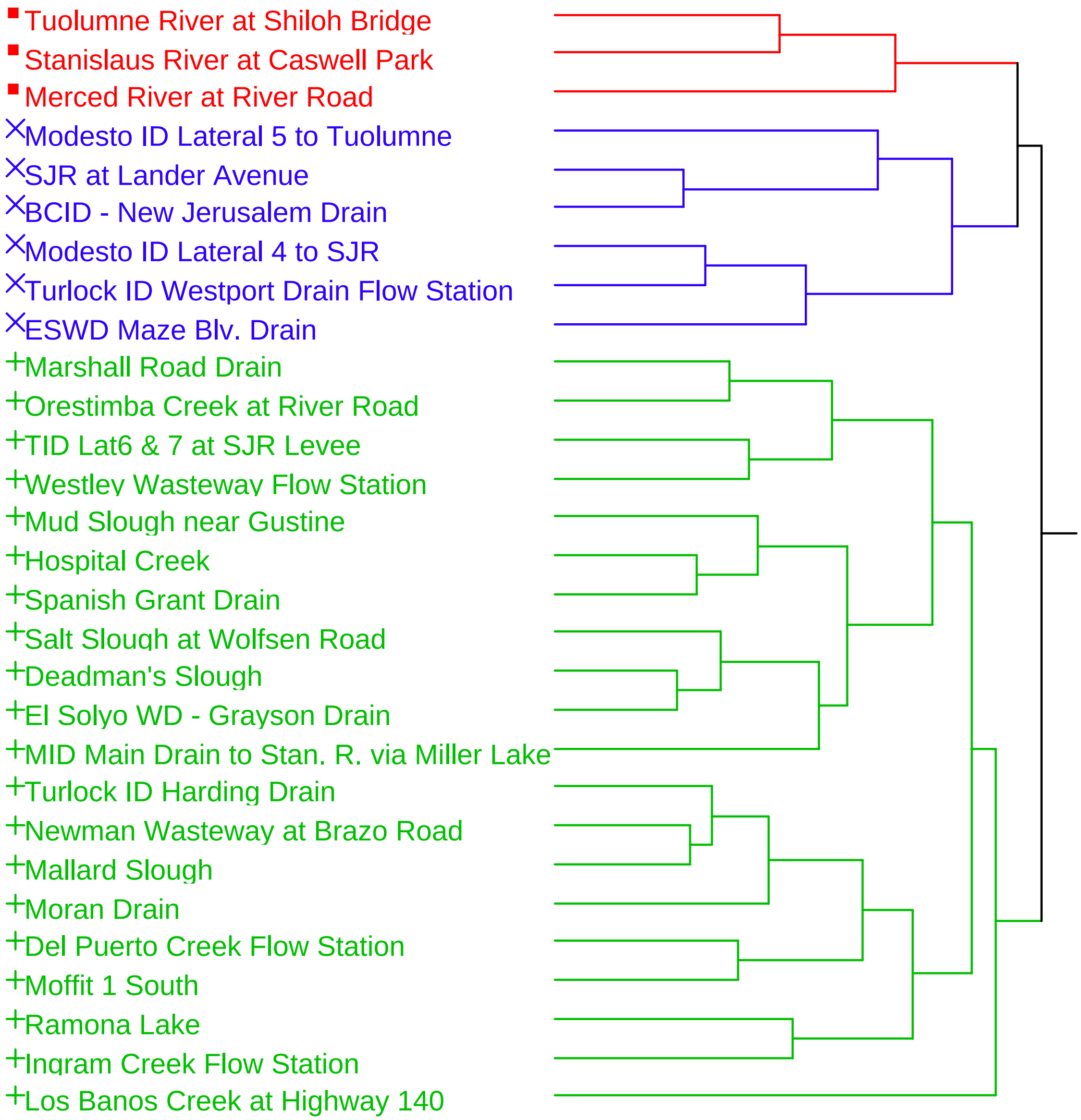

Figure 7: Normalized rank means (NRMs) of San Joaquin River tributaries in relation to each other for the water quality parameter specific conductance (EC). Cluster analysis (CA) was used to visually display NRM results from lowest to highest rankings. In this application, CA is used as a visualization tool only and there is no attempt to measure the significance of the grouping. The assignment of colors and markers is for visual effect only and has no inherent significance.

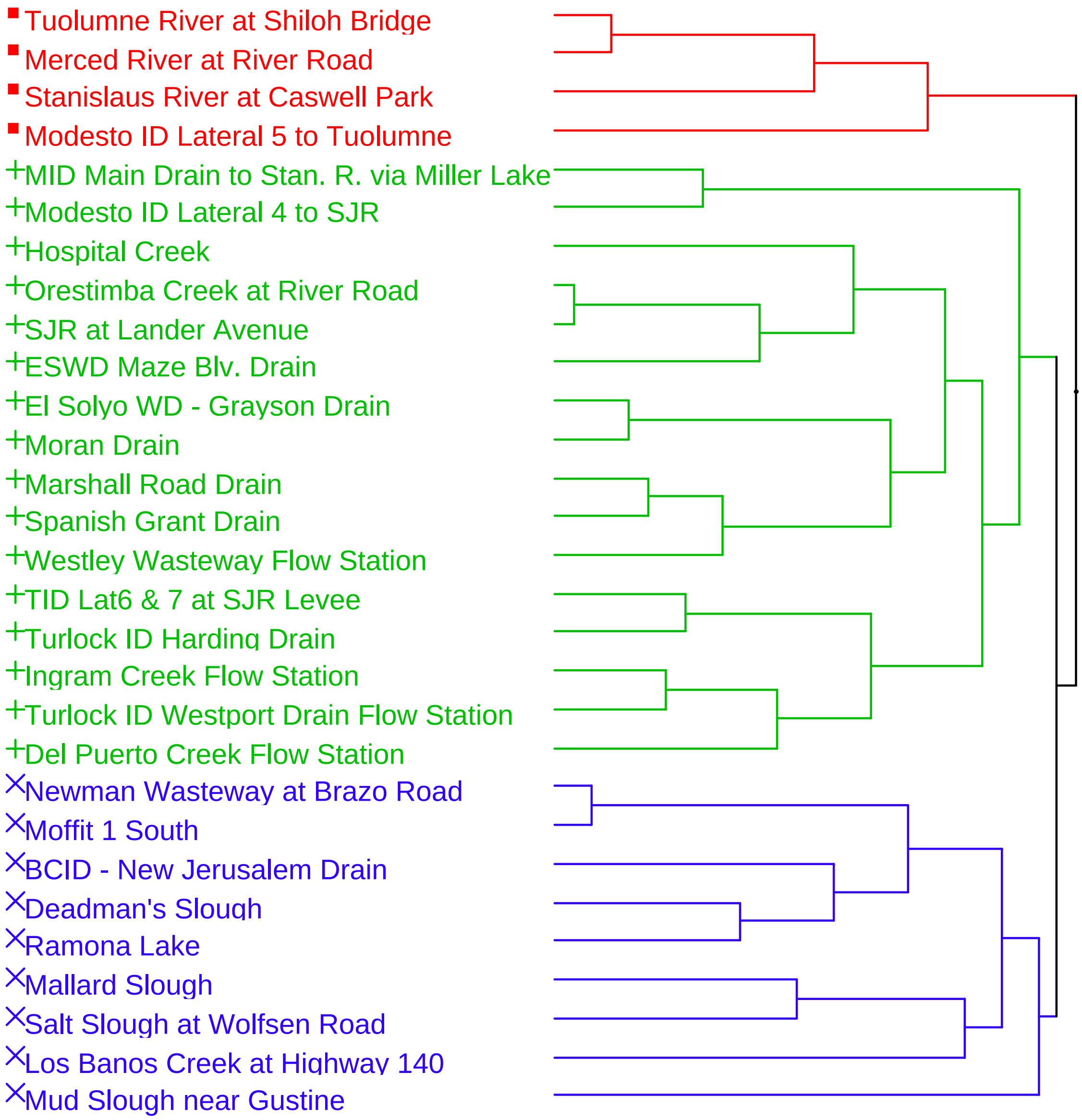

Figure 8: Normalized rank means (NRMs) of San Joaquin River tributaries in relation to each other for the water quality parameter total organic carbon (TOC). Cluster analysis (CA) was used to visually display NRM results from lowest to highest rankings. In this application, CA is used as a visualization tool only and there is no attempt to measure the significance of the grouping. The assignment of colors and markers is for visual effect only and has no inherent significance.

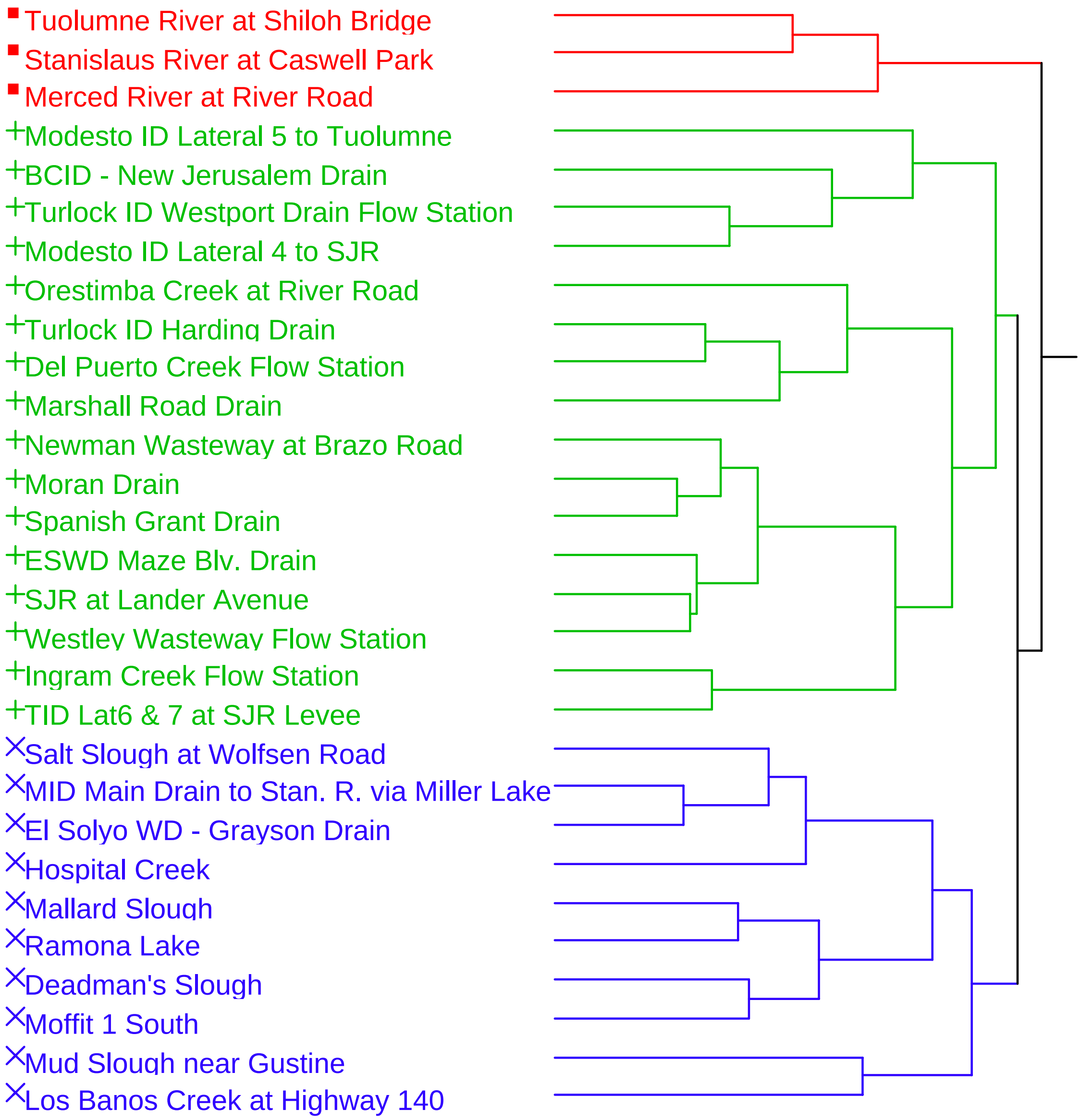

Figure 9: Normalized rank means (NRMs) of San Joaquin River tributaries in relation to each other for an "algae" index created by combining NRM results for phytoplankton biomass and the major nutrients (nitrate, ammonia, and phosphate). Sediments (MSS) were not included in this analysis, but they could be included due to their role influencing the dominance of suspended algae in this system. Cluster analysis (CA) was used to visually display NRM results from lowest to highest rankings. In this application, CA is used as a visualization tool only and there is no attempt to measure the significance of the grouping. The assignment of colors and markers is for visual effect only and has no inherent significance.

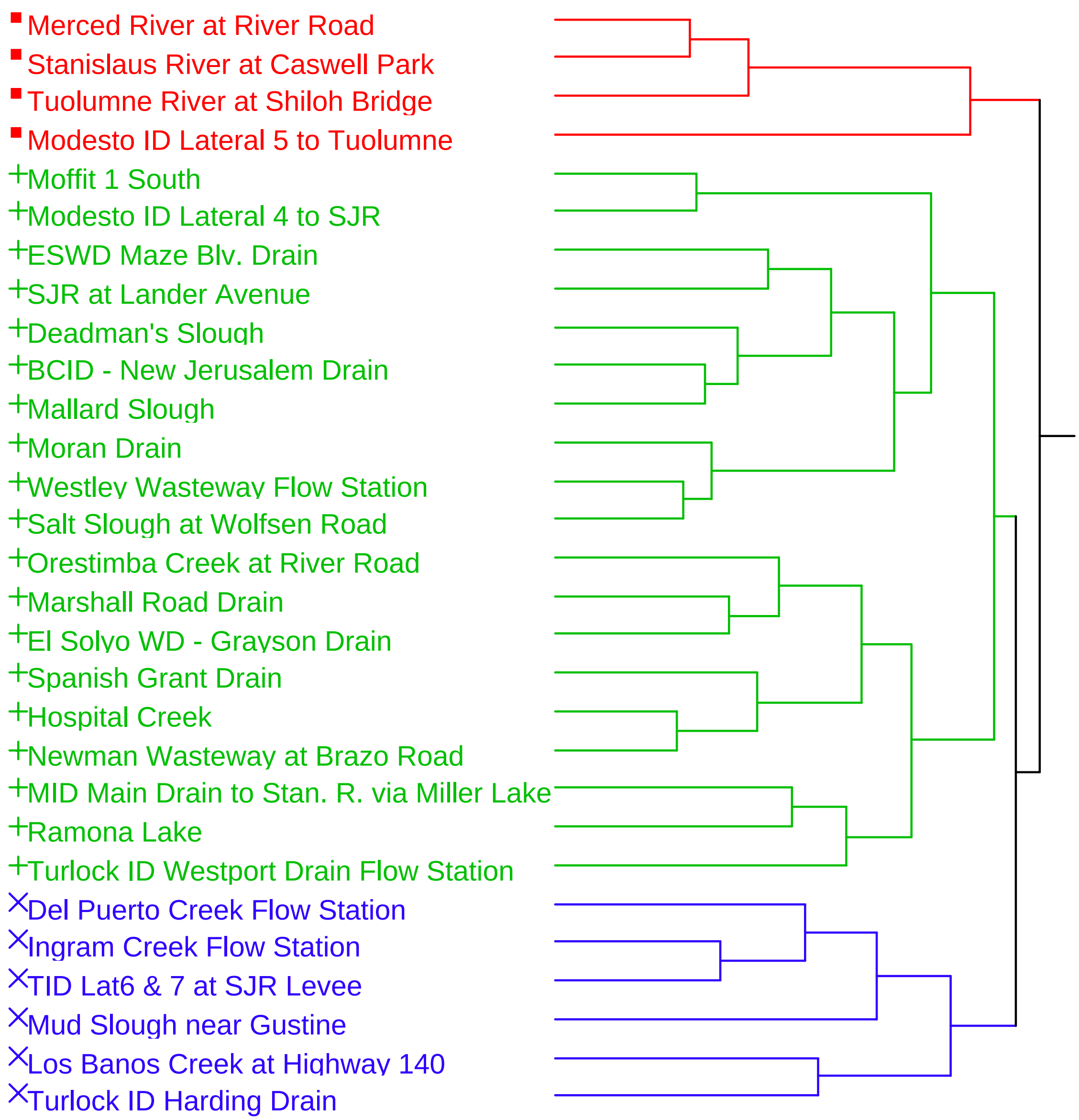

Figure 10: Normalized rank means (NRMs) of San Joaquin River tributaries in relation to each other for a general water quality index created by combining NRM results for chlorophyll-a, nitrate, ammonia, phosphate, sediments, specific conductance, total organic carbon, and biological oxygen demand. Many other water quality parameters could be included in the development of NRM indexes. Cluster analysis (CA) was used to visually display NRM results from lowest to highest rankings. In this application, CA is used as a visualization tool only and there is no attempt to measure the significance of the grouping. The assignment of colors and markers is for visual effect only and has no inherent significance.

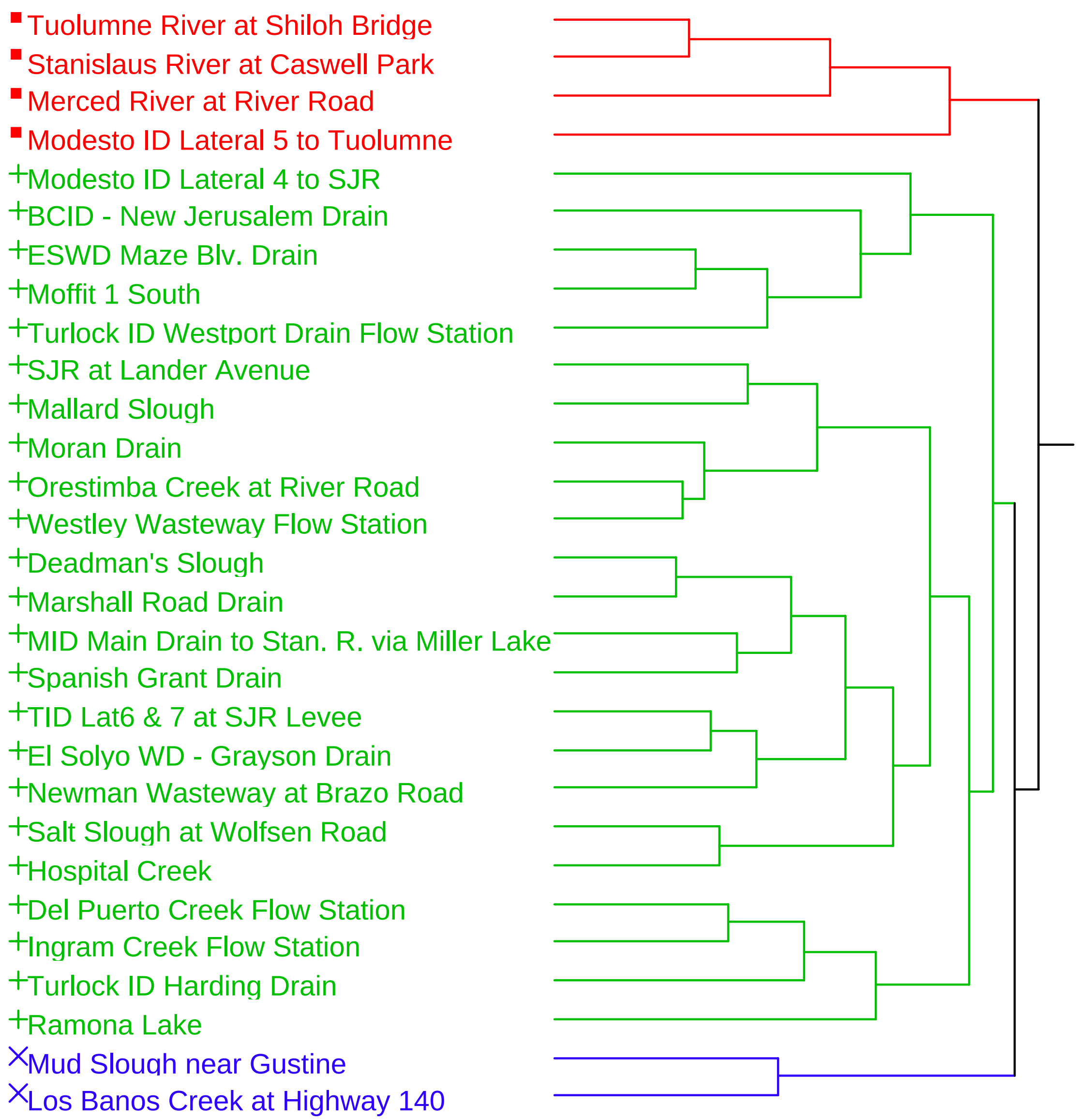

Figure 11: Normalized rank means (NRMs) of San Joaquin River tributaries in relation to each other for the load parameter chlorophyll-*a* (phytoplankton biomass). Cluster analysis (CA) was used to visually display NRM results from lowest to highest rankings. In this application, CA is used as a visualization tool only and there is no attempt to measure the significance of the grouping. The assignment of colors and markers is for visual effect only and has no inherent significance.

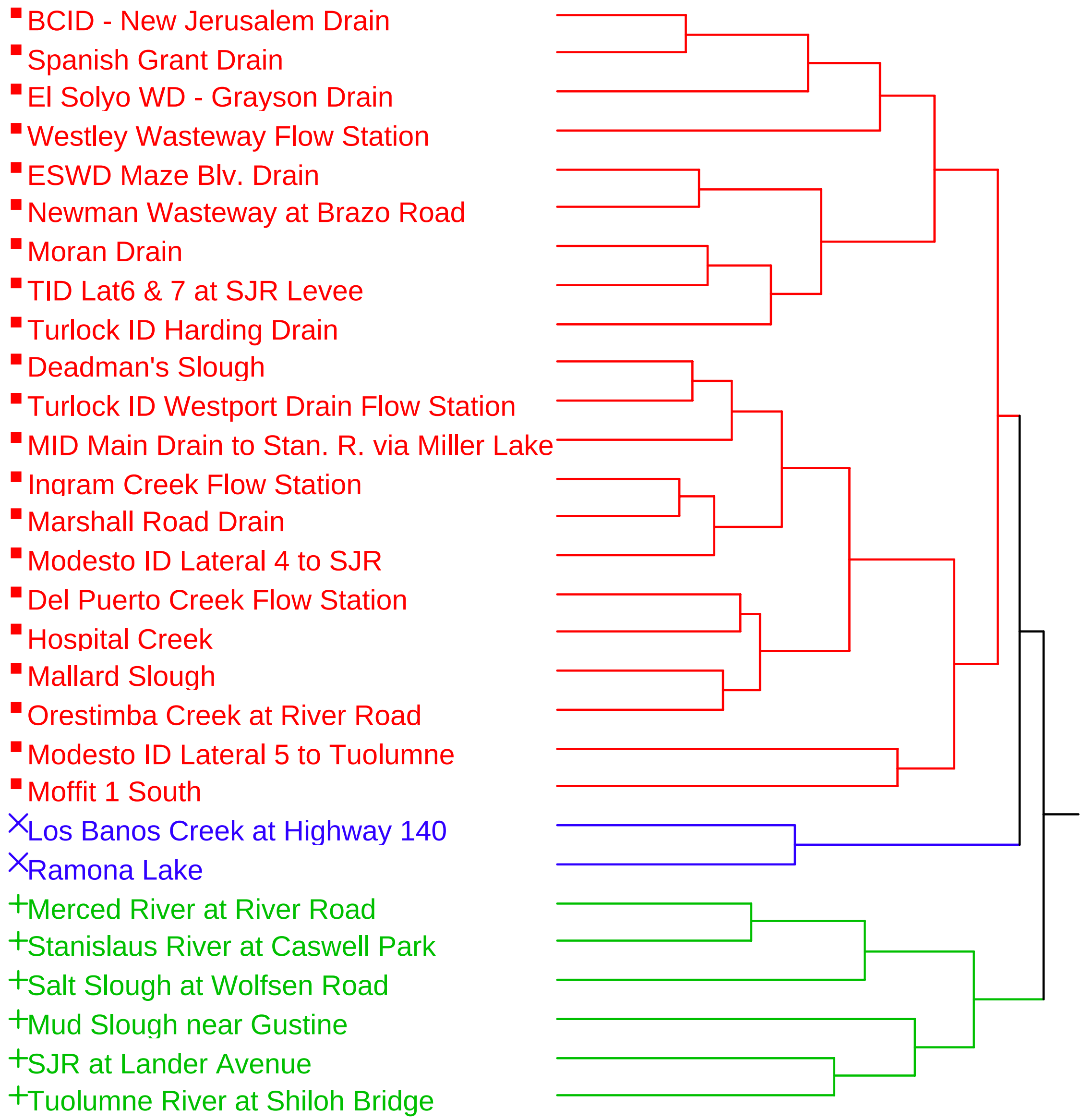

Figure 12: Normalized rank means (NRMs) of San Joaquin River tributaries in relation to each other for the load parameter nitrate-nitrogen (NO3-N). Cluster analysis (CA) was used to visually display NRM results from lowest to highest rankings. In this application, CA is used as a visualization tool only and there is no attempt to measure the significance of the grouping. The assignment of colors and markers is for visual effect only and has no inherent significance.

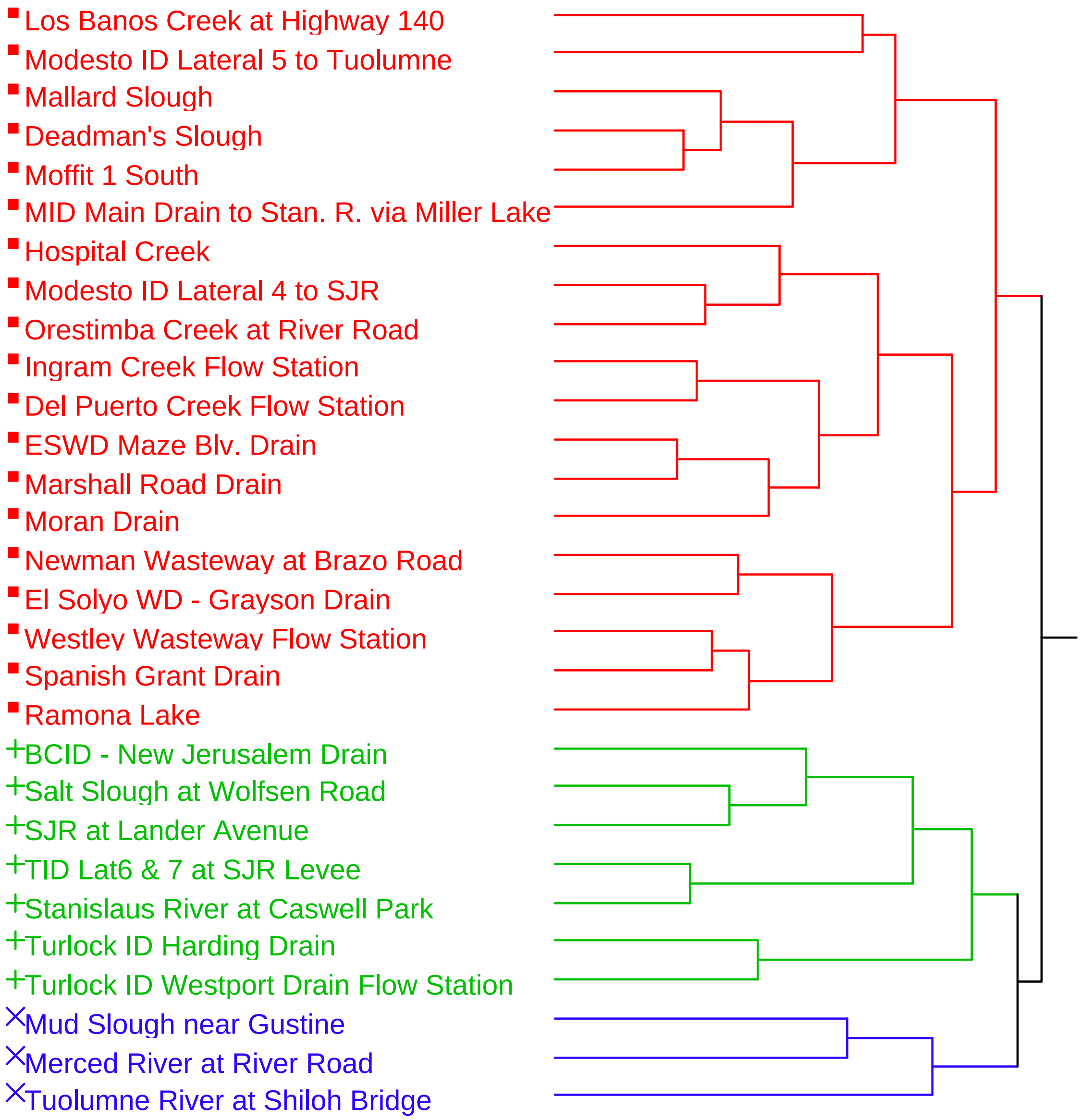

Figure 13: Normalized rank means (NRMs) of San Joaquin River tributaries in relation to each other for the load parameter soluble reactive phosphate phosphorous (oPO4-P). Cluster analysis (CA) was used to visually display NRM results from lowest to highest rankings. In this application, CA is used as a visualization tool only and there is no attempt to measure the significance of the grouping. The assignment of colors and markers is for visual effect only and has no inherent significance.

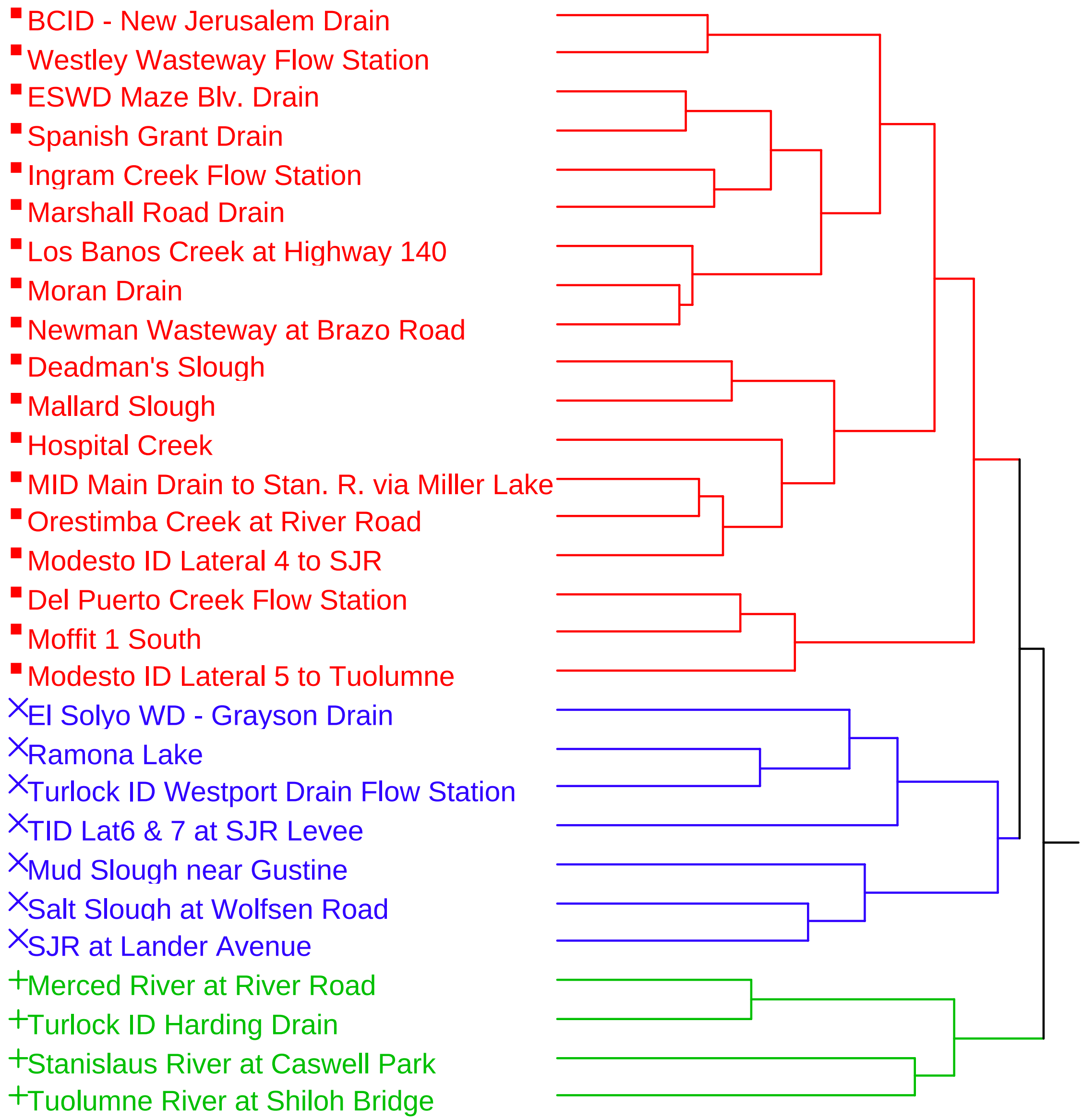

Figure 14: Normalized rank means (NRMs) of San Joaquin River tributaries in relation to each other for the load parameter mineral suspended solids (MSS). Cluster analysis (CA) was used to visually display NRM results from lowest to highest rankings. In this application, CA is used as a visualization tool only and there is no attempt to measure the significance of the grouping. The assignment of colors and markers is for visual effect only and has no inherent significance.

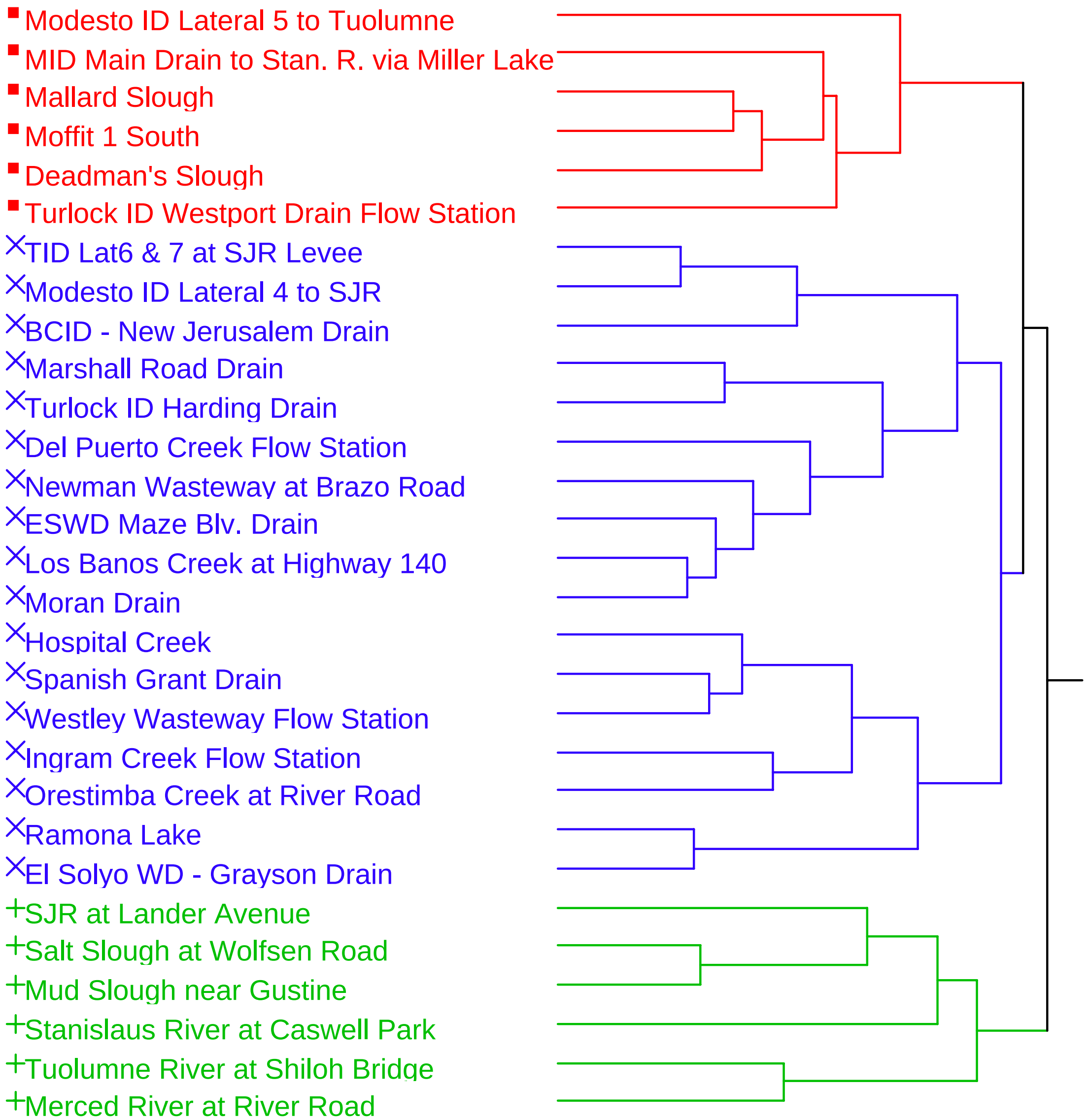

Figure 15: Normalized rank means (NRMs) of San Joaquin River tributaries in relation to each other for the load parameter biochemical oxygen demand (BOD). Cluster analysis (CA) was used to visually display NRM results from lowest to highest rankings. In this application, CA is used as a visualization tool only and there is no attempt to measure the significance of the grouping. The assignment of colors and markers is for visual effect only and has no inherent significance.

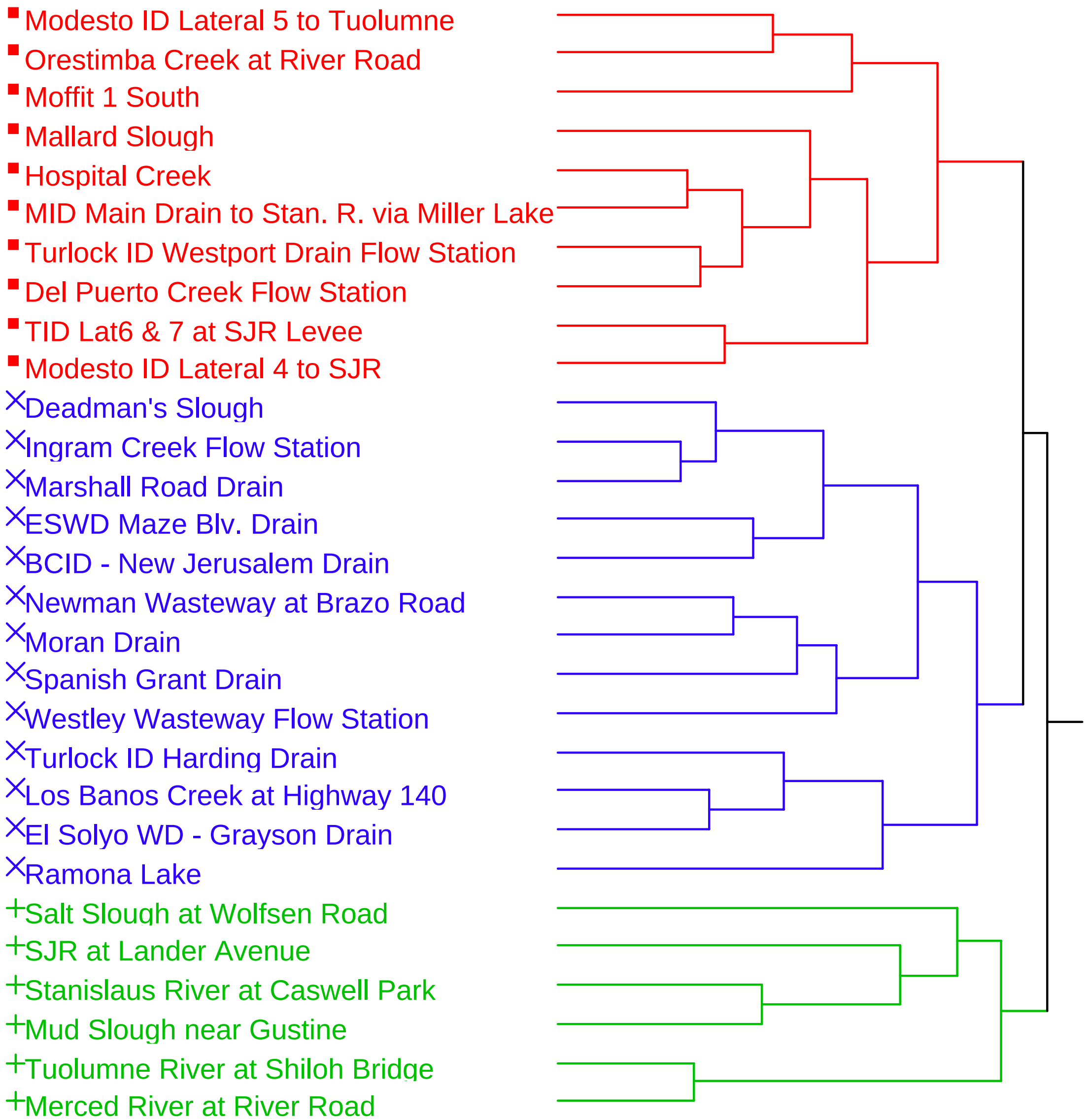

Figure 16: Normalized rank means (NRMs) of San Joaquin River tributaries in relation to each other for the load parameter ammonia-nitrogen (NH4-N). Cluster analysis (CA) was used to visually display NRM results from lowest to highest rankings. In this application, CA is used as a visualization tool only and there is no attempt to measure the significance of the grouping. The assignment of colors and markers is for visual effect only and has no inherent significance.

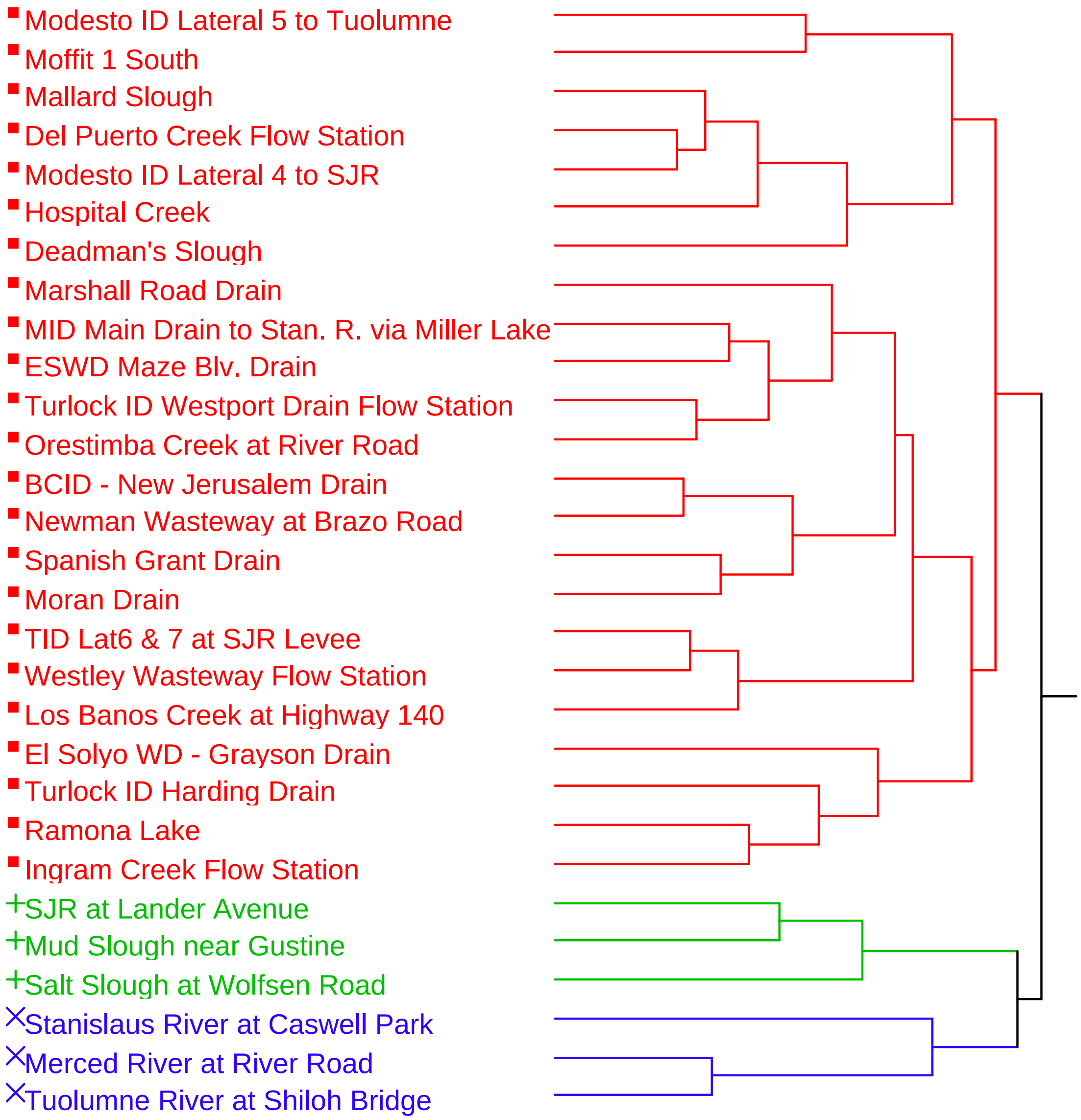

Figure 17: Normalized rank means (NRMs) of San Joaquin River tributaries in relation to each other for the load parameter total organic carbon (TOC). Cluster analysis (CA) was used to visually display NRM results from lowest to highest rankings. In this application, CA is used as a visualization tool only and there is no attempt to measure the significance of the grouping. The assignment of colors and markers is for visual effect only and has no inherent significance.

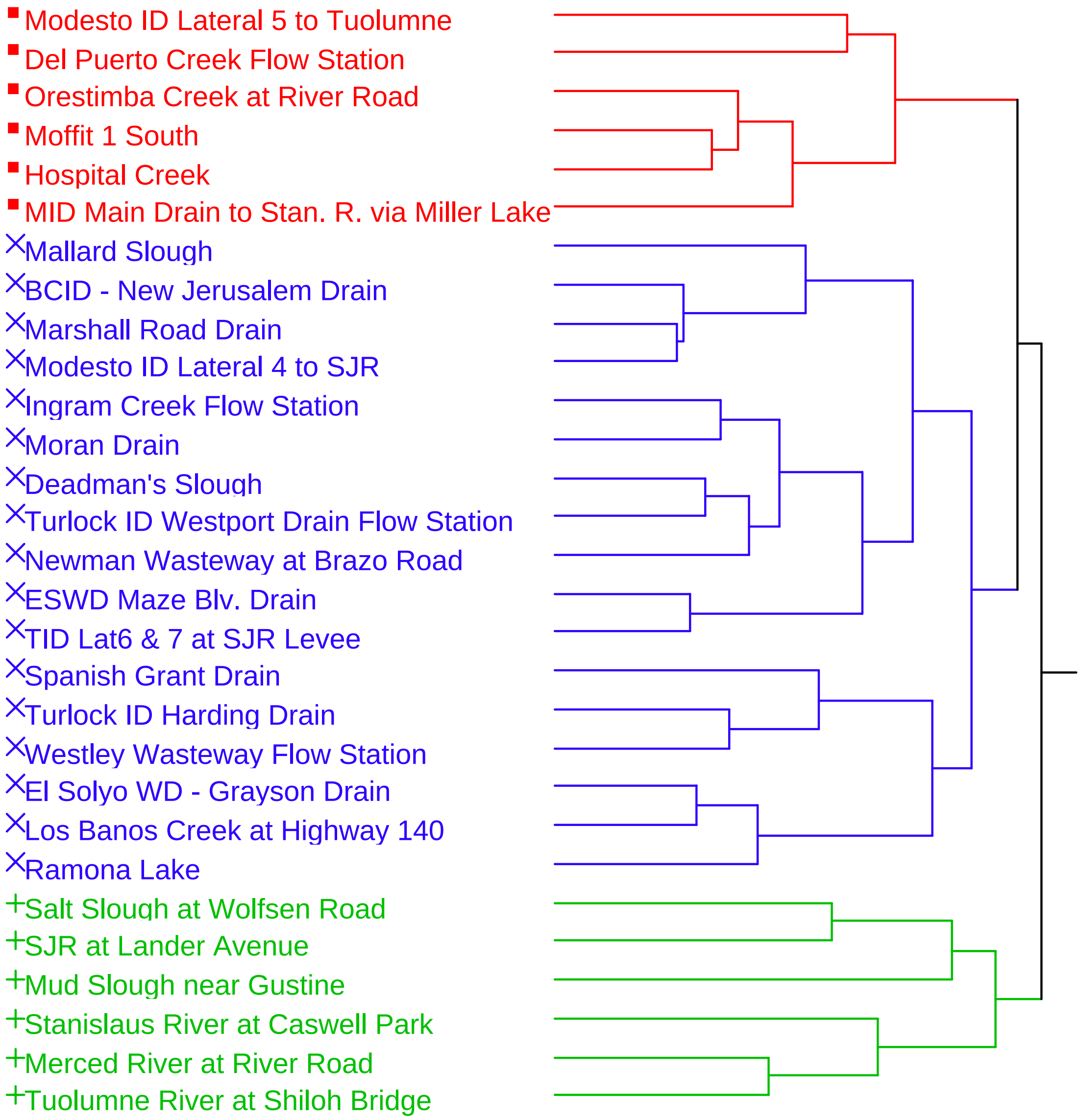

Figure 18: Normalized rank means (NRMs) of San Joaquin River tributaries in relation to each other for an "algae" index created by combining NRM results for loads of phytoplankton biomass and the major nutrients (nitrate, ammonia, and phosphate). Sediments (MSS) were not included in this analysis, but they could be included due to their role influencing the dominance of suspended algae in this system. Cluster analysis (CA) was used to visually display NRM results from lowest to highest rankings. In this application, CA is used as a visualization tool only and there is no attempt to measure the significance of the grouping. The assignment of colors and markers is for visual effect only and has no inherent significance.

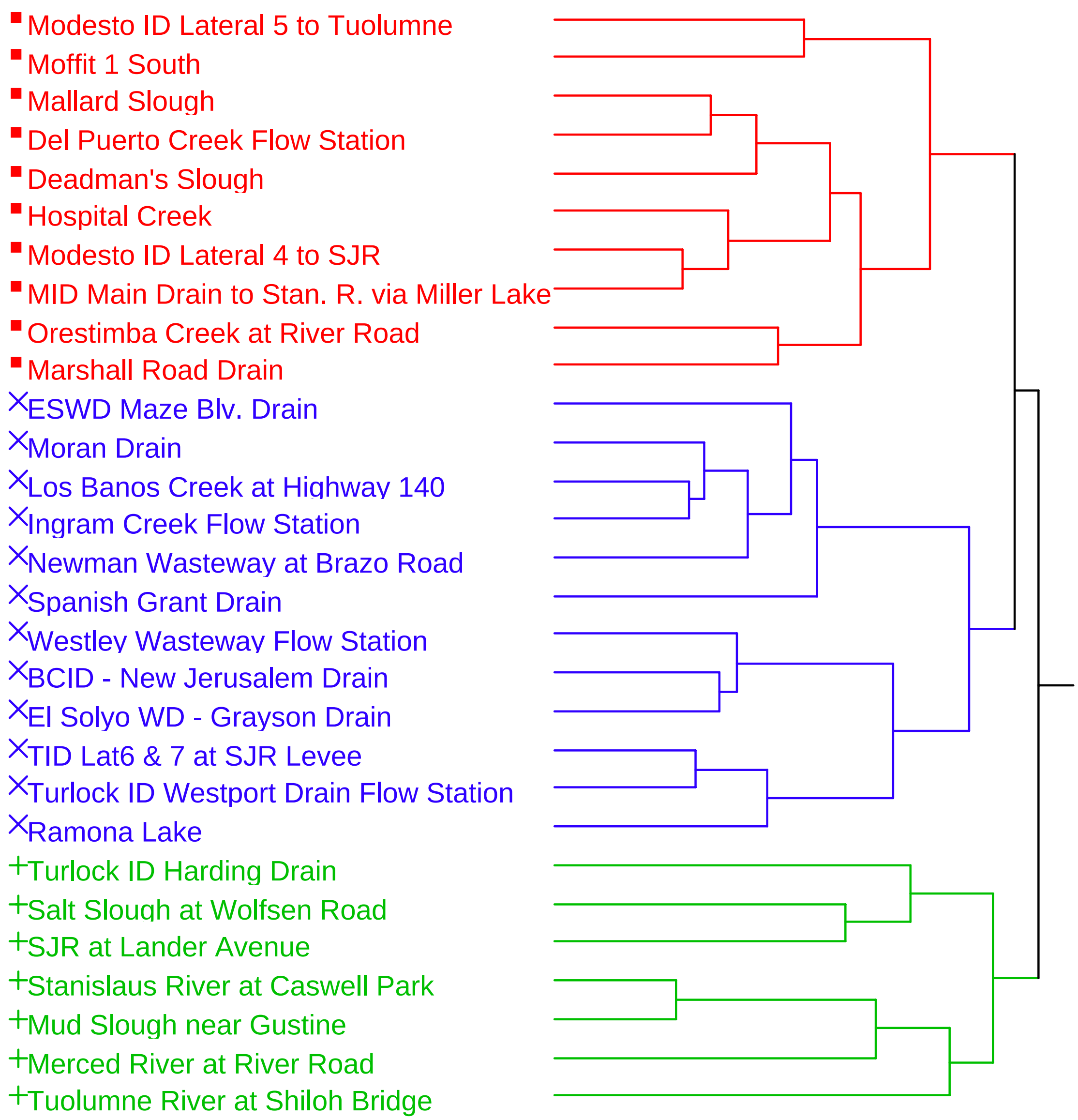

Figure 19: Normalized rank means (NRMs) of San Joaquin River tributaries in relation to each other for a load index created by combining NRM results for chlorophyll-a, nitrate, ammonia, phosphate, sediments, total organic carbon, and biological oxygen demand. Many other water quality parameters could be included in the development of NRM indexes. Cluster analysis (CA) was used to visually display NRM results from lowest to highest rankings. In this application, CA is used as a visualization tool only and there is no attempt to measure the significance of the grouping. The assignment of colors and markers is for visual effect only and has no inherent significance.

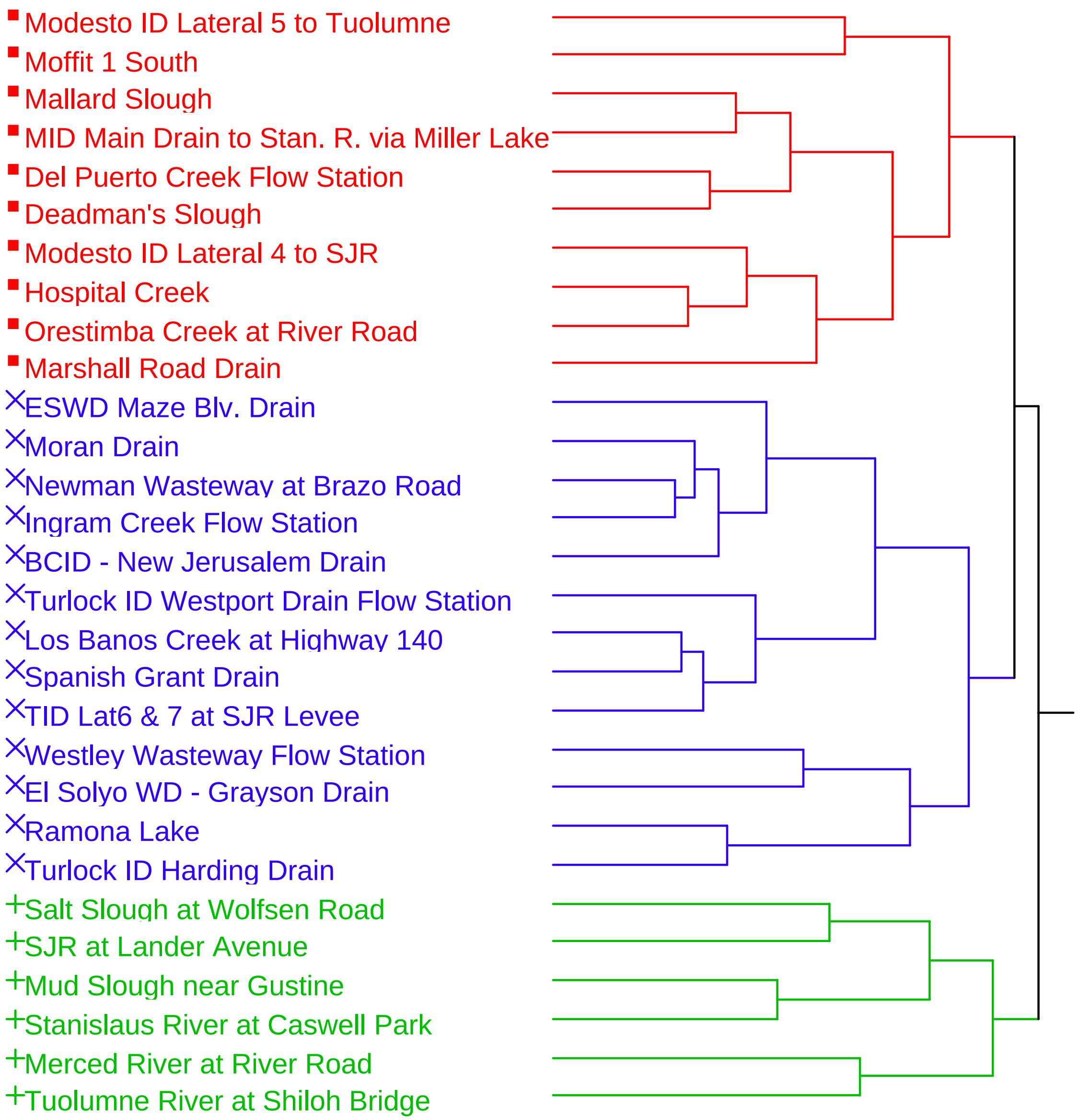

Table 1: Differences between location were not adequately differentiated using parametric statistics, as shown by the example in this table. In this example, the Tukey-Kramer HSD test was used to determine differences between tributary locations for soluble phosphate concentration. Similar results were obtained for other water quality parameters. In this test, each location is assigned to one or more groups (A, B, C, D) and locations assigned to same groups are not considered significantly different from each other. The inability of this test to differentiate locations into logical groups results from both the non-normal distribution of the data and the large variance associated with grab sample data and the collection of samples across seasons. For example, by this method, phosphate concentrations in the Merced River can not be differentiated from phosphate concentrations in Los Banos Creek, which average six times higher phosphate.

Location	**Gp 1**	**Gp 2**	**Gp 3**	**Gp 4**	**Mean oPO4 (mg/L)**
Moran Drain		B	C	D	0.053
Merced River at River Road				D	0.065
Tuolumne River at Shiloh Bridge			C	D	0.104
ESWD Maze Blv. Drain		B	C	D	0.108
Ramona Lake			C	D	0.111
Stanislaus River at Caswell Park			C	D	0.130
Moffit 1 South			C	D	0.135
Modesto ID Lateral 4 to SJR		B	C	D	0.137
Spanish Grant Drain		B	C	D	0.140
Mud Slough near Gustine			C	D	0.153
Newman Wasteway at Brazo Road		B	C	D	0.158
Westley Wasteway Flow Station		B	C	D	0.162
Modesto ID Lateral 5 to Tuolumne			C	D	0.163
BCID - New Jerusalem Drain		B	C	D	0.165
SJR at Lander Avenue			C	D	0.170
Orestimba Creek at River Road			C	D	0.179
Salt Slough at Wolfsen Road			C	D	0.200
Ingram Creek Flow Station			C	D	0.202
Deadman's Slough		B	C	D	0.210
Marshall Road Drain		B	C	D	0.217
Del Puerto Creek Flow Station			C	D	0.230
El Solyo WD - Grayson Drain		B	C	D	0.265
Hospital Creek		B	C	D	0.303
Los Banos Creek at Highway 140		B	C	D	0.420
Mallard Slough		B	C	D	0.463
Turlock ID Westport Drain Flow Station		B	C		0.496
TID Lat 6 & 7 at SJR Levee		B	C		0.617
MID Main Drain to Stan. R. via Miller Lake		B			0.756
Turlock ID Harding Drain	A				1.815

Chapter 5

SPATIAL AND TEMPORAL NITROGEN AND PHOSPHORUS DYNAMICS IN THE SAN JOAQUIN RIVER WATERSHED, 2005-2006

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Introduction

The San Joaquin River (SJR) is a hypereutrophic river with peak summer chlorophyll-concentrations generally in the range of 75 to 150 µg L^{-1} (Kratzer et al., 2004). The phytoplankton community in the SJR during the summer months is dominated by centric diatoms (*e.g., Cycotella meneghiana*) having a 10 to 15 µm diameter (Leland et al., 2001; Henson, 2006). Centric diatoms in 2004 contributed 76 to 89 percent of the total algal biovolume within the mainstem of the SJR (Henson, 2006). Pennate and filamentous diatoms, as well as blue-green algae, were the next most abundant taxa in 2004, with higher proportions found in the agricultural drains, as well as the Merced and Tuolumne Rivers (Henson, 2006).

The high standing biomass of algae is fueled in part by the high availability of nutrients, including available forms of nitrogen, phosphorus and silicon. Peak summer mineral nitrogen (NH_4^+ + NO_3^- + NO_2^-) concentrations ranged between 2 to 4 mg N L^{-1}, soluble reactive phosphorus ranged between 0.15 and 0.20 mg P L^{-1}, and Si ranged between 5.5 and 9.5 mg Si L^{-1} (Kratzer et al., 2004). These values far exceed the nutrient levels suggested to limit algae production: <0.1 mg N L^{-1}, <0.01 mg P L^{-1}, <0.06 mg Si L^{-1} (Lohman et al., 1991; Borchardt, 1996). Given the high concentrations of nutrients relative to algal growth limiting concentrations, the efficacy of nutrient reduction strategies to control eutrophication appear challenging. These nutrients originate from surface and subsurface irrigation return flows, runoff and leaching from livestock operations, nitrogen-rich bedrock in the Coast Ranges, municipal wastewater treatment facilities, and urban runoff (Kratzer et al., 2004).

To assess nutrient dynamics at the watershed scale, water quality must be evaluated at several spatial and temporal scales in order to comprehend the full range of variability within the watershed and the physical, chemical and biological processes that control this variability (Dahlgren et al., 2004). As a first step, a source-search monitoring strategy may be employed to examine spatial patterns in water quality parameters across a representative range of land use/land cover characteristics within a watershed (Ahearn et al., 2005). The synoptic sampling scheme is often employed at a biweekly to monthly time-step throughout the year. While the source-search strategy can often identify the primary pollutant sources, it does not provide an adequate level of detail concerning temporal fluctuations. Various water quality parameters may display diel, storm-event, seasonal and inter-annual variations that could greatly affect the evaluation process (Dahlgren et al., 2004).

Nutrient monitoring in the SJR watershed has been conducted on a wide range of spatial and temporal scales in an attempt to understand specific nutrient sources and their temporal patterns throughout the year. This report presents a summary of nitrogen and phosphorus concentrations and loads for the period March 2005 to December 2006 from 7 mainstem sites and 17 tributaries and drains discharging into the SJR. The major goal of this component of the overall SJR TMDL research is to identify the contribution of nutrients from various sources within the watershed. Once the major sources are identified, nutrient reduction strategies (*i.e.* load allocation) can be evaluated as to their potential for addressing the overall goal of reducing algae biomass exports from the upper watershed to the lower watershed where they contribute to hypoxia in the Stockton Deep Water Ship Channel.

The following results/discussion section is divided into four sections:

- Forms of nitrogen and phosphorus in waters from the mainstem, tributaries and drains
- Spatial patterns in nutrient concentrations in the mainstem, tributaries and drains
- Evaluation of nutrient loads along the San Joaquin River mainstem and inputs from tributaries and drains, and
- Temporal patterns in nutrient concentrations.

Methods

Study area

Water samples were taken from 7 locations along the mainstem of the San Joaquin River and 17 locations in tributaries and drains (Table 1). All sampling points in tributaries and drains were located near the confluences with the mainstem of the San Joaquin River. Thus, the constituent concentrations and water flow rates measured at these sampling points were used as representative values for each tributary merging into the SJR mainstem. Detailed sampling protocols are described in the DO TMDL QAPP (Stringfellow, 2005). Mud Slough, Salt Slough, Los Banos Creek and San Luis Drain receive discharge from the Grasslands. Mud Slough receives tile drainage from 393 km^2 of the Grasslands Ecological Area (Kratzer et al. 2004), which includes not only wetlands, but also pasture of native vegetation (Quinn et al. 1998). Drainage canals, such as Harding Drain (east-side), TID Laterals 6/7 (east-side), MID Lateral 5 (east-side), MID Main Drain (east-side), Westport Drain (east-side), Ramona Lake (west-side), Orestimba Creek (west-side), and Hospital Creek (west-side), run through agricultural fields to the San Joaquin River. The west-side drains (Orestimba Creek, Ramona Lake, Ingram Creek, Del Puerto Creek and Hospital Creek) receive mainly surface runoff from row crops and orchards, and Hospital Creek contains some tile drainage as well. The east-side Harding Drain receives treated effluent from the City of Turlock wastewater treatment plant in addition to runoff from agricultural areas (Kratzer et al. 2004).

Analytical analyses

Total nitrogen (TN) and total phosphorus (TP) were determined following oxidization with a 1% potassium persulfate solution (APHA, 1998). Total N was determined spectroscopically with a single reagent containing vanadium chloride (VCl_3) (MDL = 0.01 mg N L^{-1}) (Doane and Horwath 2003). Total P was determined spectroscopically with the stannous chloride method (MDL = 0.005 mg P L^{-1}) (APHA, 1998).

Dissolved constituents were determined on a sample filtered through a 0.2 μm polycarbonate membrane (Millipore – formerly Nuclepore). Nitrate plus nitrite were determined using the vanadium chloride method (MDL = 0.01 mg N L^{-1}) (Doane and Horwath 2003). Since nitrite was always a very small portion (generally <3%) of the nitrate+nitrite concentration, we report this measure as “nitrate” throughout the remainder of this report. Ammonium was determined spectroscopically with the Berthelot reaction, using a salicylate analog of indophenol blue (MDL = 0.01 mg N L^{-1}) (Forster, 1995). Soluble-reactive PO_4 (SRP) was determined spectroscopically with the stannous chloride method (MDL = 0.005 mg P L^{-1}) (APHA, 1998).

Laboratory quality assurance/quality control followed the Surface Water Ambient Monitoring Program protocols (SWAMP) set by the California State Water Resources Control Board (http://www.swrcb.ca.gov/swamp/qapp.html). This includes implementation of standard laboratory procedures including replicates, spikes, reference materials, setting of control limits, criteria for rejection, and data validation methods. Detailed sampling, handling and analytical protocols are described in the DO TMDL QAPP (Stringfellow, 2005).

Results and Discussion

Forms of Nutrients in the SJR mainstem, tributaries and drains

A summary of the overall nutrient concentration data for the seven mainstem and 17 tributaries and drains is shown in Table 1. The sampling period generally represents weekly to biweekly sampling for the time period March 2005 to December 2006. A few sampling sites, TID Laterals 6/7, Ramona Lake, and Hospital Creek, were added during the 2005-06 water year and therefore have a lower number of samples (n = 12-15).

The primary forms of nitrogen in waters of the SJR watershed are ammonium (NH_4), nitrate (NO_3), and organic (particulate [>0.2 μm] and dissolved [<0.2 μm]) forms. The organic component is operationally defined as total nitrogen minus the NH_4 + NO_3. While NH_4 and NO_3 are readily available for algae utilization, organic nitrogen must first undergo mineralization to mineral forms (NH_4 and NO_3) prior to algae uptake.

Nitrate was the primary form of nitrogen at six of the seven SJR mainstem sites (Table 2). With the exception of the upper most site (SJR at Lander), NO_3 represented from 65 to 81% of the total N pool. The upstream SJR site at Lander Avenue had lower median total N concentrations with only 37% in the form of NO_3. Inputs of high NO_3 agricultural drainage waters below Lander Avenue likely contribute to the higher proportion of NO_3 below this site. In addition, the high residence time of water at the Lander Avenue site further allows ample time for conversion of mineral N forms into organic N forms via algae primary production. Ammonium concentrations were less than 3.2% of the total N pool. The low proportion of NH_4 is attributable to preferentially uptake of NH_4 by algae as a nitrogen source and rapid nitrification of NH_4 to NO_3 in aerobic waters. Organic forms of nitrogen ranged between 17 and 32% at the six SJR downstream sites compared to 60% at the Lander Avenue site.

The three major east-side tributaries (Merced, Tuolumne, Stanislaus) were similarly dominated by NO_3 (50-61%) with organic forms representing 36 to 42%. The creeks and drains had more variable distributions of nitrogen with the San Luis Drain, Harding Drain, TID Laterals 6/7, and Westport Drain having greater than 90% of total N in the form of NO_3. In contrast, Los Banos Creek has a large component of wetland drainage that is reflected in the higher proportion of both organic N (66%) and NH_4 (6.3%) species and a decreased importance of NO_3 (28%).

The primary forms of phosphorus in waters of the SJR are ortho-phosphate and particulate+organic (particulate [>0.2 μm] and dissolved [<0.2 μm]). The particulate+organic component is operationally defined as total P minus SRP. The particulate fraction may include PO_4 adsorbed on inorganic particles and colloidal and dissolved organic P. Since phytoplankton utilize P almost exclusively as orthophosphate, the availability of particulate+organic forms of phosphorus depends on the extent to which it is transformed into bioavailable forms.

SRP (48 to 63%) was generally the dominant form of total P with particulate+organic (37 to 52%) about 10% less than SRP on average in the seven SJR mainstem sites. The P fractions in the three major east-side tributaries were similarly distributed between SRP (44 to 59%) particulate+organic (41 to 56%). Among the remaining tributaries and drains, the distribution of SRP (0 to 88%) and particulate+organic (12 to 100%) were highly variable. At the one extreme, the San Luis Drain had virtually no SRP owing to the origin of these waters largely as subsurface tile drainage. In contrast, the Harding Drain and TID Laterals 6/7 have SRP fractions representing 88% of total P. In the case of the Harding Drain, the high proportion of SRP results from the contribution of treated waste-water effluent.

The use of total or SRP measurements to predict the effect of agricultural runoff on algal growth is complicated due to the varying bioavailability of the particulate+organic fraction. In agricultural watersheds, particulate+organic has been found to be the dominant fraction of total phosphorus transported in surface runoff (Hart et al., 2004; Sharpley et al., 1992; Uusitalo and Ekholm, 2003). The particulate+organic fraction is associated with soil particles and organic matter eroded from fields during irrigation events. The percentage of particulate+organic P that is bioavailable is generally reported to range between 5 and 30% for agricultural runoff (DePinto et al., 1981; Dorich et al., 1985; Uusitalo et al., 2000).

Spatial nutrient concentrations

The distribution of the various N and P concentrations measured in this study are shown in Figures 1-5 (Table 1 provides data in a tabular format). Along the mainstem of the SJR, median total N concentrations display an increase from Lander Avenue to Laird Park, stepped decreases between Laird Park and Maze and again between Maze and Vernalis, and similar concentrations between Vernalis and Mossdale (Fig. 1). This pattern is due to inputs of nitrogen-rich waters within the upper reaches (above Laird Park) followed by dilution from the Tuolumne and Stanislaus Rivers above Maze and Vernalis, respectively. According to the USGS streamflow data for 1951-1995, 66% of the average streamflow in the San Joaquin River comes from the three major east-side rivers that originate in the Sierra Nevada: Merced River (15%), Tuolumne River (30%), and Stanislaus River (21%) (Kratzer et al., 2004). Thus, the Tuolumne and Stanislaus Rivers can have a large dilution effect as they contribute up to 50% of the summer flows and they have relatively low nutrient concentrations. Because there are no major water inputs between Vernalis and Mossdale, total N concentrations display very similar distributions between these sites.

Among the tributaries and drains, the three major east-side tributaries (Merced = 0.89 mg L^{-1}, Tuolumne = 1.05 mg L^{-1} and Stanislaus = 0.38 mg L^{-1}) have the lowest median total N concentrations. In contrast, some of the major drains have very high median total N concentrations (TID Lateral 6/7 = 14.3 mg L^{-1}, San Luis Drain = 13.8 mg L^{-1}, Harding Drain = 8.7 mg L^{-1}, Westport Drain = 12.5 mg L^{-1}). Nearly all of the measured tributaries and drains delivering agricultural tailwaters and tile drainage have total N concentrations higher than the SJR mainstem sites.

Ammonium concentrations in the SJR mainstem sites were generally less than 0.1 mg N L^{-1}, with most median values on the order of 0.02 to 0.03 mg N L^{-1} (Fig. 2). Only a few sites (Los Banos, TID Laterals 6/7, Ramona Lake, Harding Drain and Del Puerto Creek) had median NH_4-N concentrations greater than 0.2 mg N L^{-1}. However, there were a few individual samples (*e.g.,* Harding Drain, Del Puerto Creek, Ingram Creek, MID Main) in which NH_4-N concentrations exceed 1 mg N L^{-1}. These isolated high ammonium concentrations could be of short-term, local significance as high ammonia (NH_3) concentrations are toxic to aquatic organisms. The toxicity level of NH_4/NH_3 is dependent on the pH value which determines the partitioning between NH_4/NH_3 (pKa = 9.25 at 25°C).

The distribution of NO_3 concentrations follows a pattern very similar to that of total N because the contribution of NO_3 to total nitrogen was relatively similar among most sites (Fig. 3). As with total N, median NO_3-N concentrations along the mainstem displayed an increase from Lander Avenue to Laird Park, with decreased concentrations between Laird Park and Maze and again between Maze and Vernalis due to dilution by the Tuolumne and Stanislaus Rivers, respectively. Nitrate concentrations were similar between Vernalis and Mossdale. The highest median concentrations of NO_3-N originated from the San Luis Drain (13.09 mg N L^{-1}), TID Laterals 6/7 (13.27 mg N L^{-1}), Harding Drain (7.97 mg N L^{-1}), and Westport Drain (11.65 mg N L^{-1}). Median NO_3-N concentrations for the three major east-side tributaries (Merced, Tuolumne and Stanislaus) were below 1 mg N L^{-1} providing downstream dilution of NO_3 below their confluence with the SJR.

Median total P and soluble-reactive P concentrations along the SJR mainstem display the effects of dilution below the confluences with the Merced (Crows Landing), Tuolumne (Maze) and Stanislaus (Vernalis) Rivers, and a large increase at SJR at Patterson due to a large input of soluble-reactive PO_4 from the Harding Drain (Fig. 4 & 5). Median total P concentrations in the Harding Drain were about 1.4 mg L^{-1}, which was nearly 10 times greater than the SJR at its confluence. Higher median TP and SRP values were also found in Los Banos Creek (wetland drainage) and TID Laterals 6/7 (unknown sources). Median total P concentrations in the three east-side tributaries (Merced, Tuolumne and Stanislaus) were very low (0.04 to 0.05 mg P L^{-1}). Because of the low total P concentrations and the relative large river discharges associated with these tributaries, they have a significant dilution capacity below their confluences with the SJR. The San Luis Drain was characterized by having low median total P concentration (0.07 mg P L^{-1}) and median SRP concentration that was generally less than detection limits (<0.005 mg P L^{-1}). The origin of the majority of the water in the San Luis Drain as tile drainage results in sorption of PO_4 by soils during leaching through the vadose zone. The SRP concentrations in the San Luis Drain are generally below concentrations reported to limit algae growth (~0.01 mg P L^{-1}). Of all the sites monitored, the end of the San Luis Drain is possibly the only site where algae standing crop is nutrient limited.

Nutrient Loads along the SJR mainstem and inputs from tributaries and drains

A summary of the overall nutrient loads for the seven mainstem and 17 tributaries and drains is shown in Table 3. The sampling period generally represents weekly to biweekly sampling for the time period March 2005 to December 2006. A few sampling sites, TID Laterals 6/7, Ramona Lake, and Hospital Creek, were added during the 2005-06 water year and therefore have a lower number of samples (n=12-15).

With respect to the dissolved oxygen TMDL, the summer loads of nutrients are of more significance than either the annual loads or the nutrient concentrations. The distribution of median nutrient loads for the irrigation season (April – September) along with the median longitudinal cumulative loads from measured tributaries and drains are shown in Figs. 6-10. The cumulative load lines were drawn by summing the median daily loads of nitrogen and phosphorus species from the tributaries/drains upstream of the mainstem sites. This analysis provides an assessment of the major nutrient sources and a relative evaluation of missing sources or losses that are not accounted for in the tributary and drain loads above a given sampling site.

A load assessment based on total N and NO_3-N reveal similar results (Figs. 6 & 7). The primary nitrogen sources as a percentage of the total loads measured at Vernalis originate from the SJR above Lander (TN=8.6%, NO_3-N=4.1%), the three east-side tributaries (Merced TN=15%, NO_3-N=10.0%; Tuolumne TN=19.5%, NO_3-N=20.8%; Stanislaus TN=4.9%, NO_3-N=4.1%), Salt Slough (TN=6.7%, NO_3-N=7.6%), San Luis Drain (TN=7.6%, NO_3-N=12.8%), Harding Drain (TN=5.0%, NO_3-N=7.8%), Westport Drain (TN=3.5%, NO_3-N=5.6%), and TID Laterals 6/7 (TN=4.8%, NO_3-N=7.9%) (Table 4). The remaining measured sources each generally contributed less than 1% of the total N and NO_3-N loads measured at Vernalis. While the three major east-side tributaries had among the lowest total N and NO_3-N concentrations, the high flows associated with these tributaries resulted in appreciable total N (39.4% of Vernalis load) and NO_3-N (34.1% of Vernalis load) loads to the SJR. In sum, the measured median total N and NO_3-N loads from tributaries and drains accounted for about 79 to 82% of the Vernalis nitrogen loads, which leaves about 20% unaccounted for. In viewing the cumulative loads along the SJR mainstem (Figs. 6 & 7), it appears that the largest load discrepancies occur in the Lander to Crows Landing and Laird Park to Maze reaches for total N and in the Lander to Crows Landing reach for NO_3-N. It is possible that groundwater inputs in the upper reaches between Lander and Crows Landing contributes an appreciable N load that is not measured by the tributary and drain inputs from this study. The high water table associated with the wetland dominated land cover in the upper reaches may contribute to large groundwater inputs in this reach (Phillips et al., 1991).

A similar load assessment for total P and SRP indicate that the primary phosphorus sources as a percentage of the total loads measured at Vernalis originate from the SJR above Lander (TP=8.0%, SRP=5.9%), the three east-side tributaries (Merced TP=7.3%, SRP=6.8%; Tuolumne TP=13.7%, SRP=18.9%; Stanislaus TP=4.3%, SRP=6.5%), Salt Slough (TP=10.2%, SRP=7.8%), and the Harding Drain (TP=6.7%, SRP=10.2%) (Figs. 9 & 10; Table 4). The remaining measured sources generally each contributed less than 1% of the total P and SRP loads measured at Vernalis. As with nitrogen, the three major east-side tributaries had very low total P and SRP concentrations, but high flows that resulted in appreciable total P (25.3% of Vernalis load) and SRP (32.2% of Vernalis load) loads. In sum, the measured loads from tributaries and drains accounted for 57-63% of the Vernalis P loads, which leaves 37 to 43% unaccounted for. In viewing the cumulative median total P loads along the SJR mainstem (Figs. 9 & 10), the cumulative loads are similar to the measured loads until the Laird Park to Maze reach where a large discrepancy occurs. In contrast, the cumulative median SRP loads are similar to the measured loads at the mainstem sites. Because SRP can be transformed by biological (algae uptake) and physical (PO_4 sorption/desorption) processes during downstream transport, it appears best to use total P for cumulative longitudinal load assessments.

Temporal patterns in nutrients

Nutrient concentrations in the San Joaquin River demonstrate considerable variability at the diel, seasonal, annual and decade time steps. At the diel scale, nitrate concentrations are inversely related to algae concentrations due to algal uptake of nitrogen during growth (Fig. 11) (Dahlgren et al., submitted). Stoichiometric uptake of N according to the Redfield C:N for algae is on the order of 6.6:1. This can lead to diel fluctuation of NO_3-N on the order of 0.5 mg N L^{-1} associated with peak algae growth rates during the summer months.

A strong seasonal pattern in NO_3-N concentrations occurs due to patterns in irrigation, winter storm events, spring snowmelt runoff, and fish augmentation flows (Fig. 12). The overall NO_3-N concentration pattern varies from year-to-year, but is generally lowest in the April to early June period associated with snowmelt runoff and spring-fish attracting flow augmentations. Maximum concentrations occur during the late-summer to fall when irrigation return flows are highest and flows from the east-side tributaries are at their annual minimum. Nitrate concentrations were especially low during the very high flows associated with the spring runoff in 2006.

The long-term NO_3-N record for Vernalis consists of data from 1908, 1930, and consistent data since 1950 (Fig. 13). Prior to 1950, NO_3-N concentrations ranged from nil to about 0.5 mg N L^{-1}. Concentrations increased progressively from 1950 to about the 1990s when the concentrations appear to level out. The large increase beginning in the 1950s has been largely attributed to the increased use of nitrogen fertilizer and increased numbers of animal husbandry, primarily dairies (Kratzer and Shelton, 1998). While NO_3-N concentrations have not fallen off in recent years, there does appear to be a leveling off in NO_3-N concentrations during the past 20 years.

During the 2005-06 monitoring period, total N and NO_3-N concentrations in the SJR mainstem sites displayed a strong seasonal pattern which grow more prominent at downstream sites (Figs. 14 - 19). The highest concentrations occurred from July to December and concentrations were generally decreased during the winter and spring due to dilution from snowmelt runoff and storm events from the Sierra Nevada. Minimum concentrations were generally associated with fish augmentation flows during the May to early June period. Exceptionally high spring runoff in 2006 resulted in very low concentrations of total N and NO_3-N. Total N and NO_3-N concentrations in many of the tributaries and drains demonstrated much greater scatter and weaker seasonal patterns. In particular, the Harding

Drain did not show appreciable seasonal patterns; however, there was a wide range of scatter among data.

Seasonal patterns in total P and SRP were evident for the SJR mainstem sites, but they were weaker than for total N and NO_3-N concentrations (Figs. 20-25). The timing of maximum and minimum concentrations was comparable between nitrogen and phosphorus concentrations. As with the nitrogen concentrations, seasonal patterns in total P and SRP were less evident and displayed appreciably greater scatter in the temporal record.

Conclusions

- Nutrient concentrations demonstrate appreciable temporal variability at the diel, seasonal and inter-annual time scales. This temporal variability has ramifications for designing an appropriate monitoring program and for assessing the appropriateness of published data for answering questions concerning nutrient loads.

- The major sources of nitrogen and phosphorus loads were identified: SJR above Lander, Stanislaus, Tuolumne, Merced, San Luis Drain (N source), Salt Slough, Harding Drain, TID Laterals 6/7, and Westport Drain. Contributions from the other tributaries and drains combined accounted for less than 10% of the total load as measured at Vernalis.

- Appreciable discrepancies in measured tributary/drain loads and cumulative longitudinal loads calculated for SJR mainstem sites were indicated for total N (21% unaccounted) and total P (43% unaccounted). It is possible that riparian processes and groundwater inputs could account for some of this discrepancy while a large number of small agricultural discharge sites into the SJR could further account for some of the non-measured nitrogen and phosphorus loads. Hydrodynamic modeling is being applied (Task 6) to determine the accuracy of the mass balance and further work to explain any data gaps are planned for 2007.

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Table 1: Summary of nutrient concentrations for the 7 mainstem sites along the San Joaquin River and the 17 tributaries and drains monitored in this study for the period March 2005 to December 2006. The mean (X), standard deviation (SD), minimum (min), maximum (max), and number of samples (n) are listed for each site.

	River mile	Total N (mg/L)			NH_4-N (mg/L)			NO_3-N (mg/L)			Total P (mg/L)			SRP (mg/L)		
		X± SD	Min Max	n	X± SD	Min Max	n	X± SD	Min Max	n	X± SD	Min Max	n	X± SD	Min Max	n
SJR-Mossdale	56.2	1.49 (0.71)	0.32 2.71	37	0.04 (0.02)	<0.01 0.10	38	1.05 (0.67)	0.08 2.45	38	0.153 (0.064)	0.055 0.378	37	0.092 (0.035)	0.045 0.188	38
SJR- Vernalis	72.2	1.42 (0.71)	0.31 2.79	37	0.04 (0.03)	0.01 0.14	39	1.00 (0.65)	0.07 2.06	39	0.154 (0.101)	0.060 0.642	37	0.084 (0.033)	0.041 0.198	39
SJR – Maze	77.4	1.83 (1.04)	0.35 3.90	36	0.05 (0.03)	0.02 0.16	37	1.30 (0.87)	0.06 2.77	37	0.174 (0.075)	0.052 0.411	36	0.103 (0.037)	0.052 0.172	37
SJR – Laird Park	91.0	2.74 (1.46)	0.57 8.06	22	0.08 (0.10)	<0.01 0.39	22	2.05 (1.31)	0.16 6.64	22	0.240 (0.071)	0.147 0.377	22	0.125 (0.064)	<0.005 0.260	22
SJR – Patterson	99.4	2.31 (1.08)	0.49 4.33	38	0.06 (0.07)	<0.01 0.45	40	1.68 (1.05)	0.08 3.94	40	0.245 (0.084)	0.094 0.409	38	0.149 (0.060)	0.045 0.277	40
SJR – Crows Landing	108.6	2.19 (1.04)	0.44 5.67	38	0.05 (0.03)	0.01 0.16	40	1.54 (0.89)	0.08 3.39	40	0.179 (0.062)	0.067 0.381	38	0.083 (0.029)	0.038 0.213	40
SJR - Lander	131.9	1.81 (1.38)	0.30 5.31	41	0.06 (0.09)	0.01 0.52	43	1.06 (1.20)	0.02 5.17	43	0.217 (0.096)	0.065 0.502	41	0.104 (0.063)	0.022 0.347	43
Stanislaus	74.9	0.41 (0.17)	0.01 0.98	38	0.05 (0.07)	<0.01 0.40	40	0.21 (0.13)	0.03 0.74	40	0.059 (0.053)	0.011 0.323	38	0.044 (0.042)	0.007 0.206	40
Tuolumne	83.8	0.96 (0.58)	0.19 2.00	39	0.04 (0.03)	<0.01 0.15	41	0.67 (0.55)	0.02 1.60	41	0.073 (0.075)	0.007 0.394	39	0.040 (0.035)	<0.005 0.167	41
Merced	118.2	1.08 (0.86)	0.21 3.08	38	0.05 (0.03)	0.01 0.14	40	0.79 (0.83)	0.04 2.88	40	0.051 (0.060)	0.007 0.401	38	0.022 (0.021)	<0.005 0.142	40
Salt Slough	129	1.93 (1.02)	0.81 4.90	58	0.09 (0.06)	0.02 0.31	60	1.19 (0.97)	0.01 4.31	60	0.357 (0.136)	0.137 0.753	58	0.161 (0.110)	0.025 0.677	60
San Luis Drain	-	14.23 (5.31)	4.48 28.63	42	0.06 (0.08)	<0.01 0.42	43	13.42 (5.95)	3.05 30.29	43	0.079 (0.039)	0.022 0.215	42	0.007 (0.022)	<0.005 0.105	43
Mud Slough	122.7	5.85 (2.85)	1.85 11.56	37	0.08 (0.05)	0.01 0.25	39	4.79 (2.88)	0.53 10.41	39	0.244 (0.123)	0.066 0.563	37	0.089 (0.092)	<0.005 0.318	39

Table 1. continued	River mile	Total N (mg/L)			NH_4-N (mg/L)			NO_3-N (mg/L)			Total P (mg/L)			SRP (mg/L)		
		X± SD	Min Max	n	X± SD	Min Max	n	X± SD	Min Max	n	X± SD	Min Max	n	X± SD	Min Max	n
Los Banos	121.0	2.31 (1.06)	0.94 5.94	40	0.20 (0.19)	0.03 0.79	41	0.72 (0.49)	0.08 2.09	41	0.639 (0.280)	0.218 1.460	40	0.311 (0.199)	0.112 0.929	41
TID Lat. 6/7	110.9	15.65 (3.22)	11.25 21.03	13	0.21 (0.25)	0.02 0.91	13	14.28 (2.88)	10.71 18.92	13	0.656 (0.217)	0.292 0.995	13	0.564 (0.180)	0.292 0.831	13
Orestimba Crk	109.3	3.31 (2.27)	0.45 10.08	34	0.13 (0.26)	0.02 1.02	35	2.58 (2.07)	0.05 8.78	35	0.317 (0.187)	0.089 0.759	34	0.119 (0.074)	0.028 0.311	35
Ramona Lake	108	4.30 (1.10)	2.81 5.67	12	0.42 (0.34)	0.03 1.07	12	2.36 (0.93)	0.18 3.67	12	0.403 (0.119)	0.280 0.660	12	0.103 (0.067)	<0.005 0.210	12
Harding Drain	101	9.92 (4.22)	4.56 22.36	37	0.31 (0.52)	0.02 2.67	38	8.78 (3.79)	4.21 20.17	38	1.769 (1.225)	0.120 4.840	37	1.521 (1.150)	0.064 4.366	38
Del Puerto Crk	93.3	5.18 (3.43)	0.22 13.53	32	0.44 (0.91)	<0.01 4.93	33	3.22 (1.85)	0.01 6.57	33	0.335 (0.236)	0.046 0.923	32	0.191 (0.163)	0.024 0.711	33
Westport Drain	93	14.16 (7.10)	2.21 30.53	27	0.16 (0.29)	0.02 1.45	27	12.81 (6.73)	1.59 29.83	27	0.349 (0.238)	0.044 0.979	27	0.290 (0.228)	0.011 0.872	27
MID Lat. 5 - Tuol.	83	1.85 (3.62)	0.08 18.35	28	0.15 (0.26)	<0.01 1.16	28	1.29 (3.42)	<0.01 17.97	28	0.156 (0.304)	0.011 1.431	28	0.103 (0.221)	<0.005 1.053	28
Ingram Crk	82.8	6.66 (5.22)	1.64 16.94	20	0.42 (0.76)	0.02 2.85	20	5.33 (4.74)	0.61 16.53	20	0.365 (0.280)	0.042 1.204	20	0.133 (0.076)	0.021 0.314	20
Hospital Crk	82.8	2.50 (1.39)	0.83 4.94	15	0.15 (0.23)	0.02 0.77	15	1.07 (0.74)	0.35 2.50	15	0.531 (0.383)	0.100 1.441	15	0.265 (0.237)	0.042 0.740	15
MID Main – Stan.	76.0	3.56 (6.34)	0.59 30.79	21	1.31 (4.73)	0.01 21.76	21	1.07 (1.03)	<0.01 3.45	21	0.807 (1.335)	0.043 6.340	21	0.628 (1.139)	0.020 5.310	21

Table 2: Median concentrations for total N (TN) and total P (TP) concentrations for 7 mainstem sites along the San Joaquin River and 17 tributaries and drains for the monitoring period March 2005 to December 2006. The distribution of the median total N and P is shown for the various nutrient forms.

	River mile	Median TN mg/L	Organic %	NH_4 %	NO_3 %	Median TP mg/L	Particulate + Organic %	Soluble-reactive P %
SJR-Mossdale	56.2	1.62	32.5	2.1	65.4	0.14	41.8	58.2
SJR- Vernalis	72.2	1.56	30.6	2.3	67.1	0.12	37.1	62.9
SJR – Maze	77.4	2.01	24.4	2.0	73.6	0.15	37.8	62.2
SJR – Laird Park	91.0	2.65	17.4	1.4	81.2	0.23	48.0	52.0
SJR – Patterson	99.4	2.52	29.8	1.7	68.5	0.23	40.6	59.4
SJR – Crows Landing	108.6	2.27	23.3	1.7	75.0	0.17	52.4	47.6
SJR - Lander	131.9	1.18	59.6	3.2	37.2	0.21	52.4	47.6
Stanislaus	74.9	0.38	42.2	7.5	50.3	0.05	41.3	58.7
Tuolumne	83.8	1.05	36.5	2.9	60.6	0.05	53.7	46.3
Merced	118.2	0.89	35.9	4.8	59.4	0.04	55.8	44.2
Salt Slough	129	1.70	41.7	4.3	54.1	0.32	59.9	40.1
San Luis Drain	-	13.79	4.8	0.3	94.9	0.07	100.0	0.0
Mud Slough	122.7	5.98	9.7	1.1	89.2	0.21	85.5	14.5
Los Banos	121.0	2.23	65.7	6.3	28.0	0.58	58.8	41.2
TID Lat. 6/7	110.9	14.34	6.9	0.6	92.5	0.64	12.2	87.6
Orestimba Crk	109.3	3.03	38.2	1.5	60.3	0.26	58.9	41.1
Ramona Lake	108	4.41	32.6	7.8	59.6	0.38	74.6	25.4
Harding Drain	101	8.69	6.8	1.5	91.7	1.42	11.9	88.1
Del Puerto Crk	93.3	4.23	17.4	3.4	79.2	0.27	42.5	57.5
Westport Drain	93	12.47	6.1	0.5	93.4	0.28	20.0	80.0
MID Lat. 5 - Tuol.	83	2.18	64.6	4.1	31.3	0.44	29.2	70.8
Ingram Crk	82.8	4.13	21.0	1.8	77.2	0.34	58.8	41.2
Hospital Crk	82.8	2.16	63.2	2.5	34.3	0.48	69.9	30.1
MID Main – Stan.	76.0	2.18	64.6	4.1	31.3	0.44	29.2	70.8

Table 3: Summary of nutrient loads for the 7 mainstem sites along the San Joaquin River and the 17 tributaries and drains monitored in this study for the period March 2005 to December 2006. The mean (X), standard deviation (SD), minimum (min), maximum (max), and number of samples (n) are listed for each site.

	River mile	Total N (Mg/d)			NH_4-N (Mg/d)			NO_3-N (Mg/d)			Total P (Mg/d)			SRP (Mg/d)		
		X± SD	Min Max	n	X± SD	Min Max	n	X± SD	Min Max	n	X± SD	Min Max	n	X± SD	Min Max	n
SJR-Mossdale	56.2	18.22 (7.55)	9.39 52.80	37	0.82 (0.88)	0.11 4.01	37	11.11 (3.55)	3.68 21.69	38	2.59 (2.78)	0.72 15.90	37	1.52 (1.27)	0.52 (5.63)	38
SJR- Vernalis	72.2	18.36 (9.70)	10.52 64.70	37	1.04 (1.32)	0.08 5.66	39	10.76 (3.56)	5.19 22.73	39	2.76 (3.44)	0.71 20.57	37	1.57 (1.59)	0.43 7.43	39
SJR – Maze	77.4	16.95 (10.08)	9.41 67.21	36	0.93 (1.23)	0.08 6.09	37	9.83 (3.46)	3.86 19.65	37	2.61 (3.34)	0.40 18.79	36	1.53 (1.67)	0.33 6.77	37
SJR – Laird Park	91.0	10.57 (4.20)	3.30 18.94	22	0.46 (0.59)	0.04 2.05	21	7.17 (2.59)	1.81 12.60	22	1.18 (0.97)	0.27 4.59	22	0.53 (0.38)	<0.01 1.32	22
SJR – Patterson	99.4	12.23 (7.89)	6.43 41.09	38	0.52 (0.72)	0.04 3.14	39	7.05 (3.23)	2.73 16.60	40	1.81 (2.05)	0.46 10.41	38	1.07 (1.06)	0.31 4.34	40
SJR – Crows Landing	108.6	9.48 (6.54)	5.66 41.45	38	0.35 (0.51)	0.04 2.83	40	6.20 (2.86)	1.62 16.63	40	1.18 (1.75)	0.20 10.79	38	0.57 (0.71)	0.15 3.45	40
SJR - Lander	131.9	2.64 (4.78)	0.01 23.99	41	0.18 (0.35)	<0.01 1.52	43	0.70 (1.02)	<0.01 4.81	43	0.56 (1.19)	<0.01 6.02	41	0.32 (0.66)	<0.01 3.13	43
Stanislaus	74.9	1.39 (1.85)	0.20 10.88	38	0.14 (0.25)	<0.01 1.31	40	0.51 (0.44)	0.12 2.21	40	0.24 (0.65)	0.02 4.05	38	0.15 (0.40)	0.01 2.58	40
Tuolumne	83.8	4.68 (6.57)	1.80 38.84	39	0.27 (0.40)	<0.01 2.40	41	2.10 (1.09)	0.40 4.53	41	0.60 (1.51)	0.01 7.67	39	0.24 (0.51)	<0.01 3.37	41
Merced	118.2	3.27 (3.17)	0.94 17.46	38	0.23 (0.30)	0.01 1.67	40	1.89 (1.93)	0.37 8.88	40	0.28 (0.76)	0.02 4.81	38	0.11 (0.27)	<0.01 1.70	40
Salt Slough	129	1.68 (2.14)	0.16 11.77	58	0.08 (0.09)	0.01 0.42	60	1.14 (1.69)	<0.01 9.76	60	0.29 (0.37)	0.05 2.03	58	0.16 (0.28)	0.01 1.82	60
San Luis Drain	-	1.23 (0.67)	0.21 3.34	42	<0.01 (0.01)	<0.01 0.03	43	1.19 (0.75)	0.14 3.60	43	0.01 (<0.01)	<0.01 0.02	42	<0.01 (<0.01)	<0.01 0.01	43
Mud Slough	122.7	2.16 (2.16)	0.02 11.00	37	0.04 (0.03)	<0.01 0.13	39	1.82 (1.99)	0.01 9.69	39	0.12 (0.12)	<0.01 0.55	37	0.05 (0.06)	<0.01 0.26	39

Table 3. continued	River mile	Total N (Mg/d)			NH_4-N (Mg/d)			NO_3-N (Mg/d)			Total P (Mg/d)			SRP (Mg/d)		
		X± SD	Min Max	n	X± SD	Min Max	n	X± SD	Min Max	n	X± SD	Min Max	n	X± SD	Min Max	n
Los Banos	121.0	0.11 (0.08)	<0.01 0.34	40	0.01 (0.02)	<0.01 0.06	41	0.05 (0.08)	<0.01 0.54	41	0.03 (0.03)	<0.01 0.14	40	0.02 (0.02)	<0.01 0.14	41
TID Lat. 6/7	110.9	0.90 (0.69)	0.04 2.32	13	0.01 (0.01)	<0.01 0.06	13	0.82 (0.63)	0.04 2.01	13	0.03 (0.02)	<0.01 0.07	13	0.03 (0.02)	<0.01 0.07	13
Orestimba Crk	109.3	0.15 (0.16)	0.01 0.90	34	0.01 (0.02)	<0.01 0.07	35	0.12 (0.20)	<0.01 1.16	35	0.02 (0.04)	<0.01 0.24	34	0.01 (0.01)	<0.01 0.06	35
Ramona Lake	108	0.11 (0.03)	0.07 0.14	11	0.01 (0.01)	<0.01 0.03	11	0.06 (0.02)	<0.01 0.09	11	0.01 (<0.01)	0.01 0.02	11	<0.01 (<0.01)	<0.01 0.01	11
Harding Drain	101	0.83 (0.39)	<0.01 1.78	37	0.03 (0.05)	<0.01 0.21	38	0.75 (0.36)	<0.01 1.59	38	0.14 (0.10)	<0.01 0.40	37	0.12 (0.10)	<0.01 0.36	38
Del Puerto Crk	93.3	0.16 (0.14)	<0.01 0.52	32	0.01 (0.03)	<0.01 0.17	33	0.10 (0.08)	<0.01 0.32	33	0.01 (0.01)	<0.01 0.04	32	0.01 (0.01)	<0.01 0.03	33
Westport Drain	93	0.69 (0.35)	0.11 1.49	27	0.01 (0.01)	<0.01 0.07	27	0.63 (0.33)	0.08 1.46	27	0.02 (0.01)	<0.01 0.05	27	0.01 (0.01)	<0.01 0.04	27
MID Lat. 5 - Tuol.	83	0.05 (0.05)	<0.01 0.24	25	0.01 (0.01)	<0.01 0.06	25	0.03 (0.04)	<0.01 0.12	25	0.01 (0.01)	0.01 0.04	25	<0.01 (0.01)	<0.01 0.03	25
Ingram Crk	82.8	0.15 (0.20)	0.01 0.68	20	0.02 (0.03)	<0.01 0.11	20	0.11 (0.14)	0.01 0.45	20	0.01 (0.02)	<0.01 0.07	20	<0.01 (<0.01)	<0.01 0.01	20
Hospital Crk	82.8	0.03 (0.02)	<0.01 0.09	15	<0.01 (<0.01)	<0.01 0.01	15	0.01 (0.02)	<0.01 0.05	15	0.01 (0.01)	<0.01 0.02	15	<0.01 (<0.01)	<0.01 0.01	15
MID Main – Stan.	76.0	0.11 (0.20)	<0.01 0.87	21	0.04 (0.14)	<0.01 0.61	21	0.03 (0.05)	<0.01 0.13	21	0.02 (0.05)	<0.01 0.18	21	0.02 (0.04)	<0.01 0.15	21

Table 4: The percentage of irrigation season (April-September) median nutrient concentrations originating from the various water sources compared to the median load measured at the San Joaquin River at Vernalis. The unaccounted category reflects the missing nutrient sources not measured in this study (e.g., groundwater inputs, small return flows).

	TN %	NO_3-N %	TP %	SRP %
San Joaquin River – Lander Avenue	8.6	4.1	8.0	5.9
Stanislaus	4.9	3.3	4.3	6.5
Tuolumne	19.5	20.8	13.7	18.9
Merced	15.0	10.0	7.3	6.8
Salt Slough	6.7	7.6	10.2	7.8
San Luis Drain	7.6	12.8	0.3	0.0
Mud Slough above San Luis Drain	0.1	<0.1	1.2	0.1
Los Banos	0.5	0.3	1.2	1.1
TID Lat. 6/7	4.8	7.9	1.5	2.5
Orestimba Creek	0.6	0.9	0.5	0.4
Ramona Lake	0.7	0.7	<0.1	0.3
Harding Drain	5.0	7.8	6.7	10.2
Del Puerto Creek	0.9	1.2	0.4	0.5
Westport Drain	3.5	5.6	0.6	1.0
MID Lat. 5 – Tuol.	0.2	<0.1	0.1	0.1
Ingram Creek	0.4	0.6	0.6	0.5
Hospital Creek	0.2	0.1	0.4	0.3
MID Main – Stan.	0.1	<0.1	0.1	0.1
Unaccounted	**20.7**	**17.6**	**42.8**	**36.9**

Figure 1: Distribution of total nitrogen concentrations for San Joaquin River mainstem sites (top) and major tributaries and drains (bottom). The median (line), 25th and 75th percentile (box), 10th and 90th percentile (whisker), and outlier points (points) are displayed.

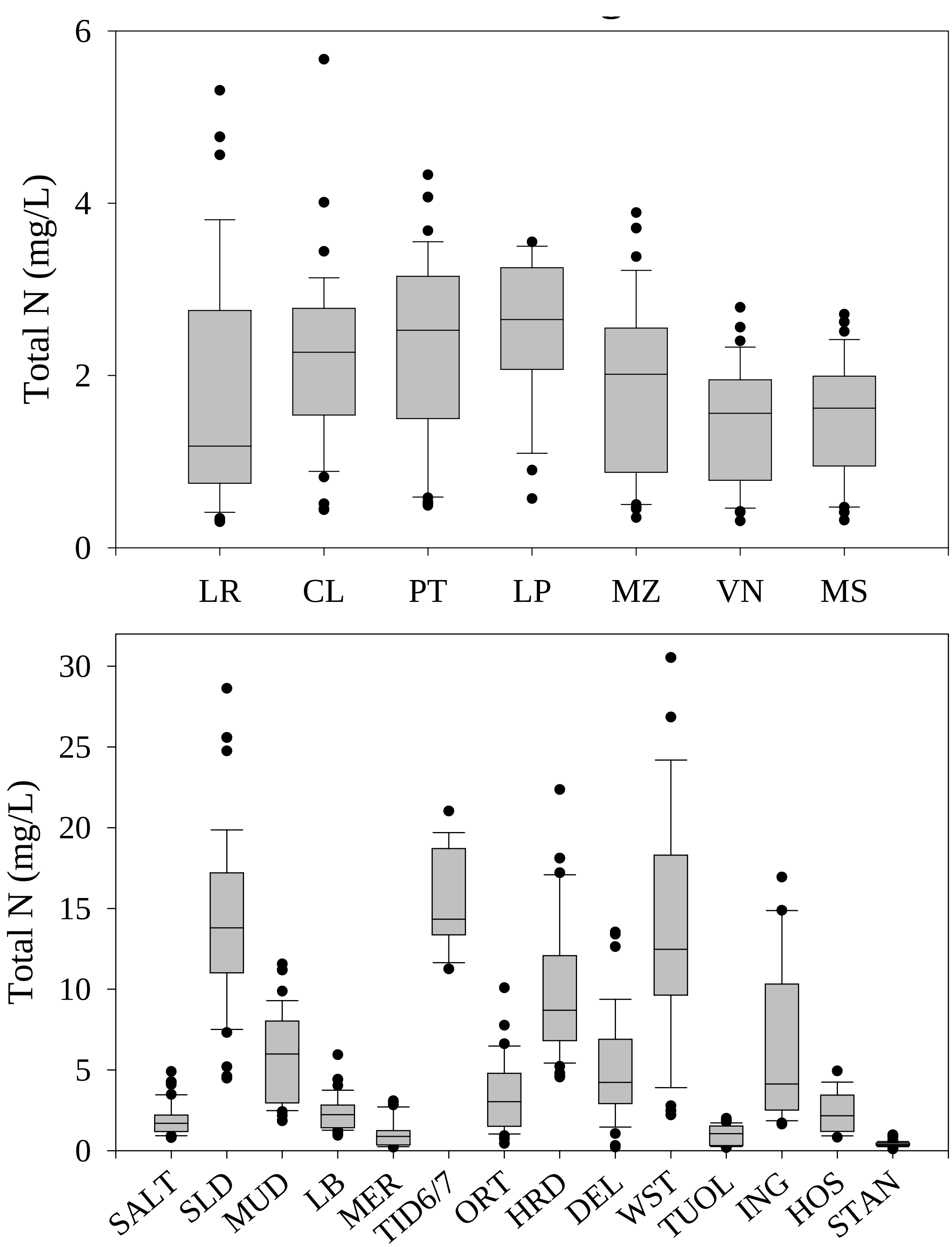
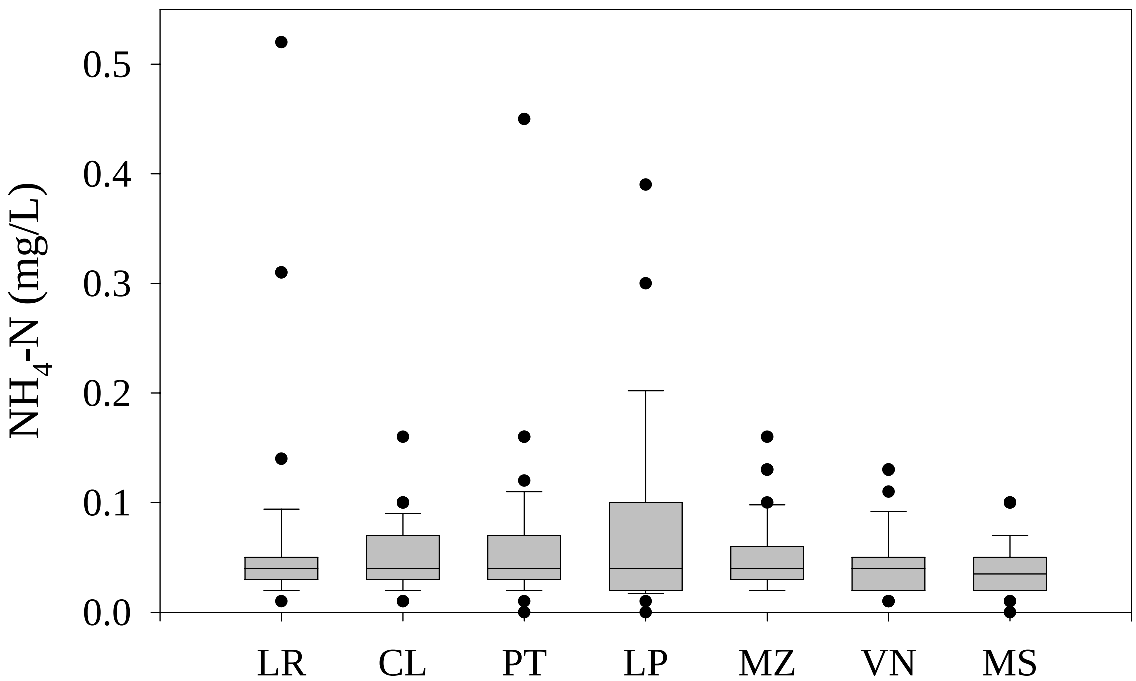


Figure 2: Distribution of ammonium concentrations for San Joaquin River mainstem sites (top) and major tributaries and drains (bottom). The median (line), 25th and 75th percentile (box), 10th and 90th percentile (whisker), and outlier points (points) are displayed.



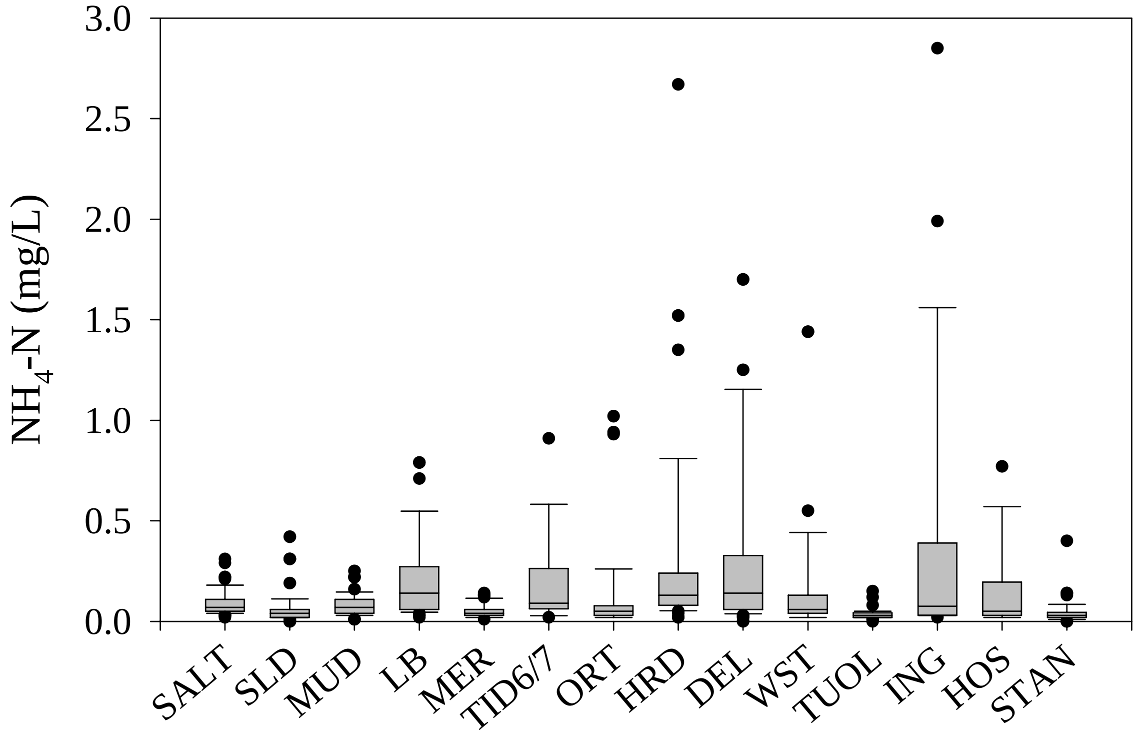
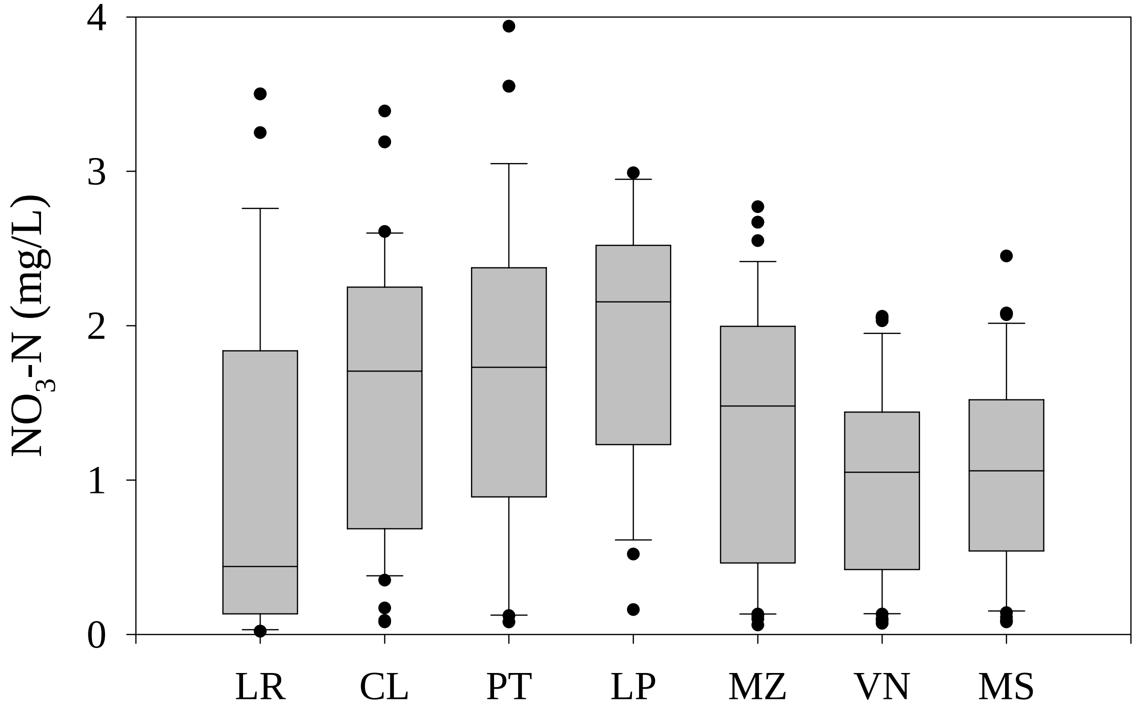


Figure 3: Distribution of nitrate concentrations for San Joaquin River mainstem sites (top) and major tributaries and drains (bottom). The median (line), 25^{th} and 75^{th} percentile (box), 10^{th} and 90^{th} percentile (whisker), and outlier points (points) are displayed.



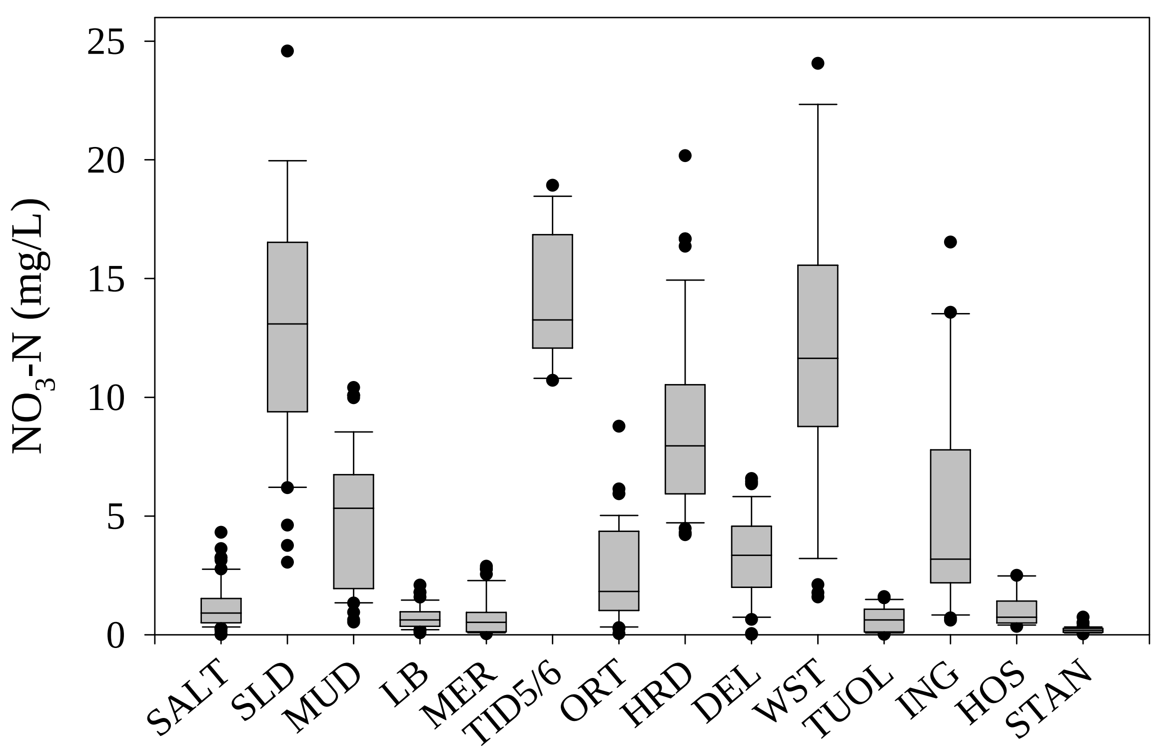


Figure 4: Distribution of total phosphorus concentrations for San Joaquin River mainstem sites (top) and major tributaries and drains (bottom). The median (line), 25th and 75th percentile (box), 10th and 90th percentile (whisker), and outlier points (points) are displayed.

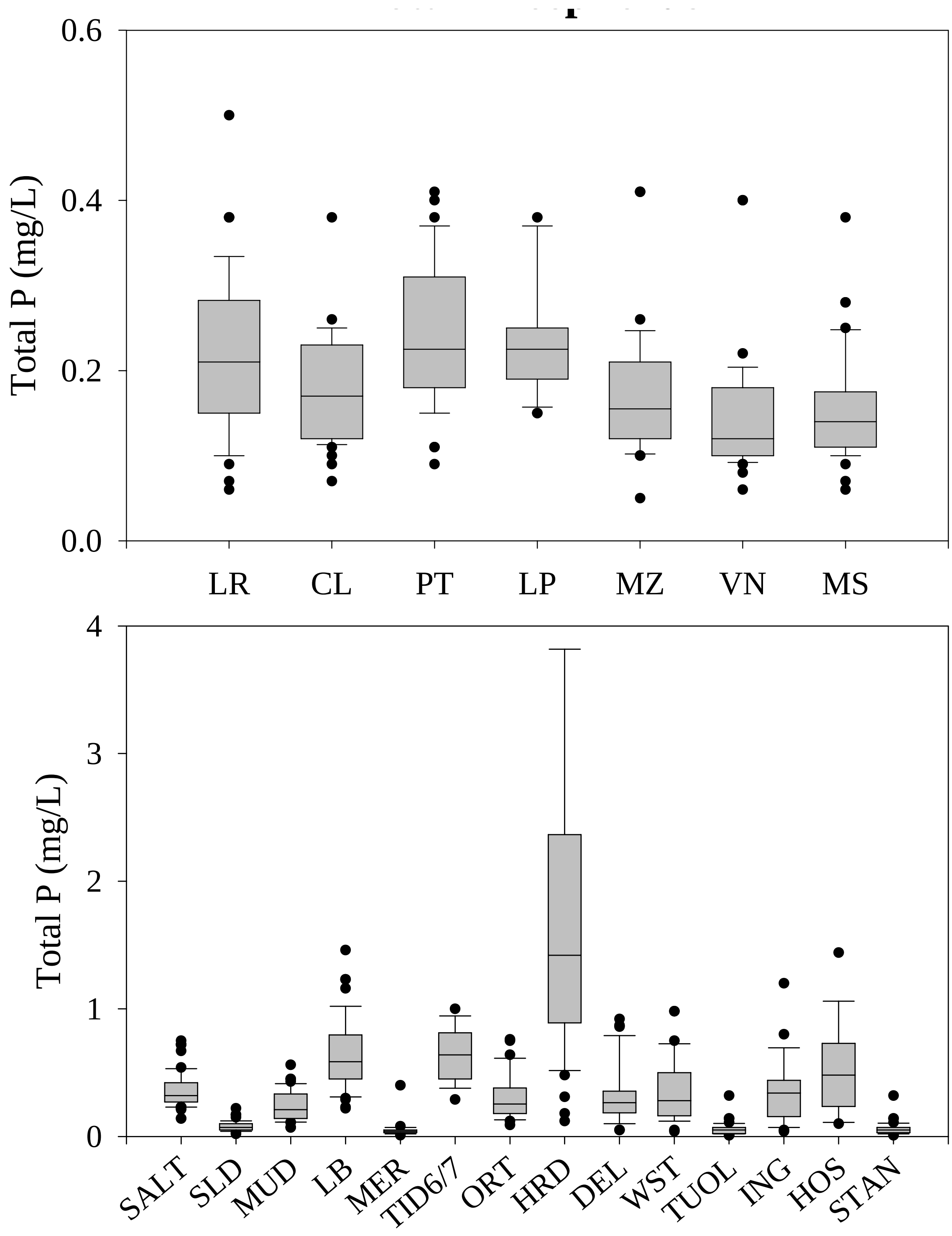


Figure 5: Distribution of soluble-reactive phosphate concentrations for San Joaquin River mainstem sites (top) and major tributaries and drains (bottom). The median (line), 25th and 75th percentile (box), 10th and 90th percentile (whisker), and outlier points (points) are displayed.

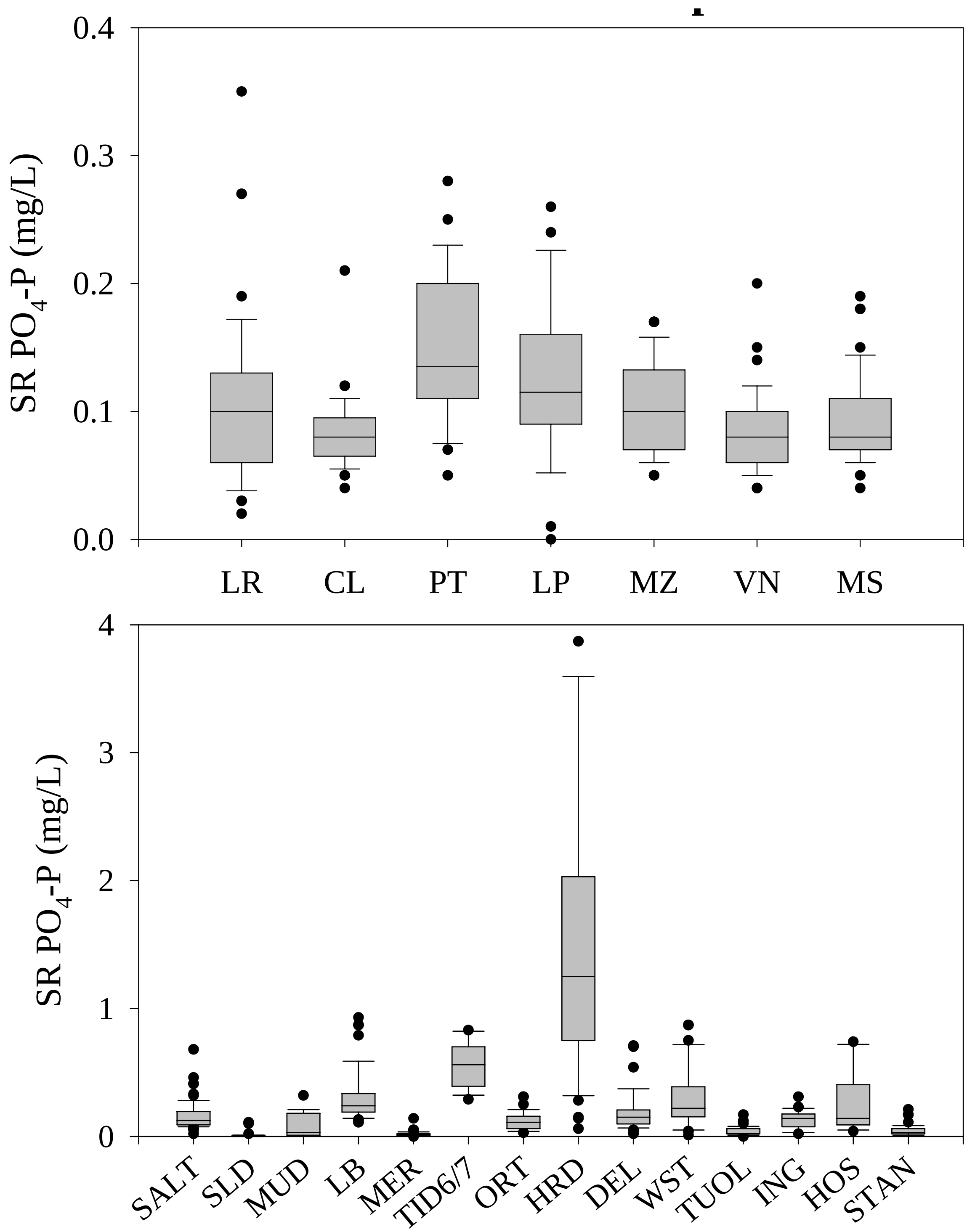


Figure 6: Distribution of total nitrogen loads for San Joaquin River mainstem sites (top) and major tributaries and drains (bottom) for the summer irrigation season (April to September). The median (line), 25th and 75th percentile (box), 10th and 90th percentile (whisker), and outlier points (points) are displayed. The line represents the cumulative loads from tributaries and drains located above each mainstem site.

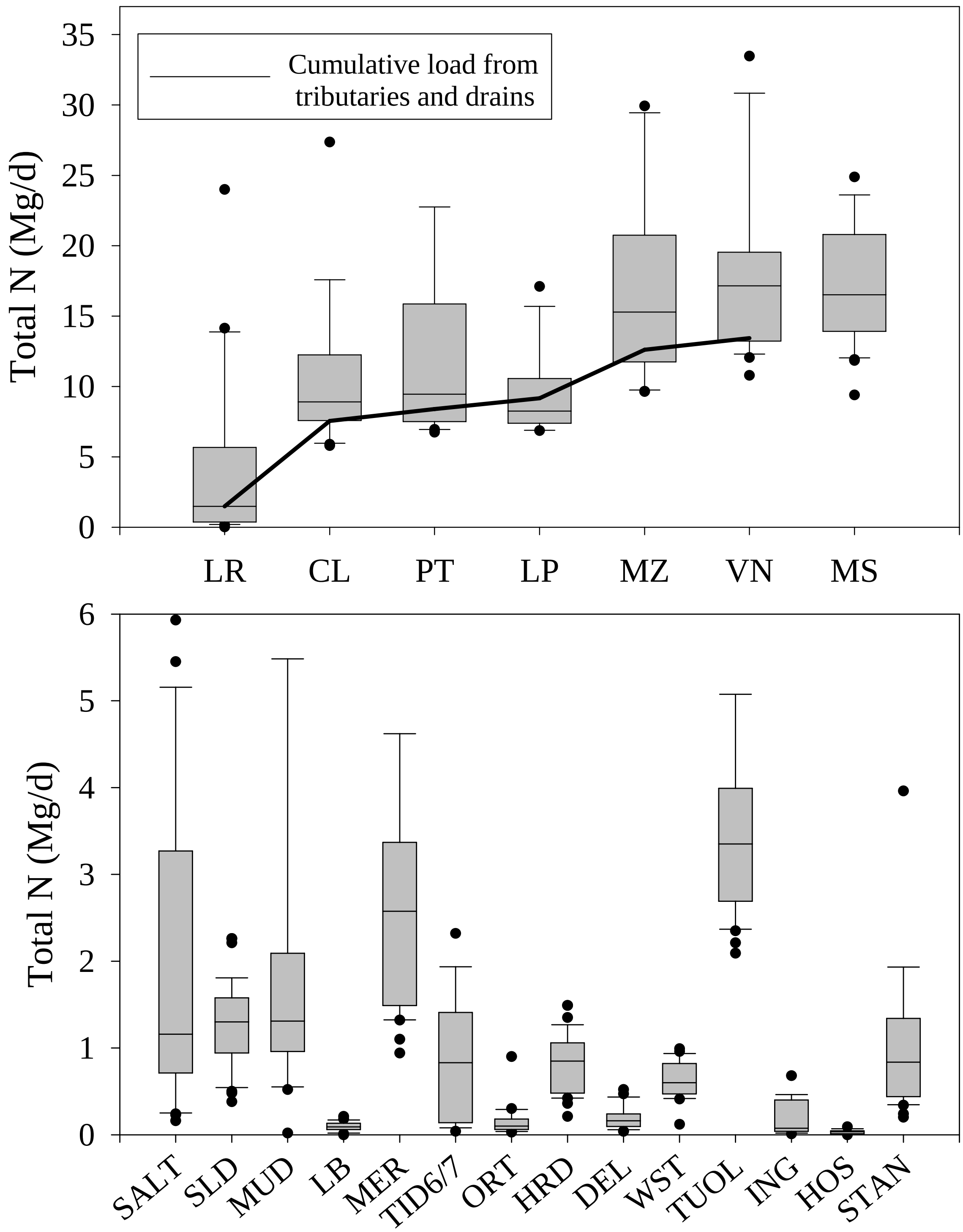


Figure 7: Distribution of nitrate-N loads for San Joaquin River mainstem sites (top) and major tributaries and drains (bottom) for the summer irrigation season (April to September). The median (line), 25th and 75th percentile (box), 10th and 90th percentile (whisker), and outlier points (points) are displayed. The line represents the cumulative loads from tributaries and drains located above each mainstem site.

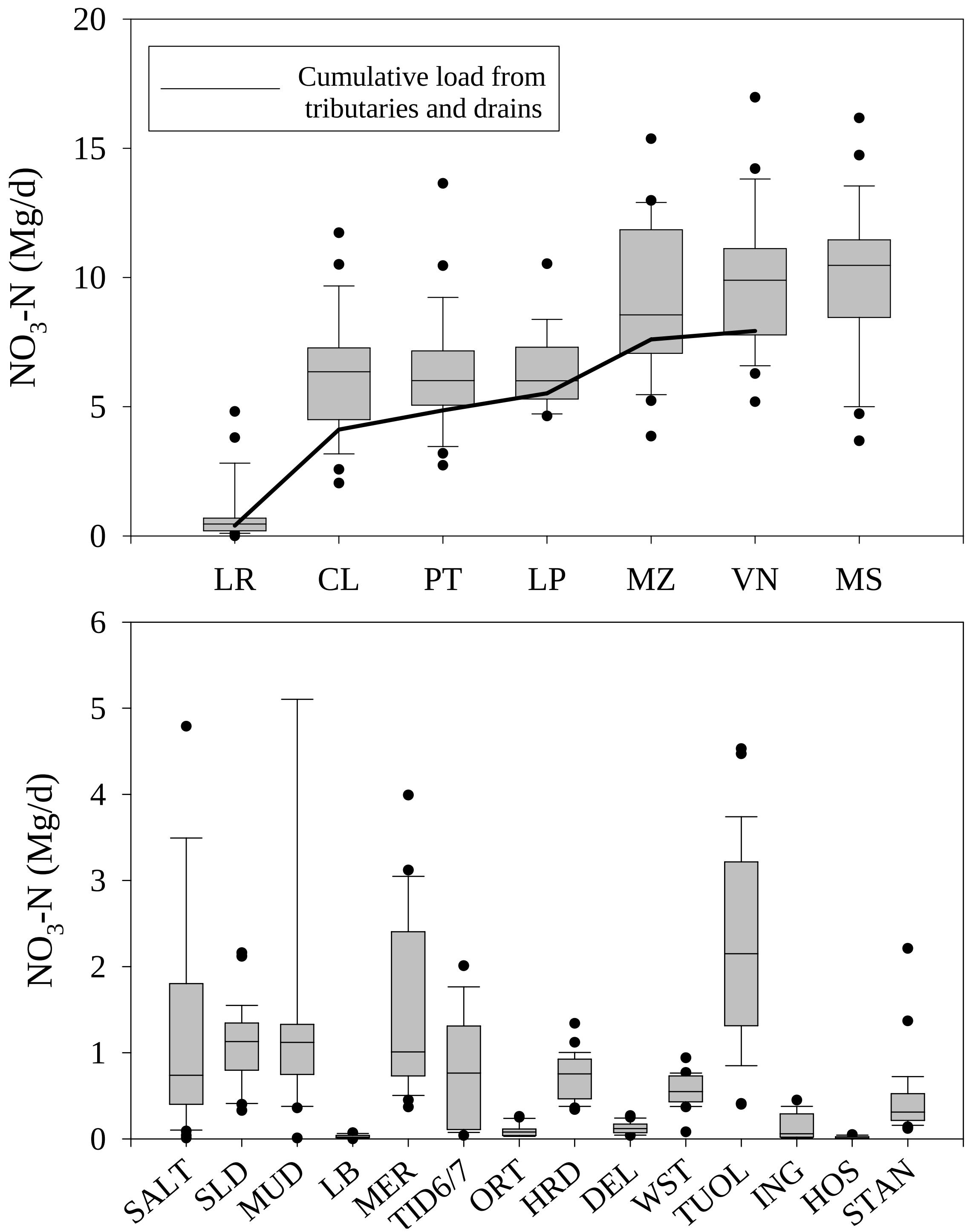


Figure 8: Distribution of ammonium-N loads for San Joaquin River mainstem sites (top) and major tributaries and drains (bottom) for the summer irrigation season (April to September). The median (line), 25th and 75th percentile (box), 10th and 90th percentile (whisker), and outlier points (points) are displayed. The line represents the cumulative loads from tributaries and drains located above each mainstem site.

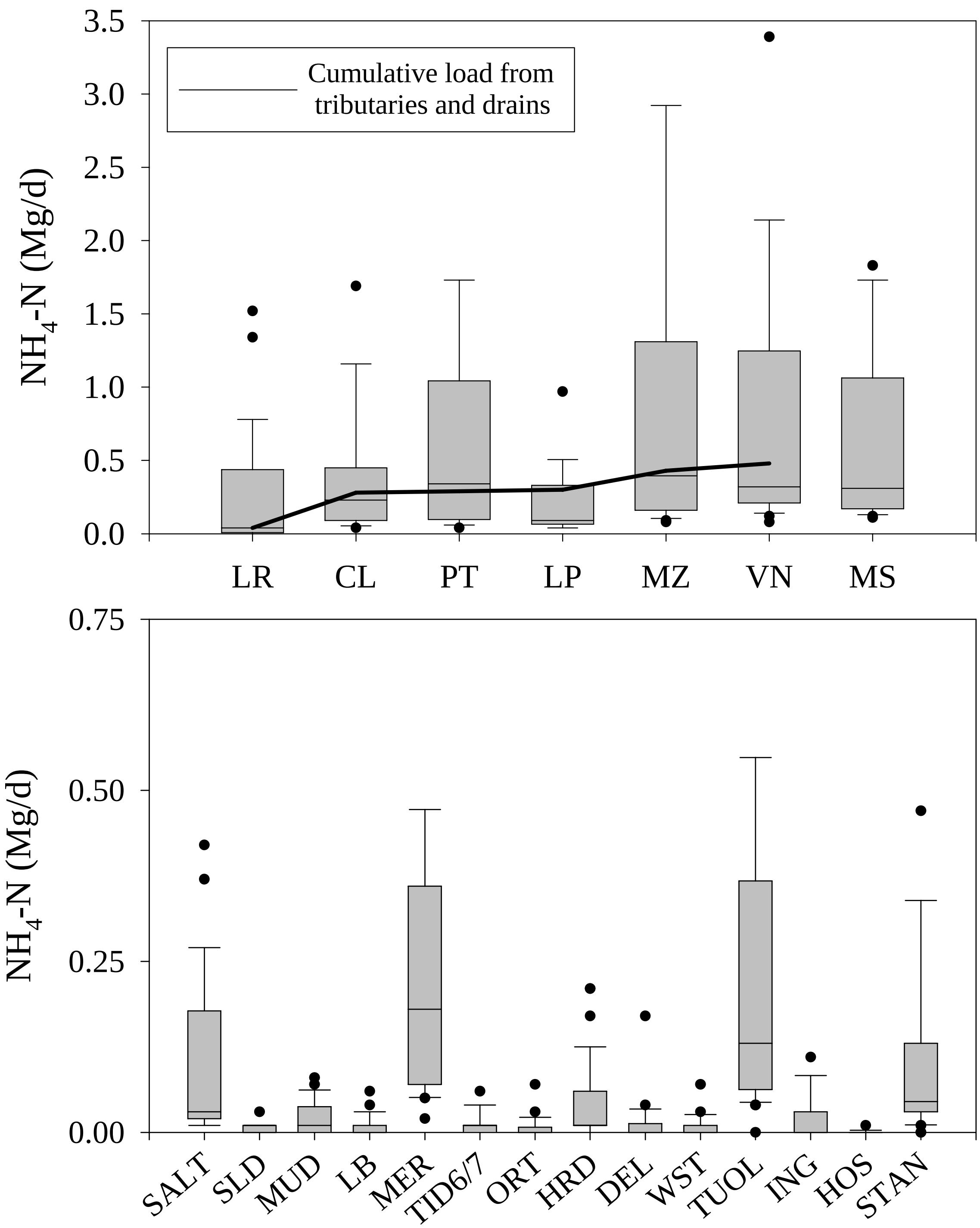
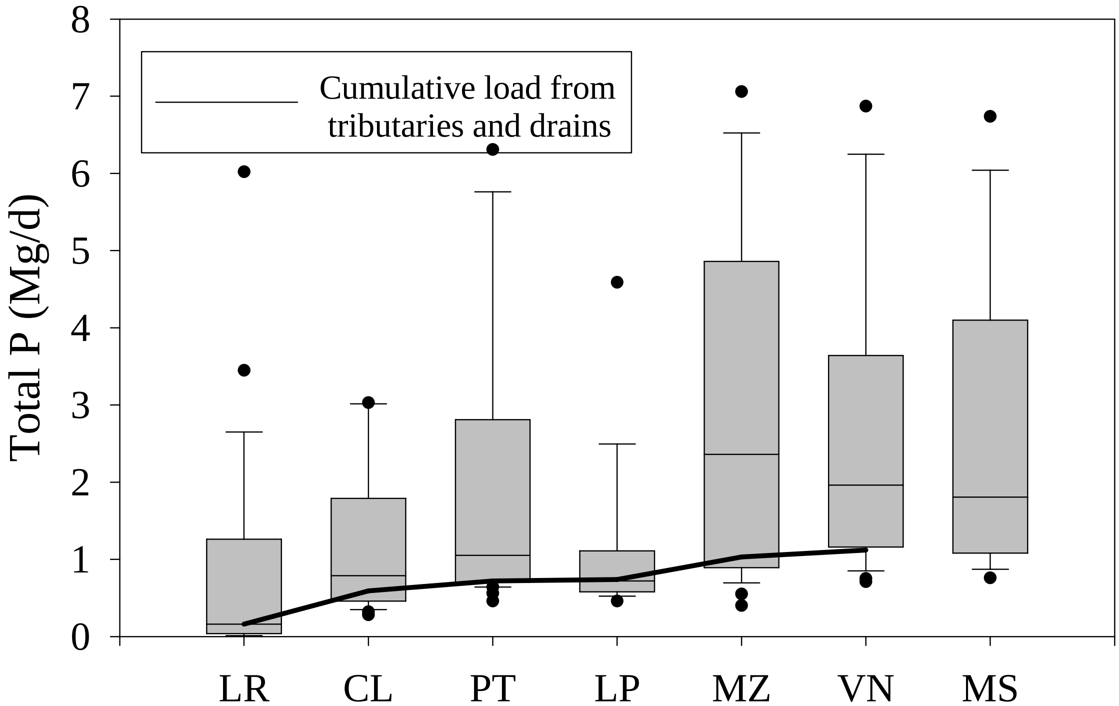


Figure 9: Distribution of total phosphorus loads for San Joaquin River mainstem sites (top) and major tributaries and drains (bottom) for the summer irrigation season (April to September). The median (line), 25th and 75th percentile (box), 10th and 90th percentile (whisker), and outlier points (points) are displayed. The line represents the cumulative loads from tributaries and drains located above each mainstem site.



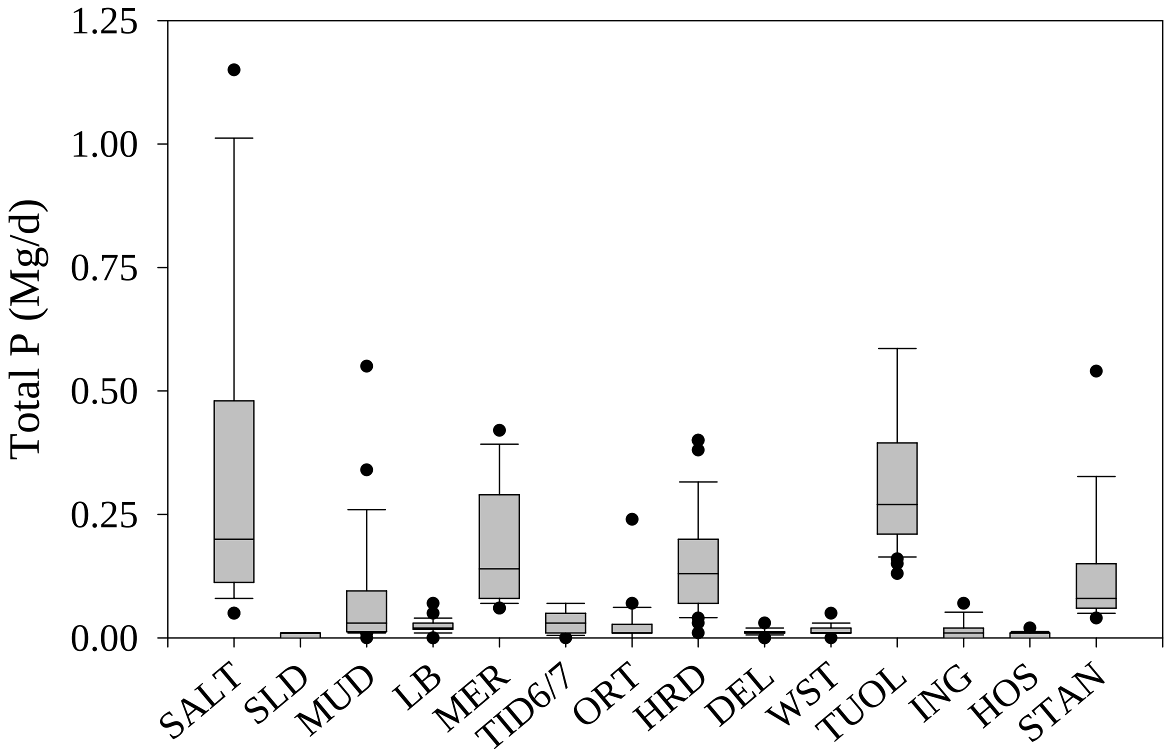


Figure 10: Distribution of soluble-reactive phosphate loads for San Joaquin River mainstem sites (top) and major tributaries and drains (bottom) for the summer irrigation season (April to September). The median (line), 25th and 75th percentile (box), 10th and 90th percentile (whisker), and outlier points (points) are displayed. The line represents the cumulative loads from tributaries and drains located above each mainstem site.

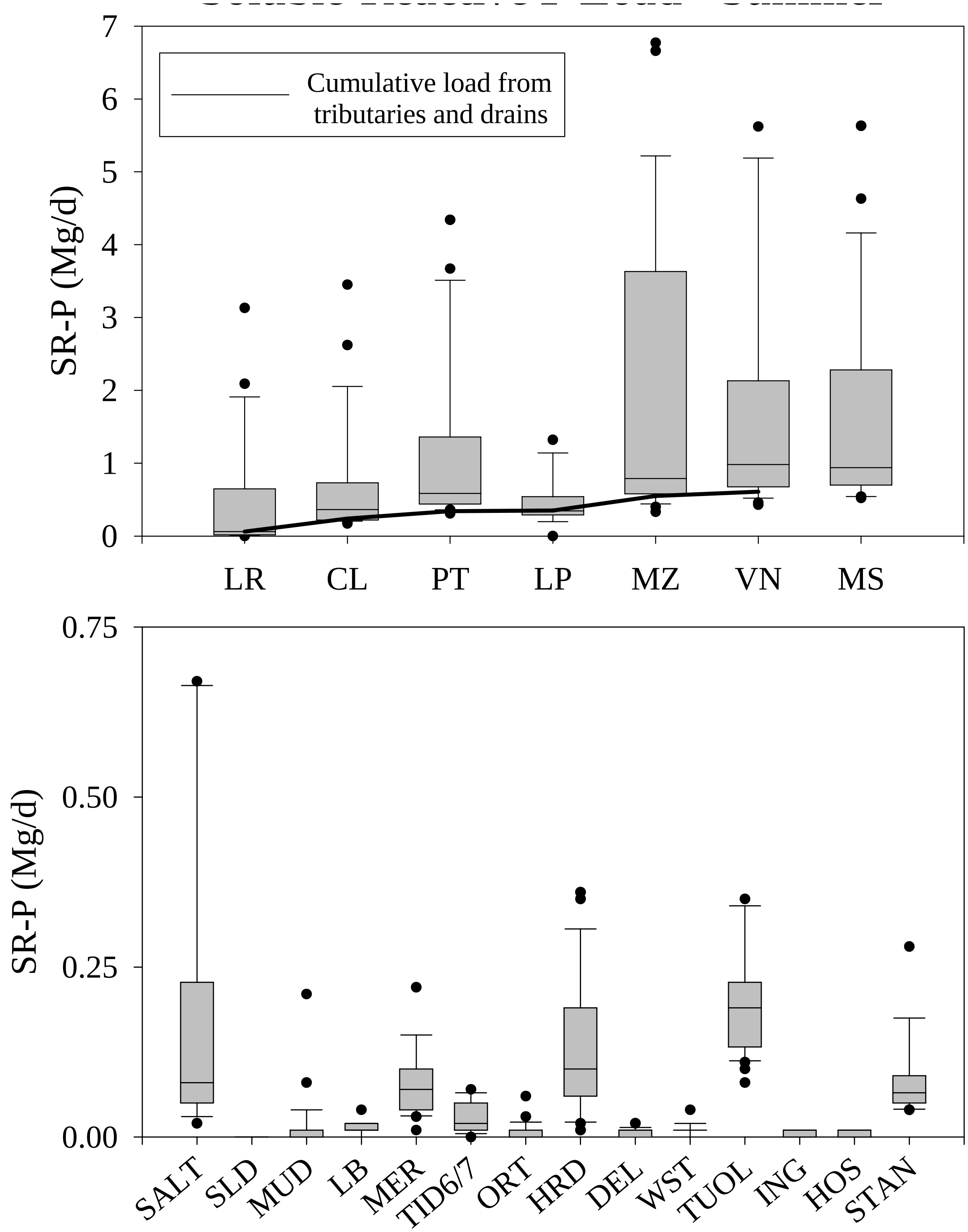


Figure 11: Diel changes in nitrate and total chlorophyll pigments over a 48 hour period in July 2004. The decrease in nitrate concentration is consistent with nitrogen uptake by algae biomass production.

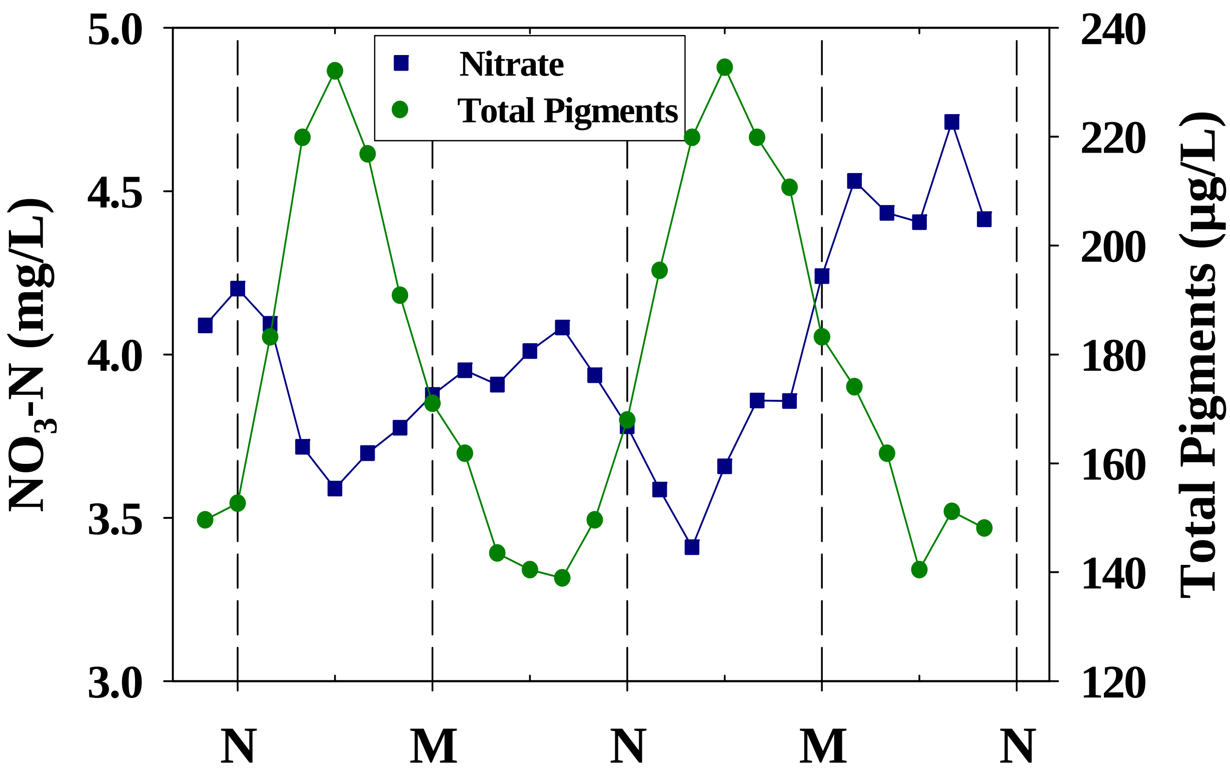


Figure 12: Seasonal variations in nitrate-N concentrations over 7 waters years (1999-2007) in the San Joaquin River at Maze Boulevard.

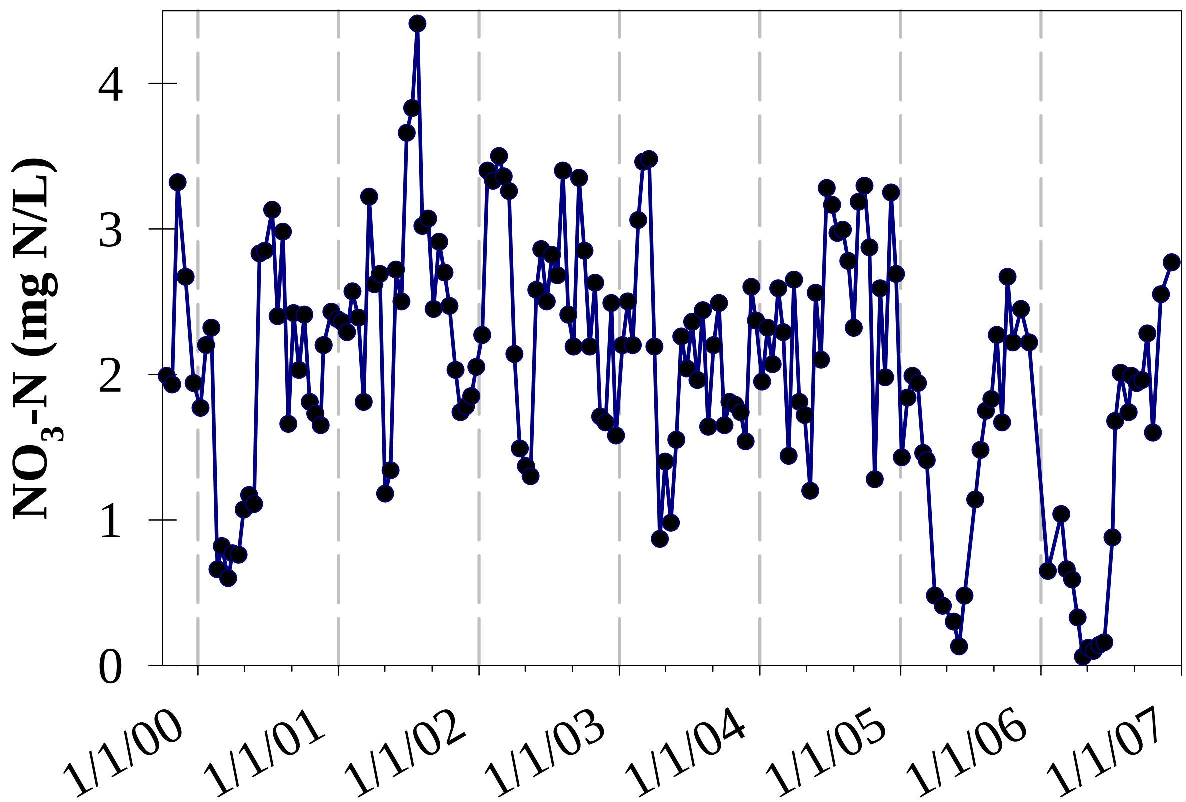


Figure 13: Long-term nitrate-N concentrations for the San Joaquin River at Vernalis.

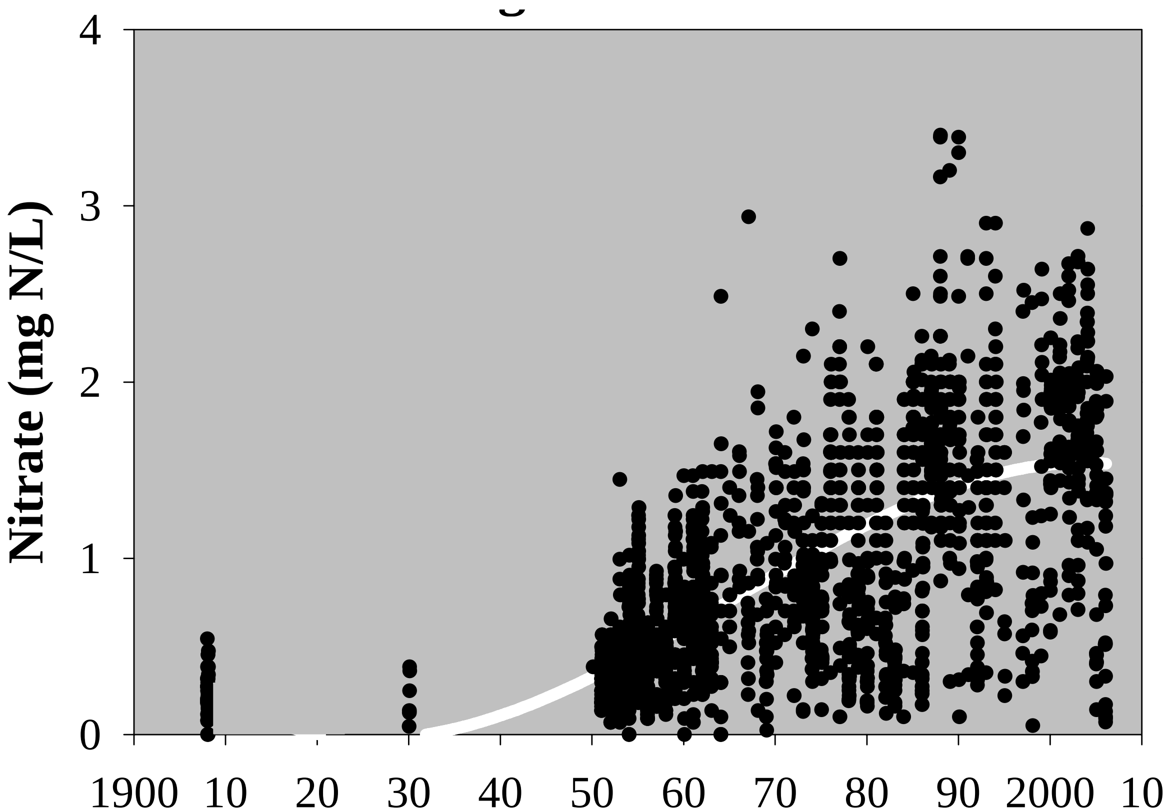


Figure 14: Temporal variability in total N concentrations for selected sites in the San Joaquin River watershed during 2005-2006.

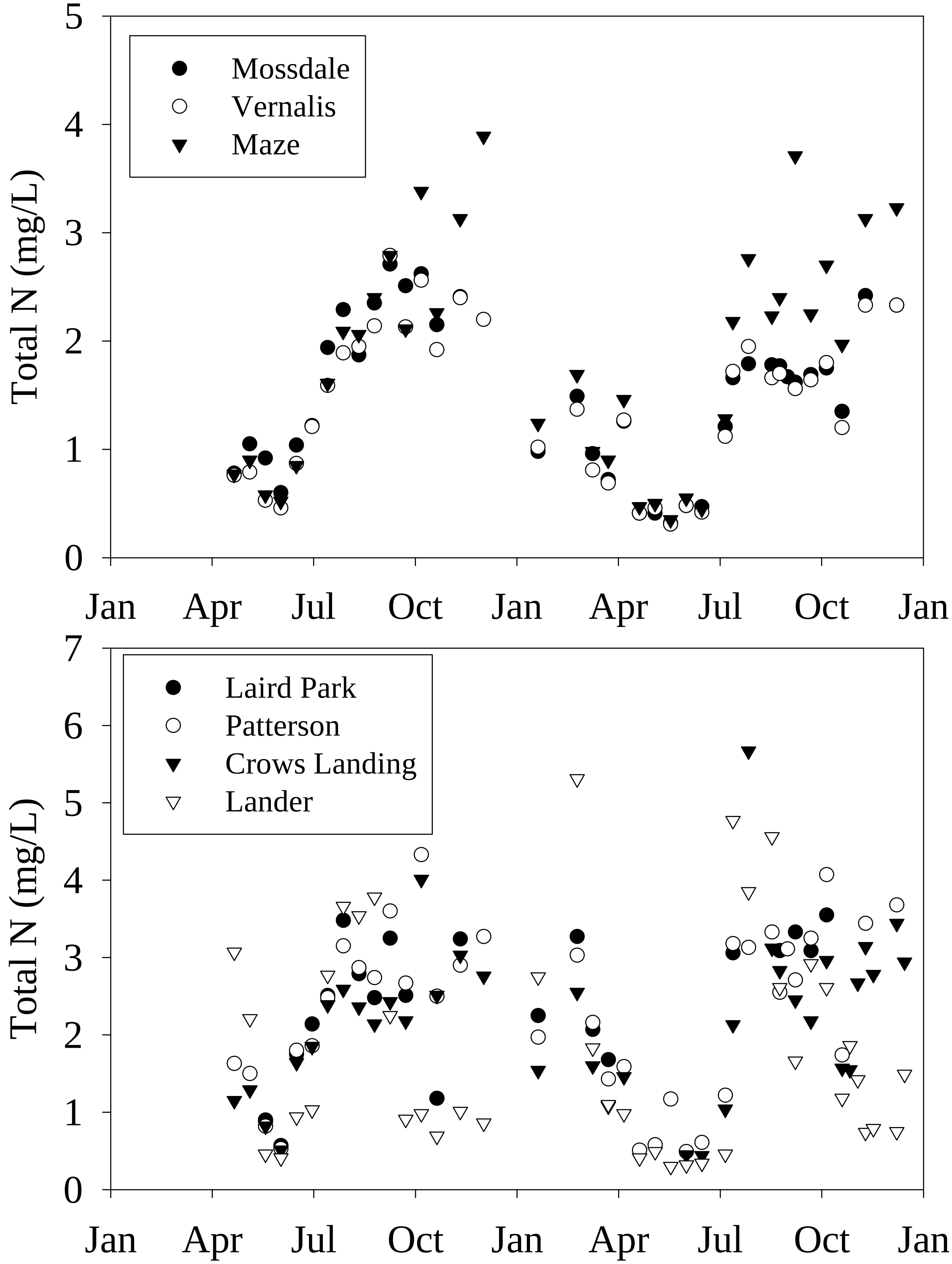


Figure 15: Temporal variability in total N concentrations for selected sites in the San Joaquin River watershed during 2005-2006.

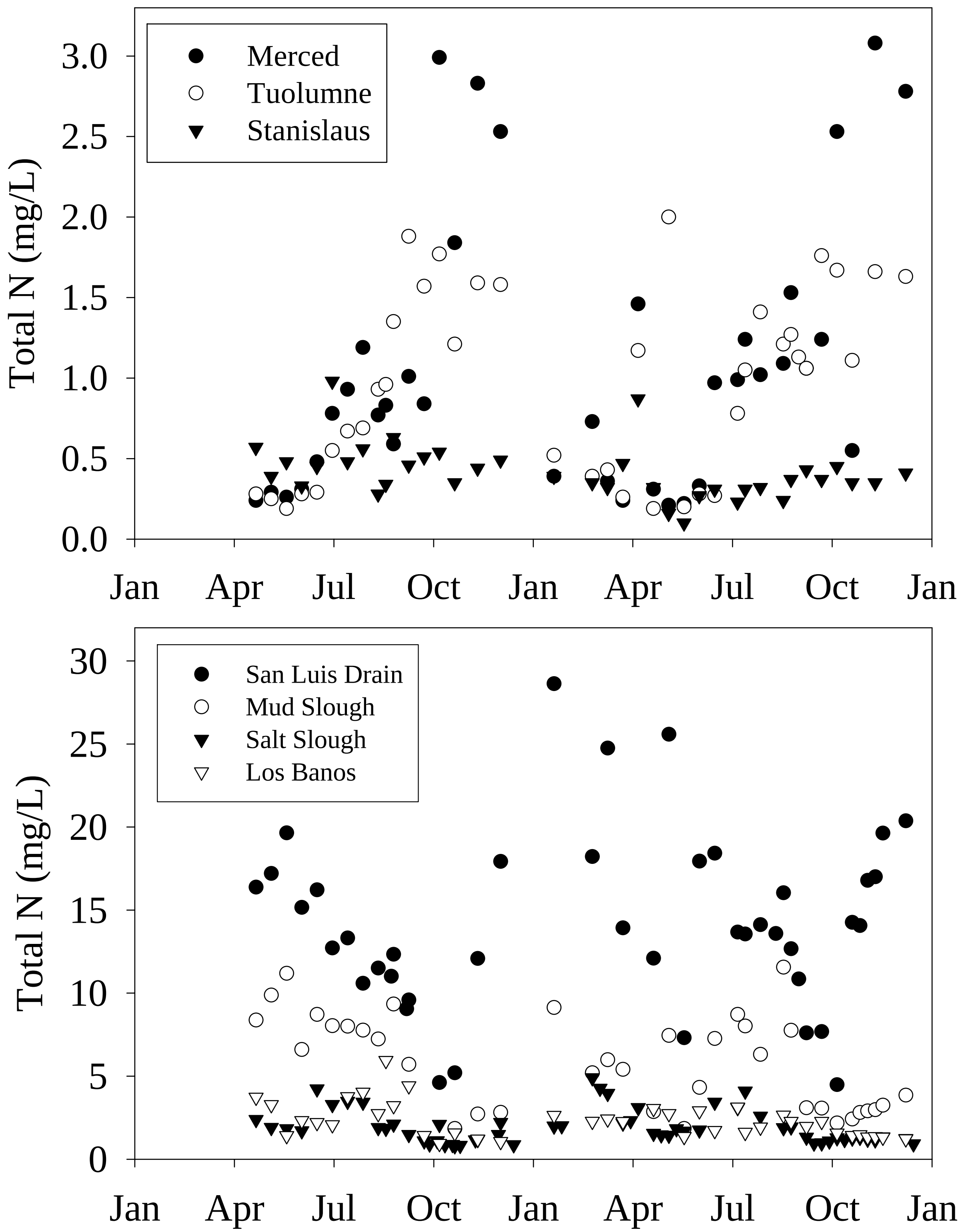


Figure 16: Temporal variability in total N concentrations for selected sites in the San Joaquin River watershed during 2005-2006.

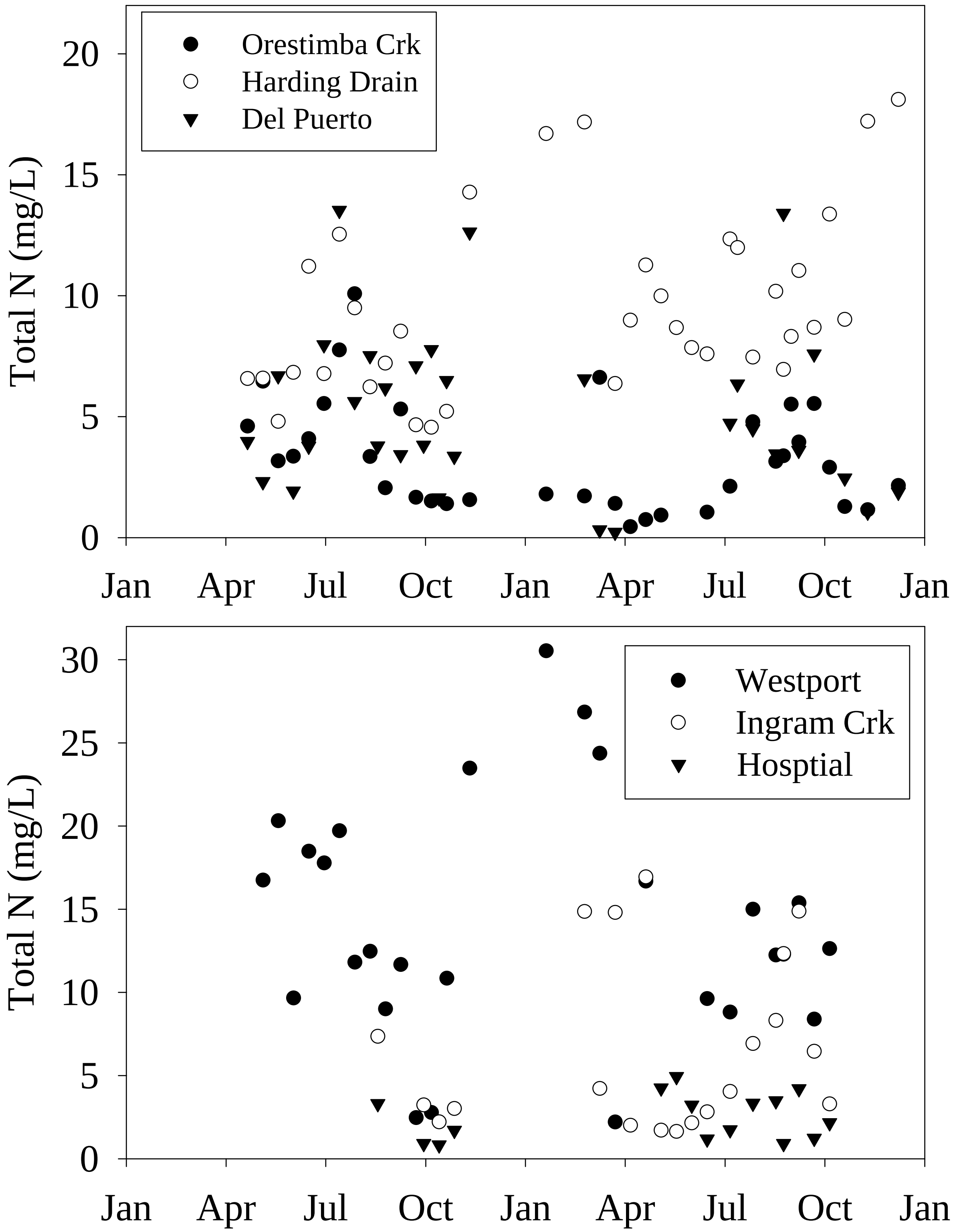


Figure 17: Temporal variability in nitrate-N concentrations for selected sites in the San Joaquin River watershed during 2005-2006.

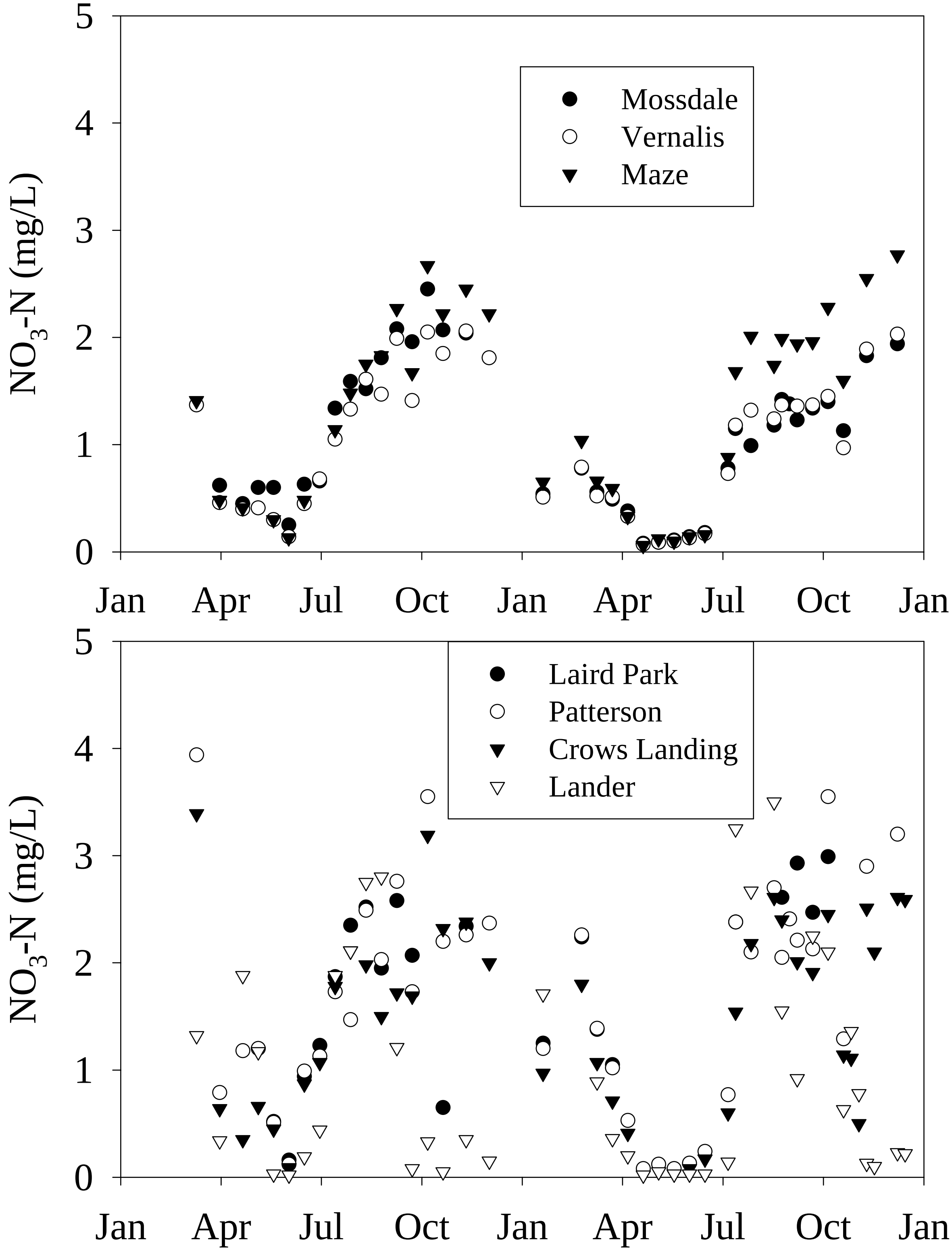


Figure 18: Temporal variability in nitrate-N concentrations for selected sites in the San Joaquin River watershed during 2005-2006.

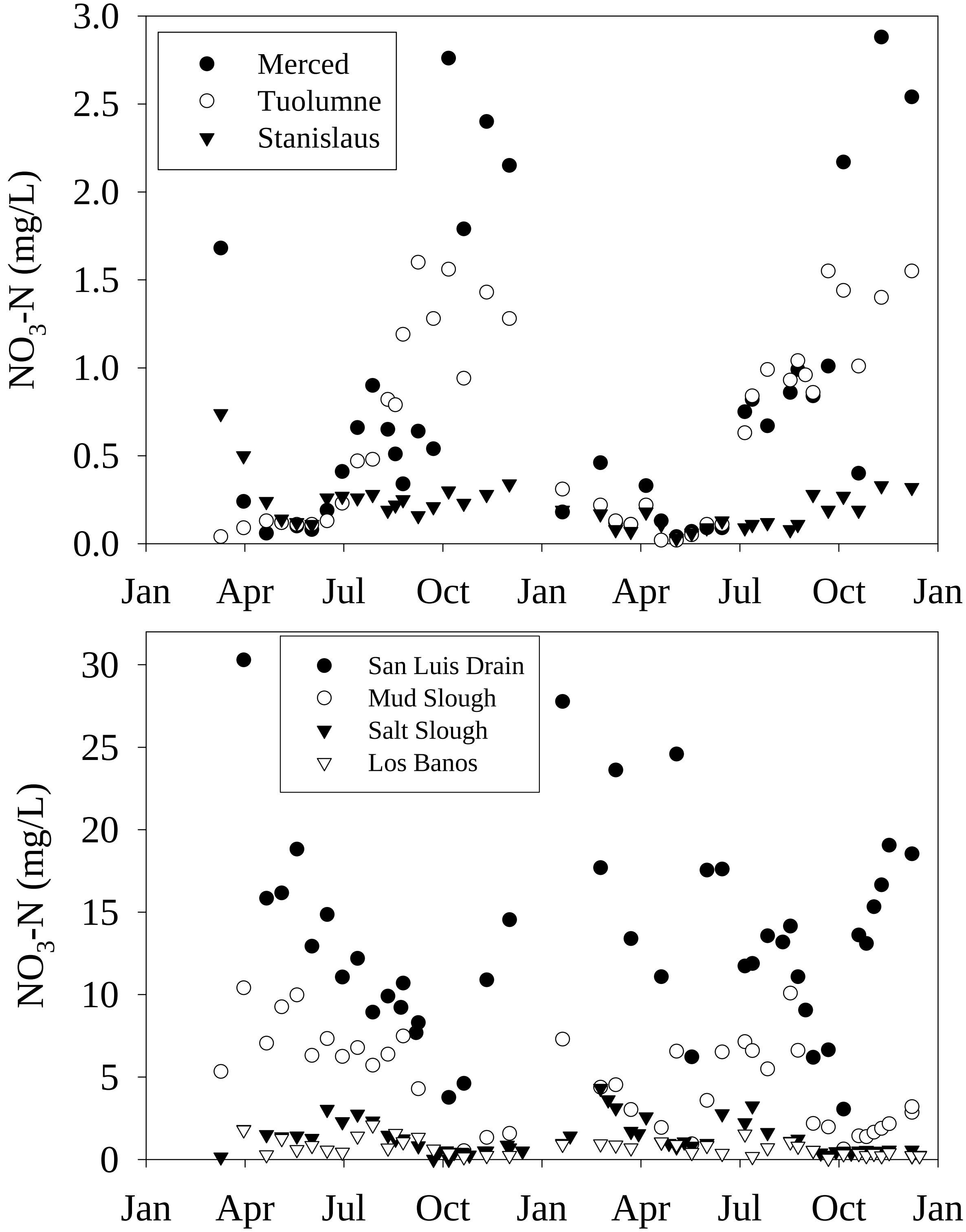


Figure 19: Temporal variability in nitrate-N concentrations for selected sites in the San Joaquin River watershed during 2005-2006.

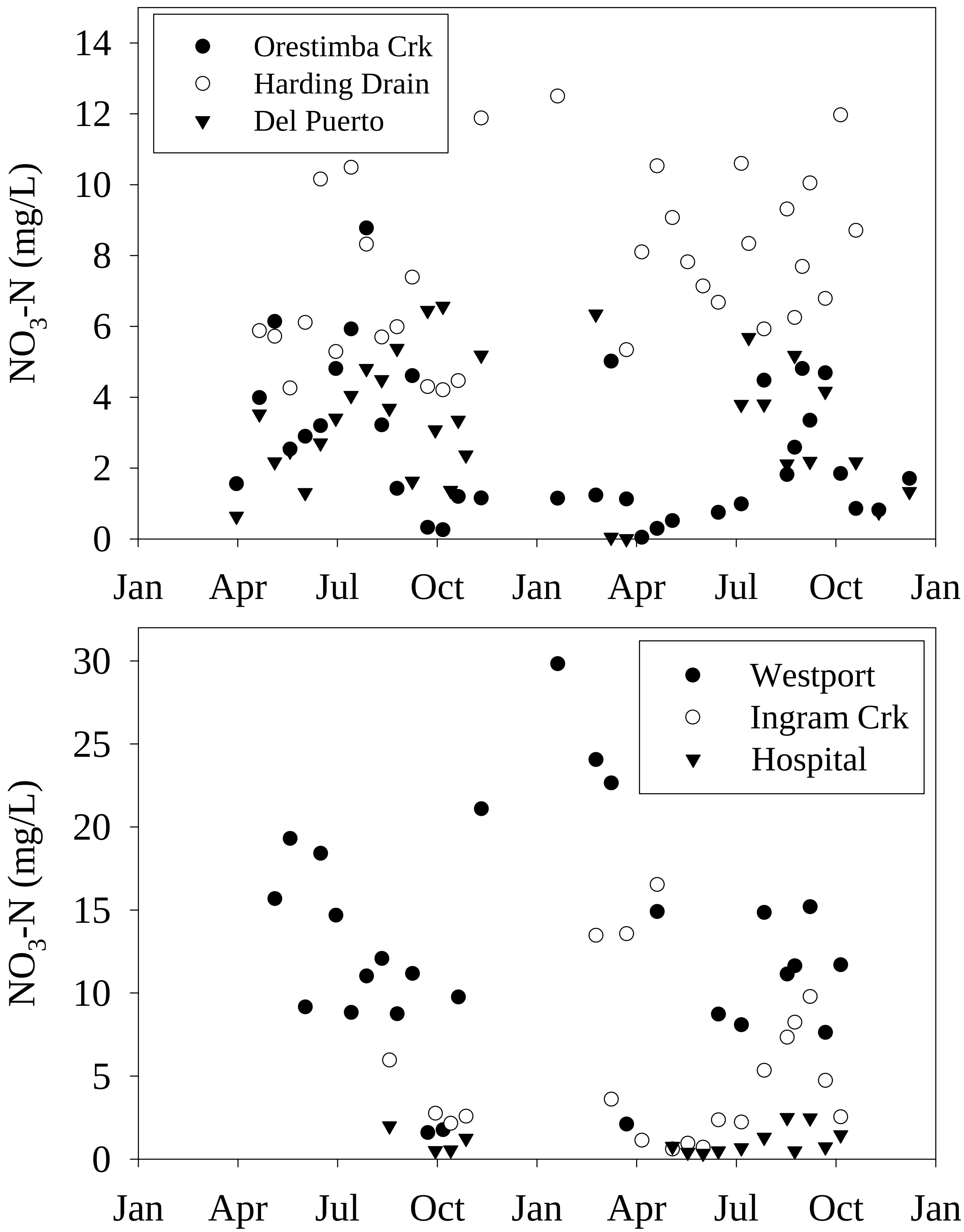


Figure 20: Temporal variability in total phosphorus concentrations for selected sites in the San Joaquin River watershed during 2005-2006.

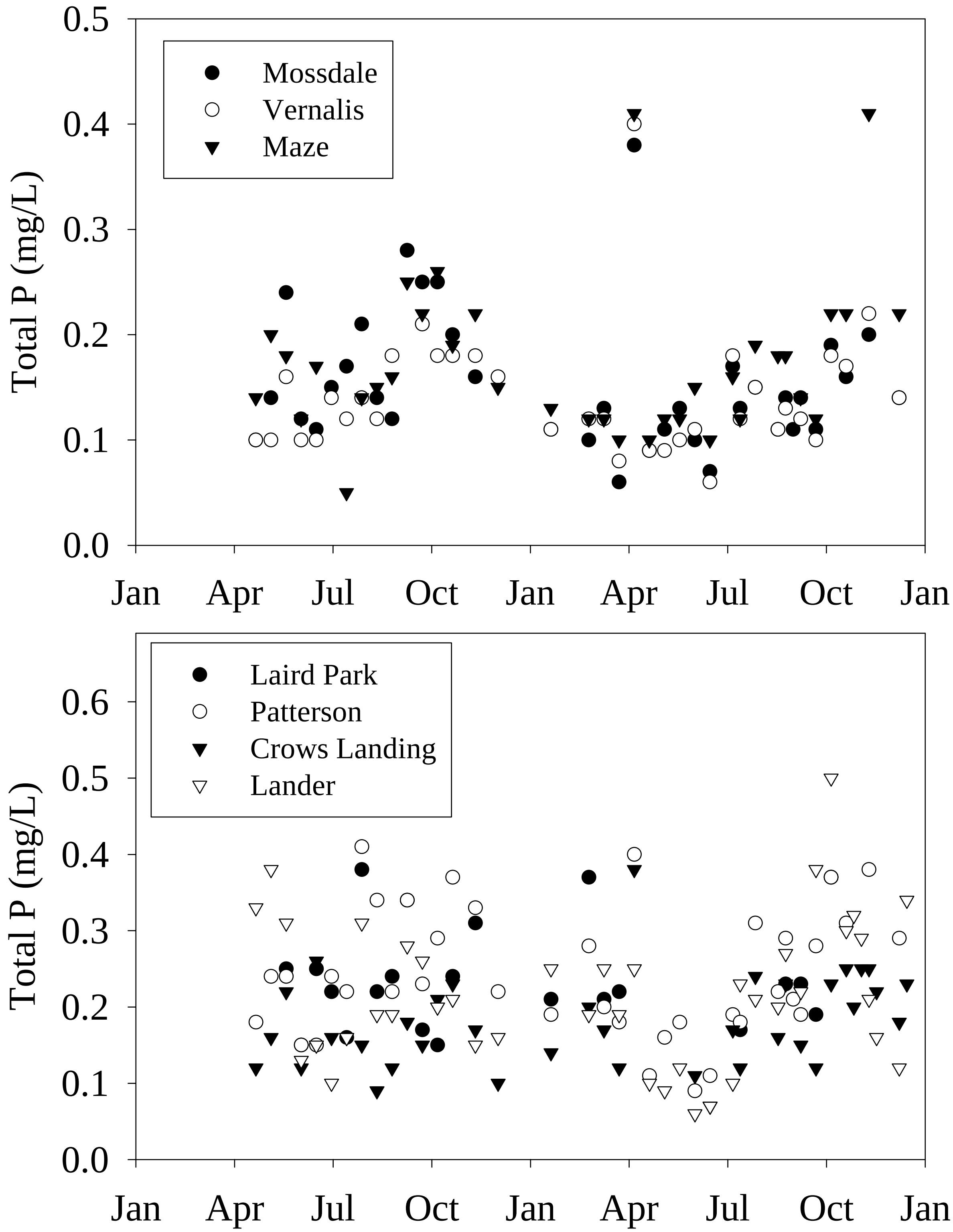


Figure 21: Temporal variability in total phosphorus concentrations for selected sites in the San Joaquin River watershed during 2005-2006.

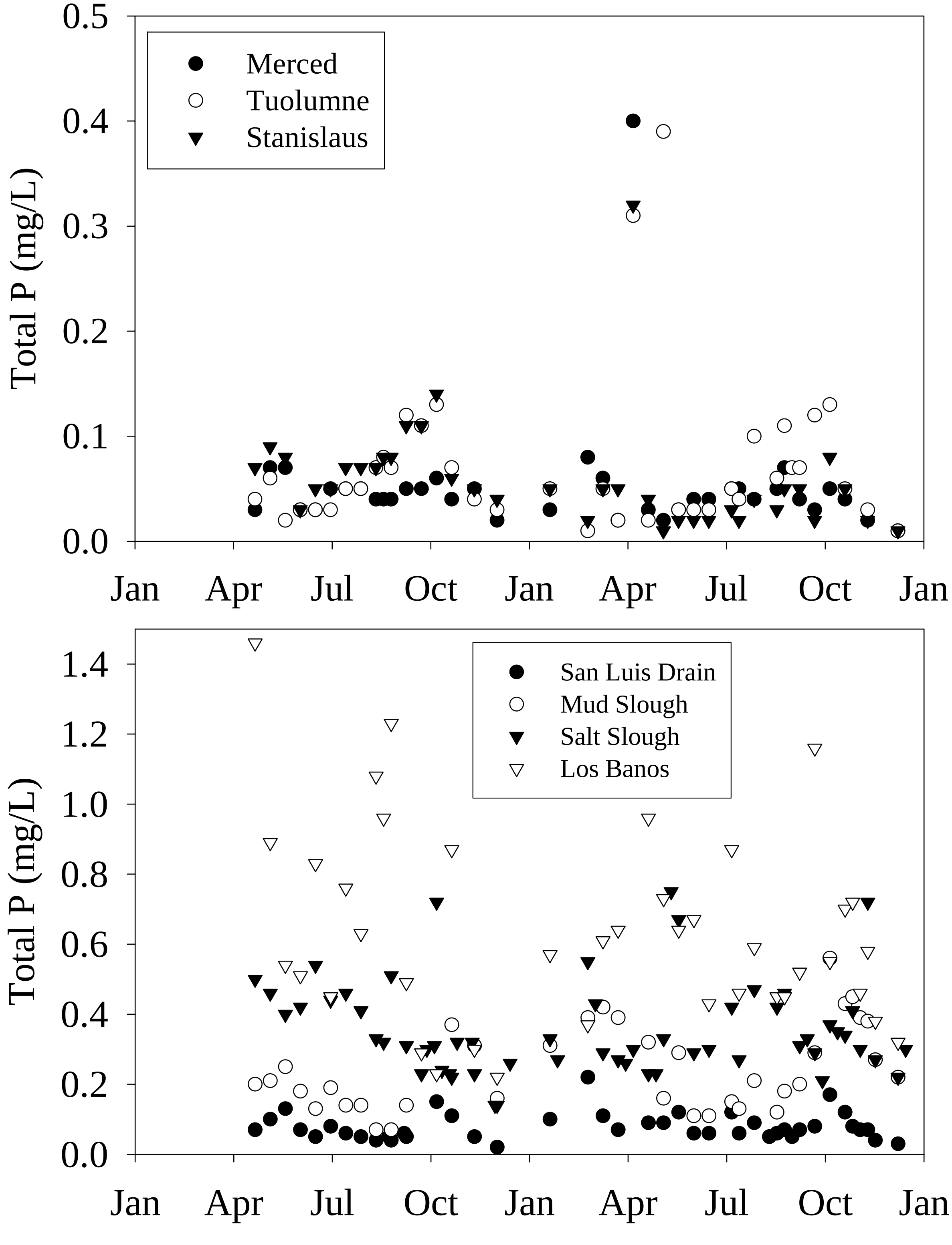


Figure 22: Temporal variability in total phosphorus concentrations for selected sites in the San Joaquin River watershed during 2005-2006.

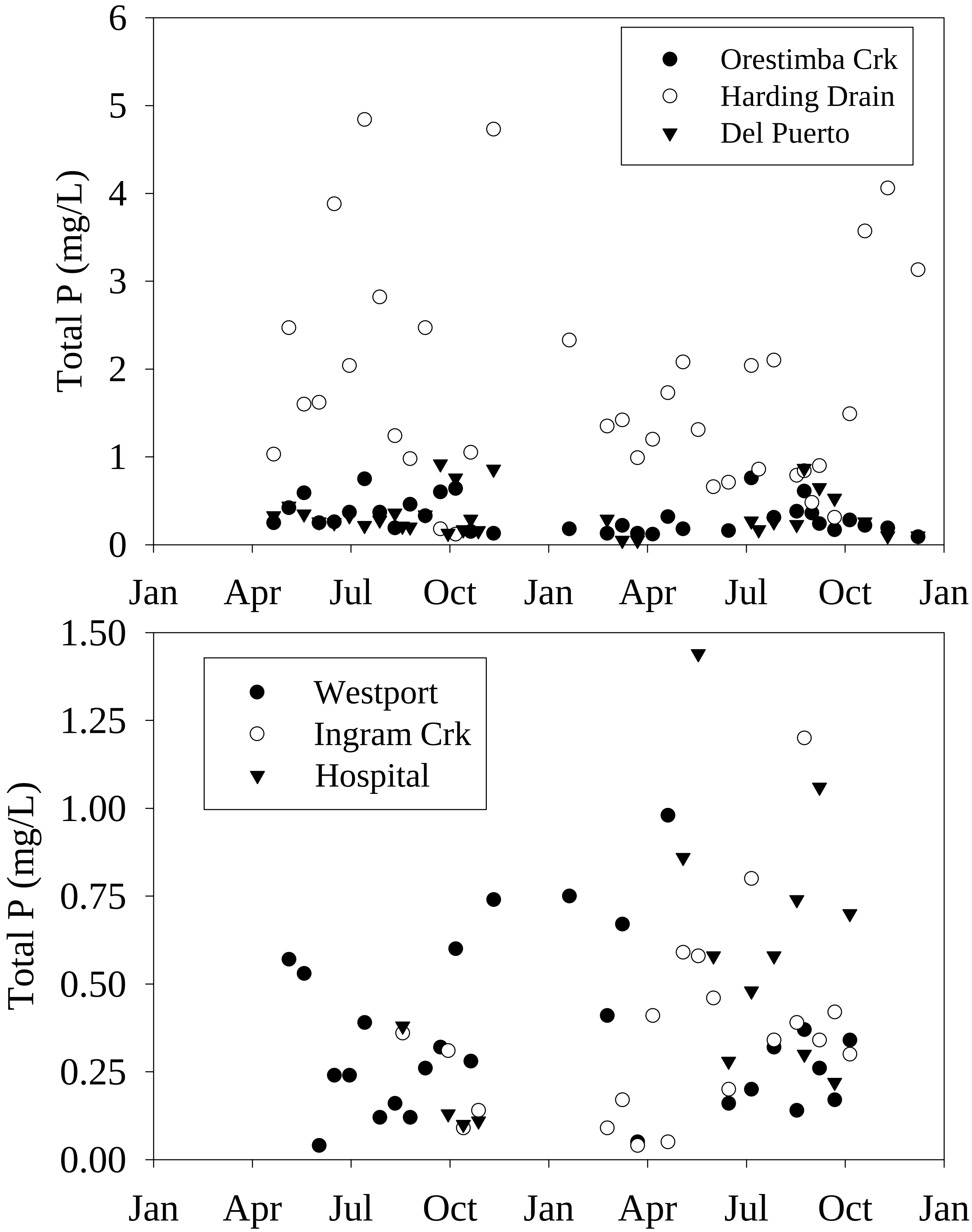


Figure 23: Temporal variability in soluble-reactive phosphate concentrations for selected sites in the San Joaquin River watershed during 2005-2006.

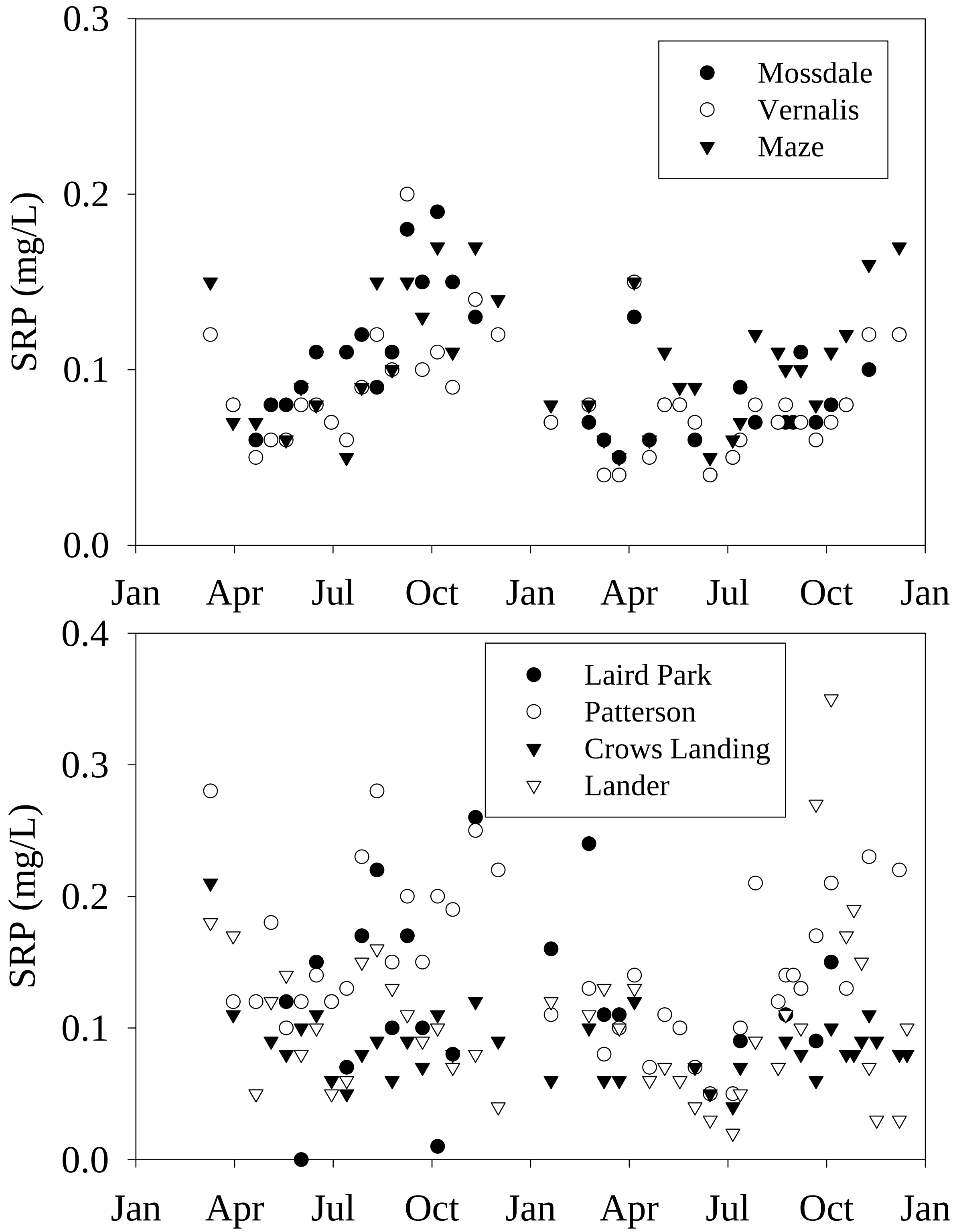


Figure 24: Temporal variability in soluble-reactive phosphate concentrations for selected sites in the San Joaquin River watershed during 2005-2006.

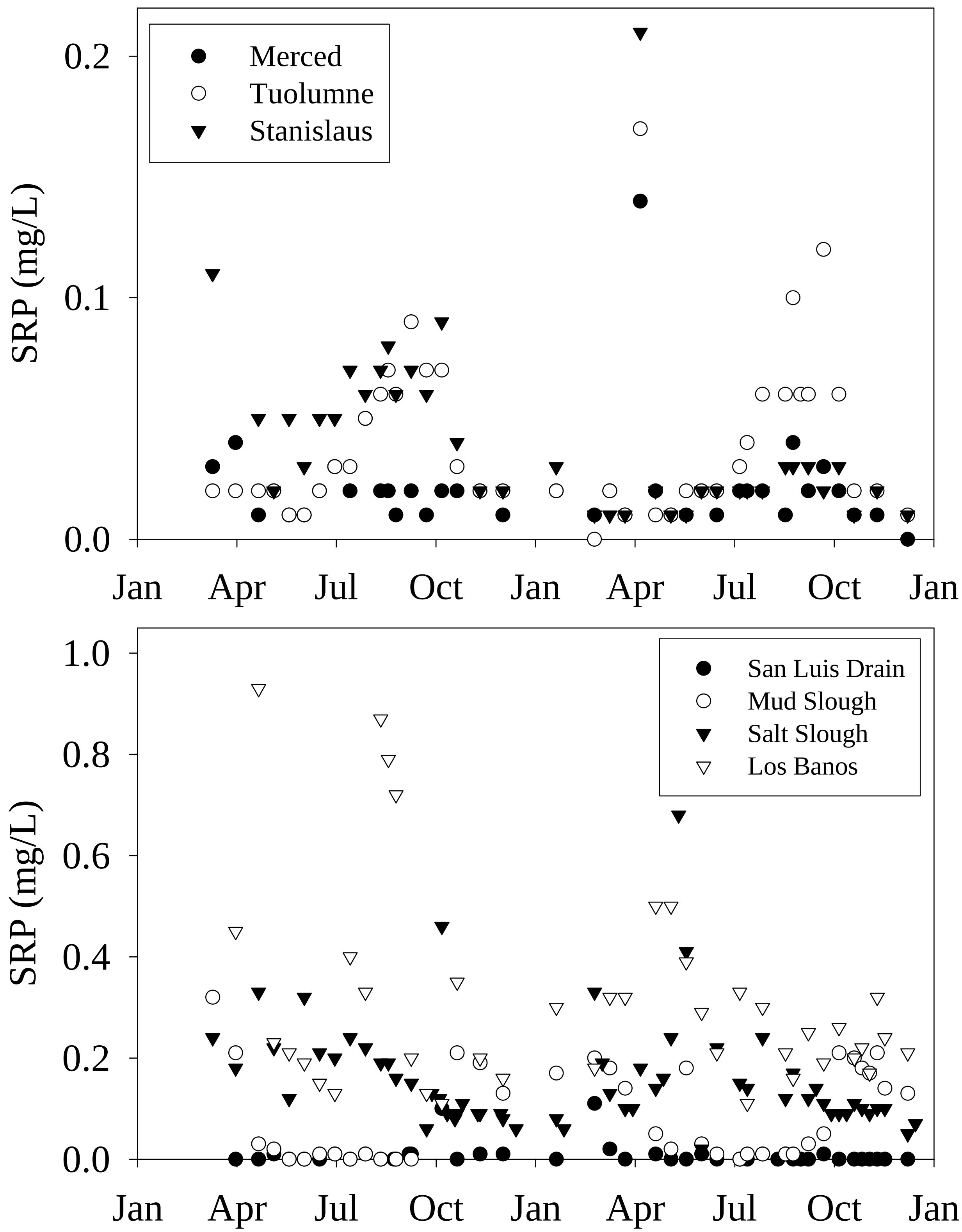
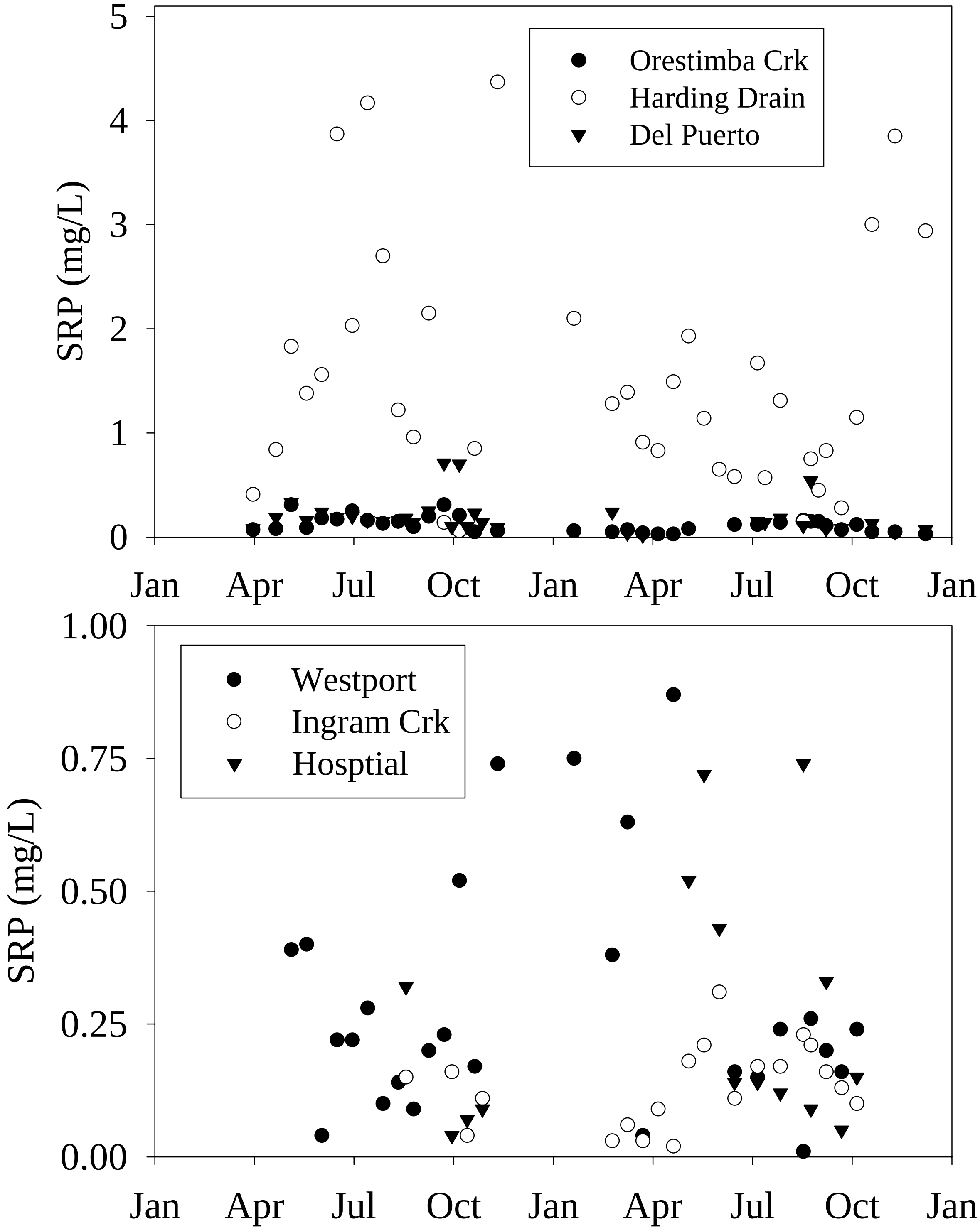


Figure 25: Temporal variability in soluble-reactive phosphate concentrations for selected sites in the San Joaquin River watershed during 2005-2006.



Chapter 6

PHYTOPLANKTON COMMUNITY ECOLOGY AND BIOMASS CHARACTERIZATION BY PHOSPHOLIPID FATTY ACID ANALYSIS

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Introduction

The purpose of this study is to apply phospholipid fatty acid analysis (PLFA) to look at the algal community composition and biomass at the sample locations to better understand algal community composition, algal growth rates, and the influences of various tributaries on the community composition.

Algae growth and decay are central in the understanding of the dissolved oxygen content of the proposed study area. Although extensive monitoring of chlorophyll to estimate algal biomass was performed, this measurement only quantifies algae and does not give information about the types of algae present or the amount of other living biomass in the system. Chl-a, because it is common to all algae species, is useful for loading and growth estimations but not for source or community composition determination.

Phospholipids, which are the one of the principal chemical constituents of the membrane, can be extracted and used as biomarkers, or specific chemical signatures for a microbial species. All microorganisms have a membrane that interfaces with the surrounding environment. The structure and chemical composition of the membrane depends primarily on the microorganism type, age, and environmental conditions. Phospholipid biomarkers have been identified that indicate the predominant types of microorganisms in a microbial community, the physiological status of the microbial community, and also provide a means for estimating the microbial biomass.

The phospholipid fatty acid analysis (PLFA) is able to identify target phospholipids that can be used to determine relative amounts of green algae, and diatoms, as well as relative proportions of higher plants (from aquatic and terrestrial sources) and bacteria. Because of some lack of specificity in lipids for algae species and the complex environment in the SJR and tributaries, phospholipid analysis in this study could not identify specific algae species.

Using PLFA, more detailed information was obtained about the types and distribution of biomass in the system during 2005 and 2006 along the main stem of the SJR and the major tributaries. By looking at both spatial and temporal changes of biomarker lipids and amounts of total lipids, some observations were made about tributaries that have an influence on the type of algae that predominates in the river.

Methods

For this study samples were collected along the main stem of the SJR and all the major tributaries from Jan 2005 to Dec 2006. To extract PLFA from water, 1000 ml of water sample was filtered through a Whatman GF/F glass fiber filter within 24 hours of collection. After filtration, the filter is placed in a 25 mm glass tube and stored at -20°C until extraction. The total lipids are extracted from the filter with a modified Bligh-Dyer solution which consists of 5 ml of chloroform, 10 ml of methanol, and 4 ml of phosphate buffer. The extract is used to estimate chlorophyll concentration by measuring absorbance at 435 and 665 nm on a UV/Vis spectrometer. The phospholipids are then separated from total lipids on C18 silicic acid column (Unisil, Clarkson Chemical, South Williamsport, PA). Isolated phospholipids are methylated and analyzed on an Agilent 6890N Gas Chromatograph (GC) equipped with a Flame Ionization Detector. Peak confirmation is accomplished on an Agilent 5972A mass spectrometer and double bond position confirmed with a dimethyl disulfide derivation [2]. Peak quantification was accomplished by use of an internal 19:0 phospholipid standard (1,2-Dinonadecanoyl-sn-Glycero-3-phophocholine) (Avanti, Alabaster, AL) which is added immediately prior to extraction, and an external 11:0 carbon fatty acid methyl ester standard (methyl decanoate) (Matreya, Pleasant Gap, GA) which is added immediately before analysis on the GC.

Lipids classes recovered from the samples were assigned to different groups of organisms as shown in Table 1. Fatty acids can be characterized by the shorthand X:YwZ, where X equals the number of carbon atoms, Y equals the number of double bonds, and Z equals the position of the first double bond counting from the methyl end. (Brepohl, 2005). In this table are listed several sources in the literature that identify specific lipids for various types of algae (Galois, 1996).

Table 1: Identification of Lipid Biomarkers used.

Descriptor	**Biomarker/characteristic Fatty Acid**	**Reference**
Diatom	16:3w3 20:5 Eicosapentaenoic acid (EPA)	Pond, 1998; Parrish (1998, 2000); Boshker, 2005; Desvilettes, 1997, Muller-Solger, 2002, Galois, 1996; Brepohl, 2005
Dinoflagellates	22:6w3 Docosahexaenoic acid (DHA)	Brepohl, 2005, Desvilettes, 1997; Parrish, 2000; Galois, 1996
Bacteria	i15:0, a15:0	Parrish, 2000; Boschker, 2005; Desvilettes, 1997
Green Algae	18:3w3 Linolenic acid (ALA)	Napolitano, 1997
Terrestrial	25:0, 26:0	Galois, 1996; Desvilettes, 1997; Napolitano, 1997

Results and Discussion

The PLFA extract measurement at 435 and 665 nm to estimate biomass were plotted against chl-a concentration in Figure 1 for the SJR at Vernalis. Both show reasonable correlation with the trends found by the chlorophyll analysis. Overall, using all the data collected from the project, the correlation of *chl-a* measurements with the PLFA data had a R^2 of 0.657 for the 665 nm measurement and 0.801 for the 435 measurement. In Figure 2, the SJR at Vernalis chlorophyll data is plotted with the total lipid recovery for the sample. This number is obtained by summing up all the known peaks from the GC analysis and normalizing it to the amount of sample. This number shows reasonable correlation with the *chl-a* data. However, overall the correlation between total lipid in pm/g and *chl-a* for when compared for 2005 and 2006 data was poor, with correlation (R^2) of 0.404. When the bacterial and terrestrial lipids are removed, the fit improves to 0.804. While both the *chl-a* and PLFA techniques quantify biomass of algae, the total PLFA biomass result will include lipids from other aquatic biomass sources such as bacteria and terrestrial organic matter, which may account for the majority of the difference in the measurements over the two year study period. These lipids may represent in some cases biological activity that influences oxygen demand and understanding their sources and load is potentially important.

Biomass measurements from PLFA analysis were further refined to show relative amounts of diatoms, dinoflagellates, bacteria, green algae, and terrestrial, as described above. As an example, Figure 3 shows the % composition of these components for each site for the 7/6/2006 samples. Note the consistent composition in the SJR after Patterson. Also notable is the input from terrestrial sources, including higher plants, that influences the composition at SJR at Lander Avenue and the Merced River. The largest source of green algae is the Stanislaus River. Diatoms come from all sources, but are most evident at the end of the San Luis Drain and Los Banos Creek. There is a large bacterial load from the Turlock ID, Harding Drain.

Focusing on the composition of only the algae types (green, diatom, dinoflagellate), Figure 4 shows the composition of the algae component of the biomass in two main stem samples, SJR at Mossdale and Crows Landing during 2005 and 2006. The plot on the left shows the distribution of species as percent of total, the plot on the right scales the data to show relative biomass amounts (in picomole lipid/ml of sample). This plot illustrates both the variation of the community structure throughout the year, as well as also the predominance of diatoms during the summer months when the algae load is the highest.

The development of the algal community down the main stem, from Lander Avenue to Mossdale, is shown in Figure 5 for March and July, 2005 and 2006. In July 2005 and July 2006 the algal communities were similar, about 70% of the algae at Mossdale are diatoms, 10% green, and 20% dinoflagellates. In March 2005 and 2006, the communities were very different and showed a pattern of increasing % diatoms in 2005 and increasing % green in 2006.

PLFA data can also be use to identify likely sources of algal seed. If a major tributary has the same composition of algae that develops in the main stem of the river, then that input may act as a seed source for the river. In Figures 6, % of diatoms is plotted against % dinoflagellates for 6/30/05 and % green for 5/5/05. Either method works equally well for identifying sources. In the 6/30/05 plot, the main stem samples, which are circled, are clustered with the inputs from the San Luis drain and Mud Slough. On 5/5/05, the upper river has a composition closely related to the same inputs, but shifts after the confluence with Del Puerto Creek. The east side tributaries, the Stanislaus, Merced, and the Tuolumne do not significantly alter the species of algae growing in the SJR.

Specific changes at a particular site were investigated by using a biplot comparing different biomass fractions at a given site throughout the year. In Figure 7, SJR at Mossdale for dates from 4/21/2005 to 7/28/2005 were plotted as diatom fraction on the horizontal axis and the dinoflagellate fraction on the vertical axis on the left and diatom compared to the terrestrial fraction on the right. These plots show that in the spring dinoflagellates are more significant and further shows increasing importance of diatoms as summer passes. The influence of the terrestrial fraction from spring runoff, influences the community structure in the spring and becomes less important in late summer.

Conclusions

The PLFA analysis has been successful as an independent measurement of biomass and will be useful in confirming load calculations from *chl-a* measurements. The PLFA data supports previous data that diatoms are the major algae type during the summer months. Furthermore, algal community structure in the SJR appears to be consistent in the summer months from 2005 to 2006. The results also suggest that algae are the major source of biomass in the river. However, during the early spring, terrestrial biomass sources become important and in some tributaries bacterial loads can be significant. Ongoing work with the 2005 and 2006 data, as well as 2007 samples will be focusing on confirming these findings as well o correlating shifts in algae community with other measurements (nutrients, solids, flow), and helping to understand the relationship between community structure of the tributaries and the predominant algae growing in the mainstem of the SJR.

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Figure 1: PLFA extract and total lipid recovery are compared with the Standard Method chlorophyll a determination for estimation of biomass in the river.

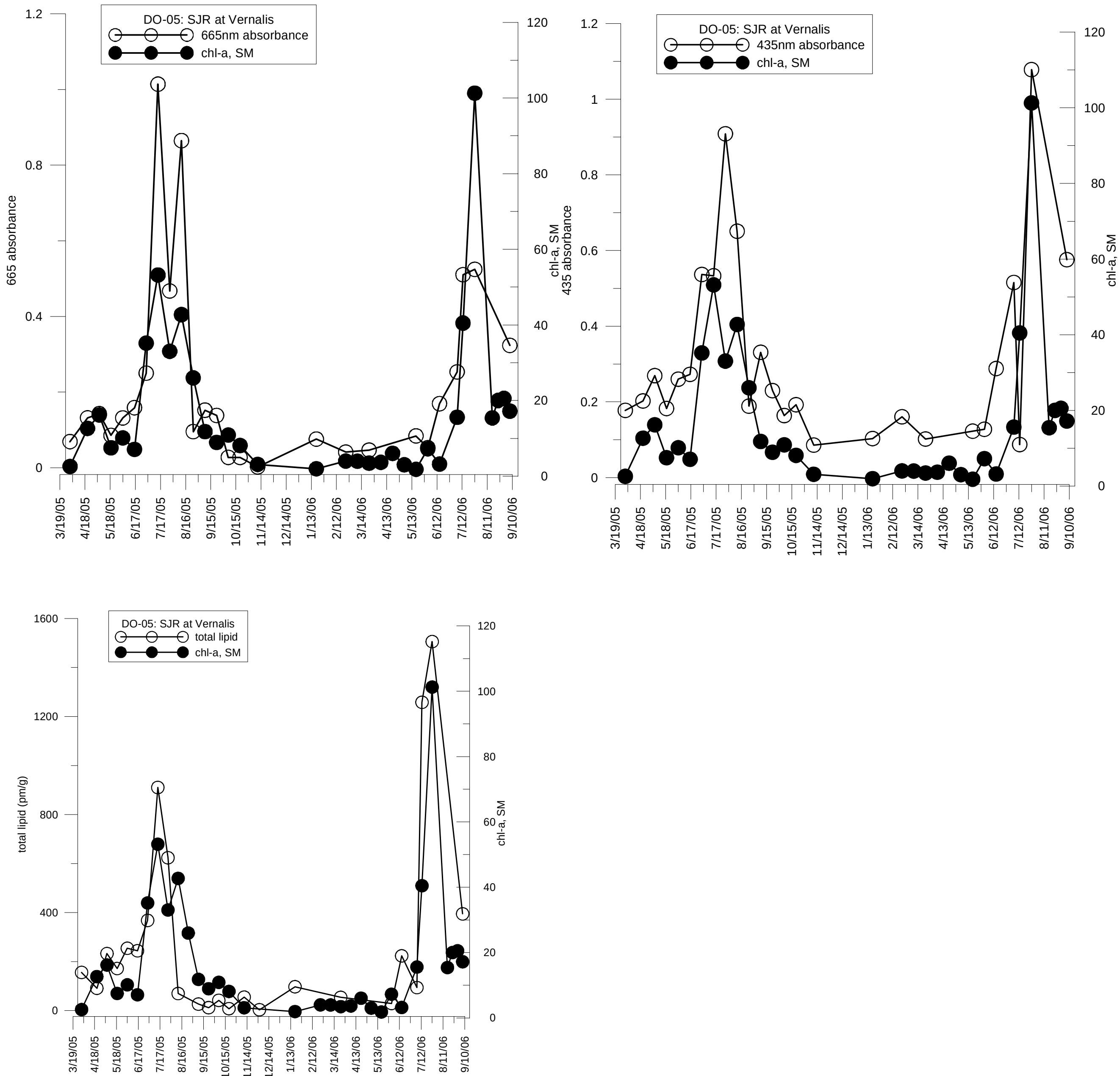


Figure 3: Results from lipid analysis for sample data 07/06/06. Plot is of all sites sampled on this date and shows percent of each type of biomass recovered in the sample.

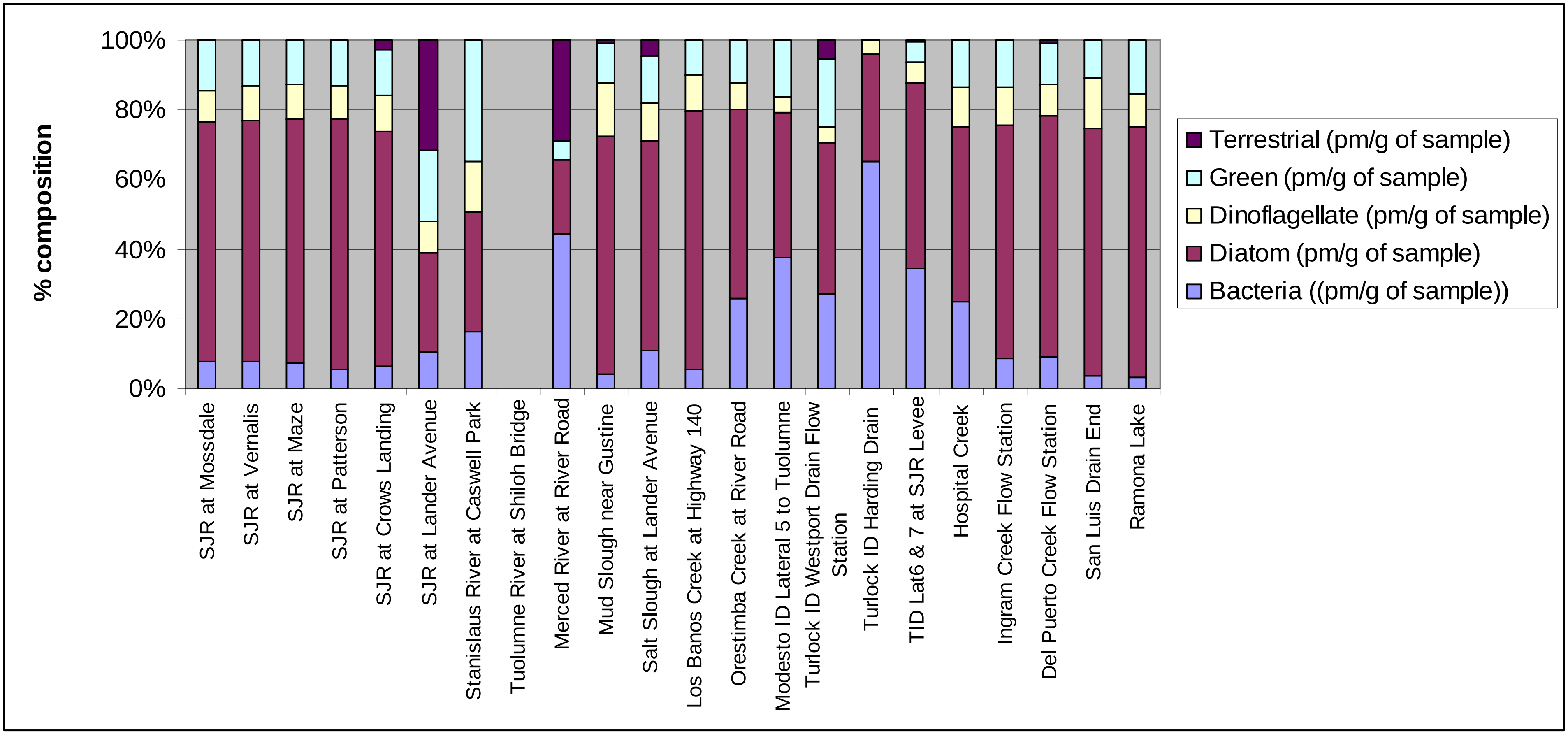


Figure 4: Community composition at main stem sites during 2005 and 2006. Shown as % of total on the left and with relative total concentrations (in pm lipid/liter sample) on the right.

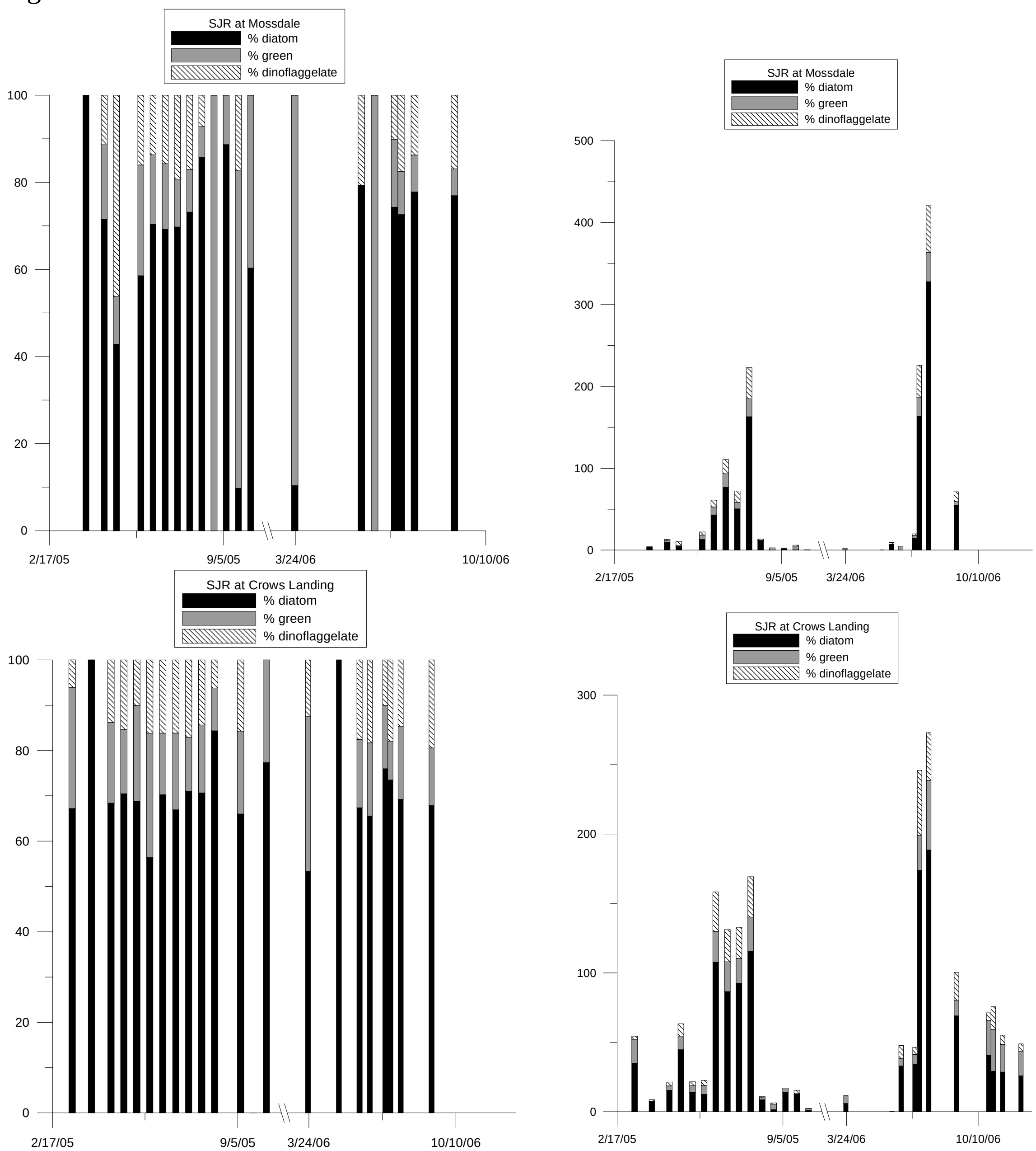


Figure 5: Community composition changes down the main stem of the SJR March 2005 and 2006, and July 2005 and 2006.

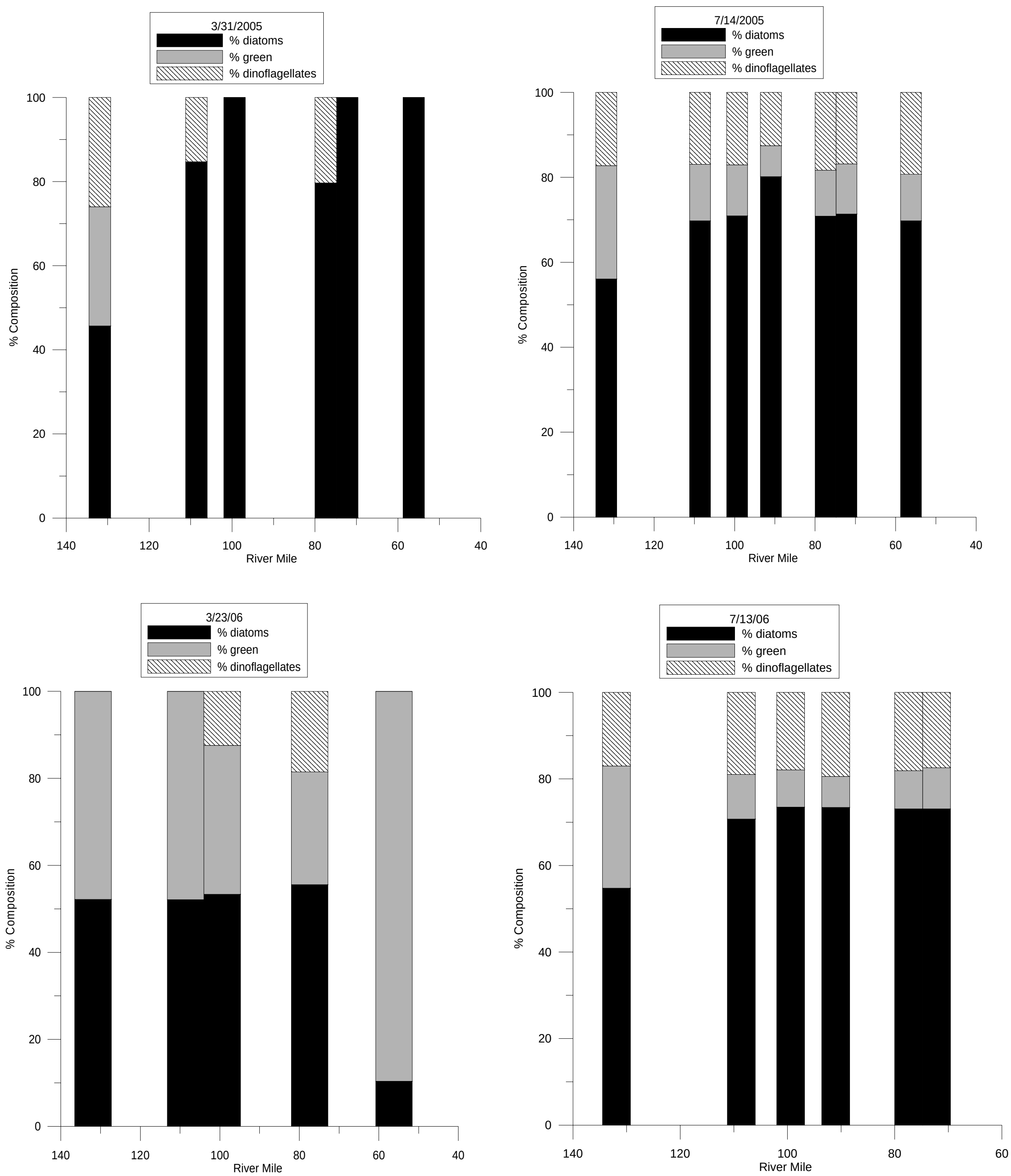
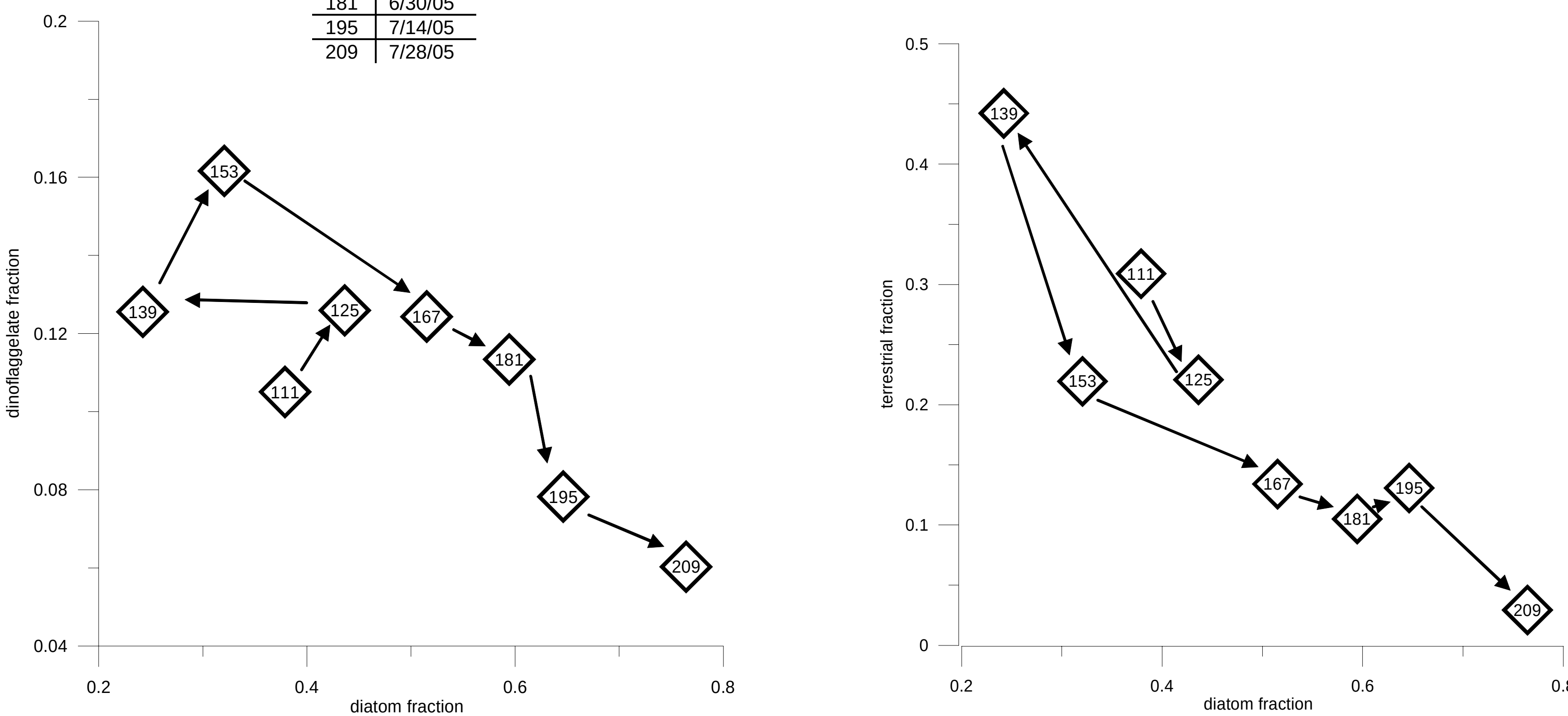


Figure 6: Determination of possible sources of algae seed along the main stem SJR. Symbols 4, 5, 6, 7, 8, 10 and 59 represent main stem samples and are circled. Major tributaries are illustrated in the inset map. Incoming tributaries between SJR at Lander avenue (site 10) and SJR at Crows landing (site 8) shift the algae community during June of 2005.

Figure 7: Transition of the community structure in the SJR at Mossdale. The first plot shows the diatom fraction and the dinoflagellate fraction, the second the diatom and the terrestrial fraction. The number in the diamond shape represents the day number (DN).

DN	DATE
111	4/21/05
125	5/5/05
139	5/19/05
153	6/2/05
167	6/16/05
181	6/30/05
195	7/14/05
209	7/28/05



Chapter 7

PHYTOPLANKTON GROWTH
IN
THE SAN LUIS DRAIN
2003 TO 2005

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Berkeley National Laboratory

Jeremy Hanlon
University of the Pacific

Introduction

Eutrophication of surface waters has been a recognized environmental problem for over forty years (Hutchins, 1973; Levin, 1967). Although phytoplankton are the foundation of many aquatic food-webs, the excessive growth of phytoplankton in eutrophic waters can have a significant negative impact on habitat quality and some phytoplankton can be directly toxic to fish and wildlife (Haider et al., 2003; Scavia and Bricker, 2006). Accumulation of phytoplankton biomass and subsequent phytoplankton population crashes can cause anoxic conditions in rivers, lakes and estuaries (Billen et al., 2001; Hagy et al., 2004; Jassby and Nieuwenhuyse, 2005; Jorgensen, 1976; Parr and Mason, 2004; Pers, 2005; Scavia and Bricker, 2006) and high phytoplankton concentrations reduce other beneficial uses by contributing foul tastes, offensive odors and formation of disinfection-by-product precursor compounds (Nikolaou and Lekkas, 2001; Sladeckova, 1998; Wnorowski, 1992).

Phytoplankton blooms, and subsequent negative impacts, have been extensively studied and modeled in estuaries, lakes, reservoirs, and ponds (Billen et al., 2001; Bowie et al., 1984; Cerco and Noel, 2004; Hilton et al., 2006; Jorgensen, 1976; Koelmans et al., 2001; Nyholm, 1978; Pers, 2005). The factors limiting the biomass yield of phytoplankton in confined waterbodies and estuaries are typically attributed to macronutrients: nitrogen and phosphorous , but growth rates can be controlled by any number of factors, including light availability, micronutrient limitation, and zooplankton grazing (Knowlton and Jones, 1995; 1996; Koch et al., 2004; Kuuppo et al., 1998; Robson, 2005; Wu and Chou, 2003). Enclosed systems are well enough understood that robust phytoplankton biokinetic models have been developed for lakes and reservoirs to describe the interactions between algal growth, algal yield, light availability, grazing, and nutrient concentrations (e.g. Bowie et al., 1984; Cugier et al., 2005; Hilton et al., 2006; Pers, 2005; Plus et al., 2006).

Phytoplankton growth in eutrophic rivers is less well understood (Hilton et al., 2006). A growing body of evidence suggests that phytoplankton growth in rivers is strongly influenced by physical factors, such as residence time and mixing rates, and that these and other physical factors may be as important as macronutrient concentrations in regulating phytoplankton growth yield and growth rates (biokinetics).

The objective of this study was to identify fundamental process controlling algal biokinetics in a highly eutrophic river. The limits of phytoplankton biokinetics were examined in a concrete-lined river in the Central Valley of California which conveys nutrient rich agricultural drainage. High nutrient conditions, combined with abundant sunlight and warm temperatures, results in significant summer phytoplankton blooms and presents an opportunity to study factors limiting algal growth in the presence of excess macronutrients. Phytoplankton growth was measured in the river and environmental conditions were related to phytoplankton biokinetics using statistical methods and a mechanist model. The mechanistic model identified limiting factors for growth and yield and suggested that suspended sediments have a stimulatory influence on diatom growth and function as a source of nutrients as dissolved nutrients are depleted.

Methods

Lagrangian studies were conducted in the San Luis Drain (SLD) over a three year period (2003 to 2005). Samples were collected at each of the 18 hydraulic checks along the 43 km study area as well as at the entrance and exit of the channel (Figure 1). Chemical and physiological measurements were made at the up-stream side of each check and grab samples were depth integrated. Flow was measured continuously at the head and exit of the channel. Residence time in the drain as a function of distance was measured by velocity and dye studies and confirmed by hydraulic calculations based on design specifications. The distance along the drain was related to residence time and data was analyzed as a function of residence time. Phytoplankton growth and water quality changes were measured in May 2004 and January 2005 and two times each in June and July 2003 and 2004. Phytoplankton biokinetic pattern in the drain was measured again in June 2005 to confirm that June year to year results were comparable.

Field measurements were made with handheld sondes and water quality measurement devices, including a YSI 6600 sonde, HACH turbidometer, and Myron combination Ultraprobe. For dye studies, Hydrolab combination sondes were used. Handheld probes were calibrated daily before each use. Stream velocity was measured using a Marsh-McBirny velocity probe. Confirmation (QC) of continuous measurements was performed using replicate sampling for laboratory analysis and duplicate calibrated instruments, as required. Measurement of incident photosynthetically active radiation (PAR) and PAR attenuation with depth in the SLD were made using quantum light detectors (LiCor, Lincoln, NE). Photozone was defined as the depth where light penetration was 2% of incident light.

Samples collected in the field were transported to Berkeley National Laboratory for analysis. All analyses were run within the allowed holding time applicable to the preservation method used (American Public Health Association, 1998). Total organic carbon (TOC) was measured by high temperature combustion according to Standard Method (SM) 5310 B (American Public Health Association, 1998). Dissolved organic carbon was measured on split samples after filtration through a GF/F glass fiber filter by the same method. Total suspended solids (TSS) and volatile suspended solids (VSS) were analyzed by SM 2540 D and E, respectively. Mineral solids (MS) was calculated as TSS minus VSS. Chlorophylls (chl-*a*, chl-*b*, chl-*c*), pheophytin-*a* (pha-a), and xanthophyll were extracted and analyzed according to SM 10200H (American Public Health Association, 1998).

Ortho-phosphate was determined on samples filtered through a glass-fiber filter (0.7 micron). Ortho-phosphate and total phosphorous were quantified by the Ascorbic Acid Method (adapted from SM 4500-P-E). Total phosphorus was determined on non-filtered samples following persulfate digestion. Total iron was determined by the Phenanthroline Method (SM 3500-Fe B) (American Public Health Association, 1998).

The algal community was characterized by measurement of phospholipid fatty-acid (PLFA) profile. To extract PLFA from suspended algae and detritus, 500 ml of water sample was filtered through a Whatman GF/F glass fiber filter within 24 hours of collection. The filter was placed in a 25 mm glass tube and stored at -20 ^{o}C until extraction. The total lipids are extracted from the filter with a modified Bligh-Dyer solution which consists of 5 ml of chloroform, 10 ml of methanol, and 4 ml of phosphate buffer. The phospholipids are then separated from total lipids on C18 column (Unisil, Clarkson Chemical, South Williamsport, PA). Isolated phospholipids are methylated and analyzed on an Agilent 6890N Gas Chromatograph (GC) equipped with a Flame Ionization Detector (Guckert et al., 1985). Peak confirmation is accomplished on an Agilent 5972A mass spectrometer and double bond position confirmed with a dimethyl disulfide derivation (Nichols et al., 1986). Peak quantification was accomplished by use of an internal 19:0 phospholipid standard (1,2-Dinonadecanoyl-sn-Glycero-3-phophocholine) (Avanti, Alabaster, AL) which is added immediately prior to extraction, and an external 11:0 carbon fatty acid methyl ester standard (methyl decanoate) (Matreya, Pleasant Gap, PA) which is added immediately before analysis on the GC.

PLFA recovered from water samples can assigned to specific organism classes and biomass estimated for each class using the amount of lipid recovered. Diatom were characterized by 16:3w3 and 20:5 fatty acids; dinoflagellates by the occurrence of 22:6w3; green algae by 18:3w3; bacteria by i15:0 and a15:0; and terrestrial biomass by 25:0 and 26:0 fatty acids (Becker et al., 2004; Galois et al., 1996; Muller-Solger et al., 2002).

Weather data was collected from three stations in the Central Valley. Central Valley temperature and precipitation averages were calculated by averaging daily data for the thirty year record from Stockton, Merced and Los Banos, CA. Weather clarity (number of clear days) was calculated from the 30 year Stockton record only.

Experimental data were fit to the logistic population model using Grapher software (Golden Software, Golden, CO). The Logistic model is used to describe resource limited biokinetic relationships:

$$N_t = \frac{K}{1 + \left[\frac{K - N_o}{N_o} \right] e^{-rt}} \qquad \text{Eq. 1}$$

where N_t is the concentration of phytoplankton at time t, N_0 is the initial concentration of phytoplankton, K is the maximum phytoplankton concentration the ecosystem will support, r is the phytoplankton growth rate, and t is the elapsed time.

Mechanistic models were written in Excel software and parameter estimates were generated by minimization of least-square difference between chlorophyll data and model predictions. Statistical analysis were conducted according to Sokol and Rohlf (1995).

Results and Discussion

The San Joaquin River is located in the Central Valley of California, one of the most productive agricultural regions in the world. The San Joaquin Valley has a Mediterranean climate characterized by a dry-season (May through October) and a wet-season (November through April). In June and July, there is typically no measurable precipitation in the Central Valley. Air temperatures are typically mild in the winter (average low temperature of 2.6 ^{o}C in December) and hot in the summer (average high temperature of 35 ^{o}C in July). In the dry season, most days are clear, there is little fog, and available sunlight is directly related to day-length. Agricultural production is highly dependent on irrigation and the summer months are commonly referred to as the "irrigation season." Irrigation return flows are a significant source of nutrients to the San Joaquin River, which is the major drainage for the region (Figure 1).

The San Luis Drain (SLD) is a major tributary to the San Joaquin River above its confluence with the Merced River (Figure 1). The 43 km SLD drains a watershed of approximately 97,000 acres of irrigated farmland located in seven drainage and irrigation districts. The SLD discharges to Mud Slough, approximately 5 km above its confluence with the San Joaquin River. The soils in the SLD drainage are of marine origin and contain high concentrations of salts and trace elements (Gronberg et al., 1998). There has been an long-term interest in the water-quality of this region, consequently drainage flows in the SLD are accurately measured and several studies have examined the water quality of the SLD (Kratzer and Shelton, 1998; Kratzer et al., 2004; Stringfellow and Quinn, 2002). Previous studies showed that chlorophyll concentrations at the end of the SLD are consistently high in the summer months and that there is significant phytoplankton growth occurring in the SLD between the entrance and exit of the drain (Stringfellow and Quinn, 2002).

The SLD is an open, shallow, concrete lined channel. During the dry season, the flow in the SLD consists entirely of agricultural drainage and inlet and outlet flows approximately balance. Flows between May and September average 1.22 $m^3 sec^{-1}$ and are consistent from year to year. In October, irrigation-return flows decline significantly and flows typically remain low throughout the wet season, except during periods of rainfall. Groundwater can enter the SLD through weep-valves, so during the wet-season exit flows may exceed input flows (data not shown).

The configuration of the SLD makes it an ideal location for meso-scale field experiments examining phytoplankton biokinetics. The SLD has no shading and is therefore fully exposed to sunlight and warm temperatures. The SLD does not support littoral plant or algal communities and all primary production in the drain is planktonic. After the first 2 km, the SLD has a uniform trapezoid shape and a consistent water depth of approximately 2.4 meters. During the summer, the hydraulic residence time of the SLD is approximately four days. The SLD contains a series of check structures at an average interval of 2.2 km. At these check structures, water drops approximately 0.5 meters and is passed through a culvert, which results in a complete mixing of the water at each structure. The uniformity of construction, flows, residence time, and depth, combined with regular mixing and resuspension of materials, allows modeling of the SLD as a complete mix, plug-flow reactor.

Phospholipid analysis shows the phytoplankton community in the SLD is dominated by diatoms (Figure 2) and that algae biomass consistently accounted for approximately 90% of the suspended biomass found at the exit of the channel, with the balance attributable to bacterial and fragments of higher plants. Diatoms were consistently 80% of the algal community, with green algae and dinoflagellates representing 15% and 5% respectively (Figure 2). The community structure was stable as biomass accumulate in the channel (data not shown) and the community structure is stable over time (Figure 2), supporting the conclusion that the SLD can be modeled as a pseudo-steady-state, plug flow reactor.

Measurement of nutrients and other water quality parameters were made at the head of the SLD in May, June, and July of 2003; June and July of 2004; and January of 2005 (Table 1). The water entering the SLD is a nutrient rich media entirely suited for algal growth. Over six years of records of water quality measurements at the terminus of the drain are also available (Kratzer et al., 2004; Stringfellow and Quinn, 2002). In all cases where nitrate was measured at the terminus of the drain during the dry-season months nitrate-N concentrations were above 8 mg L^{-1}, with the exception of one measurement in October where the nitrate-N was 4 mg L^{-1}. These reported NO_3-N concentrations are over 50 times average reported phytoplankton half-saturation constants for nitrogen (Bowie et al., 1984). Available silicon concentrations at the exit of the channel were 20 to 200 times diatom half-saturation constants (Dahlgren, personal communication). Total phosphorous concentrations were also high at the exit of the SLD, consistently being greater than 0.02 mg L^{-1} as P (Kratzer et al., 2004; Stringfellow and Quinn, 2002), but outlet concentrations are significantly lower than measured inlet concentrations (Table 1), suggesting a significant phosphorous demand in the system. Total phosphorous concentrations at the outlet were still greater than or equal to reported half-saturation constants for phosphorous (Bowie et al., 1984). These results suggest that nitrogen and silicon are not limiting in this system, but that phosphate limitation could not be ruled out, despite the high phosphorous concentrations entering the SLD.

During the May and January studies, phytoplankton growth rates appeared exponential for the entire length of the channel and it was not apparent that algae growth ever reached the maximum carrying capacity of the system (data not shown). In contrast, the June and July studies demonstrated a biomass accumulation pattern consistent with limited growth kinetics (Figure 3). The consistency of results between years suggests that in June and July environmental conditions in the channel are sufficiently stable that pseudo-steady state conditions exist. The channel demonstrated a consistent pattern of sediment loss and phytoplankton accumulation as a function of residence time during June and July (Figures 3 and 4). Total phosphorous and soluble ortho-phosphate (oP) also typically demonstrated decline with residence time (Figure 5), but total phosphorous and oP concentrations were not significantly related to sediment concentrations ($r^2 < 0.060$). Agreement between phytoplankton growth patterns between different days and different years confirms that the SLD can be analyzed as a plug-flow reactor.

The logistic population model was fit to the June and July data and it was shown that the model gave an accurate description of the observed algal growth data (Figure 3). Biokinetic parameter estimates generated for individual data sets using the logistic model are shown in Table 2. The June and July data were directly comparable and showed surprising homogeneity year to year. The analysis of this system using the logistic model suggests that algae reach a maximum carrying capacity (K) in this system and that the maximum amount of algae biomass that can be supported on this drain water corresponds to less than 200 $\mu g\ L^{-1}$ of chlorophyll-*a*.

The logistic model describes how a populations may respond to growth limiting conditions, however the model provides no mechanistic explanation as to what factors are limiting growth. As the phytoplankton population was shown to reach a maximum carrying capacity in this system, it was hypothesized that mechanisms controlling phytoplankton biokinetics could be evaluated and further analysis was conducted to determine limiting factors.

The importance of light availability as a limiting factor for phytoplankton growth in the SLD was investigated. Although volatile suspended solids (VSS) concentrations increase as a function of residence time due to algae growth (Figure 3), total suspended solids and mineral solid concentrations decline along the length of the drain, due to settling losses (Figure 4). The removal of mineral solids has a more significant effect on light attenuation than the increase in algal biomass and as a result the depth of the photic zone increases as a function of residence time in the drain (Figure 6). An examination of observed growth rates (μ) demonstrates that the highest growth rates are typically observed in the first 40 hours of residence, in zones of higher turbidity (Figures 3 and 6). Additionally, incident solar radiation averaged 720 ± 64 langleys per day (approximately 138 E/m^2 day) during the study period, which is well above reported saturating light intensities (Bowie et al., 1984; Knowlton and Jones, 1995; 1996; Sellers and Bukaveckas, 2003). Since the depth of the SLD is uniform after the first 2 km, the observation that photic zone is not correlated positively with algal growth rates is direct evidence that self-shading and light limitation are not controlling growth yields of phytoplankton in the SLD.

Analysis was conducted to determine if biomass yield correlated with initial conditions or changes in water chemistry between initial and final conditions. When both summer and winter data sets were included, yield was significantly correlated (r > 0.900, alpha = 0.05) with seasonal factors (temperature, day length and day of year). Biomass yield had a significant correlation (alpha = 0.05) with inoculum (initial phytoplankton) concentration (r = 0.859), electrical conductivity (-0.740), and changes in soluble o-phosphate (-0.977), turbidity (-0.813), and mineral solids (-0.708), but not initial ortho-phosphate concentration or change in total phosphorous concentration. There was significant correlation among independent variables and many chemical parameters varied with seasonal parameters (data not shown). The correlation between independent parameters in flowing systems limits the ability of statistical methods to identify factors limiting phytoplankton yields and growth rates. To address the limits of the statistical methods, a mechanistic approach to determining limiting factors was applied.

A mechanistic model was used to interpret the field data and evaluate the influence of light, pH, inorganic carbon, nutrient concentration, and mineral availability on algae growth in the SLD. Nitrogen, and silica were not included in the model, since direct measurements demonstrated they were not limiting in this system. Light and temperature were highly correlated and light was not modeled as an independent parameter. The mechanistic model was written using the minimum formulation approach (Bowie et al. 1985):

$$X_2 = X_1 e^{(\mu+g)(t_2-t_1)} \quad \text{Eq. 3}$$

$$\mu = f(T)\,f(L)\,\mu_{\max} \quad \text{Eq. 4}$$

$$g = f(T)\,f(Z)\,g_{\max} \quad \text{Eq. 5}$$

$$f(T) = 2^{(0.138(\mathrm{T}-26))} \quad \text{Eq. 6}$$

$$f(L) = \min[\, f(M), f(P), f(C)] \quad \text{Eq. 7}$$

$$f(M) = \frac{M}{M + K_{sm}} \quad \text{Eq. 8}$$

$$f(P) = \frac{P}{P + K_{sp}} \quad \text{Eq. 9}$$

$$f(C) = \frac{C}{C + K_{sc}} \quad \text{Eq. 10}$$

$$C = \left(\frac{[H^+]^2}{[H^+]^2 + [H^+]10^{-6.4} + 10^{-16.7}} \right) 100 \quad \text{Eq. 11}$$

$$f(Z) = \frac{X_1}{X_1 + K_{sz}} \quad \text{Eq. 12}$$

where X_1 equals initial biomass at time 1 (t_1) measured as chlorophyll *a*, X_2 equals biomass at time 2 (t_2) measured as chlorophyll *a*, μ is the algal growth rate, g is the rate of algal grazing (negative number describing algal loss due to grazing). The observed growth rate, μ, is a function of the inherent maximum growth rate (μ_{max}), temperature (T), and the most severely limiting factor of either mineral solids concentration (M), carbon dioxide expressed as a percent of total dissolved inorganic carbon (C), or ortho-phosphate (P) concentration. This model uses suspended mineral solids as a bulk measure of un-dissolved nutrients and trace minerals, including silica and iron. The temperature modification factor (*f(T)*) was developed from the Arrhenius equation using observed maximum growth rates calculated by the logistic method as described above. Other factors are based on the Michaelis-Menten relationship (Bowie et al., 1984), where K_{sm}, K_{sp}, K_{sc}, and K_{sz} are the half-saturation constants for minerals, soluble ortho-phosphate (as P), carbon dioxide, and grazing, respectively. The observed grazing rate, g, is a function of the inherent maximum zooplankton grazing rate (g_{max}), temperature, and the density of algal biomass (X_1) as measured by chlorophyll *a*.

Data was fit to the model using a least squares approach and the best fit estimates for biokinetic parameters are presented in Table 3. Regression between the predicted and actual values, using the parameters listed in Table 3, yields an r^2 of 0.956 (Figure 7), suggesting the model provides and excellent description of phytoplankton growth in the SLD. The best fit estimate for μ_{max} is consistent with maximum values for *r* estimated using the logistic model (Table 2). These estimates of μ_{max} are consistent with previously reported values for diatoms (Bowie et al., 1984; Litchman et al., 2003).

Phytoplankton growth in the drain can be described as a function of phosphate concentration, mineral solids concentration, carbon dioxide solubility, and grazing pressures (Figure 8). When μ was less than μ_{max}, 61% of the time phytoplankton growth rate was limited by nutrient availability and 39% of the time by carbon dioxide availability. Of the times when nutrients were limiting growth rates, minerals were more limiting that phosphate 59% of the time. The K_{sp} of ortho-phosphate is estimated to be 0.012 mg L^{-1} as P, which is within the range of previously reported values (Bowie et al., 1984).

Carbon dioxide limitation of growth rate occurred at pH values as low as 8.1 during periods of rapid growth. The half-saturation constant for inorganic carbon (K_{sc}), expressed as a percent of total inorganic carbon in Table 3, is equivalent to 0.03 to 0.05 mg L^{-1} of C, assuming at least 50% of the alkalinity is due to carbonate buffering. This is a reasonable estimate for K_{sc} and is comparable to previously reported values (Bowie et al., 1984).

The stimulation of diatom growth by suspended mineral solids has not been demonstrated previously, but previous research supports the concept that suspended sediments can serve as reservoirs for both micro- and macronutrients and support algal growth processes. Sediments control the bioavailability nutrients and trace metals in a wide variety of aquatic systems (Cugier et al., 2005; Ellison and Brett, 2006; Garnier et al., 2005; Simpson et al., 2004; Steveninck et al., 1992; Wu and Chou, 2003). It has been frequently observed that sediment concentrations, nutrient concentrations, and phytoplankton growth yield are often correlated (e. g. Jones and Knowlton, 2005). Results from investigations of phytoplankton blooms in the Rhine and Marne Rivers suggest that during periods of rapid algal growth, soluble nutrients become limiting and the rate of algal growth is dependent on dissolution of nutrients from suspended particles in the water column (Garnier et al., 2005; Steveninck et al., 1992). Our analysis shows a positive relation between suspended mineral solids concentration and phytoplankton growth rate, indicating that suspended mineral solids are positive influence on phytoplankton growth in the SLD. This result is a significant departure from current thinking on the issue, since suspended mineral solids typically are expected to inhibit algal growth (via light attenuation), not act as a stimulant to algal growth.

In this system, mineral solids are believed to be functioning as a reservoir for a number of trace minerals required by algae. There is a correlation between mineral solids concentrations and total iron in river sediments collected in this region (r^2 = 0.786) and other trace metals and silica are also associated with sediments in riverine ecosystems (Garnier et al., 2005; Simpson et al., 2004; Steveninck et al., 1992; Wu and Chou, 2003). Suspended mineral solids may be acting as reservoirs for the dissolution of trace nutrients as rapid phytoplankton growth depletes available (soluble) nutrients in the water column. Dissolution limited growth has been observed in bacteria which grown on poorly soluble compounds (Grimberg et al., 1994; Grimberg et al., 1996) and a similar phenomena could explain the dependence of algal growth on suspended mineral particles. The stimulatory effect of sediments on plankton algae, particularly diatoms, also makes sense in that the presence of suspended sediments and associated high turbidity would prevent the growth of benthic plants or algae, benefiting planktonic algal population in the competition for limit ecological resources. The stimulatory effect of sediments on phytoplankton growth is under further investigation.

Biomass yield (carrying capacity) is limited by a combination of phosphate depletion and zooplankton grazing. A density dependent decay component is needed to describe the decline of algae biomass observed at the end of the drain, which typically begins after sixty hours of residence time in the drain (Figure 8). The decline in biomass could not be characterized using a fixed intrinsic decay constant or settling function to describe algal losses (data not shown). The maximum grazing rate estimated by the model is high (Table 3), but the K_{sz} suggested that the process is not particularly efficient, which would suggest that the grazing impact would be from zooplankton rather than benthic bivalves. This is consistent with field observations. The concrete lined channel is inhospitable to benthic organisms, but a fish population is present in the last 16 kilometers of the SLD, suggesting a significant food web is present. Direct measurements of zooplankton were not included in this study, but will be made in future investigations.

Conclusions

The SLD was an ideal system to study factors limiting phytoplankton growth in eutrophic rivers. The hydraulic simplicity of the system allowed the modeling of the system as a plug-flow reactor and excess sunlight allowed phytoplankton to reach their maximum carrying capacity in the study reach, despite very high initial nutrient conditions. The attainment of limited growth conditions in the presence of excess light and nitrogen allowed the direct measurement of other limiting factors in this highly eutrophic system. The use of a mechanistic model provided insight into how statistically correlated factors were influencing phytoplankton biokinetics in a highly eutrophic system. The analysis using the mechanistic model showed that mineral solids were serving as a source of nutrients for the diatom dominated system, that high growth rates occurred in conjunction with high sediment concentrations, and that periods of rapid growth could result in a carbon dioxide limitation. Overall, soluble ortho-phosphate was still was associated with limits to growth yield, but grazing pressures reduced phytoplankton standing crop after maximum yield had been reached. The ability of sediments to stimulate phytoplankton growth has not been previously shown. The applicability of these findings to phytoplankton growth in the San Joaquin River and the role on sediments in the biokinetic stimulation of phytoplankton populations will be further investigated.

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Table 1: Water quality conditions for drainage entering the San Luis Drain during the study period. Data from January, May, June, and July 2003 to 2004 included (n = 6).

Parameter	Mean	Minimum	Maximum
Flow (cfs)	48.4	41.0	55.0
Temp (deg C)	20.9	9.3	26.9
EC (millisemens cm^{-1})	4.842	4.190	6.414
DO (%)	112.8	96.5	152.5
pH	8.06	7.83	8.36
Turbidity (NTU)	77.9	33.4	155.0
Dissolved organic carbon (mg L^{-1})	6.7	5.2	9.4
Total organic carbon (mg L^{-1})	8.1	5.6	11.5
Volatile suspended solids (mg L^{-1})	14.3	3.0	22.0
Total suspended solids (mg L^{-1})	135.1	69.7	199.2
Mineral suspended solids (mg L^{-1})	120.9	59.0	177.2
Nitrate-N (mg L^{-1})	12.9	9.4	16.4
Soluble o-phosphate (mg L^{-1})	0.208	0.061	0.389
Total phosphorous (mg L^{-1})	0.679	0.390	0.942
Chlorophyll-a (µg L^{-1})	32.4	4.2	49.0
Pheophytin (µg L^{-1})	9.5	3.1	11.4
Chlorophyll-b (µg L^{-1})	1.8	1.2	2.8
Xanthophyll (µg L^{-1})	1.2	0.6	1.8

Table 2. Best fit parameters for the logistic model (eq. 1) to observed algal growth patterns in the SLD.

Date	**Day of year**	**N_0** **μg Chl-a L^{-1}**	**K** **μg Chl-a L^{-1}**	**r** **hr^{-1}**	**r^2**
01/13/05	13	6.71	10.50	0.023	0.971
05/13/04	134	19.02	203.00	0.023	0.936
06/17/03	168	19.90	123.90	0.219	0.745
07/13/04	195	36.60	162.10	0.049	0.922
06/30/03	181	45.70	177.20	0.055	0.942
07/29/03	210	16.60	142.00	0.062	0.931

Table 2. Best fit estimates for parameters included in the mechanistic model for algal growth in the San Luis Drain. See text for explanation. Data from January, May, June, and July 2003 to 2004 included.

Parameter	**Best fit estimate**	**Units**
μ_{max}	0.061	hr^{-1}
g_{max}	-0.053	hr^{-1}
K_{sm}	19.3	mg Mineral solids L^{-1}
K_{sp}	0.009	mg PO_4-P L^{-1}
K_{sc}	0.25	% H_2CO_3
K_{sz}	100	µg Chlorophyll-a L^{-1}

Figure 1: Map of study area located in the San Joaquin Valley of California. The San Luis Drain is a concrete lined channel that conveys agricultural drainage from farms in the south, past sensitive wetland areas, and discharges into the San Joaquin River via Mud Slough. Measurements were made at the inlet and outlet and the 18 check structures along the length of the channel.

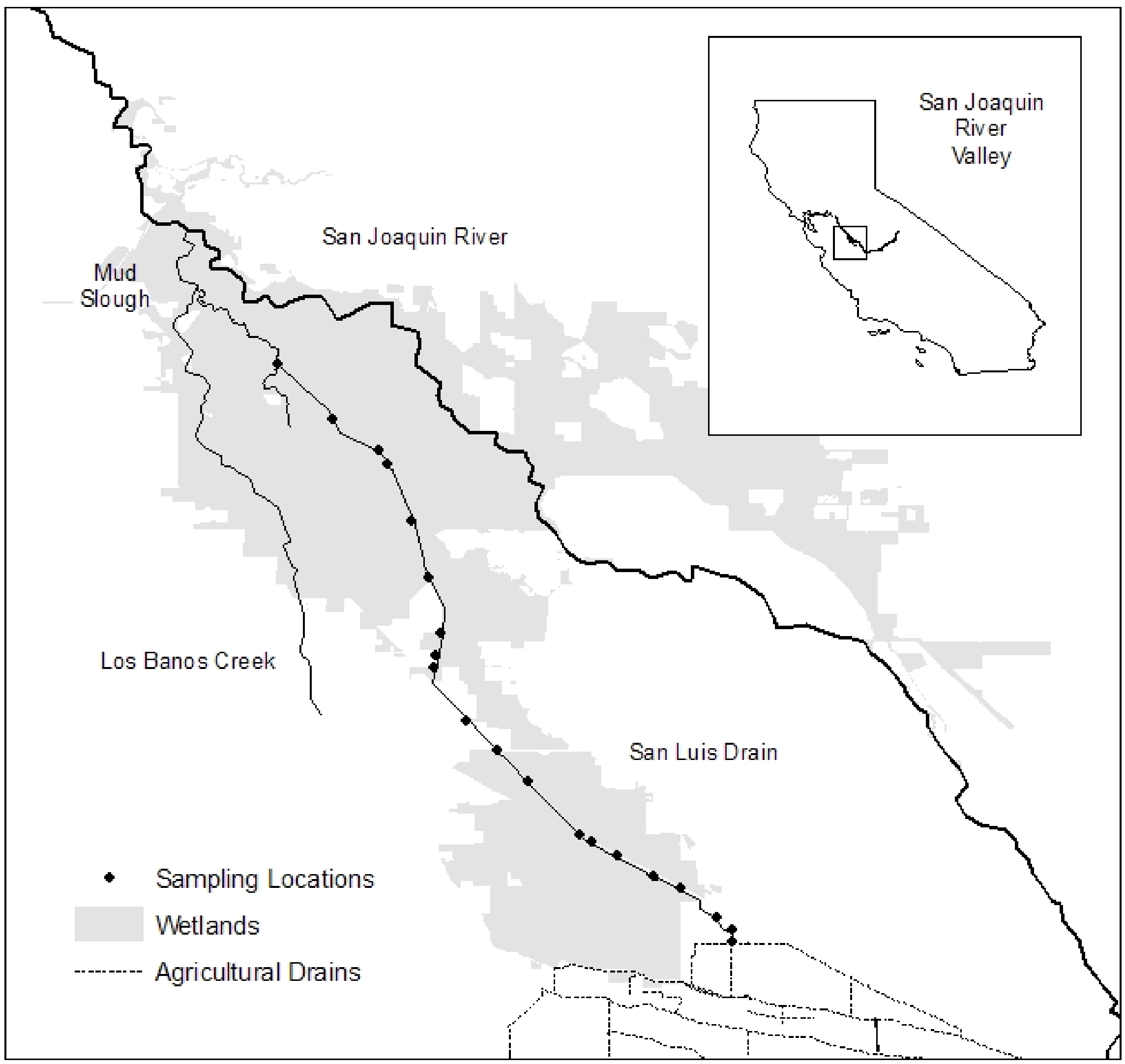


Figure 2: Community structure of biomass in the San Luis Drain as determined by phospholipid fatty acid analysis. The system is dominated by diatoms and exhibits a stable community structure. Data from 2005 shown.

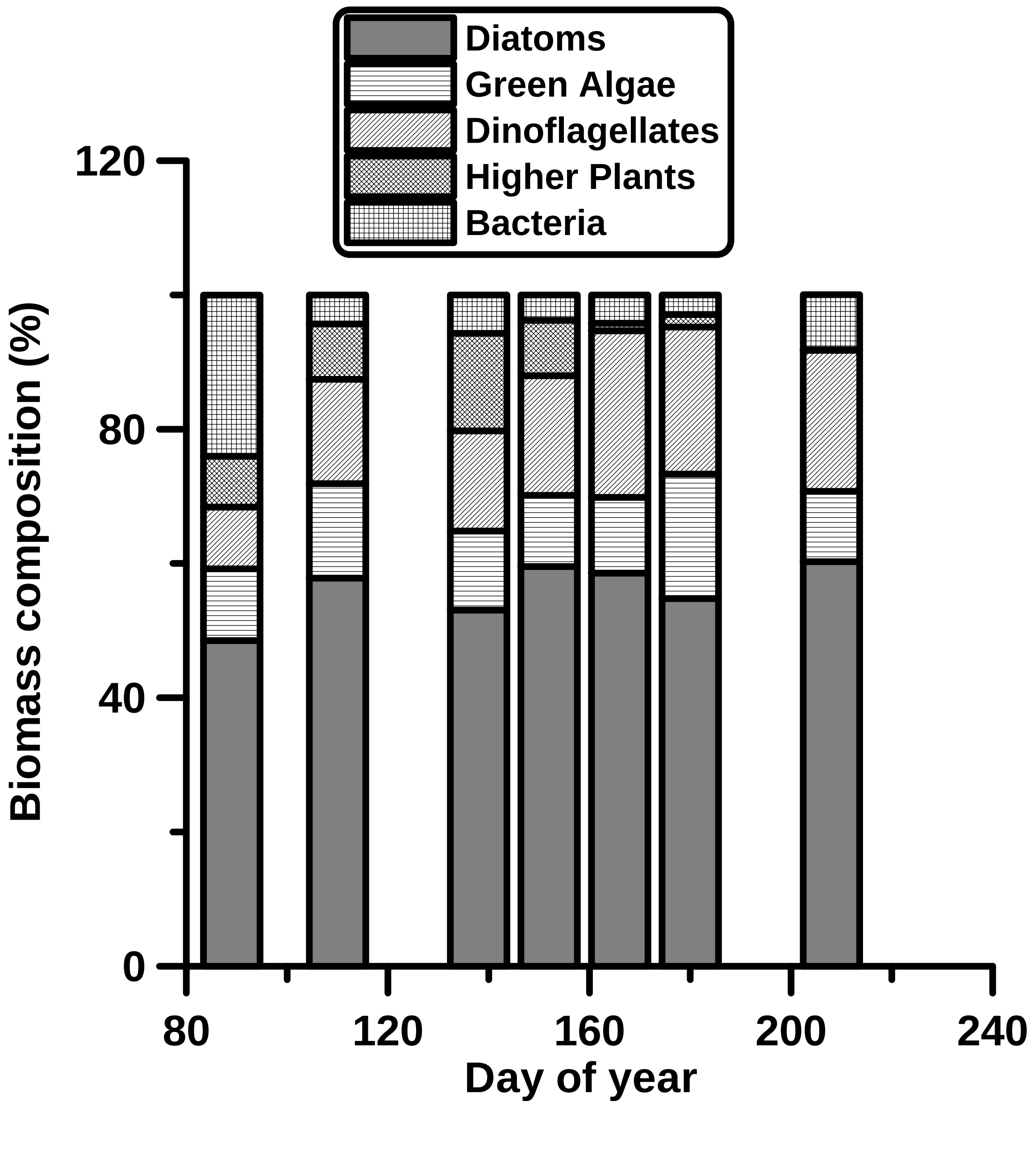


Figure 3: Phytoplankton concentration as a function of hydraulic residence time during June and July for the San Luis Drain. Mean and standard deviation for five surveys conducted between 2003 and 2005 with mean data fit using the logistic equation (eq 1).

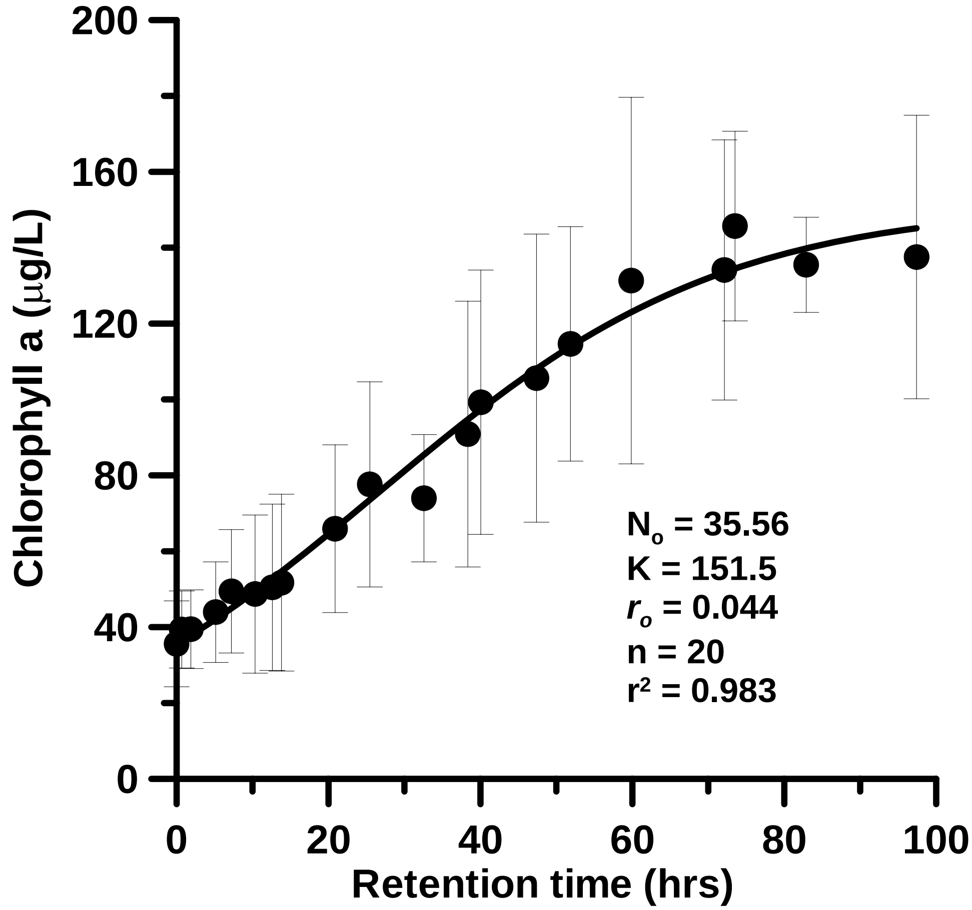


Figure 4: Sediment concentration as a function of hydraulic residence time during June and July for the San Luis Drain. Mean and standard deviation for four surveys conducted in 2003 and 2004.

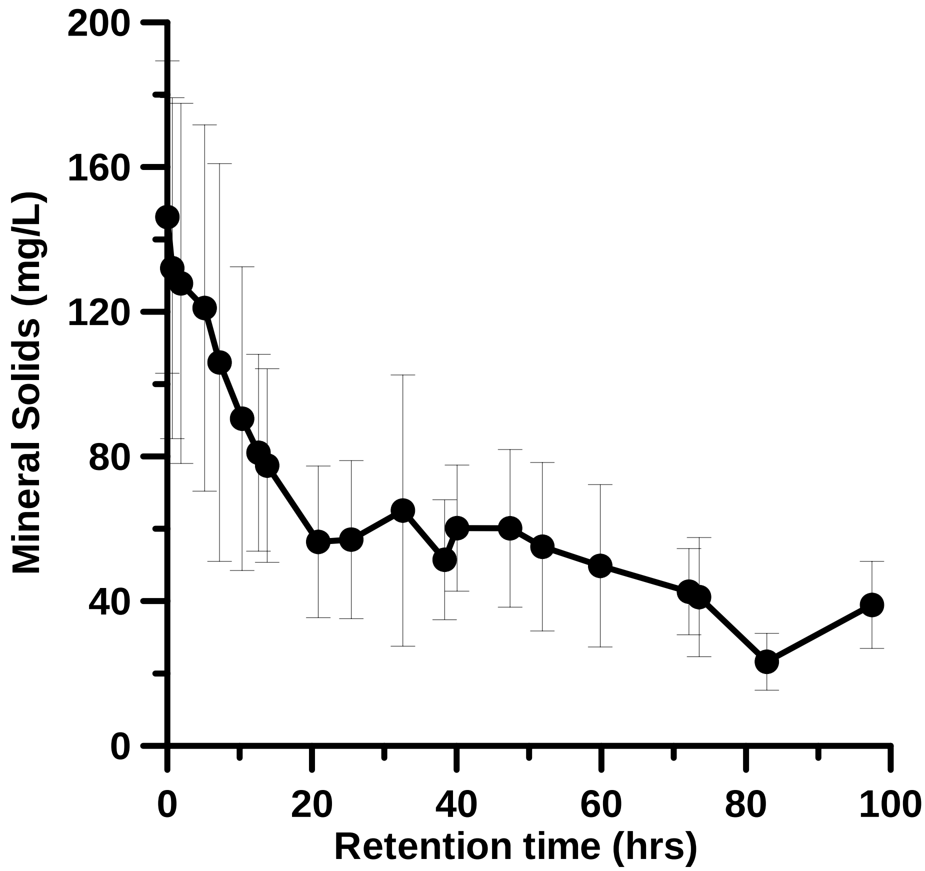


Figure 5: Phosphate concentration as a function of hydraulic residence time during June and July for the San Luis Drain. Mean and standard deviation for four surveys conducted in 2003 and 2004.

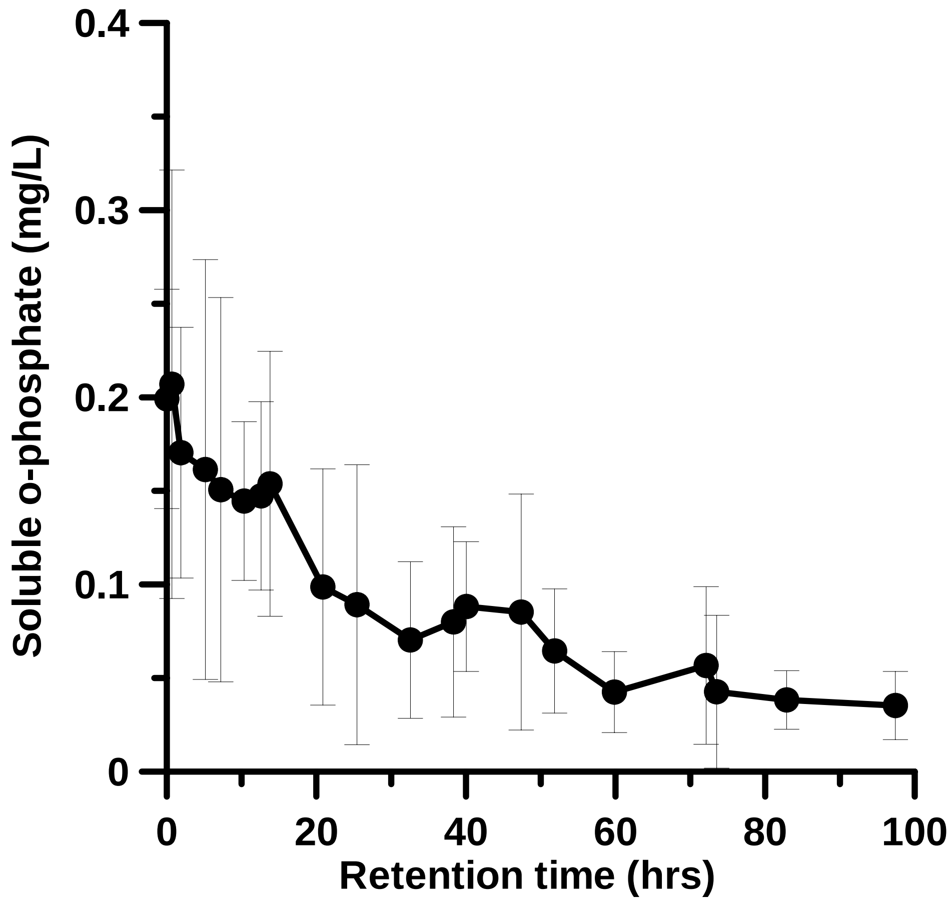


Figure 6: Depth of photic zone and observed phytoplankton growth rate as a function of hydraulic residence time during June and July for the San Luis Drain. Mean and standard deviation for four surveys conducted in 2003 and 2004. Linear least squares fit to all data, mean of all data shown.

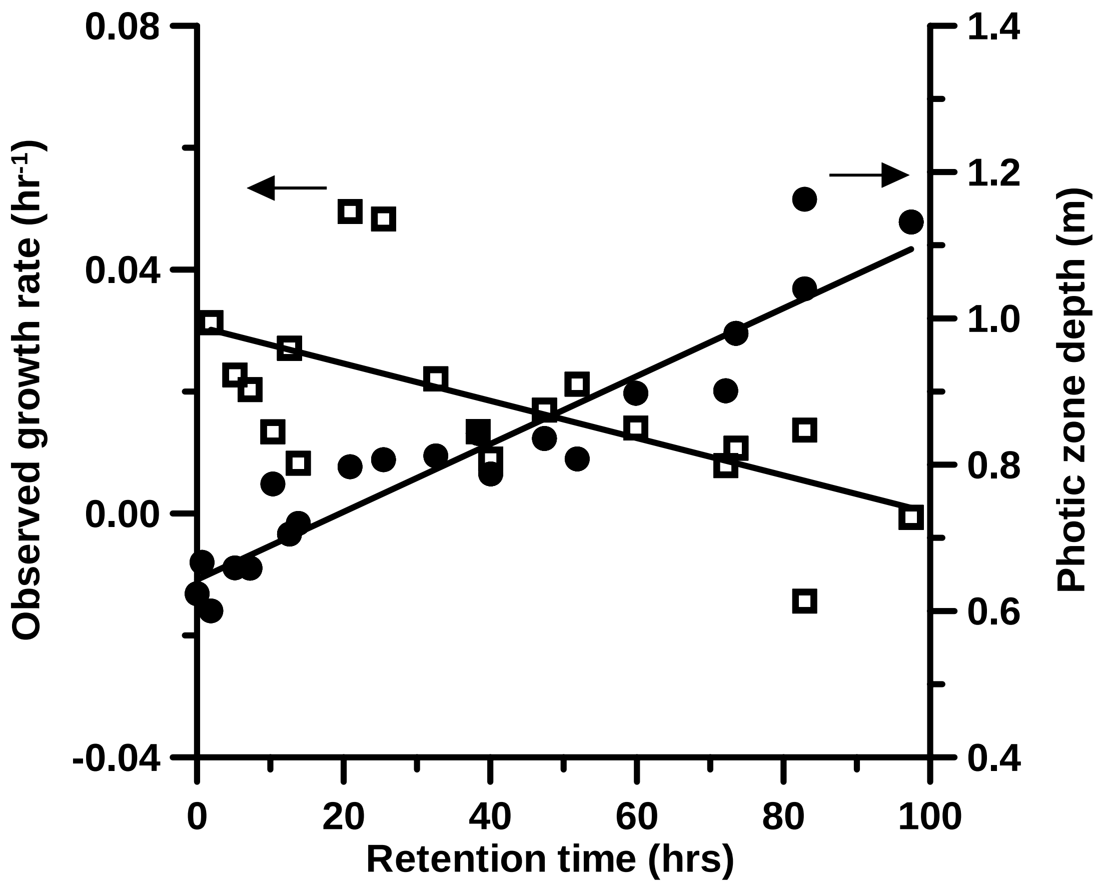


Figure 7: Mechanistic model fit to data using parameters in Table 3. Data for June and July 2003 and 2004.

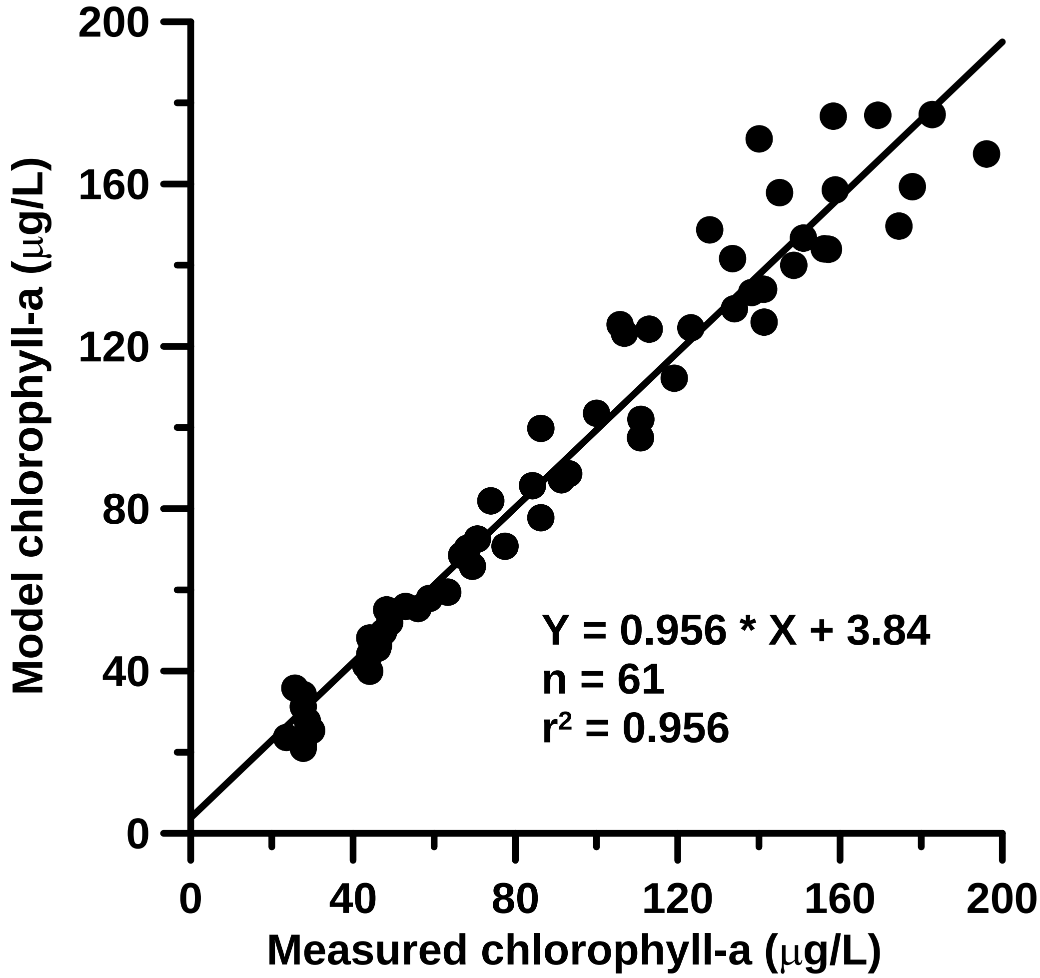
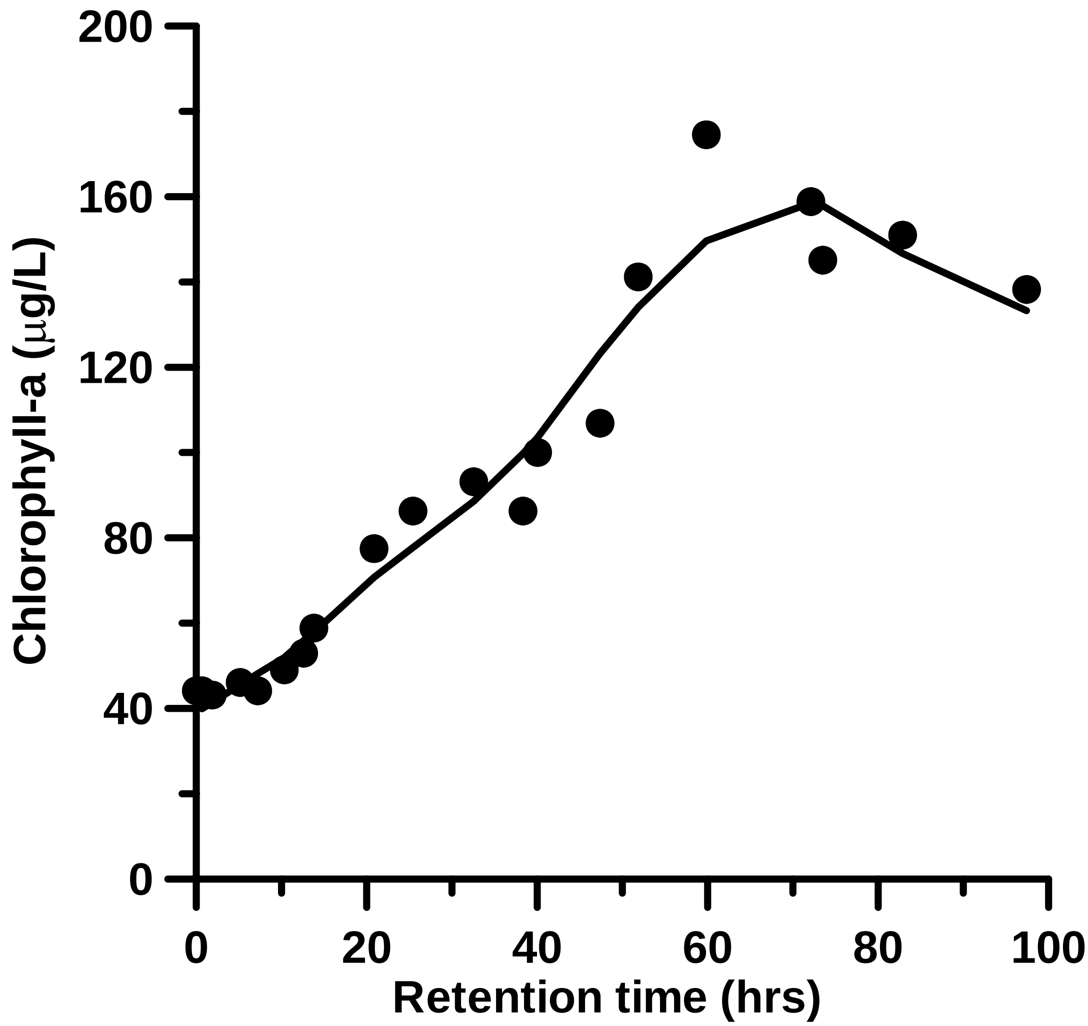


Figure 8: Model fit to data from July 13, 2004, showing decline in phytoplankton chlorophyll a at extended residence times attributed to zooplankton grazing by mechanistic model.



Chapter 8

CONTINUOUS MONITORING OF CHLOROPHYLL-*A* IN THE SAN JOAQUIN RIVER

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Introduction:

The San Joaquin river (SJR) and many of it's tributaries are continuously monitored for flow, electrical conductivity and temperature at several stations throughout the watershed. However, measurement of dissolved oxygen and algae biomass, important components influencing to downstream dissolved oxygen demand, have not been measured on a continuous basis in the past. As part of the DO TMDL project, dissolved oxygen and chlorophyll were measured continuously at key locations in the SJR watershed in 2006. Data from this experiment has not yet been fully evaluated and this Chapter serves to document the continuous monitoring effort for 2006.

Methods:

YSI (Yellow Springs OH) Data Sonde 6600EDS multi-parameter data logging instruments were calibrated at the lab and deployed at specific DO grab sample sites for 2 week intervals and programmed to measure and collect data every 15 minutes. Deployment of the continuous monitoring Sonde equipment coincided with the collection of water quality grab samples for later comparison to the recorded Sonde data.

Following the procedures in the YSI 6-Series Environmental Monitoring Systems Handbook, the Sondes were calibrated the day before being placed in the field. Dissolved oxygen was calibrated using the wet-towel method where the sonde is placed in a tube with a wet-towel around the sensors and calibrated in a water-saturated air environment. The sensor cleaning wiper was fitted with a longer extended deployment brush to better keep the sensors free of algae and debris. Sondes were programmed to run unattended for the length of deployment recording each parameter every 15 minutes. The parameters measured by the Sonde at each site include time, temperature (°C), electrical conductivity (mS/cm), total dissolved solids (g/L), dissolved oxygen (DO) percent, DO concentration (mg/L), DO charge, depth (ft), pH, oxidation-reduction potential (mV), turbidity (NTU), chlorophyll content (ug/L), fluorescence, and barometric pressure (mmHg). At the time of deployment Sondes were put into black PVC housings (figure 1) protecting the equipment from damage while at the site. Sondes were attached with a cable and padlock to an anchor, such as a metal post or bridge pylon(figure 2). Once deployed, Sondes were left unattended for periods of approximately two weeks. Upon conclusion of the deployment Sondes were retrieved and placed into ice chests with a small amount of water to keep the membranes moist until post-calibration could be performed. Post-calibration consisting of checking the sonde value to that of a standard value was completed within twenty-four hours of retrieval. After being post-calibrated sondes were cleaned up with water and mild soap, the DO membranes and batteries were changed, and the extended deploy wipers were cleaned and replaced.

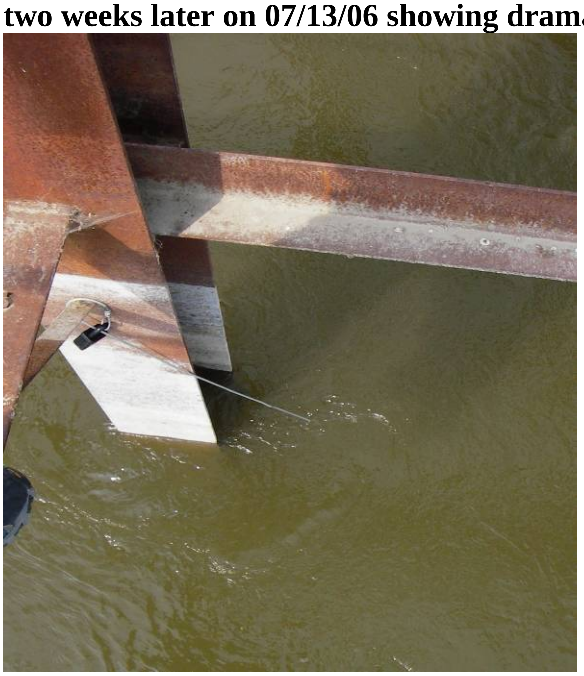
As a redundant check of the deployed Sonde, a second YSI 6600 multi-parameter Sonde connected to a YSI 650 MDS data display was placed in the water next to the deployed Sonde. The non-extended deployment sonde was set out in the sample water and programmed to log a reading for every parameter every four seconds for at least two minutes, providing a statistically significant sample size ($n > 30$). While the second Sonde logged water quality data, water quality grab samples were collected and incident sunlight and water-velocity were measured to document current field conditions. Water samples were collected in three different types of bottles [glass 1 liter bottles (Wheaton Science Products, Millville, NJ), 1 liter Trace-Clean plastic bottles (VWR International, West Chester, PA), and 250 mL Trace-Clean plastic bottles (VWR International)] in accordance with requirements for different lab analysis. Samples were depth integrated and stored at 4°C after sampling. Light measurements were taken using a handheld LUX meter (VWR International). Velocity measurements were taken with a model 2000 flow-meter (Marsh-McBirney, Frederick, MD).

Results:

Result from the continuous monitoring for DO, pH, turbidity, and chlorophyll conducted as part of Task 4 in 2006 are presented in Appendixes E and H. Appendix E contains plots and summary tables of all data. Appendix H contains an electronic deliverable of the data. Tables 1 to 15 below report the calibration results for each sonde and each deployment. Figures 1 to 5 present photo-documentation of the deployments. Analysis of the 2006 data will be conducted in 2007.

Fig.1 Waterquality Sonde with custom protective housing.

Fig.2 (Left) Sonde hanging at DO-07, San Joaquin River at Patterson pump platform for deployment on 06/27/06. Fig.3 (Right) Sonde hanging at DO-07 before retrieval two weeks later on 07/13/06 showing dramatic drop in river stage during this period.



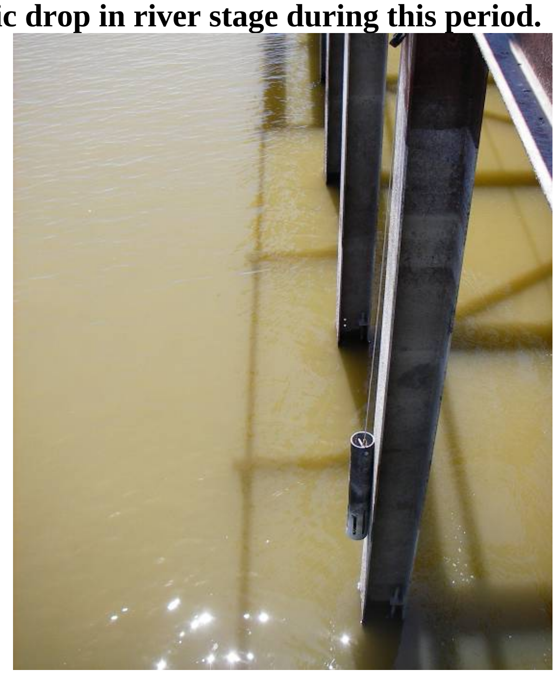


Fig.3 Sonde being deployed at DO-19 Salt Slough at Lander Ave. on 06/27/06

Fig.4 Sonde deployed at DO-44 San Luis Drain End on 06/27/06.

Fig. 5 Sonde at end of 2 week deployment showing effectiveness of wipers

Table 1: Calibration results for DO-05 SJR at Vernalis

June 27, 2006 to July 13, 2006

Notebook Reference: F10P12-15 F8P112-119 F9P21-29

The instrument was deployed in the existing 4"PVC pipe stilling wells already in place on the monitoring platform. The SONDE was attached to the platform using a 5/8 braided nylon rope and submerged to about 7-8 feet below the water surface. Upon retrieval of the SONDE, the instrument was found exactly where it was left, with the instrument still submerged, though barely.

Calibration	Sonde S/N:	06E2316AA YSI#3				
Pre-deployment					Post-deployment	
	Calibration value	Pre-Calibration	Post-Calibration	pass/fail (+/-20%)	Calibration check	pass/fail (+/-20%)
Depth (ft)	0	0.051	-0.001	Pass	0.084	Pass
Pressure (mmHg)		759.3	759.3	-	761.1	-
DO %	100		99.9	Pass	101.9	Pass
DO (mg/L)	8.445		8.45	Pass		
DO (mg/L)	8.759				8.94	Pass
DO Charge	25-75				45.1	Pass
Temp (degC)	Ambient		23.77	-	21.86	-
EC	1.408	1.397	1.408	Pass	1.382	Pass
pH	4	4	4	Pass	4.17	Pass
	7	7	7	Pass	7.03	Pass
	10	9.98	10	Pass	10.05	Pass
ORP	231	216.9	231	Pass	232.4	Pass
Turbidity (NTU)	0	0.3	0	Pass	1.9	Fail
	40	40.7	40	Pass	35.5	Pass
	200	185	200	Pass		
	180				172.6	Pass
Chla	≤0		-1.9	Pass	-2.2	Pass
Flr	≤0		-0.4	Pass	-0.5	Pass

Table 2: Calibration results for DO-05 SJR at Vernalis

July 13, 2006 to July 25, 2006

Notebook Reference: F10P12-15, 26-31 F9P17-29

The instrument was deployed in the existing 4"PVC pipe stilling wells already in place on the monitoring platform. The SONDE was attached to the platform using a 5/8 braided nylon rope and submerged to about 3-4 feet below the water surface. Upon retrieval of the SONDE, the instrument was found exactly where it was left, with the instrument still submerged. Removed values that were below 25 for DO charge.

Calibration	Sonde S/N:	05J2250 AC (YSI#9)				
Pre-deployment					Post-deployment	
	Calibration value	Pre-Calibration	Post-Calibration	pass/fail (+/- 20%)	Calibration check	pass/fail (+/- 20%)
Depth (ft)	0	0.059	0	Pass	-0.384	Fail
Pressure (mmHg)		763.1	763.1	-	753.7	-
DO %	100		100.4	Pass	58.5	Fail
DO (mg/L)	8.482		8.53	Pass		
DO (mg/L)	8.578				5.03	Fail
DO Charge	25-75				22.6	Fail
Temp (degC)	Ambient		23.54	-	22.95	-
EC	1.408	1.373	1.408	Pass	1.401	Pass
pH	4	4.09	4	Pass	4.09	Pass
	7	7.04	7	Pass	7.02	Pass
	10	10.01	10	Pass	9.98	Pass
ORP	234	No ORP sensor				
Turbidity (NTU)	0	0.9	0	Pass	-2.3	Fail
	40	39.6	40.1	Pass	40.5	Pass
	180	178.6	180	Pass		
	165				167.3	Pass
Chla	≤0	-0.1	-0.3	Pass	-1.7	Pass
Flr	≤0	0	-0.2	Pass	-0.3	Pass

Table 3: Calibration results for DO-05 SJR at Vernalis

Sep 12, 2006 to Sep 26, 2006

Notebook Reference: F9P ,90-97

The instrument was deployed in one of our custom 4"PVC pipe housings and attached to the platform using a 5/8 braided nylon rope and submerged to about 3-4 feet below the water surface. Upon retrieval of the SONDE, the instrument was found exactly where it was left, with the instrument still submerged. Removed values that were below 25 for DO charge.

Calibration	Sonde S/N:	06E2065 AB YSI#5				
Pre-deployment					Post-deployment	
	Calibration value	Pre-Calibration	Post-Calibration	pass/fail (+/-20%)	Calibration check	pass/fail (+/-20%)
Depth (ft)	0	0.151	0	Pass	0.021	Pass
Pressure (mmHg)		761.7	761.7	-	762.2	-
DO %	100		100.2	Pass	79.6	Fail
DO (mg/L)	8.737		8.77	Pass		
DO (mg/L)	8.692				6.96	Pass
DO Charge	25-75		31.8	Pass	23.7	Fail
Temp (degC)	Ambient		21.99	-	22.26	-
EC	1.408	1.385	1.408	Pass	1.395	Pass
pH	4	4.14	4	Pass	3.97	Pass
	7	6.93	7	Pass	6.95	Pass
	10	10.11	10.02	Pass	10	Pass
ORP	233.6	232.4	233.6	Pass	237.3	Pass
Turbidity (NTU)	0	0.4	0	Pass	-0.1	Pass
	40	37.7	39.9	Pass	42.5	Pass
	200	198.2	199.9	Pass	206.6	Pass
Chla	≤0	-1.7	-1.7	Pass	-2.7	Pass
Flr	≤0	-0.4	-0.3	Pass	-0.6	Pass

Table 4: Calibration results for DO-07 SJR at Patterson

June 27, 2006 to July 13, 2006

Notebook Reference: F10P12-15 F8P112-119 F9P21-29

The instrument was deployed in one of our custom 4"PVC pipe housings for added protection. The SONDE plus housing was attached with a ¼" vinyl coated cable and padlocked to the platform of the pumping station. Upon retrieval of the SONDE, the instrument was found exactly where it was left, but out of the water due to the significant drop in river level SONDE was out of the water for approx. 6 days. *wiper parked over sensor Chla and Flr reading high, removed high values/outliers.

Calibration	Sonde S/N:	06E2064 AA				
Pre-deployment					Post-deployment	
	Calibration value	Pre-Calibration	Post-Calibration	pass/fail (+/-20%)	Calibration check	pass/fail (+/-20%)
Depth (ft)	0	-0.208	0.001	Pass	0.102	Pass
Pressure (mmHg)		759	759.1	-	761.1	-
DO %	100		99.9	Pass	109.4	Pass
DO (mg/L)	8.447		8.45	Pass		
DO (mg/L)	8.662				9.44	Pass
DO Charge	25-75				34.9	Pass
Temp (degC)	Ambient		23.76	-	22.44	-
EC	1.408	1.425	1.408	Pass	1.388	Pass
pH	4	4.06	4	Pass	3.99	Pass
	7	7.03	7	Pass	6.95	Pass
	10	9.99	10	Pass	9.96	Pass
ORP	231	213.5	231	Pass	232.4	Pass
Turbidity (NTU)	0	-0.3	0	Pass	-0.3	Fail
	40	40.7	40	Pass	33.3	Pass
	200	191.4	200	Pass		
	180				160.4	Pass
Chla	≤0		-2.1	Pass	310.1	Fail
Flr	≤0		-0.5	Pass	73.8	Fail

Table 5: Calibration results for DO-07 SJR at Patterson

July 13, 2006 to July 25, 2006

Notebook Reference: F10P12-15, 26-31 F9P17-29

The instrument was deployed in one of our custom 4”PVC pipe housings for added protection. The SONDE plus housing was attached with a ¼” vinyl coated cable and padlocked to the ladder on the far end of the pumping station. Upon retrieval of the SONDE, the instrument was found exactly where it was left. All red flagged values for Turbidity on DO-19, DO-7 cannot be discounted as true values. However, they are most likely not valid (high COV, unrealistic compared to other sites upstream/downstream, higher than corresponding independent QC value). Removed values that were below 25 for DO charge.

Calibration	Sonde S/N:	06E2064 AC (YSI #10)				
Pre-deployment					Post-deployment	
	Calibration value	Pre-Calibration	Post-Calibration	pass/fail (+/-20%)	Calibration check	pass/fail (+/-20%)
Depth (ft)	0	1.169	0	Pass	-0.238	Fail
Pressure (mmHg)		762.1	762.1	-	756.6	-
DO %	100		100.3	Pass	56.9	Fail
DO (mg/L)	8.532		8.57	Pass		
DO (mg/L)	8.883				5.07	Fail
DO Charge	25-75		39	Pass	16.5	Fail
Temp (degC)	Ambient		23.23	-	21.14	-
EC	1.408	1.392	1.408	Pass	1.437	Pass
pH	4	4.09	4	Pass	3.98	Pass
	7	6.96	7	Pass	7.01	Pass
	10	9.98	10	Pass	10.07	Pass
ORP	234	213.7	234	Pass	232.9	Pass
Turbidity (NTU)	0	0.8	0	Pass	-1.9	Fail
	40	35.9	40	Pass	41	Pass
	180	176.2	180	Pass		
	165				172.1	Pass
Chla	≤0	0.2	0.2	Pass	-0.4	Pass
Flr	≤0	0.1	0.1	Pass	0	Pass

Table 6: Calibration results for DO-07 SJR at Patterson

Sep 12, 2006 to Sep 26, 2006

Notebook Reference: F9P ,90-97

The instrument was deployed in a black PVC housing. The SONDE was attached to the underside of the pump platform near the northeast corner and secured with a cable and padlock. It was submerged to about 2-3 feet below the water surface. Upon retrieval, the SONDE was found where it was left and still submerged.

Calibration	Sonde S/N:	06E2064 AA YSI#7				
Pre-deployment					Post-deployment	
	Calibration value	Pre-Calibration	Post-Calibration	pass/fail (+/-20%)	Calibration check	pass/fail (+/-20%)
Depth (ft)	0	0.136	0	Pass	0.013	Pass
Pressure (mmHg)		762.1	762.1	-	762.4	-
DO %	100		100.3	Pass	102.2	Pass
DO (mg/L)	8.787		8.82	Pass		
DO (mg/L)	8.714				8.92	Pass
DO Charge	25-75		54.3	Pass	40	Pass
Temp (degC)	Ambient		21.7	-	22.13	-
EC	1.408	1.389	1.408	Pass	1.401	Pass
pH	4	4.2	4.02	Pass	3.84	Pass
	7	6.82	7	Pass	6.9	Pass
	10	10.18	10.03	Pass	10.03	Pass
ORP	233.6	236.1	233.6	Pass	233.8	Pass
Turbidity (NTU)	0	0.3	0	Pass	-0.1	Pass
	40	44	39.9	Pass	41.9	Pass
	200	199.2	200	Pass	210.4	Pass
Chla	≤0	-1.5	-1.7	Pass	-3	Pass
Flr	≤0	-0.3	-0.3	Pass	-0.7	Pass

Table 7: Calibration results for DO-08 SJR at Crows Landing (Turlock Sportsman Club)

June 27, 2006 to July 13, 2006

Notebook Reference: F10P12-15 F8P112-119 F9P21-29

The instrument was deployed in one of our custom 4"PVC pipe housings for added protection. The SONDE plus housing was attached with a ¼" vinyl coated cable and padlocked to the dock at the Turlock Sportsman Club. Upon retrieval of the SONDE, the instrument was found exactly where it was left, with the instrument still submerged.

Calibration	Sonde S/N:	06E2065 AA				
Pre-deployment					Post-deployment	
	Calibration value	Pre-Calibration	Post-Calibration	pass/fail (+/-20%)	Calibration check	pass/fail (+/-20%)
Depth (ft)	0	0.044	0	Pass	0.079	Pass
Pressure (mmHg)		759.1	759.1	-	760.6	-
DO %	100		99.9	Pass	103.9	Pass
DO (mg/L)	8.349		8.35	Pass		
DO (mg/L)	8.452				8.78	Pass
DO Charge	25-75				38	Pass
Temp (degC)	Ambient		24.38	-	23.73	-
EC	1.408	1.406	1.408	Pass	1.359	Pass
pH	4	4	4	Pass	4.07	Pass
	7	7	7	Pass	7.02	Pass
	10	9.99	10	Pass	10.04	Pass
ORP	231	217.5	231	Pass	230.5	Pass
Turbidity (NTU)	0	0	0	Pass	0.2	Pass
	40	40.2	40.1	Pass	34.8	Pass
	200	185.1	200.2	Pass		
	180				166.5	Pass
Chla	≤0		-1.8	Pass	-1.1	Pass
Flr	≤0		-0.4	Pass	-0.3	Pass

Table 8: Calibration results for DO-08 SJR at Crows Landing (Turlock Sportsman Club)

July 13, 2006 to July 25, 2006

Notebook Reference: F10P12-15, 26-31 F9P17-29

The instrument was deployed in one of our custom 4"PVC pipe housings for added protection. The SONDE plus housing was attached with a ¼" vinyl coated cable and padlocked to the dock at the Turlock Sportsman Club. Upon retrieval of the SONDE, the instrument was found exactly where it was left, with the instrument still submerged.

Calibration	Sonde S/N:	05J2250 AB (YSI #8)				
Pre-deployment					Post-deployment	
	Calibration value	Pre-Calibration	Post-Calibration	pass/fail (+/-20%)	Calibration check	pass/fail (+/-20%)
Depth (ft)	0	0.027	0	Pass	-0.255	Fail
Pressure (mmHg)		762.7	762.7	-	756.5	-
DO %	100		99.9	Pass	102.6	Pass
DO (mg/L)	8.530		8.45	Pass		
DO (mg/L)	8.624				8.88	Pass
DO Charge	25-75				26.7	Pass
Temp (degC)	Ambient		23.24	-	22.67	-
EC	1.408	1.384	1.408	Pass	1.404	Pass
pH	4	4.12	4	Pass	4.02	Pass
	7	7.02	7	Pass	7.07	Pass
	10	9.99	10	Pass	10.09	Pass
ORP	234	288.3	237.2	Pass	No ORP sensor	
Turbidity (NTU)	0	-0.9	0	Pass	-0.1	Pass
	40	41.2	40	Pass	41.2	Pass
	180	184	180	Pass		
	165				163.2	Pass
Chla	≤0	0.3	0.4	Fail	0.5	Fail
Flr	≤0	0.1	0.2	Pass	0.1	Pass

Table 9: Calibration results for DO-08 SJR at Crows Landing (Turlock Sportsman Club)

Sep 12, 2006 to Sep 26, 2006

Notebook Reference: F9P ,90-97

The instrument was deployed in one of our custom 4"PVC pipe housings. The SONDE plus housing was attached with a ¼" vinyl coated cable and padlocked to the dock at the Turlock Sportsman Club. Upon retrieval, the SONDE was found exactly where it was left and still submerged.

Calibration	Sonde S/N:	06E2064 AC YSI#10				
Pre-deployment					Post-deployment	
	Calibration value	Pre-Calibration	Post-Calibration	pass/fail (+/-20%)	Calibration check	pass/fail (+/-20%)
Depth (ft)	0	0.143	0	Pass	0.033	Pass
Pressure (mmHg)		761.9	761.9	-	762.7	-
DO %	100		100.3	Pass	103.1	Pass
DO (mg/L)	8.787		8.82	Pass		
DO (mg/L)	8.630				8.91	Pass
DO Charge	25-75		35.9	Pass	35.9	Pass
Temp (degC)	Ambient		21.7	-	22.63	-
EC	1.408	1.391	1.408	Pass	1.381	Pass
pH	4	4.17	4	Pass	3.95	Pass
	7	6.93	7	Pass	6.99	Pass
	10	10.06	10.01	Pass	10.03	Pass
ORP	233.6	232	233.6	Pass	233.9	Pass
Turbidity (NTU)	0	0	0	Pass	0.1	Pass
	40	39.5	40	Pass	42.5	Pass
	200	199	200	Pass	211.4	Pass
Chla	≤0	0.4	0.1	Pass	0	Pass
Flr	≤0	0	0	Pass	0.2	Pass

Table 10: Calibration results for DO-19 Salt slough at Lander Ave.

June 27, 2006 to July 13, 2006

Notebook Reference: F10P12-15 F8P112-119 F9P21-29

The instrument was deployed in one of our custom 4"PVC pipe housings for added protection. The SONDE plus housing was attached with a ¼" vinyl coated cable and padlocked at arms length under the water surface to stakes which had previously been secured into the stream bed to support the existing USGS monitoring station sensor. Upon etrieval of the SONDE, the instrument was found exactly where it was left, but only the bottom ½ of the instrument was still in the water because stream levels had receded more than 3 feet. Fortunately the sensors were still submerged and able to take readings. All red flagged values for Turbidity on DO-19, DO-7 cannot be discounted as true values. However, they are most likely not valid (high COV, unrealistic compared to other sites upstream/downstream, higher than corresponding independent QC value).

Calibration	Sonde S/N:	06E2064 AB				
Pre-deployment					Post-deployment	
	Calibration value	Pre-Calibration	Post-Calibration	pass/fail (+/-20%)	Calibration check	pass/fail (+/-20%)
Depth (ft)	0	0.056	0	Pass	0.03	Pass
Pressure (mmHg)		759.2	759.2	-	760	-
DO %	100		99.9	Pass	109.2	Pass
DO (mg/L)	8.492		8.49	Pass		
DO (mg/L)	8.527				9.32	Pass
DO Charge	25-75				33.9	Pass
Temp (degC)	Ambient		23.48	-	23.26	-
EC	1.408	1.421	1.408	Pass	1.359	Pass
pH	4	4.04	4	Pass	4.14	Pass
	7	7.01	7	Pass	7.02	Pass
	10	9.98	10	Pass	10.01	Pass
ORP	231	214.9	231	Pass	230.2	Pass
Turbidity (NTU)	0	-0.2	0	Pass	0.9	Fail
	40	40.2	40	Pass	37.8	Pass
	200	185.4	200.1	Pass		
	180				156.4	Pass
Chla	≤0		-1.3	Pass	-1.2	Pass
Flr	≤0		-0.4	Pass	-0.3	Pass

Table 11: Calibration results for DO-19 Salt Slough at Lander Ave.

Sept. 12, 2006 to Sept. 26, 2006

Notebook Reference: F9P ,90-97

The instrument was deployed in one of our custom 4"PVC pipe housings and attached with a ¼" vinyl coated cable and padlocked at arms length under the water surface to stakes which had previously been secured into the stream bed to support the existing USGS monitoring station sensor. Upon retrieval, the SONDE was found where it was left and still submerged

Calibration	Sonde S/N:	05K1979 AB YSI#11				
Pre-deployment					Post-deployment	
	Calibration value	Pre-Calibration	Post-Calibration	pass/fail (+/-20%)	Calibration check	pass/fail (+/-20%)
Depth (ft)	0	0.004	0	Pass	0.067	Pass
Pressure (mmHg)		762.1	762.1	-	762.3	-
DO %	100		100.3	Pass	93.6	Pass
DO (mg/L)	8.817		8.85	Pass		
DO (mg/L)	8.776				8.25	Pass
DO Charge	25-75		49.2	Pass	38	Pass
Temp (degC)	Ambient		21.52	-	21.76	-
EC	1.408	1.391	1.413	Pass	1.404	Pass
pH	4	4.16	4	Pass	4.02	Pass
	7	6.96	7	Pass	7	Pass
	10	10.04	10	Pass	10.03	Pass
ORP	233.6	251.7	232.7	Pass	290	Fail
Turbidity (NTU)	0	-0.2	0.2	Pass	0.1	Pass
	40	45.4	40.1	Pass	41.8	Pass
	200	198.3	199.9	Pass	206.7	Pass
Chla	≤0	-1.7	-2.1	Pass	-1.3	Pass
Flr	≤0	-0.5	-0.5	Pass	-0.3	Pass

Table 12: Calibration results for DO-20 Los Banos Creek

Sept. 12, 2006 to Sept. 26, 2006

Notebook Reference: F9P ,90-97

The instrument was deployed in one of our custom 4"PVC pipe housings and attached with a ¼" vinyl coated cable and padlocked to the bridge across the stream. Upon retrieval, the SONDE was found where it was left with sensor end just submerged. Flow is calculated from old rating curve because new one hasn't been established since the bubbler was re-installed new rating curve will likely change flow values so this is preliminary data. Removed values that were below 25 for DO Charge. No ORP sensor.

Calibration	Sonde S/N:	05J2250 AC YSI#9				
Pre-deployment					Post-deployment	
	Calibration value	Pre-Calibration	Post-Calibration	pass/fail (+/-20%)	Calibration check	pass/fail (+/-20%)
Depth (ft)	0	0.277	0	Pass	0.005	Pass
Pressure (mmHg)		762.2	762.2	-	762.5	-
DO %	100		100.3	Pass	25	Fail
DO (mg/L)	8.763		8.8	Pass		
DO (mg/L)	8.635				2.17	Fail
DO Charge	25-75		53.3	Pass	7.3	Fail
Temp (degC)	Ambient		21.84	-	22.6	-
EC	1.408	1.38	1.409	Pass	1.409	Pass
pH	4	4.13	4	Pass	3.95	Pass
	7	6.86	7	Pass	6.97	Pass
	10	10.14	10.02	Pass	10.04	Pass
ORP	233.6	385	233.6	Pass	295.3	Fail
Turbidity (NTU)	0	0.4	0	Pass	-0.2	Pass
	40	38.9	40	Pass	40.7	Pass
	200	195.7	200	Pass	205.3	Pass
Chla	≤0	-0.6	-0.3	Pass	-0.2	Pass
Flr	≤0	-0.2	-0.1	Pass	-0.1	Pass

Table 13: Calibration results for DO-44 San Luis Drain End

June 27, 2006 to July 13, 2006

Notebook Reference: F10P12-15 F8P112-119 F9P21-29

The instrument was deployed in one of our custom 4"PVC pipe housings for added protection. The SONDE plus housing was attached with a ¼" vinyl coated cable and padlocked to the side of a USGS monitoring station platform near the San Luis Drain outlet pipe. Upon retrieval of the SONDE, the instrument was found exactly where it was left, with the instrument still submerged.

Calibration	Sonde S/N:	06E2065 AB				
Pre-deployment					Post-deployment	
	Calibration value	Pre-Calibration	Post-Calibration	pass/fail (+/-20%)	Calibration check	pass/fail (+/-20%)
Depth (ft)	0	0.059	0	Pass	0.04	Pass
Pressure (mmHg)		759.3	759.3	-	760.2	-
DO %	100		99.9	Pass	103	Pass
DO (mg/L)	8.384		8.39	Pass		
DO (mg/L)	8.447				8.71	Pass
DO Charge	25-75				41	Pass
Temp (degC)	Ambient		24.16	-	23.76	-
EC	1.408	1.404	1.408	Pass	1.326	Pass
pH	4	4	4	Pass	4.14	Pass
	7	7.03	7	Pass	7.06	Pass
	10	9.99	10	Pass	10.06	Pass
ORP	231	215.2	231	Pass	229.3	Pass
Turbidity (NTU)	0	-0.2	0	Pass	0.9	Fail
	40	41.1	40	Pass	42	Pass
	200	184.9	200	Pass		
	180				175.1	Pass
Chla	≤0		-1.9	Pass	-1.8	Pass
Flr	≤0		-0.4	Pass	-0.5	Pass

Table 14: Calibration results for DO-44 San Luis Drain End

July 13, 2006 to July 25, 2006

Notebook Reference: F10P12-15, 26-31 F9P17-29

The instrument was deployed in one of our custom 4"PVC pipe housings for added protection. The SONDE plus housing was attached with a ¼" vinyl coated cable and padlocked to the side of a USGS monitoring station platform near the San Luis Drain outlet pipe. Upon retrieval of the SONDE, the instrument was found exactly where it was left, with the instrument still submerged.

Calibration	Sonde S/N:	05K1978 AB (YSI #11)				
Pre-deployment					Post-deployment	
	Calibration value	Pre-Calibration	Post-Calibration	pass/fail (+/-20%)	Calibration check	pass/fail (+/-20%)
Depth (ft)	0	1.0368	0	Pass	-0.269	Fail
Pressure (mmHg)		762.8	762.8	-	756.6	-
DO %	100		100.4	Pass	97.3	Pass
DO (mg/L)	8.490		8.53	Pass		
DO (mg/L)	8.548				8.31	Pass
DO Charge	25-75		42	Pass	36.9	Pass
Temp (degC)	Ambient		23.49	-	23.13	-
EC	1.408	1.408	1.408	Pass	1.377	Pass
pH	4	4.25	4	Pass	4.06	Pass
	7	6.98	7	Pass	7.05	Pass
	10	9.97	10	Pass	10.1	Pass
ORP		No ORP sensor		Pass		Pass
Turbidity (NTU)	0	6.9	0.1	Pass	-2.1	Fail
	40	36.1	39.7	Pass	41.9	Pass
	180	182	180.1	Pass		
	165				171.1	Pass
Chla	≤0	-1.1	-1.4	Pass	-2.8	Pass
Flr	≤0	-0.2	-0.4	Pass	-0.5	Pass

Table 15: Calibration results for DO-44 San Luis Drain End

Aug 04, 2006 to Aug 18, 2006

Notebook Reference: F9P36-39, 46-52, 61-66 F10P69-73

The instrument was deployed in a black PVC housing. The SONDE was attached towards the front of the check station near the edge and secured with a cable and padlock. It was submerged to about 2-3 feet below the water surface. Upon retrieval of the SONDE, the instrument was found exactly where it was left, with the instrument still submerged.

Calibration	Sonde S/N:	06E2065 AA (YSI#4)				
Pre-deployment					Post-deployment	
	Calibration value	Pre-Calibration	Post-Calibration	pass/fail (+/-20%)	Calibration check	pass/fail (+/-20%)
Depth (ft)	0	-0.002	0	Pass	0.096	Pass
Pressure (mmHg)		758.5	758.5	-	760.6	-
DO %	100		99.8	Pass	99.4	Pass
DO (mg/L)	8.584		8.58	Pass		
DO (mg/L)	8.615				8.53	Pass
DO Charge	25-75		35.9	Pass	30.8	Pass
Temp (degC)	Ambient		22.91	-	22.72	-
EC	1.408	1.425	1.408	Pass	1.389	Pass
pH	4	4.02	4	Pass	4.12	Pass
	7	6.99	7	Pass	7.05	Pass
	10	10.02	10	Pass	10.07	Pass
ORP		NO ORP sensor		Pass		Pass
Turbidity (NTU)	0	-0.2	0	Pass	-0.3	Fail
	40	39.3	39.9	Pass	44.3	Pass
	200	190.8	199.7	Pass	228.5	Pass
Chla	≤0	-2	-1.7	Pass	-1	Pass
Flr	≤0	-0.4	-0.4	Pass	-0.3	Pass

Table 16: Calibration results for DO-44 San Luis Drain End

Sept. 12, 2006 to Sept. 26, 2006

Notebook Reference: F9P ,90-97

The instrument was deployed in one of our custom 4"PVC pipe housings and attached with a ¼" vinyl coated cable and padlocked to the side of the platform near the San Luis Drain outlet structure. Upon retrieval, the SONDE was found where it was left and still submerged.

Calibration	Sonde S/N:	06E2064 AB YSI#6				
Pre-deployment					Post-deployment	
	Calibration value	Pre-Calibration	Post-Calibration	pass/fail (+/-20%)	Calibration check	pass/fail (+/-20%)
Depth (ft)	0	0.187	0	Pass	0.014	Pass
Pressure (mmHg)		762	762	-	762.4	-
DO %	100		100.3	Pass	98.6	Pass
DO (mg/L)	8.724		8.76	Pass		
DO (mg/L)	8.724				8.65	Pass
DO Charge	25-75		43.1	Pass	38	Pass
Temp (degC)	Ambient		22.07	-		-
EC	1.408	1.382	1.408	Pass	1.401	Pass
pH	4	4.15	4	Pass	4.07	Pass
	7	6.97	7	Pass	6.96	Pass
	10	10.03	10	Pass	9.99	Pass
ORP	233.6	232.5	233.6	Pass	236	Pass
Turbidity (NTU)	0	-0.2	0	Pass	-0.1	Pass
	40	39.9	40	Pass	40.8	Pass
	200	192.2	199.8	Pass	203.9	Pass
Chla	≤0	-1.7	-1.2	Pass	-0.8	Pass
Flr	≤0	-0.3	-0.3	Pass	-0.2	Pass

Appendix A

SUMMARY STATISTICS:
WATER QUALITY MEASUREMENTS
DO TMDL PROJECT SITES 2005 AND 2006

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Abbreviations	Description
NH4-N	Ammonia nitrogen
BOD	Biochemical oxygen demand measures at 10 days
CBOD	BOD attributed to carbon compounds
NBOD	BOD attributed to nitrogen compounds
Chl-a	Chlorophyll-a
Algal pigments	Chlorophyll-a and pheophytin by standard methods method
Sonde Chl-a corr for TriC	Chlorophyll-a measured by sonde, considered the most reliable estimation of algal biomass
Chl-a by TC	Chlorophyll-a measured by the Tri-Chromatic method
CV	Coefficient of variation (%)
DOC	Dissolved organic carbon
Max	Maximum value
Mean	Mean value
MSS	Mineral suspended solids (TSS-VSS)
Min	Minimum value
NO3-N	Nitrate nitrogen
NTU	Normal turbidity units
N	Number of values
oPO4-P	soluble reactive ortho-phosphate phosphorous
Spec Cond	Specific conductance
Std Dev	Standard deviation
T-Alk	Total alkalinity
TOC	Total organic carbon
Total-P	Total phosphorous
TSS	Total suspended solids
VSS	Volatile suspended Solids
mg/L	milligrams per liter
ug/L	micrograms per liter

Site name	DO site number	Sonde Chl-a corr for TriC ug/L Mean	Sonde Chl-a corr for TriC ug/L Max	Sonde Chl-a corr for TriC ug/L Min	Sonde Chl-a corr for TriC ug/L CV	Sonde Chl-a corr for TriC ug/L Std Dev	Sonde Chl-a corr for TriC ug/L N
SJR at Channel Point	1	10.5	10.5	10.5	.	.	1
SJR at Dos Reis Lathrop	2	75.3	75.3	75.3	.	.	1
SJR at Old River	3	81.4	81.4	81.4	.	.	1
SJR at Mossdale	4	17.3	76.9	3.2	88.5	15.3	38
SJR at Vernalis	5	15.3	56.5	3.0	77.7	11.9	42
SJR at Maze	6	15.9	54.3	0.0	71.5	11.4	38
SJR at Patterson	7	23.5	88.3	3.9	65.4	15.4	45
SJR at Crows Landing	8	19.7	51.3	6.7	54.4	10.7	43
SJR at Fremont Ford	9	36.7	37.6	35.8	3.3	1.2	2
SJR at Lander Avenue	10	31.3	132.9	3.7	90.4	28.3	42
French Camp Slough	11	2.8	5.5	0.7	86.7	2.5	3
Stanislaus River at Caswell Park	12	3.3	13.7	0.0	95.2	3.2	40
Stanislaus River at Ripon	13	3.1	3.1	3.1	.	.	1
Tuolumne River at Shiloh Bridge	14	3.6	50.2	0.0	224.1	8.0	41
Merced River at River Road	16	2.5	18.9	0.0	154.0	3.9	39
Merced River near Stevinson	17	2.3	2.3	2.3	.	.	1
Mud Slough near Gustine	18	57.7	127.2	9.0	65.0	37.5	39
Salt Slough at Lander Avenue	19	14.1	27.2	0.0	42.8	6.0	62
Los Banos Creek at Highway 140	20	40.2	129.7	7.0	69.5	28.0	43
Orestimba Creek at River Road	21	11.9	24.1	3.2	47.7	5.7	37
Modesto ID Lateral 4 to SJR	22	7.1	8.3	5.5	17.1	1.2	5
Modesto ID Lateral 5 to Tuolumne	23	6.2	34.4	0.0	142.5	8.9	28
MID Lat 6 to Stanislaus River	24	6.4	6.4	6.4	.	.	1
MID Main Drain to Stan. R. via Miller Lake	25	24.6	94.9	3.6	86.6	21.3	21
TID Highline Spill	26	2.9	2.9	2.9	.	.	1
Turlock ID Lateral 2 to SJR	27	1.5	2.9	0.1	2.0	134.0	2
Turlock ID Westport Drain Flow Station	28	7.5	52.3	0.0	10.3	138.4	27
Turlock ID Harding Drain	29	8.3	32.8	0.0	100.6	8.4	38
Turlock ID Lateral 6 & 7 at Levee	30	23.2	218.3	0.0	56.6	243.8	14
BCID - New Jerusalem Drain	31	7.2	17.5	0.0	130.2	9.4	5
El Solyo WD - Grayson Drain	32	31.5	63.5	0.0	100.7	31.7	3

Site name	DO site number	Sonde Chl-a corr for TriC ug/L Mean	Sonde Chl-a corr for TriC ug/L Max	Sonde Chl-a corr for TriC ug/L Min	Sonde Chl-a corr for TriC ug/L CV	Sonde Chl-a corr for TriC ug/L Std Dev	Sonde Chl-a corr for TriC ug/L N
Hospital Creek	33	30.4	89.7	6.7	80.1	24.4	15
Ingram Creek Flow Station	34	27.1	75.9	2.0	84.4	22.9	20
Westley Wasteway Flow Station	35	25.7	66.3	3.9	89.4	23.0	6
Del Puerto Creek Flow Station	36	19.4	88.9	2.2	88.8	17.2	33
Marshall Road Drain	38	19.8	35.4	7.8	58.7	11.6	5
El Solyo Pumping Station	43	23.6	23.6	23.6	.	.	1
San Luis Drain End	44	138.7	273.2	24.0	50.3	69.8	47
Volta Wasteway	45	4.9	14.2	0.9	113.2	5.5	5
Mud Slough at Gun Club Road	46	13.4	24.3	8.5	48.9	6.6	5
FC-5 Grasslands Area Farmers	48	42.4	42.4	42.4	.	.	1
PE-14 Grasslands Area Farmers	49	52.3	52.3	52.3	.	.	1
San Luis Drain Site A (Check 18)	50	49.2	58.1	40.4	12.5	25.3	2
Salt Slough at Sand Dam	52	18.3	18.3	18.3	.	.	1
Salt Slough at Wolfsen Road	53	14.2	25.1	8.4	30.4	4.3	20
Los Banos Creek at Ingomar Grade	54	0.0	0.0	0.0	.	.	1
Ramona Lake	57	78.5	406.5	5.7	139.9	109.8	12
SJR Laird Park	59	25.9	166.6	0.8	134.8	34.9	22
Moffit 1 South	60	13.0	33.2	5.9	55.7	7.2	14
Deadman's Slough	61	20.7	102.3	6.6	105.1	21.7	18
Mallard Slough	62	20.1	73.4	7.2	92.0	18.5	15
Inlet C Canal	63	8.8	16.3	3.7	41.4	3.6	18
Moran Drain	64	17.4	19.4	14.8	13.5	2.4	3
Spanish Grant Drain	65	19.5	27.6	13.9	30.5	5.9	4
ESWD Maze Blv. Drain	66	21.0	55.0	6.5	110.3	23.1	4
Newman Wasteway at Brazo Road	67	17.8	29.3	11.2	44.9	8.0	4
S. Lake Basin	68	28.3	48.7	7.8	102.3	28.9	2
Santa Fe Canal	69	14.5	14.5	14.5	.	.	1
SJR Garwood Bridge	84	26.7	26.7	26.7	.	.	1

Site name	DO site number	NO3-N mg/L Mean	NO3-N mg/L Max	NO3-N mg/L Min	NO3-N mg/L Std Dev	NO3-N mg/L CV	NO3-N mg/L N
SJR at Channel Point	1	0.89	0.89	0.89	.	.	1
SJR at Dos Reis Lathrop	2	0.74	0.74	0.74	.	.	1
SJR at Old River	3	0.96	0.96	0.96	.	.	1
SJR at Mossdale	4	1.05	2.45	0.08	0.67	64.06	38
SJR at Vernalis	5	1.00	2.06	0.07	0.65	65.09	39
SJR at Maze	6	1.30	2.77	0.06	0.87	67.05	37
SJR at Patterson	7	1.68	3.94	0.08	1.05	62.60	40
SJR at Crows Landing	8	1.54	3.39	0.08	0.89	58.00	40
SJR at Fremont Ford	9	1.38	1.82	0.94	0.62	45.24	2
SJR at Lander Avenue	10	1.06	5.17	0.02	1.20	113.61	43
French Camp Slough	11	1.48	2.03	0.49	0.86	58.25	3
Stanislaus River at Caswell Park	12	0.21	0.74	0.03	0.13	62.43	40
Stanislaus River at Ripon	13	0.33	0.33	0.33	.	.	1
Tuolumne River at Shiloh Bridge	14	0.67	1.60	0.02	0.55	82.68	41
Merced River at River Road	16	0.79	2.88	0.04	0.83	104.86	40
Merced River near Stevinson	17	0.11	0.11	0.11	.	.	1
Mud Slough near Gustine	18	4.79	10.41	0.53	2.88	60.08	39
Salt Slough at Lander Avenue	19	1.19	4.31	0.01	0.97	81.71	60
Los Banos Creek at Highway 140	20	0.72	2.09	0.08	0.49	67.38	41
Orestimba Creek at River Road	21	2.58	8.78	0.05	2.07	80.46	35
Modesto ID Lateral 4 to SJR	22	1.32	4.69	0.01	1.98	150.23	5
Modesto ID Lateral 5 to Tuolumne	23	1.39	17.97	0.01	3.53	254.20	26
MID Lat 6 to Stanislaus River	24	0.11	0.11	0.11	.	.	1
MID Main Drain to Stan. R. via Miller Lake	25	1.12	3.45	0.03	1.03	91.77	20
TID Highline Spill	26	0.13	0.13	0.13	.	.	1
Turlock ID Lateral 2 to SJR	27	0.06	0.06	0.06			1
Turlock ID Westport Drain Flow Station	28	12.81	29.83	1.59	6.72	52.50	27
Turlock ID Harding Drain	29	8.78	20.17	4.21	3.79	43.19	38
Turlock ID Lateral 6 & 7 at Levee	30	14.28	18.92	10.71	2.88	20.14	13
BCID - New Jerusalem Drain	31	13.85	14.96	12.82	0.98	7.10	5
El Solyo WD - Grayson Drain	32	1.29	1.73	0.86	0.62	47.81	2

Site name	DO site number	NO3-N mg/L Mean	NO3-N mg/L Max	NO3-N mg/L Min	NO3-N mg/L Std Dev	NO3-N mg/L CV	NO3-N mg/L N
Hospital Creek	33	1.06	2.50	0.35	0.74	69.71	15
Ingram Creek Flow Station	34	5.33	16.53	0.61	4.74	88.87	20
Westley Wasteway Flow Station	35	1.60	4.26	0.10	1.57	98.27	5
Del Puerto Creek Flow Station	36	3.22	6.57	0.01	1.85	57.27	33
Marshall Road Drain	38	2.34	4.99	1.03	1.61	68.90	5
El Solyo Pumping Station	43	.	.	.	.	.	0
San Luis Drain End	44	13.42	30.29	3.05	5.95	44.32	43
Volta Wasteway	45	1.72	4.26	0.74	1.44	83.72	5
Mud Slough at Gun Club Road	46	0.05	0.11	0.01	0.04	85.16	5
FC-5 Grasslands Area Farmers	48	16.20	21.19	11.20	7.07	43.63	2
PE-14 Grasslands Area Farmers	49	15.53	22.16	8.91	9.37	60.32	2
San Luis Drain Site A (Check 18)	50	14.42	16.96	11.76	2.60	18.05	3
Salt Slough at Sand Dam	52	1.78	1.78	1.78	.	.	1
Salt Slough at Wolfsen Road	53	0.96	3.93	0.22	0.85	89.30	21
Los Banos Creek at Ingomar Grade	54	2.04	2.04	2.04	.	.	1
Ramona Lake	57	2.36	3.67	0.18	0.93	39.56	12
SJR Laird Park	59	2.05	6.63	0.16	1.31	63.81	22
Moffit 1 South	60	0.08	0.77	0.01	0.22	289.21	12
Deadman's Slough	61	0.39	3.24	0.01	0.85	219.63	14
Mallard Slough	62	0.11	0.45	0.01	0.16	138.59	13
Inlet C Canal	63	1.25	4.92	0.65	1.03	82.16	19
Moran Drain	64	0.75	1.04	0.39	0.33	44.26	3
Spanish Grant Drain	65	4.45	7.82	2.63	2.30	51.77	4
ESWD Maze Blv. Drain	66	0.74	1.26	0.35	0.39	52.24	4
Newman Wasteway at Brazo Road	67	3.27	4.04	2.27	0.84	25.67	4
S. Lake Basin	68	1.91	3.01	0.82	1.55	80.99	2
Santa Fe Canal	69	1.89	1.89	1.89	.	.	1
SJR Garwood Bridge	84	0.70	0.70	0.70	.	.	1

Site name	DO site number	oPO4-P mg/L Mean	oPO4-P mg/L Max	oPO4-P mg/L Min	oPO4-P mg/L Std Dev	oPO4-P mg/L CV	oPO4-P mg/L N
SJR at Channel Point	1	0.09	0.09	0.09	.	.	1
SJR at Dos Reis Lathrop	2	0.00	0.00	0.00	.	.	1
SJR at Old River	3	0.00	0.00	0.00	.	.	1
SJR at Mossdale	4	0.14	0.36	0.03	0.09	60.38	37
SJR at Vernalis	5	0.16	0.69	0.04	0.13	80.56	39
SJR at Maze	6	0.21	1.59	0.04	0.25	120.65	38
SJR at Patterson	7	0.25	0.71	0.00	0.15	60.04	40
SJR at Crows Landing	8	0.15	0.52	0.04	0.09	57.69	40
SJR at Fremont Ford	9	0.21	0.26	0.16	0.07	31.65	2
SJR at Lander Avenue	10	0.17	0.49	0.01	0.10	60.30	43
French Camp Slough	11	0.26	0.50	0.12	0.20	77.00	3
Stanislaus River at Caswell Park	12	0.13	0.54	0.00	0.12	91.73	40
Stanislaus River at Ripon	13	0.21	0.21	0.21	.	.	1
Tuolumne River at Shiloh Bridge	14	0.10	0.50	0.00	0.11	110.00	41
Merced River at River Road	16	0.07	0.34	0.00	0.08	120.81	40
Merced River near Stevinson	17	0.20	0.20	0.20	.	.	1
Mud Slough near Gustine	18	0.15	0.44	0.00	0.12	77.70	39
Salt Slough at Lander Avenue	19	0.26	0.63	0.06	0.15	59.44	60
Los Banos Creek at Highway 140	20	0.42	1.85	0.00	0.31	73.54	41
Orestimba Creek at River Road	21	0.18	0.47	0.03	0.11	58.95	36
Modesto ID Lateral 4 to SJR	22	0.14	0.26	0.05	0.08	61.38	5
Modesto ID Lateral 5 to Tuolumne	23	0.16	1.27	0.00	0.26	159.51	28
MID Lat 6 to Stanislaus River	24	0.50	0.50	0.50	.	.	1
MID Main Drain to Stan. R. via Miller Lake	25	0.76	6.06	0.04	1.35	178.88	20
TID Highline Spill	26	0.20	0.20	0.20	.	.	1
Turlock ID Lateral 2 to SJR	27	0.00	0.00	0.00			1
Turlock ID Westport Drain Flow Station	28	0.50	2.69	0.09	0.50	100.63	27
Turlock ID Harding Drain	29	1.83	6.28	0.35	1.23	66.97	38
Turlock ID Lateral 6 & 7 at Levee	30	0.62	1.19	0.09	0.28	45.31	13
BCID - New Jerusalem Drain	31	0.17	0.38	0.04	0.16	97.08	5
El Solyo WD - Grayson Drain	32	0.26	0.31	0.22	0.06	21.92	2

Site name	DO site number	oPO4-P mg/L Mean	oPO4-P mg/L Max	oPO4-P mg/L Min	oPO4-P mg/L Std Dev	oPO4-P mg/L CV	oPO4-P mg/L N
Hospital Creek	33	0.30	0.80	0.01	0.25	82.80	15
Ingram Creek Flow Station	34	0.20	0.61	0.05	0.12	60.19	20
Westley Wasteway Flow Station	35	0.16	0.48	0.02	0.18	113.85	5
Del Puerto Creek Flow Station	36	0.23	0.64	0.03	0.15	63.27	33
Marshall Road Drain	38	0.22	0.39	0.08	0.11	52.69	5
El Solyo Pumping Station	43	.	.	.	.	.	0
San Luis Drain End	44	0.07	0.47	0.00	0.11	146.44	43
Volta Wasteway	45	0.07	0.08	0.04	0.02	28.90	5
Mud Slough at Gun Club Road	46	0.25	0.63	0.12	0.21	86.42	5
FC-5 Grasslands Area Farmers	48	0.20	0.31	0.09	0.15	76.44	2
PE-14 Grasslands Area Farmers	49	0.14	0.24	0.03	0.14	105.42	2
San Luis Drain Site A (Check 18)	50	0.20	0.40	0.00	0.20	97.20	3
Salt Slough at Sand Dam	52	0.90	0.90	0.90	.	.	1
Salt Slough at Wolfsen Road	53	0.20	0.68	0.05	0.15	77.50	21
Los Banos Creek at Ingomar Grade	54	0.15	0.15	0.15	.	.	1
Ramona Lake	57	0.11	0.27	0.01	0.07	62.93	12
SJR Laird Park	59	0.23	0.42	0.09	0.10	42.74	22
Moffit 1 South	60	0.14	0.39	0.03	0.11	79.26	13
Deadman's Slough	61	0.21	0.46	0.04	0.13	60.70	16
Mallard Slough	62	0.54	2.66	0.05	0.82	153.55	16
Inlet C Canal	63	0.17	0.82	0.03	0.19	113.76	19
Moran Drain	64	0.05	0.11	0.02	0.05	94.32	3
Spanish Grant Drain	65	0.14	0.22	0.08	0.07	47.94	4
ESWD Maze Blv. Drain	66	0.11	0.21	0.04	0.08	73.45	4
Newman Wasteway at Brazo Road	67	0.16	0.24	0.10	0.07	44.62	4
S. Lake Basin	68	0.31	0.31	0.31	.	.	1
Santa Fe Canal	69	.	.	.	.	.	0
SJR Garwood Bridge	84	0.06	0.06	0.06	.	.	1

Site name	DO site number	NH4-N mg/L Mean	NH4-N mg/L Max	NH4-N mg/L Min	NH4-N mg/L Std Dev	NH4-N mg/L CV	NH4-N mg/L N
SJR at Channel Point	1	0.46	0.46	0.46	.	.	1
SJR at Dos Reis Lathrop	2	0.10	0.10	0.10	.	.	1
SJR at Old River	3	0.13	0.13	0.13	.	.	1
SJR at Mossdale	4	0.20	0.74	0.00	0.19	94.18	38
SJR at Vernalis	5	0.18	0.55	-0.06	0.14	81.33	38
SJR at Maze	6	0.21	0.71	0.00	0.17	81.90	38
SJR at Patterson	7	0.28	0.83	0.00	0.19	67.66	40
SJR at Crows Landing	8	0.25	1.14	0.00	0.21	81.59	40
SJR at Fremont Ford	9	0.17	0.23	0.12	0.08	45.53	2
SJR at Lander Avenue	10	0.28	1.02	0.00	0.24	87.08	43
French Camp Slough	11	0.18	0.19	0.17	0.01	7.20	3
Stanislaus River at Caswell Park	12	0.15	0.78	0.00	0.16	103.05	40
Stanislaus River at Ripon	13	0.11	0.11	0.11	.	.	1
Tuolumne River at Shiloh Bridge	14	0.15	0.65	0.00	0.15	104.72	41
Merced River at River Road	16	0.17	0.62	0.00	0.16	89.41	40
Merced River near Stevinson	17	0.09	0.09	0.09	.	.	1
Mud Slough near Gustine	18	0.37	1.20	0.05	0.24	66.41	38
Salt Slough at Lander Avenue	19	0.35	1.13	0.00	0.22	62.80	60
Los Banos Creek at Highway 140	20	0.68	2.35	0.26	0.46	67.63	41
Orestimba Creek at River Road	21	0.37	1.26	0.01	0.31	82.73	36
Modesto ID Lateral 4 to SJR	22	0.21	0.50	0.01	0.18	84.35	5
Modesto ID Lateral 5 to Tuolumne	23	0.28	1.93	0.00	0.42	150.18	28
MID Lat 6 to Stanislaus River	24	0.45	0.45	0.45	.	.	1
MID Main Drain to Stan. R. via Miller Lake	25	1.77	25.01	0.14	5.52	311.26	20
TID Highline Spill	26	0.17	0.17	0.17	.	.	1
Turlock ID Lateral 2 to SJR	27	0.21	0.21	0.21			1
Turlock ID Westport Drain Flow Station	28	0.33	1.74	0.00	0.35	106.27	27
Turlock ID Harding Drain	29	0.57	3.82	0.00	0.69	120.44	37
Turlock ID Lateral 6 & 7 at Levee	30	0.34	0.89	0.18	0.19	55.10	13
BCID - New Jerusalem Drain	31	0.14	0.32	0.00	0.13	93.76	5
El Solyo WD - Grayson Drain	32	0.62	0.89	0.35	0.38	61.35	2

Site name	DO site number	NH4-N mg/L Mean	NH4-N mg/L Max	NH4-N mg/L Min	NH4-N mg/L Std Dev	NH4-N mg/L CV	NH4-N mg/L N
Hospital Creek	33	0.56	1.77	0.00	0.54	97.48	15
Ingram Creek Flow Station	34	1.16	5.54	0.12	1.57	135.91	20
Westley Wasteway Flow Station	35	0.41	0.94	0.23	0.30	74.28	5
Del Puerto Creek Flow Station	36	0.69	4.50	0.01	0.94	135.32	33
Marshall Road Drain	38	0.38	0.96	0.10	0.34	90.32	5
El Solyo Pumping Station	43	.	.	.	.	.	0
San Luis Drain End	44	0.40	1.74	-0.05	0.35	89.57	42
Volta Wasteway	45	0.12	0.23	0.00	0.09	72.47	5
Mud Slough at Gun Club Road	46	0.44	0.54	0.32	0.09	19.64	5
FC-5 Grasslands Area Farmers	48	1.19	2.16	0.23	1.37	114.52	2
PE-14 Grasslands Area Farmers	49	2.31	2.31	2.31	.	.	1
San Luis Drain Site A (Check 18)	50	0.55	0.93	0.13	0.40	73.08	3
Salt Slough at Sand Dam	52	0.38	0.38	0.38	.	.	1
Salt Slough at Wolfsen Road	53	0.36	0.68	0.13	0.15	42.63	21
Los Banos Creek at Ingomar Grade	54	0.57	0.57	0.57	.	.	1
Ramona Lake	57	0.68	1.44	0.00	0.41	60.60	12
SJR Laird Park	59	0.36	1.56	0.00	0.38	105.96	22
Moffit 1 South	60	0.46	0.68	0.28	0.14	29.18	13
Deadman's Slough	61	0.39	0.71	0.01	0.20	50.55	16
Mallard Slough	62	0.50	1.31	0.19	0.34	68.13	16
Inlet C Canal	63	0.31	0.85	0.01	0.21	66.54	19
Moran Drain	64	0.81	1.41	0.51	0.51	62.85	3
Spanish Grant Drain	65	0.41	0.61	0.31	0.13	32.29	4
ESWD Maze Blv. Drain	66	0.23	0.40	0.15	0.12	53.36	4
Newman Wasteway at Brazo Road	67	0.67	1.27	0.41	0.41	60.89	4
S. Lake Basin	68	0.34	0.55	0.13	0.30	86.06	2
Santa Fe Canal	69	0.23	0.23	0.23	.	.	1
SJR Garwood Bridge	84	0.96	0.96	0.96	.	.	1

Site name	DO site number	Total-P mg/L Mean	Total-P mg/L Max	Total-P mg/L Min	Total-P mg/L Std Dev	Total-P mg/L CV	Total-P mg/L N
SJR at Channel Point	1	0.15	0.15	0.15	.	.	1
SJR at Dos Reis Lathrop	2	0.19	0.19	0.19	.	.	1
SJR at Old River	3	0.15	0.15	0.15	.	.	1
SJR at Mossdale	4	0.15	0.38	0.06	0.06	42.13	37
SJR at Vernalis	5	0.15	0.64	0.06	0.10	65.61	37
SJR at Maze	6	0.17	0.41	0.05	0.07	43.09	36
SJR at Patterson	7	0.25	0.41	0.09	0.08	34.16	38
SJR at Crows Landing	8	0.18	0.38	0.07	0.06	34.68	38
SJR at Fremont Ford	9	0.33	0.33	0.33	.	.	1
SJR at Lander Avenue	10	0.22	0.50	0.06	0.10	44.02	41
French Camp Slough	11	0.16	0.18	0.16	0.01	7.77	3
Stanislaus River at Caswell Park	12	0.06	0.32	0.01	0.05	89.64	38
Stanislaus River at Ripon	13	0.05	0.05	0.05	.	.	1
Tuolumne River at Shiloh Bridge	14	0.07	0.39	0.01	0.07	102.69	39
Merced River at River Road	16	0.05	0.40	0.01	0.06	117.25	38
Merced River near Stevinson	17	0.03	0.03	0.03	.	.	1
Mud Slough near Gustine	18	0.24	0.56	0.07	0.12	50.26	37
Salt Slough at Lander Avenue	19	0.36	0.75	0.14	0.14	38.12	58
Los Banos Creek at Highway 140	20	0.64	1.46	0.22	0.28	43.84	40
Orestimba Creek at River Road	21	0.32	0.76	0.09	0.19	58.88	34
Modesto ID Lateral 4 to SJR	22	0.06	0.10	0.03	0.03	46.17	5
Modesto ID Lateral 5 to Tuolumne	23	0.16	1.43	0.01	0.30	195.01	28
MID Lat 6 to Stanislaus River	24	0.46	0.46	0.46	.	.	1
MID Main Drain to Stan. R. via Miller Lake	25	0.81	6.34	0.04	1.34	165.47	21
TID Highline Spill	26	0.05	0.05	0.05	.	.	1
Turlock ID Lateral 2 to SJR	27	0.01	0.01	0.01			1
Turlock ID Westport Drain Flow Station	28	0.35	0.98	0.04	0.24	68.07	27
Turlock ID Harding Drain	29	1.77	4.84	0.12	1.22	69.25	37
Turlock ID Lateral 6 & 7 at Levee	30	0.66	1.00	0.29	0.22	33.01	13
BCID - New Jerusalem Drain	31	0.07	0.08	0.05	0.02	21.16	5
El Solyo WD - Grayson Drain	32	0.26	0.42	0.11	0.22	84.03	2

Site name	DO site number	Total-P mg/L Mean	Total-P mg/L Max	Total-P mg/L Min	Total-P mg/L Std Dev	Total-P mg/L CV	Total-P mg/L N
Hospital Creek	33	0.53	1.44	0.10	0.38	72.14	15
Ingram Creek Flow Station	34	0.36	1.20	0.04	0.28	76.67	20
Westley Wasteway Flow Station	35	0.23	0.55	0.12	0.18	80.48	5
Del Puerto Creek Flow Station	36	0.34	0.92	0.05	0.24	70.49	32
Marshall Road Drain	38	0.31	0.55	0.16	0.15	48.26	5
El Solyo Pumping Station	43	.	.	.	.	.	0
San Luis Drain End	44	0.08	0.22	0.02	0.04	48.78	42
Volta Wasteway	45	0.11	0.14	0.07	0.03	30.59	5
Mud Slough at Gun Club Road	46	0.38	0.77	0.22	0.23	59.46	5
FC-5 Grasslands Area Farmers	48	0.20	0.32	0.07	0.18	92.40	2
PE-14 Grasslands Area Farmers	49	0.17	0.19	0.16	0.02	12.21	2
San Luis Drain Site A (Check 18)	50	0.13	0.15	0.11	0.02	12.35	3
Salt Slough at Sand Dam	52	0.29	0.29	0.29	.	.	1
Salt Slough at Wolfsen Road	53	0.32	0.95	0.14	0.16	50.41	21
Los Banos Creek at Ingomar Grade	54	0.24	0.24	0.24	.	.	1
Ramona Lake	57	0.40	0.66	0.28	0.12	29.65	12
SJR Laird Park	59	0.24	0.38	0.15	0.07	29.55	22
Moffit 1 South	60	0.17	0.43	0.03	0.14	79.47	13
Deadman's Slough	61	0.32	0.86	0.03	0.20	63.55	16
Mallard Slough	62	0.54	2.83	0.08	0.78	144.09	16
Inlet C Canal	63	0.26	1.13	0.04	0.24	90.78	19
Moran Drain	64	0.21	0.23	0.16	0.04	17.41	3
Spanish Grant Drain	65	0.22	0.28	0.15	0.06	25.66	4
ESWD Maze Blv. Drain	66	0.18	0.35	0.06	0.13	71.53	4
Newman Wasteway at Brazo Road	67	0.32	0.52	0.19	0.15	49.01	4
S. Lake Basin	68	0.25	0.31	0.20	0.07	28.89	2
Santa Fe Canal	69	0.30	0.30	0.30	.	.	1
SJR Garwood Bridge	84	0.18	0.18	0.18	.	.	1

Site name	DO site number	BOD mg/L Mean	BOD mg/L Max	BOD mg/L Min	BOD mg/L Std Dev	BOD mg/L CV	BOD mg/L N
SJR at Channel Point	1	4.1	4.1	4.1	.	.	1
SJR at Dos Reis Lathrop	2	6.6	6.6	6.6	.	.	1
SJR at Old River	3	6.4	6.4	6.4	.	.	1
SJR at Mossdale	4	2.4	7.2	1.0	1.5	64.1	38
SJR at Vernalis	5	3.3	15.4	0.9	3.2	96.0	39
SJR at Maze	6	2.4	5.6	1.2	1.0	42.5	38
SJR at Patterson	7	3.7	8.0	1.5	1.7	45.7	40
SJR at Crows Landing	8	3.1	13.5	1.4	2.0	63.5	39
SJR at Fremont Ford	9	7.9	12.2	3.7	6.0	75.5	2
SJR at Lander Avenue	10	5.3	16.0	1.1	3.7	69.1	42
French Camp Slough	11	0.9	1.1	0.8	0.2	17.9	3
Stanislaus River at Caswell Park	12	1.3	5.3	0.2	0.9	69.3	37
Stanislaus River at Ripon	13	1.2	1.2	1.2	.	.	1
Tuolumne River at Shiloh Bridge	14	1.3	3.7	0.2	0.9	69.5	37
Merced River at River Road	16	1.7	6.5	0.6	1.2	68.9	39
Merced River near Stevinson	17	1.2	1.2	1.2	.	.	1
Mud Slough near Gustine	18	9.0	16.5	2.3	4.0	44.4	39
Salt Slough at Lander Avenue	19	3.2	12.0	1.5	1.5	47.0	57
Los Banos Creek at Highway 140	20	9.1	18.8	2.6	4.5	49.0	40
Orestimba Creek at River Road	21	3.0	19.3	0.8	3.2	107.1	36
Modesto ID Lateral 4 to SJR	22	2.3	3.3	1.6	0.7	28.2	5
Modesto ID Lateral 5 to Tuolumne	23	2.3	10.2	0.8	2.2	96.6	27
MID Lat 6 to Stanislaus River	24	5.6	5.6	5.6	.	.	1
MID Main Drain to Stan. R. via Miller Lake	25	7.0	17.7	2.4	4.7	67.0	20
TID Highline Spill	26	1.1	1.1	1.1	.	.	1
Turlock ID Lateral 2 to SJR	27	1.5	1.5	1.5			1
Turlock ID Westport Drain Flow Station	28	2.4	13.4	0.6	2.4	99.7	27
Turlock ID Harding Drain	29	5.0	16.9	1.3	3.0	60.6	38
Turlock ID Lateral 6 & 7 at Levee	30	3.4	8.4	1.0	2.6	77.5	12
BCID - New Jerusalem Drain	31	0.4	0.9	-0.3	0.6	160.6	3
El Solyo WD - Grayson Drain	32	10.0	10.0	10.0	.	.	1

Site name	DO site number	BOD mg/L Mean	BOD mg/L Max	BOD mg/L Min	BOD mg/L Std Dev	BOD mg/L CV	BOD mg/L N
Hospital Creek	33	9.3	23.0	1.0	7.8	83.7	14
Ingram Creek Flow Station	34	5.9	22.7	1.0	5.7	97.4	19
Westley Wasteway Flow Station	35	6.8	16.8	1.3	7.1	103.8	4
Del Puerto Creek Flow Station	36	6.4	23.6	1.0	5.7	88.5	30
Marshall Road Drain	38	7.2	12.4	2.5	5.0	69.5	4
El Solyo Pumping Station	43	.	.	.	.	.	0
San Luis Drain End	44	13.5	20.7	2.1	5.4	40.1	41
Volta Wasteway	45	2.0	5.0	0.7	2.0	103.7	4
Mud Slough at Gun Club Road	46	8.8	14.5	5.5	4.0	46.0	4
FC-5 Grasslands Area Farmers	48	18.3	18.3	18.3	.	.	1
PE-14 Grasslands Area Farmers	49	6.5	6.5	6.5	.	.	1
San Luis Drain Site A (Check 18)	50	5.2	5.9	4.5	1.0	18.9	2
Salt Slough at Sand Dam	52	5.7	5.7	5.7	.	.	1
Salt Slough at Wolfsen Road	53	4.0	7.2	2.2	1.5	37.4	18
Los Banos Creek at Ingomar Grade	54	20.5	20.5	20.5	.	.	1
Ramona Lake	57	12.8	23.9	3.0	6.2	48.6	12
SJR Laird Park	59	3.8	7.7	2.2	1.4	36.6	22
Moffit 1 South	60	5.4	14.6	2.0	3.8	70.8	11
Deadman's Slough	61	5.6	18.5	1.8	4.6	81.4	13
Mallard Slough	62	3.9	11.6	1.0	3.4	87.0	12
Inlet C Canal	63	2.1	7.0	0.9	1.5	74.6	16
Moran Drain	64	5.8	9.5	2.0	5.3	91.4	2
Spanish Grant Drain	65	5.5	12.0	1.7	5.7	103.1	3
ESWD Maze Blv. Drain	66	3.2	6.1	1.4	2.6	80.0	3
Newman Wasteway at Brazo Road	67	6.4	11.5	3.2	4.5	70.9	3
S. Lake Basin	68	11.0	19.5	2.5	12.0	109.2	2
Santa Fe Canal	69	2.7	2.7	2.7	.	.	1
SJR Garwood Bridge	84	6.4	6.4	6.4	.	.	1

Site name	DO site number	CBOD mg/L Mean	CBOD mg/L Max	CBOD mg/L Min	CBOD mg/L Std Dev	CBOD mg/L CV	CBOD mg/L N
SJR at Channel Point	1	2.3	2.3	2.3	.	.	1
SJR at Dos Reis Lathrop	2	5.1	5.1	5.1	.	.	1
SJR at Old River	3	4.5	4.5	4.5	.	.	1
SJR at Mossdale	4	1.6	4.8	0.3	1.1	69.2	38
SJR at Vernalis	5	2.4	14.0	0.3	2.6	108.4	38
SJR at Maze	6	1.8	7.0	0.5	1.2	67.4	38
SJR at Patterson	7	2.8	7.0	0.8	1.6	57.6	40
SJR at Crows Landing	8	2.1	4.3	0.9	0.9	41.8	39
SJR at Fremont Ford	9	2.5	2.7	2.3	0.3	11.0	2
SJR at Lander Avenue	10	3.9	14.6	1.0	3.0	77.1	42
French Camp Slough	11	0.7	1.0	0.4	0.3	45.4	3
Stanislaus River at Caswell Park	12	0.9	2.2	0.0	0.5	57.4	36
Stanislaus River at Ripon	13	.	.	.	.	.	0
Tuolumne River at Shiloh Bridge	14	0.9	3.0	0.0	0.7	70.3	37
Merced River at River Road	16	1.3	3.3	0.1	0.7	59.4	39
Merced River near Stevinson	17	.	.	.	.	.	0
Mud Slough near Gustine	18	7.1	14.8	1.9	3.9	55.4	39
Salt Slough at Lander Avenue	19	2.1	9.1	0.8	1.2	60.8	57
Los Banos Creek at Highway 140	20	6.0	15.0	1.1	3.4	57.2	41
Orestimba Creek at River Road	21	2.1	18.0	0.3	3.0	144.3	36
Modesto ID Lateral 4 to SJR	22	1.8	3.2	1.1	0.8	42.9	5
Modesto ID Lateral 5 to Tuolumne	23	1.4	4.6	0.1	1.0	68.6	26
MID Lat 6 to Stanislaus River	24	1.6	1.6	1.6	.	.	1
MID Main Drain to Stan. R. via Miller Lake	25	4.5	17.0	1.6	3.8	84.7	20
TID Highline Spill	26	.	.	.	.	.	0
Turlock ID Lateral 2 to SJR	27	1.0	1.0	1.0			1
Turlock ID Westport Drain Flow Station	28	1.8	9.0	0.4	1.7	91.5	26
Turlock ID Harding Drain	29	2.9	8.8	1.0	1.5	50.6	38
Turlock ID Lateral 6 & 7 at Levee	30	2.6	7.9	0.6	2.4	92.7	12
BCID - New Jerusalem Drain	31	0.4	0.8	-0.3	0.6	143.4	3
El Solyo WD - Grayson Drain	32	7.6	7.6	7.6	.	.	1

Site name	DO site number	CBOD mg/L Mean	CBOD mg/L Max	CBOD mg/L Min	CBOD mg/L Std Dev	CBOD mg/L CV	CBOD mg/L N
Hospital Creek	33	8.5	22.8	1.1	8.0	94.5	13
Ingram Creek Flow Station	34	2.6	7.1	0.5	1.9	74.4	19
Westley Wasteway Flow Station	35	4.0	10.6	1.4	4.5	112.8	4
Del Puerto Creek Flow Station	36	3.7	23.3	0.5	4.2	114.4	31
Marshall Road Drain	38	5.4	9.8	1.7	4.2	78.0	4
El Solyo Pumping Station	43	.	.	.	.	.	0
San Luis Drain End	44	12.1	19.8	1.5	5.3	43.4	41
Volta Wasteway	45	1.6	4.4	0.5	1.9	118.6	4
Mud Slough at Gun Club Road	46	5.3	13.1	2.1	5.2	98.8	4
FC-5 Grasslands Area Farmers	48	13.5	13.5	13.5	.	.	1
PE-14 Grasslands Area Farmers	49	5.3	5.3	5.3	.	.	1
San Luis Drain Site A (Check 18)	50	4.1	5.0	3.3	1.2	29.1	2
Salt Slough at Sand Dam	52	1.9	1.9	1.9	.	.	1
Salt Slough at Wolfsen Road	53	2.3	5.2	1.1	1.0	41.8	18
Los Banos Creek at Ingomar Grade	54	5.4	5.4	5.4	.	.	1
Ramona Lake	57	9.2	23.4	1.7	5.3	58.3	12
SJR Laird Park	59	2.7	6.1	1.2	1.3	49.6	22
Moffit 1 South	60	4.6	11.9	1.9	3.1	68.5	11
Deadman's Slough	61	4.2	15.5	1.1	3.9	92.1	13
Mallard Slough	62	3.4	11.6	1.1	3.2	93.2	11
Inlet C Canal	63	1.2	3.1	0.5	0.7	55.3	16
Moran Drain	64	4.2	7.1	1.3	4.1	97.3	2
Spanish Grant Drain	65	3.5	7.1	1.1	3.2	91.7	3
ESWD Maze Blv. Drain	66	2.3	4.4	1.2	1.8	78.7	3
Newman Wasteway at Brazo Road	67	3.6	5.6	2.0	1.8	49.0	3
S. Lake Basin	68	9.1	16.3	1.8	10.3	113.2	2
Santa Fe Canal	69	2.3	2.3	2.3	.	.	1
SJR Garwood Bridge	84	5.2	5.2	5.2	.	.	1

Site name	DO site number	NBOD mg/L Mean	NBOD mg/L Max	NBOD mg/L Min	NBOD mg/L Std Dev	NBOD mg/L CV	NBOD mg/L N
SJR at Channel Point	1	1.8	1.8	1.8	.	.	1
SJR at Dos Reis Lathrop	2	1.5	1.5	1.5	.	.	1
SJR at Old River	3	1.8	1.8	1.8	.	.	1
SJR at Mossdale	4	0.8	3.5	0.0	0.6	83.4	38
SJR at Vernalis	5	0.9	10.0	0.0	1.6	165.5	38
SJR at Maze	6	0.7	2.5	0.0	0.5	71.9	37
SJR at Patterson	7	0.9	2.4	0.2	0.6	60.6	40
SJR at Crows Landing	8	1.0	11.0	0.2	1.7	163.7	39
SJR at Fremont Ford	9	5.4	9.5	1.4	5.7	104.8	2
SJR at Lander Avenue	10	1.4	6.7	0.2	1.2	84.8	42
French Camp Slough	11	0.2	0.5	0.1	0.2	93.3	3
Stanislaus River at Caswell Park	12	0.4	4.0	0.0	0.7	186.1	35
Stanislaus River at Ripon	13	.	.	.	.	.	0
Tuolumne River at Shiloh Bridge	14	0.4	2.0	0.0	0.5	119.1	36
Merced River at River Road	16	0.5	4.3	0.0	0.7	159.9	39
Merced River near Stevinson	17	.	.	.	.	.	0
Mud Slough near Gustine	18	1.9	4.9	0.4	1.0	52.0	39
Salt Slough at Lander Avenue	19	1.2	5.2	0.0	0.8	65.9	57
Los Banos Creek at Highway 140	20	3.2	8.2	0.6	1.8	57.9	40
Orestimba Creek at River Road	21	1.0	5.0	0.0	1.0	103.5	36
Modesto ID Lateral 4 to SJR	22	0.5	1.0	0.2	0.3	53.9	5
Modesto ID Lateral 5 to Tuolumne	23	0.9	5.6	0.0	1.4	150.0	26
MID Lat 6 to Stanislaus River	24	4.1	4.1	4.1	.	.	1
MID Main Drain to Stan. R. via Miller Lake	25	2.5	13.8	0.4	2.8	111.9	20
TID Highline Spill	26	.	.	.	.	.	0
Turlock ID Lateral 2 to SJR	27	0.5	0.5	0.5			1
Turlock ID Westport Drain Flow Station	28	0.6	4.3	0.0	0.9	141.1	26
Turlock ID Harding Drain	29	2.1	8.1	0.3	1.9	88.4	38
Turlock ID Lateral 6 & 7 at Levee	30	0.8	1.4	0.1	0.4	58.1	12
BCID - New Jerusalem Drain	31	0.0	0.1	0.0	0.0	173.2	3
El Solyo WD - Grayson Drain	32	2.3	2.3	2.3	.	.	1

Site name	DO site number	NBOD mg/L Mean	NBOD mg/L Max	NBOD mg/L Min	NBOD mg/L Std Dev	NBOD mg/L CV	NBOD mg/L N
Hospital Creek	33	1.6	5.4	0.0	1.6	99.9	13
Ingram Creek Flow Station	34	3.3	17.2	0.0	4.4	133.3	19
Westley Wasteway Flow Station	35	2.9	6.2	0.0	3.0	104.7	4
Del Puerto Creek Flow Station	36	3.0	14.7	0.3	4.0	133.8	30
Marshall Road Drain	38	1.8	4.1	0.8	1.6	89.6	4
El Solyo Pumping Station	43	.	.	.	.	.	0
San Luis Drain End	44	1.5	5.4	0.0	1.2	77.6	41
Volta Wasteway	45	0.4	0.6	0.2	0.2	44.5	4
Mud Slough at Gun Club Road	46	3.5	6.5	1.4	2.2	63.8	4
FC-5 Grasslands Area Farmers	48	4.9	4.9	4.9	.	.	1
PE-14 Grasslands Area Farmers	49	1.1	1.1	1.1	.	.	1
San Luis Drain Site A (Check 18)	50	1.1	1.2	0.9	0.2	19.6	2
Salt Slough at Sand Dam	52	3.8	3.8	3.8	.	.	1
Salt Slough at Wolfsen Road	53	1.6	4.4	0.6	1.0	60.3	18
Los Banos Creek at Ingomar Grade	54	15.1	15.1	15.1	.	.	1
Ramona Lake	57	3.7	11.7	0.4	3.0	81.6	12
SJR Laird Park	59	1.1	2.5	0.4	0.6	49.5	22
Moffit 1 South	60	0.8	2.7	0.0	0.9	111.3	11
Deadman's Slough	61	1.4	4.2	0.0	1.2	87.1	13
Mallard Slough	62	0.8	2.2	0.0	0.8	109.8	10
Inlet C Canal	63	0.8	3.9	0.0	0.9	115.9	16
Moran Drain	64	1.6	2.4	0.7	1.2	75.4	2
Spanish Grant Drain	65	2.0	4.9	0.5	2.5	123.6	3
ESWD Maze Blv. Drain	66	0.9	1.7	0.3	0.7	85.1	3
Newman Wasteway at Brazo Road	67	2.7	6.0	1.1	2.8	102.9	3
S. Lake Basin	68	2.0	3.2	0.7	1.8	90.5	2
Santa Fe Canal	69	0.5	0.5	0.5	.	.	1
SJR Garwood Bridge	84	1.3	1.3	1.3	.	.	1

Site name	DO site number	TSS mg/L Mean	TSS mg/L Max	TSS mg/L Min	TSS mg/L Std Dev	TSS mg/L CV	TSS mg/L N
SJR at Channel Point	1	25.0	25.0	25.0	.	.	1
SJR at Dos Reis Lathrop	2	22.6	22.6	22.6	.	.	1
SJR at Old River	3	24.3	24.3	24.3	.	.	1
SJR at Mossdale	4	41.9	98.3	16.6	20.3	48.5	38
SJR at Vernalis	5	41.0	106.5	7.4	20.1	49.0	43
SJR at Maze	6	45.4	93.8	14.5	19.4	42.7	37
SJR at Patterson	7	52.6	146.3	19.3	24.5	46.6	44
SJR at Crows Landing	8	51.6	281.4	4.3	40.7	78.9	44
SJR at Fremont Ford	9	59.9	96.2	23.6	51.3	85.7	2
SJR at Lander Avenue	10	40.6	175.3	14.9	25.2	62.1	43
French Camp Slough	11	20.3	30.2	12.6	9.0	44.2	3
Stanislaus River at Caswell Park	12	13.0	48.5	2.0	8.0	61.5	39
Stanislaus River at Ripon	13	.	.	.	.	.	0
Tuolumne River at Shiloh Bridge	14	18.0	252.6	0.0	38.3	212.5	41
Merced River at River Road	16	23.0	109.5	2.2	21.4	93.0	40
Merced River near Stevinson	17	30.2	30.2	30.2	.	.	1
Mud Slough near Gustine	18	72.1	155.2	4.6	32.0	44.4	39
Salt Slough at Lander Avenue	19	86.2	204.7	21.0	42.8	49.7	63
Los Banos Creek at Highway 140	20	100.2	314.5	13.1	80.1	80.0	43
Orestimba Creek at River Road	21	162.4	579.9	24.7	142.5	87.7	36
Modesto ID Lateral 4 to SJR	22	6.0	11.2	3.6	3.1	51.3	5
Modesto ID Lateral 5 to Tuolumne	23	12.5	101.5	0.8	19.4	155.7	27
MID Lat 6 to Stanislaus River	24	19.3	19.3	19.3	.	.	1
MID Main Drain to Stan. R. via Miller Lake	25	28.3	138.4	3.2	30.0	105.9	20
TID Highline Spill	26	16.1	16.1	16.1	.	.	1
Turlock ID Lateral 2 to SJR	27	4.2	4.2	4.2			1
Turlock ID Westport Drain Flow Station	28	25.2	219.0	2.0	43.4	172.5	27
Turlock ID Harding Drain	29	41.6	260.6	5.5	55.1	132.3	36
Turlock ID Lateral 6 & 7 at Levee	30	16.6	77.3	6.8	18.6	112.3	13
BCID - New Jerusalem Drain	31	6.4	13.9	2.0	5.1	80.0	5
El Solyo WD - Grayson Drain	32	921.7	1448.0	395.5	744.2	80.7	2

Site name	DO site number	TSS mg/L Mean	TSS mg/L Max	TSS mg/L Min	TSS mg/L Std Dev	TSS mg/L CV	TSS mg/L N
Hospital Creek	33	1069.5	6335.4	13.7	1726.8	161.5	15
Ingram Creek Flow Station	34	534.7	3454.5	11.9	805.6	150.7	20
Westley Wasteway Flow Station	35	715.3	3106.4	14.6	1340.7	187.4	5
Del Puerto Creek Flow Station	36	158.2	1367.9	7.1	257.9	163.0	33
Marshall Road Drain	38	80.1	128.0	36.9	42.4	52.9	5
El Solyo Pumping Station	43	.	.	.	.	.	0
San Luis Drain End	44	48.1	243.2	16.9	31.7	65.8	47
Volta Wasteway	45	15.5	19.1	8.9	4.9	31.9	5
Mud Slough at Gun Club Road	46	36.4	41.7	30.7	4.8	13.2	5
FC-5 Grasslands Area Farmers	48	68.1	80.2	56.0	17.1	25.1	2
PE-14 Grasslands Area Farmers	49	86.2	94.2	78.2	11.3	13.2	2
San Luis Drain Site A (Check 18)	50	96.9	172.8	29.8	71.9	74.1	3
Salt Slough at Sand Dam	52	84.6	84.6	84.6	.	.	1
Salt Slough at Wolfsen Road	53	72.9	152.5	33.8	28.0	38.5	21
Los Banos Creek at Ingomar Grade	54	74.3	74.3	74.3	.	.	1
Ramona Lake	57	155.2	339.2	74.9	80.0	51.5	10
SJR Laird Park	59	72.6	177.9	9.3	34.5	47.5	22
Moffit 1 South	60	3.3	10.8	0.9	2.6	77.2	13
Deadman's Slough	61	28.6	121.7	1.4	32.1	112.0	16
Mallard Slough	62	14.1	55.6	1.5	14.9	105.9	16
Inlet C Canal	63	86.4	184.5	16.2	48.7	56.3	19
Moran Drain	64	169.2	265.8	120.4	83.7	49.4	3
Spanish Grant Drain	65	296.7	592.5	42.6	260.4	87.8	4
ESWD Maze Blv. Drain	66	493.8	1911.8	7.0	945.4	191.5	4
Newman Wasteway at Brazo Road	67	86.1	189.4	37.2	71.2	82.7	4
S. Lake Basin	68	272.3	333.0	211.5	85.9	31.6	2
Santa Fe Canal	69	8.0	8.0	8.0	.	.	1
SJR Garwood Bridge	84	22.6	22.6	22.6	.	.	1

Site name	DO site number	VSS mg/L Mean	VSS mg/L Max	VSS mg/L Min	VSS mg/L Std Dev	VSS mg/L CV	VSS mg/L N
SJR at Channel Point	1	5.1	5.1	5.1	.	.	1
SJR at Dos Reis Lathrop	2	8.5	8.5	8.5	.	.	1
SJR at Old River	3	7.5	7.5	7.5	.	.	1
SJR at Mossdale	4	5.2	12.3	0.5	2.6	50.5	38
SJR at Vernalis	5	5.1	13.2	0.7	2.6	51.4	43
SJR at Maze	6	5.3	11.9	0.4	2.4	45.0	38
SJR at Patterson	7	6.5	12.8	0.6	2.6	40.3	44
SJR at Crows Landing	8	6.4	13.7	0.5	2.8	43.8	43
SJR at Fremont Ford	9	8.4	11.5	5.2	4.5	53.1	2
SJR at Lander Avenue	10	7.1	25.0	0.6	4.1	58.4	43
French Camp Slough	11	2.5	4.7	0.3	2.2	87.1	3
Stanislaus River at Caswell Park	12	2.0	8.0	0.0	1.6	77.5	40
Stanislaus River at Ripon	13	4.5	4.5	4.5	.	.	1
Tuolumne River at Shiloh Bridge	14	2.1	23.4	0.0	3.7	171.1	41
Merced River at River Road	16	2.9	15.4	0.0	2.6	88.2	40
Merced River near Stevinson	17	0.7	0.7	0.7	.	.	1
Mud Slough near Gustine	18	13.8	28.5	0.5	6.3	45.7	39
Salt Slough at Lander Avenue	19	10.3	62.1	0.9	7.9	76.6	63
Los Banos Creek at Highway 140	20	13.8	37.0	1.4	9.1	66.1	43
Orestimba Creek at River Road	21	14.0	51.1	0.8	11.2	79.6	36
Modesto ID Lateral 4 to SJR	22	1.7	3.0	0.7	1.0	56.4	5
Modesto ID Lateral 5 to Tuolumne	23	3.0	19.0	0.0	3.6	121.3	27
MID Lat 6 to Stanislaus River	24	4.5	4.5	4.5	.	.	1
MID Main Drain to Stan. R. via Miller Lake	25	9.7	104.8	0.9	22.6	232.6	20
TID Highline Spill	26	1.3	1.3	1.3	.	.	1
Turlock ID Lateral 2 to SJR	27	1.1	1.1	1.1			1
Turlock ID Westport Drain Flow Station	28	2.9	8.6	0.1	2.2	75.7	27
Turlock ID Harding Drain	29	5.0	15.3	0.2	3.4	68.4	38
Turlock ID Lateral 6 & 7 at Levee	30	2.4	7.1	1.4	1.5	60.4	13
BCID - New Jerusalem Drain	31	0.6	1.2	0.0	0.5	78.1	5
El Solyo WD - Grayson Drain	32	58.1	82.7	33.4	34.9	60.1	2

Site name	DO site number	VSS mg/L Mean	VSS mg/L Max	VSS mg/L Min	VSS mg/L Std Dev	VSS mg/L CV	VSS mg/L N
Hospital Creek	33	61.8	344.2	0.5	93.0	150.4	15
Ingram Creek Flow Station	34	31.6	138.2	1.2	37.2	117.8	20
Westley Wasteway Flow Station	35	38.7	147.8	5.7	61.7	159.3	5
Del Puerto Creek Flow Station	36	15.7	126.4	0.7	23.3	148.4	33
Marshall Road Drain	38	11.4	19.3	3.9	6.1	53.1	5
El Solyo Pumping Station	43	.	.	.	.	.	0
San Luis Drain End	44	16.9	30.0	0.4	7.1	42.1	47
Volta Wasteway	45	3.0	5.2	1.5	1.4	45.9	5
Mud Slough at Gun Club Road	46	7.2	11.6	5.5	2.5	34.8	5
FC-5 Grasslands Area Farmers	48	12.5	13.9	11.2	1.9	15.5	2
PE-14 Grasslands Area Farmers	49	17.9	20.4	15.3	3.6	20.2	2
San Luis Drain Site A (Check 18)	50	10.5	15.5	4.9	5.3	50.9	3
Salt Slough at Sand Dam	52	7.6	7.6	7.6	.	.	1
Salt Slough at Wolfsen Road	53	8.7	16.5	3.3	2.8	32.4	21
Los Banos Creek at Ingomar Grade	54	6.8	6.8	6.8	.	.	1
Ramona Lake	57	19.4	40.8	3.5	11.9	61.3	10
SJR Laird Park	59	9.1	23.3	2.8	5.1	56.7	22
Moffit 1 South	60	2.2	7.9	0.3	2.3	105.0	13
Deadman's Slough	61	5.7	20.8	0.4	5.1	90.5	16
Mallard Slough	62	4.2	18.7	0.3	4.5	106.8	16
Inlet C Canal	63	8.1	16.2	1.7	3.8	47.4	19
Moran Drain	64	13.7	21.1	8.3	6.6	48.5	3
Spanish Grant Drain	65	23.7	43.3	4.4	18.7	78.8	4
ESWD Maze Blv. Drain	66	27.6	102.7	1.4	50.0	181.2	4
Newman Wasteway at Brazo Road	67	9.4	19.4	4.6	6.8	71.9	4
S. Lake Basin	68	25.8	29.3	22.3	4.9	19.2	2
Santa Fe Canal	69	2.0	2.0	2.0	.	.	1
SJR Garwood Bridge	84	7.1	7.1	7.1	.	.	1

Site name	DO site number	MSS mg/L Mean	MSS mg/L Max	MSS mg/L Min	MSS mg/L Std Dev	MSS mg/L CV	MSS mg/L N
SJR at Channel Point	1	19.9	19.9	19.9	.	.	1
SJR at Dos Reis Lathrop	2	14.1	14.1	14.1	.	.	1
SJR at Old River	3	16.7	16.7	16.7	.	.	1
SJR at Mossdale	4	36.7	86.1	14.0	18.2	49.5	38
SJR at Vernalis	5	36.0	96.5	4.4	18.0	50.2	43
SJR at Maze	6	40.1	82.6	11.6	17.4	43.4	37
SJR at Patterson	7	46.0	139.8	16.6	23.0	49.9	44
SJR at Crows Landing	8	47.6	272.9	14.3	39.0	82.0	42
SJR at Fremont Ford	9	51.5	84.6	18.3	46.9	91.0	2
SJR at Lander Avenue	10	33.5	168.6	8.1	24.7	73.8	43
French Camp Slough	11	18.0	25.4	13.0	6.6	36.5	3
Stanislaus River at Caswell Park	12	11.3	41.9	1.6	6.9	61.0	38
Stanislaus River at Ripon	13	.	.	.	.	.	0
Tuolumne River at Shiloh Bridge	14	15.9	229.2	0.0	34.8	218.6	41
Merced River at River Road	16	20.1	94.1	2.4	19.3	96.2	40
Merced River near Stevinson	17	29.4	29.4	29.4	.	.	1
Mud Slough near Gustine	18	58.3	140.7	1.4	28.6	49.1	39
Salt Slough at Lander Avenue	19	76.0	183.0	15.6	38.5	50.7	63
Los Banos Creek at Highway 140	20	86.4	284.7	11.4	71.6	82.9	43
Orestimba Creek at River Road	21	148.4	528.7	23.8	132.1	89.0	36
Modesto ID Lateral 4 to SJR	22	4.2	10.5	1.9	3.5	83.4	5
Modesto ID Lateral 5 to Tuolumne	23	14.3	119.4	0.0	28.4	198.3	26
MID Lat 6 to Stanislaus River	24	14.8	14.8	14.8	.	.	1
MID Main Drain to Stan. R. via Miller Lake	25	22.8	114.2	2.3	25.0	110.0	20
TID Highline Spill	26	14.8	14.8	14.8	.	.	1
Turlock ID Lateral 2 to SJR	27	3.1	3.1	3.1			1
Turlock ID Westport Drain Flow Station	28	15.0	85.0	0.5	18.5	123.0	26
Turlock ID Harding Drain	29	37.2	248.0	5.2	52.3	140.4	36
Turlock ID Lateral 6 & 7 at Levee	30	14.2	70.2	4.4	17.2	121.6	13
BCID - New Jerusalem Drain	31	5.8	12.7	1.8	4.7	81.9	5
El Solyo WD - Grayson Drain	32	863.7	1365.2	362.1	709.3	82.1	2

Site name	DO site number	MSS mg/L Mean	MSS mg/L Max	MSS mg/L Min	MSS mg/L Std Dev	MSS mg/L CV	MSS mg/L N
Hospital Creek	33	1007.7	5991.1	13.2	1635.5	162.3	15
Ingram Creek Flow Station	34	503.1	3316.3	10.5	770.2	153.1	20
Westley Wasteway Flow Station	35	676.6	2958.6	8.2	1279.3	189.1	5
Del Puerto Creek Flow Station	36	142.5	1241.6	4.5	234.9	164.8	33
Marshall Road Drain	38	68.7	108.7	24.2	38.3	55.7	5
El Solyo Pumping Station	43	.	.	.	.	.	0
San Luis Drain End	44	32.1	217.7	11.1	29.5	92.0	46
Volta Wasteway	45	12.5	16.6	7.4	4.4	35.1	5
Mud Slough at Gun Club Road	46	29.2	35.4	19.1	6.4	22.0	5
FC-5 Grasslands Area Farmers	48	55.6	69.1	42.1	19.1	34.3	2
PE-14 Grasslands Area Farmers	49	68.3	78.9	57.7	15.0	21.9	2
San Luis Drain Site A (Check 18)	50	86.5	157.3	24.9	66.7	77.1	3
Salt Slough at Sand Dam	52	77.0	77.0	77.0	.	.	1
Salt Slough at Wolfsen Road	53	64.2	136.0	26.3	25.7	40.0	21
Los Banos Creek at Ingomar Grade	54	67.5	67.5	67.5	.	.	1
Ramona Lake	57	138.5	301.0	67.4	68.3	49.3	11
SJR Laird Park	59	63.5	154.6	6.5	31.6	49.7	22
Moffit 1 South	60	1.6	5.3	0.0	1.3	82.1	11
Deadman's Slough	61	22.9	114.9	1.0	29.4	127.9	16
Mallard Slough	62	9.9	47.0	0.0	12.4	125.9	16
Inlet C Canal	63	78.3	168.3	12.2	45.0	57.5	19
Moran Drain	64	155.6	244.7	108.8	77.3	49.7	3
Spanish Grant Drain	65	273.0	549.1	38.1	241.8	88.6	4
ESWD Maze Blv. Drain	66	466.2	1809.1	5.6	895.4	192.1	4
Newman Wasteway at Brazo Road	67	76.7	170.0	32.6	64.4	84.1	4
S. Lake Basin	68	246.5	303.7	189.2	81.0	32.9	2
Santa Fe Canal	69	6.0	6.0	6.0	.	.	1
SJR Garwood Bridge	84	15.5	15.5	15.5	.	.	1

Site name	DO site number	TOC mg/L Mean	TOC mg/L Max	TOC mg/L Min	TOC mg/L Std Dev	TOC mg/L CV	TOC mg/L N
SJR at Channel Point	1	3.8	3.8	3.8	.	.	1
SJR at Dos Reis Lathrop	2	4.3	4.3	4.3	.	.	1
SJR at Old River	3	4.7	4.7	4.7	.	.	1
SJR at Mossdale	4	3.9	11.9	0.4	1.6	41.7	37
SJR at Vernalis	5	4.2	12.0	2.6	1.6	38.6	38
SJR at Maze	6	4.2	11.6	2.1	1.5	35.3	37
SJR at Patterson	7	5.4	13.4	2.4	1.8	33.9	39
SJR at Crows Landing	8	5.4	13.0	3.2	2.1	40.0	39
SJR at Fremont Ford	9	7.7	7.8	7.6	0.2	2.0	2
SJR at Lander Avenue	10	6.4	16.1	3.2	2.2	34.9	41
French Camp Slough	11	4.4	5.0	4.1	0.5	11.4	3
Stanislaus River at Caswell Park	12	2.7	8.5	1.4	1.1	42.0	38
Stanislaus River at Ripon	13	1.8	1.8	1.8	.	.	1
Tuolumne River at Shiloh Bridge	14	2.6	9.2	1.1	1.3	51.0	38
Merced River at River Road	16	3.1	14.3	1.1	1.9	63.1	40
Merced River near Stevinson	17	1.4	1.4	1.4	.	.	1
Mud Slough near Gustine	18	11.2	16.3	4.6	2.5	22.1	39
Salt Slough at Lander Avenue	19	7.4	11.5	4.1	1.5	20.8	58
Los Banos Creek at Highway 140	20	12.8	21.7	6.8	3.6	27.9	41
Orestimba Creek at River Road	21	5.5	14.3	2.5	2.6	46.6	35
Modesto ID Lateral 4 to SJR	22	2.7	3.0	2.6	0.2	6.4	4
Modesto ID Lateral 5 to Tuolumne	23	4.2	18.5	1.9	4.0	94.4	26
MID Lat 6 to Stanislaus River	24	3.7	3.7	3.7	.	.	1
MID Main Drain to Stan. R. via Miller Lake	25	10.0	40.9	3.8	8.2	81.7	19
TID Highline Spill	26	2.2	2.2	2.2	.	.	1
Turlock ID Lateral 2 to SJR	27	2.1	2.1	2.1			1
Turlock ID Westport Drain Flow Station	28	4.8	14.8	2.5	2.9	61.2	26
Turlock ID Harding Drain	29	6.0	18.2	2.5	2.9	48.1	37
Turlock ID Lateral 6 & 7 at Levee	30	7.8	13.7	3.9	3.1	39.9	12
BCID - New Jerusalem Drain	31	2.1	2.8	1.8	0.4	21.2	4
El Solyo WD - Grayson Drain	32	21.6	22.7	20.5	1.5	7.1	2

Site name	DO site number	TOC mg/L Mean	TOC mg/L Max	TOC mg/L Min	TOC mg/L Std Dev	TOC mg/L CV	TOC mg/L N
Hospital Creek	33	13.1	52.5	3.3	12.5	94.9	14
Ingram Creek Flow Station	34	9.5	34.5	2.0	8.1	85.2	19
Westley Wasteway Flow Station	35	12.4	33.6	3.9	14.2	114.4	4
Del Puerto Creek Flow Station	36	7.2	43.6	2.0	7.6	105.0	31
Marshall Road Drain	38	5.9	8.6	3.7	2.1	34.7	4
El Solyo Pumping Station	43	.	.	.	.	.	0
San Luis Drain End	44	11.3	17.7	4.8	3.5	30.8	41
Volta Wasteway	45	3.8	4.7	2.7	0.8	20.0	5
Mud Slough at Gun Club Road	46	12.1	14.9	10.5	1.7	14.0	5
FC-5 Grasslands Area Farmers	48	12.2	16.8	7.6	6.5	53.2	2
PE-14 Grasslands Area Farmers	49	9.5	10.0	9.0	0.7	7.6	2
San Luis Drain Site A (Check 18)	50	7.5	8.6	6.1	1.3	17.2	3
Salt Slough at Sand Dam	52	7.8	7.8	7.8	.	.	1
Salt Slough at Wolfsen Road	53	7.7	11.5	5.6	1.4	18.0	20
Los Banos Creek at Ingomar Grade	54	7.6	7.6	7.6	.	.	1
Ramona Lake	57	11.0	16.3	5.0	2.9	26.8	12
SJR Laird Park	59	4.8	6.7	3.0	1.1	23.8	20
Moffit 1 South	60	11.9	16.2	9.0	2.6	22.0	12
Deadman's Slough	61	11.5	21.5	6.5	4.9	42.1	15
Mallard Slough	62	11.7	38.8	6.6	8.2	70.5	15
Inlet C Canal	63	4.7	8.5	2.4	1.4	30.8	18
Moran Drain	64	7.2	9.7	4.3	2.7	38.0	3
Spanish Grant Drain	65	7.7	13.2	4.6	4.7	60.9	3
ESWD Maze Blv. Drain	66	10.5	21.7	3.3	9.9	94.5	3
Newman Wasteway at Brazo Road	67	7.0	10.5	4.6	3.1	43.7	3
S. Lake Basin	68	14.7	25.0	4.4	14.5	98.7	2
Santa Fe Canal	69	3.9	3.9	3.9	.	.	1
SJR Garwood Bridge	84	3.9	3.9	3.9	.	.	1

Site name	DO site number	DOC mg/L Mean	DOC mg/L Max	DOC mg/L Min	DOC mg/L Std Dev	DOC mg/L CV	DOC mg/L N
SJR at Channel Point	1	3.5	3.5	3.5	.	.	1
SJR at Dos Reis Lathrop	2	3.5	3.5	3.5	.	.	1
SJR at Old River	3	3.3	3.3	3.3	.	.	1
SJR at Mossdale	4	3.1	7.0	0.9	0.9	30.1	38
SJR at Vernalis	5	3.5	8.1	1.8	1.3	37.4	39
SJR at Maze	6	3.5	10.1	1.7	1.5	42.5	38
SJR at Patterson	7	4.6	10.2	2.6	1.5	31.8	40
SJR at Crows Landing	8	4.5	8.1	2.7	1.4	30.9	40
SJR at Fremont Ford	9	6.0	7.5	4.5	2.1	35.6	2
SJR at Lander Avenue	10	5.2	10.8	2.9	1.6	30.9	43
French Camp Slough	11	5.1	7.3	3.9	1.9	36.2	3
Stanislaus River at Caswell Park	12	2.4	5.3	1.3	0.8	34.7	40
Stanislaus River at Ripon	13	1.4	1.4	1.4	.	.	1
Tuolumne River at Shiloh Bridge	14	2.2	5.9	1.0	0.8	34.9	41
Merced River at River Road	16	2.6	7.4	1.0	1.0	38.2	40
Merced River near Stevinson	17	1.3	1.3	1.3	.	.	1
Mud Slough near Gustine	18	9.3	18.8	3.5	3.5	37.1	39
Salt Slough at Lander Avenue	19	6.0	8.7	4.1	1.1	17.8	59
Los Banos Creek at Highway 140	20	11.2	20.4	4.8	3.7	32.7	41
Orestimba Creek at River Road	21	4.8	22.2	2.4	3.8	79.1	36
Modesto ID Lateral 4 to SJR	22	2.4	2.8	1.9	0.4	16.1	5
Modesto ID Lateral 5 to Tuolumne	23	3.1	11.3	1.5	2.1	68.3	28
MID Lat 6 to Stanislaus River	24	4.4	4.4	4.4	.	.	1
MID Main Drain to Stan. R. via Miller Lake	25	8.8	24.2	3.4	5.8	65.9	20
TID Highline Spill	26	1.6	1.6	1.6	.	.	1
Turlock ID Lateral 2 to SJR	27	2.6	2.6	2.6			1
Turlock ID Westport Drain Flow Station	28	4.0	10.0	2.1	1.7	40.8	27
Turlock ID Harding Drain	29	5.1	10.0	2.2	1.6	32.0	38
Turlock ID Lateral 6 & 7 at Levee	30	7.0	14.1	3.9	3.1	44.3	13
BCID - New Jerusalem Drain	31	7.3	13.8	2.5	4.5	61.8	5
El Solyo WD - Grayson Drain	32	10.3	15.0	5.5	6.7	65.3	2

Site name	DO site number	DOC mg/L Mean	DOC mg/L Max	DOC mg/L Min	DOC mg/L Std Dev	DOC mg/L CV	DOC mg/L N
Hospital Creek	33	6.7	16.7	2.6	4.1	61.8	15
Ingram Creek Flow Station	34	4.2	11.2	1.8	2.3	53.6	20
Westley Wasteway Flow Station	35	3.6	5.3	1.8	1.5	40.4	5
Del Puerto Creek Flow Station	36	4.7	19.1	2.2	3.4	71.8	33
Marshall Road Drain	38	11.8	37.6	2.8	14.8	125.5	5
El Solyo Pumping Station	43	.	.	.	.	.	0
San Luis Drain End	44	7.1	11.2	3.7	1.5	21.4	43
Volta Wasteway	45	3.3	3.9	2.4	0.7	19.7	5
Mud Slough at Gun Club Road	46	11.0	13.8	9.5	1.8	15.9	5
FC-5 Grasslands Area Farmers	48	8.8	10.8	6.9	2.8	31.1	2
PE-14 Grasslands Area Farmers	49	7.9	9.0	6.8	1.6	20.1	2
San Luis Drain Site A (Check 18)	50	6.4	7.3	5.5	0.9	13.9	3
Salt Slough at Sand Dam	52	4.2	4.2	4.2	.	.	1
Salt Slough at Wolfsen Road	53	6.3	8.3	4.6	1.1	17.6	20
Los Banos Creek at Ingomar Grade	54	5.8	5.8	5.8	.	.	1
Ramona Lake	57	7.3	9.8	3.6	2.0	27.3	12
SJR Laird Park	59	3.9	6.8	2.5	1.0	26.6	22
Moffit 1 South	60	11.4	14.7	8.6	2.1	18.6	12
Deadman's Slough	61	10.5	22.0	5.3	4.8	45.8	15
Mallard Slough	62	10.9	34.5	6.4	7.0	63.9	15
Inlet C Canal	63	3.2	5.9	1.8	0.9	28.3	18
Moran Drain	64	4.4	6.6	1.5	2.6	59.0	3
Spanish Grant Drain	65	4.7	7.9	3.0	2.2	47.9	4
ESWD Maze Blv. Drain	66	4.0	6.2	1.8	1.9	47.9	4
Newman Wasteway at Brazo Road	67	20.7	37.7	4.5	17.8	85.9	4
S. Lake Basin	68	12.2	21.0	3.4	12.5	102.4	2
Santa Fe Canal	69	2.9	2.9	2.9	.	.	1
SJR Garwood Bridge	84	3.5	3.5	3.5	.	.	1

Site name	DO site number	Turbidity NTU Mean	Turbidity NTU Max	Turbidity NTU Min	Turbidity NTU Std Dev	Turbidity NTU CV	Turbidity NTU N
SJR at Channel Point	1	15.6	15.6	15.6	.	.	1
SJR at Dos Reis Lathrop	2	10.7	10.7	10.7	.	.	1
SJR at Old River	3	9.7	9.7	9.7	.	.	1
SJR at Mossdale	4	21.4	64.0	4.9	11.1	51.9	38
SJR at Vernalis	5	21.3	74.0	3.7	11.9	56.1	43
SJR at Maze	6	25.7	78.7	7.6	13.8	53.5	37
SJR at Patterson	7	31.5	94.5	10.0	15.5	49.2	45
SJR at Crows Landing	8	28.3	90.8	10.9	13.9	49.3	44
SJR at Fremont Ford	9	34.6	56.3	12.9	30.7	88.6	2
SJR at Lander Avenue	10	28.9	191.3	12.4	26.6	92.1	43
French Camp Slough	11	13.5	20.5	7.4	6.6	49.1	3
Stanislaus River at Caswell Park	12	7.2	32.0	0.0	7.3	101.5	40
Stanislaus River at Ripon	13	2.7	2.7	2.7	.	.	1
Tuolumne River at Shiloh Bridge	14	6.2	46.3	0.0	8.1	131.7	41
Merced River at River Road	16	11.4	116.1	0.0	18.0	158.4	40
Merced River near Stevinson	17	7.2	7.2	7.2	.	.	1
Mud Slough near Gustine	18	39.5	95.6	10.0	19.3	49.0	39
Salt Slough at Lander Avenue	19	51.5	116.3	0.5	26.2	50.9	62
Los Banos Creek at Highway 140	20	78.5	207.0	11.1	55.6	70.9	43
Orestimba Creek at River Road	21	125.8	417.3	4.7	102.7	81.6	37
Modesto ID Lateral 4 to SJR	22	1.9	3.3	0.9	1.0	54.8	5
Modesto ID Lateral 5 to Tuolumne	23	7.0	46.8	0.0	11.0	158.2	28
MID Lat 6 to Stanislaus River	24	11.9	11.9	11.9	.	.	1
MID Main Drain to Stan. R. via Miller Lake	25	19.6	77.7	1.6	17.3	88.4	21
TID Highline Spill	26	9.9	9.9	9.9	.	.	1
Turlock ID Lateral 2 to SJR	27	2.3	2.8	1.9	0.7	29.1	2
Turlock ID Westport Drain Flow Station	28	12.0	73.4	-0.1	17.4	144.9	27
Turlock ID Harding Drain	29	17.7	77.4	1.7	15.6	88.3	37
Turlock ID Lateral 6 & 7 at Levee	30	10.1	43.7	1.9	12.5	123.2	14
BCID - New Jerusalem Drain	31	11.7	21.4	5.2	8.5	72.5	3
El Solyo WD - Grayson Drain	32	653.9	1582.1	90.7	810.0	123.9	3

Site name	DO site number	Turbidity NTU Mean	Turbidity NTU Max	Turbidity NTU Min	Turbidity NTU Std Dev	Turbidity NTU CV	Turbidity NTU N
Hospital Creek	33	524.3	2049.7	30.7	696.0	132.8	14
Ingram Creek Flow Station	34	436.6	2103.1	7.8	545.8	125.0	20
Westley Wasteway Flow Station	35	329.9	1282.9	12.6	483.1	146.4	6
Del Puerto Creek Flow Station	36	100.8	651.0	1.1	142.6	141.5	32
Marshall Road Drain	38	84.0	127.2	44.5	43.5	51.8	4
El Solyo Pumping Station	43	43.6	43.6	43.6	.	.	1
San Luis Drain End	44	23.4	47.2	8.6	9.1	39.0	45
Volta Wasteway	45	9.4	12.5	4.6	3.1	33.5	5
Mud Slough at Gun Club Road	46	16.2	19.3	13.9	2.0	12.5	5
FC-5 Grasslands Area Farmers	48	19.0	19.0	19.0	.	.	1
PE-14 Grasslands Area Farmers	49	30.6	30.6	30.6	.	.	1
San Luis Drain Site A (Check 18)	50	57.2	70.5	43.8	18.9	33.1	2
Salt Slough at Sand Dam	52	95.7	95.7	95.7	.	.	1
Salt Slough at Wolfsen Road	53	44.5	106.8	1.4	21.1	47.4	20
Los Banos Creek at Ingomar Grade	54	74.0	74.0	74.0	.	.	1
Ramona Lake	57	97.6	250.3	49.3	54.4	55.7	12
SJR Laird Park	59	29.8	52.4	4.8	15.1	50.7	17
Moffit 1 South	60	1.8	7.5	-1.7	2.8	154.4	14
Deadman's Slough	61	14.2	43.7	-0.1	15.0	105.7	18
Mallard Slough	62	8.5	27.8	0.0	8.9	105.0	15
Inlet C Canal	63	48.9	92.7	11.4	23.5	48.1	18
Moran Drain	64	119.2	181.1	43.0	70.1	58.8	3
Spanish Grant Drain	65	227.2	427.7	20.5	170.8	75.2	4
ESWD Maze Blv. Drain	66	378.8	1422.3	20.5	695.8	183.7	4
Newman Wasteway at Brazo Road	67	87.6	137.6	43.8	42.1	48.0	4
S. Lake Basin	68	23.5	27.0	19.9	5.0	21.5	2
Santa Fe Canal	69	.	.	.	.	.	0
SJR Garwood Bridge	84	14.1	14.1	14.1	.	.	1

Site name	DO site number	Spec Cond mS/cm Mean	Spec Cond mS/cm Max	Spec Cond mS/cm Min	Spec Cond mS/cm Std Dev	Spec Cond mS/cm CV	Spec Cond mS/cm N
SJR at Channel Point	1	0.458	0.458	0.458	.	.	1
SJR at Dos Reis Lathrop	2	0.511	0.511	0.511	.	.	1
SJR at Old River	3	0.523	0.523	0.523	.	.	1
SJR at Mossdale	4	0.352	0.742	0.042	0.199	56.493	38
SJR at Vernalis	5	0.358	0.762	0.094	0.195	54.493	43
SJR at Maze	6	0.451	1.002	0.104	0.250	55.504	37
SJR at Patterson	7	0.641	1.447	0.117	0.358	55.805	45
SJR at Crows Landing	8	0.630	1.470	0.002	0.339	53.776	44
SJR at Fremont Ford	9	1.189	1.391	0.986	0.286	24.057	2
SJR at Lander Avenue	10	0.556	1.264	0.049	0.371	66.702	43
French Camp Slough	11	0.483	0.736	0.099	0.338	70.043	3
Stanislaus River at Caswell Park	12	0.097	0.415	0.059	0.058	59.872	40
Stanislaus River at Ripon	13	0.104	0.104	0.104	.	.	1
Tuolumne River at Shiloh Bridge	14	0.103	0.494	0.041	0.078	75.880	41
Merced River at River Road	16	0.104	0.569	0.036	0.094	89.626	40
Merced River near Stevinson	17	0.039	0.039	0.039	.	.	1
Mud Slough near Gustine	18	2.462	4.299	1.118	0.898	36.463	39
Salt Slough at Lander Avenue	19	1.168	2.379	0.499	0.380	32.554	62
Los Banos Creek at Highway 140	20	1.263	3.154	0.499	0.627	49.632	43
Orestimba Creek at River Road	21	0.525	1.059	0.090	0.219	41.656	37
Modesto ID Lateral 4 to SJR	22	0.190	0.292	0.046	0.117	61.697	5
Modesto ID Lateral 5 to Tuolumne	23	0.123	0.536	0.030	0.116	94.742	28
MID Lat 6 to Stanislaus River	24	0.068	0.068	0.068	.	.	1
MID Main Drain to Stan. R. via Miller Lake	25	0.363	0.968	0.065	0.203	55.984	21
TID Highline Spill	26	0.038	0.038	0.038	.	.	1
Turlock ID Lateral 2 to SJR	27	0.069	0.083	0.054	0.021	29.936	2
Turlock ID Westport Drain Flow Station	28	0.695	1.184	0.140	0.290	41.768	27
Turlock ID Harding Drain	29	0.655	1.227	0.298	0.226	34.529	38
Turlock ID Lateral 6 & 7 at Levee	30	0.694	1.511	0.366	0.296	42.568	14
BCID - New Jerusalem Drain	31	2.391	2.536	2.156	0.165	6.905	4
El Solyo WD - Grayson Drain	32	0.545	0.761	0.425	0.187	34.361	3

Site name	DO site number	Spec Cond mS/cm Mean	Spec Cond mS/cm Max	Spec Cond mS/cm Min	Spec Cond mS/cm Std Dev	Spec Cond mS/cm CV	Spec Cond mS/cm N
Hospital Creek	33	0.455	1.241	0.146	0.277	60.844	15
Ingram Creek Flow Station	34	0.767	2.030	0.247	0.503	65.528	20
Westley Wasteway Flow Station	35	0.629	0.683	0.564	0.051	8.112	6
Del Puerto Creek Flow Station	36	0.687	1.441	0.338	0.229	33.384	33
Marshall Road Drain	38	0.614	0.785	0.449	0.166	27.019	4
El Solyo Pumping Station	43	0.533	0.533	0.533	.	.	1
San Luis Drain End	44	4.552	5.706	3.243	0.592	13.003	46
Volta Wasteway	45	0.613	1.356	0.325	0.422	68.758	5
Mud Slough at Gun Club Road	46	1.058	1.375	0.821	0.228	21.532	5
FC-5 Grasslands Area Farmers	48	5.165	5.165	5.165	.	.	1
PE-14 Grasslands Area Farmers	49	5.908	5.908	5.908	.	.	1
San Luis Drain Site A (Check 18)	50	5.108	5.437	4.779	0.465	9.107	2
Salt Slough at Sand Dam	52	0.726	0.726	0.726	.	.	1
Salt Slough at Wolfsen Road	53	1.219	2.033	0.811	0.329	26.973	20
Los Banos Creek at Ingomar Grade	54	0.680	0.680	0.680	.	.	1
Ramona Lake	57	1.145	1.502	0.957	0.159	13.918	12
SJR Laird Park	59	0.592	0.958	0.149	0.274	46.304	17
Moffit 1 South	60	0.894	1.463	0.530	0.318	35.519	14
Deadman's Slough	61	1.075	2.019	0.566	0.456	42.378	18
Mallard Slough	62	1.784	5.984	0.594	1.406	78.858	15
Inlet C Canal	63	0.620	1.551	0.357	0.306	49.392	18
Moran Drain	64	0.552	0.652	0.434	0.110	19.947	3
Spanish Grant Drain	65	0.627	0.719	0.505	0.092	14.587	4
ESWD Maze Blv. Drain	66	0.488	0.543	0.417	0.052	10.700	4
Newman Wasteway at Brazo Road	67	1.309	1.740	0.930	0.380	29.037	4
S. Lake Basin	68	0.651	0.836	0.467	0.261	40.094	2
Santa Fe Canal	69	.	.	.	.	.	0
SJR Garwood Bridge	84	0.513	0.513	0.513	.	.	1

Site name	DO site number	pH Mean	pH Max	pH Min	pH Std Dev	pH CV	pH N
SJR at Channel Point	1	7.59	7.59	7.59	.	.	1
SJR at Dos Reis Lathrop	2	9.05	9.05	9.05	.	.	1
SJR at Old River	3	8.94	8.94	8.94	.	.	1
SJR at Mossdale	4	7.62	8.84	6.84	0.40	5.27	38
SJR at Vernalis	5	7.64	8.65	7.06	0.31	4.02	43
SJR at Maze	6	7.64	8.08	7.14	0.22	2.83	37
SJR at Patterson	7	7.71	8.19	7.14	0.26	3.34	45
SJR at Crows Landing	8	7.72	8.24	7.32	0.19	2.48	44
SJR at Fremont Ford	9	7.91	7.93	7.89	0.02	0.31	2
SJR at Lander Avenue	10	8.00	9.14	7.20	0.40	5.05	43
French Camp Slough	11	7.80	7.90	7.69	0.11	1.39	3
Stanislaus River at Caswell Park	12	7.54	8.34	6.76	0.36	4.75	40
Stanislaus River at Ripon	13	7.64	7.64	7.64	.	.	1
Tuolumne River at Shiloh Bridge	14	7.79	8.73	6.96	0.43	5.58	41
Merced River at River Road	16	7.49	8.39	7.02	0.28	3.77	40
Merced River near Stevinson	17	7.37	7.37	7.37	.	.	1
Mud Slough near Gustine	18	8.10	8.66	7.52	0.34	4.19	39
Salt Slough at Lander Avenue	19	7.66	8.01	7.11	0.17	2.25	62
Los Banos Creek at Highway 140	20	7.66	8.50	7.08	0.31	4.00	43
Orestimba Creek at River Road	21	7.95	8.57	7.60	0.23	2.88	37
Modesto ID Lateral 4 to SJR	22	8.68	8.96	8.50	0.23	2.60	5
Modesto ID Lateral 5 to Tuolumne	23	8.32	9.76	7.44	0.64	7.74	28
MID Lat 6 to Stanislaus River	24	7.35	7.35	7.35	.	.	1
MID Main Drain to Stan. R. via Miller Lake	25	7.62	7.99	7.22	0.22	2.90	21
TID Highline Spill	26	8.32	8.32	8.32	.	.	1
Turlock ID Lateral 2 to SJR	27	8.20	8.95	7.44	1.07	13.05	2
Turlock ID Westport Drain Flow Station	28	8.00	8.58	7.30	0.29	3.67	27
Turlock ID Harding Drain	29	7.77	8.28	7.00	0.21	2.68	38
Turlock ID Lateral 6 & 7 at Levee	30	7.70	8.10	7.43	0.20	2.62	14
BCID - New Jerusalem Drain	31	7.43	7.65	7.27	0.17	2.30	4
El Solyo WD - Grayson Drain	32	7.91	8.38	7.48	0.45	5.70	3

Site name	DO site number	pH Mean	pH Max	pH Min	pH Std Dev	pH CV	pH N
Hospital Creek	33	7.96	8.56	7.35	0.37	4.61	15
Ingram Creek Flow Station	34	7.90	8.19	7.32	0.24	2.98	20
Westley Wasteway Flow Station	35	8.43	9.13	7.91	0.40	4.69	6
Del Puerto Creek Flow Station	36	8.21	9.36	7.60	0.40	4.84	33
Marshall Road Drain	38	7.69	7.78	7.58	0.08	1.08	4
El Solyo Pumping Station	43	7.76	7.76	7.76	.	.	1
San Luis Drain End	44	8.47	9.08	7.75	0.27	3.14	46
Volta Wasteway	45	7.78	7.91	7.63	0.12	1.54	5
Mud Slough at Gun Club Road	46	7.76	8.53	7.47	0.44	5.67	5
FC-5 Grasslands Area Farmers	48	8.46	8.46	8.46	.	.	1
PE-14 Grasslands Area Farmers	49	8.44	8.44	8.44	.	.	1
San Luis Drain Site A (Check 18)	50	8.13	8.29	7.98	0.22	2.67	2
Salt Slough at Sand Dam	52	7.40	7.40	7.40	.	.	1
Salt Slough at Wolfsen Road	53	7.46	7.74	7.05	0.14	1.92	20
Los Banos Creek at Ingomar Grade	54	7.75	7.75	7.75	.	.	1
Ramona Lake	57	7.91	9.49	7.49	0.52	6.61	12
SJR Laird Park	59	7.83	8.27	7.60	0.20	2.60	17
Moffit 1 South	60	7.25	7.58	6.95	0.19	2.56	14
Deadman's Slough	61	7.35	8.25	6.96	0.31	4.22	18
Mallard Slough	62	7.23	7.97	6.84	0.29	3.95	15
Inlet C Canal	63	7.79	7.98	7.38	0.16	2.07	18
Moran Drain	64	7.91	8.11	7.71	0.20	2.48	3
Spanish Grant Drain	65	7.89	8.15	7.46	0.31	3.88	4
ESWD Maze Blv. Drain	66	8.45	8.82	8.07	0.35	4.16	4
Newman Wasteway at Brazo Road	67	7.45	7.61	7.35	0.12	1.67	4
S. Lake Basin	68	7.85	8.18	7.52	0.47	5.93	2
Santa Fe Canal	69	.	.	.	.	.	0
SJR Garwood Bridge	84	8.13	8.13	8.13	.	.	1

Site name	DO site number	Chl-a by TC ug/L Mean	Chl-a by TC ug/L Max	Chl-a by TC ug/L Min	Chl-a by TC ug/L Std Dev	Chl-a by TC ug/L CV	Chl-a by TC ug/L N
SJR at Channel Point	1	25.5	25.5	25.5	.	.	1
SJR at Dos Reis Lathrop	2	95.6	95.6	95.6	.	.	1
SJR at Old River	3	103.5	103.5	103.5	.	.	1
SJR at Mossdale	4	18.7	112.0	3.0	21.2	113.5	38
SJR at Vernalis	5	15.6	66.6	2.8	15.2	97.2	43
SJR at Maze	6	16.3	70.6	1.6	16.0	98.1	38
SJR at Patterson	7	24.5	102.7	2.4	22.1	90.0	43
SJR at Crows Landing	8	23.0	67.1	7.3	15.3	66.8	39
SJR at Fremont Ford	9	45.5	46.4	44.6	1.3	2.8	2
SJR at Lander Avenue	10	37.9	192.7	3.1	40.2	105.9	39
French Camp Slough	11	4.2	8.0	1.2	3.5	83.8	3
Stanislaus River at Caswell Park	12	2.2	6.8	0.1	1.4	65.2	37
Stanislaus River at Ripon	13	3.0	3.0	3.0	.	.	1
Tuolumne River at Shiloh Bridge	14	2.4	18.0	0.3	2.9	120.9	40
Merced River at River Road	16	2.1	9.7	0.0	1.7	84.9	39
Merced River near Stevinson	17	2.1	2.1	2.1	.	.	1
Mud Slough near Gustine	18	69.6	273.5	5.6	56.4	81.0	36
Salt Slough at Lander Avenue	19	13.0	42.3	3.6	7.2	55.5	44
Los Banos Creek at Highway 140	20	42.6	149.0	2.8	40.4	94.8	39
Orestimba Creek at River Road	21	5.9	30.5	0.9	6.2	104.9	36
Modesto ID Lateral 4 to SJR	22	3.5	4.7	2.1	1.2	34.9	5
Modesto ID Lateral 5 to Tuolumne	23	5.3	48.2	0.2	9.1	172.7	28
MID Lat 6 to Stanislaus River	24	3.4	3.4	3.4	.	.	1
MID Main Drain to Stan. R. via Miller Lake	25	21.9	80.8	1.2	21.2	96.8	19
TID Highline Spill	26	1.2	1.2	1.2	.	.	1
Turlock ID Lateral 2 to SJR	27	3.1	3.1	3.1			1
Turlock ID Westport Drain Flow Station	28	7.3	48.7	0.8	10.4	142.4	24
Turlock ID Harding Drain	29	5.0	14.5	1.1	3.2	63.0	37
Turlock ID Lateral 6 & 7 at Levee	30	5.9	26.5	1.1	6.6	112.3	13
BCID - New Jerusalem Drain	31	0.2	0.8	0.0	0.3	133.8	5
El Solyo WD - Grayson Drain	32	54.3	100.7	7.8	65.7	121.0	2

Site name	DO site number	Chl-a by TC ug/L Mean	Chl-a by TC ug/L Max	Chl-a by TC ug/L Min	Chl-a by TC ug/L Std Dev	Chl-a by TC ug/L CV	Chl-a by TC ug/L N
Hospital Creek	33	13.6	73.2	0.8	19.0	139.1	15
Ingram Creek Flow Station	34	17.1	97.0	0.7	23.3	136.0	20
Westley Wasteway Flow Station	35	39.1	146.1	7.8	60.0	153.4	5
Del Puerto Creek Flow Station	36	23.3	213.2	2.6	37.6	161.7	33
Marshall Road Drain	38	18.3	42.6	5.0	15.2	83.4	5
El Solyo Pumping Station	43	.	.	.	.	.	0
San Luis Drain End	44	120.8	315.6	10.7	74.4	61.6	43
Volta Wasteway	45	23.7	23.7	23.7	.	.	1
Mud Slough at Gun Club Road	46	22.7	22.7	22.7	.	.	1
FC-5 Grasslands Area Farmers	48	83.1	110.2	56.0	38.3	46.1	2
PE-14 Grasslands Area Farmers	49	59.4	66.8	51.9	10.5	17.7	2
San Luis Drain Site A (Check 18)	50	46.6	84.9	17.3	34.7	74.3	3
Salt Slough at Sand Dam	52	20.8	20.8	20.8	.	.	1
Salt Slough at Wolfsen Road	53	13.3	13.3	13.3	.	.	1
Los Banos Creek at Ingomar Grade	54	20.3	20.3	20.3	.	.	1
Ramona Lake	57	107.4	688.3	5.8	188.8	175.7	12
SJR Laird Park	59	36.1	166.6	3.3	35.5	98.4	22
Moffit 1 South	60	.	.	.	.	.	0
Deadman's Slough	61	.	.	.	.	.	0
Mallard Slough	62	.	.	.	.	.	0
Inlet C Canal	63	.	.	.	.	.	0
Moran Drain	64	12.9	14.1	12.1	1.1	8.3	3
Spanish Grant Drain	65	9.4	10.3	8.4	1.0	10.5	4
ESWD Maze Blv. Drain	66	19.1	41.0	3.3	19.6	102.9	3
Newman Wasteway at Brazo Road	67	12.0	14.5	8.1	2.8	23.2	4
S. Lake Basin	68	13.0	19.8	6.2	9.7	74.3	2
Santa Fe Canal	69	14.5	14.5	14.5	.	.	1
SJR Garwood Bridge	84	67.3	67.3	67.3	.	.	1

Site name	DO site number	Algal pigments ug/L Mean	Algal pigments ug/L Max	Algal pigments ug/L Min	Algal pigments ug/L Std Dev	Algal pigments ug/L CV	Algal pigments ug/L N
SJR at Channel Point	1	31.2	31.2	31.2	.	.	1
SJR at Dos Reis Lathrop	2	97.7	97.7	97.7	.	.	1
SJR at Old River	3	103.7	103.7	103.7	.	.	1
SJR at Mossdale	4	20.0	112.2	3.2	22.4	111.9	35
SJR at Vernalis	5	16.6	67.0	3.1	15.7	94.5	41
SJR at Maze	6	17.8	71.6	1.3	16.6	93.6	37
SJR at Patterson	7	26.1	102.9	2.2	22.6	86.6	43
SJR at Crows Landing	8	23.9	66.9	8.1	15.6	65.3	37
SJR at Fremont Ford	9	48.2	48.6	47.7	0.7	1.4	2
SJR at Lander Avenue	10	41.0	202.0	3.6	41.9	102.3	38
French Camp Slough	11	4.5	8.3	1.6	3.5	77.0	3
Stanislaus River at Caswell Park	12	2.8	6.7	-0.4	1.5	55.5	31
Stanislaus River at Ripon	13	3.9	3.9	3.9	.	.	1
Tuolumne River at Shiloh Bridge	14	3.1	22.2	0.7	3.7	121.8	35
Merced River at River Road	16	2.5	10.0	0.0	1.9	76.9	35
Merced River near Stevinson	17	2.6	2.6	2.6	.	.	1
Mud Slough near Gustine	18	71.1	278.5	6.3	56.5	79.5	35
Salt Slough at Lander Avenue	19	14.4	43.5	3.8	7.4	51.5	41
Los Banos Creek at Highway 140	20	48.3	174.0	3.2	46.2	95.7	39
Orestimba Creek at River Road	21	6.6	31.9	0.8	6.8	102.0	34
Modesto ID Lateral 4 to SJR	22	4.0	5.1	2.4	1.4	35.7	3
Modesto ID Lateral 5 to Tuolumne	23	6.7	57.5	0.6	11.6	172.8	24
MID Lat 6 to Stanislaus River	24	4.3	4.3	4.3	.	.	1
MID Main Drain to Stan. R. via Miller Lake	25	25.3	82.6	1.3	24.1	95.3	19
TID Highline Spill	26	2.4	2.4	2.4	.	.	1
Turlock ID Lateral 2 to SJR	27	2.9	2.9	2.9			1
Turlock ID Westport Drain Flow Station	28	8.3	50.9	0.9	11.1	133.2	23
Turlock ID Harding Drain	29	6.1	17.6	1.3	4.0	65.1	33
Turlock ID Lateral 6 & 7 at Levee	30	7.2	29.7	1.3	7.6	105.2	13
BCID - New Jerusalem Drain	31	0.3	0.7	0.1	0.2	76.3	4
El Solyo WD - Grayson Drain	32	53.2	98.4	8.1	63.8	119.9	2

Site name	DO site number	Algal pigments ug/L Mean	Algal pigments ug/L Max	Algal pigments ug/L Min	Algal pigments ug/L Std Dev	Algal pigments ug/L CV	Algal pigments ug/L N
Hospital Creek	33	14.0	70.8	0.4	18.8	133.8	15
Ingram Creek Flow Station	34	17.9	98.3	0.0	23.6	131.4	20
Westley Wasteway Flow Station	35	43.0	151.6	9.2	61.0	141.9	5
Del Puerto Creek Flow Station	36	27.4	258.1	3.0	45.6	166.7	33
Marshall Road Drain	38	20.6	49.5	6.0	17.4	84.5	5
El Solyo Pumping Station	43	.	.	.	.	.	0
San Luis Drain End	44	126.4	439.0	11.2	86.5	68.4	43
Volta Wasteway	45	25.6	25.6	25.6	.	.	1
Mud Slough at Gun Club Road	46	24.0	24.0	24.0	.	.	1
FC-5 Grasslands Area Farmers	48	84.5	110.7	58.4	37.0	43.8	2
PE-14 Grasslands Area Farmers	49	59.7	66.9	52.5	10.2	17.1	2
San Luis Drain Site A (Check 18)	50	47.8	86.6	17.8	35.2	73.6	3
Salt Slough at Sand Dam	52	25.3	25.3	25.3	.	.	1
Salt Slough at Wolfsen Road	53	15.7	15.7	15.7	.	.	1
Los Banos Creek at Ingomar Grade	54	21.8	21.8	21.8	.	.	1
Ramona Lake	57	106.1	671.1	6.3	183.8	173.3	12
SJR Laird Park	59	40.3	182.3	4.0	39.8	98.8	22
Moffit 1 South	60	.	.	.	.	.	0
Deadman's Slough	61	.	.	.	.	.	0
Mallard Slough	62	.	.	.	.	.	0
Inlet C Canal	63	.	.	.	.	.	0
Moran Drain	64	14.4	14.6	14.3	0.2	1.1	3
Spanish Grant Drain	65	10.3	11.7	8.5	1.4	13.7	4
ESWD Maze Blv. Drain	66	19.4	41.1	4.1	19.3	99.6	3
Newman Wasteway at Brazo Road	67	15.4	21.6	9.7	5.0	32.4	4
S. Lake Basin	68	14.0	21.2	6.7	10.2	73.3	2
Santa Fe Canal	69	16.0	16.0	16.0	.	.	1
SJR Garwood Bridge	84	75.6	75.6	75.6	.	.	1

Site name	DO site number	T-Alk mg CaCO3/L Mean	T-Alk mg CaCO3/L Max	T-Alk mg CaCO3/L Min	T-Alk mg CaCO3/L Std Dev	T-Alk mg CaCO3/L CV	T-Alk mg CaCO3/L N
SJR at Channel Point	1	75.0	75.0	75.0	.	.	1
SJR at Dos Reis Lathrop	2	82.0	82.0	82.0	.	.	1
SJR at Old River	3	84.0	84.0	84.0	.	.	1
SJR at Mossdale	4	63.6	118.0	29.0	23.3	36.7	37
SJR at Vernalis	5	64.1	118.0	27.0	26.0	40.6	37
SJR at Maze	6	72.7	149.0	28.0	32.8	45.1	37
SJR at Patterson	7	88.3	177.0	27.0	36.4	41.2	38
SJR at Crows Landing	8	88.8	166.0	26.0	34.9	39.2	39
SJR at Fremont Ford	9	148.0	148.0	148.0	.	.	1
SJR at Lander Avenue	10	106.7	198.0	18.0	53.7	50.4	42
French Camp Slough	11	87.3	119.0	39.0	42.5	48.7	3
Stanislaus River at Caswell Park	12	35.6	56.6	22.0	6.9	19.5	38
Stanislaus River at Ripon	13	43.0	43.0	43.0	.	.	1
Tuolumne River at Shiloh Bridge	14	34.9	54.0	18.0	11.6	33.3	38
Merced River at River Road	16	30.7	61.0	16.0	11.1	36.3	39
Merced River near Stevinson	17	17.0	17.0	17.0	.	.	1
Mud Slough near Gustine	18	165.7	300.0	102.0	53.9	32.5	37
Salt Slough at Lander Avenue	19	154.6	254.0	104.0	36.3	23.5	59
Los Banos Creek at Highway 140	20	217.6	544.0	0.0	94.4	43.4	40
Orestimba Creek at River Road	21	112.9	212.0	42.0	38.5	34.1	36
Modesto ID Lateral 4 to SJR	22	49.6	100.0	21.0	34.3	69.1	5
Modesto ID Lateral 5 to Tuolumne	23	35.7	160.0	15.0	30.7	86.1	28
MID Lat 6 to Stanislaus River	24	27.0	27.0	27.0	.	.	1
MID Main Drain to Stan. R. via Miller Lake	25	145.7	405.0	77.0	79.6	54.6	20
TID Highline Spill	26	17.0	17.0	17.0	.	.	1
Turlock ID Lateral 2 to SJR	27	19.0	19.0	19.0			1
Turlock ID Westport Drain Flow Station	28	210.0	361.0	47.0	97.0	46.2	27
Turlock ID Harding Drain	29	131.5	225.0	60.0	39.6	30.1	37
Turlock ID Lateral 6 & 7 at Levee	30	161.8	286.0	80.0	62.6	38.7	13
BCID - New Jerusalem Drain	31	307.2	324.0	292.0	13.8	4.5	5
El Solyo WD - Grayson Drain	32	96.0	102.0	90.0	8.5	8.8	2

Site name	DO site number	T-Alk mg CaCO3/L Mean	T-Alk mg CaCO3/L Max	T-Alk mg CaCO3/L Min	T-Alk mg CaCO3/L Std Dev	T-Alk mg CaCO3/L CV	T-Alk mg CaCO3/L N
Hospital Creek	33	79.4	116.0	36.0	20.1	25.3	15
Ingram Creek Flow Station	34	116.4	262.0	27.1	62.9	54.1	20
Westley Wasteway Flow Station	35	87.0	100.0	74.0	9.4	10.8	5
Del Puerto Creek Flow Station	36	128.8	388.0	64.0	78.4	60.9	33
Marshall Road Drain	38	97.0	125.0	73.0	18.9	19.5	5
El Solyo Pumping Station	43	.	.	.	.	.	0
San Luis Drain End	44	141.4	226.0	86.0	38.5	27.3	42
Volta Wasteway	45	132.8	312.0	75.0	100.8	75.9	5
Mud Slough at Gun Club Road	46	201.0	236.0	185.0	20.6	10.3	5
FC-5 Grasslands Area Farmers	48	185.0	198.0	172.0	18.4	9.9	2
PE-14 Grasslands Area Farmers	49	152.0	162.0	142.0	14.1	9.3	2
San Luis Drain Site A (Check 18)	50	175.7	182.0	169.0	6.5	3.7	3
Salt Slough at Sand Dam	52	120.0	120.0	120.0	.	.	1
Salt Slough at Wolfsen Road	53	163.1	369.0	117.0	54.4	33.3	21
Los Banos Creek at Ingomar Grade	54	72.5	72.5	72.5	.	.	1
Ramona Lake	57	159.2	200.0	135.0	22.9	14.4	12
SJR Laird Park	59	100.6	166.0	36.0	30.7	30.6	22
Moffit 1 South	60	138.1	186.0	117.0	23.0	16.7	12
Deadman's Slough	61	159.3	290.0	83.0	59.2	37.2	15
Mallard Slough	62	254.1	782.0	90.0	161.2	63.4	16
Inlet C Canal	63	104.4	250.0	65.0	43.2	41.4	18
Moran Drain	64	87.0	99.0	81.0	10.4	11.9	3
Spanish Grant Drain	65	132.0	192.0	102.0	40.6	30.8	4
ESWD Maze Blv. Drain	66	79.0	82.0	74.0	3.8	4.8	4
Newman Wasteway at Brazo Road	67	304.5	412.0	193.0	105.5	34.6	4
S. Lake Basin	68	189.0	190.0	188.0	1.4	0.7	2
Santa Fe Canal	69	97.0	97.0	97.0	.	.	1
SJR Garwood Bridge	84	81.0	81.0	81.0	.	.	1

Appendix B

SAN JOAQUIN RIVER FLOW DATA
PLOTS OF MEAN DAILY FLOW 2006

Jeremy Hanlon
Justin Graham
University of the Pacific

Kathleen Hutchison
Lawrence Berkeley National Laboratory

Figure 1. SJR at Channel Point (DO-01) daily average flow.

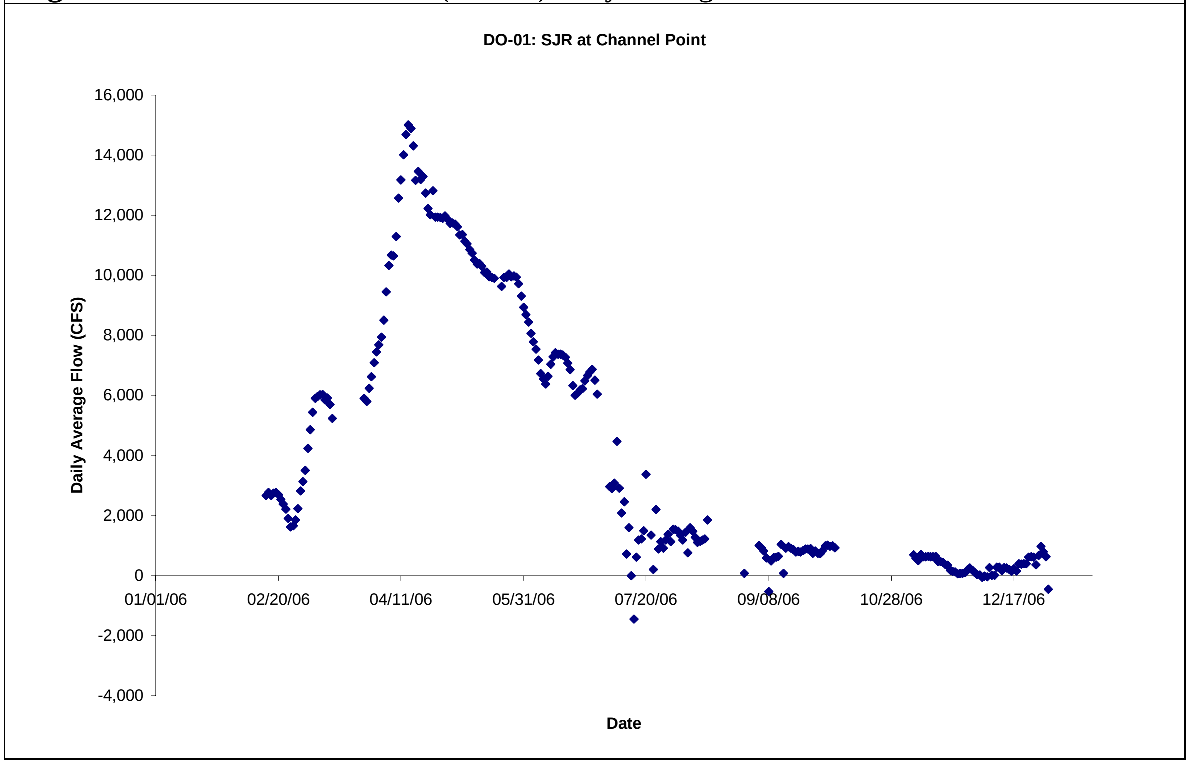


Figure 2. SJR at Lathrop (DO-02) daily average flow.

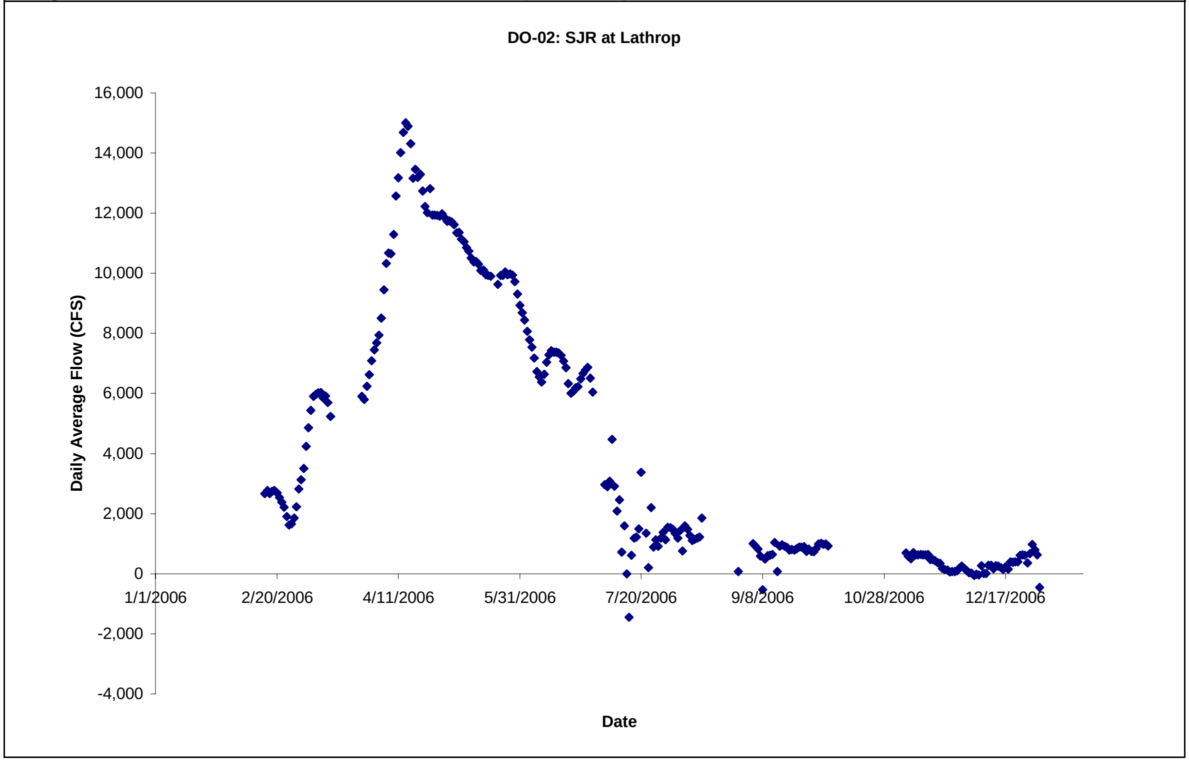


Figure 3. SJR at Old River (DO-03) daily average flow.

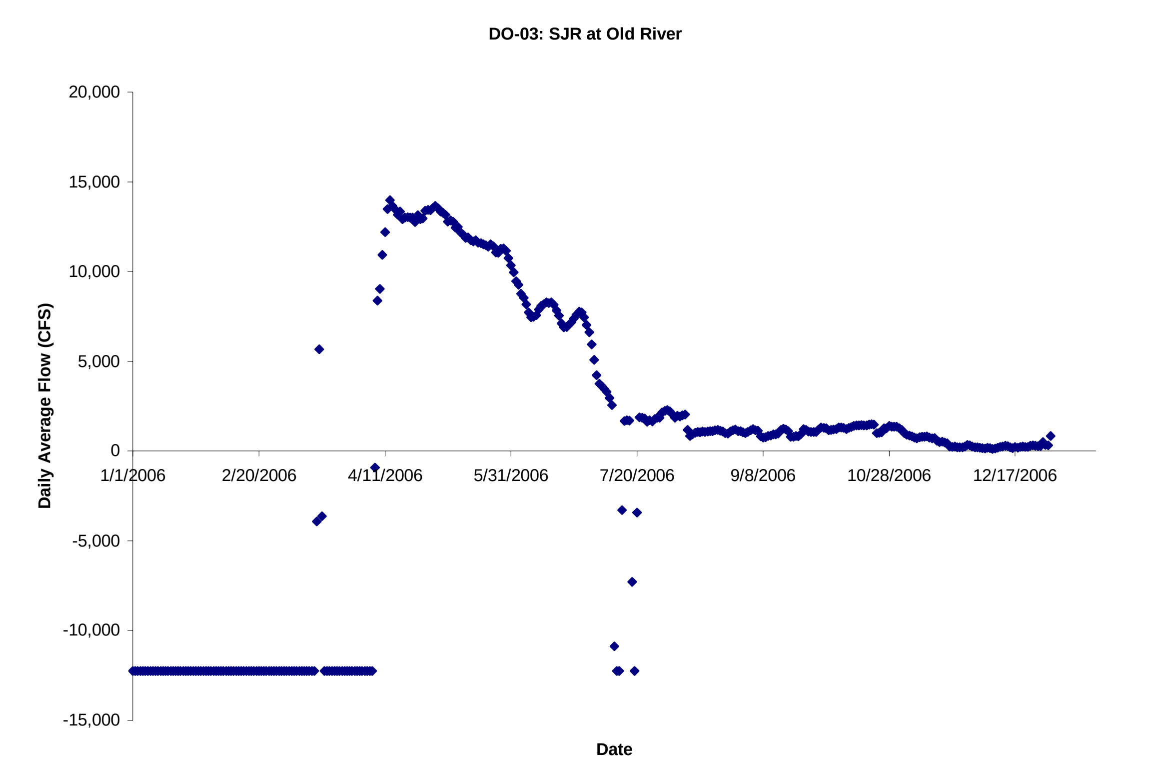


Figure 4. SJR at Mossdale (DO-04) daily average flow.

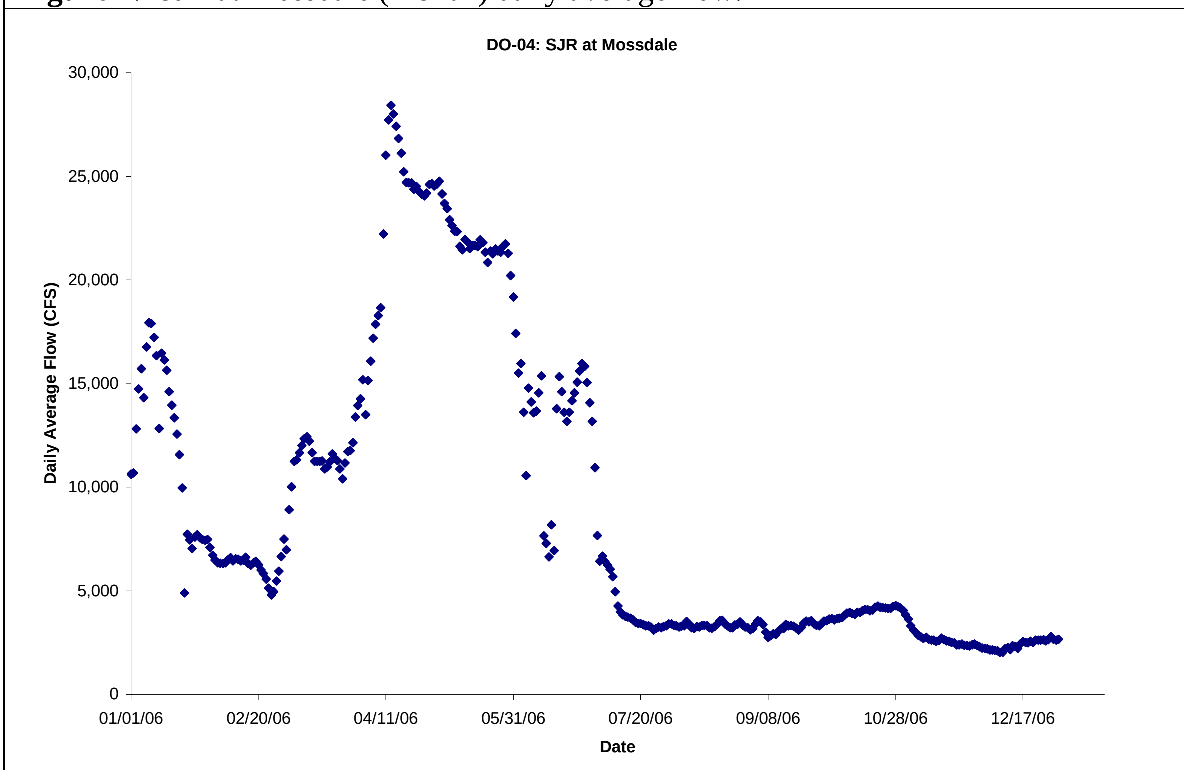


Figure 5. SJR at Vernalis (DO-05) daily average flow.

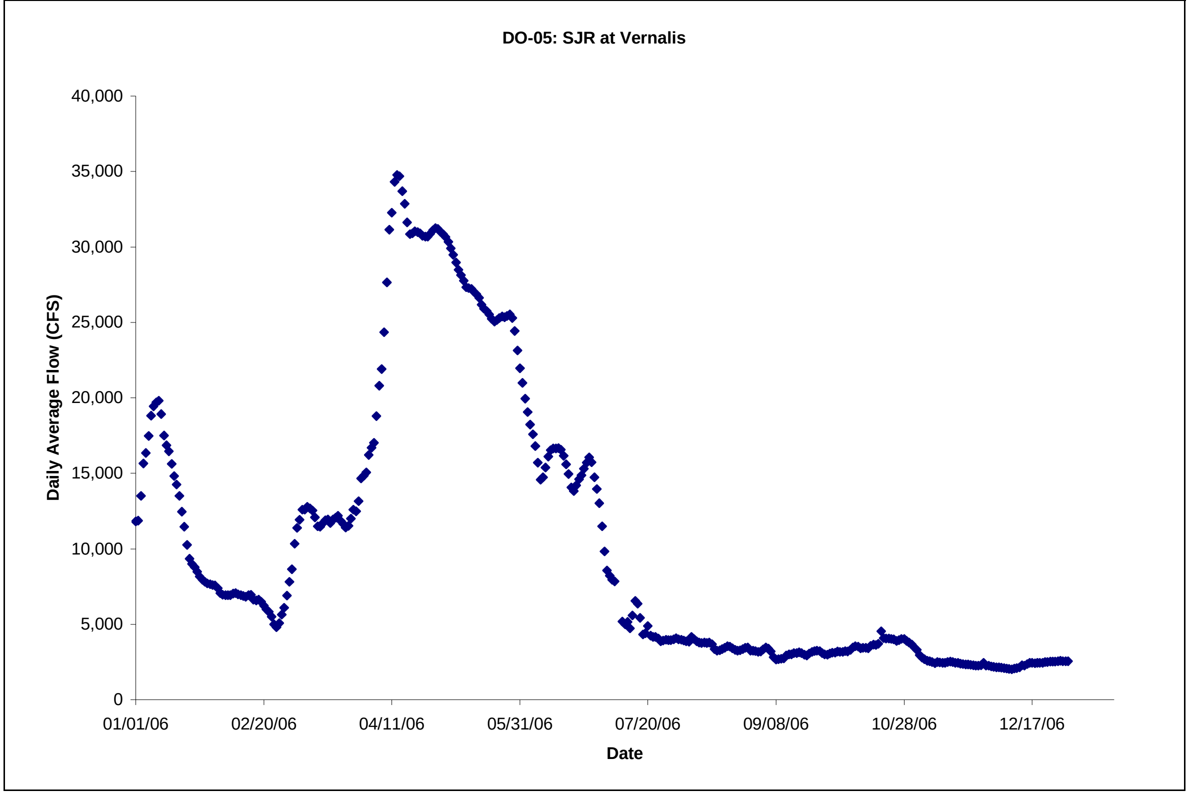


Figure 6. SJR at Maze (DO-06) daily average flow.

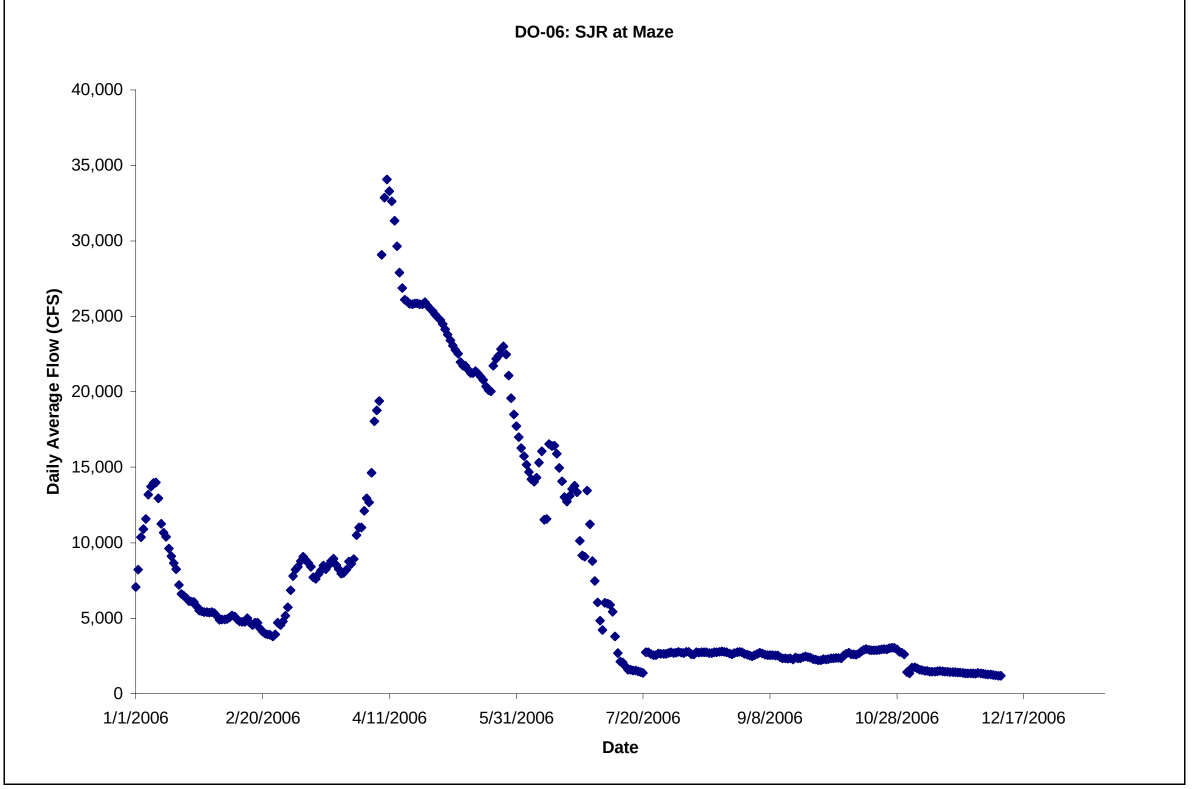


Figure 7. SJR at Patterson (DO-07) daily average flow.

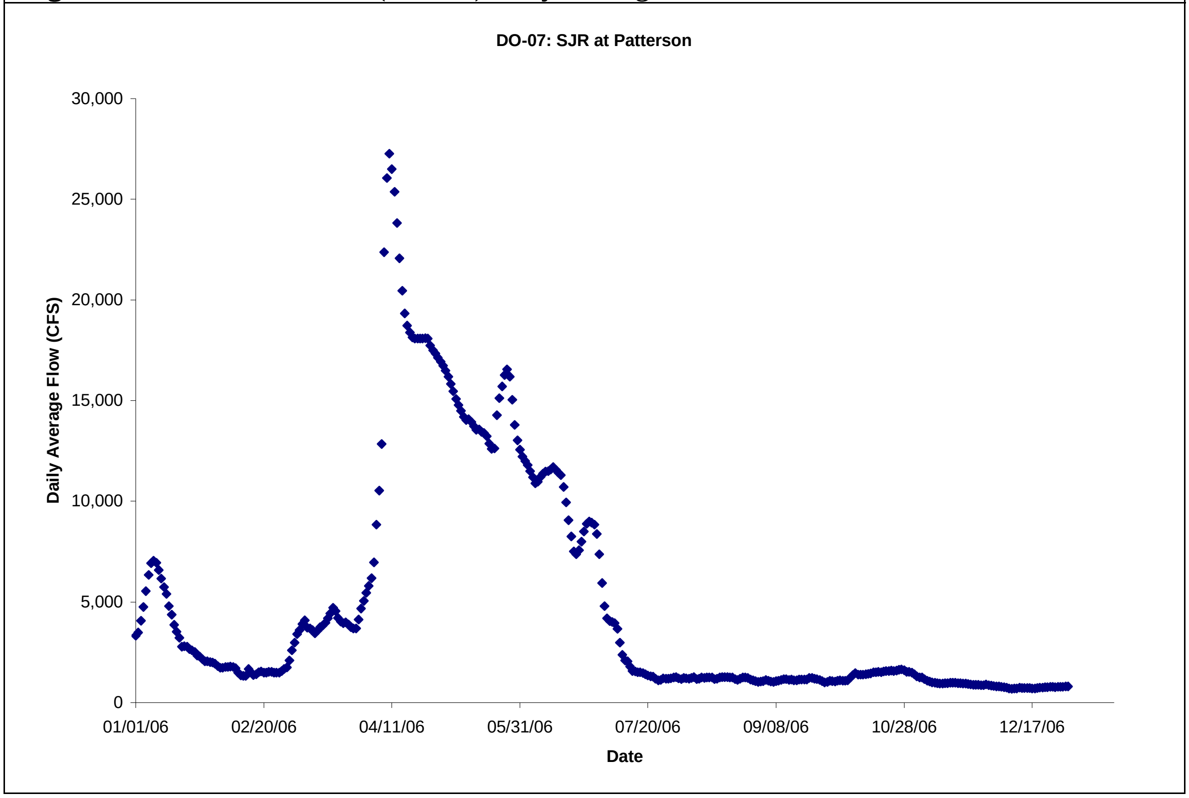


Figure 8. SJR at Crows Landing (DO-08) daily average flow.

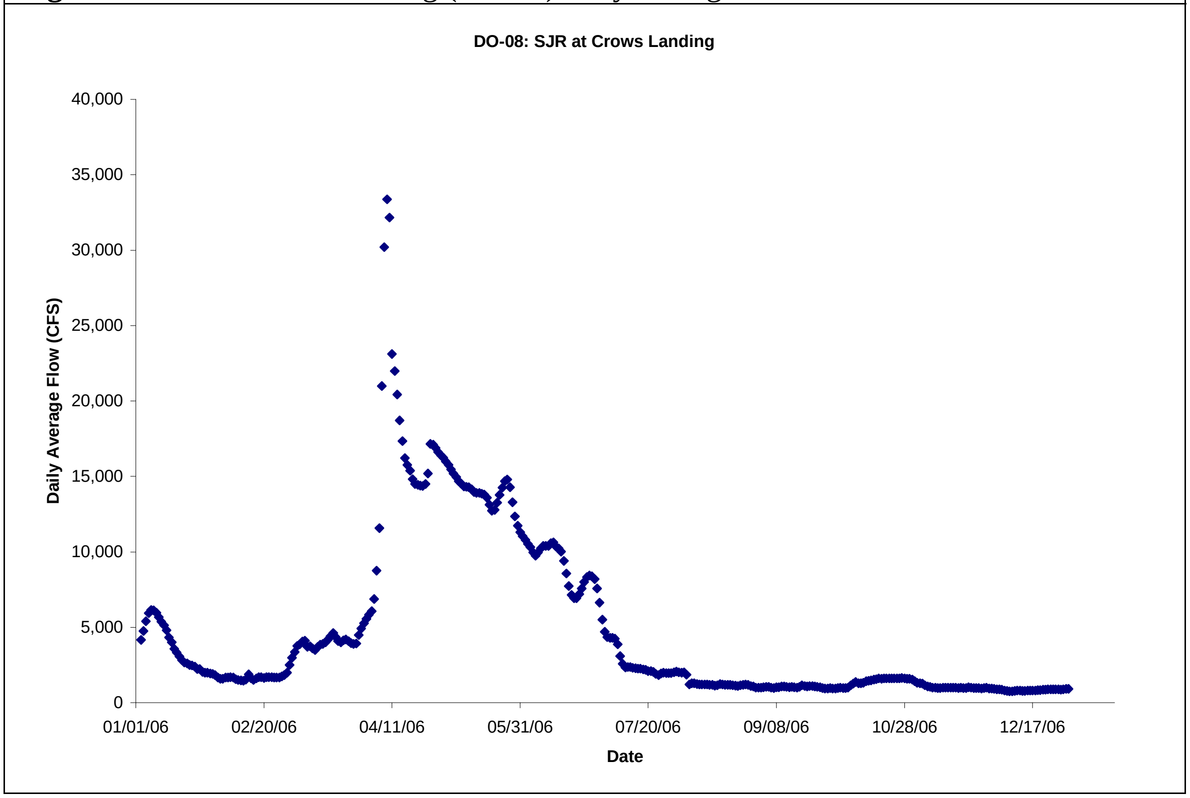


Figure 9. SJR at Fremont Ford Bridge (DO-09) daily average flow.

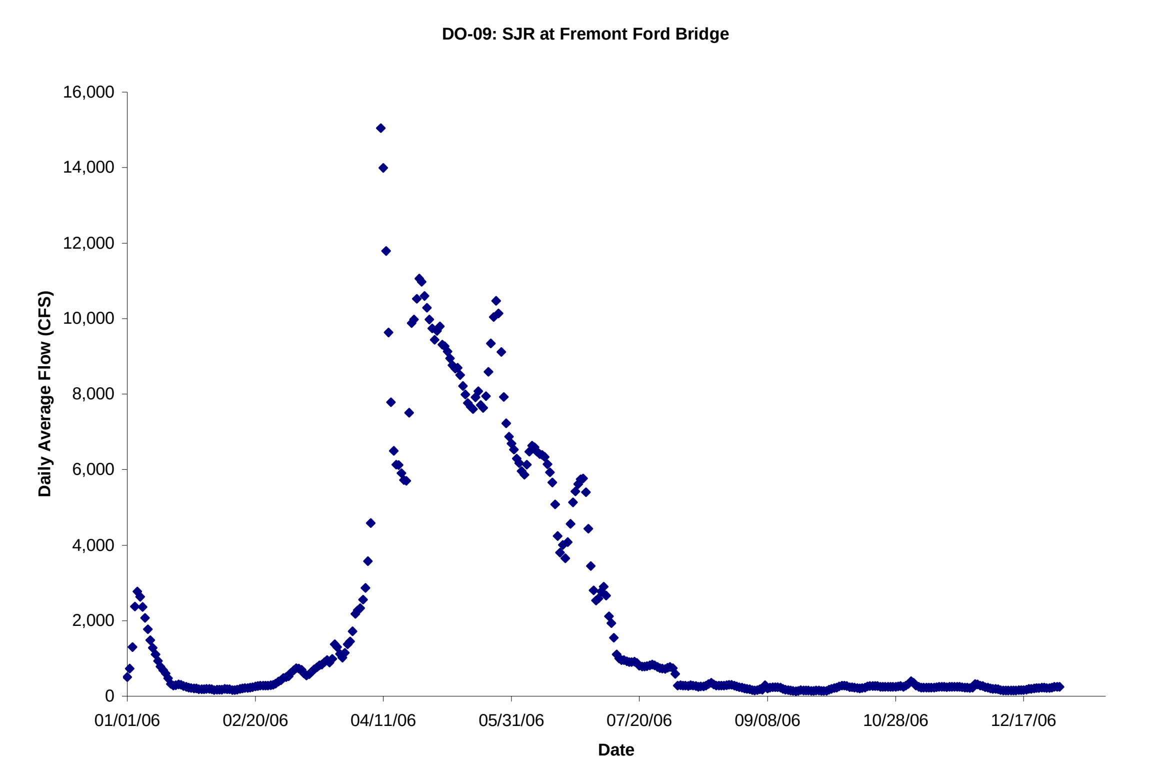


Figure 10. SJR at Lander Avenue (DO-10) daily average flow.

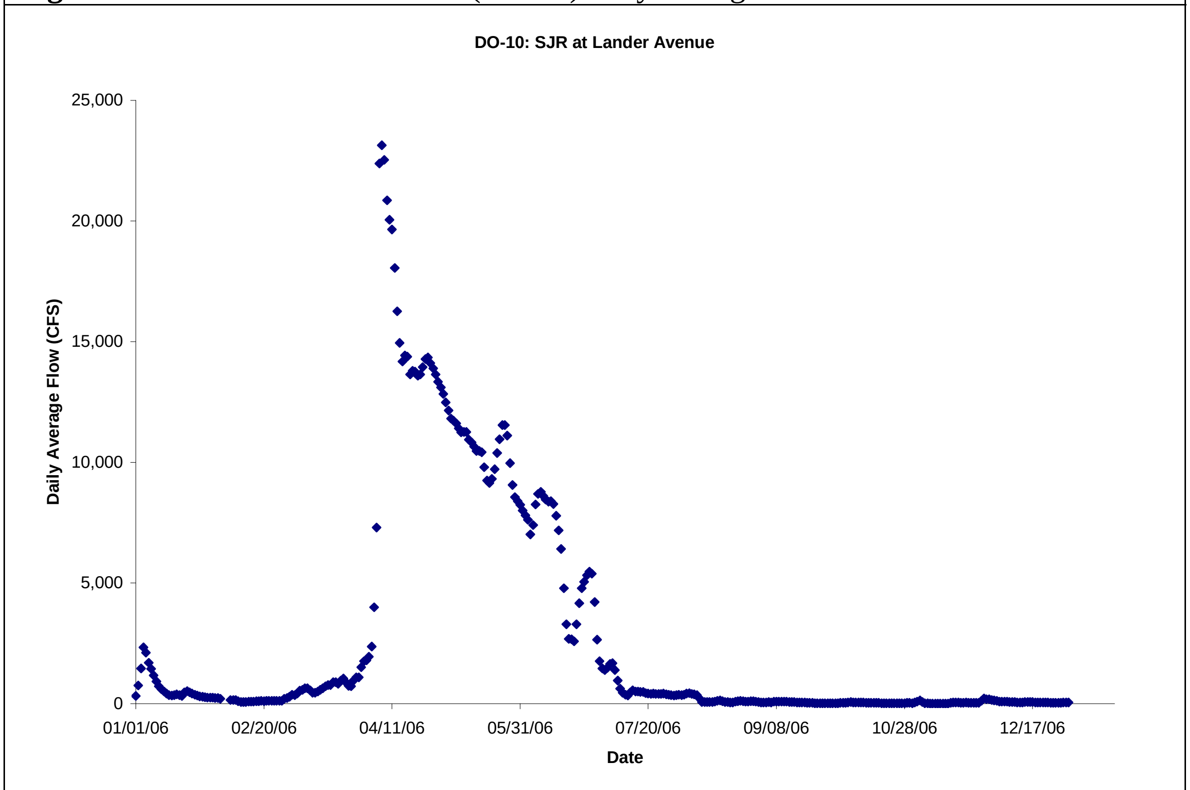


Figure 11. Stanislaus River at Ripon (DO-13) daily average flow.

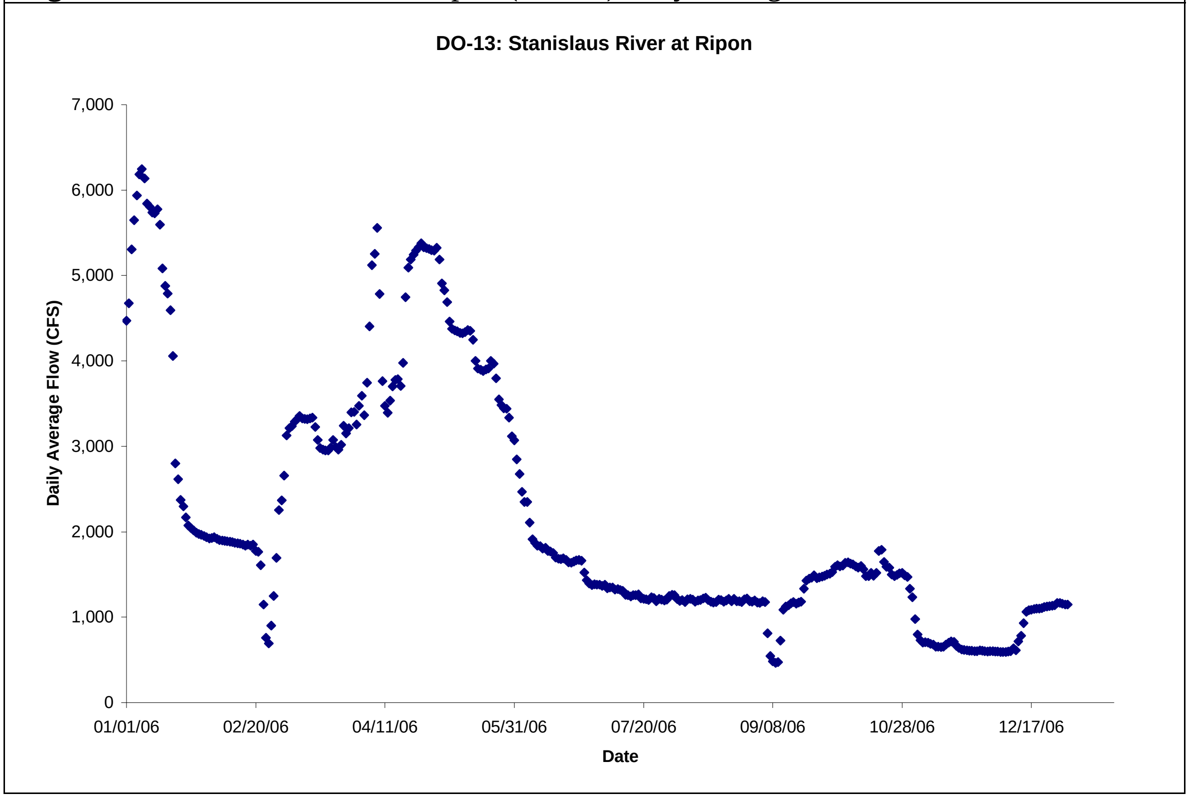


Figure 12. Tuolumne River at Modesto (DO-15) daily average flow.

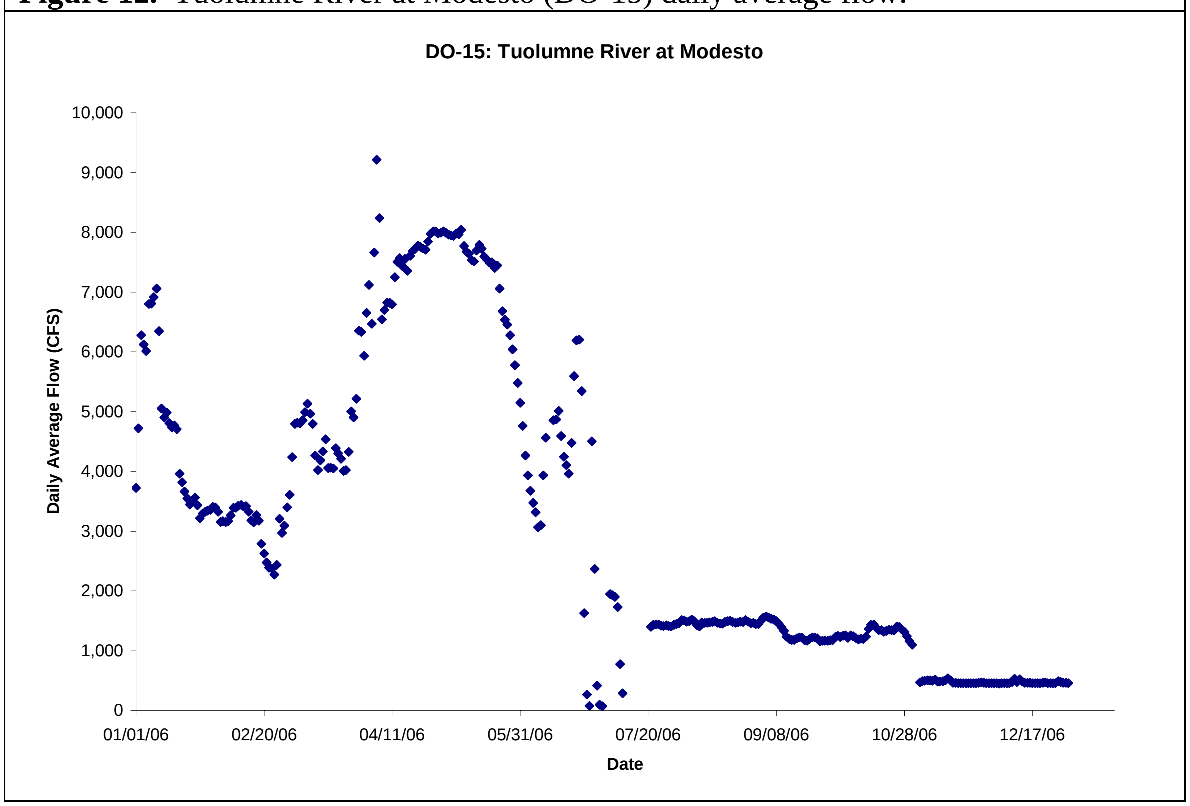


Figure 13. Merced River near Stevinson (DO-17) daily average flow.

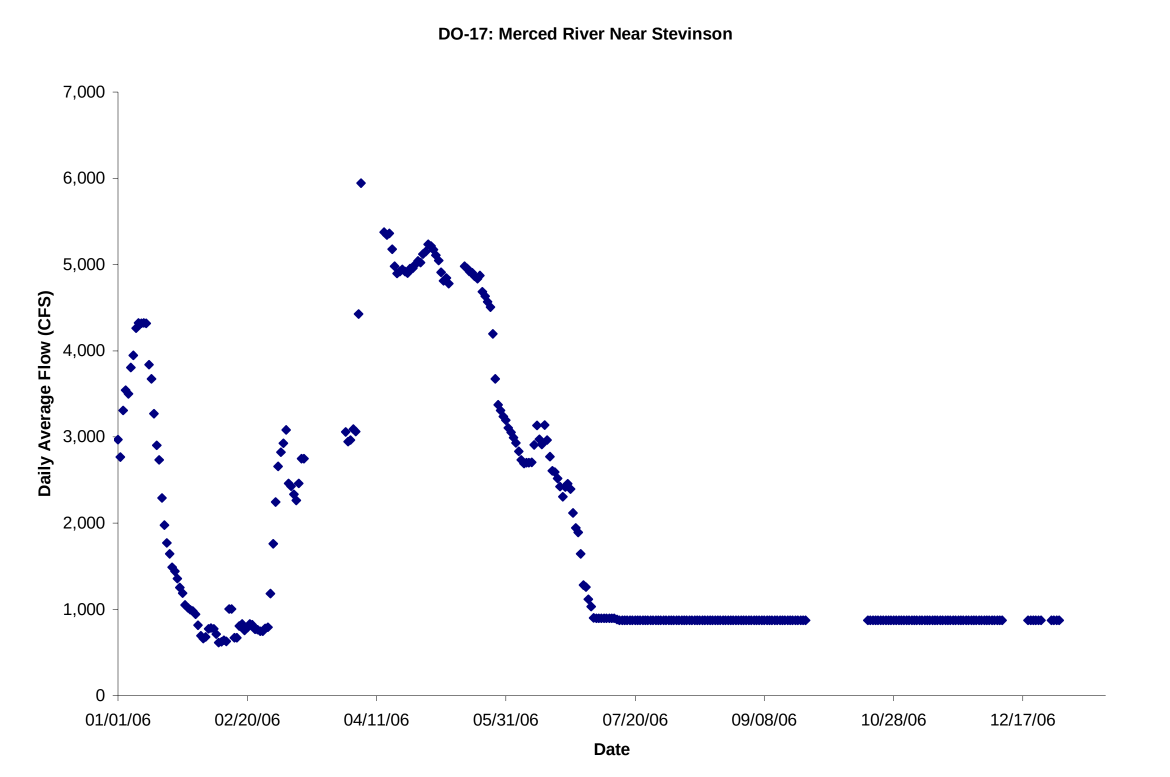


Figure 14. Mud Slough near Gustine (DO-18) daily average flow.

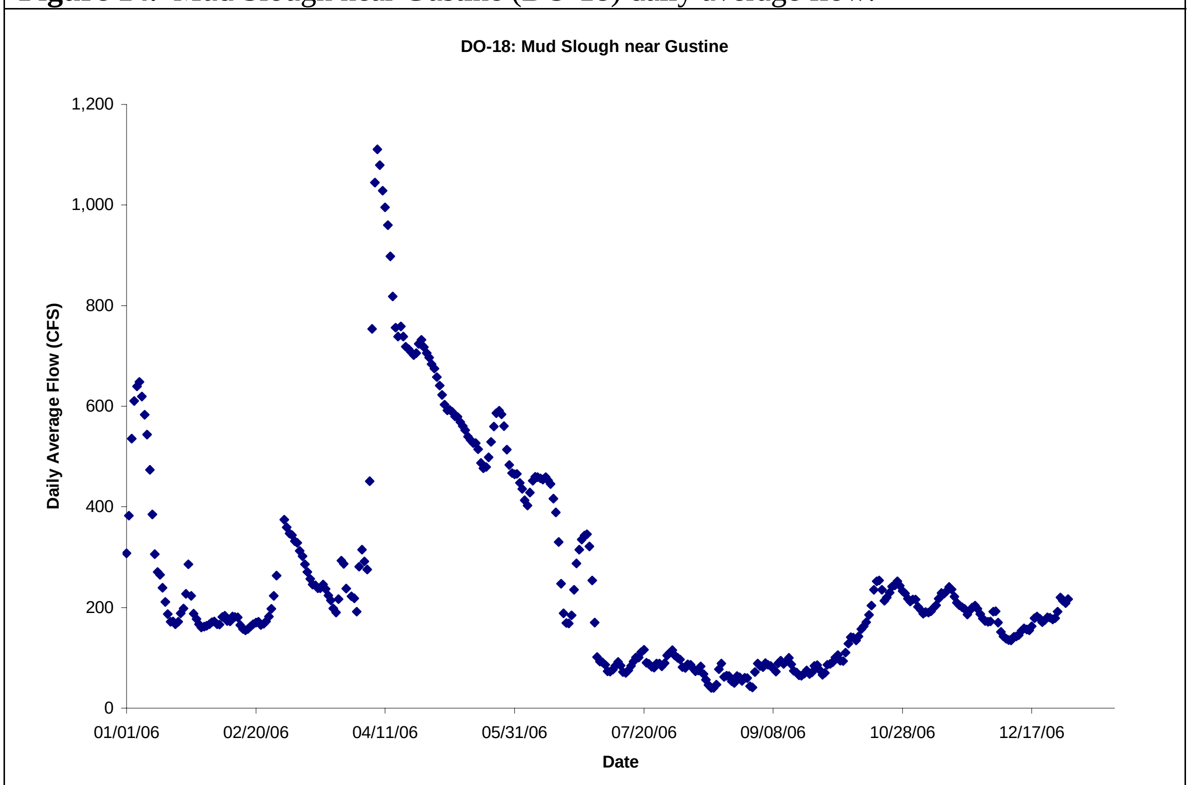


Figure 15. Salt Slough at Lander Avenue (DO-19) daily average flow.

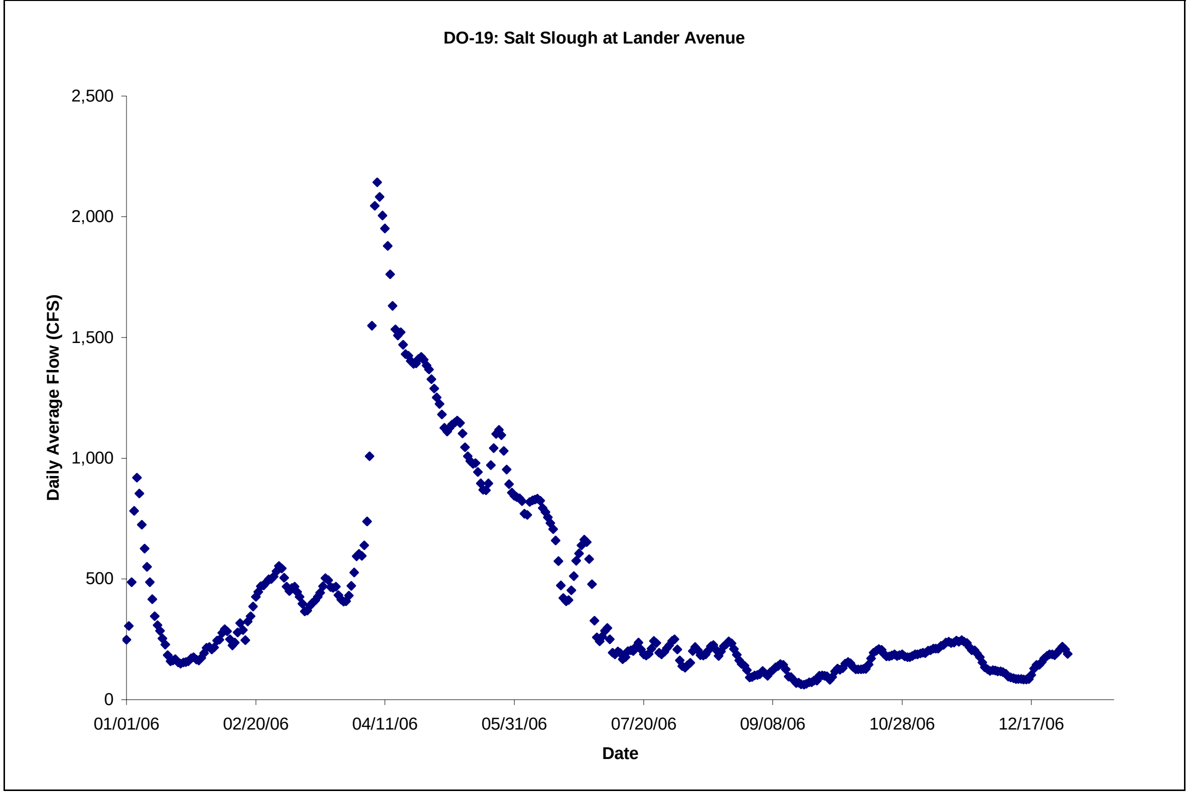


Figure 16. Los Banos Creek at Highway 140 (DO-20) daily average flow.

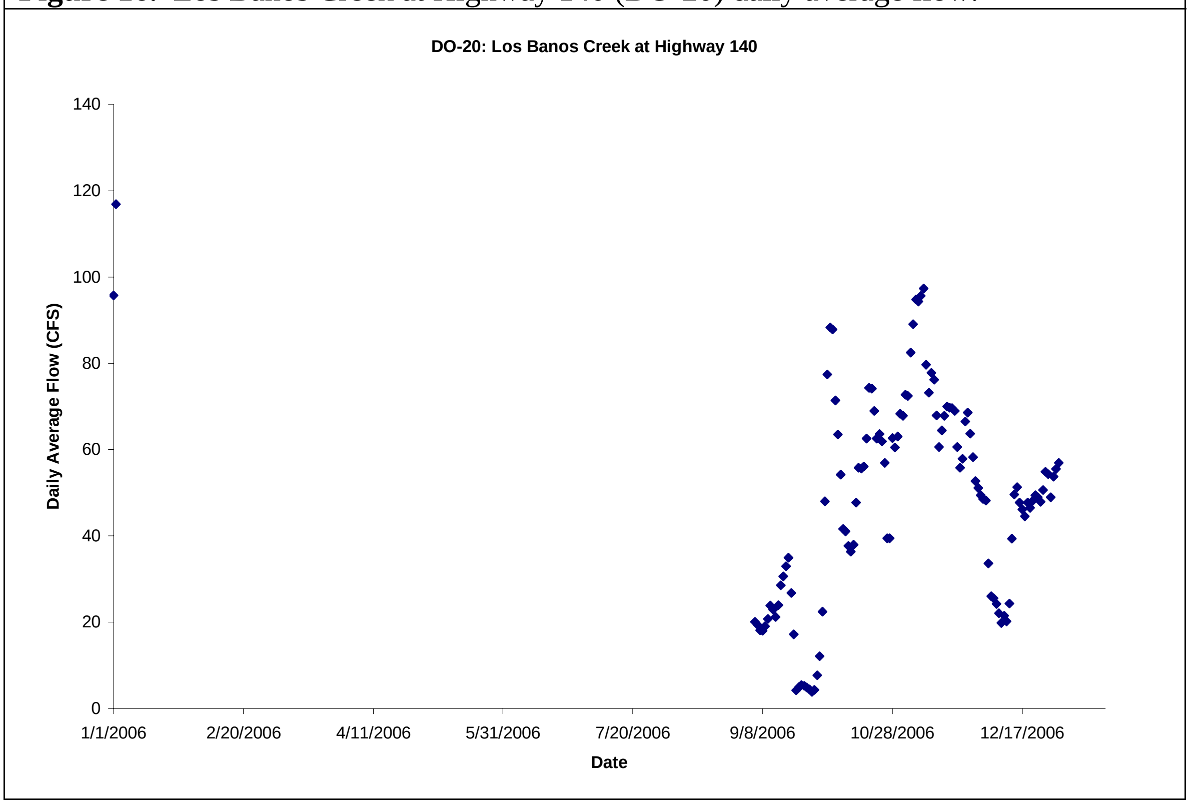


Figure 17. Orestimba Creek at River Road (DO-21) daily average flow.

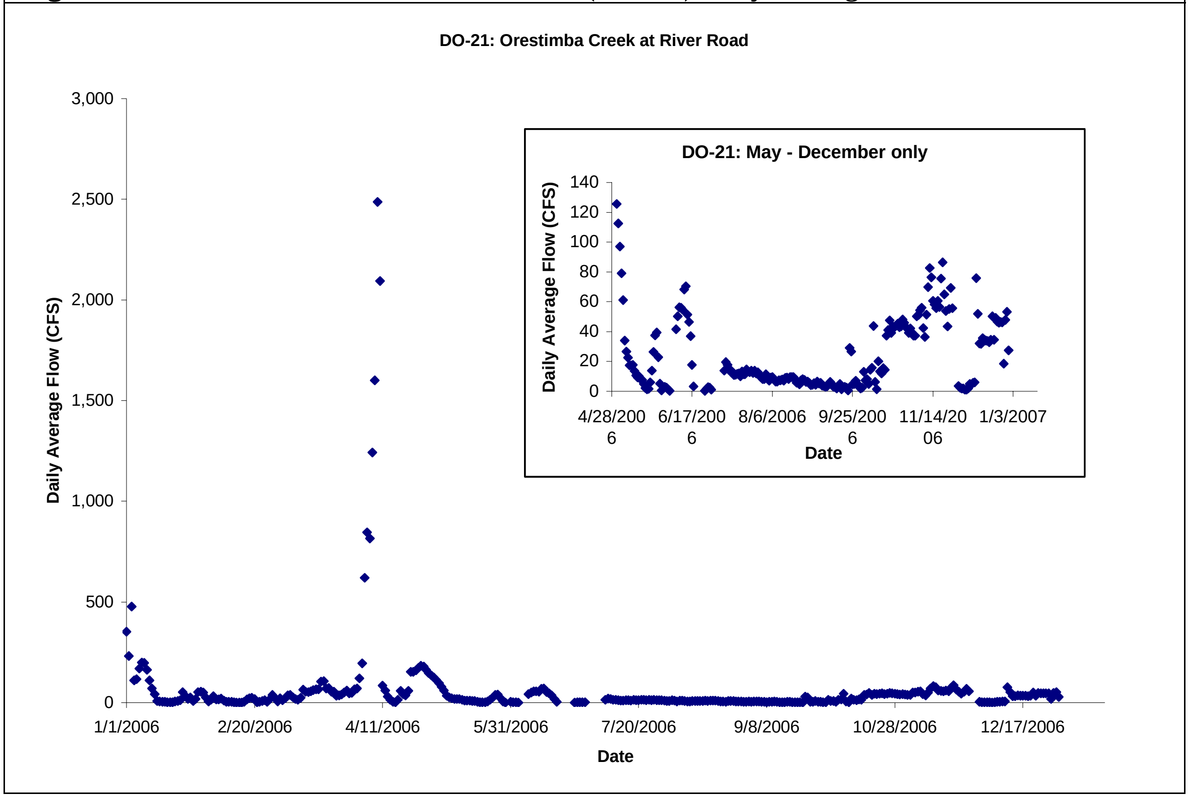


Figure 18. MID Lateral 4 to SJR (DO-22) daily average flow.

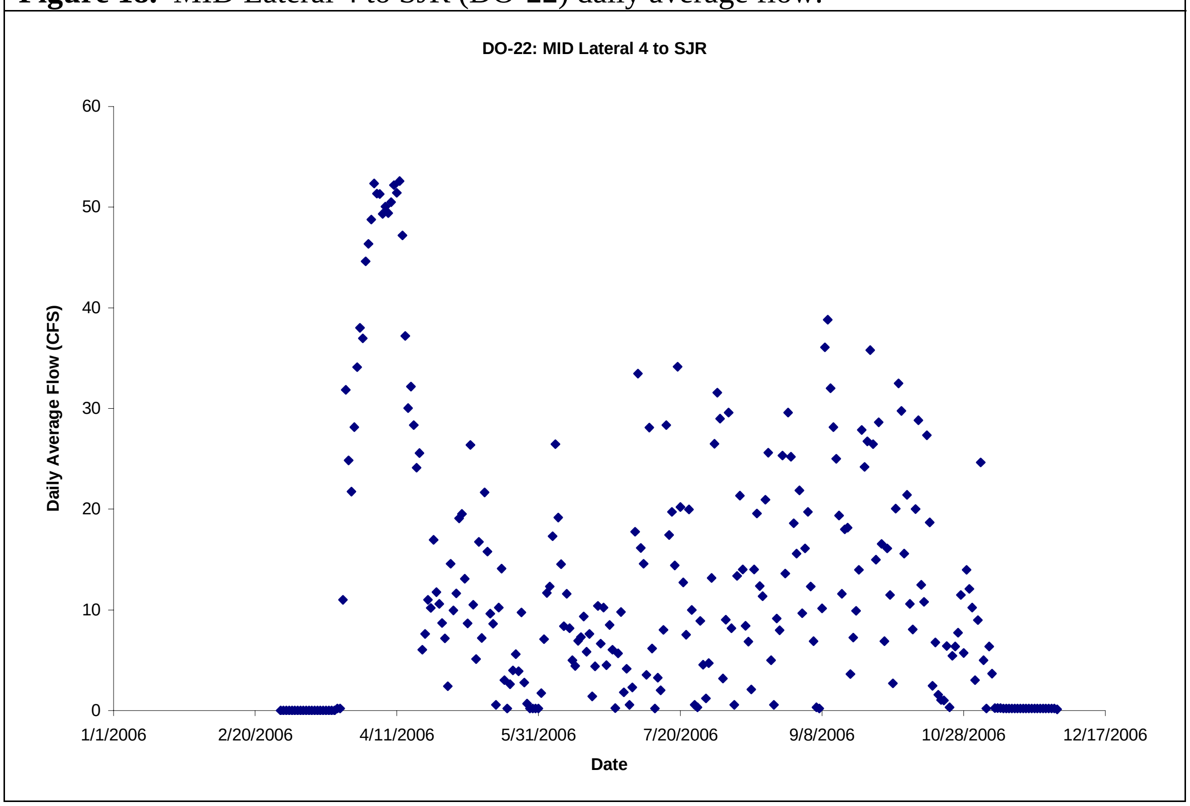


Figure 19. MID Lateral 5 to Tuolumne (DO-23) daily average flow.

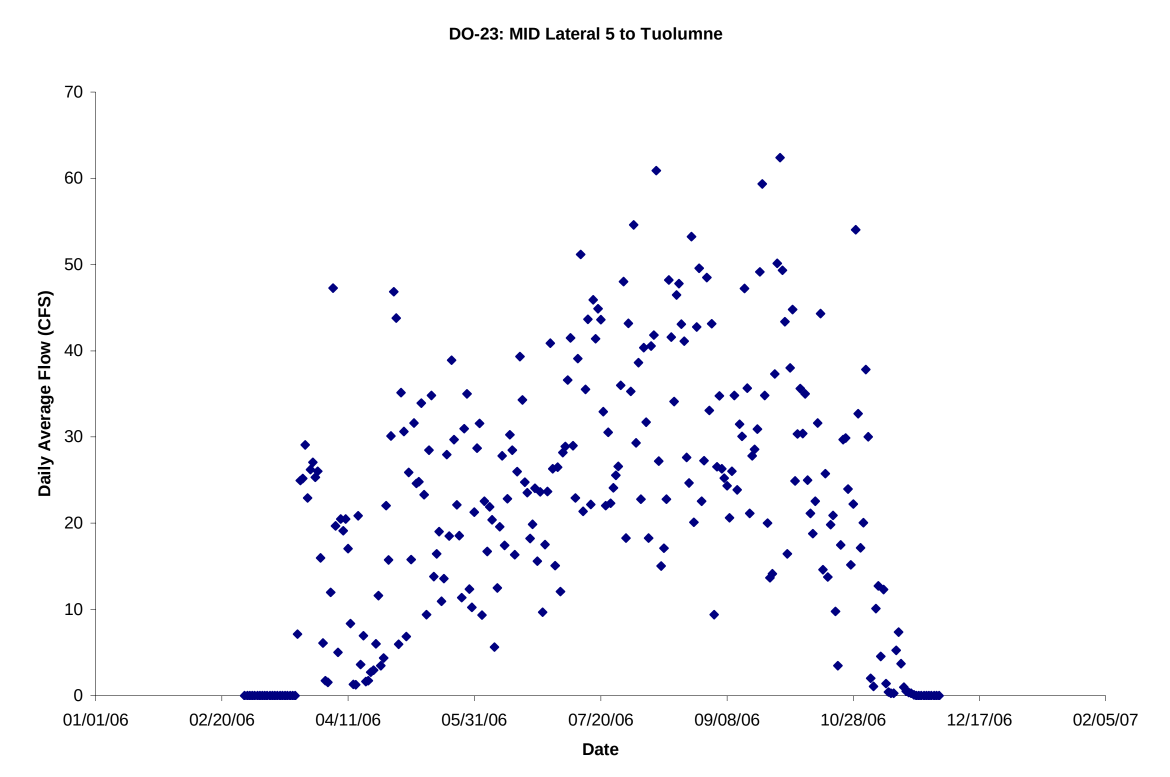


Figure 20. MID Lateral 6 to Stanislaus River (DO-24) daily average flow.

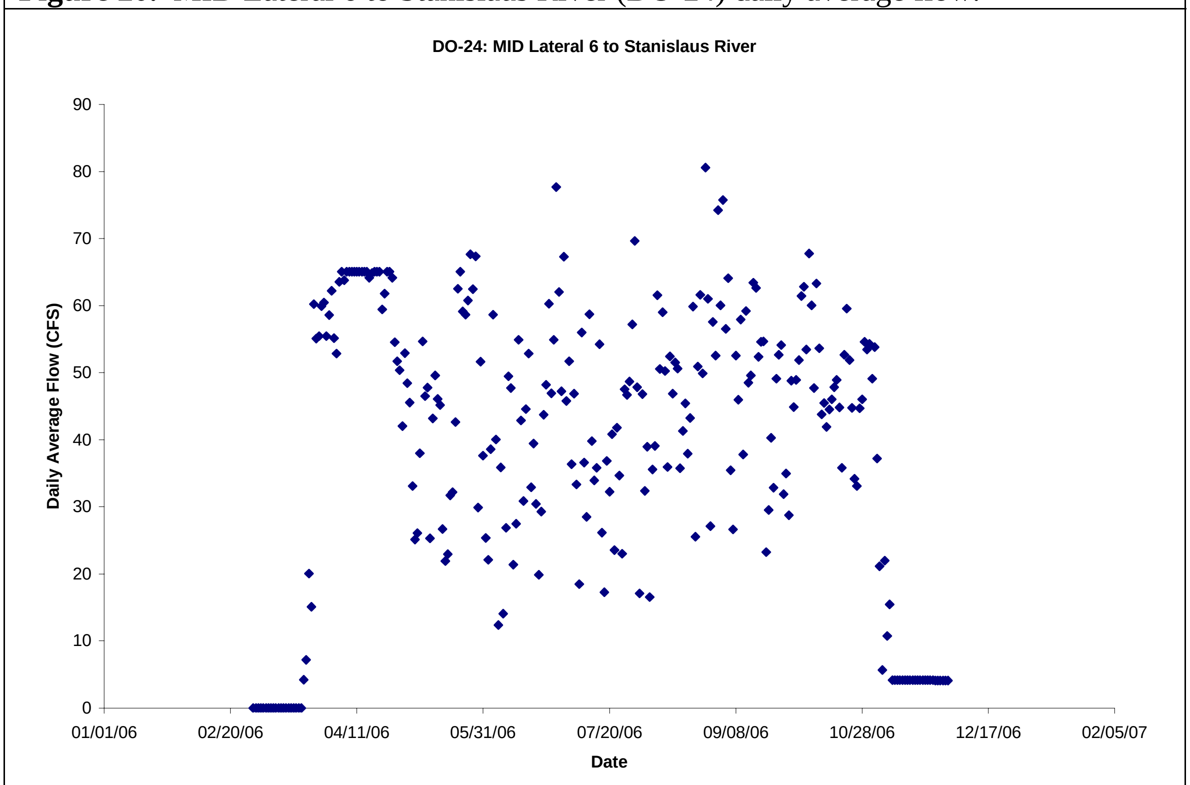


Figure 21. MID Main Drain to Stanislaus River via Miller Lake (DO-25) daily average flow.

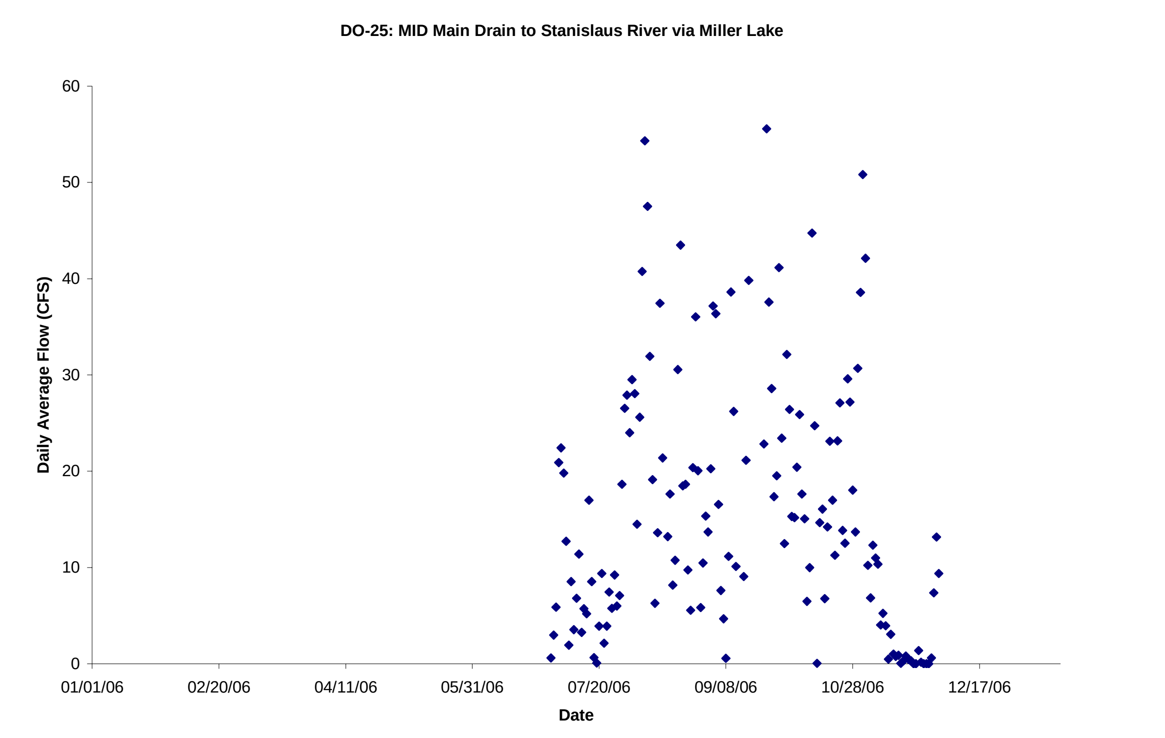


Figure 22. TID Highline Spill (DO-26) daily flow.

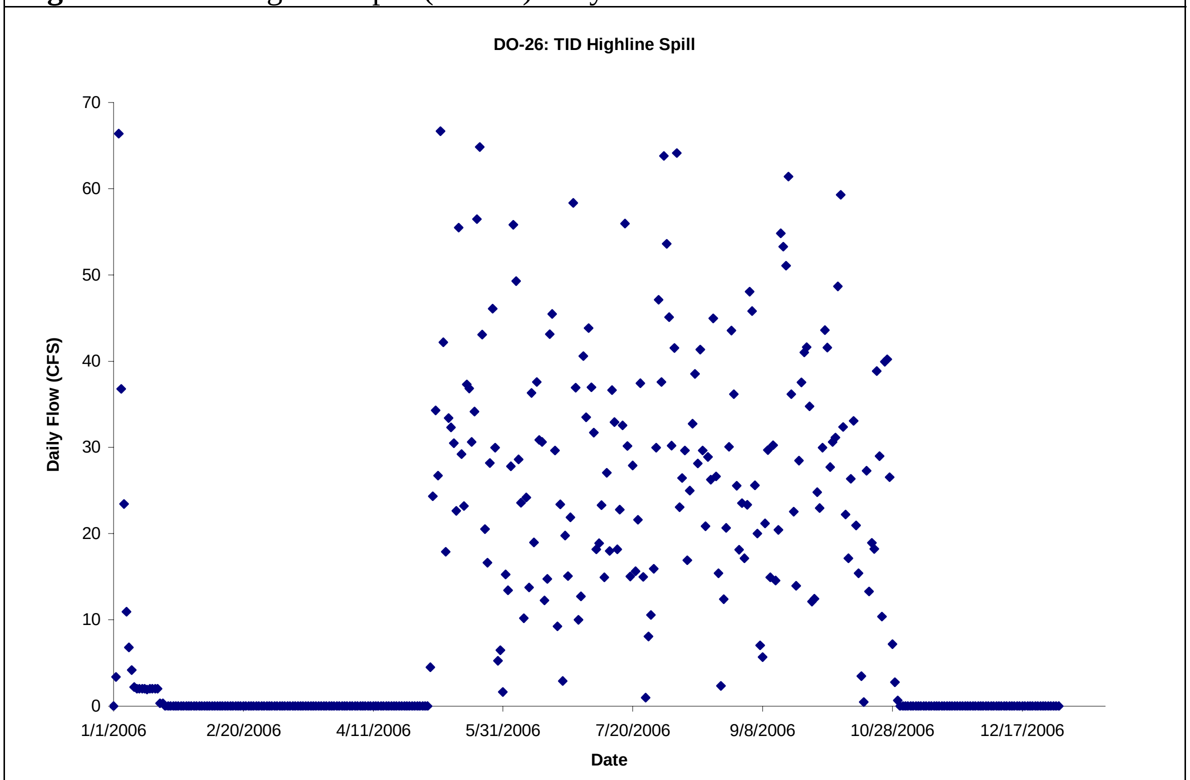


Figure 23. TID Lateral 2 (DO-27) daily flow.

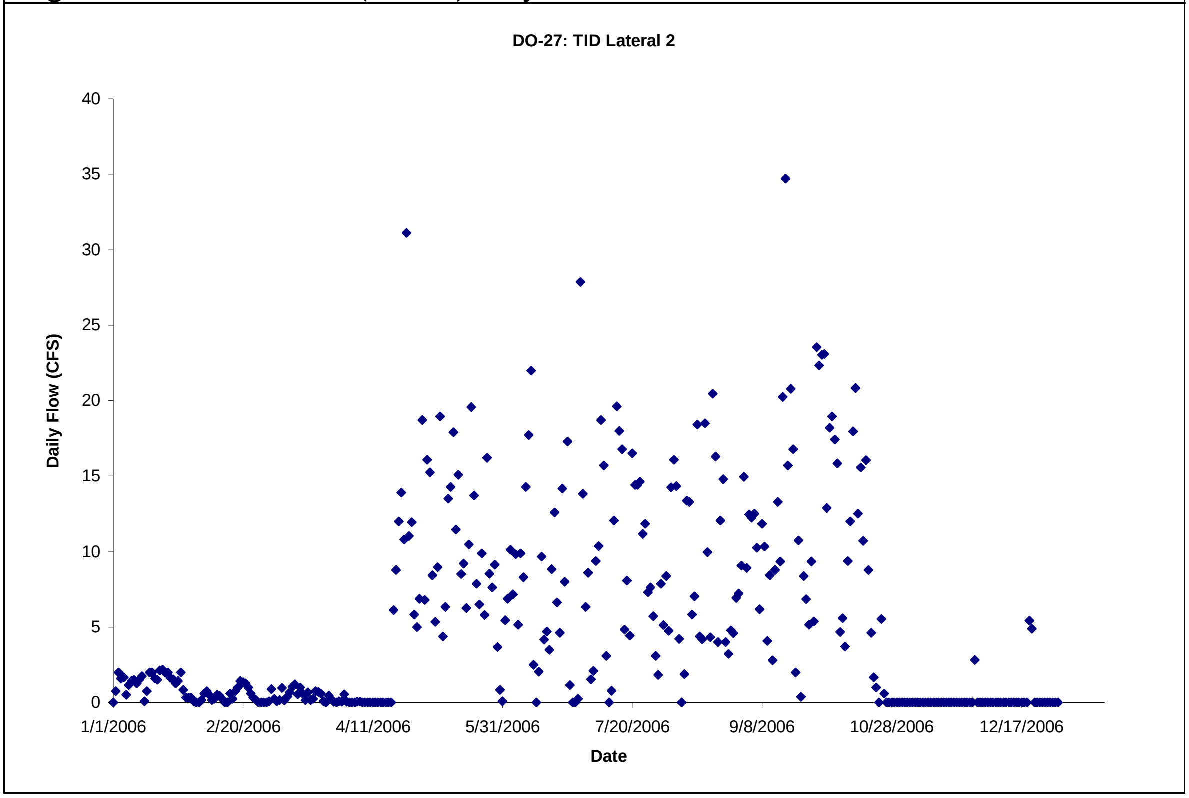


Figure 24. TID Harding Drain (DO-29) daily flow.

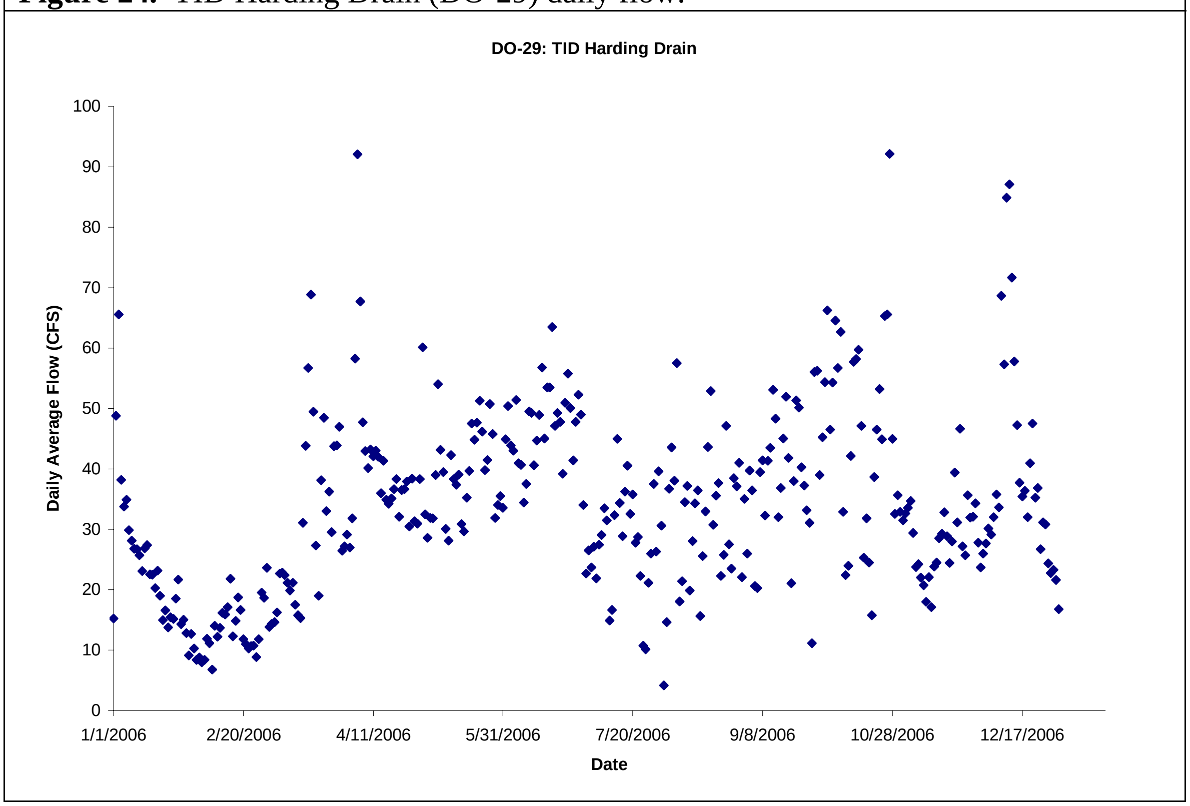


Figure 25. TID Lateral 6 & 7 at Levee (DO-30) daily flow.

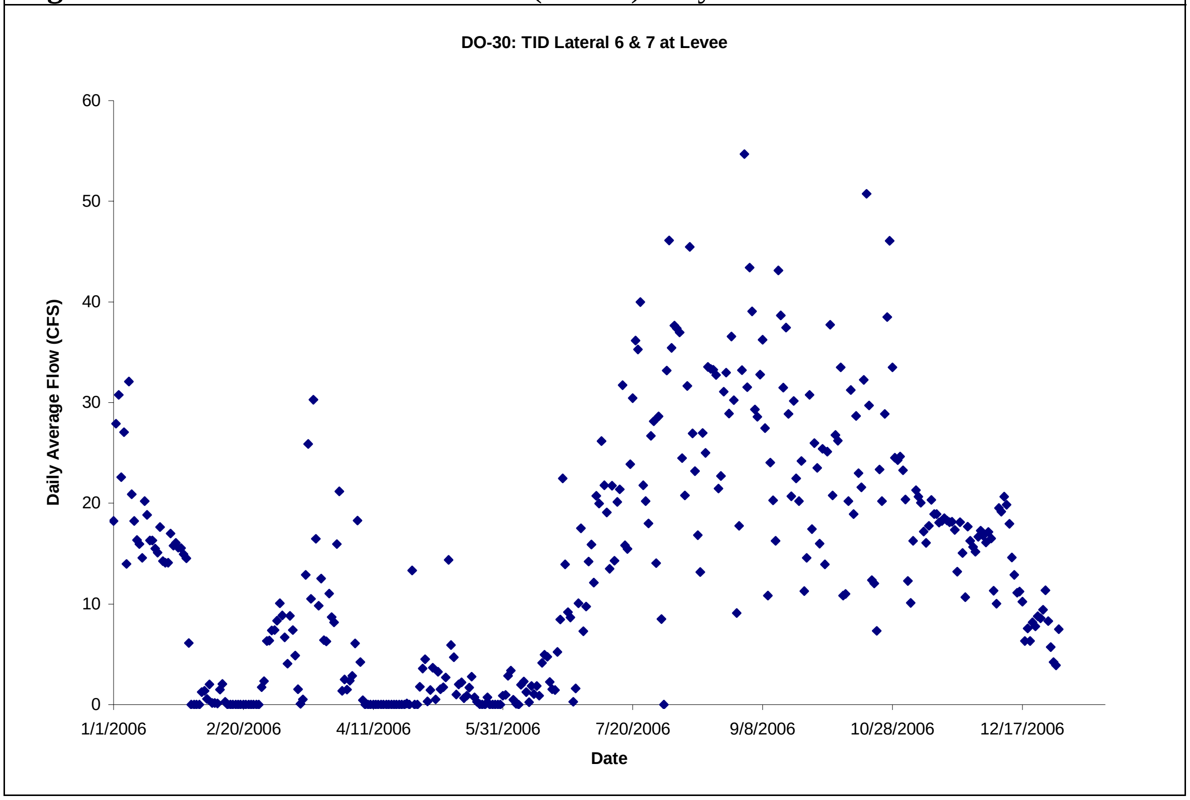


Figure 26. New Jerusalem Drain (DO-31) daily average flow.

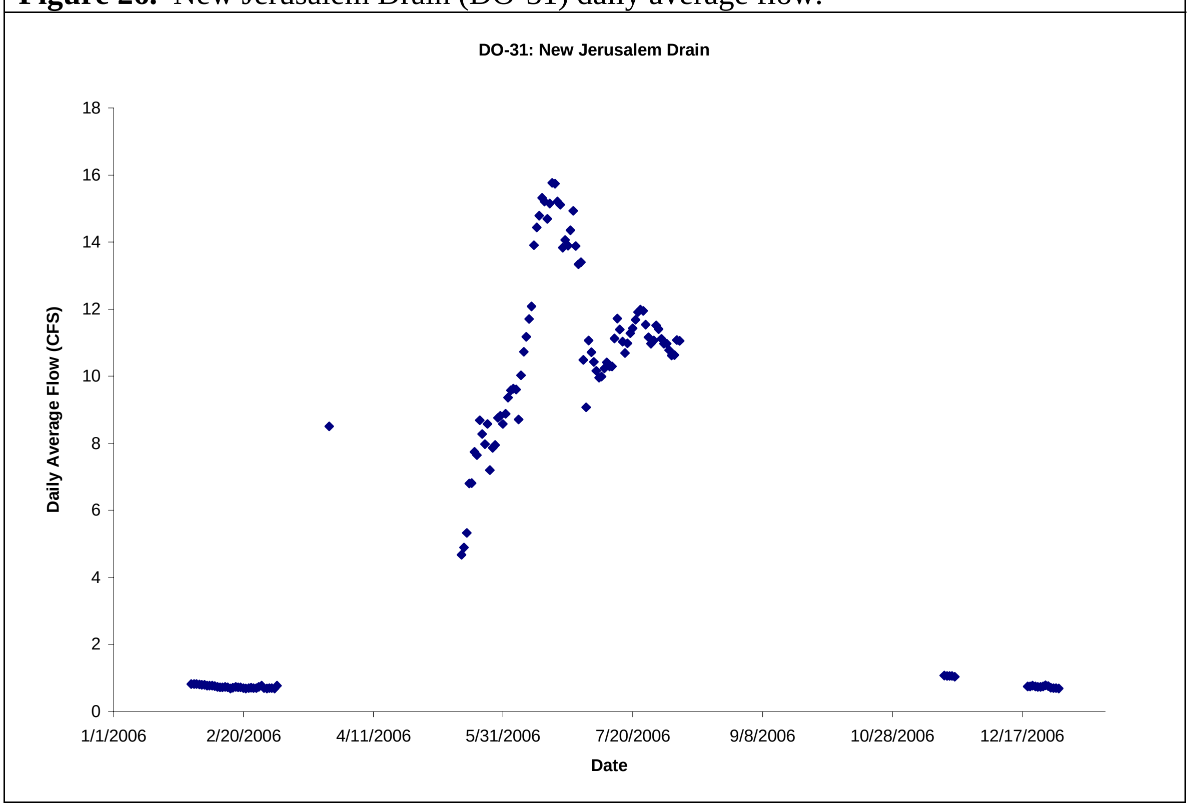


Figure 27. Hospital Creek (DO-33) daily average flow.

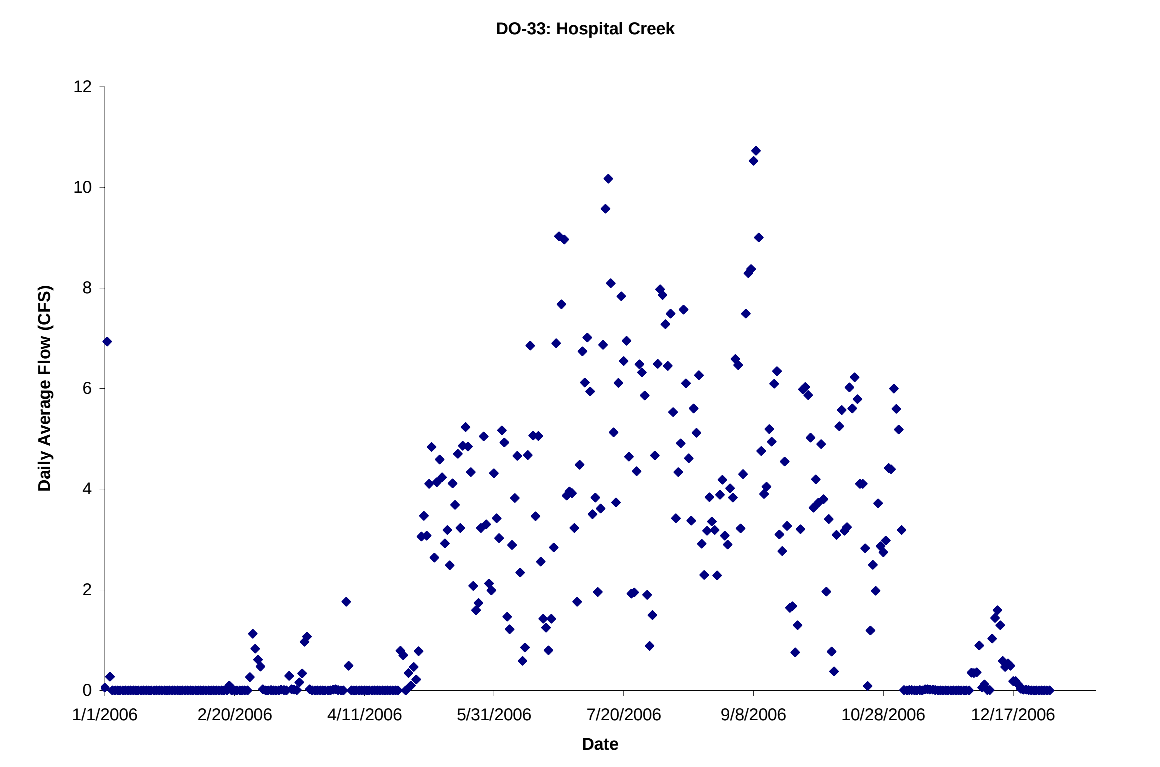


Figure 28. Ingram Creek (DO-34) daily average flow.

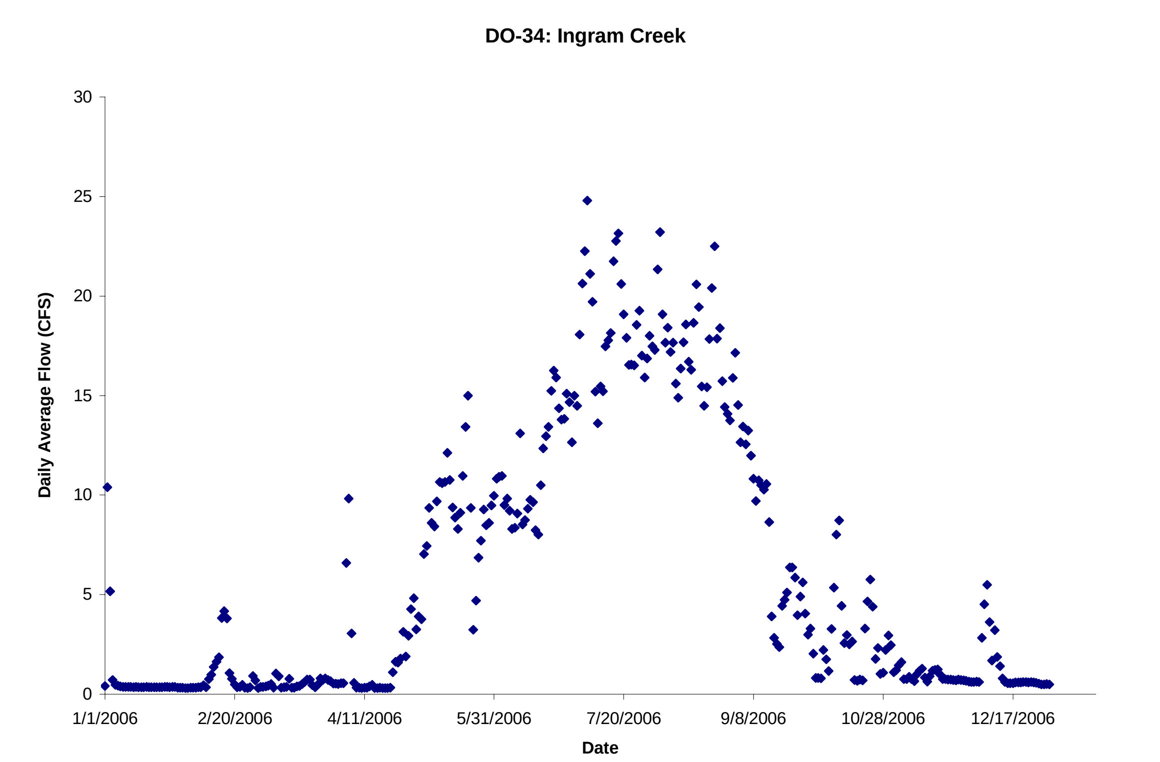


Figure 29. Westley Wasteway Flow Station (DO-35) daily average flow.

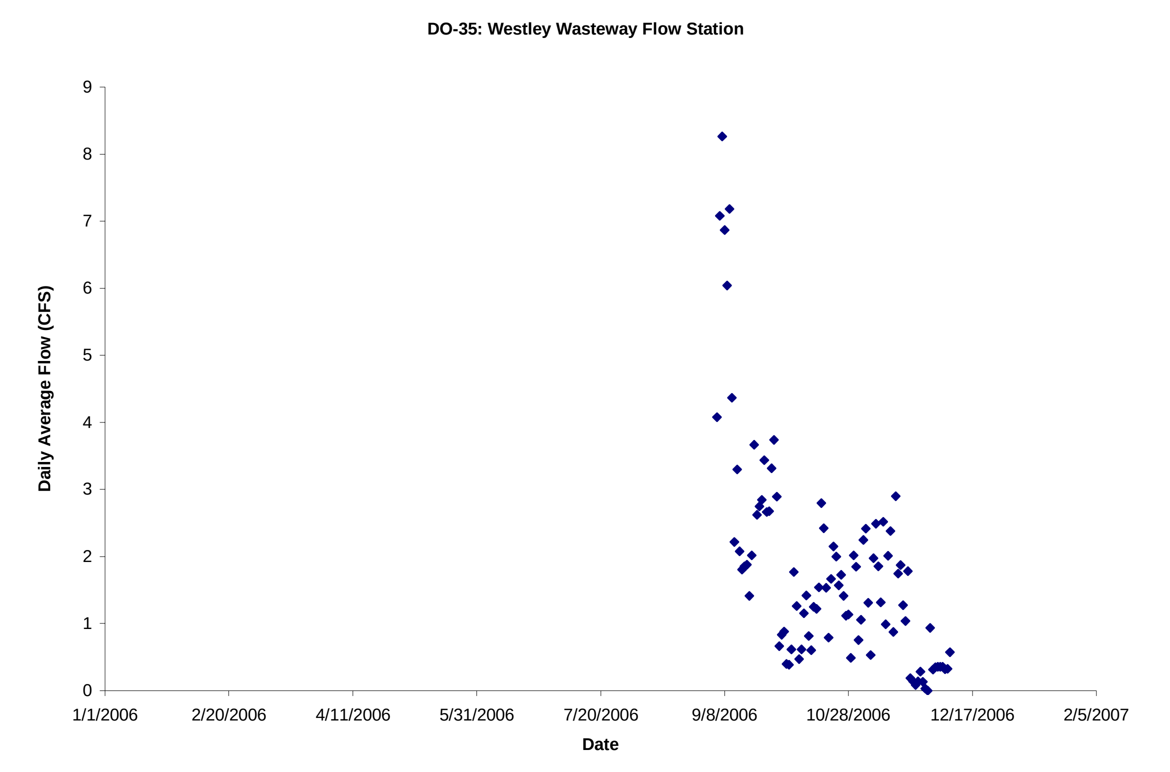


Figure 30. Del Puerto Creek Flow Station (DO-36) daily average flow.

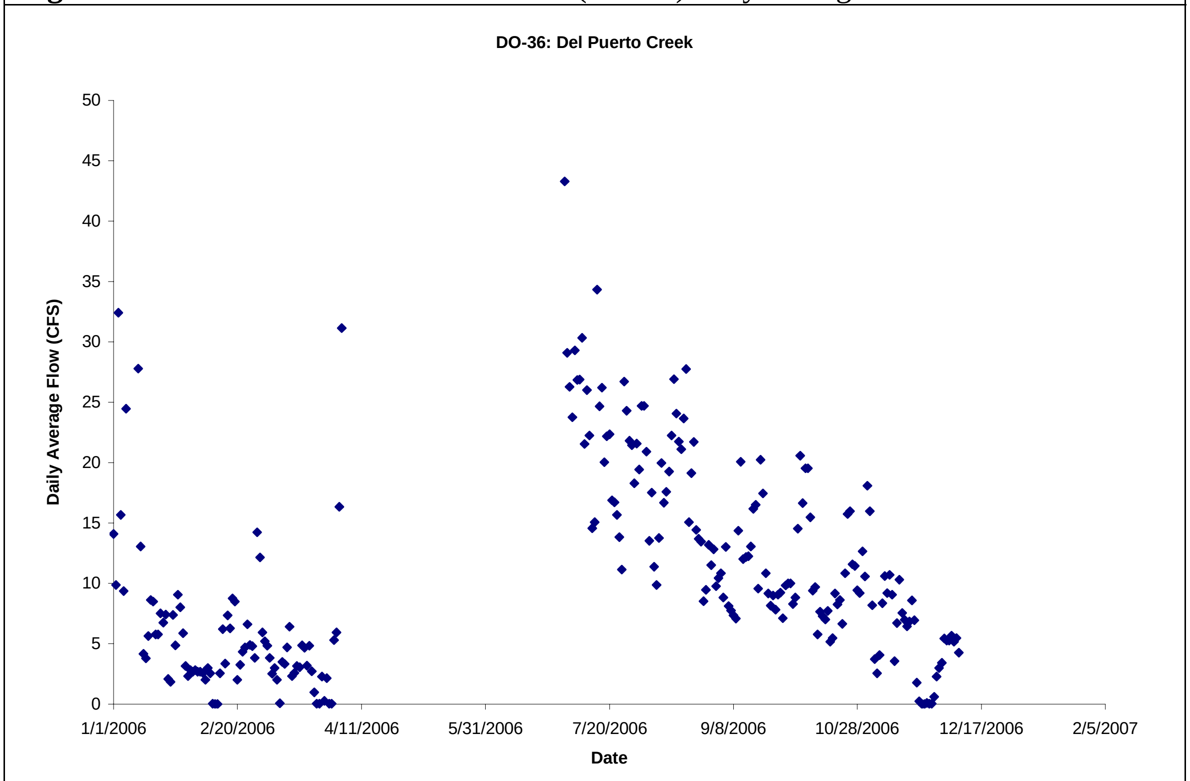


Figure 31. Marshall Road Drain (DO-38) daily average flow.

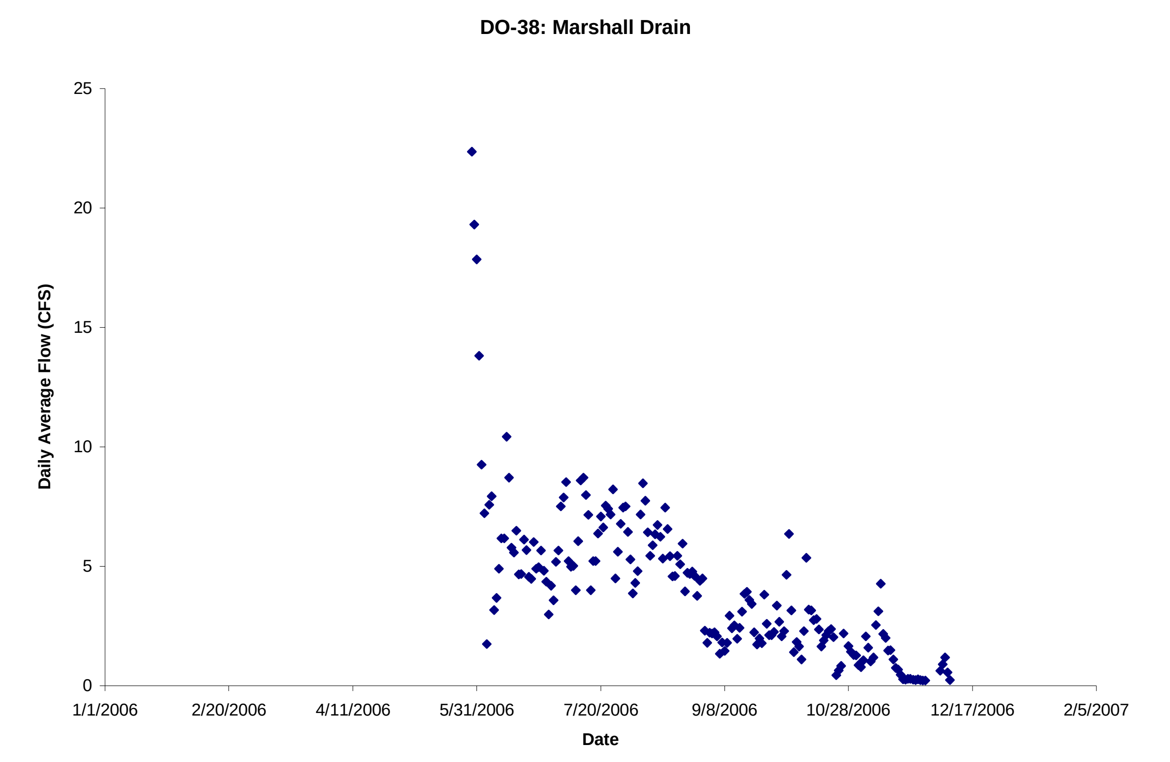


Figure 32. Patterson Irrigation District diversions (DO-40) daily average flow.

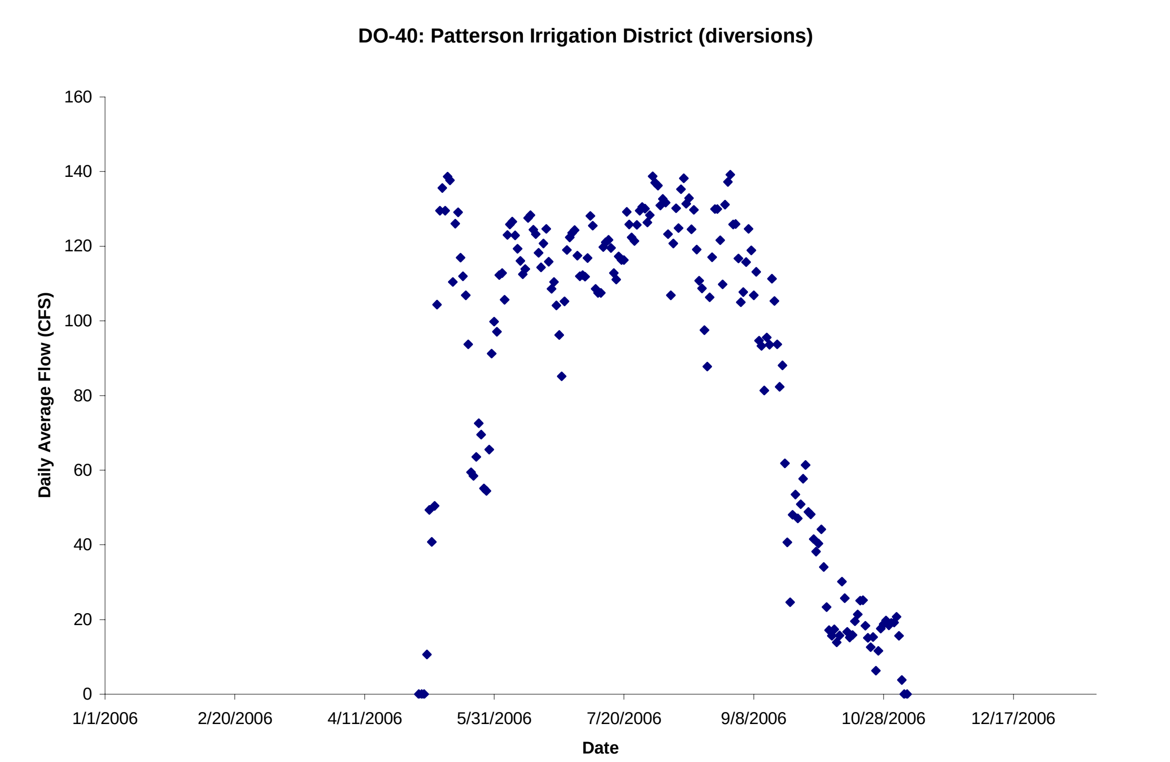


Figure 33. West Stanislaus Irrigation District diversions (DO-41) daily flow.

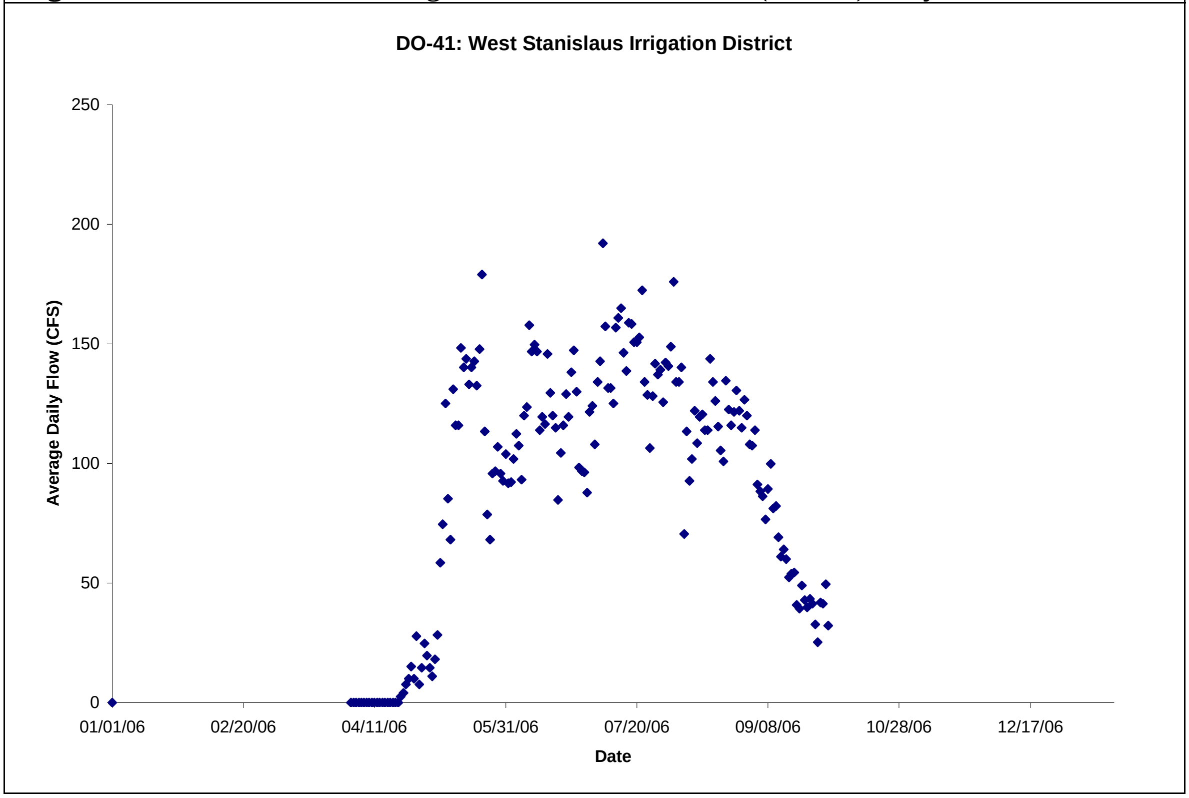


Figure 34. Banta Carbona Irrigation District diversions (DO-42) daily flow.

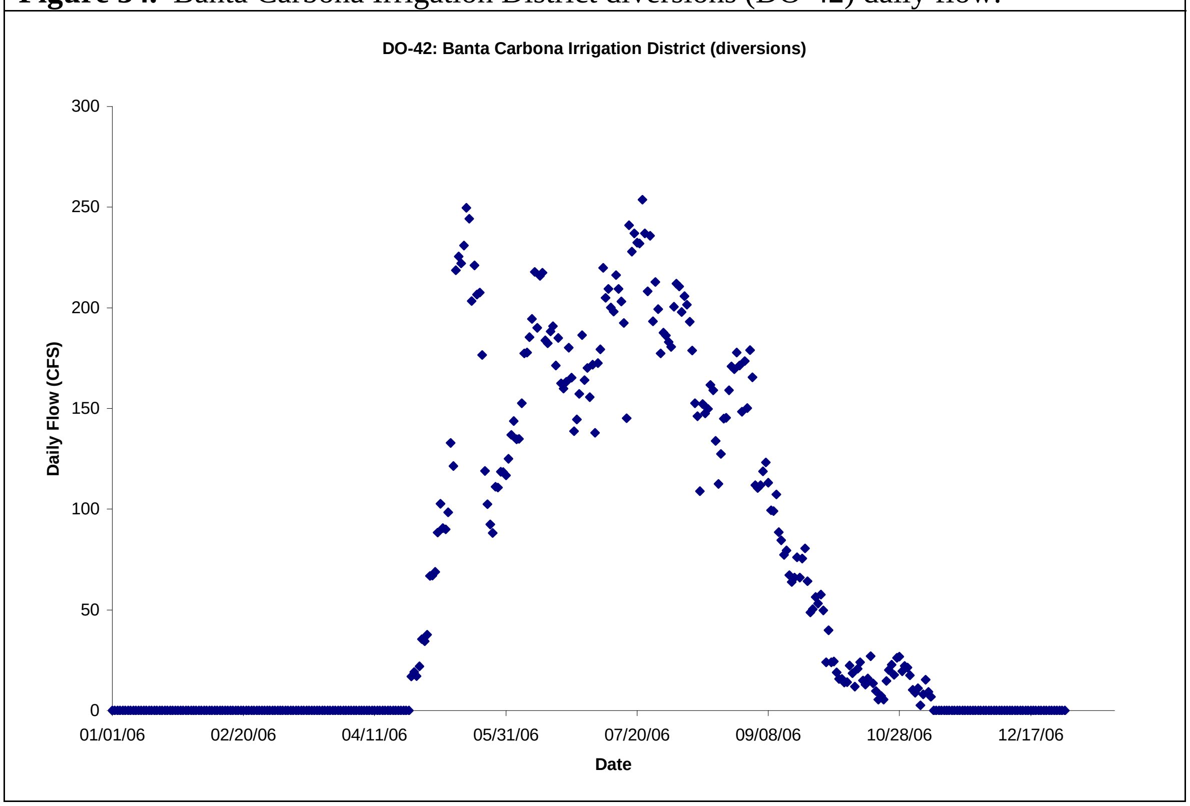


Figure 35. El Soylo Pumping Station diversions (DO-43) monthly flow.

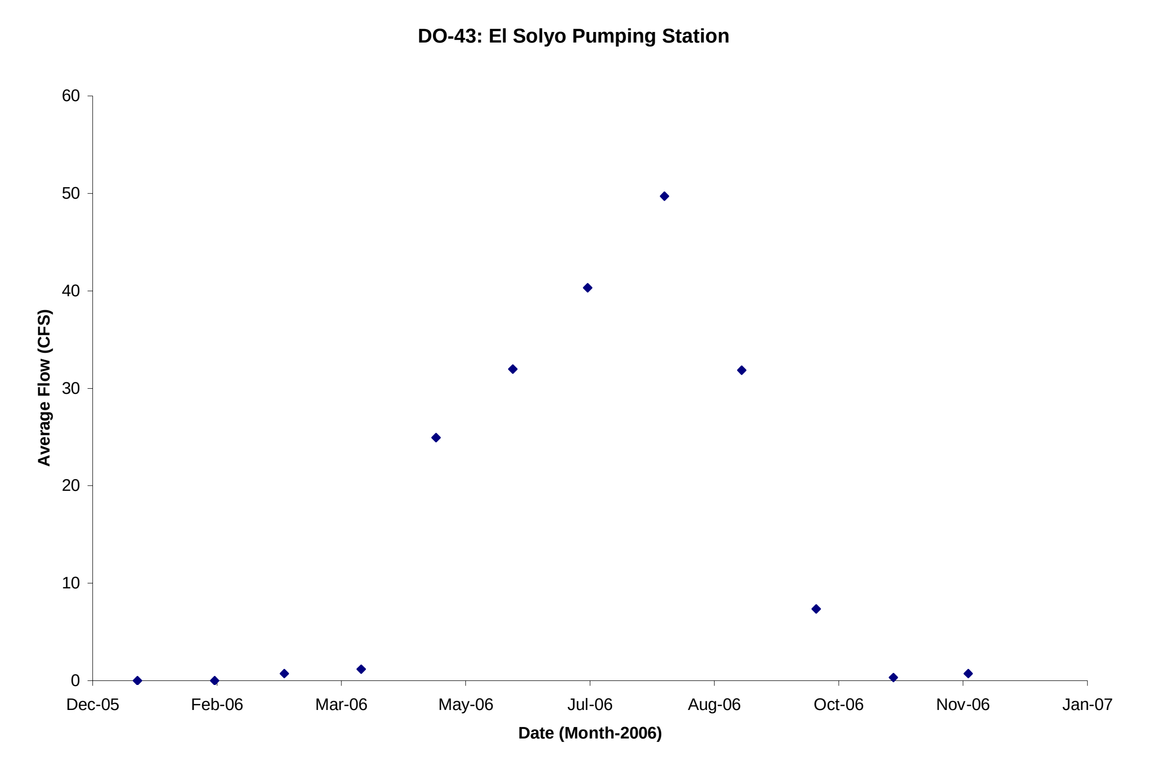


Figure 36. San Luis Drain End (DO-44) daily average flow.

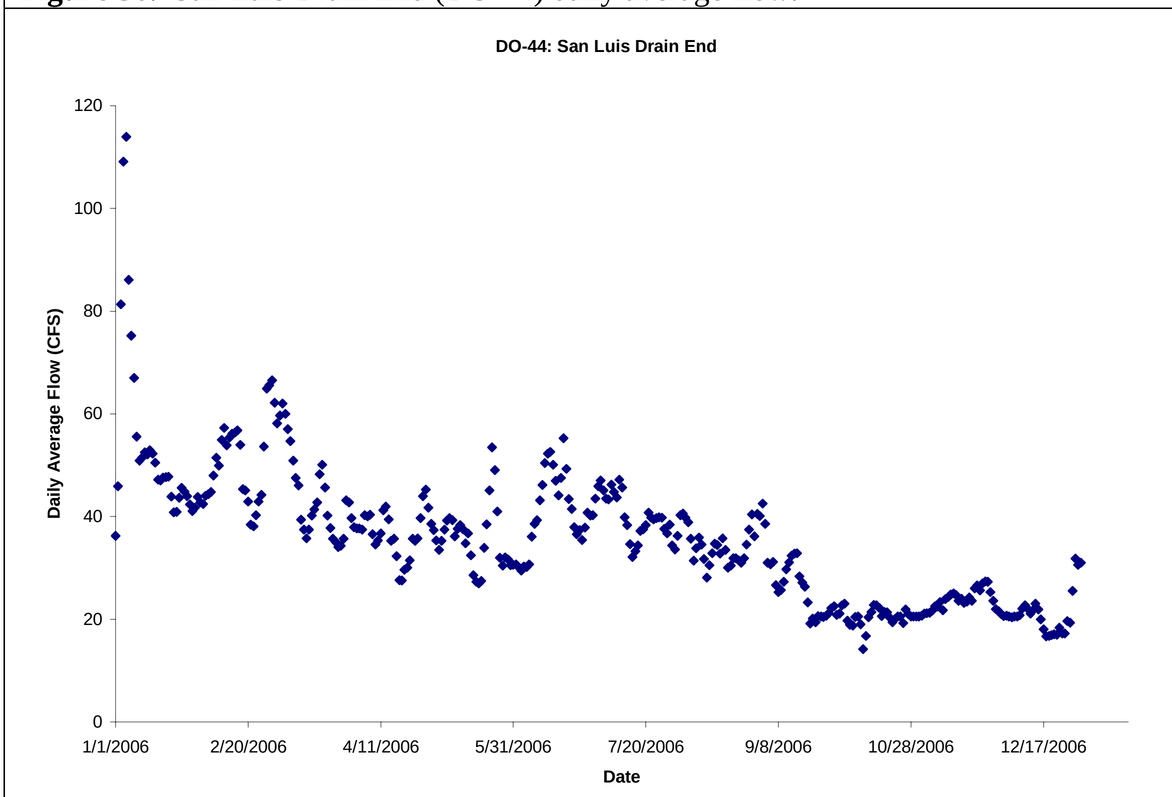


Figure 37. Volta Wasteway (DO-45) daily average flow.

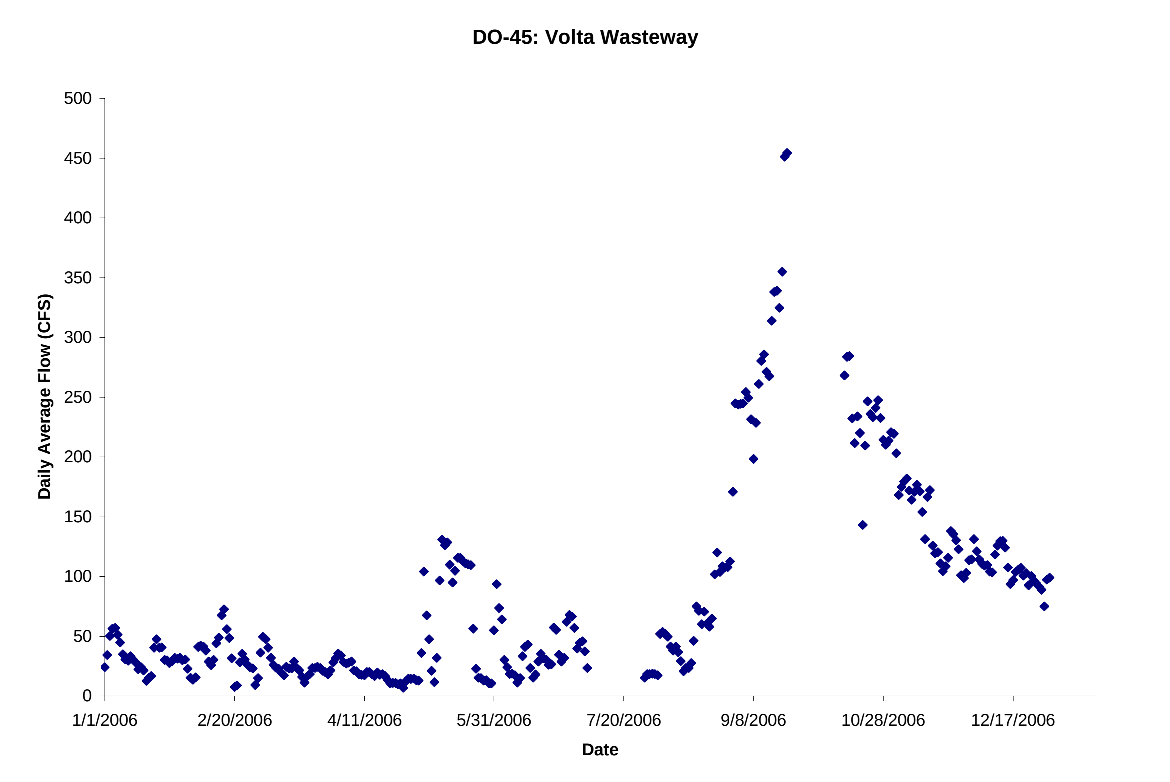


Figure 38. Mud Slough at Gun Club Road (DO-46) daily average flow.

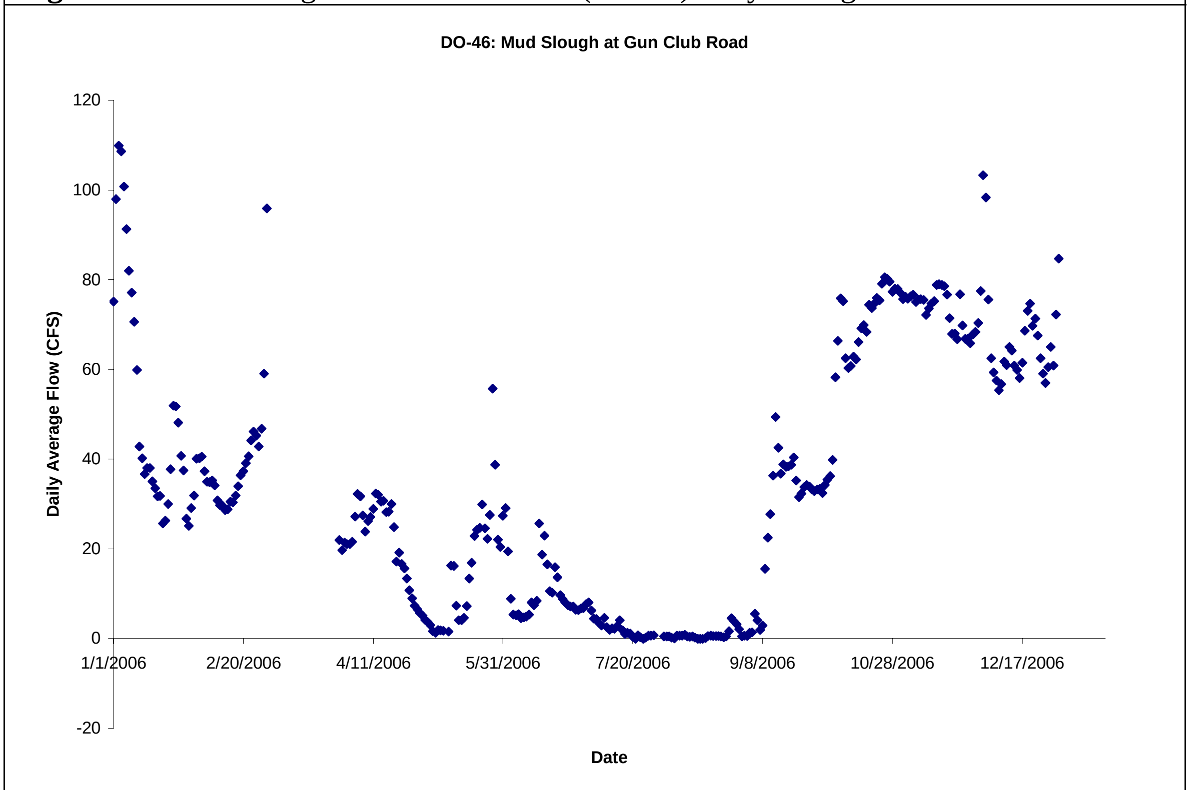


Figure 39. PE-14 Grasslands Area Farmers (DO-49) daily average flow.

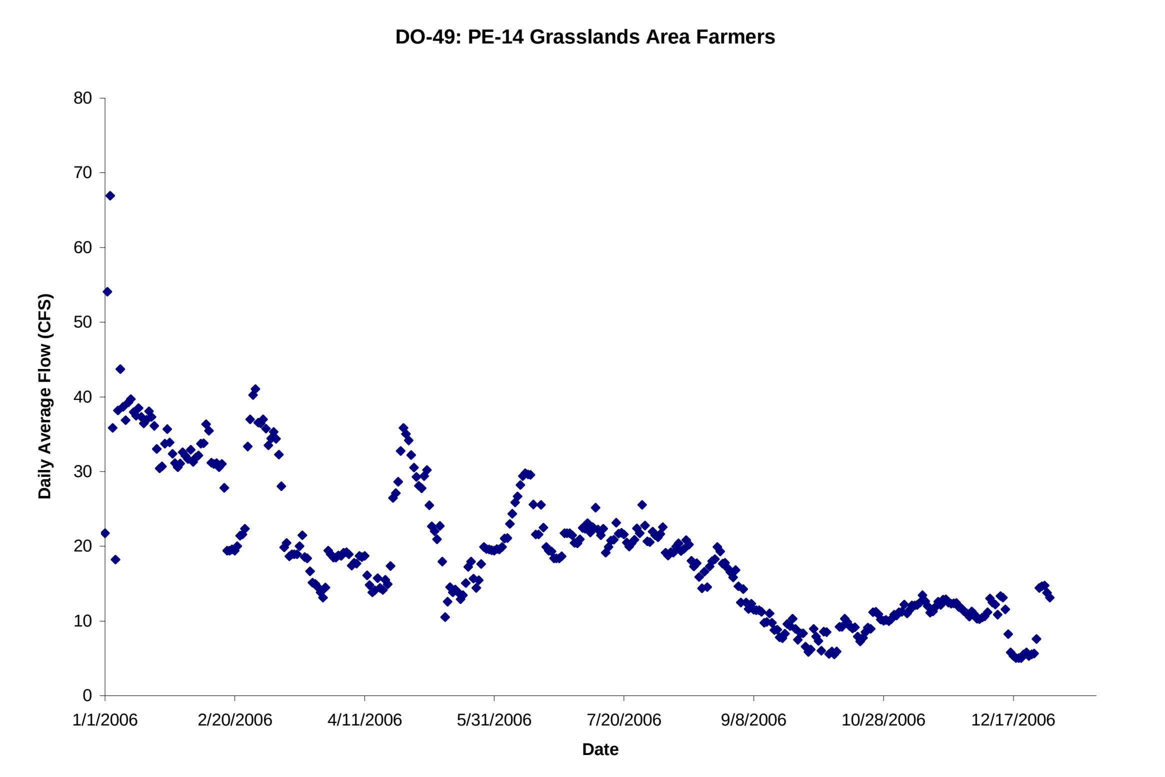


Figure 40. San Luis Drain Site A (DO-50) daily average flow.

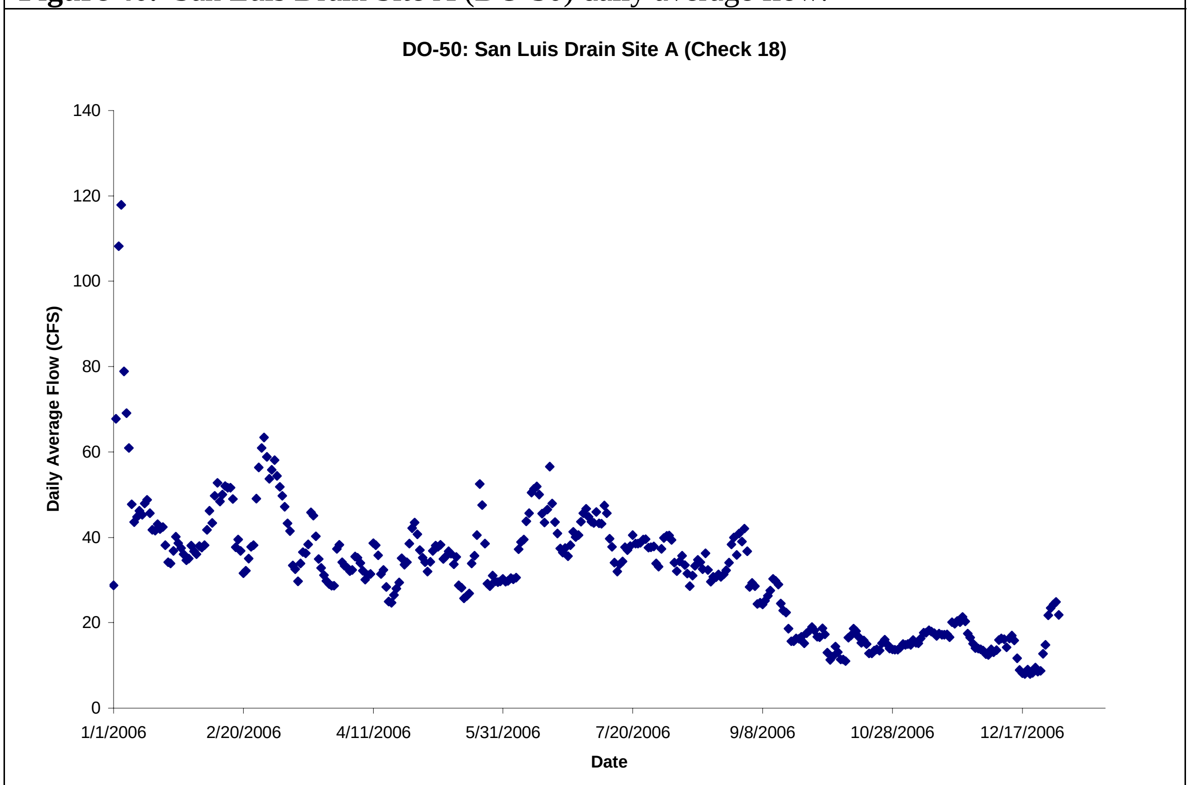


Figure 41. Salt Slough at Wolfsen Road (DO-53) daily average flow.

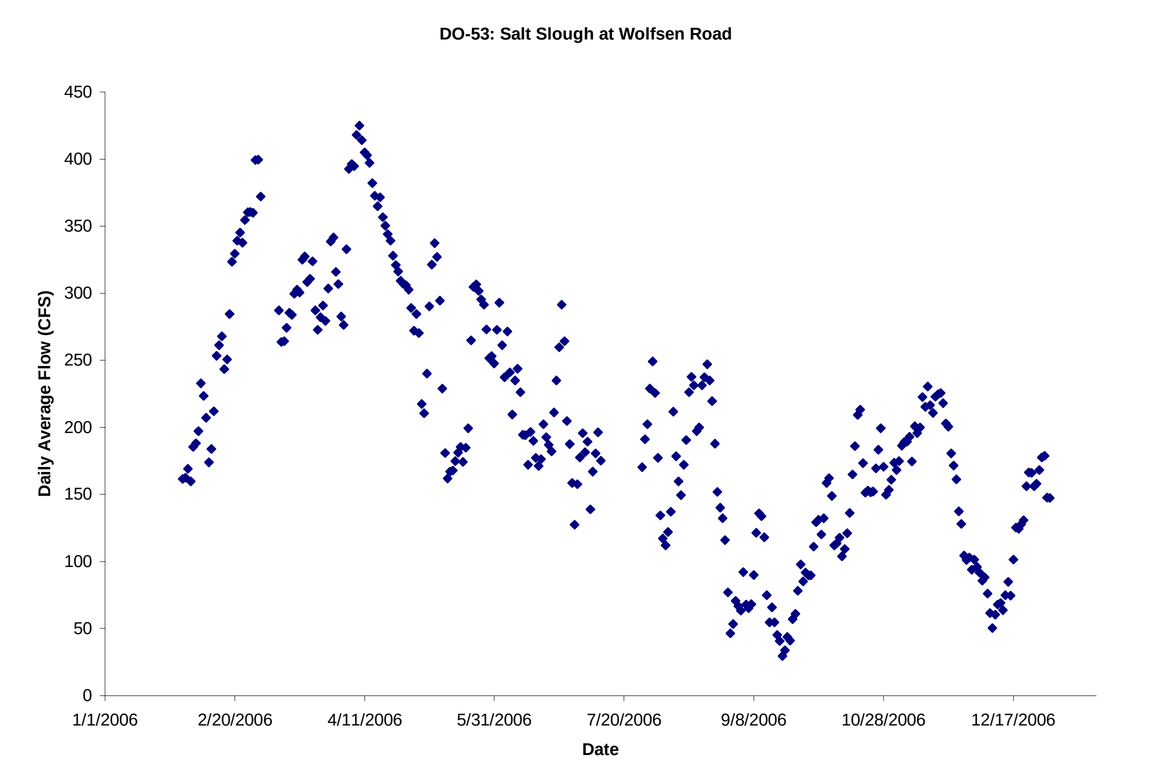


Figure 42. SJR Laird Park (DO-59) daily average flow.

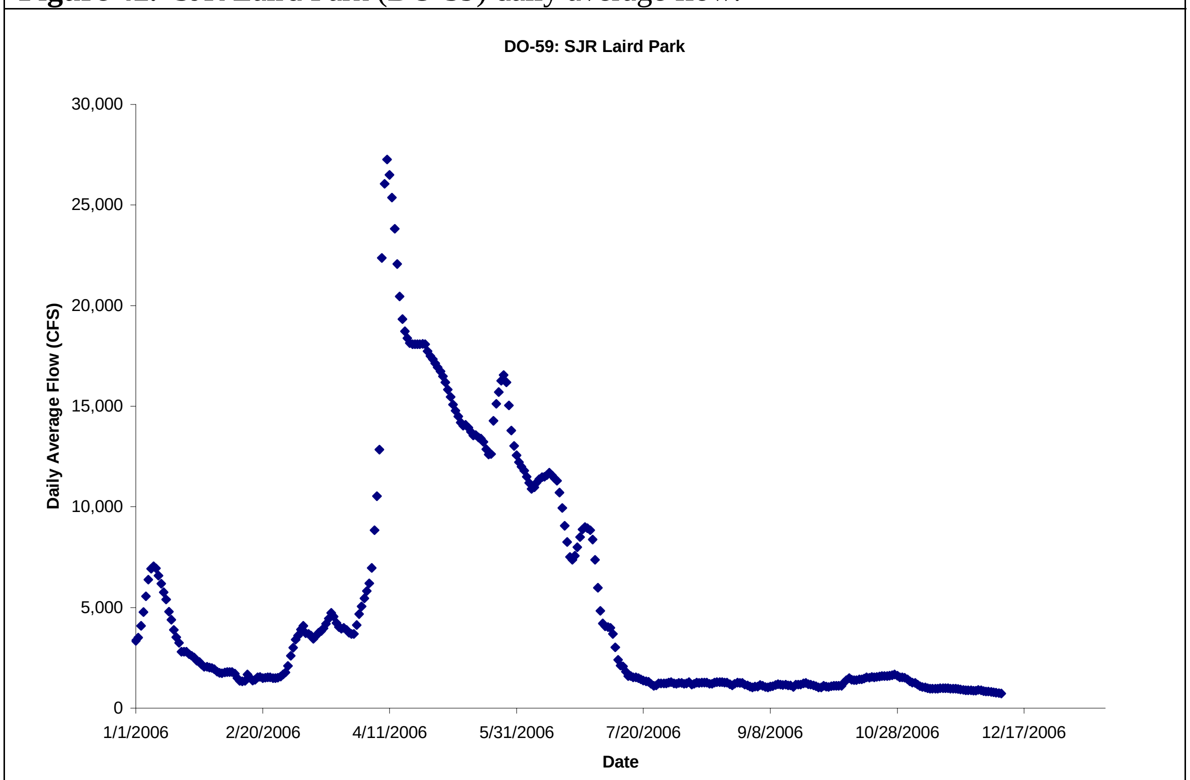


Figure 43. Moffit 1 South (DO-60) daily average flow.

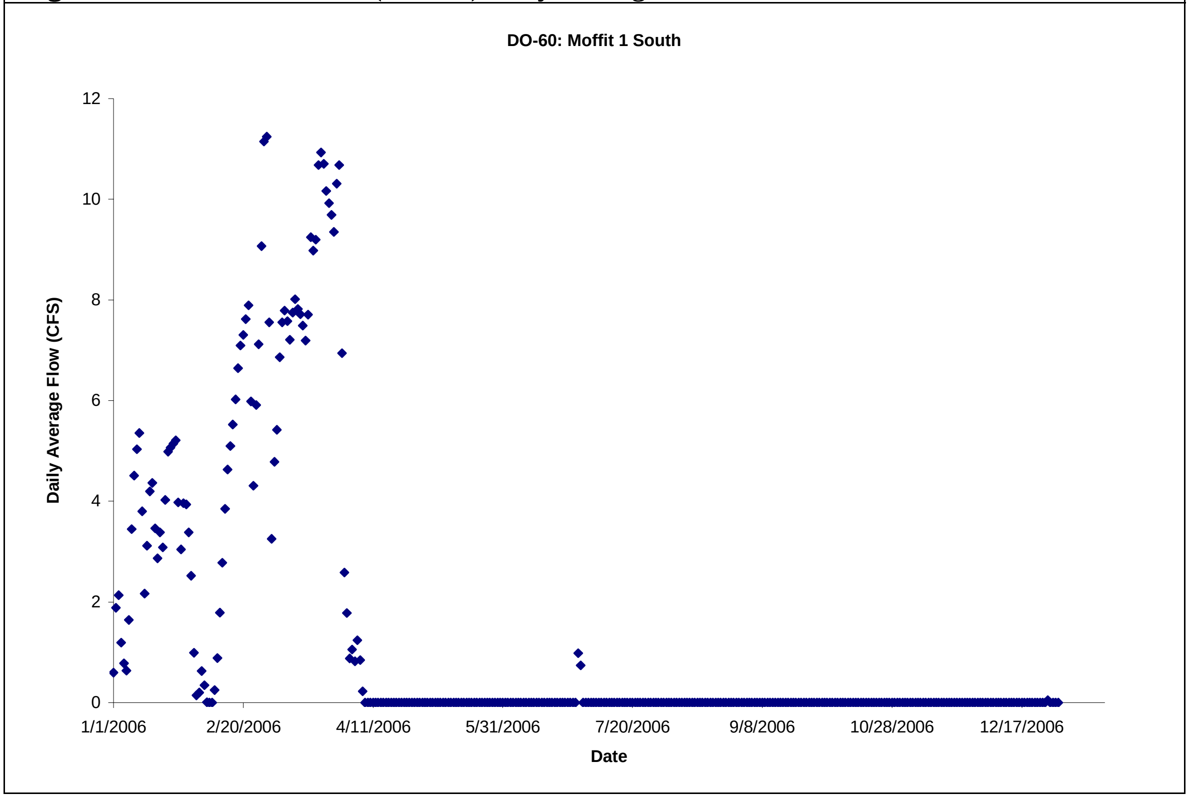


Figure 44. Deadman's Slough (DO-61) daily average flow.

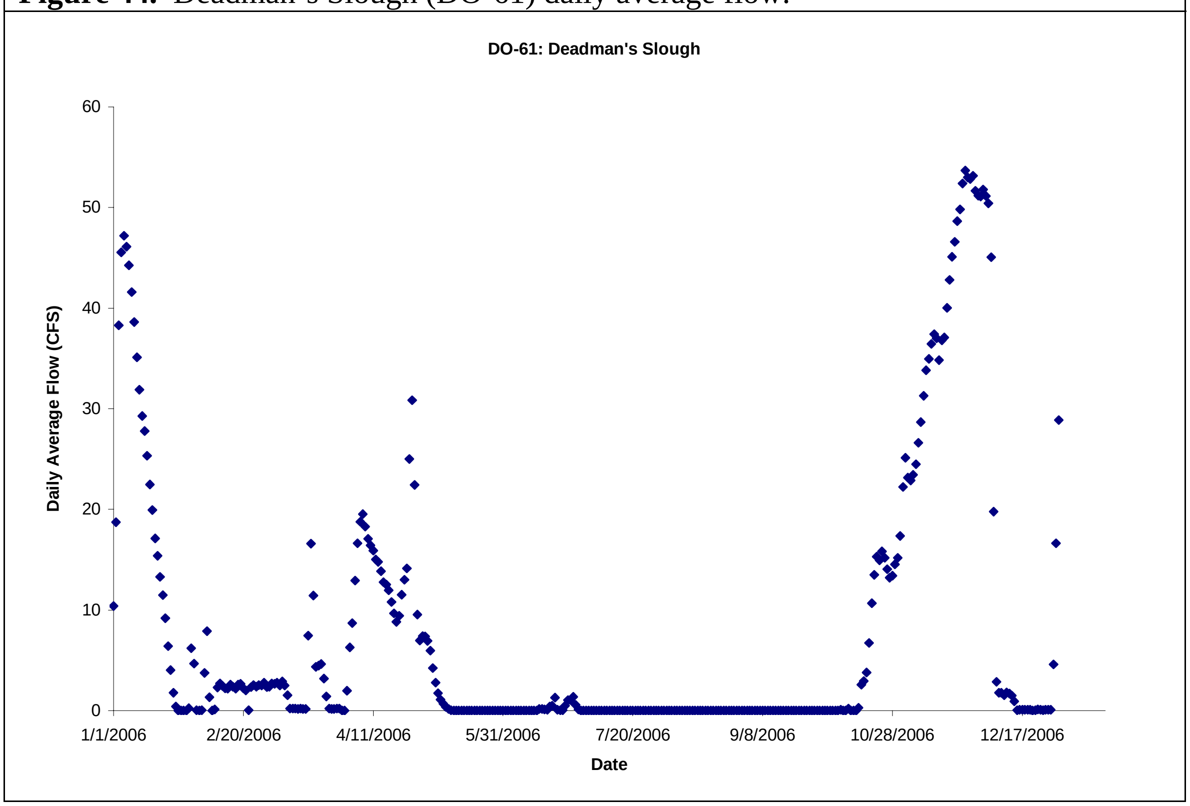


Figure 45. Mallard Slough (DO-62) daily average flow.

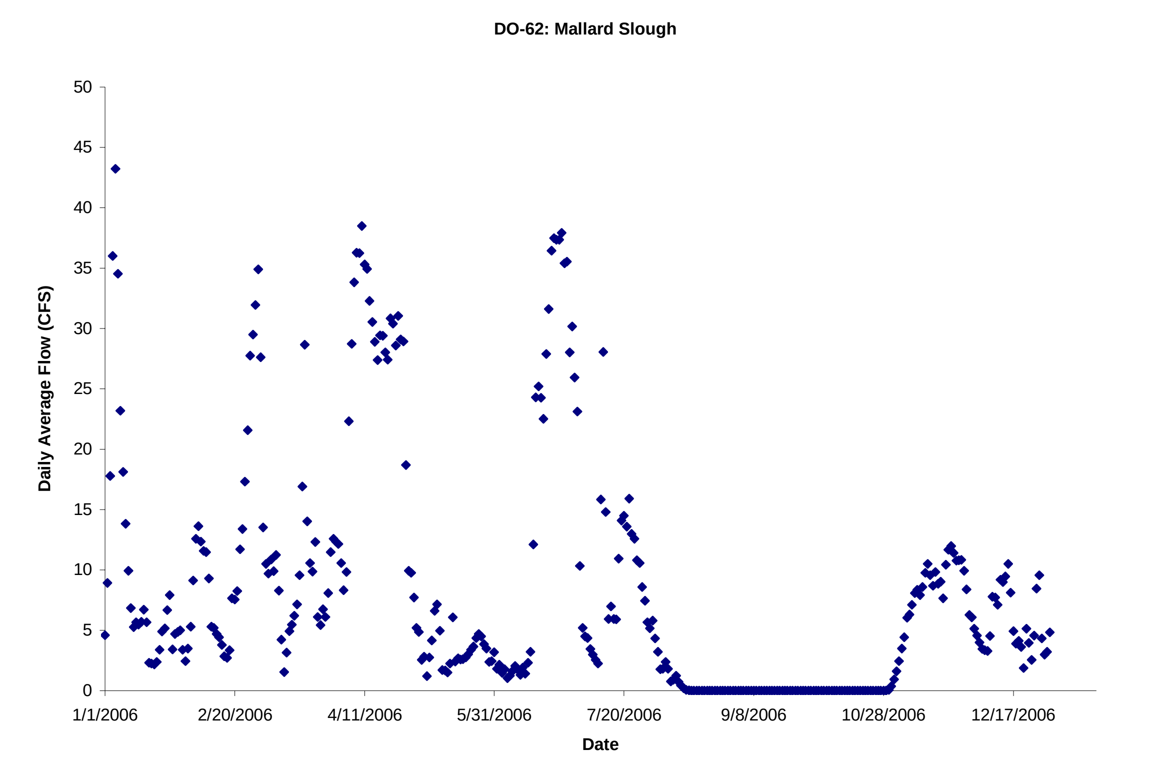


Figure 46. Inlet C Canal (DO-63) daily average flow.

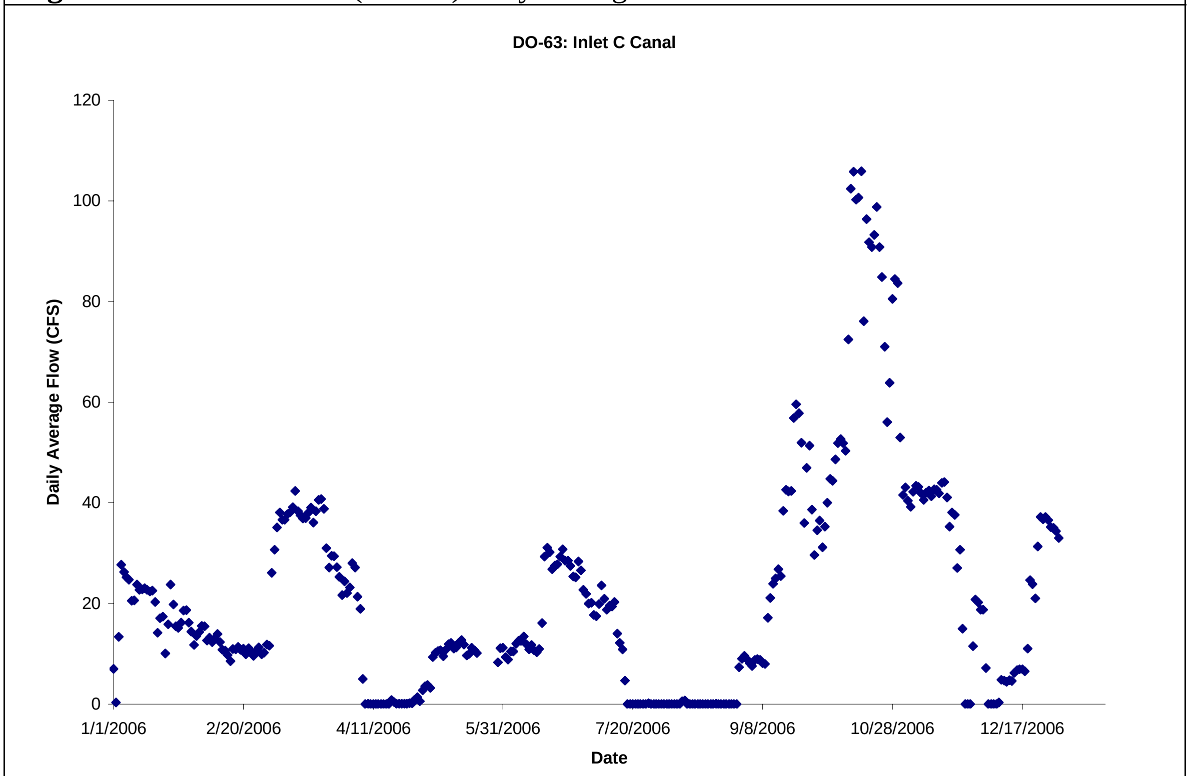


Figure 47. Moran Drain (DO-64) daily average flow.

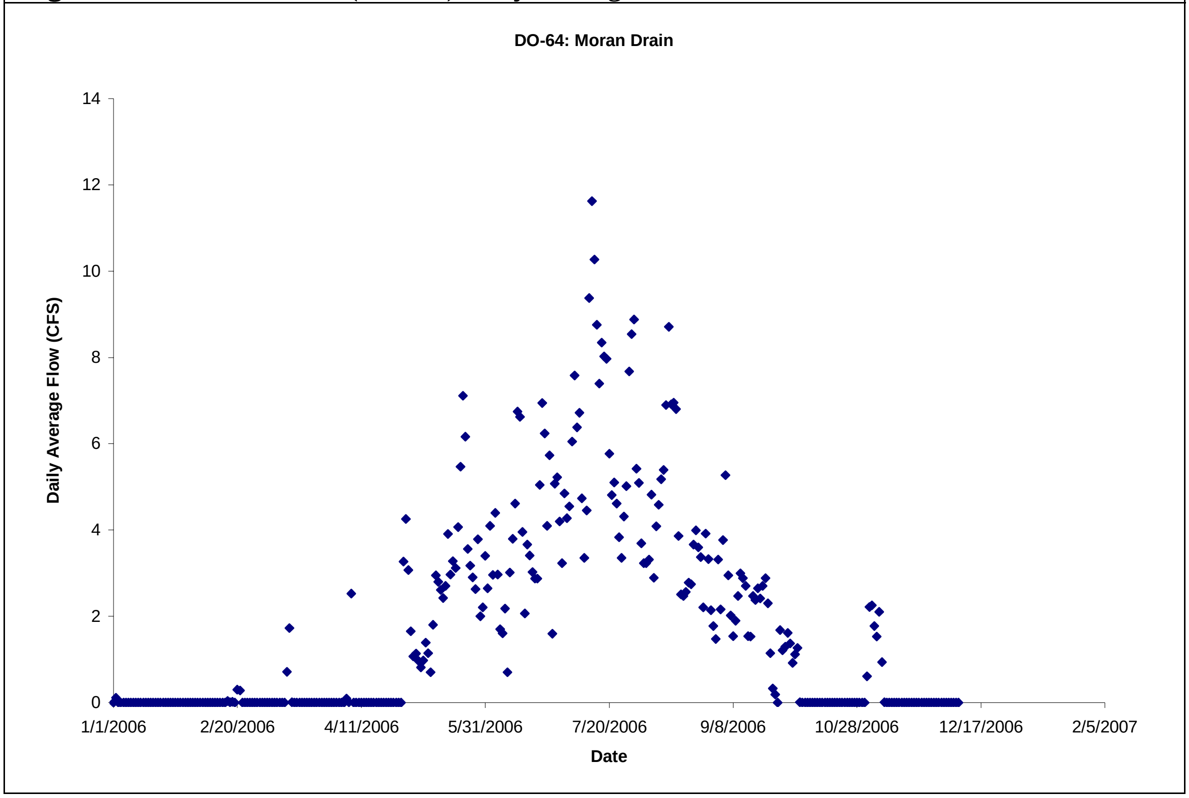


Figure 48. Spanish Grant Drain (DO-65) daily average flow.

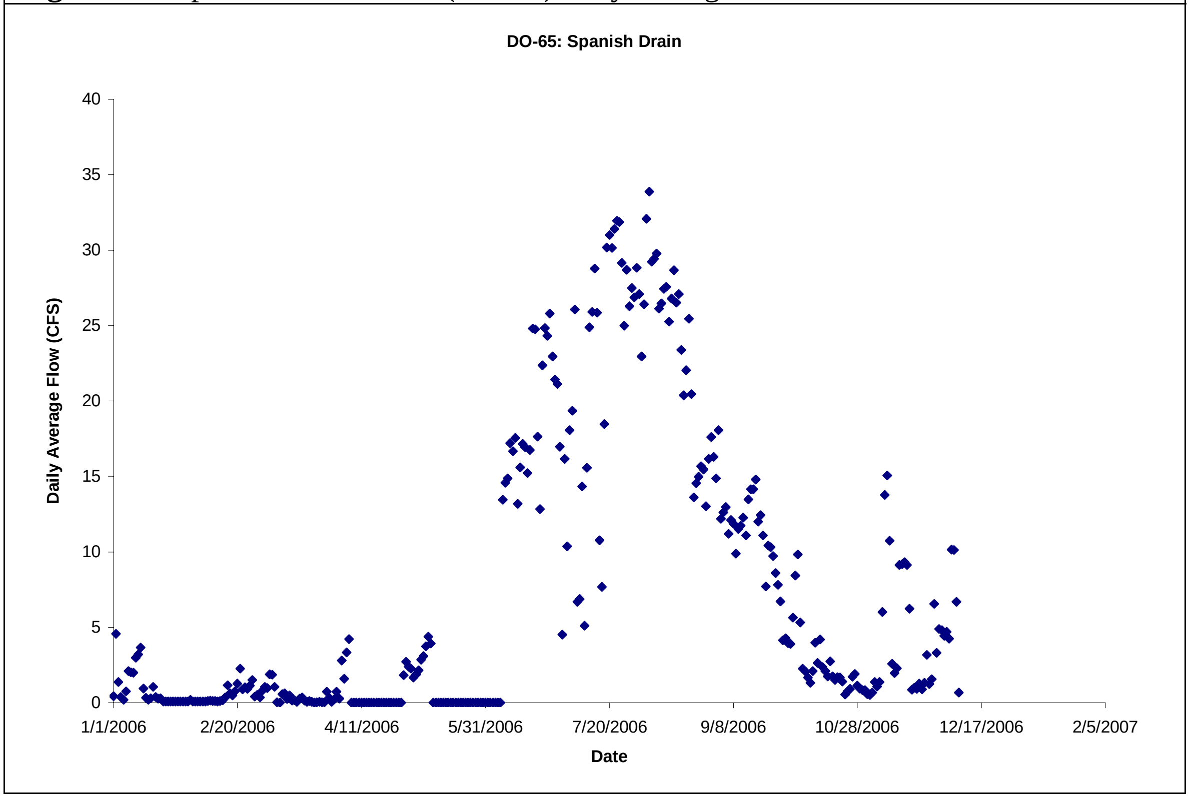


Figure 49. S. Lake Basin (DO-68) daily average flow.

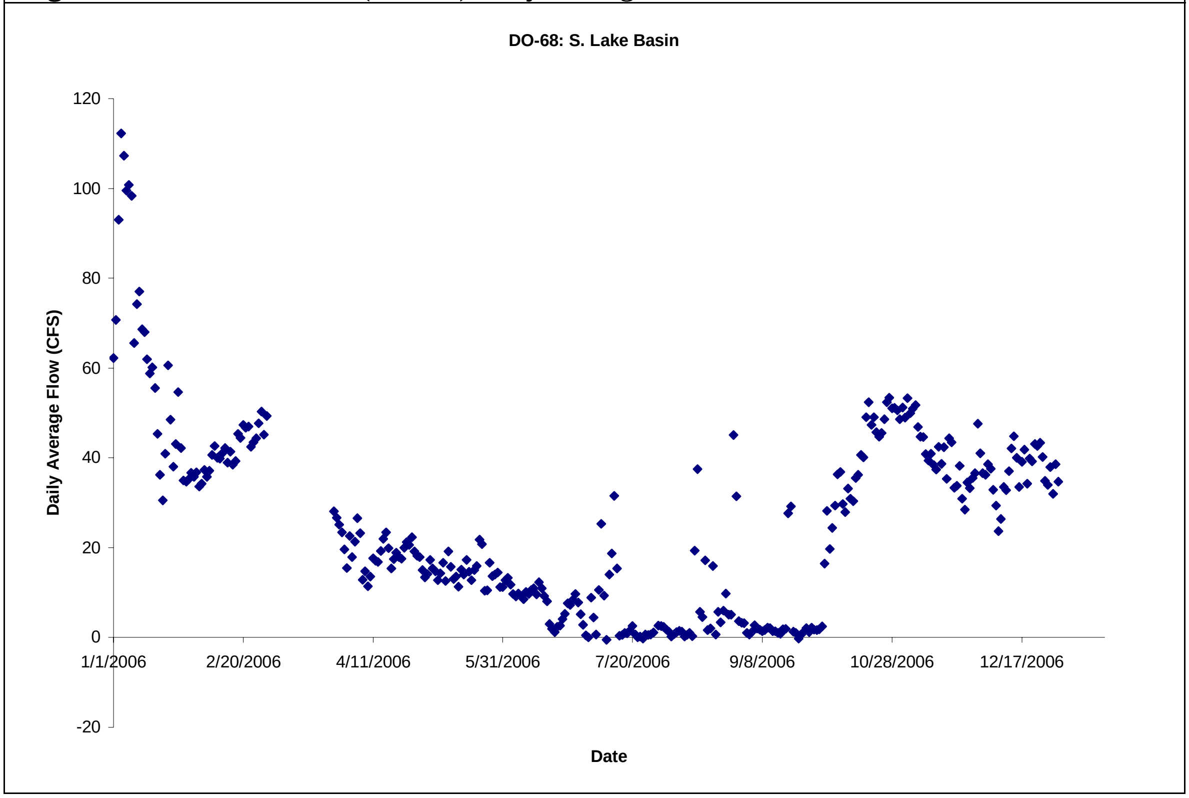
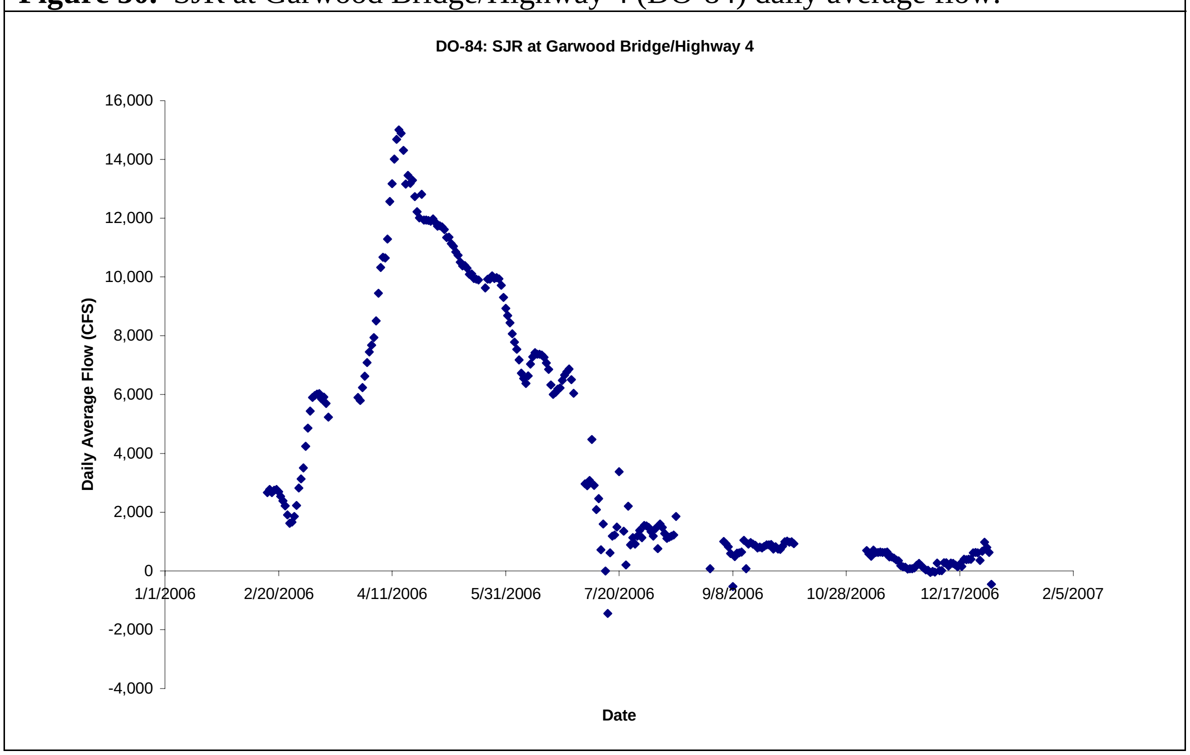


Figure 50. SJR at Garwood Bridge/Highway 4 (DO-84) daily average flow.



Appendix C

RATING AND QUALITY ASSURANCE
FOR
FLOW MONITORING STATIONS MAINTAINED BY THE ENVIRONMENTAL ENGINEERING RESEARCH PROGRAM & COOPERATING STAKEHOLDERS

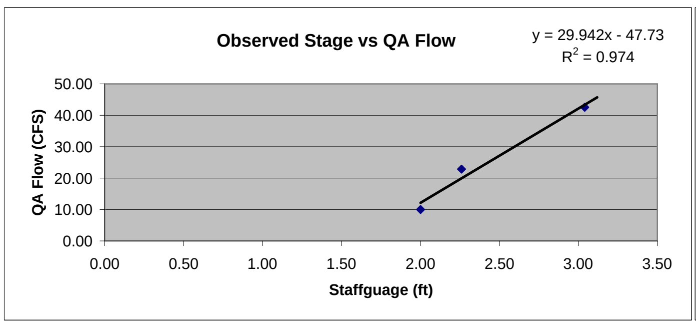
Jeremy Hanlon
Justin Graham
William Stringfellow
University of the Pacific
Lawrence Berkeley National Laboratory

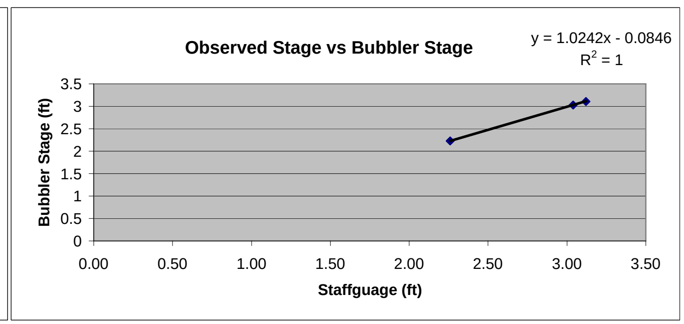
LosBanosCreek
Quality Assurance

DO-20 LosBanos Creek 2006 QA data
WS = Weir Stick SG = Streamgage

Reference					Measured Variables								Constants			
Site	Date	Time	Notebook Reference	Method	Observed Bubbler reading	Observed Staffguage Stage	Observed ITRC Weirstick reading	Observed EC from handheld meter	Pre-cleaning EC from logger data	Post-Cleaning EC from logger data	Observed Temp from handheld meter (F)	Temperature from Logger data (F)	Structure/ Equipment	Width of Weir in ft.	Bubbler to staffguage offset (add to bubbler value to get stage)	Rating Quality
LosBanos Creek	1/9/2006	11:00	G2P17	SG	na	5.80	na	1467	1357	na	51.6	50.92	stream/bubbler		#VALUE!	fair
LosBanos Creek	7/28/2006	na	F6P43	SG	na	2.00	na	na	na	na	na	na	stream/bubbler		#VALUE!	fair
LosBanos Creek	9/19/2006	11:30	G2P76	SG	2.23	2.26	na	796.6	na	na	71.4	na	stream/bubbler		0.030	fair
LosBanos Creek	12/1/2006	12:15	G2P86	SG	3.11	3.12	na	915.3	869	890	49.3	47.6	stream/bubbler		0.010	fair
LosBanos Creek	12/21/2006	9:00	F10P86	SG	3.03	3.04	na	1098	1042	1089	43.9	43.3	stream/bubbler		0.010	fair
													Average offset		0.017	

Reference					Calculations								Comments
Site	Date	Time	Notebook Reference	Method	QA Average Velocity (calculated from flow rating velocities)	QA Area (calculated from flow rating area)	Bubbler Calculated Area	QA Flow	Bubbler Calculated Flow (= 3.8335x2 + 6.5477x - 8.0518)	Pre-Cleaning EC deviation (logger/QA *100)	Post-Cleaning EC deviation (logger/QA*100)	Temperature Deviation (logger/QA*100)	
LosBanos Creek	1/9/2006	11:00	G2P17	SG			#VALUE!		#VALUE!	92.50	#VALUE!	98.68	Bridge and equipment washed out.
LosBanos Creek	7/28/2006	na	F6P43	SG	0.48	17.44	#VALUE!	9.95	#VALUE!				stage reading taken from photo
LosBanos Creek	9/19/2006	11:30	G2P76	SG	0.68	29.58	26.16	22.88	25.61	#VALUE!	#VALUE!	#VALUE!	EC meter not installed
LosBanos Creek	12/1/2006	12:15	G2P86	SG			49.32		49.39				
LosBanos Creek	12/21/2006	9:00	F10P86	SG	0.87	46.45	47.22	42.56	46.98	94.90	99.18	98.63	





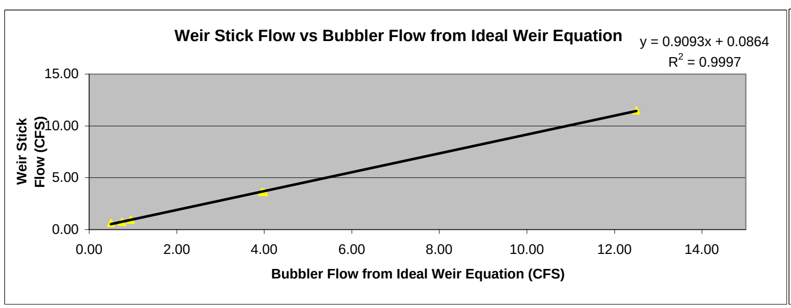
New Jerusalem Drain

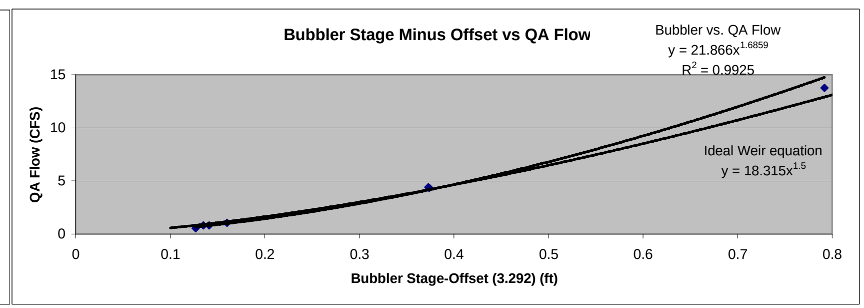
Quality Assurance

DO-31 New Jerusalem Drain 2006 QA data
WS = Weir Stick SG = Streamgage

Reference					Measured Variables								Constants				
Site	Date	Time	Notebook Reference	Method	Observed Bubbler reading	Observed Staffguage Stage	Observed ITRC Weirstick reading	Observed EC from handheld meter	Pre-cleaning EC from logger data	Post-Cleaning EC from logger data	Observed Temp from handheld meter (C)	Temperature from Logger data (F)	Structure/ Equipment	Width of Weir in ft.	Bubbler to staffguage offset (add to bubbler value to get stage)	Bubbler to Top of Weir Offset (subtract from bubbler to get Head for flow calculation) from back calculation of weirstick reading	Rating Quality
New Jerusalem Drain	1/11/2006	11:04	TT011106P95	WS	2.864	7.30	na	2340	2417		17.9	64.3	Weir/bubbler	5	4.436	#VALUE!	good
New Jerusalem Drain	1/31/2006	8:30	F5P83	WS	3.427		0.15	na	na	na	na	na	Weir/bubbler	5	-3.427	3.300	good
New Jerusalem Drain	2/8/2006	12:37	TT020806P105	WS	3.419	na	0.1	2420	2400		17.3	63.28	Weir/bubbler	5	#VALUE!	3.322	good
New Jerusalem Drain	3/8/2006	11:17	TT030806	WS	4.618	3.50	na	2321	2395		16.58	62.11	Weir/bubbler	5	-1.118	#VALUE!	good
New Jerusalem Drain	4/4/2006	na	na	WS	na	na	na	na	na	na	na	na	Weir/bubbler	5	#VALUE!	#VALUE!	good
New Jerusalem Drain	5/9/2006	11:20	TT050906P135	WS	12.514	na	na	2297	2266		17.06	62.8	Weir/bubbler	5	#VALUE!	#VALUE!	good
New Jerusalem Drain	6/6/2006	8:20	TT060606P145	WS	7.46	na	na	2553	2432		17.5	63.61	Weir/bubbler	5	#VALUE!	#VALUE!	good
New Jerusalem Drain	7/21/2006	12:00	TT072106Pxx	WS	4.084	3.00	2.5	2479	2419		18.48	65.37	Weir/bubbler	5	-1.084	3.258	good
New Jerusalem Drain	8/22/2006	na	TT082206Pxx	WS	na	na	na	2507	2523		18.83	66	Weir/bubbler	5	#VALUE!	#VALUE!	good
New Jerusalem Drain	9/28/2006	13:00	TT092806P19	WS	na	na	na	2468	2404		19.07	66.35	Weir/bubbler	5	#VALUE!	#VALUE!	good
New Jerusalem Drain	10/3/2006	11:15	F9P133N7	WS	3.665	na	0.8	na	na		na	na	Weir/bubbler	5	#VALUE!	3.279	good
New Jerusalem Drain	10/27/2006	12:00	TT102706P27	WS	3.666	na	0.79	2529	2477		19.74	66.61	Weir/bubbler	5	#VALUE!	3.283	good
New Jerusalem Drain	11/17/2006	11:30	TT111706P36	WS	3.452	2.40	0.19	2494	2599		19.12	66.4	Weir/bubbler	5	-1.052	3.304	good
New Jerusalem Drain	12/8/2006	11:00	TT120806P45	WS	3.433	na	0.15	2575	2517		18.11	65.32	Weir/bubbler	5	#VALUE!	3.306	good
													Average Offset		-1.085	3.292	

Reference					Calculations						Comments
Site	Date	Time	Notebook Reference	Method	stage above boards as back calculated from ITRC Weirstick Reading [H=(WS/3.33)^(2/3)]	Weirstick Flow Calculated from (weirstick reading * boardwidth)	Bubbler Flow calculated from (3.33 * Weir width * (bubbler stage-offset)^1.5)	Pre-Cleaning EC deviation (logger/QA*100)	Post-Cleaning EC deviation (logger/QA*100)	Temperature Deviation (logger/QA*100)	Comments
New Jerusalem Drain	1/11/2006	11:04	TT011106P95	WS	#VALUE!	#VALUE!	#NUM!	103.29	0.00	100.12	Bubbler line found to have leak
New Jerusalem Drain	1/31/2006	8:30	F5P83	WS	0.13	0.75	0.73	#VALUE!	#VALUE!	#VALUE!	Bubbler repaired
New Jerusalem Drain	2/8/2006	12:37	TT020806P105	WS	0.10	0.50	0.66	99.17	0.00	100.22	
New Jerusalem Drain	3/8/2006	11:17	TT030806	WS	#VALUE!	#VALUE!	25.11	103.19	0.00	100.43	
New Jerusalem Drain	4/4/2006	na	na	WS	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	Notebook was lost
New Jerusalem Drain	5/9/2006	11:20	TT050906P135	WS	#VALUE!	#VALUE!	465.45	98.65	0.00	100.15	submerged weir, river backed up into site
New Jerusalem Drain	6/6/2006	8:20	TT060606P145	WS	#VALUE!	#VALUE!	141.12	95.26	0.00	100.17	
New Jerusalem Drain	7/21/2006	12:00	TT072106Pxx	WS	0.83	12.50	11.49	97.58	0.00	100.16	
New Jerusalem Drain	8/22/2006	na	TT082206Pxx	WS	#VALUE!	#VALUE!	#VALUE!	100.64	0.00	100.16	
New Jerusalem Drain	9/28/2006	13:00	TT092806P19	WS	#VALUE!	#VALUE!	#VALUE!	97.41	0.00	100.04	
New Jerusalem Drain	10/3/2006	11:15	F9P133N7	WS	0.39	4.00	3.63	#VALUE!	#VALUE!	#VALUE!	
New Jerusalem Drain	10/27/2006	12:00	TT102706P27	WS	0.38	3.95	3.64	97.94	0.00	98.63	
New Jerusalem Drain	11/17/2006	11:30	TT111706P36	WS	0.15	0.95	0.96	104.21	0.00	99.98	
New Jerusalem Drain	12/8/2006	11:00	TT120806P45	WS	0.13	0.75	0.78	97.75	0.00	101.12	





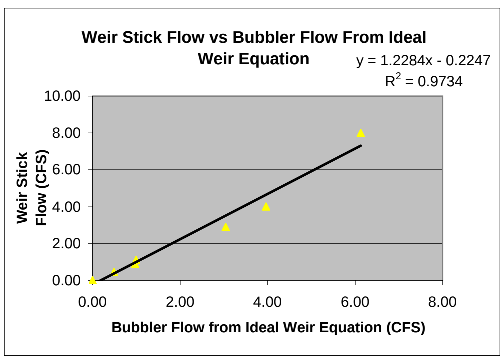
Hospital Creek
Quality Assurance

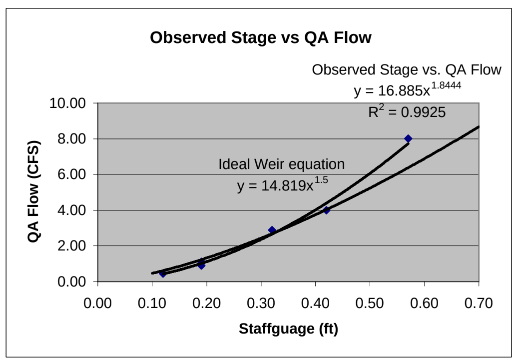
DO-33 Hospital Creek 2006 QA data

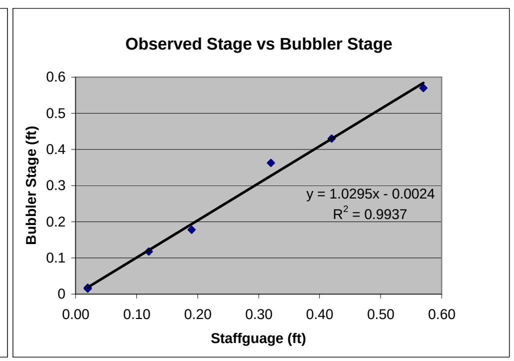
WS = Weir Stick SG = Streamgage

Reference					Measured Variables									Constants				
Site	Date	Time	Notebook Reference	Method	Observed Bubbler reading	Observed Staffguage Stage	Observed ITRC Weirstick reading	Observed EC from handheld meter	Pre-cleaning EC from logger data	Post-Cleaning EC from logger data	Observed Temp from handheld meter (C)	Temperature from Logger data (F)	Structure/ Equipment	Width of Weir in ft.	Bubbler to staffguage offset (add to bubbler value to get stage)	Bubbler to top of weir offset (subtract from bubbler to get Head above Weir)	Rating Quality
Hospital Creek	1/11/2006	10:35	TT011106P94	WS	-0.002	0.01	No flow	163	186	168	9.22	48.6	Weir/bubbler	4.45	0.012	#VALUE!	good
Hospital Creek	2/8/2006	12:15	TT020806P104	WS	-0.154	dry(<0)	No flow	NA	0	2	NA	62.48	Weir/bubbler	4.45	#VALUE!	#VALUE!	good
Hospital Creek	3/8/2006	10:51	TT030806P114	WS	0.007	NA	NA	361	355	356	9.6	49.16	Weir/bubbler	4.45	#VALUE!	#VALUE!	good
Hospital Creek	4/4/2006	12:45	TT040406P124	WS	0.18	0.19	0.25	205	202	212	12.77	59.3	Weir/bubbler	4.45	0.010	0.002	good
Hospital Creek	5/9/2006	10:55	TT050906P134	WS	0.365	NA	NA	188	296	192	18.42	65.68	Weir/bubbler	4.45	#VALUE!	#VALUE!	good
Hospital Creek	6/6/2006	8:45	TT060606P144	WS	0.178	0.19	0.2	198	213	195	18.95	66.4	Weir/bubbler	4.45	0.012	0.025	good
Hospital Creek	7/21/2006	11:25	TT072106Pxx	WS	0.57	0.57	1.8	488	497	318	28.27	99.3	Weir/bubbler	4.45	0.000	-0.094	good
Hospital Creek	8/22/2006	11:45	TT082206Pxx	WS	0.363	0.32	0.65	514	527	545	22.26	71.73	Weir/bubbler	4.45	-0.043	0.027	good
Hospital Creek	9/28/2006	12:30	TT092806P18	WS	0.43	0.42	0.9	584	577	610	19.94	67.61	Weir/bubbler	4.45	-0.010	0.012	good
Hospital Creek	10/27/2006	11:30	TT102706P26	WS	0.118	0.12	0.1	575	573	593	11.61	52.49	Weir/bubbler	4.45	0.002	0.021	good
Hospital Creek	11/17/2006	11:00	TT111706P35	WS	0.018	0.02	0	1177	1258		15.35	59.66	Weir/bubbler	4.45	0.002	0.018	good
Hospital Creek	12/8/2006	10:30	TT120806P45	WS	0.015	0.02	0	635	661		7.18	46.928	Weir/bubbler	4.45	0.005	0.015	good
													Average offset		-0.001	0.017	

Reference					Calculations						Comments
Site	Date	Time	Notebook Reference	Method	stage above boards as back calculated from ITRC Weirstick Reading [H=(WS/3.33)^(2/3)]	Weirstick Flow Calculated from (weirstick reading * boardwidth)	Bubbler Flow calculated from (3.33 * Weir width * (bubbler stage-offset)^1.5)	Pre-Cleaning EC deviation (logger/QA*100)	Post-Cleaning EC deviation (logger/QA*100)	Temperature Deviation (logger/QA*100)	
Hospital Creek	1/11/2006	10:35	TT011106P94	WS	#VALUE!	#VALUE!	#NUM!	114.11	103.07	100.01	
Hospital Creek	2/8/2006	12:15	TT020806P104	WS	#VALUE!	#VALUE!	#NUM!	#VALUE!	#VALUE!	#VALUE!	
Hospital Creek	3/8/2006	10:51	TT030806P114	WS	#VALUE!	#VALUE!	#NUM!	98.34	98.61	99.76	
Hospital Creek	4/4/2006	12:45	TT040406P124	WS	0.18	1.11	0.99	98.54	103.41	107.85	
Hospital Creek	5/9/2006	10:55	TT050906P134	WS	#VALUE!	#VALUE!	3.07	157.45	102.13	100.80	
Hospital Creek	6/6/2006	8:45	TT060606P144	WS	0.15	0.89	0.98	107.58	98.48	100.44	
Hospital Creek	7/21/2006	11:25	TT072106Pxx	WS	0.66	8.01	6.13	101.84	65.16	119.80	
Hospital Creek	8/22/2006	11:45	TT082206Pxx	WS	0.34	2.89	3.04	102.53	106.03	99.53	post cleaning value questionable since EC was changing very rapidly at that time
Hospital Creek	9/28/2006	12:30	TT092806P18	WS	0.42	4.01	3.96	98.80	104.45	99.58	post cleaning value questionable since EC was changing very rapidly at that time
Hospital Creek	10/27/2006	11:30	TT102706P26	WS	0.10	0.45	0.49	99.65	103.13	99.23	
Hospital Creek	11/17/2006	11:00	TT111706P35	WS	0.00	0.00	0.00	106.88	0.00	100.05	
Hospital Creek	12/8/2006	10:30	TT120806P45	WS	0.00	0.00	0.00	104.09	0.00	104.46	







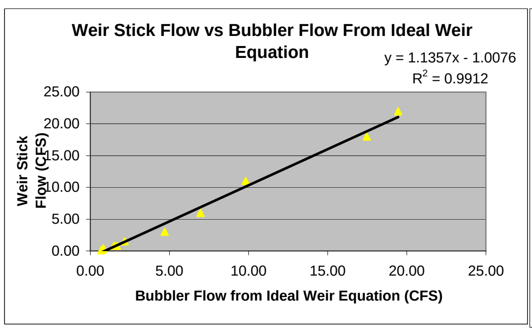
Ingram Creek

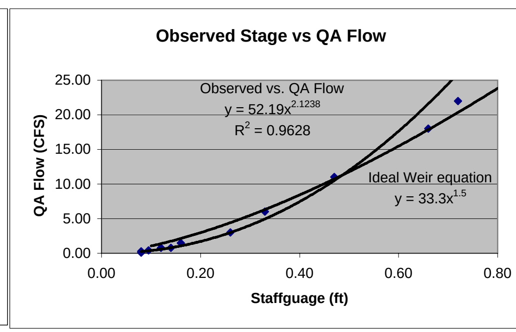
Quality Assurance

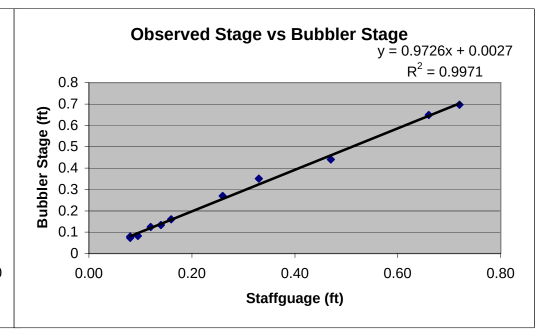
DO-34 Ingram Creek 2006 QA data
WS = Weir Stick SG = Streamgage

Reference					Measured Variables								Constants				
Site	Date	Time	Notebook Reference	Method	Observed Bubbler reading	Observed Staffguage Stage	Observed ITRC Weirstick reading	Observed EC from handheld meter	Pre-cleaning EC from logger data	Post-Cleaning EC from logger data	Observed Temp from handheld meter (C)	Temperature from Logger data (F)	Structure/ Equipment	Width of Weir in ft.	Bubbler to staffguage offset (add to bubbler value to get stage)	Bubbler to top of Weir offset (subtract from bubbler to get Head above weir)	Rating Quality
Ingram Creek	1/11/2006	10:35	TT011106P93	WS	0.073	0.08	0.01	1926	1346	1601	11.98	57.97	Weir/bubbler	10	0.007	0.052	good
Ingram Creek	2/8/2006	11:45	TT020806P102	WS	0.083	0.10	0.04	1332	1908	1338	13.08	57.36	Weir/bubbler	10	0.012	0.031	good
Ingram Creek	3/8/2006	10:25	TT030806P113	WS	0.08	0.08	0.03	1664	1437	1631	10.7	53.22	Weir/bubbler	10	0.000	0.037	good
Ingram Creek	4/4/2006	12:30	TT040406P123	WS	0.1597	0.16	0.15	550	722	573	15.95	60.542	Weir/bubbler	10	0.000	0.033	good
Ingram Creek	5/9/2006	10:30	TT050906P133	WS	0.35	0.33	0.6	269	351	270	17.81	76.505	Weir/bubbler	10	-0.020	0.031	good
Ingram Creek	6/6/2006	9:10	TT060606P143	WS	0.441	0.47	1.1	559	433	553	19.58	66.84	Weir/bubbler	10	0.029	-0.037	good
Ingram Creek	7/21/2006	11:00	TT072106Pxx	WS	0.6486	0.66	1.8	818	696	819	27.4	94.978	Weir/bubbler	10	0.011	-0.015	good
Ingram Creek	8/22/2006	11:30	TT082206Pxx	WS	0.697	0.72	2.2	825	780	859	23.77	74.1	Weir/bubbler	10	0.023	-0.062	good
Ingram Creek	9/28/2006	12:15	TT092806P17	WS	0.182	NA	NA	914	702	848	19.62	68.78	Weir/bubbler	10	#VALUE!	#VALUE!	good
Ingram Creek	10/27/2006	11:00	TT102806P25	WS	0.134	0.14	0.08	906	449	848	14.31	57.34	Weir/bubbler	10	0.006	0.051	good
Ingram Creek	11/17/2006	10:30	TT111716P34	WS	0.124	0.12	0.08	1443	1440		16.3	61.42	Weir/bubbler	10	-0.004	0.041	good
Ingram Creek	12/8/2006	10:00	TT120806P43	WS	0.269	0.26	0.3	774	735		7.53	45.154	Weir/bubbler	10	-0.009	0.068	good
													Average offset		0.006	0.021	

Reference					Calculations						Comments
Site	Date	Time	Notebook Reference	Method	stage above boards as back calculated from ITRC Weirstick Reading [H=(WS/3.33)^(2/3)]	Weirstick Flow Calculated from (weirstick reading * boardwidth)	Bubbler Flow calculated from (3.33 * Weir width * (bubbler stage-offset)^1.5)	Pre-Cleaning EC deviation (logger/QA*100)	Post-Cleaning EC deviation (logger/QA*100)	Temperature Deviation (logger/QA*100)	
Ingram Creek	1/11/2006	10:35	TT011106P93	WS	0.02	0.10	0.68	69.89	83.13	108.23	
Ingram Creek	2/8/2006	11:45	TT020806P102	WS	0.05	0.40	0.83	143.24	100.45	103.27	
Ingram Creek	3/8/2006	10:25	TT030806P113	WS	0.04	0.30	0.78	86.36	98.02	103.82	
Ingram Creek	4/4/2006	12:30	TT040406P123	WS	0.13	1.50	2.17	131.27	104.18	99.72	
Ingram Creek	5/9/2006	10:30	TT050906P133	WS	0.32	6.00	6.95	130.48	100.37	119.43	
Ingram Creek	6/6/2006	9:10	TT060606P143	WS	0.48	11.00	9.82	77.46	98.93	99.40	
Ingram Creek	7/21/2006	11:00	TT072106Pxx	WS	0.66	18.00	17.47	85.09	100.12	116.80	
Ingram Creek	8/22/2006	11:30	TT082206Pxx	WS	0.76	22.00	19.46	94.55	104.12	99.08	
Ingram Creek	9/28/2006	12:15	TT092806P17	WS	#VALUE!	#VALUE!	2.63	76.81	92.78	102.17	
Ingram Creek	10/27/2006	11:00	TT102806P25	WS	0.08	0.80	1.67	49.56	93.60	99.28	
Ingram Creek	11/17/2006	10:30	TT111716P34	WS	0.08	0.80	1.49	99.79	0.00	100.13	
Ingram Creek	12/8/2006	10:00	TT120806P43	WS	0.20	3.00	4.70	94.96	0.00	99.12	







Westley Wasteway

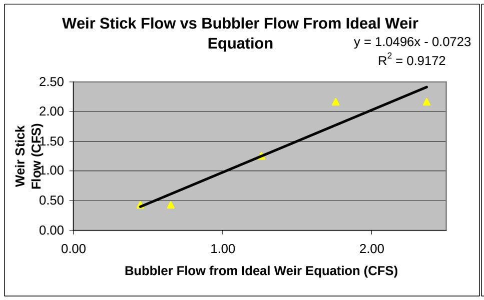
Quality Assurance

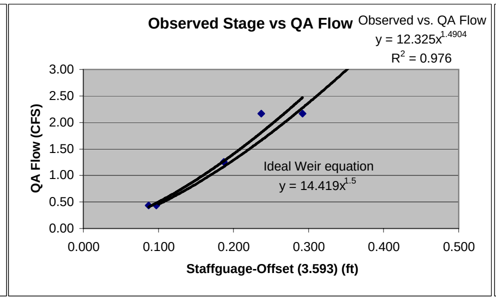
DO-35 Westley Wasteway 2006 QA data

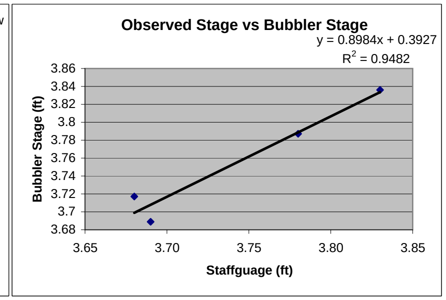
WS = Weir Stick   SG = Streamgage

Reference					Measured Variables								Constants				
Site	Date	Time	Notebook Reference	Method	Observed Bubbler reading	Observed Staffguage Stage	Observed ITRC Weirstick reading	Observed EC from handheld meter	Pre-cleaning EC from logger data	Post-Cleaning EC from logger data	Observed Temp from handheld meter (C)	Temperature from Logger data (F)	Structure/ Equipment	Width of Weir in ft.	Bubbler to staffguage offset (add to bubbler value to get stage)	Bubbler to top of weir offset (subtract from bubbler to get Head above Weir)	Rating Quality
Westley Wasteway	1/11/2006	9:40	TT011106P92	WS	1.714	na	na	190	na	na	9.15	na	Weir/bubbler	4.33	#VALUE!	#VALUE!	poor
Westley Wasteway	2/8/2006	10:45	TT020806P102	WS	0.587	na	na	356	na	na	7.51	na	Weir/bubbler	4.33	#VALUE!	#VALUE!	poor
Westley Wasteway	3/8/2006	10:00	TT030806P112	WS	0.073	0.29	na	257	275	259	7.61	45.71	Weir/bubbler	4.33	0.217	#VALUE!	poor
Westley Wasteway	4/4/2006	na	TT040406P122	WS	na	na	na	na	na	na	na	na	Weir/bubbler	4.33	#VALUE!	#VALUE!	poor
Westley Wasteway	5/9/2006	10:00	TT050906P132	WS	0.53	0.80	na	230	415	350	19.36	60.25	Weir/bubbler	4.33	0.270	#VALUE!	poor
Westley Wasteway	6/6/2006	9:30	TT060606P142	WS	2.158	1.69	na	413	318	390	22.22	73.06	Weir/bubbler	4.33	-0.468	#VALUE!	poor
Westley Wasteway	7/21/2006	na	na	WS	na	na	na	na	na	na	na	na	Weir/bubbler	4.33	#VALUE!	#VALUE!	poor
Westley Wasteway	8/1/2006	na	F10P48	WS	na	3.70	1	na	na	na	na	na	Weir/bubbler	4.33	#VALUE!	#VALUE!	poor
Westley Wasteway	8/22/2006	11:00	TT082206Pxx	WS	na	na	0.75	614	na	na	26.95	na	Weir/bubbler	4.33	#VALUE!	#VALUE!	poor
Westley Wasteway	9/5/2006	9:00	F10P77	WS	3.89	3.89	0.5	450	449	455	65	65.76	Weir/bubbler	4.33	-0.005	3.608	fair
Westley Wasteway	9/28/2006	11:45	TT092806P16	WS	3.968	na	na	440	451	438	21.52	69.86	Weir/bubbler	4.33	#VALUE!	#VALUE!	fair
Westley Wasteway	10/3/2006	10:00	F9P133	WS	3.689	3.69	0.1	na	na	na	na	na	Weir/bubbler	4.33	0.001	3.592	fair
Westley Wasteway	10/27/2006	10:30	TT102806P24	WS	3.787	3.78	0.29	389	511	456	9.95	49.3	Weir/bubbler	4.33	-0.007	3.591	fair
Westley Wasteway	11/17/2006	10:00	TT111706P33	WS	3.836	3.83	0.5	443	634	425	15.52	58.23	Weir/bubbler	4.33	-0.006	3.554	fair
Westley Wasteway	12/8/2006	9:45	TT1208006P42	WS	3.717	3.68	0.1	517	1176	575	5.39	39.92	Weir/bubbler	4.33	-0.037	3.620	fair
													Average offset		-0.011	3.593	

Reference					Calculations						Comments
Site	Date	Time	Notebook Reference	Method	stage above boards as back calculated from ITRC Weirstick Reading [H=(WS/3.33)^(2/3)]	Weirstick Flow Calculated from (weirstick reading * boardwidth)	Bubbler Flow calculated from (3.33 * Weir width * (bubbler stage-offset)^1.5)	Pre-Cleaning EC deviation (logger/QA *100)	Post-Cleaning EC deviation (logger/QA* 100)	Temperature Deviation (logger/QA*100)	
Westley Wasteway	1/11/2006	9:40	TT011106P92	WS	#VALUE!	#VALUE!	#NUM!	#VALUE!	#VALUE!	#VALUE!	
Westley Wasteway	2/8/2006	10:45	TT020806P102	WS	#VALUE!	#VALUE!	#NUM!	#VALUE!	#VALUE!	#VALUE!	
Westley Wasteway	3/8/2006	10:00	TT030806P112	WS	#VALUE!	#VALUE!	#NUM!	107.00	100.78	100.03	
Westley Wasteway	4/4/2006	na	TT040406P122	WS	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	no access to site due to weather
Westley Wasteway	5/9/2006	10:00	TT050906P132	WS	#VALUE!	#VALUE!	#NUM!	180.43	152.17	90.13	
Westley Wasteway	6/6/2006	9:30	TT060606P142	WS	#VALUE!	#VALUE!	#NUM!	77.00	94.43	101.48	
Westley Wasteway	7/21/2006	na	na	WS	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	
Westley Wasteway	8/1/2006	na	F10P48	WS	0.45	4.33	#VALUE!	#VALUE!	#VALUE!	#VALUE!	
Westley Wasteway	8/22/2006	11:00	TT082206Pxx	WS	0.37	3.25	#VALUE!	#VALUE!	#VALUE!	#VALUE!	
Westley Wasteway	9/5/2006	9:00	F10P77	WS	0.28	2.17	2.37	99.78	101.11	101.17	
Westley Wasteway	9/28/2006	11:45	TT092806P16	WS	#VALUE!	#VALUE!	3.35	102.50	99.55	98.76	
Westley Wasteway	10/3/2006	10:00	F9P133	WS	0.10	0.43	0.45	#VALUE!	#VALUE!	#VALUE!	
Westley Wasteway	10/27/2006	10:30	TT102806P24	WS	0.20	1.26	1.26	131.36	117.22	98.78	
Westley Wasteway	11/17/2006	10:00	TT111706P33	WS	0.28	2.17	1.76	143.12	95.94	97.15	
Westley Wasteway	12/8/2006	9:45	TT1208006P42	WS	0.10	0.43	0.65	227.47	111.22	95.73	







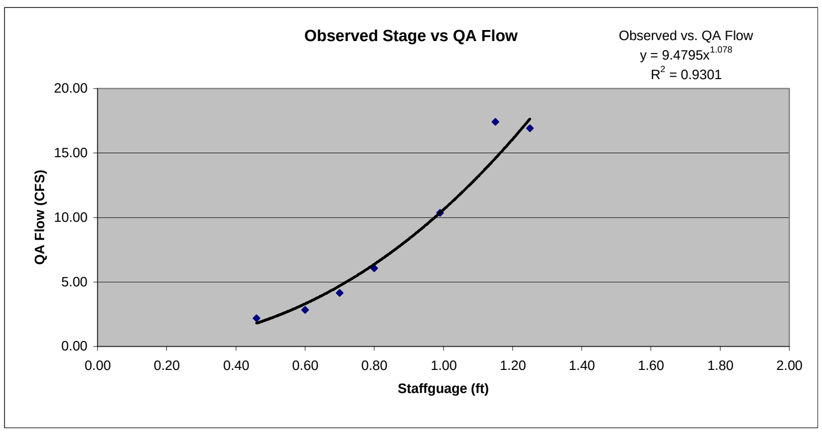
Del Puerto Creek

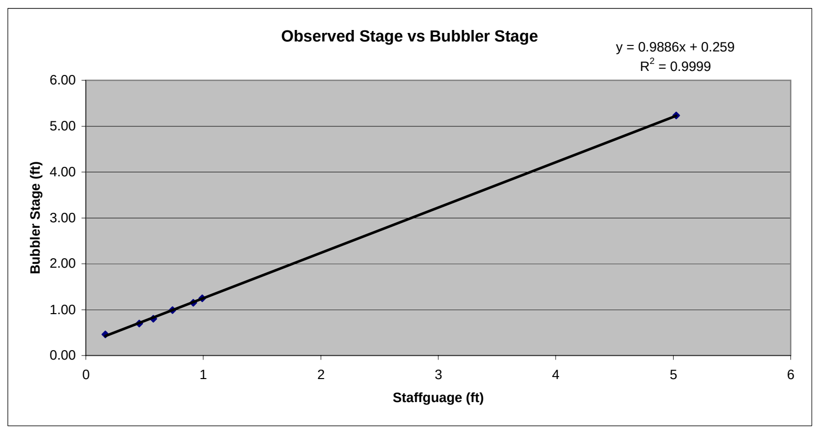
Quality Assurance

DO-36 Del Puerto Creek 2006 QA data
WS = Weir Stick SG = Streamgage

Reference					Measured Variables								Constants			
Site	Date	Time	Notebook Reference	Method	Observed Bubbler reading	Observed Staffguage Stage	Observed ITRC Weirstick reading	Observed EC from handheld meter	Pre-cleaning EC from logger data	Post-Cleaning EC from logger data	Observed Temp from handheld meter (C)	Temperature from Logger data (F)	Structure/ Equipment	Width of Weir in ft.	Bubbler to staffguage offset (add to bubbler value to get stage)	Rating Quality
DelPuerto Creek	1/11/2006	9:05	TT011106P91	SG	2.329	1.93		533	534	538	8.47	47.54	stream/bubbler		-0.399	good
DelPuerto Creek	2/8/2006	10:00	TT020806P101	SG	1.155	0.60		425	414	416	9.16	48.65	stream/bubbler		-0.555	good
DelPuerto Creek	3/8/2006	9:02	TT030806P111	SG	0.167	0.46		814	793	830	9.53	49.02	stream/bubbler		0.293	good
DelPuerto Creek	4/4/2006	na	TT040406P121	SG	2.22	na		na	463	463	na	na	stream/bubbler		#VALUE!	good
DelPuerto Creek	5/9/2006	9:40	TT050906	SG	7.088	na		304	600	600	16.9	65.24	stream/bubbler		#VALUE!	good
DelPuerto Creek	6/6/2006	10:10	TT060606P141	SG	5.025	5.23		472	620	473	20.16	68.83	stream/bubbler		0.205	good
DelPuerto Creek	7/21/2006	10:15	TT072106PXX	SG	0.992	1.25		1096	923	1117	23.92	74.66	stream/bubbler		0.258	good
DelPuerto Creek	8/22/2006	9:00	TT082206Pxx	SG	0.916	1.15		703	623	727	21.24	70.57	stream/bubbler		0.234	good
DelPuerto Creek	9/28/2006	11:00	TT092806P15	SG	0.533	na		591	581	583	17.81	64.02	stream/bubbler		#VALUE!	good
DelPuerto Creek	10/27/2006	9:00	TT102706P23	SG	0.739	0.99		954	919	964	12.59	54.82	stream/bubbler		0.251	good
DelPuerto Creek	11/17/2006	9:30	TT111706P31	SG	0.574	0.80		572	571	604	14.32	57.96	stream/bubbler		0.226	good
DelPuerto Creek	12/8/2006	9:20	TT120806P41	SG	0.455	0.7		1060	1063	1079	12.43	54.51	stream/bubbler		0.245	good
													Average offset		0.245	

Reference					Calculations								Comments
Site	Date	Time	Notebook Reference	Method	QA Average Velocity (calculated from flow rating velocities)	QA Area (calculated from flow rating area)	Bubbler Calculated Area	QA Flow	Bubbler Calculated Flow (20.975*G5*G5)-(4.5073*G5)+(2.1521)	Pre-Cleaning EC deviation (logger/QA*100)	Post-Cleaning EC deviation (logger/QA*100)	Temperature Deviation (logger/QA*100)	
DelPuerto Creek	1/11/2006	9:05	TT011106P91	SG	0.00				42.82	100.19	100.94	100.62	bubbler calculated flow takes into account different bubbler offset for these dates
DelPuerto Creek	2/8/2006	10:00	TT020806P101	SG	0.00			2.82	2.95	97.41	97.88	100.33	Bubbler adjusted to match staff guage
DelPuerto Creek	3/8/2006	9:02	TT030806P111	SG	0.00	1.33		2.19	1.98	97.42	101.97	99.73	
DelPuerto Creek	4/4/2006	na	TT040406P121	SG	0.00				95.52	#VALUE!	#VALUE!	#VALUE!	No Access to site due to weather. Backwater conditions.
DelPuerto Creek	5/9/2006	9:40	TT050906	SG	0.00				1023.98	197.37	197.37	104.52	Stream Guage submerged, EC probe not cleaned, inaccessable. Backwater conditions.
DelPuerto Creek	6/6/2006	10:10	TT060606P141	SG	0.00				509.13	131.36	100.21	100.79	flood stage, unable to rate, backwater conditions
DelPuerto Creek	7/21/2006	10:15	TT072106PXX	SG	2.27	6.85		16.93	18.32	84.22	101.92	99.47	
DelPuerto Creek	8/22/2006	9:00	TT082206Pxx	SG	2.12	7.32		17.42	15.62	88.62	103.41	100.48	
DelPuerto Creek	9/28/2006	11:00	TT092806P15	SG	0.00				5.71	98.31	98.65	99.94	
DelPuerto Creek	10/27/2006	9:00	TT102706P23	SG	1.98	5.50		10.37	10.28	96.33	101.05	100.29	
DelPuerto Creek	11/17/2006	9:30	TT111706P31	SG	1.41	3.78		6.07	6.48	99.83	105.59	100.32	
DelPuerto Creek	12/8/2006	9:20	TT120806P41	SG	1.37	2.97		4.14	4.44	100.28	101.79	100.25	





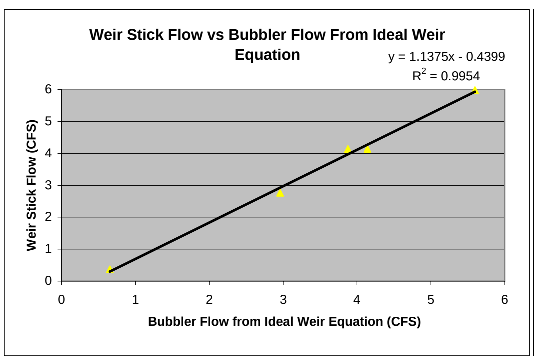
Marshall Road Drain

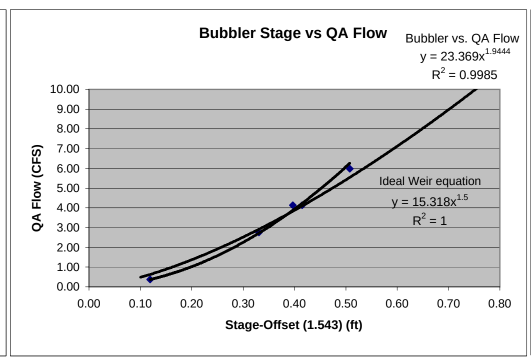
Quality Assurance

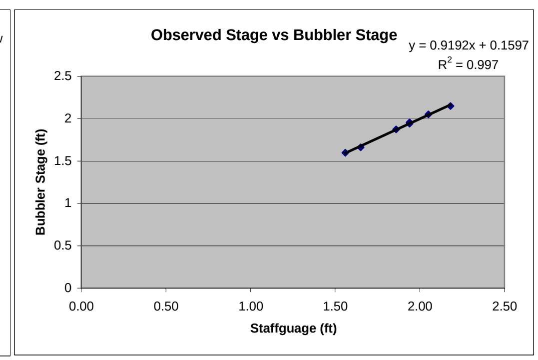
DO-38 Marshall Road Drain 2006 QA data
WS = Weir Stick SG = Streamgage

Reference					Measured Variables									Constants				
Site	Date	Time	Notebook Reference	Method	Observed Bubbler reading	Observed Staffguage Stage	Observed ITRC Weirstick reading	Observed EC from handheld meter	Pre-cleaning EC from logger data	Post-Cleaning EC from logger data	Observed Temp from handheld meter (C)	Temperature from Logger data (F)	Structure/ Equipment	Width of Weir in ft.	Bubbler to staffguage offset (add to bubbler value to get stage)	Bubbler to Top of Weir Offset (Subtract from Bubbler to Get Head Over Weir)	Rating Quality
Marshall Road Drain	1/11/2006	8:15	TT011106P88	WS	0.98	na	0	547	564	523	10.67	51.29	Weir/bubbler	4.6	#VALUE!	0.980	poor
Marshall Road Drain	2/8/2006	8:20	TT020806P97	WS	1.007	0.99	0.02	885	935	890	13.09	55.31	Weir/bubbler	4.6	-0.017	0.974	poor
Marshall Road Drain	3/8/2006	8:00	TT030806P107	WS	0.991	na	na	305	316	308	12.49	55.03	Weir/bubbler	4.6	#VALUE!	#VALUE!	poor
Marshall Road Drain	4/4/2006	8:30	TT040406P117	WS	1.398	1.74	0.35	182	200	196	13.81	57.84	Weir/bubbler	4.6	0.342	1.175	poor
Marshall Road Drain	5/9/2006	8:00	TT050906P127	WS	3.923	na	na	712	858	623	17.99	65.86	Weir/bubbler	4.6	#VALUE!	#VALUE!	poor
Marshall Road Drain	6/6/2006	11:00	TT060606P137	WS	1.94	1.94	0.9	187	123	185	20.96	69.66	Weir/bubbler	4.6	0.000	1.522	good
Marshall Road Drain	7/21/2006	9:00	TT072106Pxx	WS	2.15	2.18	na	816	285	816	23.92	75.12	Weir/bubbler	4.6	0.030	#VALUE!	good
Marshall Road Drain	8/22/2006	8:30	TT082206Pxx	WS	2.051	2.05	1.3	639	436	695	19.96	68	Weir/bubbler	4.6	-0.001	1.517	good
Marshall Road Drain	9/28/2006	9:45	TT092806P12	WS	1.708	na	na	638	678	645	18.64	65.76	Weir/bubbler	4.6	#VALUE!	#VALUE!	good
Marshall Road Drain	10/3/2006	8:30	F9P133N2	WS	1.958	1.94	0.9	na	na	na	na	na	Weir/bubbler	4.6	-0.018	1.540	good
Marshall Road Drain	10/27/2006	8:30	TT102706P20	WS	1.874	1.86	0.6	665	680	675	12.38	54.12	Weir/bubbler	4.6	-0.014	1.555	good
Marshall Road Drain	11/17/2006	8:45	TT111706P28	WS	1.662	1.65	0.08	446	478		14.56	58.78	Weir/bubbler	4.6	-0.012	1.579	good
Marshall Road Drain	12/8/2006	8:15	TT120806P38	WS	1.597	1.56	na	1300	1341		10.7	51.64	Weir/bubbler	4.6	-0.037	#VALUE!	good
													Average offset		-0.009	1.543	

Reference					Calculations						Comments
Site	Date	Time	Notebook Reference	Method	stage above boards as back calculated from ITRC Weirstick Reading [H=(WS/3.33)^(2/3)]	Weirstick Flow Calculated from (weirstick reading * boardwidth)	Bubbler Flow calculated from (3.33 * Weir width * (bubbler stage offset)^1.5)	Pre-Cleaning EC deviation (logger/QA*100)	Post-Cleaning EC deviation (logger/QA*100)	Temperature Deviation (logger/QA*100)	
Marshall Road Drain	1/11/2006	8:15	TT011106P88	WS	0.00	0.00	0.00	103.11	95.61	100.16	
Marshall Road Drain	2/8/2006	8:20	TT020806P97	WS	0.03	0.09	0.07	105.65	100.56	99.55	
Marshall Road Drain	3/8/2006	8:00	TT030806P107	WS	#VALUE!	#VALUE!	0.02	103.61	100.98	101.01	Added 8" board
Marshall Road Drain	4/4/2006	8:30	TT040406P117	WS	0.22	1.61	4.14	109.89	107.69	101.73	
Marshall Road Drain	5/9/2006	8:00	TT050906P127	WS	#VALUE!	#VALUE!	77.34	120.51	87.50	102.30	Bubbler line had leak, repaired. Weirboard dislodged, floated out because weir was submerg
Marshall Road Drain	6/6/2006	11:00	TT060606P137	WS	0.42	4.14	3.88	65.78	98.93	99.90	
Marshall Road Drain	7/21/2006	9:00	TT072106Pxx	WS	#VALUE!	#VALUE!	7.30	34.93	100.00	100.09	
Marshall Road Drain	8/22/2006	8:30	TT082206Pxx	WS	0.53	5.98	5.60	68.23	108.76	100.11	
Marshall Road Drain	9/28/2006	9:45	TT092806P12	WS	#VALUE!	#VALUE!	1.05	106.27	101.10	100.32	
Marshall Road Drain	10/3/2006	8:30	F9P133N2	WS	0.42	4.14	4.14	#VALUE!	#VALUE!	#VALUE!	
Marshall Road Drain	10/27/2006	8:30	TT102706P20	WS	0.32	2.76	2.96	102.26	101.50	99.70	
Marshall Road Drain	11/17/2006	8:45	TT111706P28	WS	0.08	0.37	0.65	107.17	0.00	100.98	
Marshall Road Drain	12/8/2006	8:15	TT120806P38	WS	#VALUE!	#VALUE!	0.21	103.15	0.00	100.74	





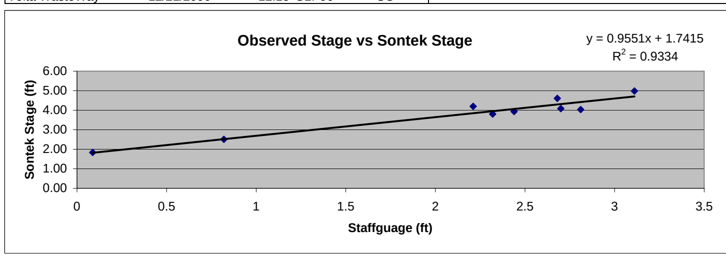


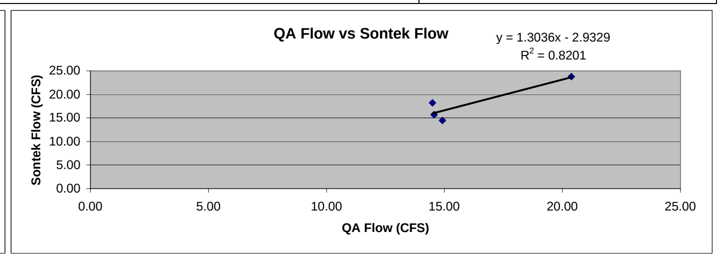
Volta Wasteway
Quality Assurance

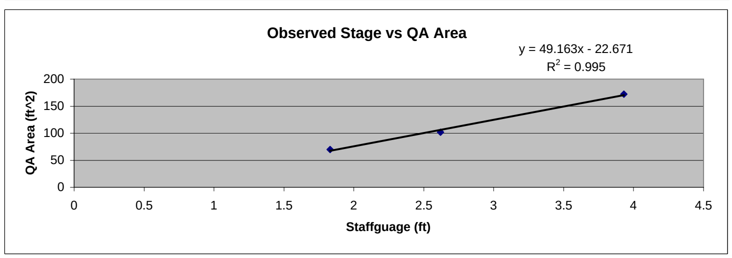
DO45 Volta Wasteway 2006 QA data
WS = Weir Stick SG = Streamgage

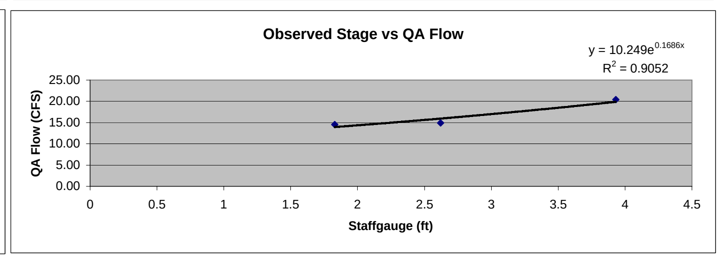
Reference					Measured Variables									Constants			
Site	Date	Time	Notebook Reference	Method	Observed Sontek reading	Observed Staffguage Stage	Observed ITRC Weirstick reading	Observed EC from handheld meter	Pre-cleaning EC from logger data	Post-Cleaning EC from logger data	Observed Temp from handheld meter (C)	Temperature from Logger data (F)	Structure/ Equipment	Width of Weir in ft.	Bubbler to staffguage offset (add to bubbler value to get stage)	Rating Quality
Volta WasteWay	1/9/2006	13:45	G2P20	SG	1.91	na	na	2023	1928		54.9	54.41	stream/bubbler		#VALUE!	poor
Volta WasteWay	2/2/2006	11:45	G2P27	SG	2.44	3.93	na	956.5	999		58.3	57.04	stream/bubbler		1.490	poor
Volta WasteWay	3/1/2006	12:00	G2P34	SG	2.32	3.81	na	1218	1397		60	57.61	stream/bubbler		1.490	poor
Volta WasteWay	5/8/2006	12:45	G2P53	SG	0.088	1.83	na	744.5	715		72.7	71.9	stream/bubbler		1.742	poor
Volta WasteWay	6/9/2006	9:00	G2P57	SG	na	2.04	na	896.7	910		70.7	70.5	stream/bubbler		#VALUE!	poor
Volta WasteWay	7/6/2006	10:15	G2P63	SG	0.82	2.51	na	714.2	706		73.8	73.7	stream/bubbler		1.690	poor
Volta WasteWay	7/28/2006		F10P44	SG		2.62	na	na	na		na	na	stream/bubbler		2.620	poor
Volta WasteWay	8/31/2006	13:45	G2P72	SG	2.21	4.20	na	441.1	431		77.2	76.5	stream/bubbler		1.990	poor
Volta WasteWay	9/21/2006	11:00	G2P76	SG	3.11	4.98	na	398	388		68.2	67.67	stream/bubbler		1.870	poor
Volta WasteWay	10/10/2006	8:15	G2P76	SG	2.68	4.60	na	385.7	437		62.4	64.94	stream/bubbler		1.920	poor
Volta WasteWay	11/30/2006	13:45	G2P85	SG	2.81	4.04	na	741.6	717		51.1	51.8	stream/bubbler		1.230	poor
Volta WasteWay	12/21/2006	12:15	G2P90	SG	2.7	4.09	na	700.8	695		47.5	47.4	stream/bubbler		1.390	poor
													Average offset		1.743	

Reference					Calculations								Comments
Site	Date	Time	Notebook Reference	Method	QA Average Velocity (calculated from flow rating velocities)	QA Area (calculated from flow rating area)	Sontek Calculated Area	QA Flow	sontek Calculated Flow	Pre-Cleaning EC deviation (logger/QA*100)	Post-Cleaning EC deviation (logger/QA*100)	Temperature Deviation (logger/QA*100)	
Volta WasteWay	1/9/2006	13:45	G2P20	SG	0.08	139.40	156.92	14.56	15.69	95.30	0.00	99.11	Staffguage loose and moving
Volta WasteWay	2/2/2006	11:45	G2P27	SG	0.10	172.12	182.98	20.38	23.79				
Volta WasteWay	3/1/2006	12:00	G2P34	SG			177.08			114.70	0.00	96.02	
Volta WasteWay	5/8/2006	12:45	G2P53	SG	0.14	79.72	67.35	14.49	18.18				
Volta WasteWay	6/9/2006	9:00	G2P57	SG						101.48	0.00	99.72	
Volta WasteWay	7/6/2006	10:15	G2P63	SG			103.33						
Volta WasteWay	7/28/2006		F10P44	SG	0.12	101.93	63.02	14.92	14.49				
Volta WasteWay	8/31/2006	13:45	G2P72	SG									
Volta WasteWay	9/21/2006	11:00	G2P76	SG									
Volta WasteWay	10/10/2006	8:15	G2P76	SG									
Volta WasteWay	11/30/2006	13:45	G2P85	SG									
Volta WasteWay	12/21/2006	12:15	G2P90	SG									









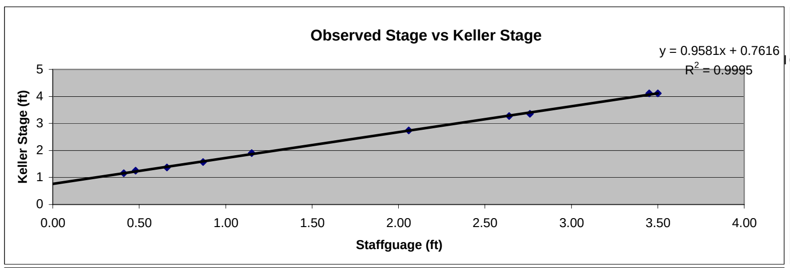
MudSlough at GunClub Rd.

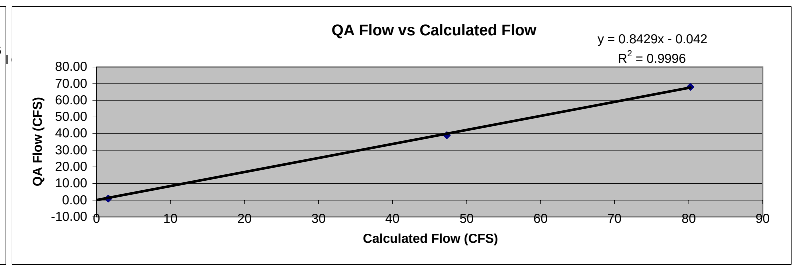
Quality Assurance

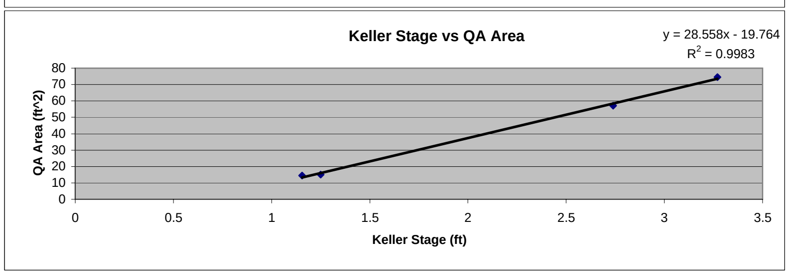
DO-46 MudSlough at GunClub Rd. 2006 QA data
WS = Weir Stick SG = Streamgage

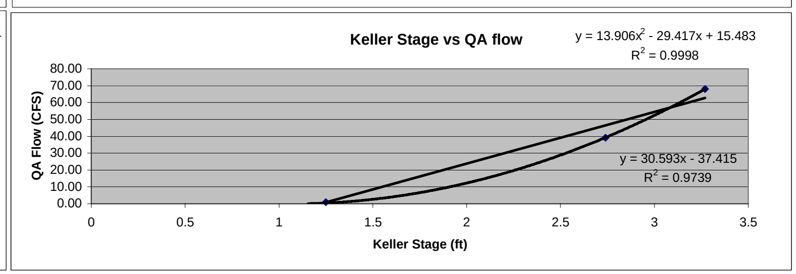
Reference					Measured Variables								Constants			
Site	Date	Time	Notebook Reference	Method	Observed Keller reading	Observed Staffguage Stage	Sontek Velocity	Observed EC from handheld meter	Pre-cleaning EC from logger data	Post-Cleaning EC from logger data	Observed Temp from handheld meter (C)	Temperature from Logger data (F)	Structure/ Equipment	Width of Weir in ft.	Keller to staffguage offset (add to bubbler value to get stage)	Rating Quality
MudSlough at GunClub Rd.	1/9/2006	12:45	G2P19	SG	4.116	3.50	0.82	1468	1548		52.7	52.75	stream/Sontek/Keller Transducer	na	-0.616	good
MudSlough at GunClub Rd.	2/2/2006	10:30	G2P25	SG	2.739	2.06	0.81	1963	2055		56.3	56.35	stream/Sontek/Keller Transducer	na	-0.679	good
MudSlough at GunClub Rd.	3/1/2006	9:45	G2P32	SG	4.111	3.45	1.26	1585	1573		55.8	55.86	stream/Sontek/Keller Transducer	na	-0.661	good
MudSlough at GunClub Rd.	4/19/2006	12:15	G2P42	SG	1.9	1.15	0.81	2740	2711		64.4	63.89	stream/Sontek/Keller Transducer	na	-0.750	good
MudSlough at GunClub Rd.	5/8/2006	11:15	G2P48	SG	1.249	0.48	0.1	3350	3291		73.2	75.1	stream/Sontek/Keller Transducer	na	-0.769	good
MudSlough at GunClub Rd.	6/9/2006	12:15	G2P59	SG	1.568	0.87	0.25	2013	1988		79.7	78.4	stream/Sontek/Keller Transducer	na	-0.698	good
MudSlough at GunClub Rd.	7/9/2006	11:30	G2P63	SG	1.375	0.66	0.17	1155	1135		77.2	77.1	stream/Sontek/Keller Transducer	na	-0.715	good
MudSlough at GunClub Rd.	7/28/2006	10:30	F10P44	SG	1.155	0.41	-0.09	na	na	na	na	na	stream/Sontek/Keller Transducer	na	-0.745	good
MudSlough at GunClub Rd.	8/31/2006	12:45	G2P71	SG	0.742	-0.02	0.38	1064	1098		82.9	83.4	stream/Sontek/Keller Transducer	na	-0.762	good
MudSlough at GunClub Rd.	11/30/2006	14:45	G2P85	SG	3.36	2.76	1.11	1139	1174		49.1	48.75	stream/Sontek/Keller Transducer	na	-0.600	good
MudSlough at GunClub Rd.	12/21/2006	11:00	G2P90	SG	3.27	2.64	1.09	1275	1338		44.8	44.9	stream/Sontek/Keller Transducer	na	-0.630	good
													Average offset		-0.688	

Reference					Calculations								Comments
Site	Date	Time	Notebook Reference	Method	QA Average Velocity (calculated from flow rating velocities)	QA Area (calculated from flow rating area)	Keller transducer Calculated Area	QA Flow	sontek/keller Calculated Flow	Pre-Cleaning EC deviation (logger/QA*100)	Post-Cleaning EC deviation (logger/QA*100)	Temperature Deviation (logger/QA*100)	
MudSlough at GunClub Rd.	1/9/2006	12:45	G2P19	SG			97.78		67.54	105.45	0.00	100.09	water level above top of staffguage, staff reading is an estimate
MudSlough at GunClub Rd.	2/2/2006	10:30	G2P25	SG	0.61	57.20	58.46	39.11	39.87	104.69	0.00	100.09	
MudSlough at GunClub Rd.	3/1/2006	9:45	G2P32	SG			97.64		103.65	99.24	0.00	100.11	water level above top of staffguage, staff reading is an estimate
MudSlough at GunClub Rd.	4/19/2006	12:15	G2P42	SG			34.50		23.51	98.94	0.00	99.21	
MudSlough at GunClub Rd.	5/8/2006	11:15	G2P48	SG	0.05	15.00	15.90	1.00	1.30	98.24	0.00	102.60	
MudSlough at GunClub Rd.	6/9/2006	12:15	G2P59	SG			25.01		5.23	98.76	0.00	98.37	
MudSlough at GunClub Rd.	7/9/2006	11:30	G2P63	SG			19.50		2.75	98.27	0.00	99.87	
MudSlough at GunClub Rd.	7/28/2006	10:30	F10P44	SG	-0.03	14.40	13.22	-0.45	-1.04	#VALUE!	#VALUE!	#VALUE!	
MudSlough at GunClub Rd.	8/31/2006	12:45	G2P71	SG			1.43		0.41	103.20	0.00	100.60	
MudSlough at GunClub Rd.	11/30/2006	14:45	G2P85	SG			76.19		71.24	103.07	0.00	99.29	
MudSlough at GunClub Rd.	12/21/2006	11:00	G2P90	SG	0.77	74.60	73.62	68.06	67.60	104.94	0.00	100.22	







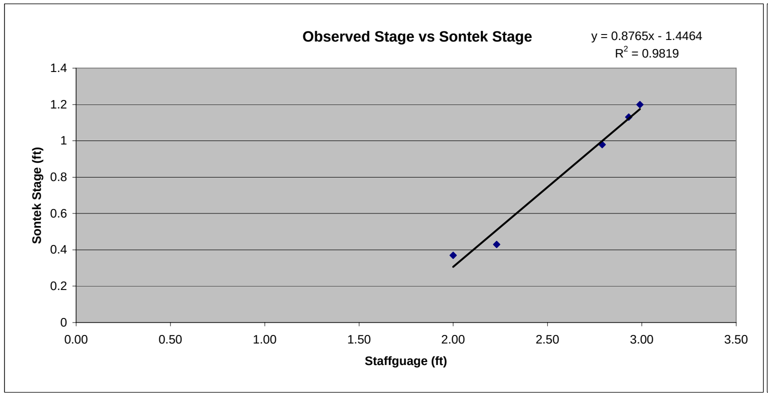


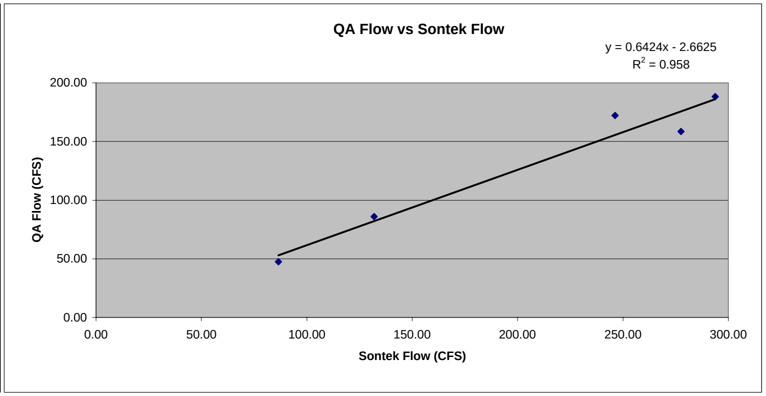
Salt Slough at Wolfsen Rd.
Quality Assurance

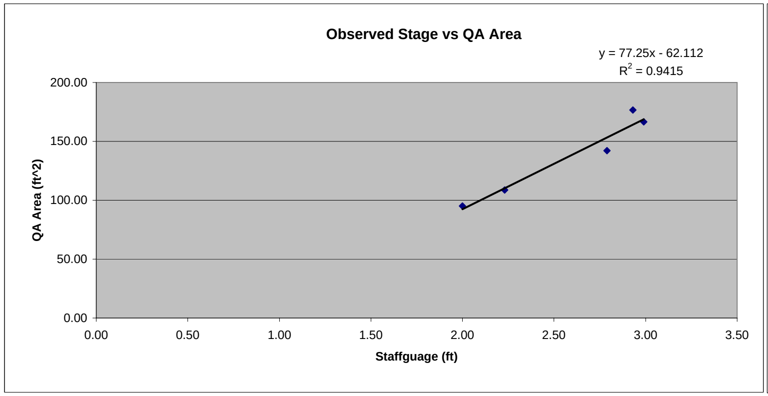
DO-53 Salt Slough at Wolfsen Rd. 2006 QA data
WS = Weir Stick SG = Streamgage

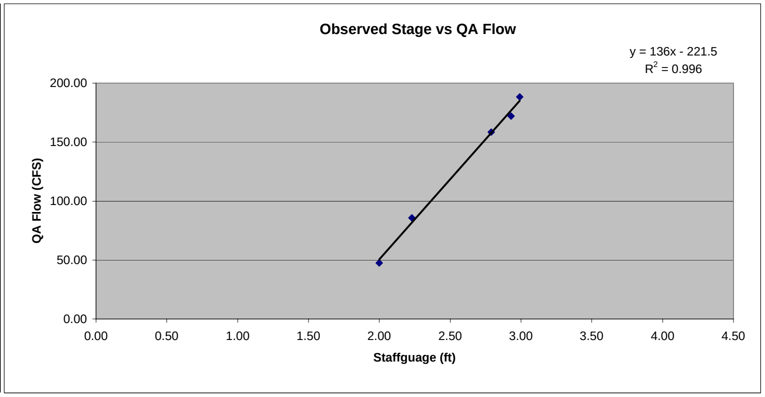
Reference					Measured Variables								Constants			
Site	Date	Time	Notebook Reference	Method	Observed Staffguage Stage	Observed Sontek Pressure	Observed Sontek Vert. Beam	Observed EC from handheld meter	Pre-cleaning EC from logger data	Post-Cleaning EC from logger data	Observed Temp from handheld meter (C)	Temperature from Logger data (F)	Structure/ Equipment	Sontek pressure stage to staffguage offset (should be 1.54)	Sontek Vert. Beam stage to staffguage offset (should be 1.79)	Rating Quality
SS at Wolfsen	1/31/2006	13:10	F5p84	SG	2.93	0.537	1.13		1528	1528		55.33	Natural streambed/Sontek	1.691	1.800	fair
SS at Wolfsen	7/11/2006	11:05	F9p14n1-2	SG	2.79	0.319	0.98	826	719	719	26.33	79.2	Natural streambed/Sontek	2.054	1.810	fair
SS at Wolfsen	7/28/2006	13:00	F10p45n1	SG	2.99	0.406	1.2		874	874		81.1	Natural streambed/Sontek	2.053	1.790	fair
SS at Wolfsen	9/14/2006	12:55	F9p104n1	SG	2.23	-0.023	0.43	1214	1000	1000	22.77	72.3	Natural streambed/Sontek	2.283	1.800	fair
SS at Wolfsen	12/14/2006	13:00	F11p65n2	SG	2.00	0.213	0.37	2033	1944	1944	12.5	54.43	Natural streambed/Sontek	1.509	1.630	fair

Reference					Calculations										Comments
Site	Date	Time	Notebook Reference	Method	QA Average Velocity (calculated from flow rating velocities)	Sontek Velocity (sqrt(X^2+Y^2))	QA Area (calculated from flow rating area)	Sontek Calculated Area	QA Flow	Uncorrected Sontek derived Flow	Sontek Corrected Flow calculated from (0.6422*(Sontek flow) - 2.6455)	Pre-Cleaning EC deviation (logger/QA*100)	Post-Cleaning EC deviation (logger/QA*100)	Temperature Deviation (logger/QA*100)	
SS at Wolfsen	1/31/2006	13:10	F5p84	SG	0.803	1.5	176.60	164.20	172.18	246.31	155.53	#DIV/0!	#DIV/0!	172.91	
SS at Wolfsen	7/11/2006	11:05	F9p14n1-2	SG	1.027	1.81	142.20	153.35	158.49	277.56	175.61	87.05	87.05	99.76	
SS at Wolfsen	7/28/2006	13:00	F10p45n1	SG	0.891	1.74	166.56	168.85	188.25	293.81	186.04	#DIV/0!	#DIV/0!	253.44	
SS at Wolfsen	9/14/2006	12:55	F9p104n1	SG	0.606	1.2	108.60	109.94	85.88	131.93	82.08	82.37	82.37	99.06	
SS at Wolfsen	12/14/2006	13:00	F11p65n2	SG	0.579	0.94	95.10	92.11	47.53	86.58	52.96	95.62	95.62	99.87	









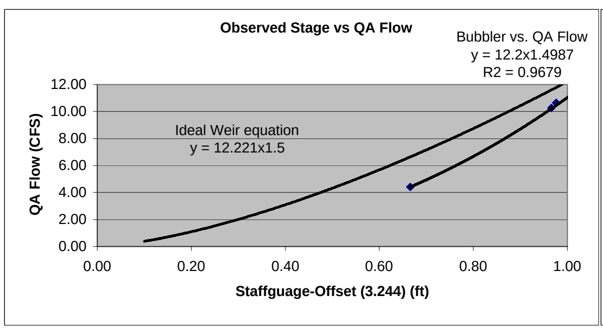
Moffit 1 South

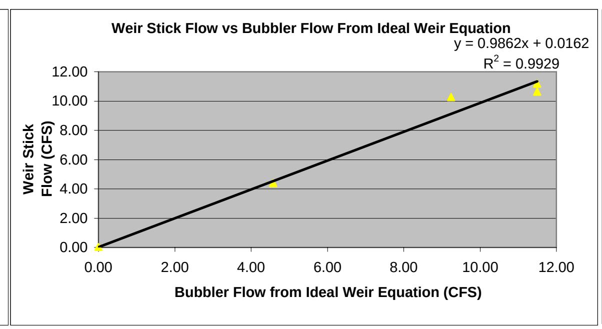
Quality Assurance

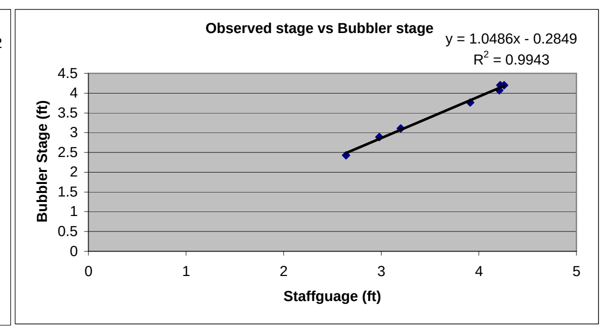
DO-60 Moffit 1 South 2006 QA data
WS = Weir Stick SG = Streamgage

Reference					Measured Variables								Constants				
Site	Date	Time	Notebook Reference	Method	Observed Bubbler reading	Observed Staffguage Stage	Observed ITRC Weirstick reading	Observed EC from handheld meter	Pre-cleaning EC from logger data	Post-Cleaning EC from logger data	Observed Temp from handheld meter (C)	Temperature from Logger data (F)	Structure/ Equipment	Width of Weir in ft.	Bubbler to staffguage offset (add to bubbler value to get stage)	Bubbler to top of weir offset (subtract from bubbler to get Head)	Rating Quality
Moffit 1 South	1/17/2006	10:00	F5p69n1	WS	3.76	3.91	1.2	1.224	1.151	1.293	8.5	47.21	Weir/bubbler	3.67	0.150	3.254	fair
Moffit 1 South	3/2/2006	9:00	F5p93n1	WS	4.2	4.26	3.05	1.315	1.247	1.337	12.35	54.06	Weir/bubbler	3.67	0.060	3.257	fair
Moffit 1 South	3/2/2006	9:00	F5p93n1	WS	4.2	4.22	2.9	1.315	1.247	1.337	12.35	54.06	Weir/bubbler	3.67	0.020	3.288	fair
Moffit 1 South	3/30/2006	10:00	F8p45n1	WS	4.07	4.21	2.8	1.164	1.053	1.052	13.11	55.87	Weir/bubbler	3.67	0.140	3.179	fair
Moffit 1 South	4/27/2006	8:00	F8p69n1	WS	2.89	2.98	0	1.464	1.127	1.127	17.14	62.99	Weir/bubbler	3.67	0.090	2.890	fair
Moffit 1 South	07/11/06	7:00	F9p11n1	WS	2.43	n/a	0	n/a	0.005	0.005	n/a	69.55	Weir/bubbler	3.67	#VALUE!	2.430	fair
Moffit 1 South	09/14/06	9:00	F9P99n1	WS	2.45	n/a	0	n/a	0.005	0.005	n/a	67.88	Weir/bubbler	3.67	#VALUE!	2.450	fair
Moffit 1 South	9/28/2006	9:00	F9p126n1	WS	2.44	n/a	0	n/a	0.005	0.005	n/a	62.8	Weir/bubbler	3.67	#VALUE!	2.440	fair
Moffit 1 South	10/12/2006	9:00	F9p144n1	WS	2.43	n/a	0	n/a	0.005	0.005	n/a	59.67	Weir/bubbler	3.67	#VALUE!	2.430	fair
Moffit 1 South	10/26/2006	9:00	F11p12n1	WS	2.43	n/a	0	n/a	0.005	0.005	n/a	49.18	Weir/bubbler	3.67	#VALUE!	2.430	fair
Moffit 1 South	11/2/2006	9:00	F11p23n1	WS	2.43	n/a	0	1.114	0.005	0.005	12.77	55.28	Weir/bubbler	3.67	#VALUE!	2.430	fair
Moffit 1 South	11/16/2006	9:00	F11p40n1	WS	2.43	2.64	0	0.584	0.005	0.005	12.13	53.4	Weir/bubbler	3.67	0.210	2.430	fair
Moffit 1 South	12/14/2006	9:00	F11p60n1	WS	3.11	3.2	0	0.679	0.619	0.619	10.01	49.64	Weir/bubbler	3.67	0.090	3.110	fair
													Average offset		0.109	3.244	

Reference					Calculations							Comments
Site	Date	Time	Notebook Reference	Method	Stage above boards as back calculated from ITRC Weirstick Reading [H=(WS/3.33)^(2/3)]	Weirstick Flow Calculated from (weirstick reading * boardwidth)	Bubbler Flow calculated from bubbler stage to weirstick flow relationship (12.84*(bubbler stage+offset)-42.913)	Bubbler Flow calculated from (3.33 * Weir width * (bubbler stage+offset-weir height)^1.5)	Pre-Cleaning EC deviation (logger/QA*100)	Post-Cleaning EC deviation (logger/QA*100)	Temperature Deviation (logger/QA*100)	
Moffit 1 South	1/17/2006	10:00	F5p69n1	WS	0.51	4.40	6.76	4.58	94.04	105.64	99.81	
Moffit 1 South	3/2/2006	9:00	F5p93n1	WS	0.94	11.19	12.41	11.50	94.83	101.67	99.69	
Moffit 1 South	3/2/2006	9:00	F5p93n1	WS	0.91	10.64	12.41	11.50	94.83	101.67	99.69	
Moffit 1 South	3/30/2006	10:00	F8p45n1	WS	0.89	10.28	10.74	9.24	90.46	90.38	100.49	
Moffit 1 South	4/27/2006	8:00	F8p69n1	WS	0.00	0.00	0.00	0.00	76.98	76.98	100.22	
Moffit 1 South	07/11/06	7:00	F9p11n1	WS	0.00	0.00	0.00	0.00	#VALUE!	#VALUE!	#VALUE!	
Moffit 1 South	09/14/06	9:00	F9P99n1	WS	0.00	0.00	0.00	0.00	#VALUE!	#VALUE!	#VALUE!	
Moffit 1 South	9/28/2006	9:00	F9p126n1	WS	0.00	0.00	0.00	0.00	#VALUE!	#VALUE!	#VALUE!	
Moffit 1 South	10/12/2006	9:00	F9p144n1	WS	0.00	0.00	0.00	0.00	#VALUE!	#VALUE!	#VALUE!	
Moffit 1 South	10/26/2006	9:00	F11p12n1	WS	0.00	0.00	0.00	0.00	#VALUE!	#VALUE!	#VALUE!	
Moffit 1 South	11/2/2006	9:00	F11p23n1	WS	0.00	0.00	0.00	0.00	0.45	0.45	100.53	
Moffit 1 South	11/16/2006	9:00	F11p40n1	WS	0.00	0.00	0.00	0.00	0.86	0.86	99.19	
Moffit 1 South	12/14/2006	9:00	F11p60n1	WS	0.00	0.00	0.00	0.00	91.16	91.16	99.24	







Deadmans Slough

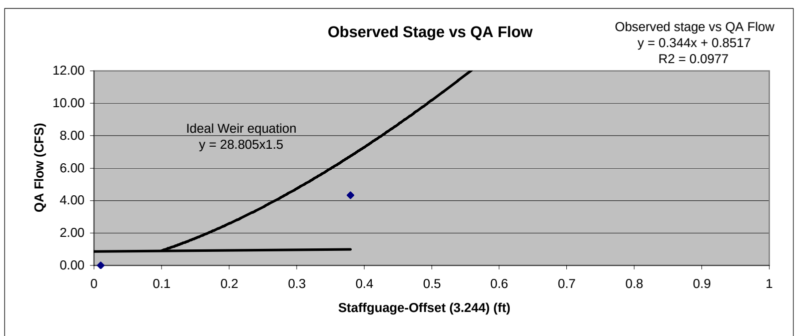
Quality Assurance

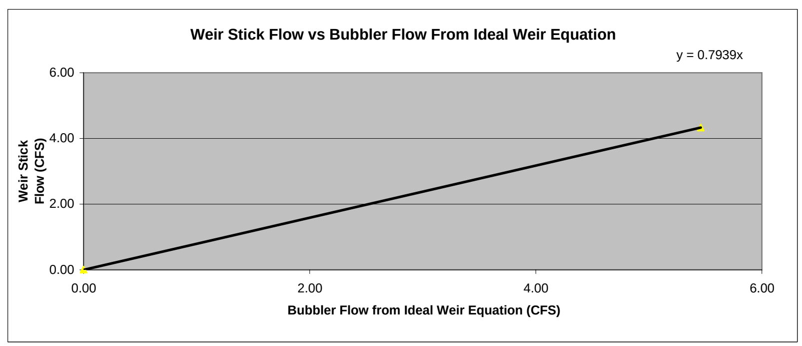
DO-61 Deadmans Slough 2006 QA data

WS = Weir Stick SG = Streamgage

Reference					Measured Variables									Constants						
Site	Date	Time	Notebook Reference	Method	Observed Bubbler reading	Observed Staffguage Stage	Observed ITRC Weirstick reading West Weir	Observed ITRC Weirstick reading East Weir	Observed EC from handheld meter	Pre-cleaning EC from logger data	Post-Cleaning EC from logger data	Observed Temp from handheld meter (C)	Temperature from Logger data (F)	Structure/ Equipment	Width of Weir in ft.	Width of Weir in ft.	Bubbler to staffguage offset (add to bubbler value to get stage)	Bubbler to Top of Westweir Offset (Subtract from Bubbler to get WestHead)	Bubbler to Top of Eastweir offset (Subtract from bubbler to get East Head)	Rating Quality
Deadmans Slough	1/17/2006	9:50	F5p69n4	WS	8.26	8.34	na	na	1077	1332	1332	8.9	47.95	Weir/bubbler	4.35	4.3	0.080	#VALUE!	#VALUE!	none
Deadmans Slough	1/26/2006	10:18	F5p77n4	WS	7.44	7.51	0	0	1321	1572	1572	9.44	47.89	Weir/bubbler	4.35	4.3	0.070	7.440	7.440	none
Deadmans Slough	3/2/2006	9:42	F5p93n2	WS	7.83	7.88	0.3	0.7	1382	1258	1258	13.4	55.71	Weir/bubbler	4.35	4.3	0.050	7.629	7.476	none
Deadmans Slough	3/30/2006	9:50	F8p45n2	WS	7.42	7.48	0	0	1290	1354	1354	13.48	55.67	Weir/bubbler	4.35	4.3	0.060	7.420	7.420	none
Deadmans Slough	4/27/2006	9:45	F8p69n2	WS	8.5	8.58	na	na	2126	2303	2303	15.99	59.79	Weir/bubbler	4.35	4.3	0.080	#VALUE!	#VALUE!	none
Deadmans Slough	7/11/2006	9:50	F9p11n2	WS	6.54	6.56	0	0	1335	1326	1326	24.9	76.6	Weir/bubbler	4.35	4.3	0.020	6.540	6.540	none
Deadmans Slough	9/14/2006	9:24	F9p99n4	WS	3.84	3.57	0	0	2483	2400	2400	43.13	72.7	Weir/bubbler	4.35	4.3	-0.270	3.840	3.840	none
Deadmans Slough	9/28/2006	9:20	F9p126n4	WS	7.32	7.38	0	0	1027	1063	1063	19.84	67.71	Weir/bubbler	4.35	4.3	0.060	7.320	7.320	none
Deadmans Slough	10/12/2006	9:07	F9p144n3	WS	7.44	7.39	0	0	966	1203	1203	17.42	63.18	Weir/bubbler	4.35	4.3	-0.050	7.440	7.440	none
Deadmans Slough	10/26/2006	9:18	F11p12n4	WS	8.17	8.06	na	na	669	1030	1030	14.21	57	Weir/bubbler	4.35	4.3	-0.110	#VALUE!	#VALUE!	none
Deadmans Slough	11/2/2006	9:40	F11p23n4	WS	8.49	8.39	1.1	1.1	582	843	843	12.74	53.73	Weir/bubbler	4.35	4.3	-0.100	8.012	8.012	none
Deadmans Slough	11/16/2006	9:30	F11p40n4	WS	8.74	8.7	na	na	589	644	644	12.52	53.19	Weir/bubbler	4.35	4.3	-0.040	#VALUE!	#VALUE!	none
Deadmans Slough	12/14/2006	9:41	F11p60n4	WS	7.79	7.67	na	na	1985	2044	2044	12.61	54.15	Weir/bubbler	4.35	4.3	-0.120	#VALUE!	#VALUE!	none
														Average offset			-0.021			

Reference					Calculations							Comments
Site	Date	Time	Notebook Reference	Method	stage above Westweir back calculated from ITRC Weirstick Reading [H=(WS/3.33)^(2/3)]	stage above Eastweir back calculated from ITRC Weirstick Reading [H=(WS/3.33)^(2/3)]	Weirstick Flow Calculated from (weirstick reading * boardwidth)	Bubbler Flow calculated from (3.33 * Weir width * (bubbler stage-weir height)^1.5)	Pre-Cleaning EC deviation (logger/QA*100)	Post-Cleaning EC deviation (logger/QA*100)	Temperature Deviation (logger/QA*100)	
Deadmans Slough	1/17/2006	9:50	F5p69n4	WS	#VALUE!	#VALUE!	#VALUE!	19.08	123.68	123.68	99.85	
Deadmans Slough	1/26/2006	10:18	F5p77n4	WS	0.00	0.00	0.00	0.00	119.00	119.00	97.75	
Deadmans Slough	3/2/2006	9:42	F5p93n2	WS	0.20	0.35	4.34	5.46	91.03	91.03	99.27	
Deadmans Slough	3/30/2006	9:50	F8p45n2	WS	0.00	0.00	0.00	0.00	104.96	104.96	98.94	
Deadmans Slough	4/27/2006	9:45	F8p69n2	WS	#VALUE!	#VALUE!	#VALUE!	28.80	108.33	108.33	98.37	
Deadmans Slough	7/11/2006	9:50	F9p11n2	WS	0.00	0.00	0.00	0.00	99.33	99.33	99.71	
Deadmans Slough	9/14/2006	9:24	F9p99n4	WS	0.00	0.00	0.00	0.00	96.66	96.66	66.31	
Deadmans Slough	9/28/2006	9:20	F9p126n4	WS	0.00	0.00	0.00	0.00	103.51	103.51	100.00	
Deadmans Slough	10/12/2006	9:07	F9p144n3	WS	0.00	0.00	0.00	0.00	124.53	124.53	99.72	
Deadmans Slough	10/26/2006	9:18	F11p12n4	WS	#VALUE!	#VALUE!	#VALUE!	15.80	153.96	153.96	99.00	
Deadmans Slough	11/2/2006	9:40	F11p23n4	WS	0.48	0.48	4.79	28.37	144.85	144.85	97.81	Weir was clogged with debris, weir stick not accurate
Deadmans Slough	11/16/2006	9:30	F11p40n4	WS	#VALUE!	#VALUE!	#VALUE!	39.77	109.34	109.34	97.53	
Deadmans Slough	12/14/2006	9:41	F11p60n4	WS	#VALUE!	#VALUE!	#VALUE!	4.50	102.97	102.97	99.00	





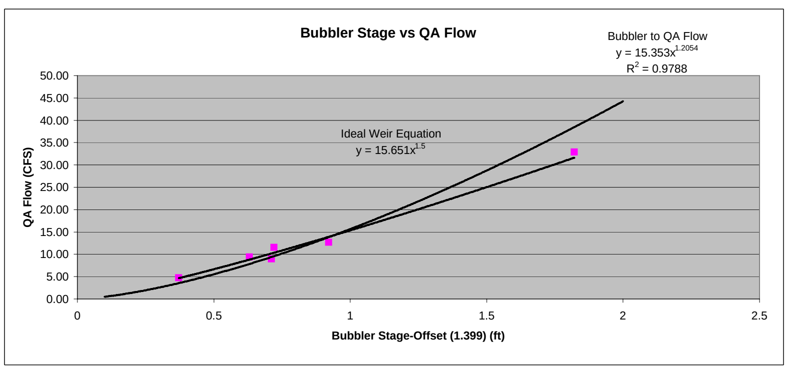
Mallard Slough

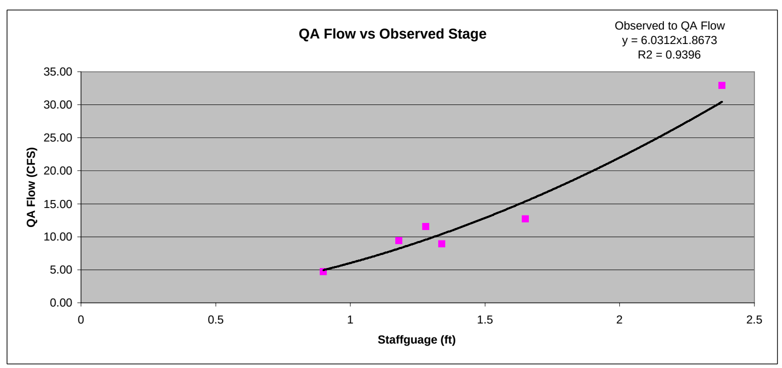
Quality Assurance

DO-62 Mallard Slough 2006 QA data
WS = Weir Stick SG = Streamgage

Reference					Measured Variables										Constants				
Site	Date	Time	Notebook Reference	Method	Observed Bubbler reading	Observed Staffguage Stage	Observed ITRC Weirstick reading	Observed EC from handheld meter	Starflow Level (ft) from logger data	Starflow Velocity (ft/sec) from logger data	Pre-cleaning EC from logger data	Post-Cleaning EC from logger data	Observed Temp from handheld meter (C)	Temperature from Logger data (F)	Structure/ Equipment	Width of Weir in ft.	Bubbler to staffguage offset (add to bubbler value to get stage)	Bubbler to top of weir offset	Rating Quality
Mallard Slough	1/17/2006	10:15	F5p69n5	WS	2.11	1.34	1.9	1.593	1.263	0.18	1.07	1.541	na	46.98	Weir/bubbler/starflow	4.7	-0.770	1.422	fair
Mallard Slough	1/26/2006	10:50	F5p78n2	WS	2.32	1.65	2.7	1.668	1.408	0.141	1.532	1.532	8.28	45.78	Weir/bubbler/starflow	4.7	-0.670	1.450	fair
Mallard Slough	1/26/2006	10:50	F5p78n2	WS	2.12	1.28	2.45	na	1.408	0.141	1.532	1.532	na	45.78	Weir/bubbler/starflow	4.7	-0.840	1.305	fair
Mallard Slough	1/26/2006	10:50	F5p78n2	WS	2.03	1.18	2	na	1.408	0.141	1.532	1.532	na	45.78	Weir/bubbler/starflow	4.7	-0.850	1.318	fair
Mallard Slough	1/26/2006	10:50	F5p78n2	WS	1.77	0.9	1	na	1.453	0.41	1.532	1.532	na	45.78	Weir/bubbler/starflow	4.7	-0.870	1.322	fair
Mallard Slough	3/2/2006	10:25	F5p64n1	WS	3.22	2.38	7	1.857	3.645	0.345	1.728	1.728	11.61	52.88	Weir/bubbler/starflow	4.7	-0.840	1.579	fair
Mallard Slough	3/30/2006	10:00	F8p46n3	WS	2.32	1.58	na	1.542	3.274	0.157	1.581	1.58	12.66	54.86	Weir/bubbler/starflow	4.7	-0.740	#VALUE!	fair
Mallard Slough	4/27/2006	10:17	F8p70n3	WS	2.91	2.59	na	1.964	3.127	6.516	1.862	2.067	16.1	60.68	Weir/bubbler/starflow	4.7	-0.320	#VALUE!	fair
Mallard Slough	7/11/2006	10:09	F9p12n1	WS	2.52	2.43	na	2.93	1.476	0.266	0.564	3.098	21.68	71.7	Weir/bubbler/starflow	4.7	-0.090	#VALUE!	fair
Mallard Slough	9/14/2006	9:57	F9p100n1	WS	0.65	na	na	na	0.637	0.217	0.028	0.035	na	70.4	Weir/bubbler/starflow	4.7	na	#VALUE!	fair
Mallard Slough	9/28/2006	9:43	F9p127n5	WS	0.65	na	na	na	0.738	0.217	0.008	0.008	na	67.04	Weir/bubbler/starflow	4.7	na	#VALUE!	fair
Mallard Slough	10/12/2006	9:41	F9p145n1	WS	0.65	na	na	na	1.188	0.217	0.007	0.008	na	63.83	Weir/bubbler/starflow	4.7	na	#VALUE!	fair
Mallard Slough	10/26/2006	9:50	F11p13n1	WS	1.05	0.43	na	5.847	1.522	0.217	6.252	6.261	10.83	56.44	Weir/bubbler/starflow	4.7	-0.620	#VALUE!	fair
Mallard Slough	11/2/2006	10:05	F11p24n1	WS	1.6	na	na	3.667	1.568	0.217	3.765	3.773	12.12	51.93	Weir/bubbler/starflow	4.7	na	#VALUE!	fair
Mallard Slough	11/16/2006	9:53	F11p41n1	WS	2.07	1.7	na	1.055	1.975	0.121	1.114	1.126	12.09	53.31	Weir/bubbler/starflow	4.7	-0.370	#VALUE!	fair
Mallard Slough	12/14/2006	10:06	F11p61n1	WS	2.08	2.02	na	1.132	0.682	0.095	1.107	1.107	8.99	47.42	Weir/bubbler/starflow	4.7	-0.060	#VALUE!	fair
															Average offset		-0.587	1.399	

Reference					Calculations								Comments
Site	Date	Time	Notebook Reference	Method	stage above boards as back calculated from ITRC Weirstick Reading [H=(WS/3.33)^(2/3)]	Weirstick Flow Calculated from (weirstick reading * boardwidth)	Starflow flow Calculated by starflow-pipe eq	Bubbler Flow calculated from bubbler stage to weirstick flow relationship (17.882*(bubbler stage)-27.599)	Bubbler Flow calculated from (3.33 * Weir width * (bubbler stage-weir height)^1.5)	Pre-Cleaning EC deviation (logger/QA*100)	Post-Cleaning EC deviation (logger/QA*100)	Temperature Deviation (logger/QA*100)	
Mallard Slough	1/17/2006	10:15	F5p69n5	WS	0.69	8.93	0.61	10.13	9.36	67.17	96.74	#VALUE!	
Mallard Slough	1/26/2006	10:50	F5p78n2	WS	0.87	12.69	0.55	13.89	13.81	91.85	91.85	97.60	
Mallard Slough	1/26/2006	10:50	F5p78n2	WS	0.81	11.52	0.55	10.31	9.56	#VALUE!	#VALUE!	#VALUE!	
Mallard Slough	1/26/2006	10:50	F5p78n2	WS	0.71	9.40	0.55	8.70	7.83	#VALUE!	#VALUE!	#VALUE!	
Mallard Slough	1/26/2006	10:50	F5p78n2	WS	0.45	4.70	1.68	4.05	3.52	#VALUE!	#VALUE!	#VALUE!	
Mallard Slough	3/2/2006	10:25	F5p64n1	WS	1.64	32.90	4.13	29.98	38.43	93.05	93.05	99.97	
Mallard Slough	3/30/2006	10:00	F8p46n3	WS	#VALUE!	#VALUE!	1.73	13.89	13.81	102.53	102.46	100.13	
Mallard Slough	4/27/2006	10:17	F8p70n3	WS	#VALUE!	#VALUE!	68.75	24.44	29.04	94.81	105.24	99.51	
Mallard Slough	7/11/2006	10:09	F9p12n1	WS	#VALUE!	#VALUE!	1.11	17.46	18.55	19.25	105.73	100.95	
Mallard Slough	9/14/2006	9:57	F9p100n1	WS	#VALUE!	#VALUE!	0.29	0.00	0.00	#VALUE!	#VALUE!	#VALUE!	
Mallard Slough	9/28/2006	9:43	F9p127n5	WS	#VALUE!	#VALUE!	0.35	0.00	0.00	#VALUE!	#VALUE!	#VALUE!	
Mallard Slough	10/12/2006	9:41	F9p145n1	WS	#VALUE!	#VALUE!	0.67	0.00	0.00	#VALUE!	#VALUE!	#VALUE!	
Mallard Slough	10/26/2006	9:50	F11p13n1	WS	#VALUE!	#VALUE!	0.95	0.00	0.00	106.93	107.08	109.61	
Mallard Slough	11/2/2006	10:05	F11p24n1	WS	#VALUE!	#VALUE!	0.98	1.01	1.40	102.67	102.89	96.50	
Mallard Slough	11/16/2006	9:53	F11p41n1	WS	#VALUE!	#VALUE!	0.75	9.42	8.58	105.59	106.73	99.16	
Mallard Slough	12/14/2006	10:06	F11p61n1	WS	#VALUE!	#VALUE!	0.14	9.60	8.78	97.79	97.79	98.42	





Inlet C Canal

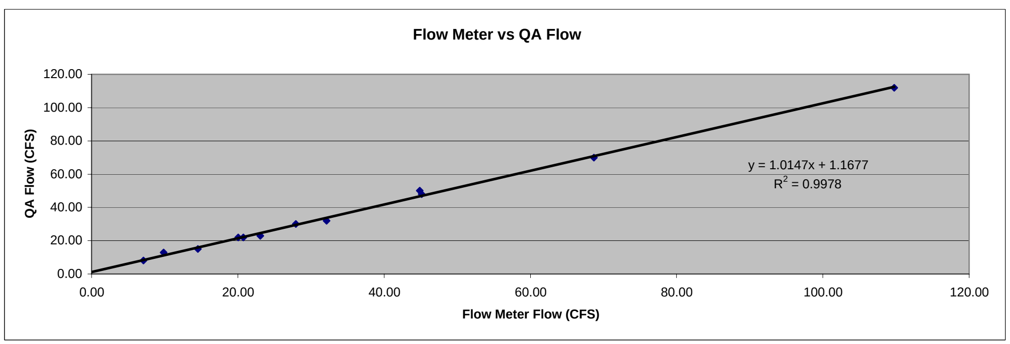
Quality Assurance

DO-63 Inlet C Canal 2006 QA data

WS = Weir Stick SG = Streamgage FM=Propeller Flow Meter

Reference					Measured Variables																Constants			
Site	Date	Time	Notebook Reference	Method	Observed Bubbler reading	Observed Staffguage Stage	Observed ITRC Weirstick reading East	Observed ITRC Weirstick reading Middle	Observed ITRC Weirstick reading West	Observed EC from handheld meter	Logger East pipe Propeller Meter (CFS)	Logger Middle pipe Propeller Meter (CFS)	Logger West pipe Propeller Meter (CFS)	Analog East pipe Propeller Meter (CFS)	Analog Middle pipe Propeller Meter (CFS)	Analog West pipe Propeller Meter (CFS)	Pre-cleaning EC from logger data	Post-Cleaning EC from logger data	Observed Temp from handheld meter (C)	Temperature from Logger data (F)	Structure/ Equipment	Width of Weir in ft.	Bubbler to staffguage offset (add to bubbler value to get stage)	Rating Quality
Inlet C Canal	1/17/2006	10:00	F5p70n1	FM	na	na	na	na	na	1791	11.66	-0.086	11.48	11	0	12	1888	1888	na	47.93	Weir/Propeller Meter	5.5	na	Good
Inlet C Canal	1/26/2006	12:37	F5p80n10	FM	na	na	0.4	na	2.3	572	1.358	-0.068	13.26	3	0	12	529	529	10.37	49.08	Weir/Propeller Meter	5.5	na	Good
Inlet C Canal	3/2/2006	11:20	F5p95n2	FM	na	na	na	na	1.8	927	-0.279	-0.056	10.2	2	0	11	967	967	13.43	55.12	Weir/Propeller Meter	5.5	na	Good
Inlet C Canal	3/30/2006	11:01	F8p47n1	FM	na	na	na	na	na	390	-19.99	-0.081	20.84	na	0	22	445	445	14.25	57.25	Weir/Propeller Meter	5.5	na	Good
Inlet C Canal	4/27/2006	11:06	F8p71n5	FM	na	na	na	na	na	na	-19.98	-0.07	-0.305	0	0	0	458	458	na	65.4	Weir/Propeller Meter	5.5	na	Good
Inlet C Canal	7/11/2006	9:00	F9p12n5	FM	na	na	na	na	na	569	20.34	0.013	-0.288	22	0	0	598	598	25.59	77.1	Weir/Propeller Meter	5.5	na	Good
Inlet C Canal	9/14/2006	11:17	F9p101n3	FM	na	6.01	na	na	na	767	-0.363	-0.02	28.31	0	0	30	855	855	21.41	70.3	Weir/Propeller Meter	5.5	na	Good
Inlet C Canal	9/28/2006	10:37	F9p128n7	FM	na	5.86	na	na	na	507	-20.01	-0.069	32.21	0	na	32	525	525	20.53	69.6	Weir/Propeller Meter	5.5	na	Good
Inlet C Canal	10/12/2006	11:00	F9p148n1	FM	na	na	na	na	na	428	50.39	12.76	46.62	50	12	50	462	462	18.19	65.03	Weir/Propeller Meter	5.5	na	Good
Inlet C Canal	10/26/2006	12:02	F11p16n1	FM	na	5.3	na	na	na	357	35.43	-0.088	33.36	40	0	30	378	378	15.14	60.01	Weir/Propeller Meter	5.5	na	Good
Inlet C Canal	11/2/2006	12:07	F11p27n1	FM	na	5.68	na	na	na	373	45.19	-0.036	-20	48	0	na	395	395	16.07	60.49	Weir/Propeller Meter	5.5	na	Good
Inlet C Canal	11/16/2006	11:54	F11p44n1	FM	na	na	na	na	na	393	44.97	-0.097	-20	50	0	na	420	420	15	58.73	Weir/Propeller Meter	5.5	na	Good
Inlet C Canal	12/14/2006	11:56	F11p64n1	FM	na	na	na	na	na	1551	7.18	-0.076	-19.98	8	0	na	1652	1652	12.02	53.21	Weir/Propeller Meter	5.5	na	Good
																					Average offset		#DIV/0!	

Reference					Calculations							Comments
Site	Date	Time	Notebook Reference	Method	stage above boards as back calculated from ITRC Weirstick Reading [H=(WS/3.33)^(2/3)]	Weirstick Flow Calculated from (weirstick reading * boardwidth)	QA Sum Flow (CFS) from Analog (East Pipe + Middle Pipe + West Pipe)	Sum Flow (CFS) from Logger (East Pipe + Middle Pipe + West Pipe)	Pre-Cleaning EC deviation (logger/QA *100)	Post-Cleaning EC deviation (logger/QA *100)	Temperature Deviation (logger/QA *100)	
Inlet C Canal	1/17/2006	10:00	F5p70n1	FM	#VALUE!	#VALUE!	23.00	23.05	105.42	105.42	#VALUE!	
Inlet C Canal	1/26/2006	12:37	F5p80n10	FM	0.78	14.85	15.00	14.55	92.48	92.48	96.87	
Inlet C Canal	3/2/2006	11:20	F5p95n2	FM	0.66	9.90	13.00	9.87	104.31	104.31	98.12	
Inlet C Canal	3/30/2006	11:01	F8p47n1	FM	#VALUE!	#VALUE!	22.00	20.76	114.10	114.10	99.31	*Logger propeller meter values around -20 are invalid and correspond to a missing propeller meter
Inlet C Canal	4/27/2006	11:06	F8p71n5	FM	#VALUE!	#VALUE!	0.00	-0.38	#VALUE!	#VALUE!	#VALUE!	*Logger propeller meter values around -20 are invalid and correspond to a missing propeller meter
Inlet C Canal	7/11/2006	9:00	F9p12n5	FM	#VALUE!	#VALUE!	22.00	20.07	105.10	105.10	98.77	
Inlet C Canal	9/14/2006	11:17	F9p101n3	FM	#VALUE!	#VALUE!	30.00	27.93	111.47	111.47	99.66	
Inlet C Canal	9/28/2006	10:37	F9p128n7	FM	#VALUE!	#VALUE!	32.00	32.14	103.55	103.55	100.94	*Logger propeller meter values around -20 are invalid and correspond to a missing propeller meter
Inlet C Canal	10/12/2006	11:00	F9p148n1	FM	#VALUE!	#VALUE!	112.00	109.77	107.94	107.94	100.44	
Inlet C Canal	10/26/2006	12:02	F11p16n1	FM	#VALUE!	#VALUE!	70.00	68.70	105.88	105.88	101.28	
Inlet C Canal	11/2/2006	12:07	F11p27n1	FM	#VALUE!	#VALUE!	48.00	45.15	105.90	105.90	99.28	*Logger propeller meter values around -20 are invalid and correspond to a missing propeller meter
Inlet C Canal	11/16/2006	11:54	F11p44n1	FM	#VALUE!	#VALUE!	50.00	44.87	106.87	106.87	99.54	*Logger propeller meter values around -20 are invalid and correspond to a missing propeller meter
Inlet C Canal	12/14/2006	11:56	F11p64n1	FM	#VALUE!	#VALUE!	8.00	7.10	106.51	106.51	99.21	*Logger propeller meter values around -20 are invalid and correspond to a missing propeller meter

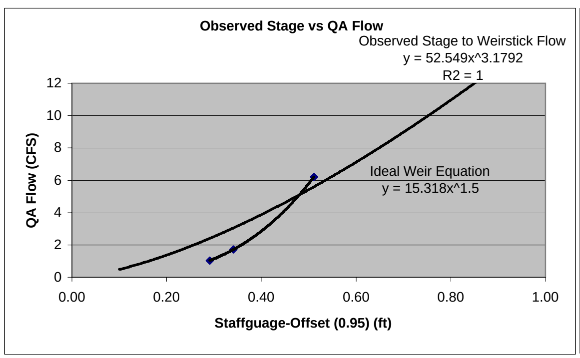


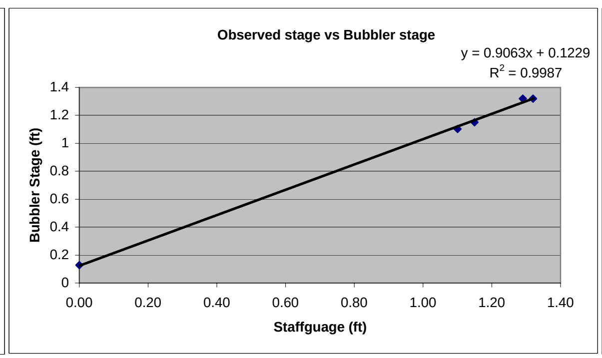
Moran Drain
Quality Assurance

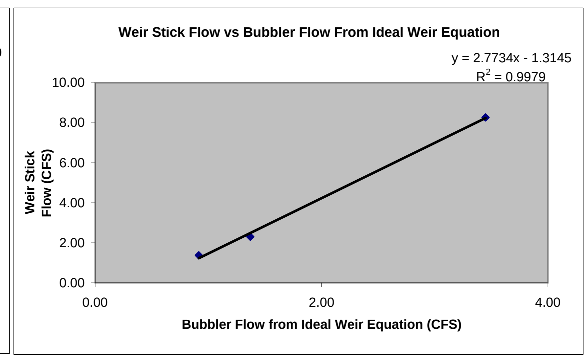
DO-64 Moran Drain 2006 QA data
WS = Weir Stick SG = Streamgage

Reference					Measured Variables								Constants				
Site	Date	Time	Notebook Reference	Method	Observed Bubbler reading	Observed Staffguage Stage	Observed ITRC Weirstick reading	Observed EC from handheld meter	Pre-cleaning EC from logger data	Post-Cleaning EC from logger data	Observed Temp from handheld meter (C)	Temperature from Logger data (F)	Structure/ Equipment	Width of Weir in ft.	Bubbler to staffguage offset (add to bubbler value to get stage)	Bubbler to Top of Weir Offset (Subtract from Bubbler to Get Head Over Weir)	Rating Quality
Moran Drain	1/11/2006	8:15	TT011106P89	WS	0.127	0.00	na	na	na	na	na	na	Weir/bubbler	4.6	-0.127	#VALUE!	poor
Moran Drain	2/8/2006	8:30	TT020806P99	WS	0.127	0.00	na	na	na	na	na	na	Weir/bubbler	4.6	-0.127	#VALUE!	poor
Moran Drain	3/8/2006	8:00	TT030806P109	WS	0.128	0.00	na	na	na	na	na	na	Weir/bubbler	4.6	-0.128	#VALUE!	poor
Moran Drain	4/4/2006	8:30	TT040406P119	WS	0.126	0.00	na	na	na	na	na	na	Weir/bubbler	4.6	-0.126	#VALUE!	poor
Moran Drain	5/9/2006	8:00	TT050906P129	WS	2.075	na	na	207	214		16.69	62.17	Weir/bubbler	4.6	#VALUE!	#VALUE!	poor
Moran Drain	6/6/2006	11:00	TT060606P139	WS	1.103	1.10	0.3	197	195		20.68	69.42	Weir/bubbler	4.6	-0.003	0.902	poor
Moran Drain	7/21/2006	9:30	TT072106Pxx	WS	1.319	1.29	na	371	371		25.71	77.94	Weir/bubbler	4.6	-0.029	#VALUE!	poor
Moran Drain	8/22/2006	8:30	TT082206Pxx	WS	1.32	1.32	1.8	441	471		20.41	68.29	Weir/bubbler	4.6	0.000	0.656	poor
Moran Drain	9/28/2006	10:00	TT092806P14	WS	1.146	na	na	446	337		18.56	65.51	Weir/bubbler	4.6	#VALUE!	#VALUE!	poor
Moran Drain	10/3/2006	8:45	F9P133N4	WS	1.15	1.15	0.5	na	na	na	na	na	Weir/bubbler	4.6	0.000	0.868	poor
Moran Drain	10/27/2006	8:45	TT102706P22	WS	0.127	0.00	na	na	na	na	na	na	Weir/bubbler	4.6	-0.127	#VALUE!	poor
Moran Drain	11/17/2006	8:45	TT111706P30	WS	0.127	0.00	na	na	na	na	na	na	Weir/bubbler	4.6	-0.127	#VALUE!	poor
Moran Drain	12/8/2006	8:15	TT120806P40	WS	0.128	0.00	na	na	na	na	na	na	Weir/bubbler	4.6	-0.128	#VALUE!	poor
													Average offset		-0.008	0.809	

Reference					Calculations						Comments
Site	Date	Time	Notebook Reference	Method	Stage above boards as back calculated from ITRC Weirstick Reading [H=(WS/3.33)^(2/3)]	Weirstick Flow Calculated from (weirstick reading * boardwidth)	Bubbler Flow calculated from (3.33 * Weir width * (bubbler stage-offset)^1.5)	Pre-Cleaning EC deviation (logger/QA*100)	Post-Cleaning EC deviation (logger/QA*100)	Temperature Deviation (logger/QA*100)	
Moran Drain	1/11/2006	8:15	TT011106P89	WS	#VALUE!	#VALUE!	#NUM!	#VALUE!	#VALUE!	#VALUE!	site was dry
Moran Drain	2/8/2006	8:30	TT020806P99	WS	#VALUE!	#VALUE!	#NUM!	#VALUE!	#VALUE!	#VALUE!	site was dry
Moran Drain	3/8/2006	8:00	TT030806P109	WS	#VALUE!	#VALUE!	#NUM!	#VALUE!	#VALUE!	#VALUE!	site was dry
Moran Drain	4/4/2006	8:30	TT040406P119	WS	#VALUE!	#VALUE!	#NUM!	#VALUE!	#VALUE!	#VALUE!	site was dry
Moran Drain	5/9/2006	8:00	TT050906P129	WS	#VALUE!	#VALUE!	18.28	103.38	0.00	100.21	
Moran Drain	6/6/2006	11:00	TT060606P139	WS	0.20	1.38	0.92	98.98	0.00	100.28	
Moran Drain	7/21/2006	9:30	TT072106Pxx	WS	#VALUE!	#VALUE!	3.43	100.00	0.00	99.57	
Moran Drain	8/22/2006	8:30	TT082206Pxx	WS	0.66	8.28	3.45	106.80	0.00	99.35	
Moran Drain	9/28/2006	10:00	TT092806P14	WS	#VALUE!	#VALUE!	1.33	75.56	0.00	100.16	EC QA only
Moran Drain	10/3/2006	8:45	F9P133N4	WS	0.28	2.30	1.37	#VALUE!	#VALUE!	#VALUE!	flow QA only
Moran Drain	10/27/2006	8:45	TT102706P22	WS	#VALUE!	#VALUE!	#NUM!	#VALUE!	#VALUE!	#VALUE!	site was dry
Moran Drain	11/17/2006	8:45	TT111706P30	WS	#VALUE!	#VALUE!	#NUM!	#VALUE!	#VALUE!	#VALUE!	site was dry
Moran Drain	12/8/2006	8:15	TT120806P40	WS	#VALUE!	#VALUE!	#NUM!	#VALUE!	#VALUE!	#VALUE!	Top of weir measured at .95ft







Spanish Grant Drain Drain

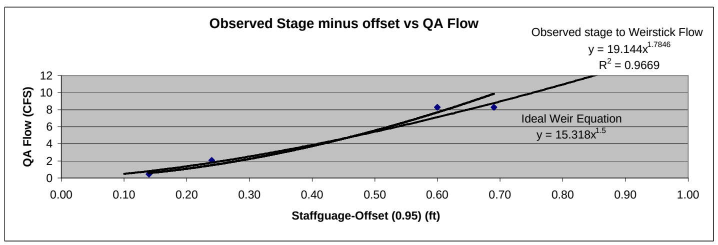
Quality Assurance

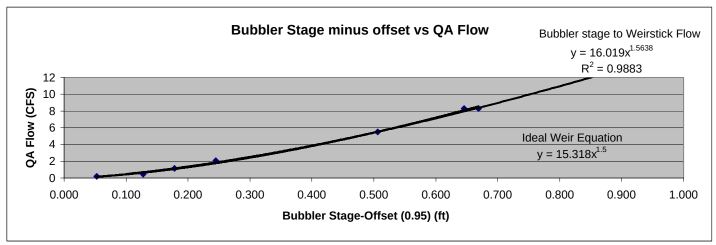
DO-65 Spanish Grant Drain 2006 QA data

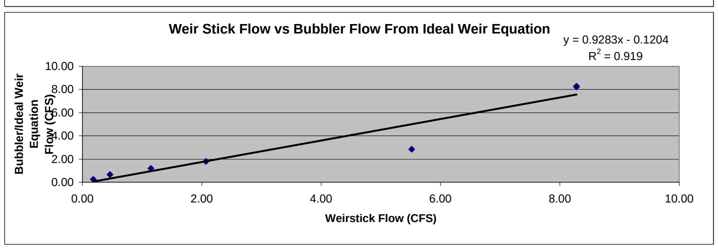
WS = Weir Stick SG = Streamgage

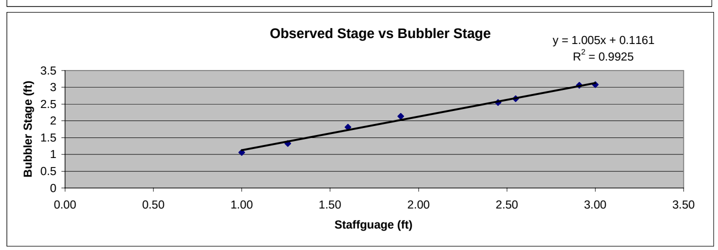
Reference					Measured Variables									Constants				
Site	Date	Time	Notebook Reference	Method	Observed Bubbler reading	Observed Staffguage Stage	Observed ITRC Weirstick reading	Observed EC from handheld meter	Pre-cleaning EC from logger data	Post-Cleaning EC from logger data	Observed Temp from handheld meter (C)	Temperature from Logger data (F)	Structure/ Equipment	Width of Weir in ft.	Bubbler to staffguage offset (add to bubbler value to get stage)	Bubbler to top of weirboard offset (subtract from bubbler for Head over weir)	Rating Quality
Spanish Grant Drain	1/11/2006	8:00	TT011106P87	WS	1.325	1.26	1.2	621	293	636	10.72	51.49	Weir/bubbler	4.6	-0.065	0.819	good
Spanish Grant Drain	2/8/2006	8:31	TT020806P98	WS	1.063	1.00	0.04	1362	1398		12.45	55.04	Weir/bubbler	4.6	-0.063	1.011	good
Spanish Grant Drain	3/8/2006	8:15	TT030806P108	WS	1.021	na	na	1533	1352		12.16	54.03	Weir/bubbler	4.6	#VALUE!	#VALUE!	good
Spanish Grant Drain	4/4/2006	8:25	TT040406P118	WS	1.811	1.60	0.25	223	210		13.94	57.3	Weir/bubbler	4.6	-0.211	1.633	good
Spanish Grant Drain	5/9/2006	8:00	TT050906P128	WS	5.144	na	na	515	524		17.22	63.14	Weir/bubbler	4.6	#VALUE!	#VALUE!	good
Spanish Grant Drain	6/6/2006	10:50	TT060606P138	WS	3.105	na	na	400	606		21.94	68.84	Weir/bubbler	4.6	#VALUE!	#VALUE!	good
Spanish Grant Drain	7/21/2006	9:15	TT072106Pxx	WS	2.135	1.90	na	650	653		24.22	75.88	Weir/bubbler	4.6	-0.235	#VALUE!	good
Spanish Grant Drain	8/22/2006	8:30	TT082206Pxx	WS	1.698	na	na	747	451	754	20.45	68.71	Weir/bubbler	4.6	#VALUE!	#VALUE!	good
Spanish Grant Drain	9/28/2006	9:45	TT092806P13	WS	2.82	na	na	1263	1123		19.49	67.03	Weir/bubbler	4.6	#VALUE!	#VALUE!	good
Spanish Grant Drain	10/3/2006	8:30	F9P133	WS	3.061	2.91	1.8	na	na	na	na	na	Weir/bubbler	4.6	-0.151	2.397	good
Spanish Grant Drain	10/27/2006	8:40	TT102706P21	WS	2.66	2.55	0.45	994	1043		12.97	55.74	Weir/bubbler	4.6	-0.110	2.397	good
Spanish Grant Drain	11/17/2006	8:50	TT111706P29	WS	3.084	3.00	1.8	345	411		14.21	57.95	Weir/bubbler	4.6	-0.084	2.420	good
Spanish Grant Drain	12/8/2006	8:15	TT120806P39	WS	2.543	2.45	0.1	1712	1961		12.02	53.8	Weir/bubbler	4.6	-0.093	2.446	good
													Average offset		-0.123	2.415	

Reference					Calculations						Comments
Site	Date	Time	Notebook Reference	Method	Height above boards as back calculated from ITRC Weirstick Reading [H=(WS/3.33)^(2/3)]	Weirstick Flow Calculated from (weirstick reading * boardwidth)	Bubbler Flow calculated from (3.33 * Weir width * (bubbler stage-offset)^1.5)	Pre-Cleaning EC deviation (logger/QA*100)	Post-Cleaning EC deviation (logger/QA*100)	Temperature Deviation (logger/QA*100)	
Spanish Grant Drain	1/11/2006	8:00	TT011106P87	WS	0.51	5.52	2.84	47.18	102.42	100.38	
Spanish Grant Drain	2/8/2006	8:31	TT020806P98	WS	0.05	0.18	0.24	102.64	0.00	101.16	
Spanish Grant Drain	3/8/2006	8:15	TT030806P108	WS	#VALUE!	#VALUE!	0.05	88.19	0.00	100.26	installed new 8" weirboard
Spanish Grant Drain	4/4/2006	8:25	TT040406P118	WS	0.18	1.15	1.18	94.17	0.00	100.36	
Spanish Grant Drain	5/9/2006	8:00	TT050906P128	WS	#VALUE!	#VALUE!	100.90	101.75	0.00	100.23	
Spanish Grant Drain	6/6/2006	10:50	TT060606P138	WS	#VALUE!	#VALUE!	27.44	151.50	0.00	96.29	
Spanish Grant Drain	7/21/2006	9:15	TT072106Pxx	WS	#VALUE!	#VALUE!	5.50	100.46	0.00	100.38	Weir was submerged! At least one board lost
Spanish Grant Drain	8/22/2006	8:30	TT082206Pxx	WS	#VALUE!	#VALUE!	0.27	60.37	100.94	99.85	installed new 6" weirboard
Spanish Grant Drain	9/28/2006	9:45	TT092806P13	WS	#VALUE!	#VALUE!	4.17	88.92	0.00	99.92	
Spanish Grant Drain	10/3/2006	8:30	F9P133	WS	0.66	8.28	8.23	#VALUE!	#VALUE!	#VALUE!	
Spanish Grant Drain	10/27/2006	8:40	TT102706P21	WS	0.26	2.07	1.80	104.93	0.00	100.71	
Spanish Grant Drain	11/17/2006	8:50	TT111706P29	WS	0.66	8.28	8.29	119.13	0.00	100.65	
Spanish Grant Drain	12/8/2006	8:15	TT120806P39	WS	0.10	0.46	0.66	114.54	0.00	100.31	









S-Lake Drain

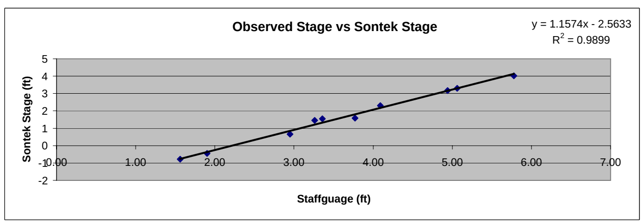
Quality Assurance

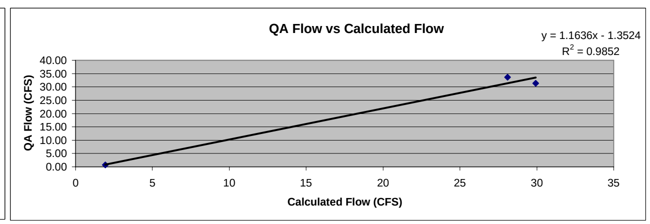
DO-68 S-Lake Drain 2006 QA data

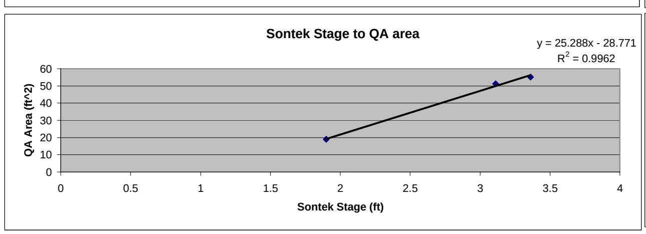
WS = Weir Stick SG = Streamgage

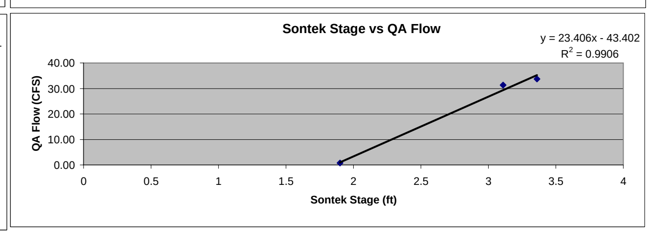
Reference					Measured Variables									Constants			
Site	Date	Time	Notebook Reference	Method	Observed Sontek reading	Observed Staffguage Stage	Sontek Velocity	Observed EC from handheld meter	Pre-cleaning EC from logger data	Post-Cleaning EC from logger data	Observed Temp from handheld meter (C)	Temperature from Logger data (F)	Structure/ Equipment	Width of Weir in ft.	Keller to staffguage offset (add to bubbler value to get stage)	Rating Quality
S-Lake Drain	1/9/2006	12:15	G2P18	SG	4.47	6.05	0.31	1389	1334		53.1	50.29	stream/Sontek/Keller Transducer	na	1.580	fair
S-Lake Drain	2/2/2006	9:30	G2P23	SG	1.36	3.11	0.6	1926	1956		55.4	54.84	stream/Sontek/Keller Transducer	na	1.750	fair
S-Lake Drain	3/1/2006	10:45	G2P33	SG	3.3	5.06	0.51	1761	1770		55	55.03	stream/Sontek/Keller Transducer	na	1.760	fair
S-Lake Drain	4/19/2006	13:19	G2P43	SG	4.02	5.78		2062	3030		66.7	59.76	stream/Sontek/Keller Transducer	na	1.760	fair
S-Lake Drain	5/8/2006	10:30	G2P46	SG	3.17	4.94	0.21	859.8	2446		72	66.61	stream/Sontek/Keller Transducer	na	1.770	fair
S-Lake Drain	6/9/2006	13:30	G2P61	SG	2.3	4.09	0.11	1539	2195		81.5	68.92	stream/Sontek/Keller Transducer	na	1.790	fair
S-Lake Drain	7/6/2006	12:15	G2P64	SG		1.22	na	3045	2844		80.6	82	stream/Sontek/Keller Transducer	na	na	fair
S-Lake Drain	7/28/2006	9:30	G2P66	SG	-0.45	1.90	0.1	1771	2290		79.3	78.3	stream/Sontek/Keller Transducer	na	2.350	fair
S-Lake Drain	8/31/2006	12:00	G2P70	SG		0.98	na	2635	2268		81.3	76.7	stream/Sontek/Keller Transducer	na	na	fair
S-Lake Drain	9/19/2006	10:45	G2P75	SG	-0.78	1.56	na	1180	1216		68.2	68.89	stream/Sontek/Keller Transducer	na	2.340	fair
S-Lake Drain	10/10/2006	10:45	G2P77	SG	0.668	2.95	0.54	654.8	662		66.6	66.81	stream/Sontek/Keller Transducer	na	2.282	fair
S-Lake Drain	10/31/2006	15:30	G2P79	SG	1.58	3.77	0.4	965.2	955		61.2	61.41	stream/Sontek/Keller Transducer	na	2.190	fair
S-Lake Drain	12/1/2006	11:45	G2P86	SG	1.45	3.26	0.35	1130	1115		48	47.1	stream/Sontek/Keller Transducer	na	1.810	fair
S-Lake Drain	12/21/2006	10:15	G2P89	SG	1.55	3.36	0.5	1390	1401		44.2	43.8	stream/Sontek/Keller Transducer	na	1.810	fair
													Average vert beam offset		1.779	
													Average pressure offset		2.291	

Reference					Calculations								Comments
Site	Date	Time	Notebook Reference	Method	QA Average Velocity (calculated from flow rating velocities)	QA Area (calculated from flow rating area)	Keller/Sontek transducer Calculated Area	QA Flow	sontek/keller Calculated Flow	Pre-Cleaning EC deviation (logger/QA*100)	Post-Cleaning EC deviation (logger/QA*100)	Temperature Deviation (logger/QA*100)	
S-Lake Drain	1/9/2006	12:15	G2P18	SG						96.04	0.00	94.71	
S-Lake Drain	2/2/2006	9:30	G2P23	SG	0.52	51.20	49.87	31.31	29.92	101.56	0.00	98.99	Staff guage moved to footbridge
S-Lake Drain	3/1/2006	10:45	G2P33	SG						100.51	0.00	100.05	
S-Lake Drain	4/19/2006	13:19	G2P43	SG						146.94	0.00	89.60	
S-Lake Drain	5/8/2006	10:30	G2P46	SG						284.48	0.00	92.51	
S-Lake Drain	6/9/2006	13:30	G2P61	SG						142.63	0.00	84.56	
S-Lake Drain	7/6/2006	12:15	G2P64	SG						93.40	0.00	101.74	
S-Lake Drain	7/28/2006	9:30	G2P66	SG	0.04	19.05	19.28	0.74	1.93	129.31	0.00	98.74	
S-Lake Drain	8/31/2006	12:00	G2P70	SG						86.07	0.00	94.34	
S-Lake Drain	9/19/2006	10:45	G2P75	SG						103.05	0.00	101.01	
S-Lake Drain	10/10/2006	10:45	G2P77	SG						101.10	0.00	100.32	
S-Lake Drain	10/31/2006	15:30	G2P79	SG						98.94	0.00	100.34	
S-Lake Drain	12/1/2006	11:45	G2P86	SG						98.67	0.00	98.13	
S-Lake Drain	12/21/2006	10:15	G2P89	SG	0.51	55.10	56.20	33.65	28.10	100.79	0.00	99.10	









Appendix D

DESCRIPTION AND PHOTO-DOCUMENTATION
OF
FIELD WORK ACTIVITIES FOR 2006

Jeremy Hanlon
Justin Graham
University of the Pacific

January 9, 2006

Grasslands Station Maintenance and QA
Met with Lara Sparks (Grasslands Water District/Department of Fish and Game) to assist her with stream ratings and equipment issues at the DO sites she manages within the Grasslands water district.
DO-20 Los Banos Creek Flow Station: Arrived to find old bridge completely washed out and dangling downstream from the instrument cables. Used rope and truck to pull bridge onto east bank of stream. Removed Sontek and pulled cable into pipe along with EC probe. Disconnected bubbler orifice and pulled pipe up onto shore. Brought Sontek unit in for cleaning and functionality check. Equipment was functional.
DO-68 S-Lake basin and Hollow tree Drain: S-Lake was at flood stage, boards for platform where the staff gauge was attached were floating. Hyacinth was 2+ft thick. EC probe was lifted out of water by Hyacinth. Keller Pressure Transducer in Hollowtree was non-functional. Measured length of cable for replacement sensor.
DO-46 MudSlough at Gun Club Rd.: Flood stage. Staff gauge was completely submerged by several inches.

Coyote in Wetland
Typical wildlife encountered during wetland trips.

January 11, 2006

Westside Station Maintenance and QA
Met with Chris Linneman (Summers Engineering) and Kyle Kearney (Tetra Tech) at the 'three drains site' DO-38 Marshall Drain, DO-64 Moran Drain, and DO-65 Spanish Grant Drain for routine Westside station maintenance. In addition to the above sites, DO-36 DelPuerto Creek, DO-33 Hospital Creek, DO-35 Westley Wasteway, and DO-31 New Jerusalem Drain were visited for data downloads, cleaning, flow, EC, and temperature QA.

DO-34 Ingram Creek
(left) Student Intern, Kyle Kearney, Jeremy Hanlon, and Chris Linneman removing EC probe which had been encased in sediment. (right) Chris and Jeremy clearing away sediment buildup.

DO-38 Marshall Drain
Chris is preparing for his confined space entry to make flow measurements while Kyle cleans the YSI EC probe from the surface.

January 17, 2006

SLNWR Station Maintenance
Data downloads and station maintenance/QA performed at DO-60 Moffit, DO-61 Deadmans Slough, DO-62 Mallard Slough, and DO-63 Inlet C canal.

Ducks flying over refuge
Waterfowl were often seen flying around the refuge.

January 19, 2006

Core Sampling Event
Sampling for DOTMDL core sites. Picture taken from DO-05 SJR at Vernalis from the Department of Water Resources (DWR) McClune station platform looking north, shows San Joaquin River (SJR) swollen with runoff from recent rains.

DO-05 SJR at Vernalis
Debris caught on DWR platform pylons.

DO-28 TID Westport Drain Flow station
Newly Installed flume and SCADA monitoring system, about 300 ft downstream of the previous station location.

DO-36 Del Puerto Creek monitoring site
Streambed is dry despite recent rains and high levels in SJR.

DO-06 SJR at Maze Blvd.
El Solyo pump platform submerged under swollen SJR.

January 26, 2006

Wetlands Sampling Event
Sampling for DOTMDL wetland sites.

DO-61 Deadmans Slough
Picture taken at DO-61 Deadmans Slough in the San Luis National Wildlife Refuge. William Stringfellow is taking YSI sonde measurements. Additional measurements were taken throughout the wetlands sampling area.

January 31, 2006

Station Maintenance
DO-31 New Jerusalem Drain was visited in response to the discovery of a leaky bubbler line. The Swagelok fitting was removed and properly re-inserted, the connection was tightened, and checked for leaks. No leaks were found. The weir was rated for correlation to the bubbler reading. DO-34 Ingram Creek was visited to remove some of the sediment from behind the weirboard. The Sontek Doppler instrument at DO-53 Salt Slough at Wolfsen Road was re-installed because the mounting had been discovered to be completely rusted through the previous month. A new mount with stainless steel attachments was used. Met with Karl Stromayer of USFWS while at DO-53 to discuss upcoming training on station maintenance and QA procedures.

DO-31 New Jerusalem Drain
(left) Station house on top of levee with SJR behind. Ropes are rigged for lowering or belaying confined space entrant. (right) Rope system rigged for hauling up of confined space entrant.

DO-31 New Jerusalem Drain
Shows location of bubbler line orifice and YSI EC meter just upstream of weirboards. The unusually clear water here made the Starflow unable to read velocity and so it was removed and eventually upgraded to a MACE Agriflo unit that was placed downstream of the weirboards.

February 2, 2006

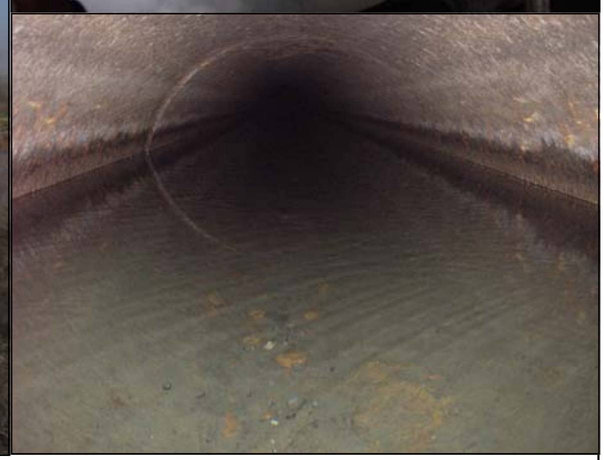
Grasslands Station Maintenance and QA
Met with Lara Sparks (Grasslands Water District/Department of Fish and Game) to assist her with stream ratings and QA at the DO sites she manages within the Grasslands water district. DO-45 Volta Wasteway Flow station staff gauge had been mounted to wood post that rotted away. The staff gauge was re-installed and anchored directly to a pole on the bridge with stainless steel clamps.

Stream Ratings
Pictures taken at DO-68 S-Lake Basin Monitoring site with Jeremy Hanlon and Lara Sparks performing a stream rating. Ratings were made at DO-68 S-Lake basin, Hollow tree Drain, DO-46 Mud Slough at Gun Club, and DO-45 Volta Wasteway Flow station.

February 8, 2006

Westside Station Maintenance
Accompanied Kyle Kearney (Tetra Tech) to Westside stations and performed flow measurements. Added weir board to DO-38 Marshal Road Drain, DO-64 Moran Drain, and DO-65 Spanish Drain. DO-35 Westley Wasteway Flow station DA logger was not communicating with YSI EC probe. Removed Logger for inspection and testing at UOP. At DO-57 Ramona Lake noted that the cable the YSI EC probe hung from was almost rusted out. Measured length for replacement.





DO-31 New Jerusalem Drain
Installed new MACE Agriflow Doppler flow meter. Note new smaller solar panel in picture (left) provides 6V power supply for Agriflo unit. Picture of water flowing over weir boards (top right) and picture looking upstream of pipe under levee (bottom right).

February 14, 2006

Westside Station Repairs
Returned to DO-31 New Jerusalem Drain to update Firmware on new MACE Agriflo unit so it would correctly output SDI-12 to the DA logger.
Returned to DO-35 Westley Wasteway Flow station to re-install DA logger after ensuring it was functioning properly with equipment at UOP. Found that the cable to the Starflow Doppler flow meter had been sliced open while a backhoe was clearing debris from the channel. Determined that the destroyed Starflow Doppler flow meter was causing a short circuit and making the logger freeze every time it tried to take a measurement. Disconnecting the cable solved the problem.

Starflow Doppler flow meter
Picture of Sontek Doppler flow meter with protective tubing around cord. The Starflow is put on the bottom of the channel to measure flow.

February 23, 2006

Core Sampling Event
Sampling for DOTMDL core sites. All sites were accessible and no problems were encountered.

DO-07 San Joaquin River at Patterson
Picture of Jeremy Hanlon's truck near the pump platform.

March 2, 2006

Wetland sampling event
Sampling for DOTMDL wetland sites. In addition to collecting grab samples, data was downloaded from the stations and QA measurements were taken. Beaver dams and other debris were cleared from weir boards where possible.

Beaver Activity
Picture of beaver dam at DO-60 Moffit 1 South. Debris and beaver activity clogged the weirs which often had to be cleared.

March 8, 2006

Westside Station Maintenance and QA
Accompanied Kyle Kearney (Tetra Tech) to provide support for safe entry into confined spaces. Took flow measurements. Added one 2x8 board to each of the three drains sites DO-38 Marshall Road Drain, DO-64 Moran Drain, and DO-65 Spanish Grant Drain. DO-34 Ingram creek, repositioned rocks in stream to help avoid siltation of EC probe.

DO-33 Hospital Creek
Close-up photo of installation showing bubbler pipe, EC meter in cage, and stream gauge all just upstream of weirboard.

DO-33 Hospital Creek
Student Intern in foreground with Kyle Kearney in station.

March 9, 2006

Core Sampling Event
Sampling for DOTMDL core sites. No problems encountered. All sites sampled despite extensive flooding.

Flooded Wetlands
The Kesterson unit of SLNWR. Near DO-20 Los Banos Creek.

March 10, 2006

Station Maintenance
Met with Nigel Quinn (LBNL) to scout out locations of West Stanislaus Irrigation District diversion canal monitoring station and Patterson Irrigation District diversion canal monitoring station.



DO-41 West Stanislaus ID Diversion canal
Scouting location of West Stanislaus ID diversion monitoring station with Nigel Quinn to clean EC sensor and download data from the Campbell logger for Ron Roos of WSID.

DO-20 Los Banos Creek
Jeremy Hanlon met with Nigel Quinn, Lara Sparks (Grasslands Water District/Fish and Game), and William Stringfellow to review construction by Grasslands Water District on new bridge and to discuss plans for upgrading the Los Banos station equipment installation (see July28, 2006, September 5, 2006, and October 31, 2006).

DO-40 Patterson ID Diversion Canal
Scouting for location of YSI EC probe for periodic cleaning for Nigel Quinn.

March 21, 2006

USFWS training
Presented a 4 hour instructional clinic for US Fish and Wildlife Staff of the SLNWR on methods for flow monitoring; continuous data collection and compiling; station maintenance; and QA procedures. Training session attendees included: Karl Stromayer, Dennis Wollington, Tom Denniston, Brandon Jordan, Louise Zeringue, Ken Griggs, and Mike Enos.

Field Monitoring Training Station in UOP Hydraulics Laboratory
The training station set up at the UOP Hydraulics laboratory was used to simulate a real field monitoring station and allowed trainees the opportunity for hands-on practice.

March 23, 2006

Core Sampling Event
Sampling for DOTMDL core sites. DO-33 Hospital Creek was dry and DO-57 Ramona Lake had no flow. Neither site was sampled. All other sites were sampled.

DO-16 Merced River at River Road
Parking location for sampling vehicle to grab samples from the Merced River. Photo was taken from the bridge where samples are bucket sampled.

March 30, 2006

Wetland Sampling Event
Sampling for DOTMDL wetland sites. Met with Karl Stromayer (USFW) to deliver data CD. Weir at DO-60 Moffit 1 South was plugged with debris upon arrival. There was standing water and no flow so a sonde measurement was taken but no grab sample. DO-61 Deadmans Slough had no flow out of weir, but Bear creek unit pump was running so samples were collected. No samples were taken at DO-80 Marsh 1 Inlet because the screw gate was closed resulting in no flow at the site.

Photo of Hawk over Wetlands
One of the scenes during wetland sampling trips.

April 6, 2006

Core Sampling Event
Sampling for DOTMDL core sites. Flood conditions existed at most sites. DO-20 Los Banos Creek was not sampled because the access road was flooded. However, DO-33 Hospital Creek was dry and not sampled.

DO-21 Orestimba Creek at River Rd.
Photo of flooded Orestimba Creek. At non-flood stage the flow is a small stream at the bottom of the gorge.

DO-08 San Joaquin River at Crows Landing
Our normal access site at the Turlock sportsmans club is from the floating dock at the end of the normally dry boat ramp. High flows in the SJR made access impossible so samples were taken from the bank just to the left of this photograph's view.

DO-07 San Joaquin River at Patterson
Student Intern collecting grab samples from the Patterson Irrigation District diversion platform on the SJR. Water level in the SJR was just a couple feet below the platform.

April 11, 2006

YSI Training in Sacramento
YSI sponsored a free sonde features and calibration seminar at a hotel in Sacramento.

YSI Training
Remie Burks and Jeremy Hanlon attended an all day training seminar. This was a good opportunity for Remie to learn calibration procedures and for Jeremy to learn some trouble shooting tips and maintenance techniques.

April 20, 2006

Core Sampling Event
Sampling for DOTMDL core sites. River at flood conditions. DO-25 Miller Lake and DO-33 Hospital Creek had no flow and were not sampled. DO-59 SJR at Laird Park was not sampled because Laird Park was closed. DO-30 TID Lat 6&7 was not sampled because there was no access key. DO-36 Del Puerto Creek and DO-08 SJR at Crow's Landing were not sampled because they were flooded.

DO-44 San Luis Drain End
Remie Burks and Student Intern collecting samples.

DO-19 Salt Slough at Lander Avenue
Student Intern and Remie collecting samples.

DO-08 SJR at Crows Landing
Turlock Sportsman Club under water after flooding. Grab samples are normally pulled from a site just beyond the big tree in the center of the picture.

DO-07 SJR at Patterson
Sampling site off a PID pump structure

April 26, 2006

Port of Stockton Aeration Site Visit
Site Visit for Demonstration of Dissolved Oxygen Aeration Facility U-Tube Drilling at the Port of Stockton, Warehouse 20. The Department of Water Resources and Jones & Stokes invited the DOTMDL Technical Work Group to participate in a tour of the aeration device site.

Port of Stockton
Photos of tour of Dissolved Oxygen Aeration Facility.

April 27, 2006

Wetland Sampling Event
Sampling for DOTMDL Wetland sites. There was no flow at both DO-60 Moffit 1 South and DO-63 Inlet C Canal, so no samples was taken. DO-81 Marsh 1 Outlet was dry and had no water to sample.

DO-60 Moffit 1 South
Student Interns clear debris from a weir in the wetlands.

DO-19 Salt Slough at Lander Avenue
Collecting water samples and recording sonde data.

May 4, 2006

Core Sampling event
Sampling for DOTMDL core sites. River still flooded. DO-08 SJR at Crow's Landing was not sampled since the site was still flooded.

DO-07 SJR at Patterson
Photo of SJR near Patterson during flood conditions.

May 8, 2006

Grasslands Station Maintenance and QA
Met with Lara Sparks (Grasslands Water District/Department of Fish and Game) to assist her with stream ratings and station maintenance at the DO sites she manages within the Grasslands water district.

Wetland ponds near DO-20 Los Banos Creek
Pictures are of drying temporary wetland ponds near DO-20.

May 9, 2006

Westside Maintenance and QA
Assisted in maintenance of Westside stations. Cleaned EC probe at DO-40 Patterson ID diversion canal at Elm Street. Downloaded data and cleaned EC probe at DO-41 West Stanislaus ID diversion canal. DO-57 Ramona Lake station was destroyed due to the high flood levels. Three drain site were backed up from the river, weirboards floated out, and access to road was blocked by telephone pole. Found that DO-38 Marshall Road Drain bubbler line had a leak, removed “T” valve which seemed to fix problem.

DO-57 Ramona Lake
Doing maintenance at the field station at Ramona Lake. The station at DO-57 was destroyed from high water levels in the SJR.

DO-41 West Stanislaus Irrigation District Diversion
Photo looking upstream of West Stanislaus Irrigation District Diversion monitoring station house.

May 11, 2006

Wetland Sampling Event
Sampling for DOTMDL wetland sites. DO-80 Marsh 1 Inlet had no flow and DO-81 Marsh 1 Outlet was dry, so samples were not taken.

DO-80 Marsh 1 Inlet
No flow at site, so no samples where taken.

DO-81 Marsh 1 Outlet
Photo of dry Marsh 1 Outlet

DO-82 Marsh 3 Inlet
Photo of Marsh 3 Inlet.

May 17, 2006

BMP Maintenance
Visited Perez Farms and Westside Patterson Farms to look at ideas for BMP project.

Drainage Ditch at Perez Farms
Cement weir structure at end of drainage ditch. Water is colored brown with tannins from the alfalfa field.

Westside Patterson Farms
Picture of Westside Patterson Farms and ditch next to the alfalfa fields.

May 18, 2006

Core Sampling Event
Sampling for DOTMDL core sites. Flood levels still high. DO-08 SJR at Crow's Landing was not sampled. DO-21 Orestimba Creek had stagnant water, so no samples were taken.

DO-7 SJR at Patterson
Photo of pipe structure near DO-07 SJR at Patterson.

May 31, 2006

BMP Maintenance
Will Stringfellow and Jeremy Hanlon met with Chris Linneman (Summers Engineering) at Westside Patterson Farms. Crew installed weir in un-vegetated ditch and created vegetated ditch for water to flow down. Survey work was done on the two ditches.

Head of Vegetated Ditch
Dirt pile from digging out canal. Notice the un-vegetated ditch next to the vegetated ditch.

Un-vegetated Ditch
Student Intern and Matt Rogers (LBNL) surveying ditch on Westside Patterson Farms.

Vegetated Ditch
Sonde in vegetated ditch. Water barely covered the sensors.

DO-101 WPF-UD-IN
Jeremy Hanlon working on weir structure for inflow into un-vegetated ditch.

June 01, 2006

Core Sampling Event
Sampling for DOTMDL core sites. DO-36 Del Puerto Creek and DO-23 MID Lat 5 to Tuolumne had no flow and were not sampled. DO-21 Orestimba Creek was backed up with water from the San Joaquin River, no sample was taken.

DO-07 SJR at Patterson
Saturated San Joaquin River near Patterson

June 06, 2006

Westside Station Maintenance and QA
Accompanied Kyle Kearney (Tetra Tech) to provide assistance in maintenance of Westside stations. DO-38 Marshall Drain, DO-64 Moran Drain, DO-65 Spanish Grant Drain, DO-36 Del Puerto Creek, DO-35 Westley Wasteway, and DO-31 New Jerusalem Drain were visited for data downloads, cleaning, flow, EC and temperature QA.

DO-31 New Jerusalem Drain
Exit of New Jerusalem Drain into the San Joaquin River.

DO-31 New Jerusalem Drain
San Joaquin River at high water level near DO-31.

Three Drain Site
Road leading up to levee with the three drain sites: DO-38, DO-64, and DO-65.

DO-35 Westley Wasteway
Westley Wasteway pond before being re-installed (see July 07, 2006 and August 01, 2006).

June 07, 2006

BMP Sample Site Scouting
Met with Matt Rogers (LBNL) at Westside Patterson Farms to discuss potential BMP sampling locations.

Un-vegetated Ditch near DO-86
Will Stringfellow and Matt Rogers (LBNL) follow irrigation runoff from Westside Patterson Farms.

DO-88 Ramona Drain at Apricot
Trash and Duckweed floating on top of the water at DO-88.

DO-88 Ramona Drain at Apricot
Matt Rogers looking at debris near DO-88.

DO-57 Ramona Lake
Cattle blocking the road near DO-57.

June 08, 2006

Boat Sampling
Tried to take the boat out for sampling. Started to go out, but engine kept lagging. Went back to dock and tried to locate problem. Called boat manufacturer, suggested fuel filter problems or auxiliary fuel intake getting air into it. Took boat out of water. Replaced fuel filter and caped off extra auxiliary fuel line at a later date. No further problems were encountered.

Photo of Boat
The boat is used in boat sampling events and boat studies on the San Joaquin River.

June 15, 2006

Core Sampling Event
Sampling for DOTMDL core sites. DO-36 Del Puerto Creek was not sampled because it had no flow.

DO-29 Harding Drain
Drain was backed up and full of debris. Crew sampled from clear area on the side.

DO-57 Ramona Lake
Student Intern and Justin Graham collecting water samples from Ramona Lake pump platform.

June 21, 2006

Boat Work
Cabinet was built and installed on back of boat to house gear and laptop for sampling trips.

Boat Work
Student Intern and Justin Graham worked on building and installing a cabinet for the boat. The cabinet houses boat equipment and a laptop for sampling (See July 27, 2006).

June 22, 2006

BMP Sampling Event
Sampling for DOTMDL BMP sites. DO-57 Ramona Lake and DO-91 Paradise at Prune had no flow and were not sampled. DO-90 Ramona at Almond was not accessible. DO-94 Paradise at Almond was blocked by a pipeline. Sample was taken south of actual sample site. DO-88 Ramona at Apricot was flowing in reverse to the south.

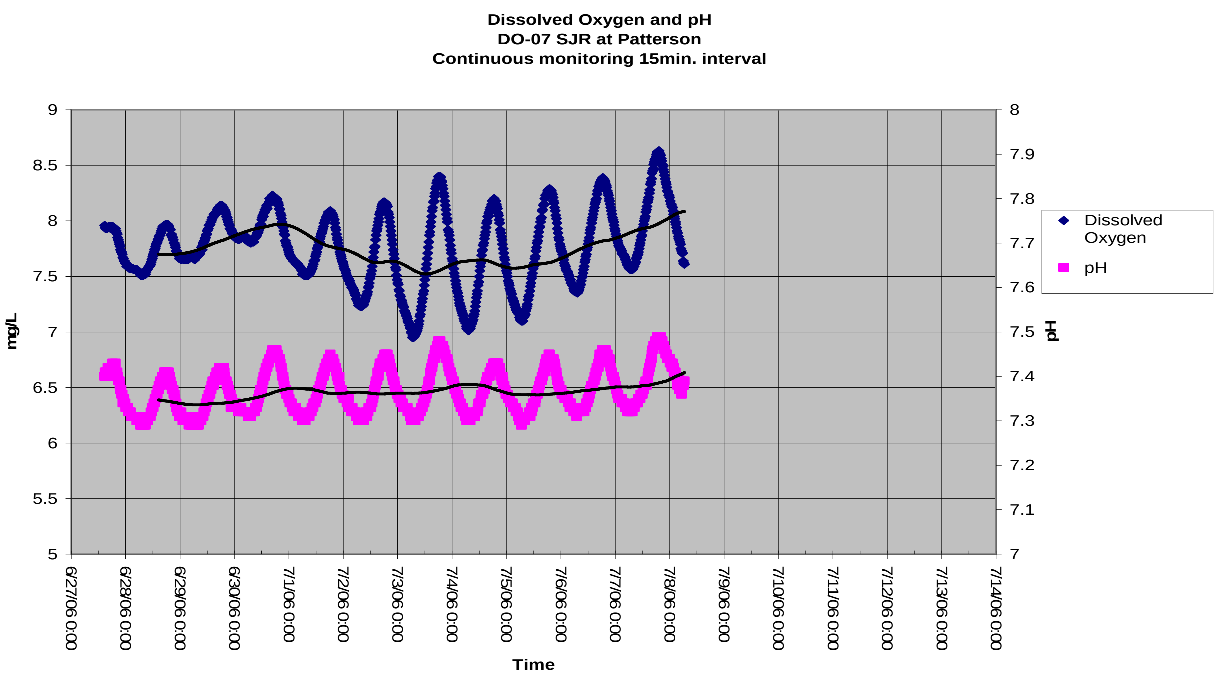
DO-91 Paradise at Prune
Site had no flow and was not sampled.

DO-92 Paradise at Apricot
Student intern and Justin Graham collecting samples from drain on side of road.

DO-94 Paradise at Almond
Pump was blocking access to actual sample site. Pump was taking water out of paradise drain and putting it onto adjacent fields. Velocity was flowing towards the pump intake.

June 27, 2006

Extended Deployment
Crew deployed Sondes in field for extended deployment. Sondes were deployed at DO-44 San Luis Drain End, DO-19 Salt Slough at Lander, DO-08 SJR at Crows Landing, DO-07 SJR at Patterson, and DO-05 SJR at Vernalis.



Extended Deployment Data
Example of pH and dissolved oxygen data collected from extended deployment at DO-07 San Joaquin River at Patterson. Notice the daily fluctuations in the two graphs.

June 29, 2006

BMP sampling event
Sampling for DOTMDL BMP sites. No problems encountered.

Westside Patterson Farms
Photo of the landscape around Westside Patterson Farms.

July 06, 2006

Core Sampling Event
Sampling for DOTMDL core sites. No problems were encountered.

Photo of Sampling Vehicle
This is the EERP van that is used by one of the two field crews to collect grab samples.

July 11, 2006

Station Maintenance and QA
Stations in the San Luis National Wildlife Refuge were visited for cleaning, downloads, flow, and EC QA. DO-60 Moffit 1 South, DO-61 Deadmans Slough, DO-62 Mallard Slough, DO-63 Inlet C Canal, DO-53 Salt Slough at Wolfsen, DO-40 Patterson Irrigation District Diversion, and DO-41 West Stanislaus Irrigation District Diversion were visited. A flow rating was performed at DO-53. Mallard Slough's weir boards were clogged with mud and plants. Stopped by DO-35 Westley Wasteway to check on progress of station re-installation.

DO-35 Westley Wasteway
Checked on progress of Westley Wasteway. Irrigation District was installing a new weir board structure and reshaping canal. Installed new bubbler and EC line at a later date (see Aug 01, 2006).

July 13, 2006

Core Sampling Event and Extended Deployment
Sampling for DOTMDL core sites. Sampling Crew picked up and deployed extended deployment Sondes at Sites DO-44 San Luis Drain End, DO-19 Salt Slough at Lander, DO-08 SJR at Crows Landing, DO-07 SJR at Patterson, and DO-05 SJR at Vernalis.

Post Deployment Sonde
Sonde covered in algae after extended deployment. Notice how the wipers kept the sensors free of algae.

DO-08 SJR at Crows Landing
Student Intern and Justin Graham Sampling from boat dock at Turlock Sportsman Club.

DO-19 Salt Slough at Lander
Custom fabricated PVC housing covered in algae.

DO-10 SJR at Lander
Custom float holds sonde off of river bottom to take water quality measurements. The green tint is due to suspended algae in river.

July 20, 2006

Intermittent Sampling Event
Sampling for DOTMDL Intermittent sites. Samples taken at DO-54 Los Banos Creek at Ingomar Grade, DO-45 Volta Wasteway at Ingomar Road, DO-46 Mud Slough at Gun Club Road, DO-67 Newman Wasteway at Brazo Road, DO-38 Marshall Road Drain, DO-65 Spanish Grant Drain, DO-64 Moran Drain, DO-35 Westley Wasteway, DO-32 El Soyo Grayson Drain, DO-27 TID Lat 2 to SJR, DO-66 Maze Blvd Drain, and DO-31 New Jerusalem Drain.

DO-54 Los Banos Creek at Ingomar
Student intern taking samples from bridge over Los Banos creek.

DO-46 Mud Slough at Gun Club
Sampling crew deploying Sonde and taking water samples from bridge.

DO-64 Moran Drain
Student intern and Justin Graham taking samples from manhole.

DO-31 New Jerusalem Drain
Student intern and Justin Graham using bucket to sample down manhole over New Jerusalem Drain.

July 21, 2006

Westside Station Maintenance and QA
Accompanied Kyle Kearney (Tetra Tech) to provide assistance in maintenance of Westside stations. DO-38 Marshall Drain, DO-64 Moran Drain, DO-65 Spanish Grant Drain, DO-36 Del Puerto Creek, DO-34 Ingram Creek, DO-33 Hospital Creek, and DO-31 New Jerusalem Drain were visited for data downloads, cleaning, flow, EC, and temperature QA.

DO-34 Ingram Creek
While working on the monitoring station, this school of fish was spotted near the outflow of a drainage pipe.

July 25, 2006

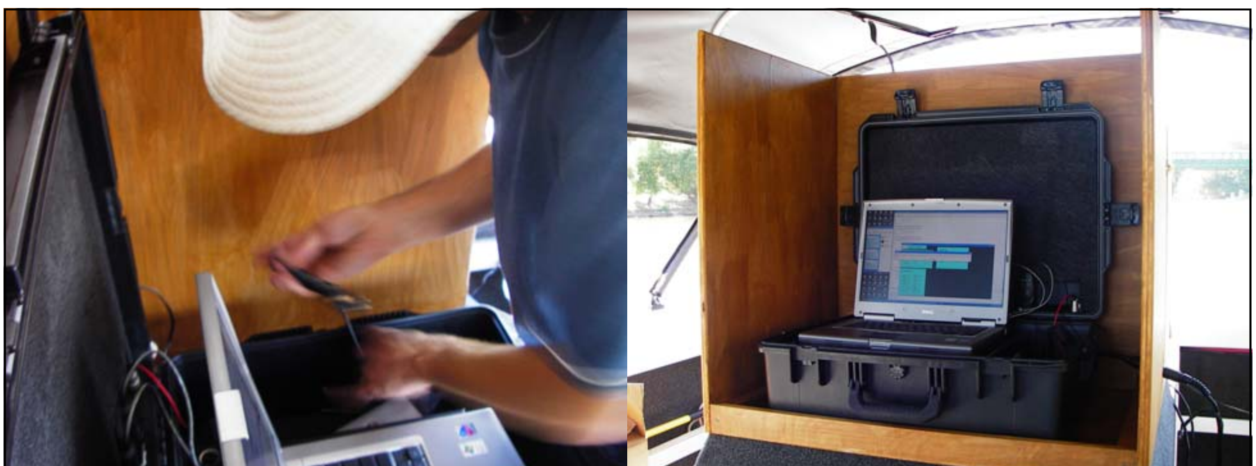
Extended Deployment
Crew picked up sondes left in field for extended deployment. Deployed sondes were picked up at DO-44 San Luis Drain End, DO-08 SJR at Crows Landing, DO-07 SJR at Patterson, and DO-05 SJR at Vernalis.

Post Deployment
Sondes were covered in algae and small aquatic macro invertebrates after being left in the field for an extended deployment. Sondes were put into coolers to keep the sensors moist while transporting.

July 27, 2006

Core Sampling Event
Sampling for DOTMDL core sites. Delta sites were sampled by boat.

Boat Sampling
Jeremy Hanlon (left) driving the boat. Will Stringfellow (right) collecting water samples off bow of boat.



Boat Sampling Equipment
Jeremy Hanlon putting cables through cabinet box. Jeremy Hanlon created a linked Sontek, Sonde, and GPS unit to provide his laptop with correlated sampling data while on the boat.

July 28, 2006

Grasslands Station Maintenance and QA
Met with Lara Sparks (Grasslands Water District/Department of Fish and Game) to assist her with stream ratings and station maintenance at the DO sites she manages within the Grasslands water district. DO-20 Los Banos Creek, Fremont Canal, DO-46 Mud Slough at Gun Club, DO-68 S-Lake Basin, Volta Wasteway, and DO-53 Salt Slough at Wolfsen were visited for maintenance and flow ratings.

DO-20 Los Banos Creek
Performed a flow rating at DO-20. Took pictures to get ideas for installation of bubbler, EC, and Sontek (See September 5, 2006 and October 31, 2006).

August 01, 2006

Station Upgrade
Visited DO-35 Westley Wasteway Flow station. Cut and installed five weir boards for a total of eight. Allowed pond to fill up and equilibrate. Took measurement for installation of bubbler line and EC probe (see September 5, 2006).


DO-35 Westley Wasteway
Pictures taken after weir boards installed. Bubbler and EC line have not yet been installed.

August 03, 2006

BMP sampling event
Sampling for DOTMDL BMP sites. DO-91 Paradise Drain at Prune Ave had no flow and was not sampled. A flow rating was done at DO-86 Ramona Drain at Apple Ave.

DO-86 Ramona Drain at Apple Ave.
Jeremy Hanlon performing a stream rating across Ramona Drain.

DO-101 WFP-UD-IN
Will Stringfellow looking at weir structure at start of un-vegetated ditch on Westside Patterson Farms.

DO-88 Ramona Drain at Apricot Ave.
Sonde deployed off of pipe. The site has large amounts of duck weed and other aquatic vegetation.

DO-101 WFP-UD-IN
The Sonde is in the un-vegetated ditch with a custom made shield to protect it from the plants in the ditch.

August 04, 2006

San Luis Drain Extended Deployment Study
Crew deployed Sondes in the San Luis Drain for extended deployment. No samples were taken. Sites deployed at were DO-103 Check 18, DO-106 Check 14, DO-108 Check 12, DO-110 Check 10, DO-112 Check 8, DO-114 Check 6, DO-116 Check 4, DO-118 Check 2, and DO-44 San Luis Drain End.

DO-115 Check 5
Photo of water flowing over weir structure during extended deployment. Note the green color due to algae in the water.

August 10, 2006

San Luis Drain Study
Sampling for DOTMDL San Luis Drain extended deployment sites. Samples were taken at sites where Sondes had been left for extended deployment. Sites sampled were DO-103 Check 18, DO-48 San Luis Drain Site A (Check 17), DO-104 Check 16, DO-105 Check 15, DO-106 Check 14, DO-107 Check 13, DO-108 Check 12, DO-109 Check 11, DO-110 Check 10, DO-111 Check 9, DO-112 Check 8, DO-113 Check 7, DO-114 Check 6, DO-115 Check 5, DO-116 Check 4, DO-117 Check 3, DO-118 Check 2, DO-119 Check 1, and DO-44 San Luis Drain End.

DO-106 Check 14
Student Intern and Justin Graham collecting water samples over drain.

DO-115 Check 5
Student Intern and Justin Graham deploying sonde and collecting water samples.

DO-103 Check 18
Sampling sonde next to extended deployment sonde in PVC housing.

August 17, 2006

Core Sampling Event
Sampling for DOTMDL core sites. DO-34 Ingram Creek wasn't well mixed at normal sample location. Grab samples were taken on other side of road where stream had a better chance to mix. Sonde was kept at normal sample location, downstream was too aerated to put Sonde in.

DO-28 TID Westport Drain
Pictures of DO-28 and sampling from levee road.

August 18, 2006

San Luis Drain Extended Deployment Study
Crew retrieved Sondes left in the San Luis Drain for extended deployment. Sondes were picked up from DO-103 Check 18, DO-106 Check 14, DO-108 Check 12, DO-110 Check 10, DO-112 Check 8, DO-114 Check 6, DO-116 Check 4, DO-118 Check 2, and DO-44 San Luis Drain End. No grab samples were taken.

DO-44 San Luis Drain End
Photo of platform at San Luis Drain End.

August 22, 2006

Westside Station Maintenance and QA
Accompanied Kyle Kearney (Tetra Tech) to provide assistance in maintenance of Westside stations. DO-38 Marshall Drain, DO-64 Moran Drain, DO-65 Spanish Grant Drain, DO-36 Del Puerto Creek, DO-35 Westley Wasteway, DO-34 Ingram Creek, DO-40 Patterson Irrigation District Diversion Canal, and DO-41 West Stanislaus Irrigation District Diversion canal were visited for data downloads, cleaning, EC and temperature QA. Flow QA was measured at Marshall Drain, Spanish Drain, Moran Drain, Del Puerto Creek, Westley Wasteway, and Ingram Creek.

Wildlife in the Road
An occasional scene during Westside Station Maintenance.

August 24, 2006

Core Sampling Event and meeting with Summers Engineering
Sampling for DOTMDL core sites. The sonde cable for the southern sampling crew would not stay connected. Crew was able to fix problem by briefly connecting to sonde and having it log every 10 seconds. Will Stringfellow and Jeremy Hanlon met with Chris Linneman (Summers Engineering) at Marshall Road Pond.

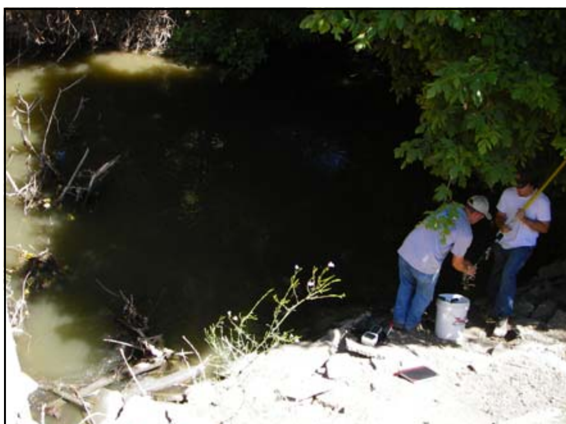
Marshall Road Pond
Will Stringfellow and Jeremy Hanlon met with Chris Linneman at Marshall Road Pond to plan scientific studies examining water quality impact of water reuse facilities.

August 31, 2006

Intermittent Sampling Event
Sampling for DOTMDL intermittent sites. Samples were taken from DO-44 San Luis Drain End, DO-09 SJR at Fremont Ford, DO-21 Orestimba Creek, DO-38 Marshal Road Drain, DO-29 Harding Drain, DO-07 SJR at Patterson, DO-14 Tuolumne River, DO-25 Miller Lake, DO-31 New Jerusalem Drain, and DO-04 SJR at Mossdale.

DO-21 Orestimba Creek
Samples were taken from under the bridge at DO-21.

DO-14 Tuolumne River
Justin Graham and Student Intern taking samples from under bridge at DO-14.



DO-25 Miller Lake
Justin Graham and Student Intern taking water samples near outlet from Miller Lake.

DO-29 Harding Drain
Sampling crew taking water samples. On the left Megan Young (USGS) was collecting samples for her isotope work.

September 05, 2006

Station Upgrades
DO-35 Westley Wasteway Flow station and DO-20 Los Banos Creek were upgraded. A new bubbler and EC line were installed at DO-35. A junction box and bubbler liner were installed at DO-20. Two weir boards were added at DO-65 Spanish Grant Drain.



DO-35 Westley Wasteway Flow Station
A new bubbler and EC line were installed at DO-35. The green basket on the EC probe (right) protects the probe from debris. The picture in the middle shows Jeremy Hanlon clearing sediment in front of the weir boards.



DO-20 Los Banos Creek
A new bubbler line was installed at DO-20. A junction box (left) , fabricated by Jeremy Hanlon, was installed at the edge of the water. A separate EC and Sontek line were run from this junction box across the bridge at a later date (See October 31, 2006).

September 07, 2006

Core Sampling Event
Sampling for DOTMDL core sites. Sonde for northern crew was having chlorophyll sensor wiper parking problems. Data was still usable. DO-25 Miller Lake was sampled at a new location upstream in the same channel on opposite bank 100 ft downstream of bridge because old sample location was no longer safe to access due to a slippery embankment.

DO-25 Miller Lake
Photo of the usual sampling site. Due to the slippery slope that makes it unsafe to sample, samples were taken a few hundred feet to the right of this photo where it was safe to sample.

September 12, 2006

Extended Deployment
Crew deployed Sondes in field for extended deployment. Sondes were deployed at DO-20 Los Banos Creek, DO-44 San Luis Drain End, DO-19 Salt Slough at Lander, DO-08 San Joaquin River at Crows Landing, DO-07 San Joaquin River at Patterson, and DO-05 San Joaquin River at Vernalis.

Sonde Deployment
At DO-20 Los Banos Creek (left) Sonde was deployed from bridge in a pvc housing using cable. At DO-07 SJR at Patterson (Right) Sonde was deployed from pump housing platform.

DO-44 San Luis Drain End
Sonde was deployed along the side of the outflow pipe at DO-44. The Sonde was secured using a cable and padlock.

DO-08 SJR at Crows Landing
Picture shows the dock structure at the Turlock Sportsman Club. The Sonde was deployed on the far side of the dock.

September 14, 2006

Wetland Sampling Event and Station Maintenance.
Sampling for DOTMDL wetland sites. Downloaded data from stations. Extra samples were taken at three sites for experiments at LBNL. Did not take a sample at DO-60 Moffit 1 South because there was no water. No flow and no sample taken at DO-61 Deadmans Slough and DO-62 Mallard Slough. A flow rating was done at DO-53 Salt Slough at Wolfsen.

DO-81 Marsh 1 Outlet
Pictures of flooded marsh and outflow structure of Marsh 1 in San Luis National Wildlife Refuge.

DO-82 Marsh 3 Inlet
Justin Graham and Student Intern at DO-82 taking water samples and Sonde measurements.

DO-120 Marsh 1 Intermediary
Sampling crew and EERP van next to sample site DO-120.

September 19, 2006

Grasslands Station Maintenance and QA
Met with Lara Sparks (Grasslands Water District/Department of Fish and Game) to assist her with stream ratings and station maintenance at the DO sites she manages within the Grasslands water district. Performed stream ratings at DO-46 Mud Slough at Gun Club Road, DO-20 Los Banos Creek, and Fremont Slough.

Station in the Grasslands
One of the stations managed by Lara Sparks.

September 21, 2006

Core Sampling Event
Sampling for DOTMDL core sites. Sonde got stuck in weir at DO-29 Harding Drain. Crew was able to retrieve it after thirty minutes. Sonde values were not recorded for DO-29.

Photo of Spider
Spiders are commonly seen during summer and fall sampling events.

September 26, 2006

Extended Deployment
Crew retrieved Sondes left in field for extended deployment. Sondes were retrieved from DO-20 Los Banos Creek, DO-44 San Luis Drain End, DO-19 Salt Slough at Lander, DO-08 San Joaquin River at Crows Landing, DO-07 San Joaquin River at Patterson, and DO-05 San Joaquin River at Vernalis. The Turbidity wiper was not working properly from sonde at DO-05.

DO-20 Los Banos Creek
Sonde was deployed from bridge in a pvc housing using cable. Sonde was halfway out of water, but sensors were still submerged

DO-19 Salt Slough at Lander
Sonde was deployed next to pipe running into the water. Cable was secured around the metal fence post.

DO-07 SJR at Patterson
Sonde was hung from bottom of pump platform. All cables were padlocked to the structure they were secured to.

September 28, 2006

Wetland Sampling Event
Sampling for DOTMDL wetland sites. Jeremy Hanlon and Will Stringfellow scouted new sampling locations for Marsh 1 temporary wetland.

DO-122 Marsh 1 West
(left) Picture of Will Stringfellow taking notes next to DO-122 Marsh 1 West. (right) Picture showing DO-122 Sampling location next to tree in levee road.

October 03, 2006

Westside Station Maintenance
Visited Westside station for routine maintenance. DO-38 Marshall Drain, DO-64 Moran Drain, DO-65 Spanish Grant Drain, DO-36 Del Puerto Creek, DO-35 Westley Wasteway, and DO-31 New Jerusalem Drain were visited for data downloads, cleaning, flow, EC and temperature QA.

YSI 600 XL EC Probe
Photo of YSI 600 XL and hand-held used to measure independent EC for QA.

October 05, 2006

Core Sampling Event
Sampling for DOTMDL core sites. DO-36 Del Puerto Creek was inaccessible due to muddy road conditions.

DO-59 SJR at Laird Park
Remie Burks preparing to collect sample from Laird Park.

DO-25 Miller Lake
Looking north over bridge at start of the drain out of Miller lake. Sample site is north west of picture.

October 12, 2006

Wetland Sampling Event
Sampling for DOTMDL Wetland sites. DO-60 Moffit 1 South and DO-62 Mallard Slough were not sampled because they both had no flow.

Sandhill Cranes
Picture of Sandhill Cranes near a temporary wetland.

October 19, 2006

Core Sampling Event and Boat Study
Sampling for DOTMDL core sites. Jeremy Hanlon and Will Stringfellow used boat to run an integrated GPS, Sonde, and Sontek sampling program on the San Joaquin River near Patterson. Boat was put in at the boat ramp at DO-07 SJR at Patterson and taken a few miles upstream.

Boat Study
Picture from bow of boat on San Joaquin River.

DO-07 SJR at Patterson
Picture of Patterson pump platform from the Boat.

Boat Study
Picture looking upstream of the San Joaquin River near Patterson.

DO-07 SJR at Patterson
Will Stringfellow setting up Par light meter for deployment off of boat.

October 24, 2006

Boat Training
Jeremy Hanlon, Remie Burks, and Justin Graham took the EERP boat out on the SJR from the Port of Stockton to Mossdale. Outing was a hands on boat training session for Remie Burks and Justin Graham.

Boat Training
Photo of Remie Burks (left) and Justin Graham (right) driving the EERP boat on the San Joaquin River.

October 26, 2006

Wetland Sampling Event
Sampling for DOTMDL wetland sites. DO-60 Moffit 1 South was not sampled because it had no flow. Dissolved Oxygen values for DO-80 Marsh 1 Inlet were not valid because the DO membrane on YSI sonde # 1 became punctured and had to be changed.

DO-60 Moffit 1 South
Water was below weir and site was not sampled.

DO-80 Marsh 1 Inlet
Canal inlet for Marsh 1. DO membrane became punctured and had to be changed.

DO-121 Marsh 1 East
Student Intern sampling Marsh 1, a temporary wetland.

DO-82 Marsh 3 Inlet
Algae across the surface of the water at Marsh 3, a permanent wetland.

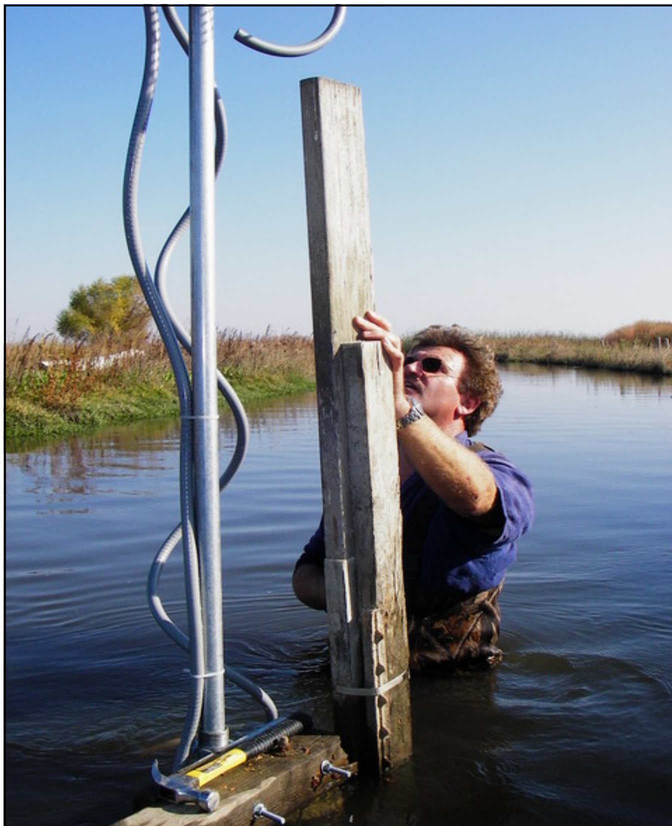
October 27, 2006

Westside Station Maintenance
Accompanied Kyle Kearney (Tetra Tech) to Westside stations and performed flow measurements. No water was flowing through DO-64 Moran Drain. Performed a stream rating at DO-36 Del Puerto Creek. Measured weir width at DO-35 Westley Wasteway Flow Station.

DO-31 New Jerusalem Drain
Station shed at DO-31. Data from monitoring equipment was stored on a data logger located in the station shed and downloaded during station maintenance.

October 31, 2006

Station Maintenance
Upgraded DO-20 Los Banos creek and DO-53 Salt Slough at Wolfsen. Installed Sontek mount to bridge at DO-20 and ran Sontek and EC line across bridge. Installed a solar panel at DO-53. Station was taken off of land power because it kept tripping the circuit breaker of a nearby house.



DO-20 Los Banos Creek
(Above) Nigel Quinn (LBNL) helping install Sontek mount to pylon. (Top right) Lara Sparks (Grasslands Water District/Department of Fish and Game) next to junction box for bubbler, EC, and Sontek lines. (Middle right) Jeremy Hanlon and Nigel Quinn installing Sontek mount.

DO-53 Salt Slough at Wolfsen
(Bottom right) New solar panel installed at Salt Slough at Wolfsen.

November 02, 2006

Wetland Sampling Event
Sampling for DOTMDL wetland sites. DO-60 Moffit 1 South had no flow but was still sampled.

DO-46 Mud Slough at Gun Club Road
Photo of aquatic vegetation near DO-46 Mud Slough at Gun Club Road.

November 09, 2006

Core Sampling Event
Sampling for DOTMDL core sites. Sample crew was locked out of pump platform at DO-07 SJR at Patterson. Sample taken from boat launch dock.

DO-07 SJR at Patterson
Photo taken from pump platform. Crew was locked out of pump platform and had to sample from boat launch dock seen on left side of photo.

November 16, 2006

Wetland Sampling Event
Sampling for DOTMDL wetland sites. All sites were accessible and no problems were encountered.

DO-20 Los Banos Creek
Student Intern Sampling near recently completed bridge.

DO-46 Mud Slough at Gun Club
Student Intern Sampling from bridge over Mud Slough.

November 17, 2006

Station Maintenance
Visited DO-31 New Jerusalem Drain for maintenance. Tried downloading data from MACE unit but got error. Downloaded config file. Restarted unit and downloaded data again. Cleared stored memory and ran bubble line test for three minutes.

DO-31 New Jerusalem Drain
Photo shows general setup of equipment in station shed. The MACE unit is on the right. Flow data is downloaded from the unit with a laptop connected via com port.

December 07, 2006

Core Sampling Event
Sampling for DOTMDL core sites. DO-25 Miller Lake the spill way was blocked with just a trickle through the boards. Sample was taken.

DO-19 Salt Slough at Lander Ave
Photo of sample location at DO-19. Samples are taken next to bridge.

December 8, 2006

Westside Station Maintenance and QA
Accompanied Kyle Kearney (Tetra Tech) to provide assistance in maintenance of Westside stations. DO-38 Marshall Drain, DO-64 Moran Drain, DO-65 Spanish Grant Drain, DO-36 Del Puerto Creek, DO-35 Westley Wasteway, and DO-31 New Jerusalem Drain were visited for data downloads, cleaning, flow, EC and temperature QA. The logger at DO-31 New Jerusalem Drain stopped recording data and was showing error 145 and 149. The logger was restarted and was able to record data without any further problems. Logger was replaced at a later date (see December 18, 2006).

Station Maintenance
YSI EC probe being cleaned at the three drain site.

December 14, 2006

Wetland Sampling Event
Sampling for DOTMDL wetland sites. DO-122 Marsh 1 West was just mud with no water, no sample was taken. Ground water was being pumped in east of sample site DO-82 Marsh 3 Inlet. The pond was stratified and sampling was depth integrated.

DO-122 Marsh 1 West
Sample location was not sampled because there was just mud and no water.

DO-61 Deadmans Slough
Weir boards were blocked by debris, making an accurate flow rating impossible.

DO-08 SJR at Crows Landing
Student intern taking water samples from dock.

DO-53 Salt Slough at Wolfsen Road
Downstream across bridge. Both a sample and a flow rating were taken at DO-53.

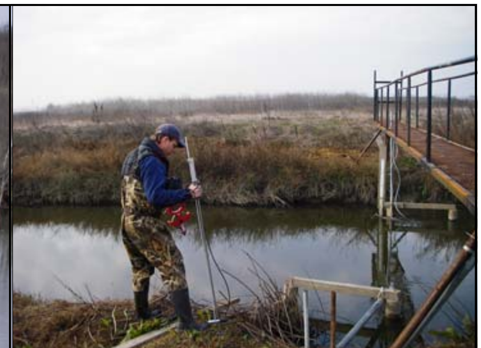
December 18, 2006

DO-31 New Jerusalem Drain Station Maintenance
Jeremy Hanlon switched out the logger at DO-31 New Jerusalem Drain with the logger from the Hydraulics lab training station. The logger at DO-31 randomly shut off and stopped logging data. It was taken to the Hydraulics lab training station to be tested.

H-350XL Design Analysis Logger
Photo of data logger used in the Westside stations.

December 21, 2006

Grasslands Station Maintenance and QA
Met with Lara Sparks (Grasslands Water District/Department of Fish and Game) to assist her with stream ratings and station maintenance at the DO sites she manages within the Grasslands water district.



Stream Ratings
(Left) Jeremy Hanlon performing a stream rating at Volta Wasteway Flow Station. Water was too deep to complete rating safely. (Right) Jeremy Hanlon at DO-20 Los Banos Creek performing another stream rating. Note completed bridge with handrails along both sides and hinged ramps.

In addition to the above sites, Hollow Tree, Fremont Canal, DO-46 Mud Slough at Gun Club, and DO-68 S-Lake Basin were visited for maintenance and flow ratings. DO-33 Hospital Creek was also visited to verify the weir board width.

Appendix E

PLOTS OF CONTINUOUS CHLOROPHYLL MONITORING DATA COLLECTED IN THE MAIN-STEM OF THE SAN JOAQUIN RIVER FOR 2006

Jeremy Hanlon
Justin Graham
University of the Pacific

William Stringfellow
University of the Pacific
Lawrence Berkeley National Laboratory

Table:5A Daily Averages for Sample Site DO-05 San Joaquin River at Vernalis. Includes all available 15 minute data from 06/27/06 to 07/13/06

DO-05 SJR at Vernalis

June 27, 2006 to July 13, 2006

Daily averages

Date	Temp	SpCond	TDS	DOsat	DO	DOchrg	Depth	pH	Orp	Turbid+	Chl	Chl	Battery	Notes
	C	mS/cm	g/L	%	mg/L		feet		mV	NTU	ug/L	RFU	volts	
6/27/2006	20.71	0.097	0.063	100.06	8.97	38.8	7.04	7.43	171.3	17.1	3.83	0.90	12.95	Partial Day
6/28/2006	21.04	0.105	0.068	95.61	8.52	37.1	6.97	7.39	166.5	18.3	3.82	0.90	12.77	
6/29/2006	21.63	0.108	0.070	94.54	8.32	36.2	6.47	7.38	178.7	20.8	4.01	0.94	12.66	
6/30/2006	21.80	0.118	0.076	93.75	8.23	35.6	5.97	7.38	186.2	23.4	4.05	0.95	12.52	
7/1/2006	21.86	0.140	0.091	91.79	8.04	34.9	5.29	7.39	183.0	25.5	4.56	1.08	12.40	
7/2/2006	22.08	0.184	0.119	89.11	7.78	34.5	4.28	7.38	178.0	28.4	5.55	1.31	12.31	
7/3/2006	22.12	0.238	0.154	87.05	7.59	34.0	3.19	7.39	168.7	30.3	7.54	1.77	12.30	
7/4/2006	21.93	0.276	0.180	86.66	7.58	33.7	2.33	7.43	166.8	30.7	8.33	1.96	12.22	
7/5/2006	21.76	0.291	0.189	87.14	7.65	33.5	1.95	7.46	178.9	32.9	7.58	1.79	12.13	
7/6/2006	21.68	0.275	0.178	88.30	7.76	33.5	1.86	7.47	181.5	35.6	6.56	1.55	12.06	
7/7/2006	21.68	0.261	0.170	89.64	7.88	33.5	1.75	7.48	247.2	34.8	6.27	1.47	12.00	
7/8/2006	22.18	0.258	0.167	91.72	7.98	33.8	1.47	7.50	221.6	31.1	6.22	1.46	11.99	
7/9/2006	22.77	0.295	0.192	93.65	8.06	34.0	0.97	7.52	195.8	27.2	8.20	1.94	11.90	
7/10/2006	22.79	0.326	0.212	94.85	8.16	34.0	0.42	7.55	184.9	24.0	8.70	2.05	11.73	
7/11/2006	21.96	0.366	0.238	95.24	8.32	33.9	0.08	7.61	180.4	28.3	9.11	2.15	11.63	
7/12/2006	21.50	0.386	0.251	99.75	8.79	34.2	0.10	7.73	181.1	23.5	10.30	2.43	11.72	
7/13/2006	21.18	0.414	0.269	97.64	8.66	33.9	0.10	7.70	179.4	22.4	10.26	2.41	11.64	Partial Day

Fig.5A San Joaquin River at Vernalis, Flow (CFS). Includes all available 15min data from 06/27/06 to 07/13/06.

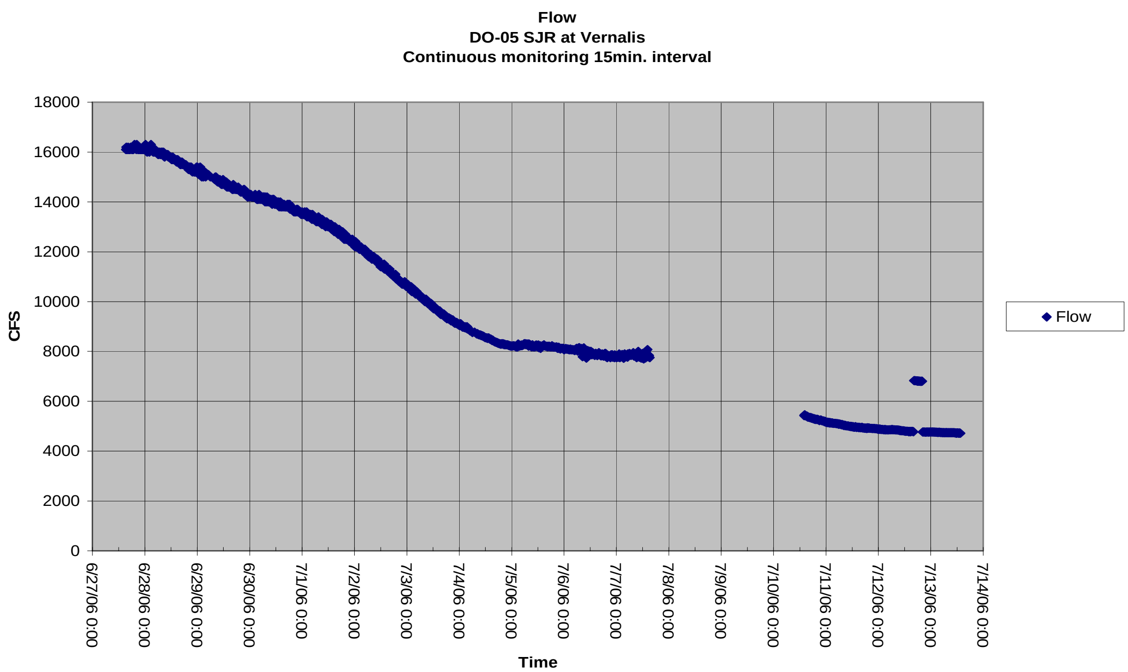


Fig.5B San Joaquin River at Vernalis, Relative Fluorescence Units (%RFU) with Turbidity (NTU) and 96 point moving average trend lines. Includes all available 15 minute data from 06/27/06 to 07/13/06.

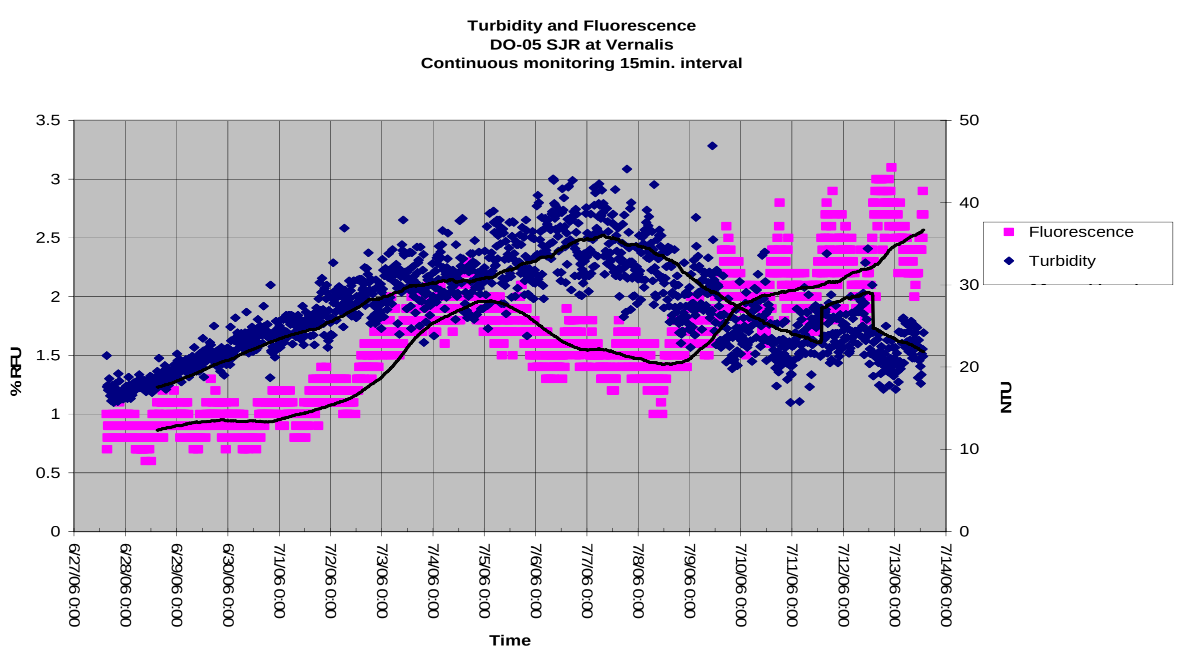


Fig.5C San Joaquin River at Vernalis, Relative Fluorescence Units (%RFU) and 96 point moving average trend line. Includes all available data from 06/27/06 to 07/13/06.

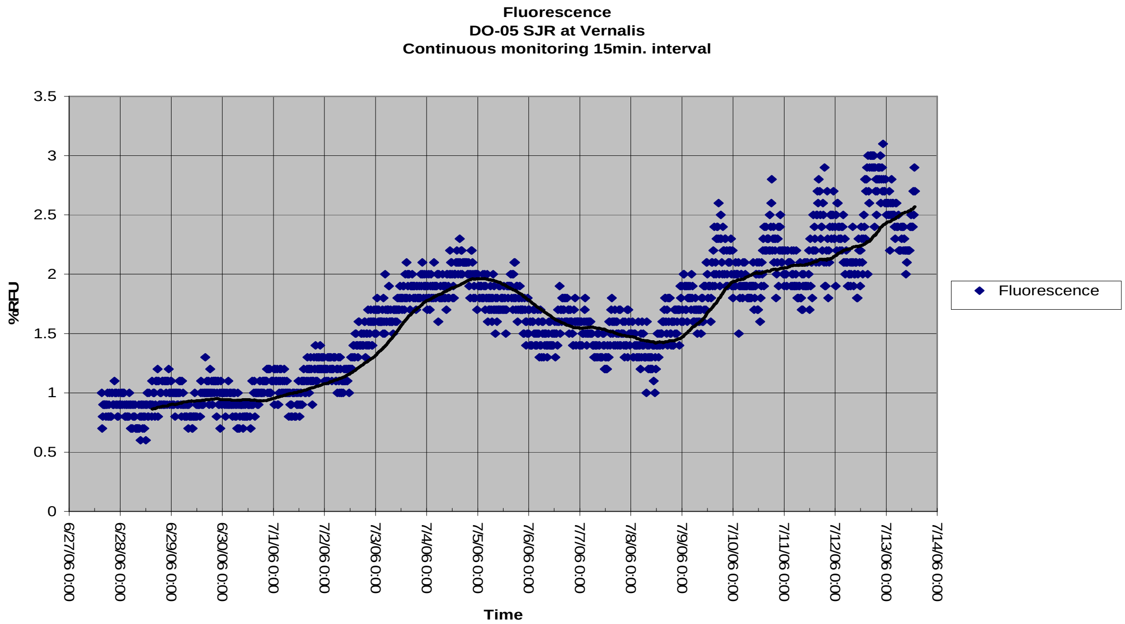


Fig.5D San Joaquin River at Vernalis, Turbidity (NTU) and 96 point moving average trend line. Includes all available 15 minute data from 06/27/06 to 07/13/06.

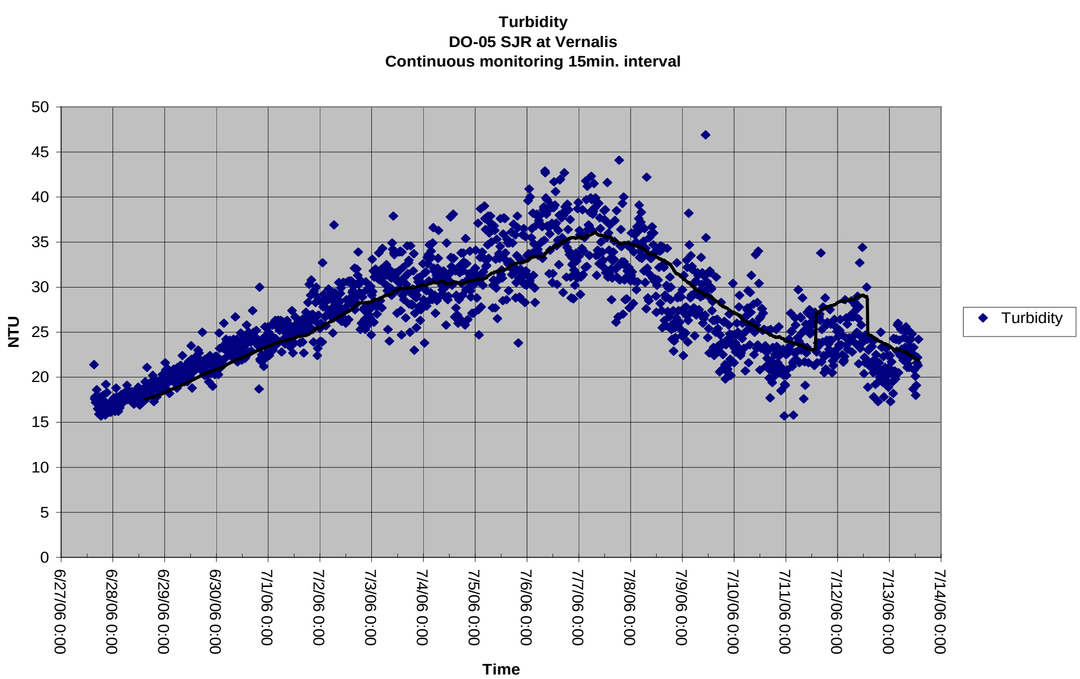


Fig.5E San Joaquin River at Vernalis, Dissolved Oxygen (mg/l) and pH with 96 point moving average trend line. Includes all available 15 minute data from 06/27/06 to 07/13/06.

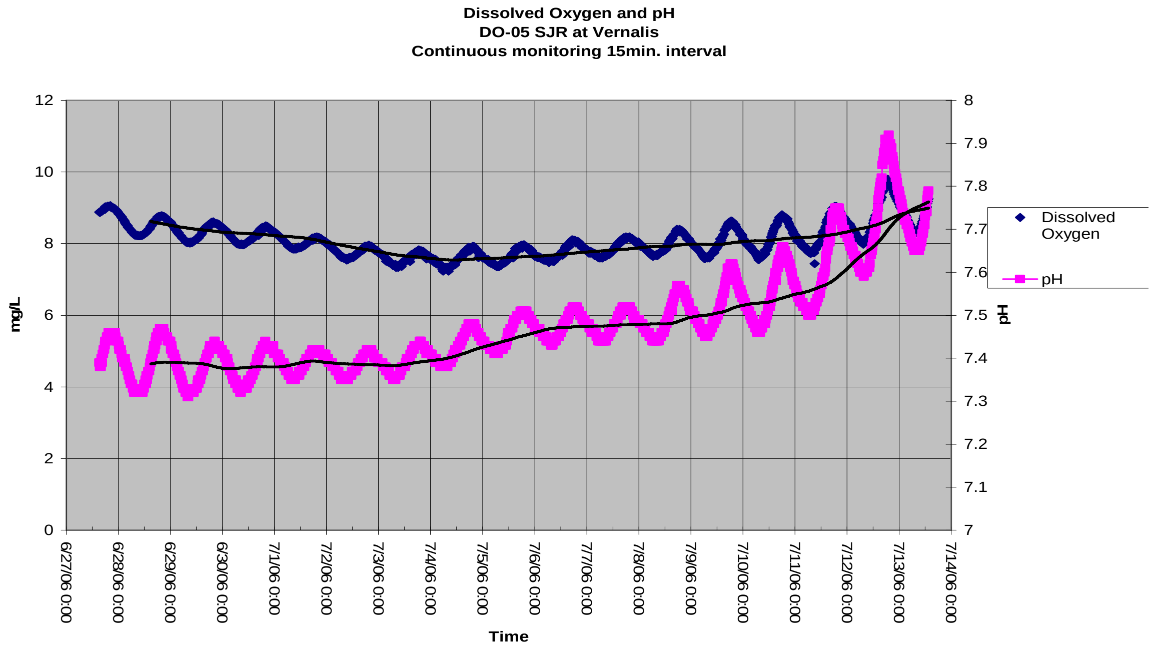


Fig.5F San Joaquin River at Vernalis, Dissolved Oxygen (mg/l) with 96 point moving average trend line. Includes all available 15 minute data from 06/27/06 to 07/13/06.

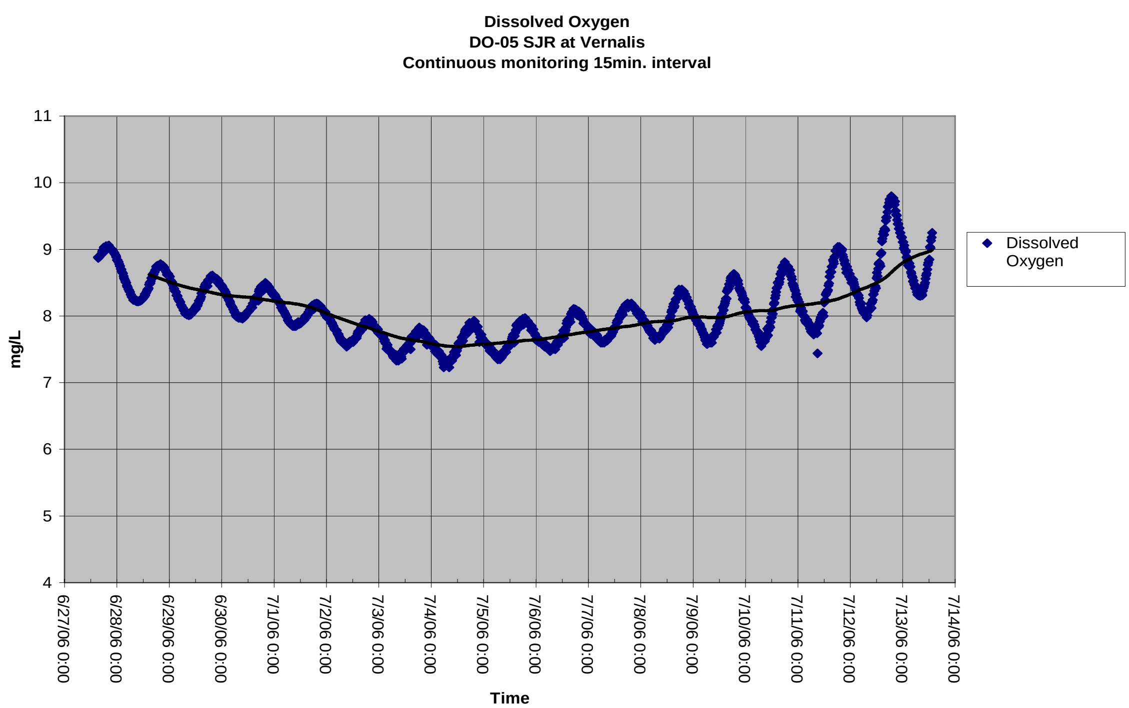


Fig.5G San Joaquin River at Vernalis, pH and 96 point moving average trend line. Includes all available 15 minute data from 06/27/06 to 07/13/06.

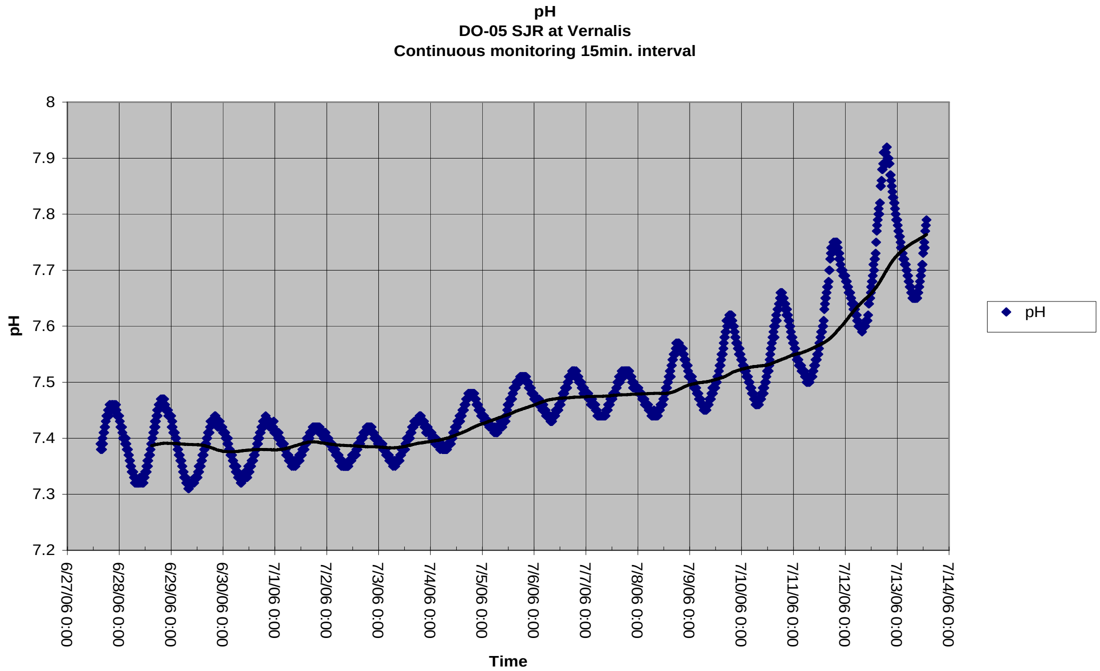


Fig.5H San Joaquin River at Vernalis, Specific Conductance (mS/cm). Includes all available 15 minute data from 06/27/06 to 07/13/06.

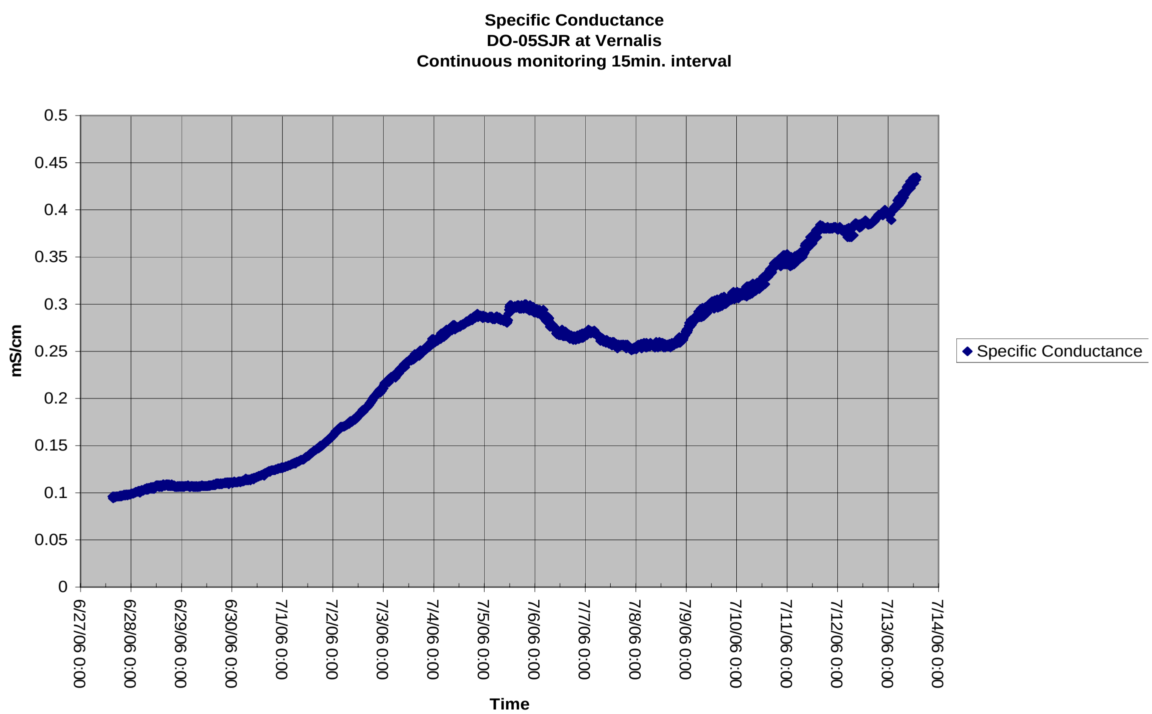


Fig.5I San Joaquin River at Vernalis, Temperature (Deg. C) with 96 point moving average trend line. Includes all available 15 minute data from 06/27/06 to 07/13/06.

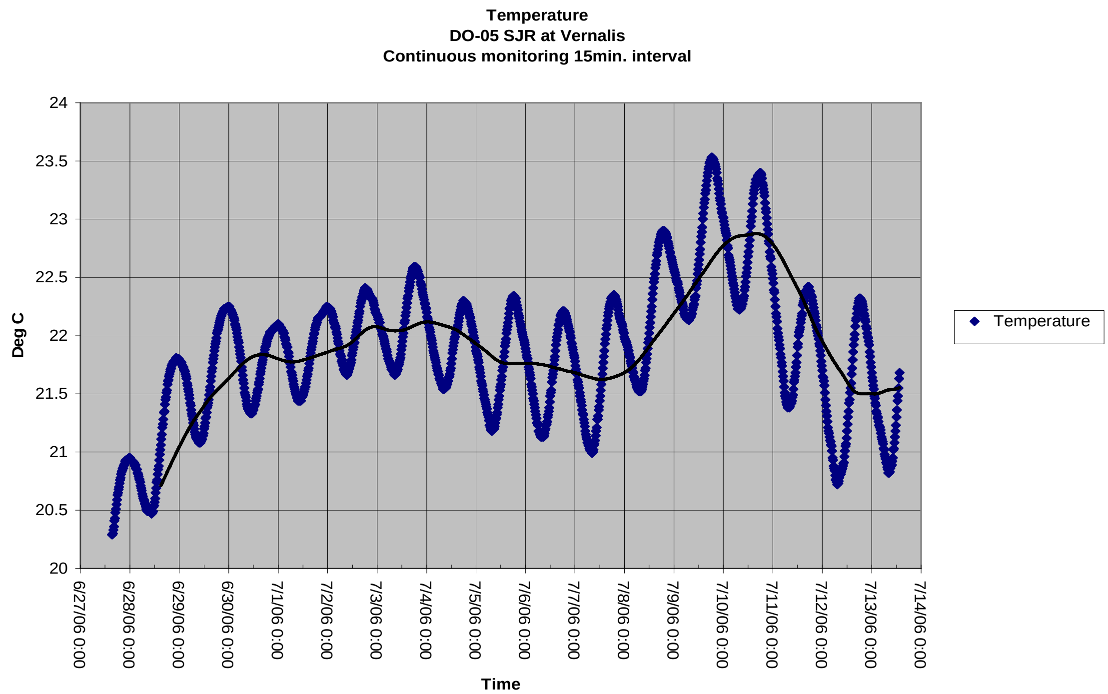


Fig.5J San Joaquin River at Vernalis, Temperature (Deg. C) and Fluorescence (%RFU) with 96 point moving average trend lines. Includes all available 15 minute data from 06/27/06 to 07/13/06.

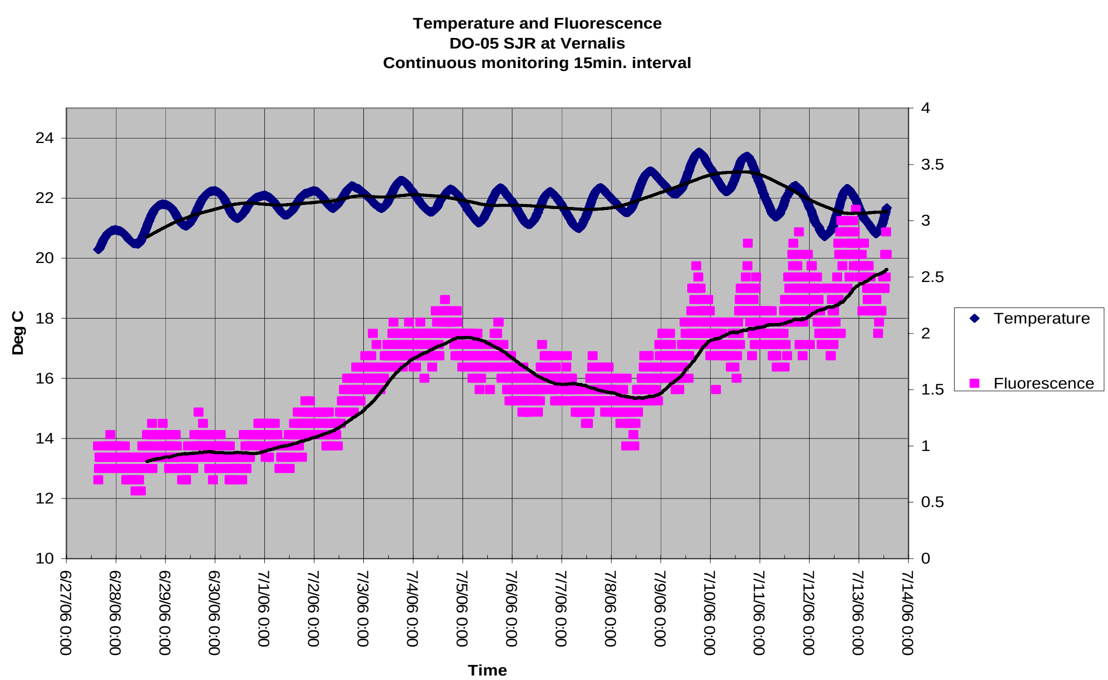


Table:7A Daily Averages for Sample Site DO-07 San Joaquin River at Patterson. Includes all available 15 minute data from 06/27/06 to 07/13/06. Data from 07/09/06 to 07/13/06 was unavailable because the river level dropped below the instrument.

DO-07 SJR at Patterson

June 27, 2006 to July 8, 2006

Daily averages

Date	Temp	SpCond	TDS	DOsat	DO	DOchrg	Depth	pH	Orp	Turbid+	Chl	Chl	Battery	Notes
	C	mS/cm	g/L	%	mg/L		feet		mV	NTU	ug/L	RFU	volts	
6/27/2006	25.29	0.14	0.09	95.61	7.85	40.97	3.81	7.40	185.10	25.54	7.63	1.79	12.45	Partial Day
6/28/2006	24.77	0.13	0.09	92.85	7.70	40.19	3.94	7.34	191.77	156.35	45.56	10.72	12.35	
6/29/2006	24.53	0.13	0.09	94.37	7.86	40.08	4.03	7.34	196.01	495.38	335.03	78.84	12.20	
6/30/2006	24.51	0.15	0.10	95.50	7.96	39.86	3.66	7.37	199.09	355.58	333.90	78.58	12.15	
7/1/2006	24.41	0.20	0.13	92.75	7.74	39.18	2.92	7.36	198.76	113.93	334.28	78.67	12.05	
7/2/2006	24.67	0.29	0.19	91.88	7.63	38.64	1.73	7.36	193.47	38.97	368.11	86.78	12.03	
7/3/2006	24.70	0.36	0.23	91.64	7.61	38.25	0.73	7.38	182.42	44.89	430.25	101.42	12.01	
7/4/2006	24.53	0.38	0.25	91.07	7.58	37.63	0.11	7.36	169.68	46.31	389.43	92.16	12.00	
7/5/2006	24.10	0.34	0.22	91.25	7.66	37.22	0.00	7.36	171.64	46.04	372.74	87.89	11.98	
7/6/2006	24.01	0.32	0.21	93.25	7.84	37.18	0.07	7.38	175.60	43.00	360.78	85.14	11.96	
7/7/2006	23.91	0.31	0.20	95.29	8.03	37.08	0.11	7.39	183.53	50.45	327.03	76.96	11.90	
7/8/2006	23.64	0.18	0.12	95.15	8.06	36.87	0.07	7.40	184.34	38.95	324.84	76.46	11.90	Partial Day
7/9/2006	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	out of water
7/10/2006	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	out of water
7/11/2006	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	out of water
7/12/2006	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	out of water
7/13/2006	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	out of water

Fig.7A San Joaquin River at Patterson, Flow (CFS) from CDEC database. Includes Corresponding 15 minute data from 06/27/06 to 07/13/06

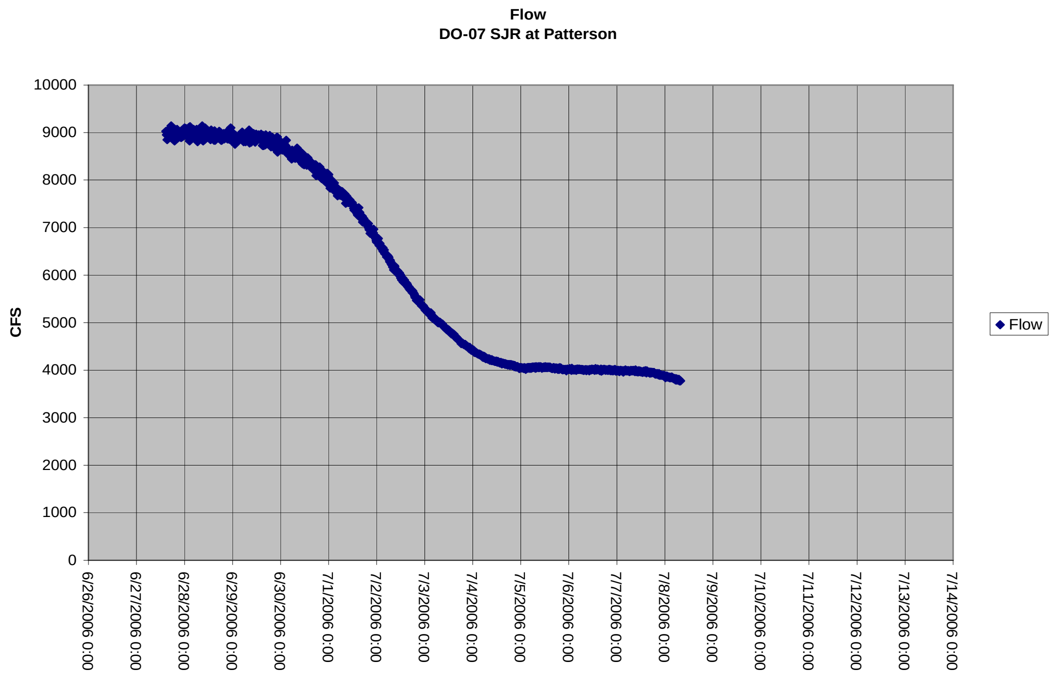


Fig.7B San Joaquin River at Patterson, Turbidity (NTU) and Relative Fluorescence Units (%RFU) with 96 point moving average trend lines. RFU values after second day are instrument error as are NTU values above 100. Includes all available 15 minute data from 06/27/06 to 07/13/06

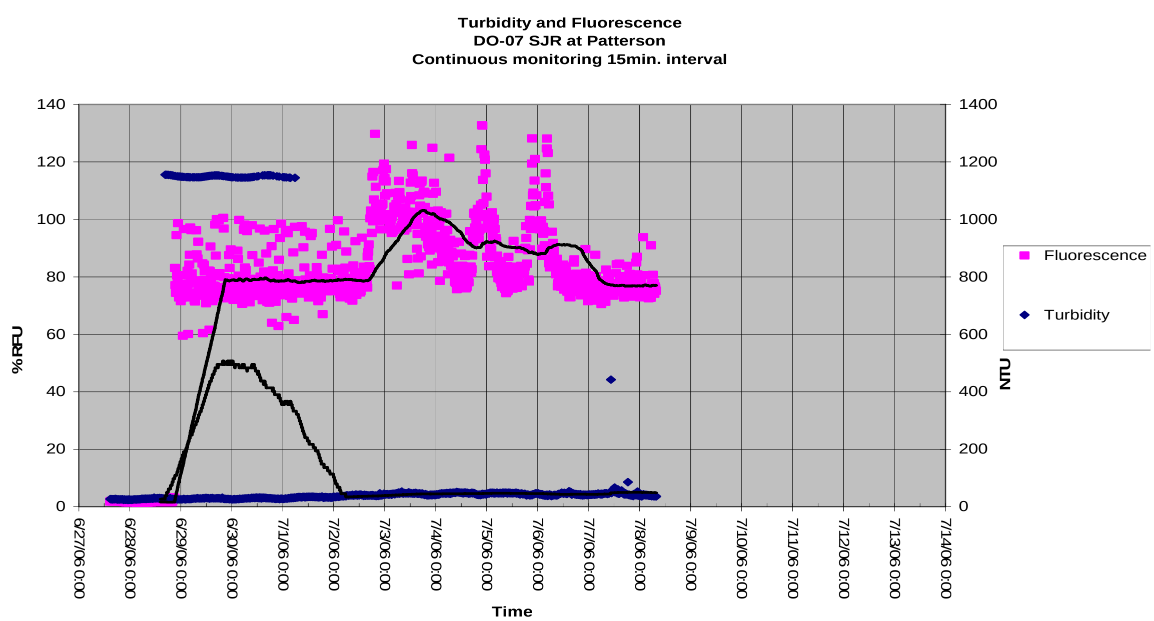


Fig.7C San Joaquin River at Patterson, Turbidity (NTU). Includes all valid and available 15 minute data from 06/27/06 to 07/13/06

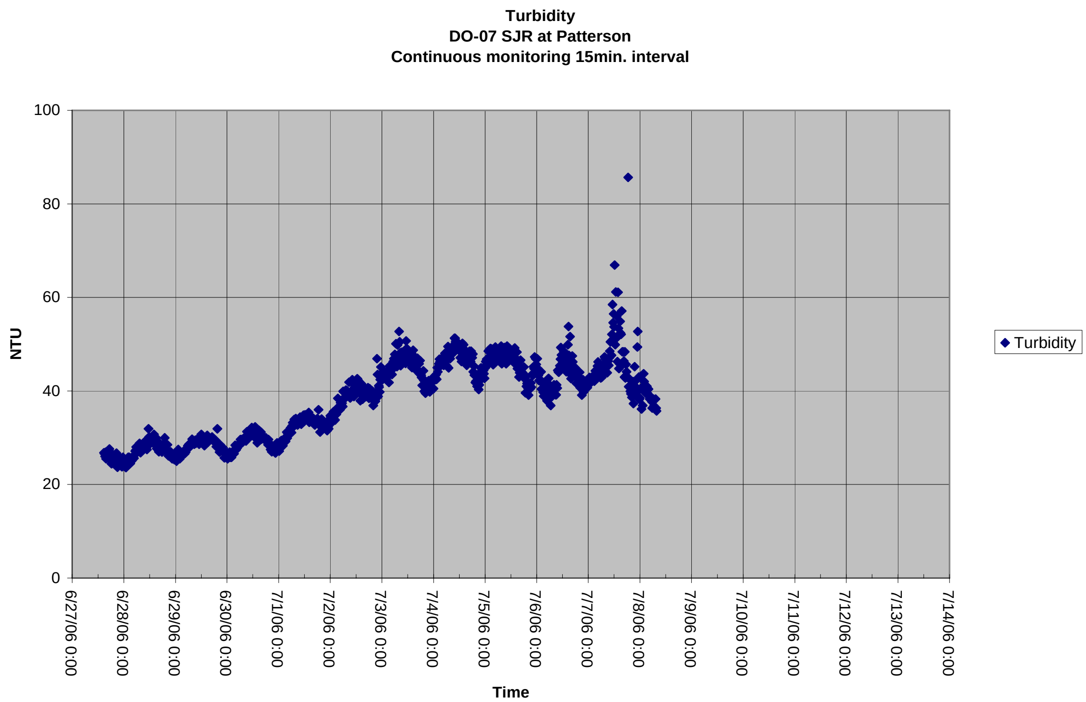


Fig.7D San Joaquin River at Patterson, Relative Fluorescence Units (%RFU) with 96 point moving average trend line. Includes all available 15 minute data from 06/27/06 to 07/13/06. Data after 9:00pm on 06/28/06 is a sensor error from the wiping mechanism.

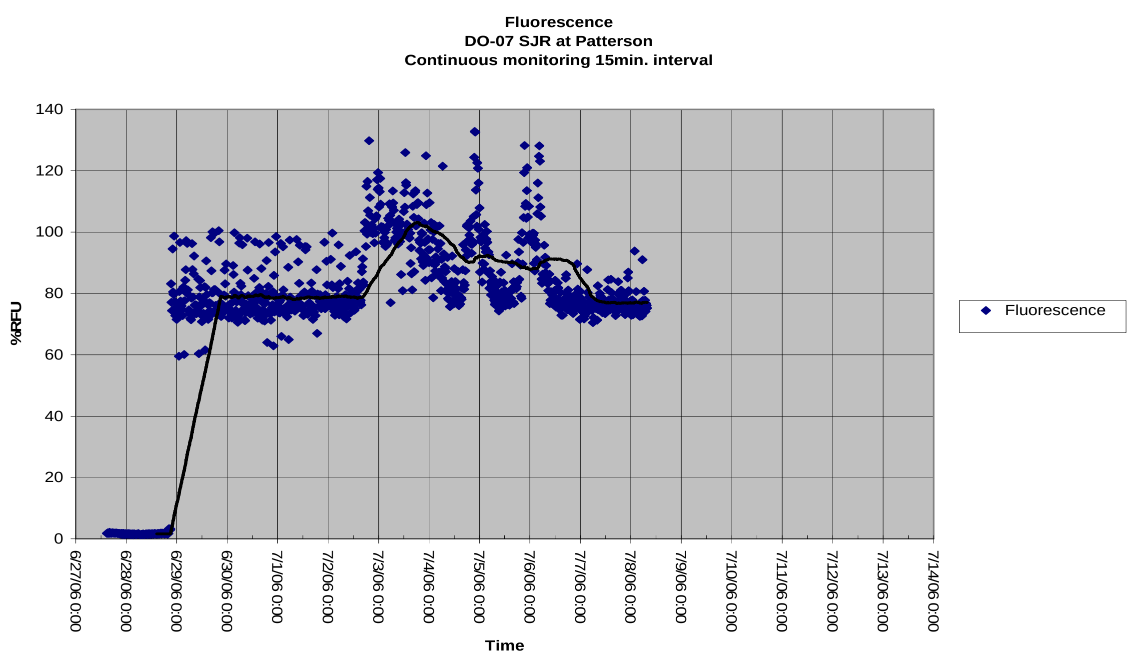


Fig.7E San Joaquin River at Patterson, Dissolved Oxygen (mg/l) and pH with 96 point moving average trend lines. Includes all available 15 minute data from 06/27/06 to 07/13/06.

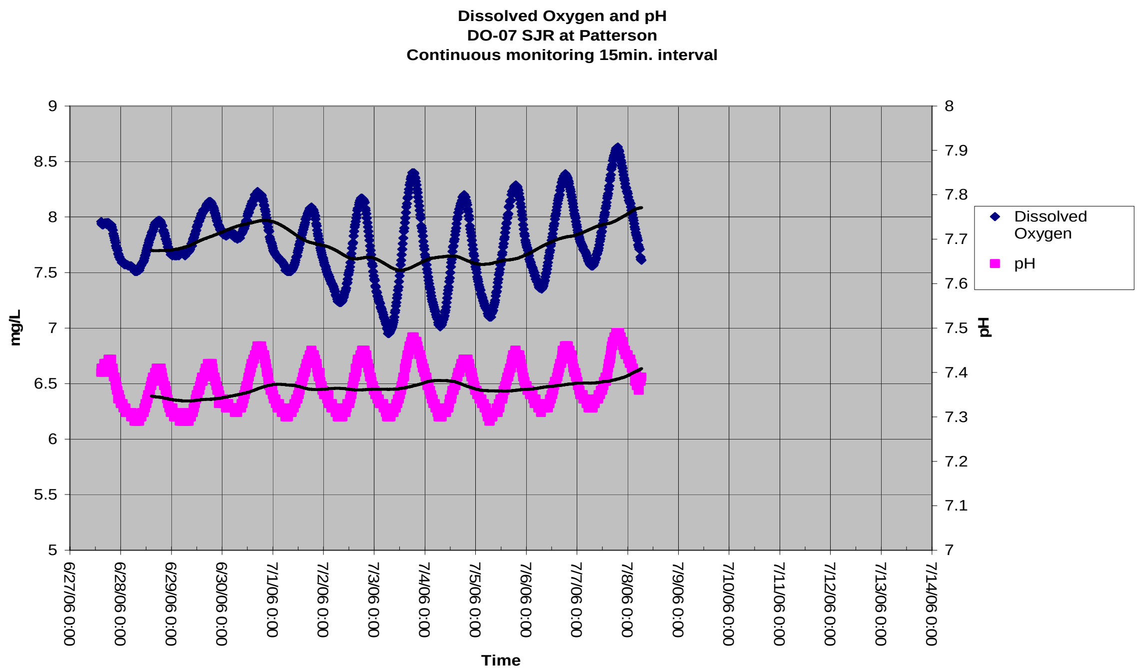


Fig.7F San Joaquin River at Patterson, pH with 96 point moving average trend line. Includes all available 15 minute data from 06/27/06 to 07/13/06.

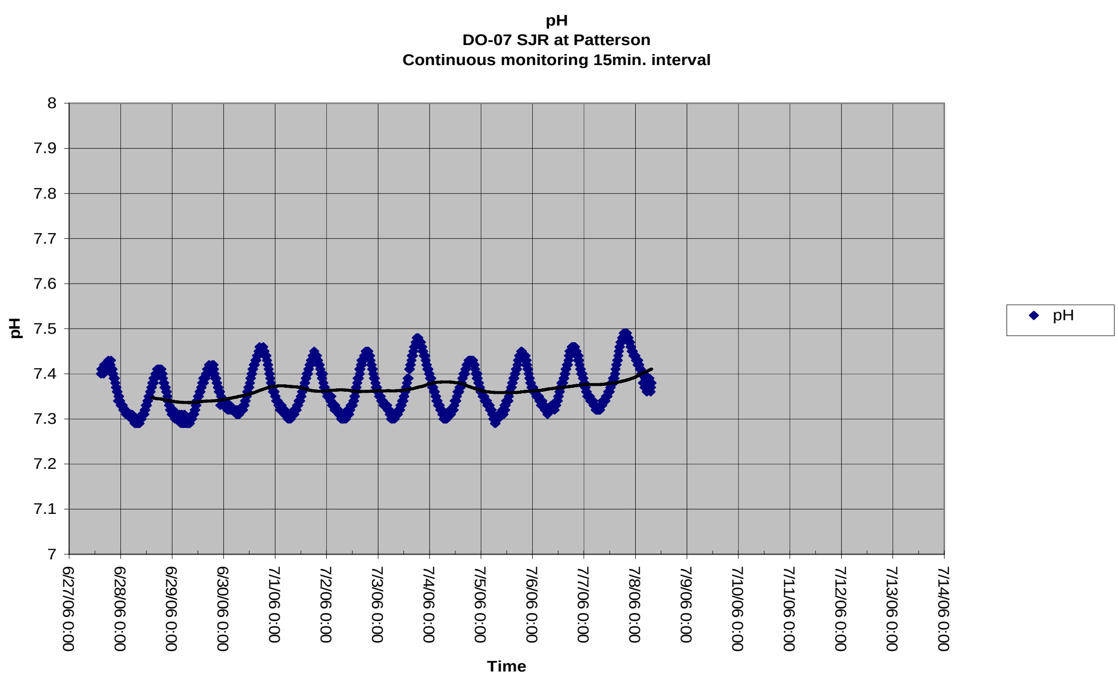


Fig.7G San Joaquin River at Patterson, Dissolved Oxygen (mg/l) with 96 point moving average trend lines. Includes all available 15 minute data from 06/27/06 to 07/13/06.

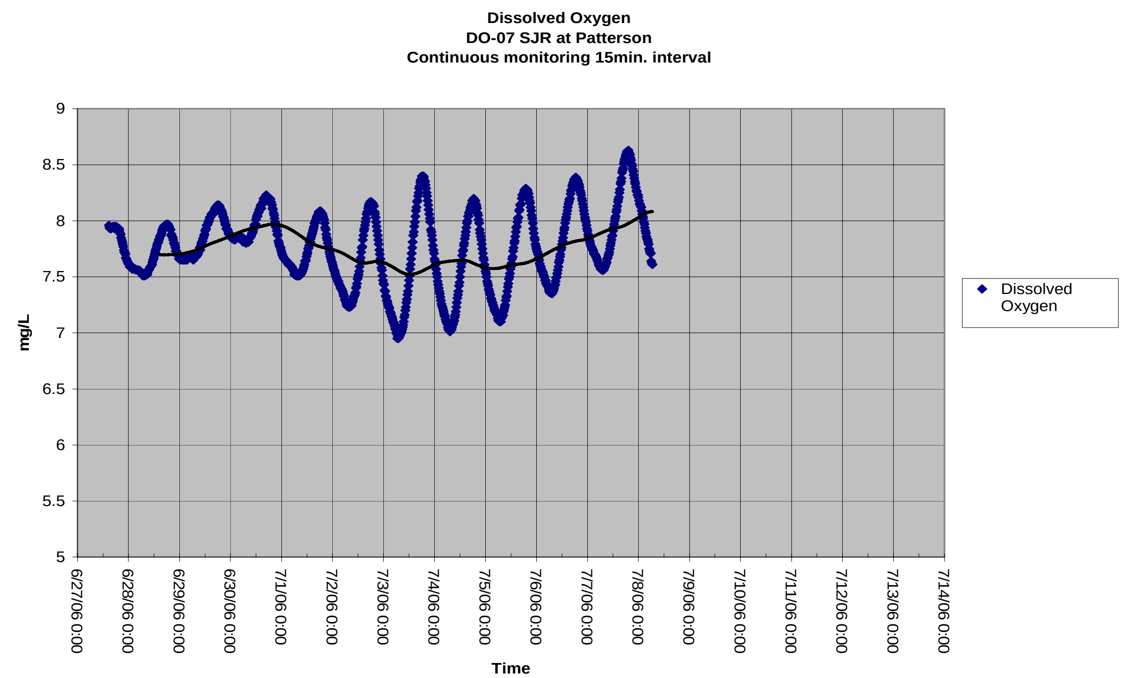


Fig.7H San Joaquin River at Patterson, Specific Conductance (mS/cm). Includes all available 15 minute data from 06/27/06 to 07/13/06.

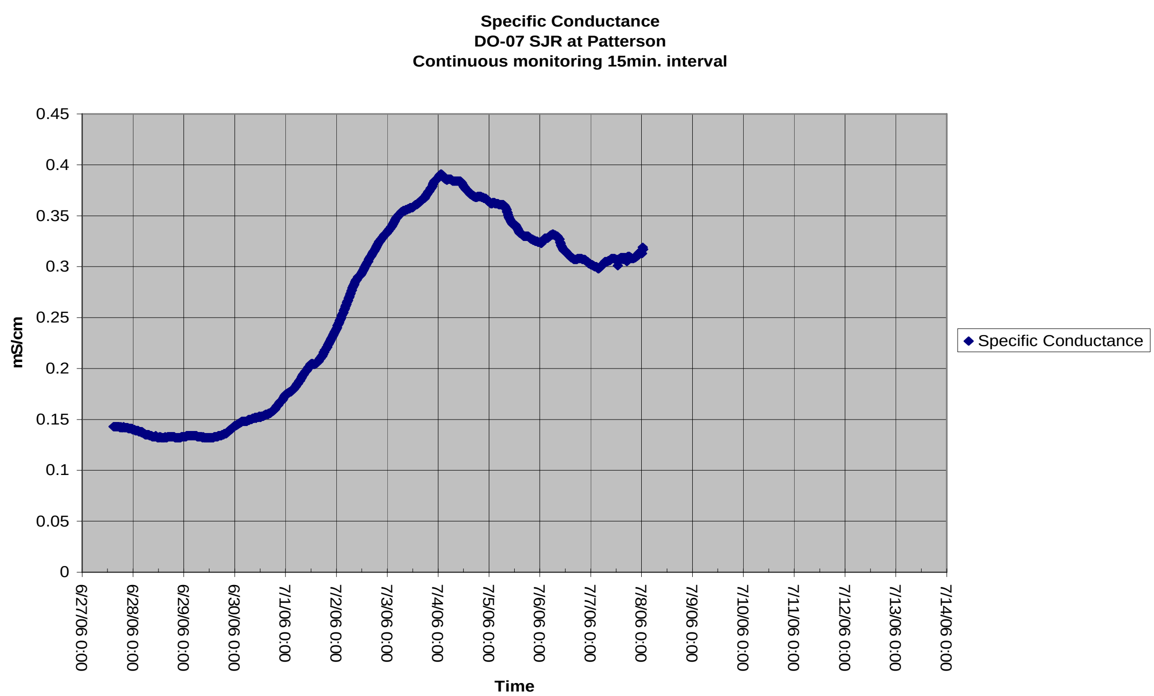


Fig.7I San Joaquin River at Patterson, Temperature (Deg. C). Includes all available 15 minute data from 06/27/06 to 07/13/06.

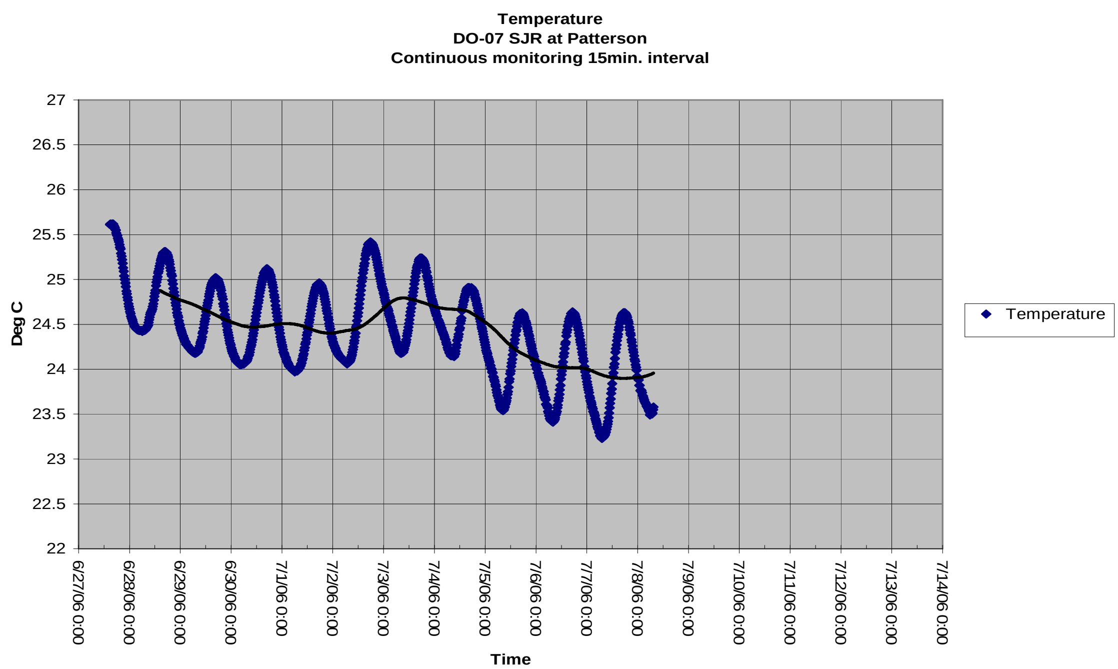


Fig.7J San Joaquin River at Patterson, Temperature (Deg. C) and Fluorescence (%RFU). Includes all available 15 minute data from 06/27/06 to 07/13/06.

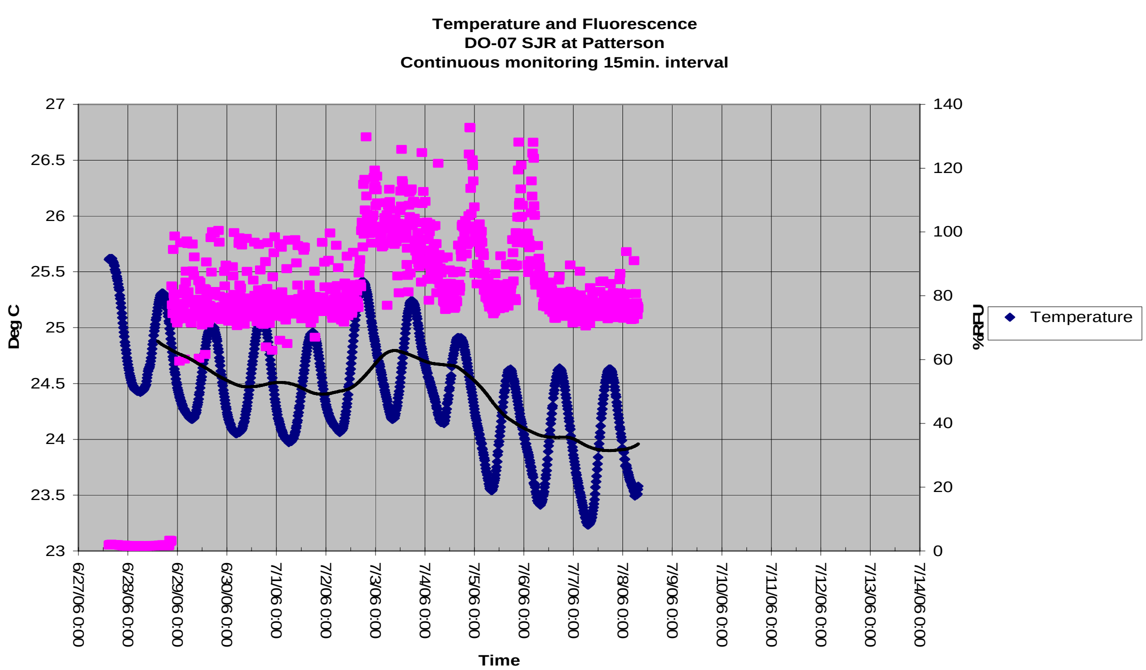


Table:8A Daily Averages for Sample Site DO-08 San Joaquin River at Crows Landing. Includes all available 15 minute data from 06/27/06 to 07/13/06

DO-08 SJR at Crows Landing (Turlock Sportsman Club)

June 27, 2006 to July 13, 2006

Daily averages

Date	Temp	SpCond	TDS	DOsat	DO	DOchrg	Depth	pH	Orp	Turbid+	Chl	Chl	Battery	
	C	mS/cm	g/L	%	mg/L		feet		mV	NTU	ug/L	RFU	volts	
6/27/2006	24.69	0.14	0.09	93.18	7.74	41.29	0.45	7.32	118.76	25.03	6.41	1.51	12.91	Partial Day
6/28/2006	24.50	0.13	0.09	91.61	7.64	40.53	0.51	7.28	134.52	26.36	5.58	1.31	12.75	
6/29/2006	24.20	0.13	0.09	93.31	7.82	40.00	0.61	7.30	164.15	27.01	5.23	1.22	12.68	
6/30/2006	24.37	0.16	0.10	92.66	7.74	39.59	0.65	7.34	184.39	28.98	6.05	1.42	12.56	
7/1/2006	24.20	0.21	0.14	89.08	7.47	38.81	0.69	7.34	190.63	33.94	7.79	1.83	12.44	
7/2/2006	24.57	0.30	0.19	87.23	7.26	38.35	0.99	7.36	196.39	43.21	11.49	2.69	12.33	
7/3/2006	24.50	0.34	0.22	87.14	7.26	38.04	1.20	7.39	211.81	47.98	13.11	3.07	12.30	
7/4/2006	24.32	0.33	0.21	85.76	7.17	37.54	1.25	7.38	219.17	50.61	15.52	3.65	12.22	
7/5/2006	23.92	0.29	0.19	86.95	7.32	37.41	1.20	7.39	224.79	48.84	8.98	2.11	12.07	
7/6/2006	23.84	0.27	0.18	88.41	7.46	37.49	1.25	7.40	228.70	47.06	8.14	1.92	12.00	
7/7/2006	23.68	0.28	0.18	90.89	7.69	37.52	1.28	7.45	231.99	48.22	8.61	2.02	11.41	
7/8/2006	24.24	0.35	0.23	93.99	7.87	37.94	1.21	7.53	232.94	44.51	11.30	2.66	11.23	
7/9/2006	25.28	0.51	0.33	94.45	7.75	38.19	1.39	7.53	230.13	59.82	16.35	3.84	11.22	
7/10/2006	25.92	0.69	0.45	96.42	7.81	38.39	1.60	7.60	228.92	41.96	21.63	5.08	11.55	
7/11/2006	25.56	0.80	0.52	99.11	8.08	38.64	1.73	7.67	229.29	36.73	23.32	5.48	11.31	
7/12/2006	24.56	0.82	0.53	98.62	8.20	38.27	1.90	7.71	230.02	34.83	22.75	5.34	11.36	
7/13/2006	24.19	0.74	0.48	88.96	7.45	37.24	1.90	7.60	226.90	30.10	16.53	3.89	11.54	Partial Day

Fig.8A San Joaquin River at Crows Landing, Flow (CFS) from CDEC database. Includes all available 15 minute data from 06/27/06 to 07/13/06.

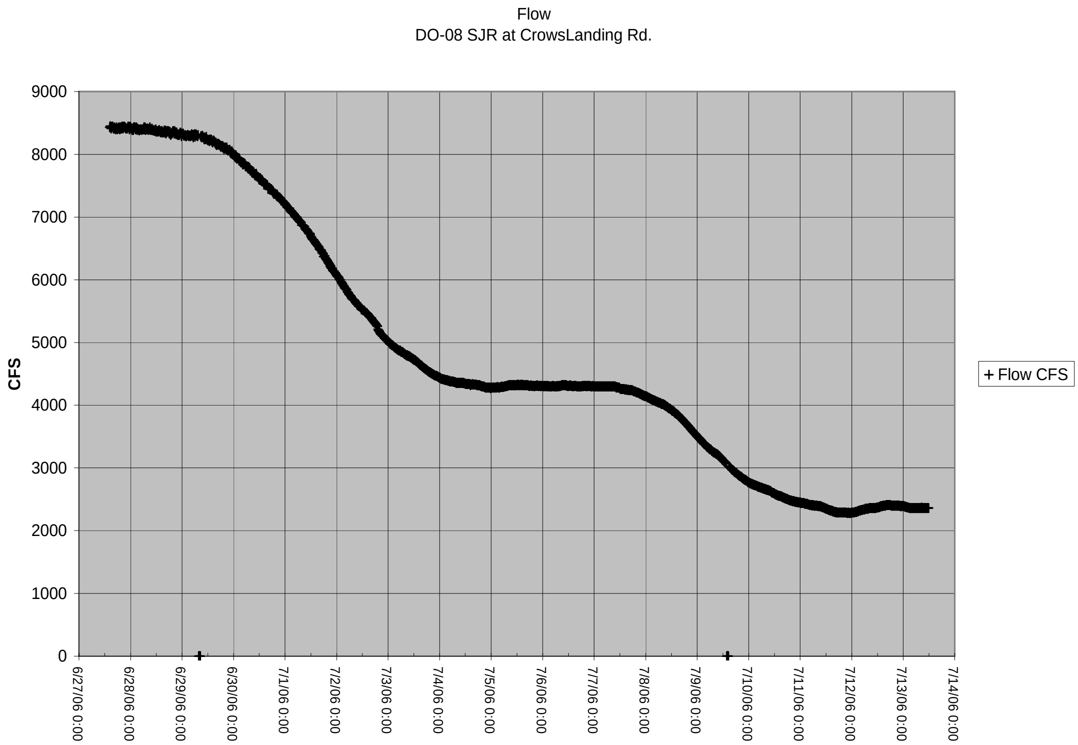


Fig.8B San Joaquin River at Crows Landing, Turbidity (NTU) and Relative Fluorescence Units (%RFU) with 96 point moving average trend lines. Includes all available 15 minute data from 06/27/06 to 07/13/06.

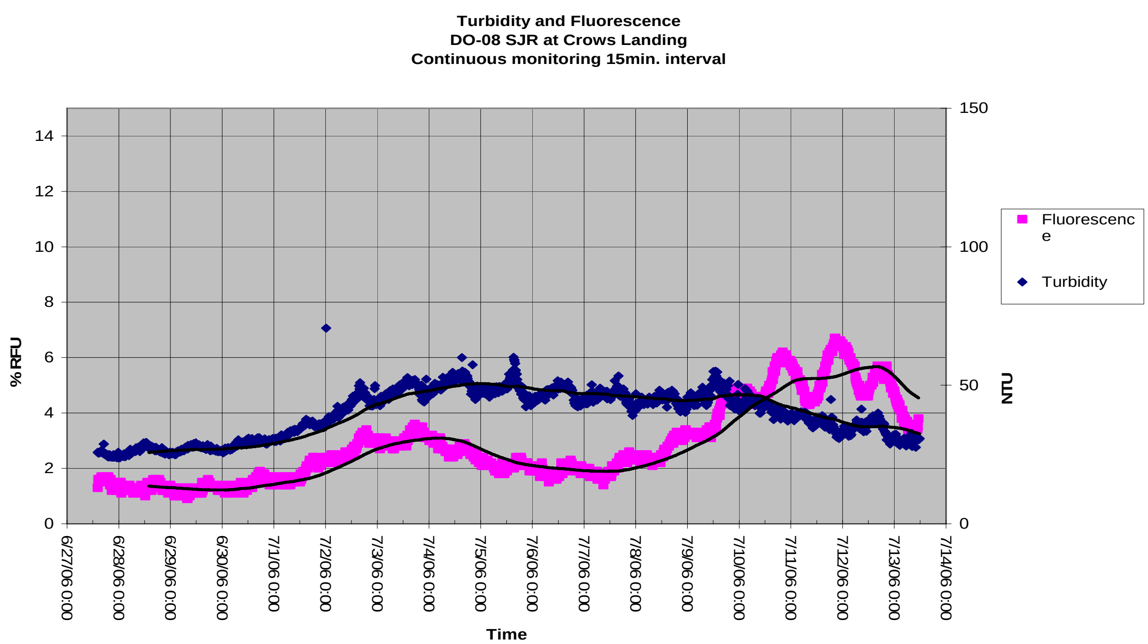


Fig.8C San Joaquin River at Crows Landing, Turbidity (NTU) with 96 point moving average trend line . Includes all available 15 minute data from 06/27/06 to 07/13/06.

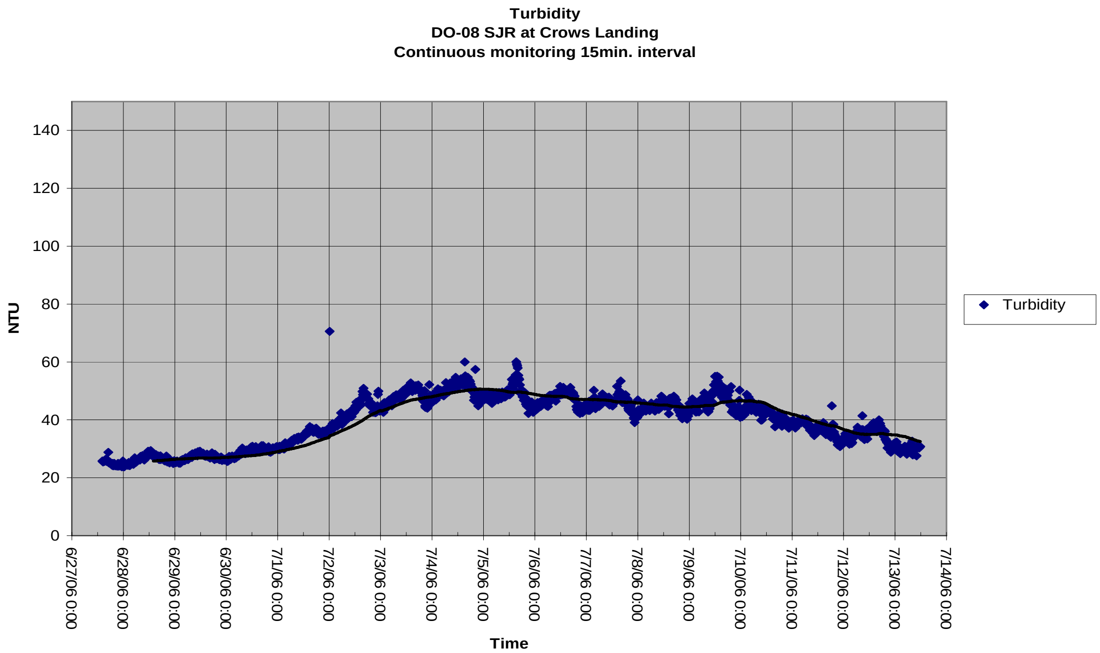


Fig.8D San Joaquin River at Crows Landing, Relative Fluorescence Units (%RFU) with 96 point moving average trend line. Includes all available 15 minute data from 06/27/06 to 07/13/06.

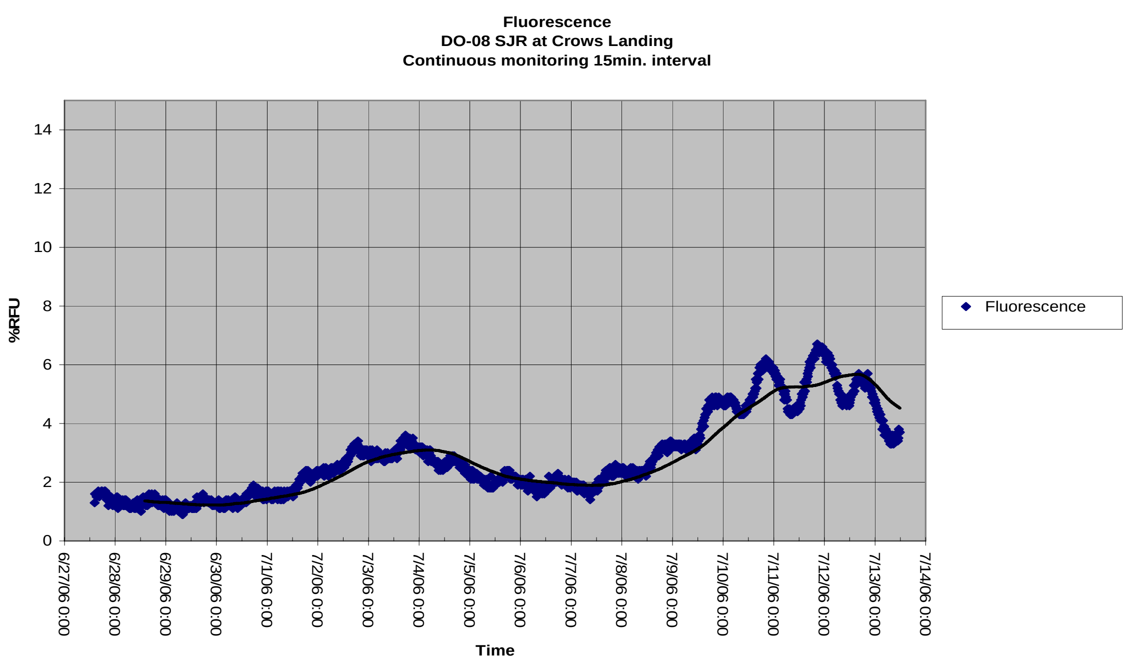


Fig.8E San Joaquin River at Crows Landing, Dissolved Oxygen (mg/l) and pH with 96 point moving average trend line. Includes all available 15 minute data from 06/27/06 to 07/13/06.

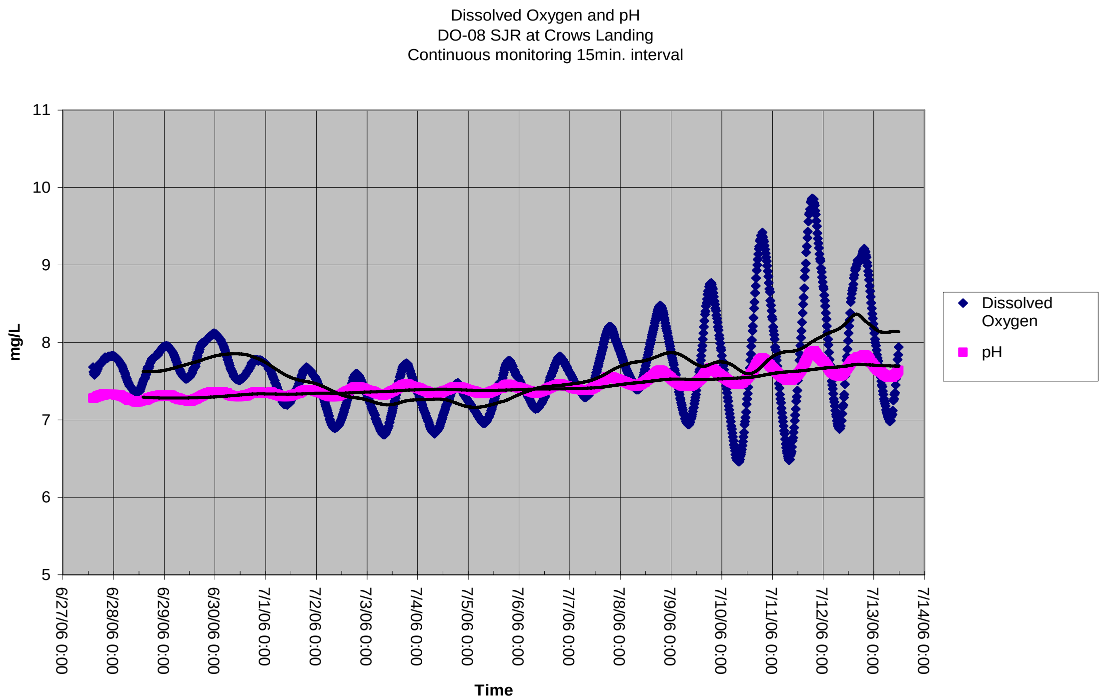


Fig.8F San Joaquin River at Crows Landing, pH with 96 point moving average trend line. Includes all available 15 minute data from 06/27/06 to 07/13/06.

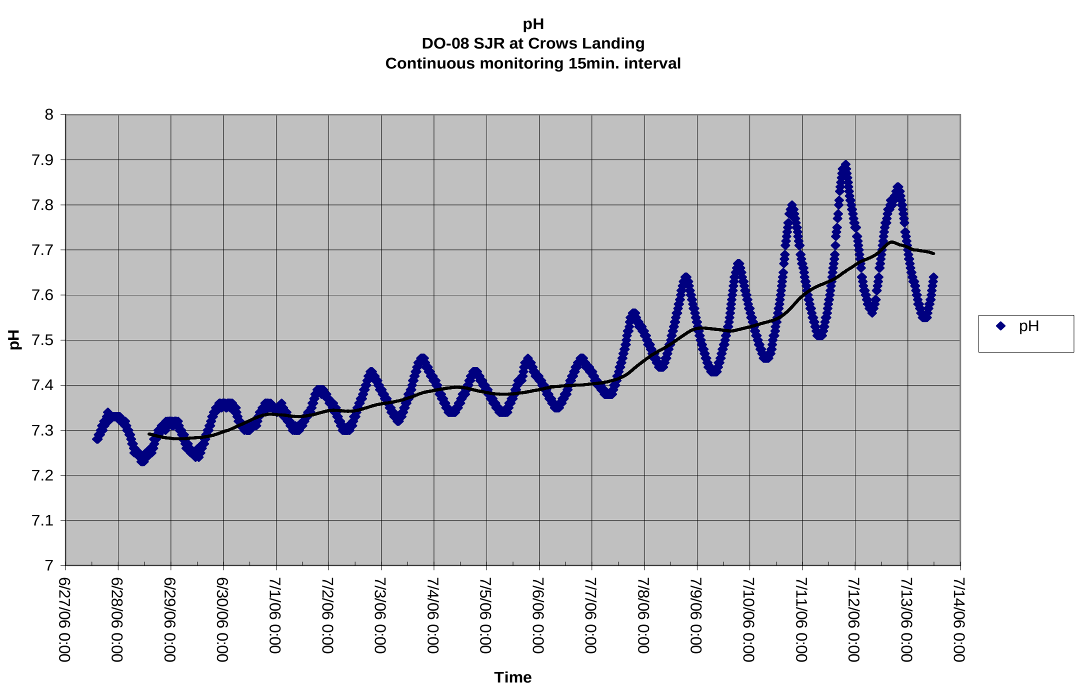


Fig.8G San Joaquin River at Crows Landing, Dissolved Oxygen (mg/l) and pH with 96 point moving average trend line. Includes all available 15 minute data from 06/27/06 to 07/13/06.

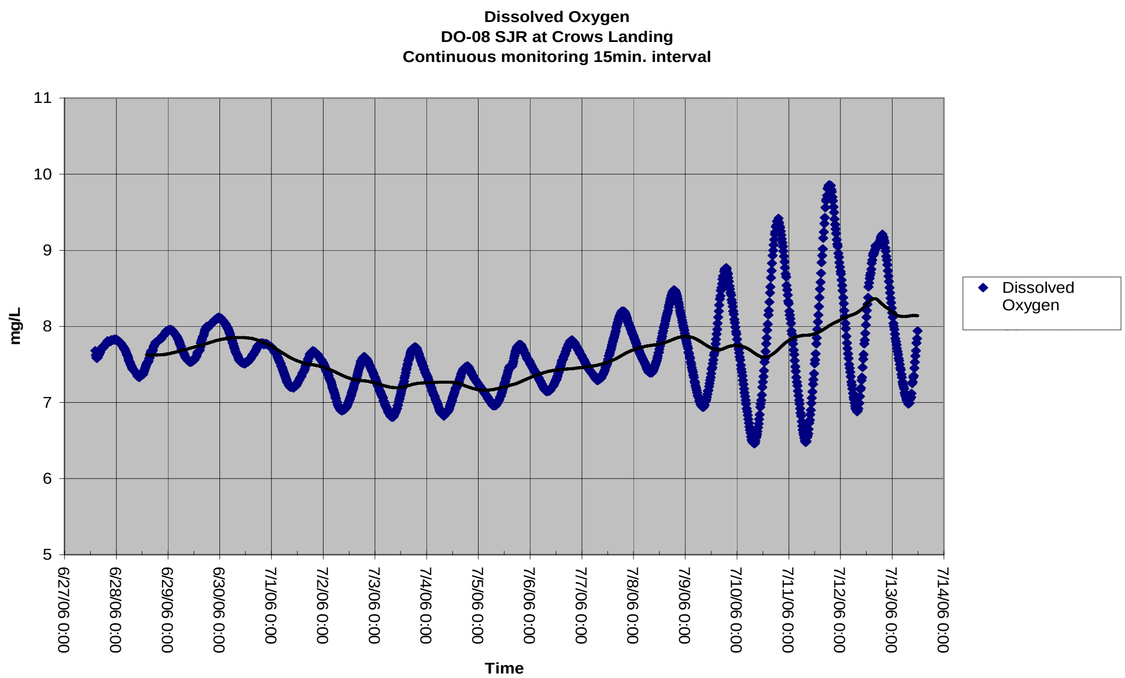


Fig.8H San Joaquin River at Crows Landing, Specific Conductance (mS/cm). Includes all available 15 minute data from 06/27/06 to 07/13/06.

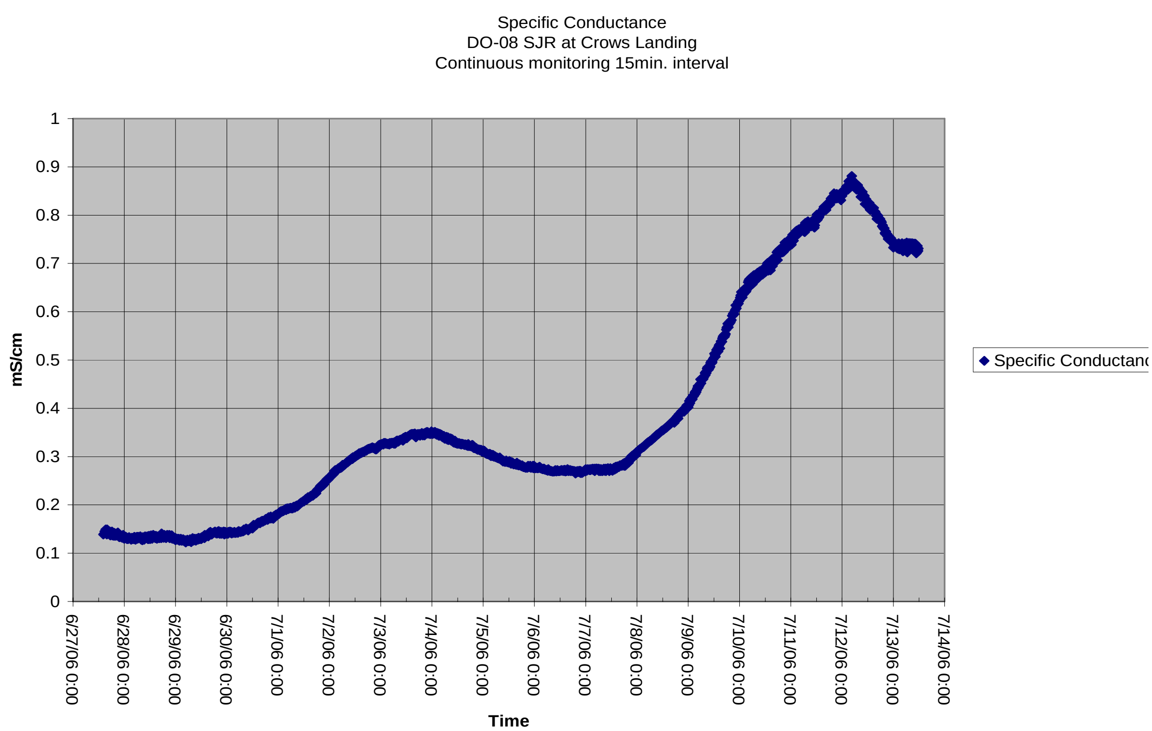


Fig.8I San Joaquin River at Crows Landing, Temperature (Deg. C). Includes all available 15 minute data from 06/27/06 to 07/13/06.

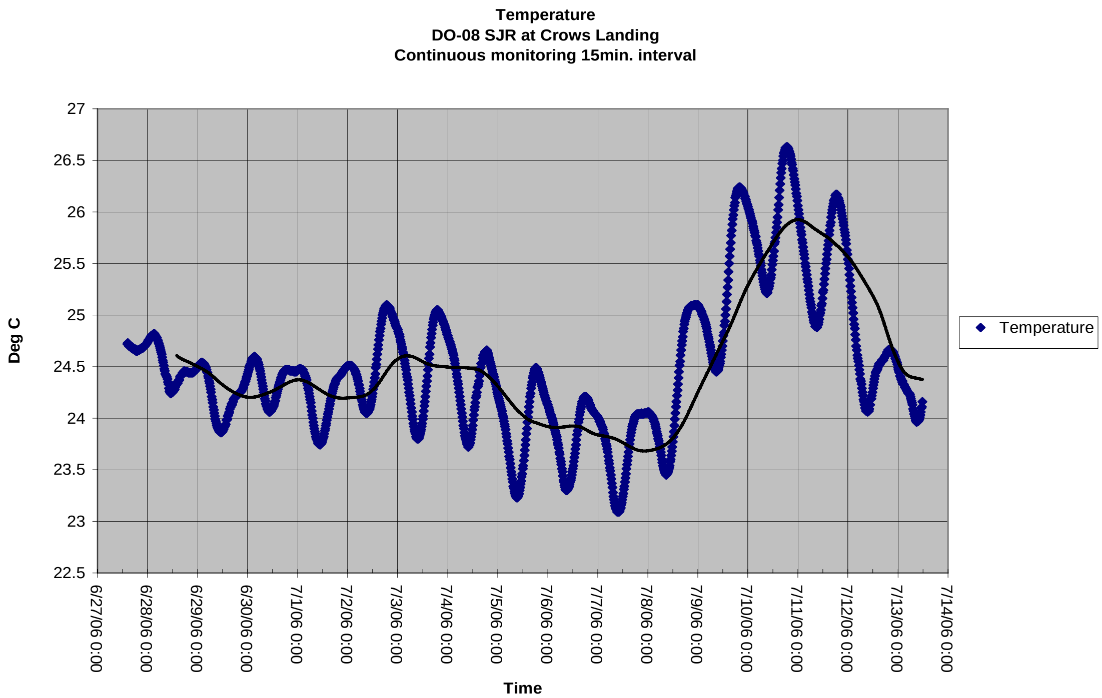


Fig.8J San Joaquin River at Crows Landing, Temperature (Deg. C) and Fluorescence (%RFU). Includes all available 15 minute data from 06/27/06 to 07/13/06.

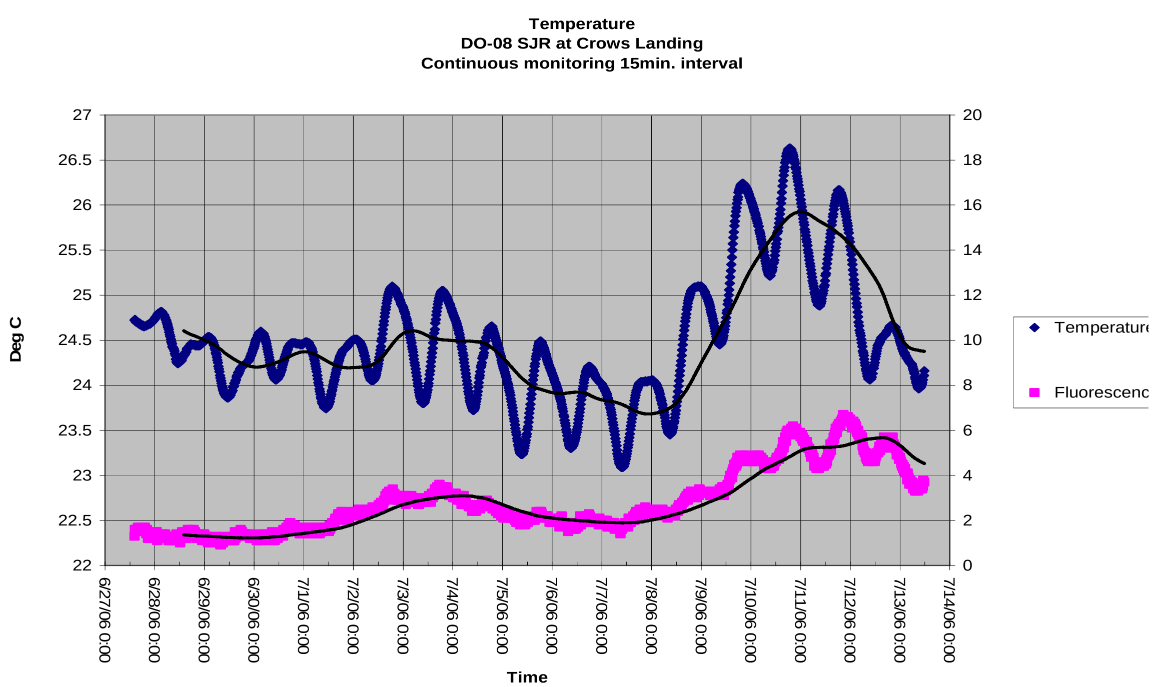


Table:19A Daily Averages for Sample Site DO-19 Salt Slough at Lander Ave. Includes all available 15 minute data from 06/27/06 to 07/13/06

DO-19 Salt slough at Lander Ave.

June 27, 2006 to July 13, 2006

Daily averages

Date	Temp	SpCond	TDS	DOsat	DO	DOchrg	Depth	pH	Orp	Turbid+	Chl	Chl	Battery	
	C	mS/cm	g/L	%	mg/L		feet		mV	NTU	ug/L	RFU	volts	
6/27/2006	28.43	0.71	0.46	71.78	5.57	40.61	2.75	7.46	148.46	58.12	7.19	1.71	12.55	Partial Day
6/28/2006	26.79	0.74	0.48	71.33	5.69	39.52	2.83	7.49	149.16	59.75	7.47	1.78	12.38	
6/29/2006	26.76	0.85	0.56	73.70	5.88	39.13	2.65	7.52	156.34	208.29	7.99	1.90	12.28	
6/30/2006	26.80	0.82	0.53	74.75	5.96	38.47	2.22	7.53	158.70	84.94	9.24	2.20	11.98	
7/1/2006	26.44	0.92	0.60	78.44	6.29	38.50	1.40	7.57	156.70	85.93	10.98	2.62	11.81	
7/2/2006	26.67	0.84	0.55	75.27	6.01	37.80	0.95	7.55	147.73	120.93	12.64	3.01	11.63	
7/3/2006	26.55	0.82	0.54	78.33	6.27	37.67	0.88	7.56	153.08	110.96	10.28	2.45	11.73	
7/4/2006	26.27	0.84	0.54	80.29	6.46	37.54	1.03	7.57	156.34	106.23	12.22	2.91	11.23	
7/5/2006	25.77	0.79	0.52	83.64	6.79	37.41	1.15	7.60	161.89	101.32	17.29	4.13	11.43	
7/6/2006	25.04	0.84	0.55	86.85	7.15	37.41	1.26	7.63	166.76	88.77	17.50	4.17	11.29	
7/7/2006	24.81	0.82	0.53	89.31	7.37	37.38	0.96	7.63	169.36	82.62	13.31	3.17	11.09	
7/8/2006	26.38	0.85	0.55	86.64	6.96	37.16	0.42	7.60	167.60	93.32	12.87	3.07	10.98	
7/9/2006	27.84	0.81	0.53	83.28	6.51	36.78	0.21	7.56	165.58	103.66	15.89	3.79	11.02	
7/10/2006	28.21	0.80	0.52	81.29	6.32	36.19	0.29	7.55	167.44	128.99	16.08	3.83	11.62	
7/11/2006	27.39	0.81	0.52	86.35	6.81	36.21	0.30	7.60	171.84	107.64	21.12	5.03	11.63	
7/12/2006	25.91	0.91	0.59	90.22	7.31	36.30	0.21	7.64	173.14	223.13	15.20	3.62	11.64	
7/13/2006	24.70	0.91	0.59	80.86	6.70	35.79	0.21	7.58	157.55	161.20	12.63	3.01	11.61	Partial Day

Fig.19A Salt Slough at Lander Ave., Flow (CFS) from CDEC database. Includes all available 15 minute data from 06/27/06 to 07/13/06.

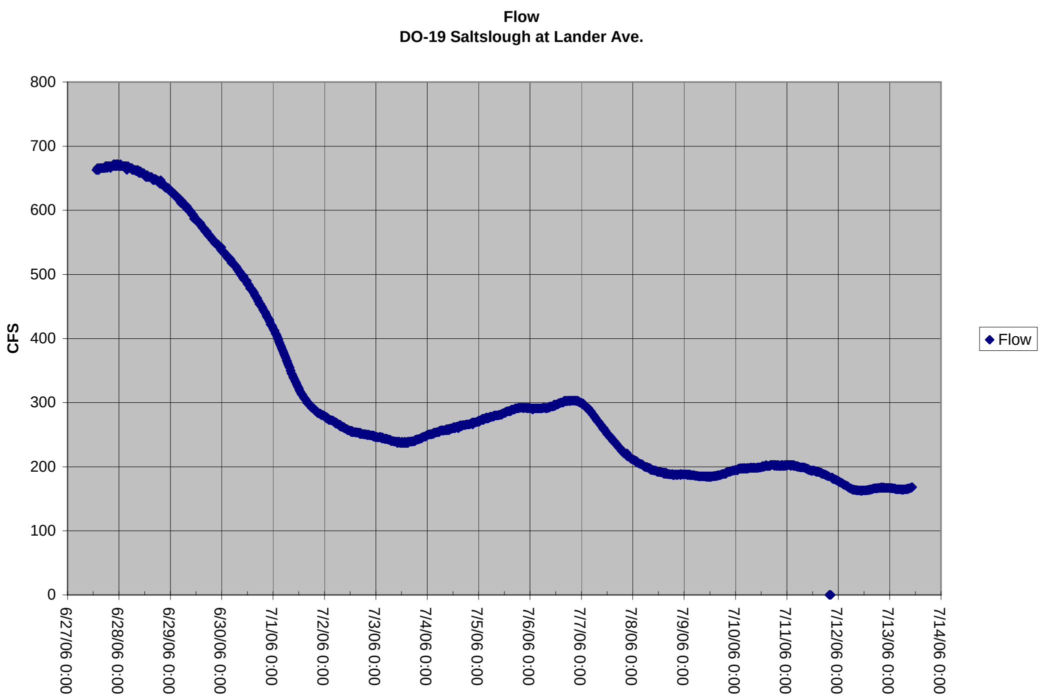


Fig.19B Salt Slough at Lander Ave., Turbidity (NTU) and Relative Fluorescence Units(%RFU) with 96 point moving average trend lines. Includes all available 15 minute data from 06/27/06 to 07/13/06.

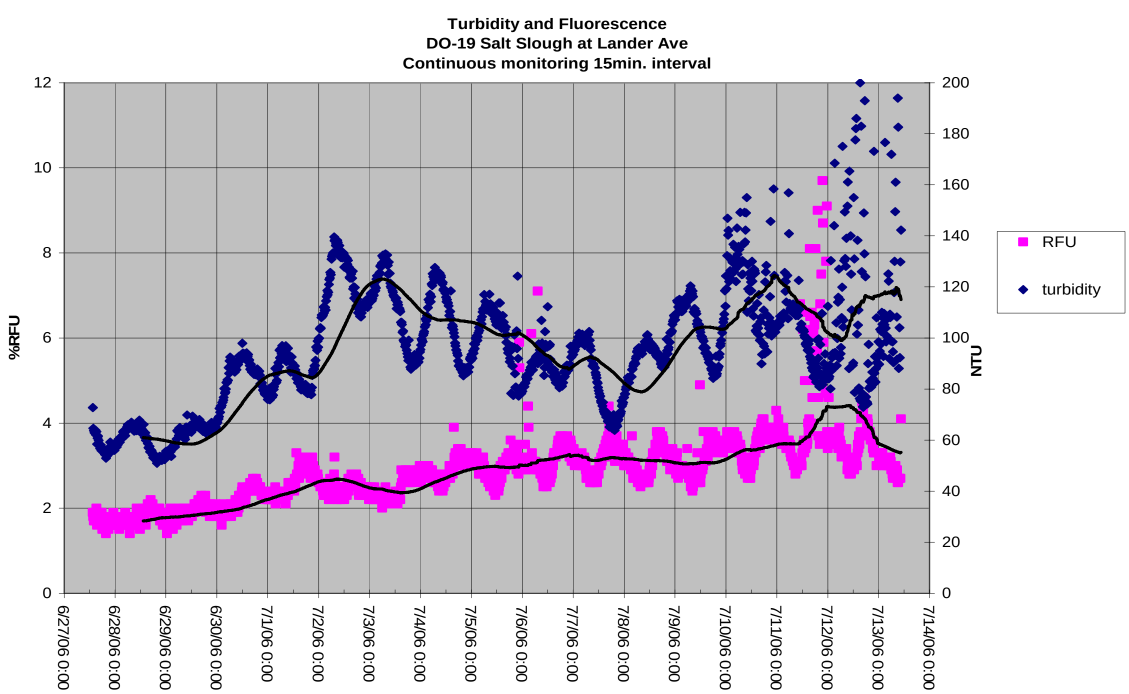


Fig.19C Salt Slough at Lander Ave., Turbidity (NTU) with 96 point moving average trend line. Units(%RFU). Includes all available 15 minute data from 06/27/06 to 07/13/06.

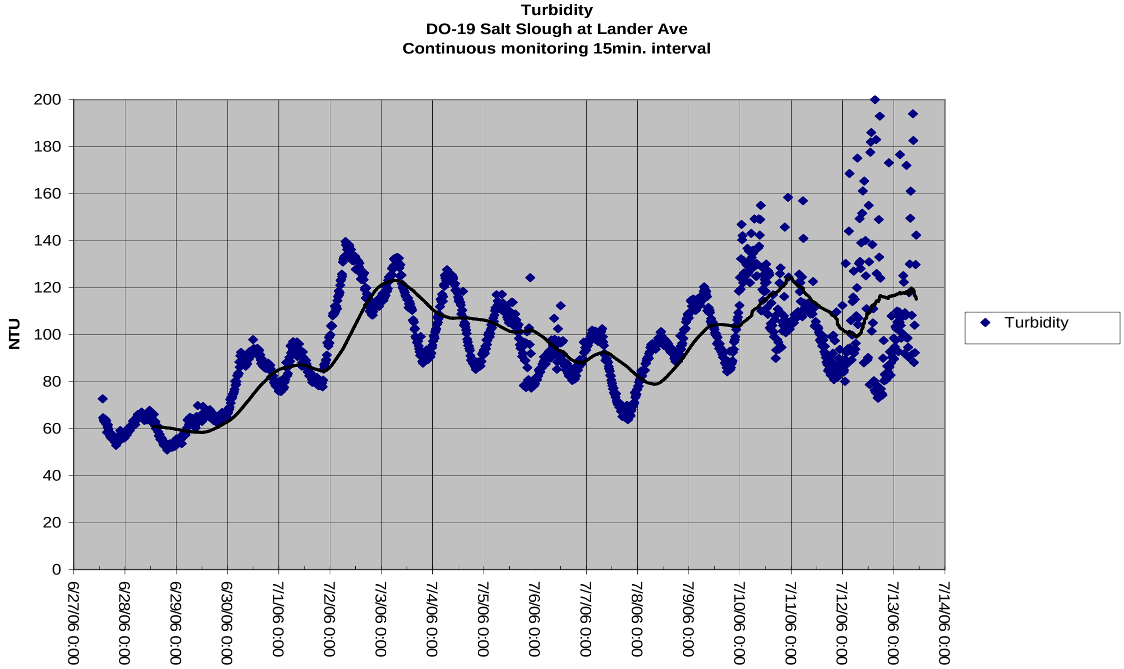


Fig.19D Salt Slough at Lander Ave., Relative Fluorescence Units(%RFU) with 96 point moving average trend lines. Includes all available 15 minute data from 06/27/06 to 07/13/06.

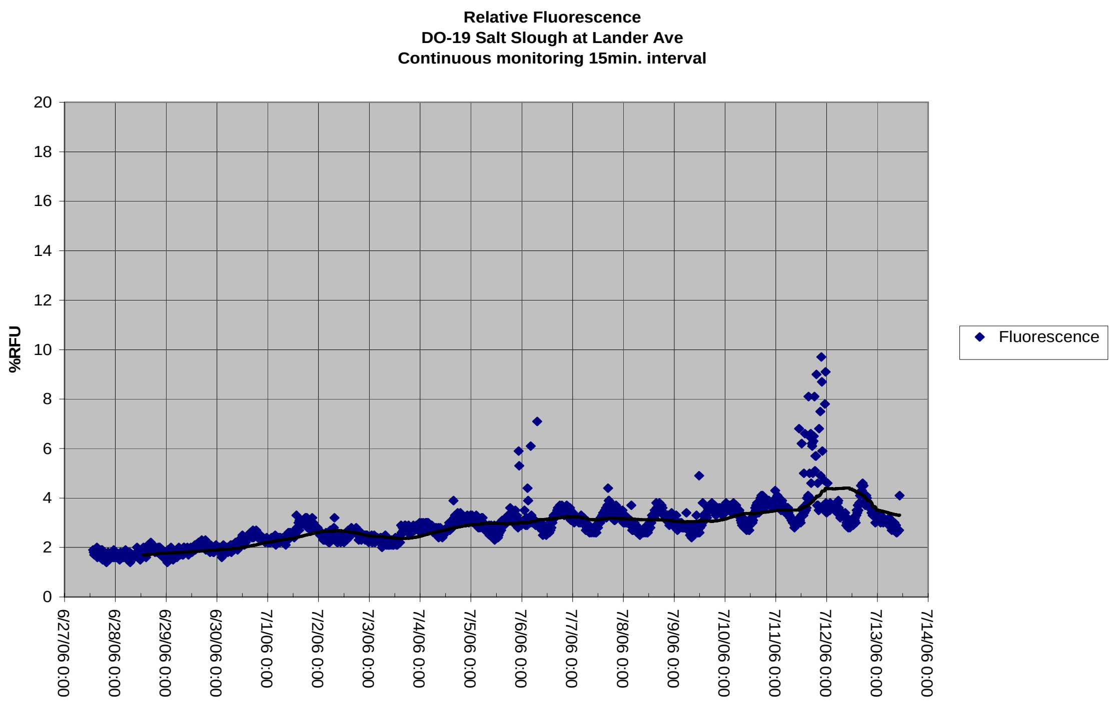


Fig.19E Salt Slough at Lander Ave., Dissolved Oxygen (mg/l) and pH with 96 point moving average trend lines. Includes all available 15 minute data from 06/27/06 to 07/13/06.

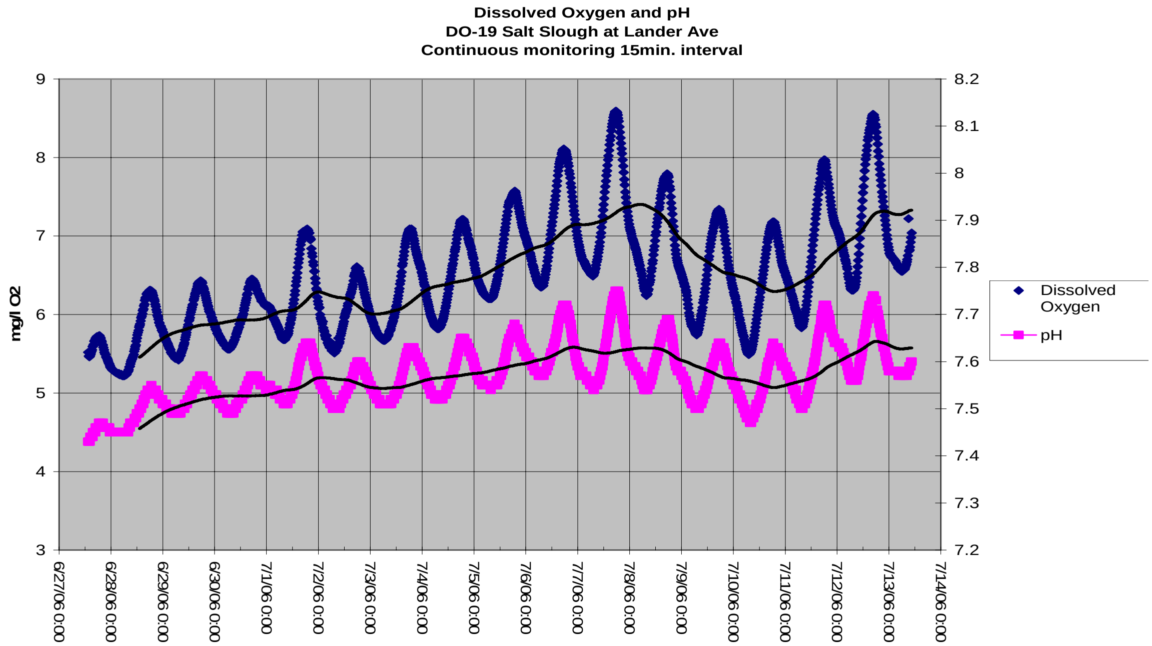


Fig.19FSalt Slough at Lander Ave., Dissolved Oxygen (mg/l) with 96 point moving average trend line. Includes all available 15 minute data from 06/27/06 to 07/13/06.

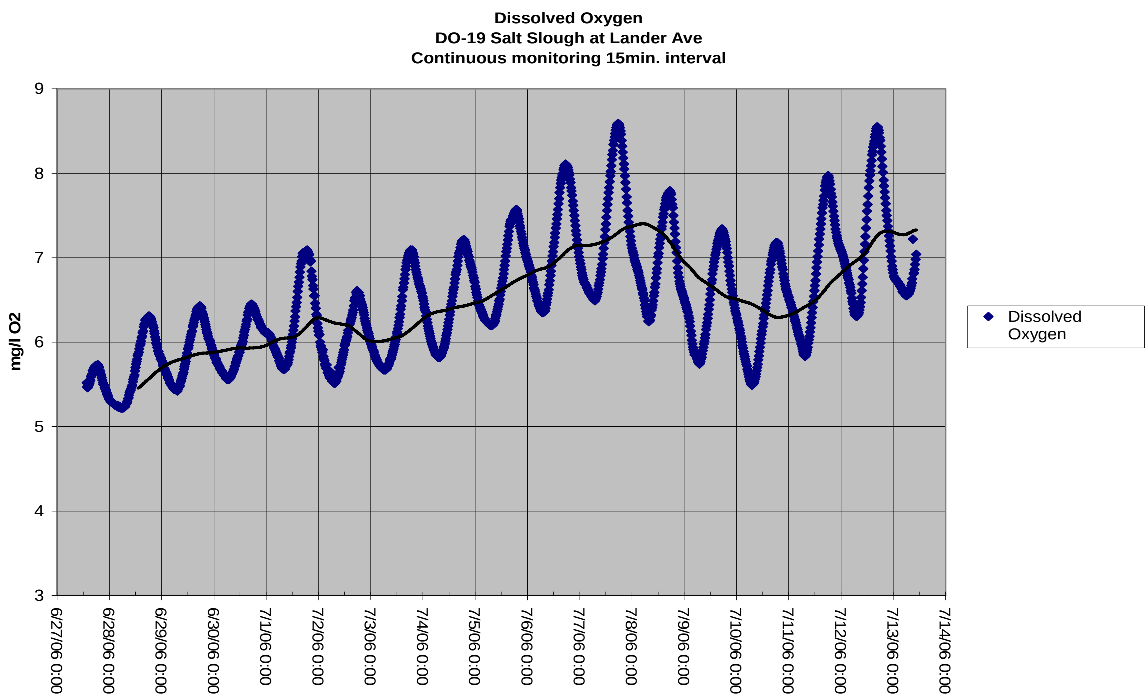


Fig.19G Salt Slough at Lander Ave., pH with 96 point moving average trend line. Includes all available 15 minute data from 06/27/06 to 07/13/06.

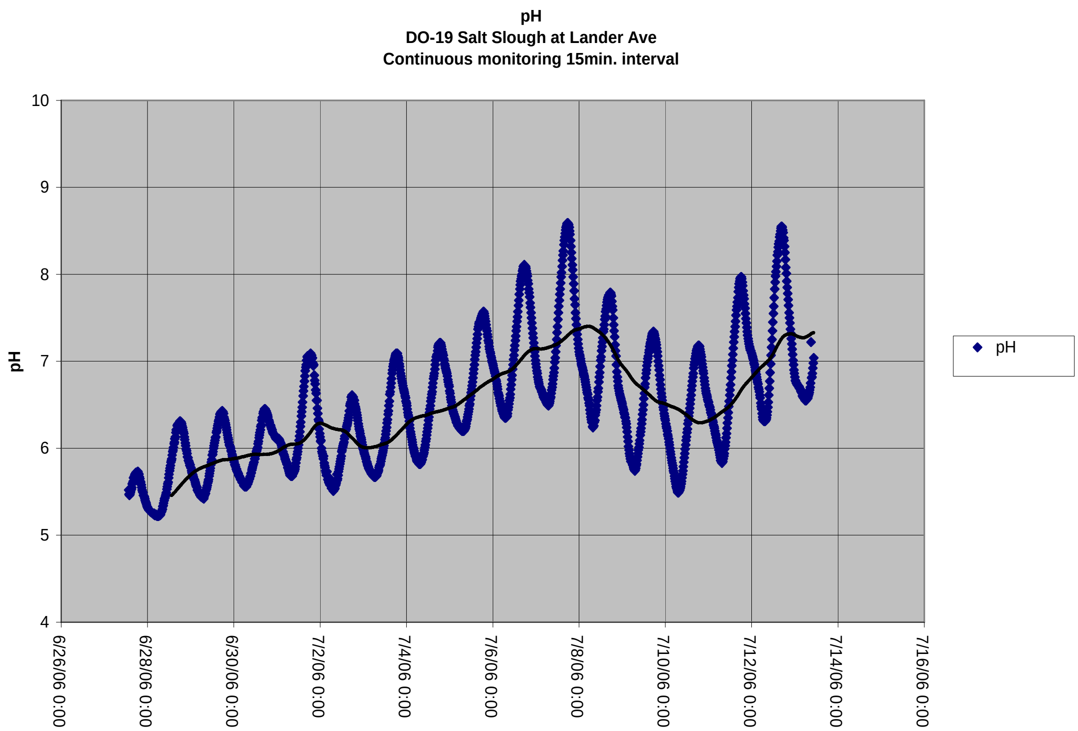


Fig.19H Salt Slough at Lander Ave., Specific Conductance (mS/cm). Includes all available 15 minute data from 06/27/06 to 07/13/06.

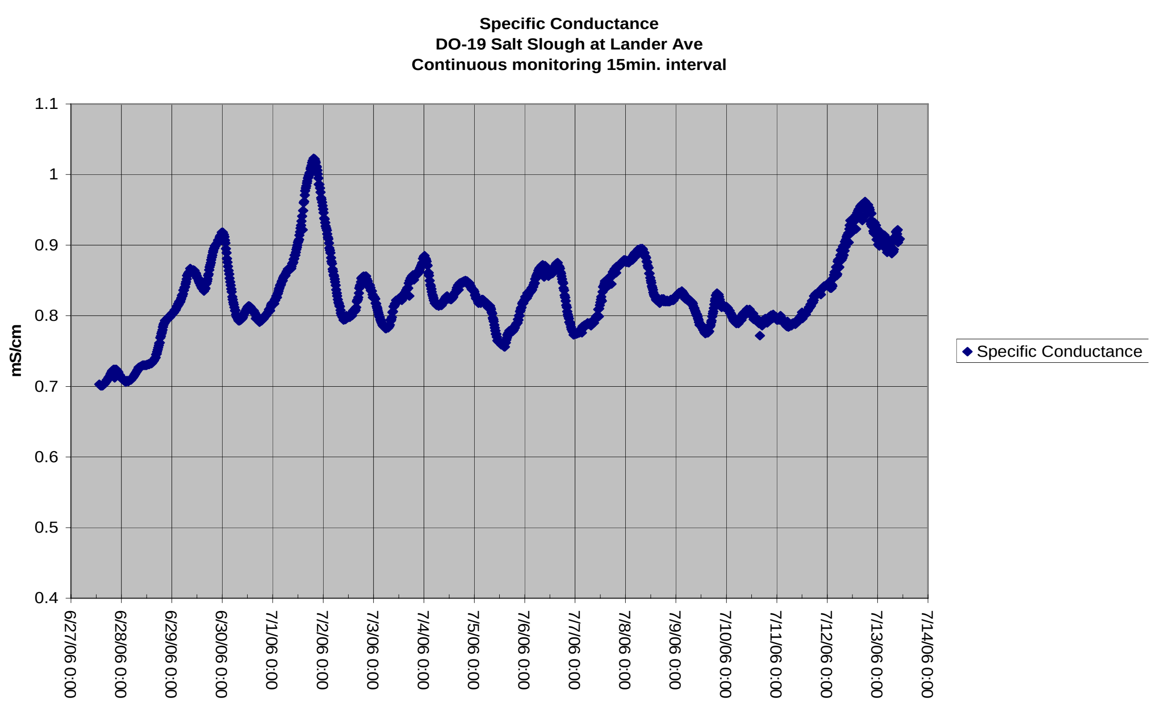


Fig.19ISalt Slough at Lander Ave., Temperature (Deg. C) with 96 point moving average trend lines. Includes all available 15 minute data from 06/27/06 to 07/13/06.

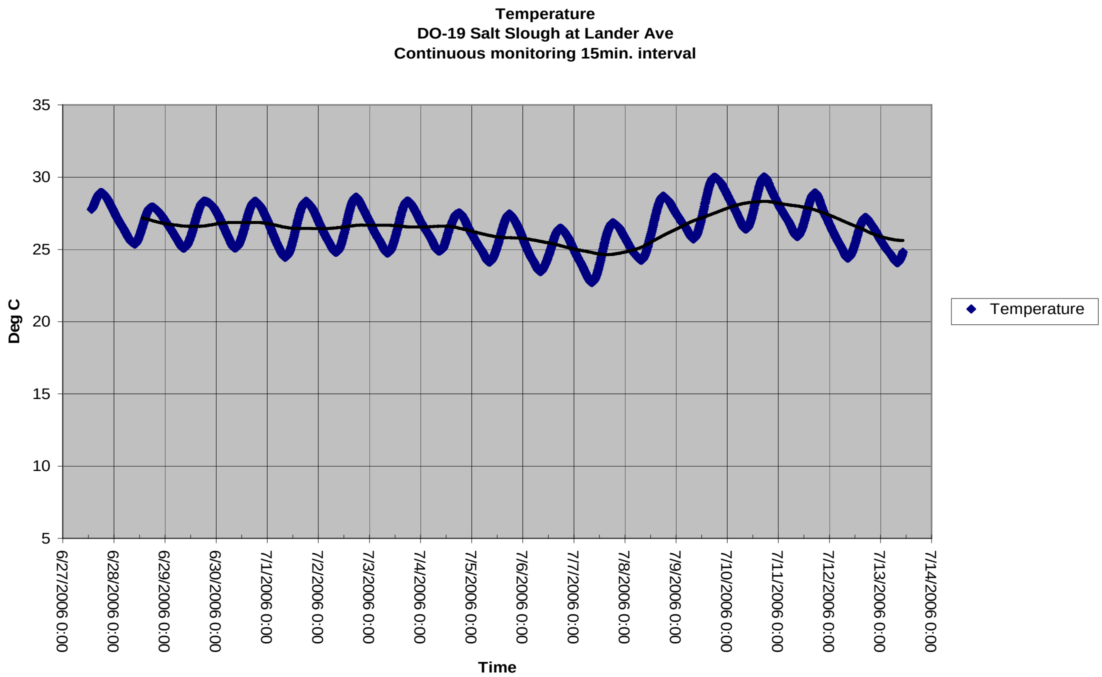


Fig.19J Salt Slough at Lander Ave., Temperature (Deg. C) and Fluorescence (%RFU) with 96 point moving average trend lines. Includes all available 15 minute data from 06/27/06 to 07/13/06.

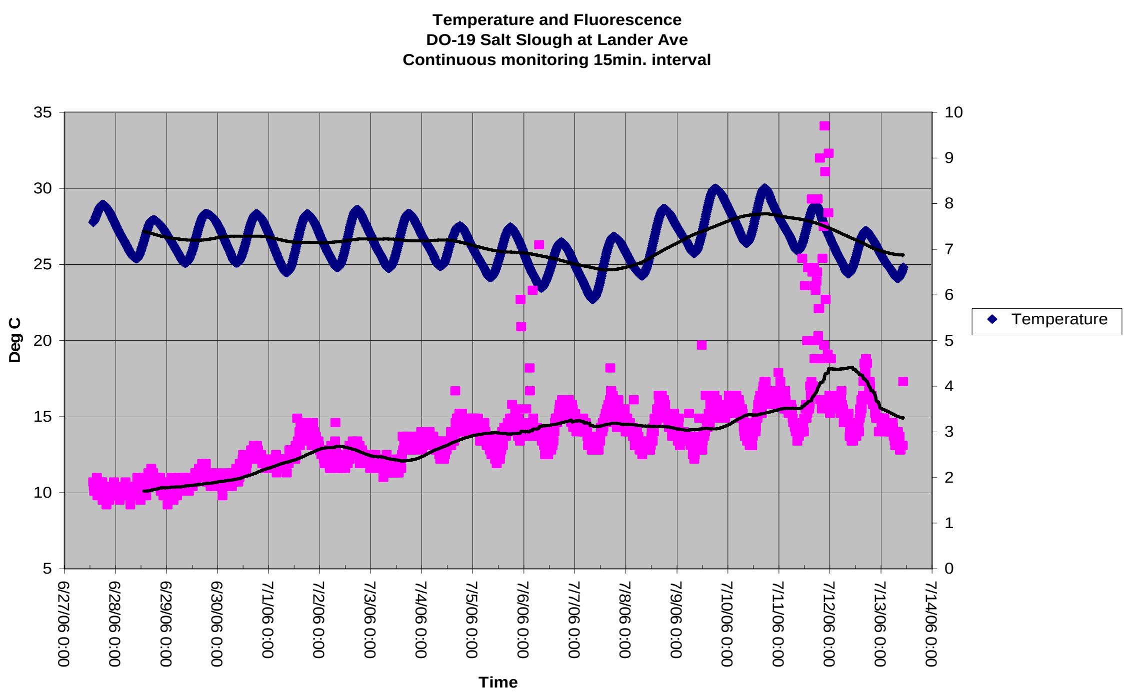


Table:44A Daily averages for sample site, DO-44 San Luis Drain End. Includes all available 15 minute data from 06/27/06 to 07/13/06

DO-44 San Luis Drain End

June 27, 2006 to July 13, 2006

Daily averages

Date	Temp	SpCond	TDS	DOsat	DO	DOchrg	Depth	pH	Orp	Turbid+	Chl	Chl	Battery	
	C	mS/cm	g/L	%	mg/L		feet		mV	NTU	ug/L	RFU	volts	
6/27/2006	29.79	4.64	3.02	158.04	11.82	48.40	2.37	8.42	138.62	14.24	25.55	5.97	12.94	Partial Day
6/28/2006	28.38	4.59	2.99	144.03	11.00	45.91	2.51	8.45	157.34	13.70	28.09	6.56	12.76	
6/29/2006	27.93	4.85	3.15	122.34	9.42	42.97	2.60	8.47	159.77	15.63	18.87	4.41	12.67	
6/30/2006	27.67	4.81	3.12	158.98	12.30	46.37	2.60	8.66	172.53	14.59	26.24	6.13	12.54	
7/1/2006	27.28	4.75	3.08	183.00	14.26	48.47	2.58	8.87	186.21	17.64	43.50	10.17	12.43	
7/2/2006	27.67	4.82	3.13	190.87	14.75	49.28	2.60	8.87	192.56	20.12	56.33	13.17	12.34	
7/3/2006	27.31	4.60	2.99	189.61	14.77	48.94	2.68	8.89	196.39	21.90	72.83	17.03	12.30	
7/4/2006	27.01	4.51	2.93	179.80	14.09	47.57	2.67	8.87	200.83	21.67	82.75	19.35	12.27	
7/5/2006	26.77	4.44	2.88	169.81	13.36	46.39	2.61	8.83	201.08	21.61	71.30	16.67	12.18	
7/6/2006	26.17	4.18	2.72	163.83	13.05	45.42	2.69	8.81	203.70	23.71	76.83	17.96	12.10	
7/7/2006	25.86	4.34	2.82	162.91	13.03	44.96	2.74	8.82	203.19	25.46	85.30	19.94	12.02	
7/8/2006	26.42	4.23	2.75	174.72	13.82	46.04	2.62	8.82	205.63	23.95	101.34	23.69	12.00	
7/9/2006	27.58	4.09	2.66	172.02	13.35	46.27	2.47	8.79	206.44	23.20	95.61	22.36	11.99	
7/10/2006	28.40	4.02	2.62	150.70	11.53	44.47	2.48	8.73	201.25	25.66	86.55	20.23	11.88	
7/11/2006	28.04	4.34	2.82	132.85	10.23	42.53	2.54	8.72	188.03	31.41	90.81	21.23	11.69	
7/12/2006	27.11	4.61	3.00	118.51	9.27	40.66	2.61	8.68	192.65	24.80	68.75	16.08	11.58	
7/13/2006	26.32	4.23	2.75	82.03	6.53	37.08	2.61	8.48	190.02	19.48	31.80	7.44	11.60	Partial Day

Fig.44A San Luis Drain End, Flow. Includes all available data from 06/27/06 to 07/13/06.

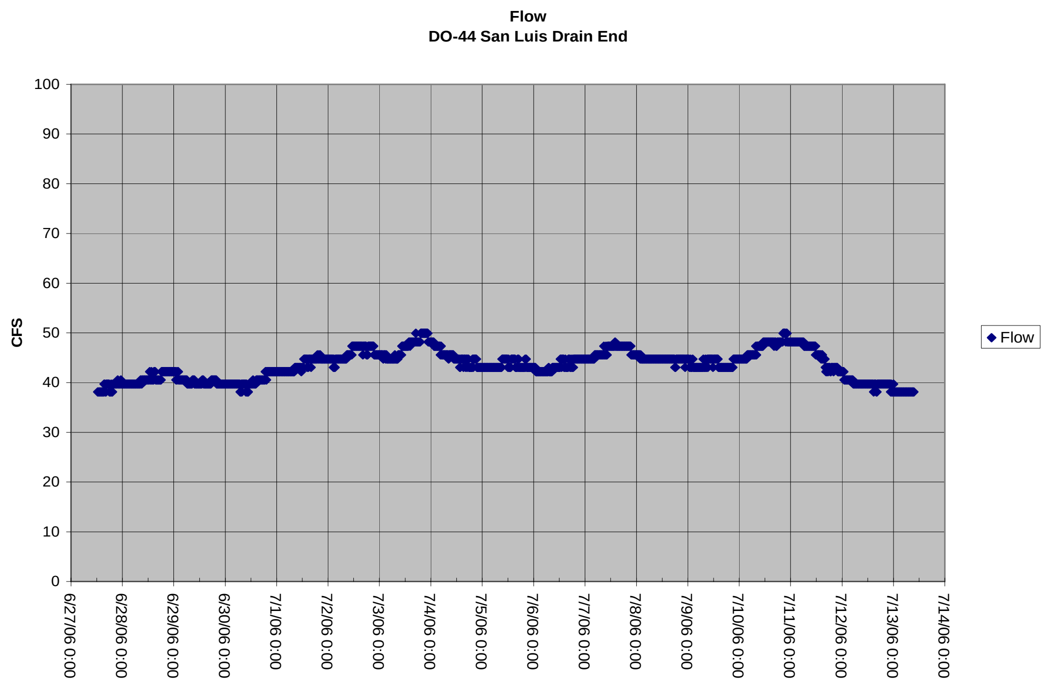


Fig.44B San Luis Drain End, Turbidity (NTU) and Relative Fluorescence Units (RFU) with 96 point moving average trend lines. Includes all available 15 minute data from 06/27/06 to 07/13/06.

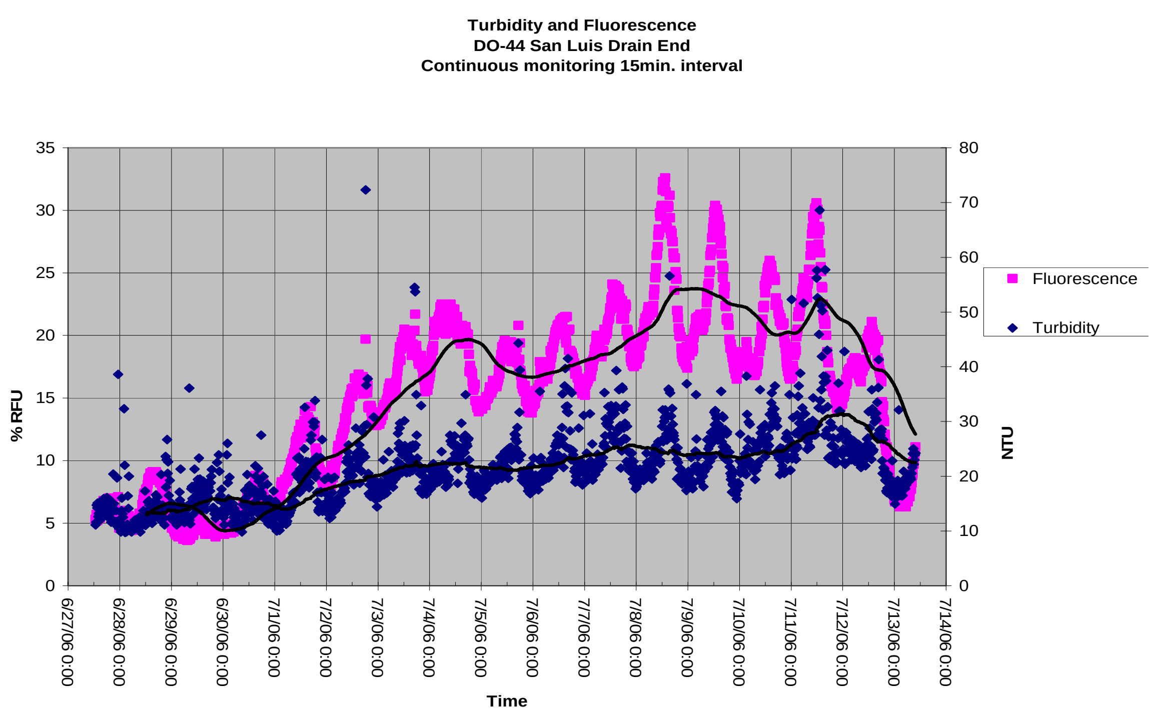


Fig.44C San Luis Drain End, Turbidity (NTU) with 96 point moving average trend line. Includes all available 15 minute data from 06/27/06 to 07/13/06.

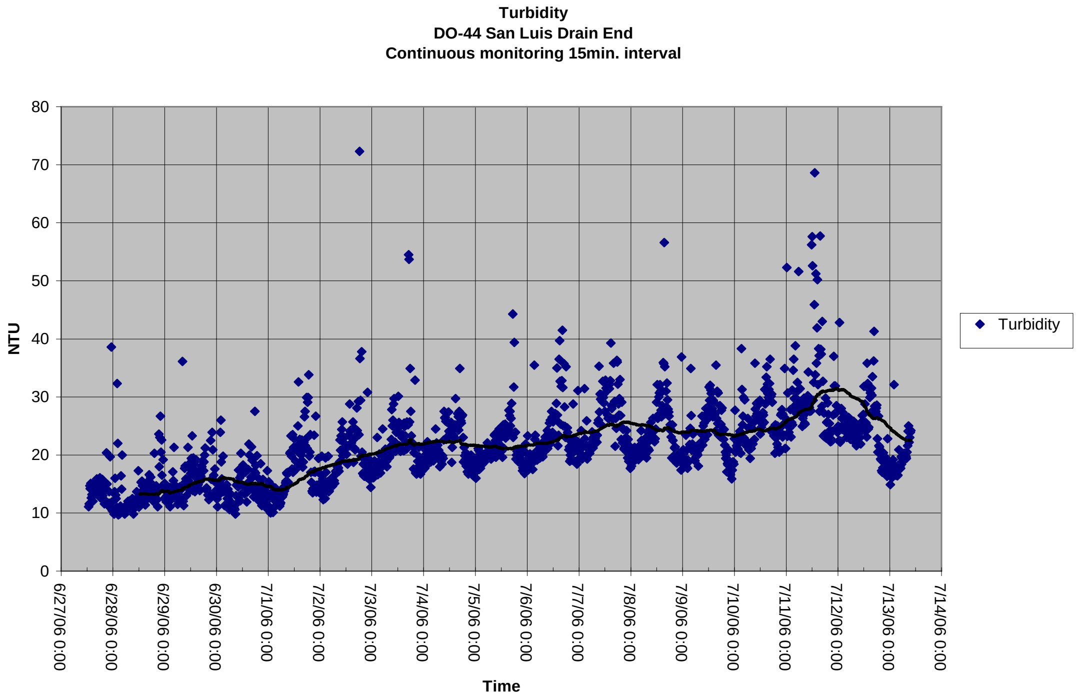


Fig.44D San Luis Drain End, Relative Fluorescence Units (RFU) with 96 point moving average trend line. Includes all available 15 minute data from 06/27/06 to 07/13/06.

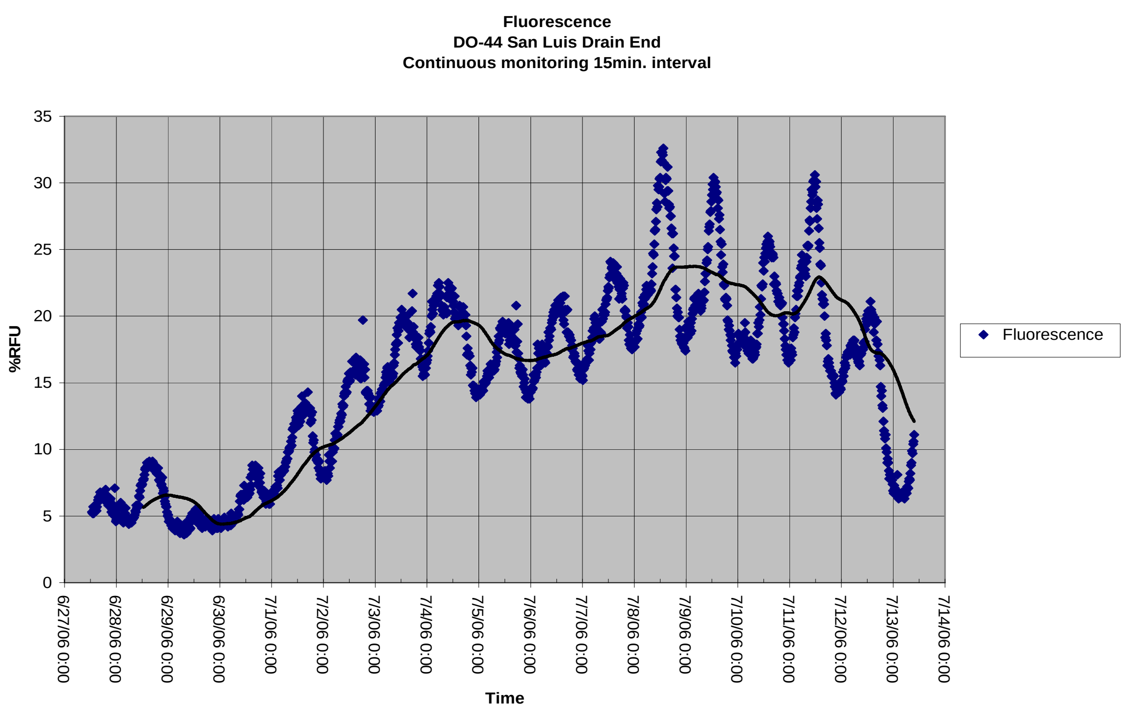


Fig.44E San Luis Drain End, Dissolved Oxygen (mg/l) and pH with 96 point moving average trend lines. Includes all available 15 minute data from 06/27/06 to 07/13/06.

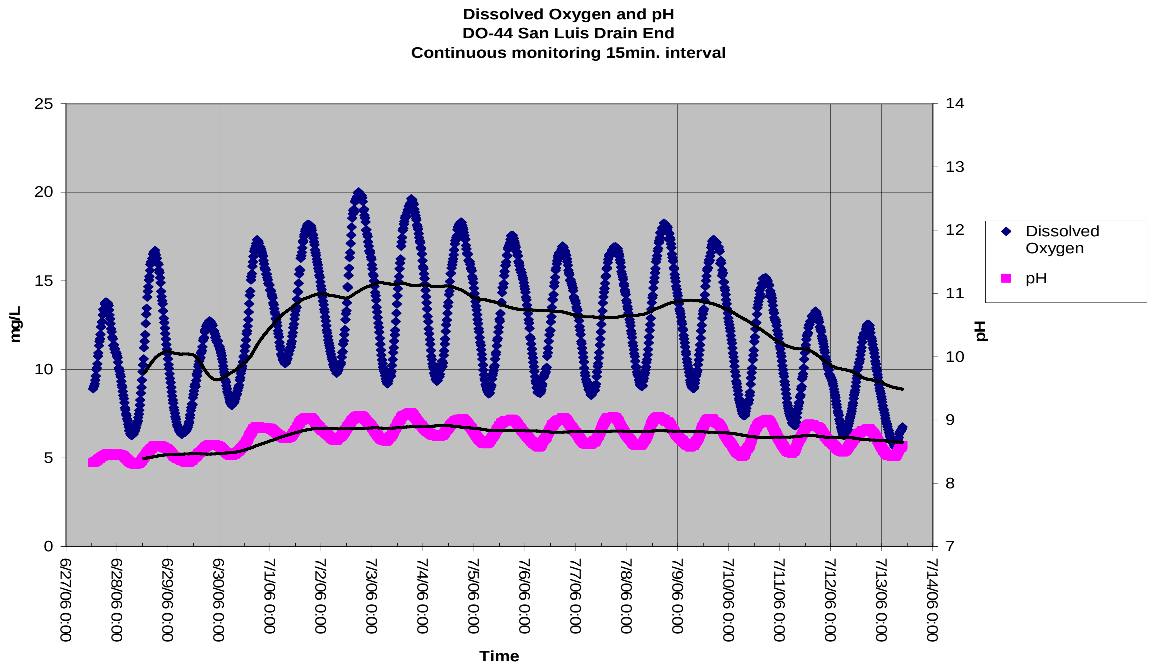


Fig.44F San Luis Drain End, pH with 96 point moving average trend line. Includes all available 15 minute data from 06/27/06 to 07/13/06.

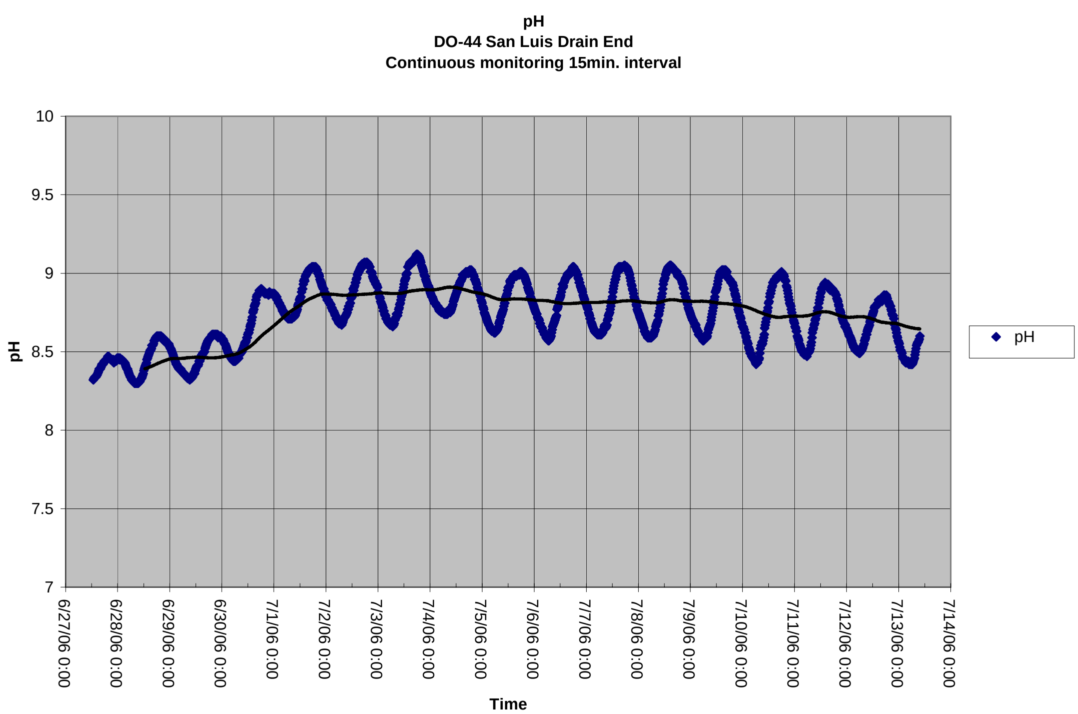


Fig.44G San Luis Drain End, Dissolved Oxygen (mg/l) with 96 point moving average trend line. Includes all available 15 minute data from 06/27/06 to 07/13/06.

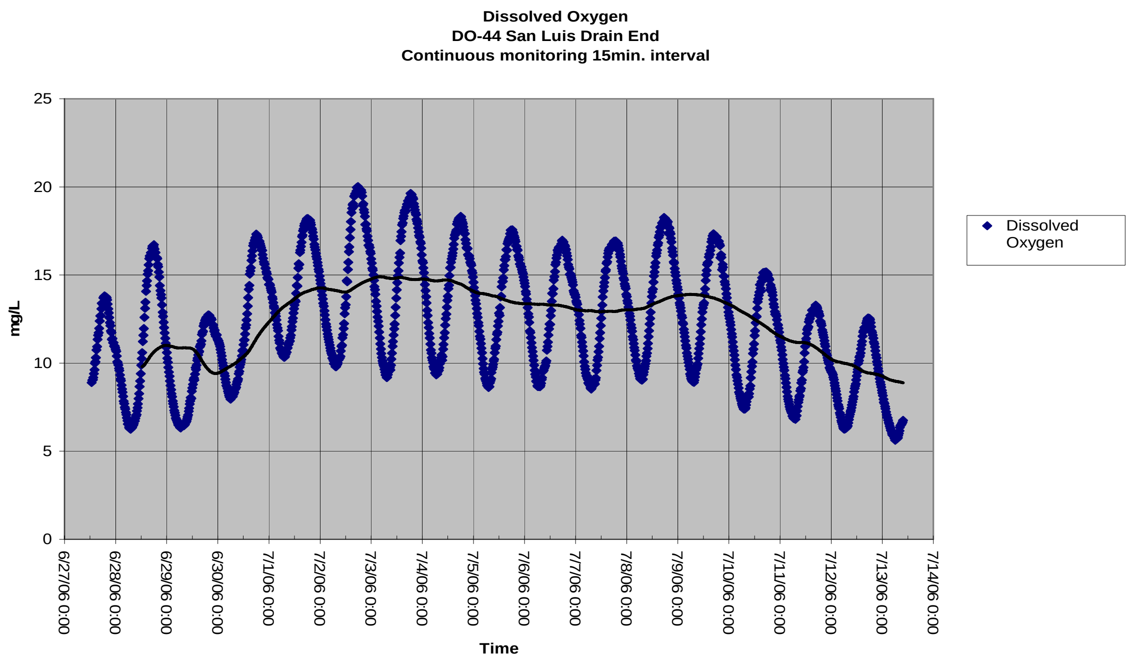


Fig.44H San Luis Drain End, Specific Conductance (mS/cm). Includes all available 15 minute data from 06/27/06 to 07/13/06.

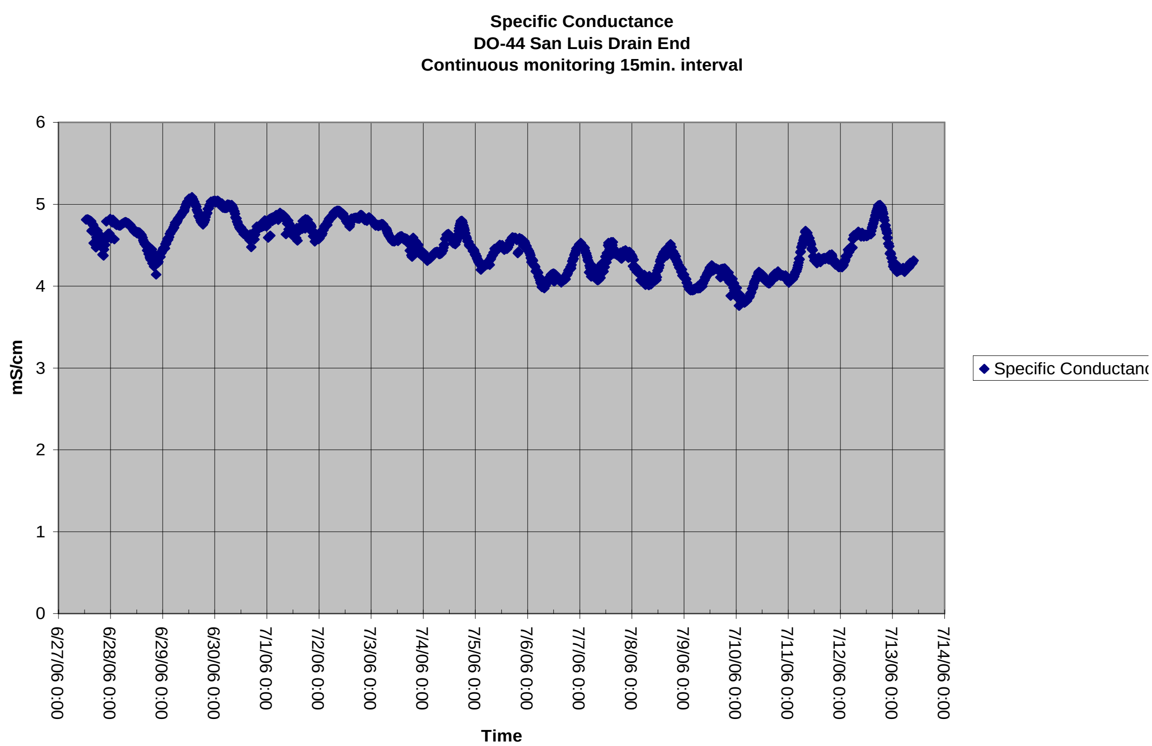


Fig.44I San Luis Drain End, Temperature (Deg. C). Includes all available 15 minute data from 06/27/06 to 07/13/06.

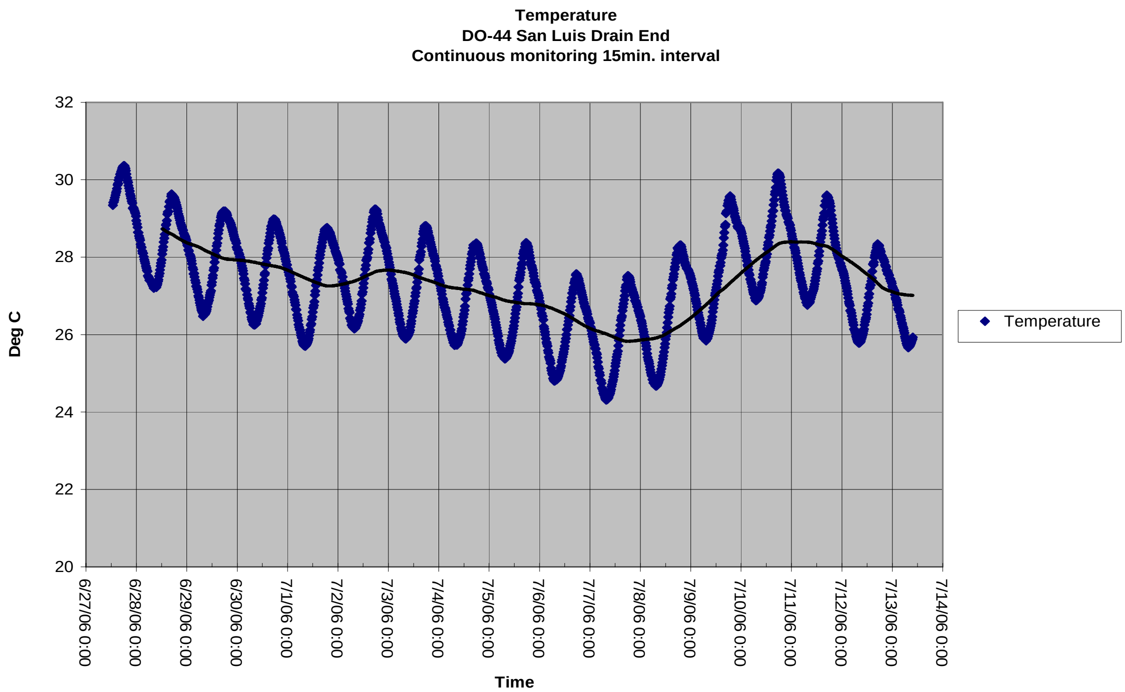


Fig.44J San Luis Drain End, Temperature (Deg. C) and Relative Fluorescence Units (%RFU) with 96 point moving average trend lines. Includes all available 15 minute data from 06/27/06 to 07/13/06.

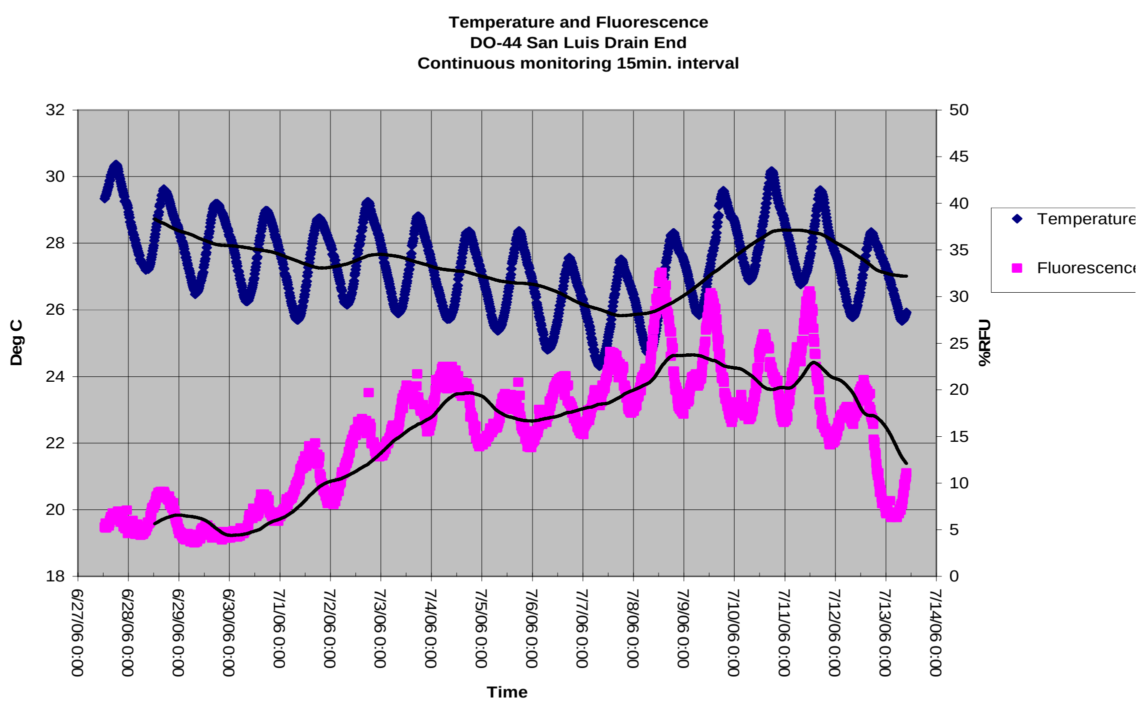


Table:5B Daily Averages for Sample Site DO-05 San Joaquin River at Vernalis. Includes all available 15 minute data from 07/13/06 to 07/25/06

DO-05 SJR at Vernalis

July 13, 2006 to July 25, 2006

Daily averages

Date	Temp	SpCond	TDS	DOsat	DO	DOchrg	Depth	pH	Orp	Turbid+	Chl	Chl	Battery	Flow	
	C	mS/cm	g/L	%	mg/L		feet		mV	NTU	ug/L	RFU	volts	CFS	
7/13/2006	22.35	0.46	0.30	121.85	10.57	27.69	3.82	7.83	265.02	30.08	15.76	4.48	12.69	4712.93	Partial Day
7/14/2006	22.18	0.43	0.28	110.64	9.63	27.89	3.80	7.71	243.00	29.43	13.09	3.73	12.57	5509.79	
7/15/2006	22.44	0.42	0.28	105.88	9.17	27.74	3.78	7.83	245.47	26.85	14.17	4.03	12.44	6549.40	
7/16/2006	22.70	0.42	0.28	100.34	8.64	27.70	3.65	7.89	250.35	22.67	13.84	3.94	12.32	6378.23	
7/17/2006	23.11	0.42	0.27	100.09	8.55	27.64	3.52	8.05	252.46	19.61	16.31	4.64	12.29	5531.95	
7/18/2006	23.60	0.43	0.28	99.46	8.42	27.72	3.31	8.07	259.50	21.36	16.35	4.66	12.21	4318.65	
7/19/2006	23.88	0.43	0.28	100.01	8.43	27.67	3.23	8.17	261.93	20.13	17.93	5.10	12.13	4409.06	
7/20/2006	24.01	0.43	0.28	100.41	8.44	27.69	3.17	8.27	262.33	20.03	18.36	5.22	12.05	4808.25	
7/21/2006	24.45	0.44	0.28	98.72	8.23	27.49	3.03	8.30	270.37	18.99	17.09	4.86	12.00	4310.96	
7/22/2006	25.10	0.47	0.30	95.47	7.86	27.15	2.88	8.21	286.82	16.90	16.36	4.66	11.97	4158.33	
7/23/2006	25.61	0.46	0.30	92.35	7.53	26.49	2.86	8.17	298.49	15.37	17.23	4.91	11.74	4170.31	
7/24/2006	25.80	0.45	0.29	95.48	7.76	26.25	2.65	8.38	298.27	12.07	21.27	6.05	11.69	4072.08	
7/25/2006	25.27	0.46	0.30	91.30	7.50	25.76	2.55	8.46	290.86	10.33	25.22	7.18	11.40	3913.88	partial day

Fig.5K San Joaquin River at Vernalis, Flow from CDEC database. Includes all available 15 minute data from 07/13/06 to 07/25/06.

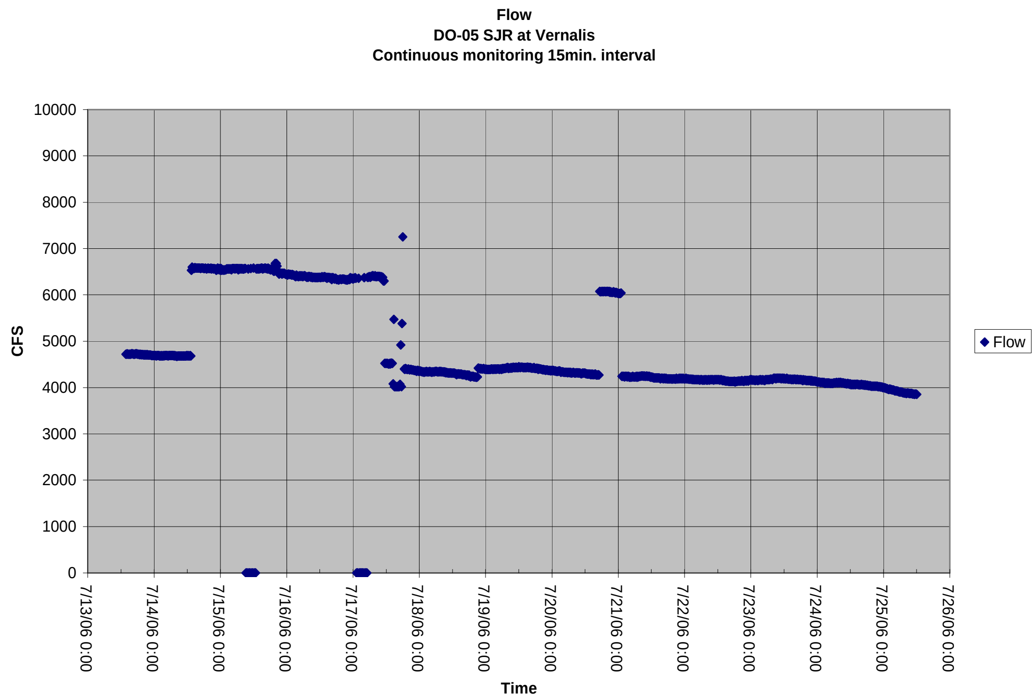


Fig.5L San Joaquin River at Vernalis, Relative Fluorescence Units (%RFU) and Turbidity (NTU) with 96 point moving average trend lines. Includes all available 15 minute data from 07/13/06 to 07/25/06.

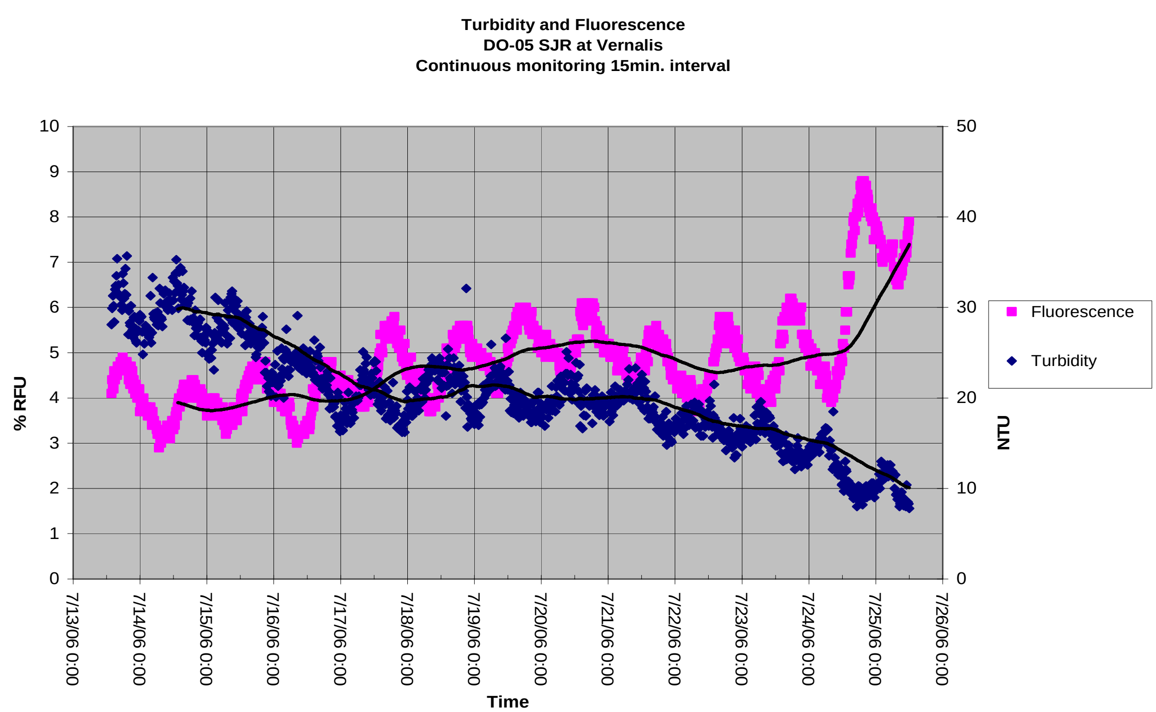


Fig.5M San Joaquin River at Vernalis, Turbidity (NTU) with 96 point moving average trend line. Includes all available 15 minute data from 07/13/06 to 07/25/06.

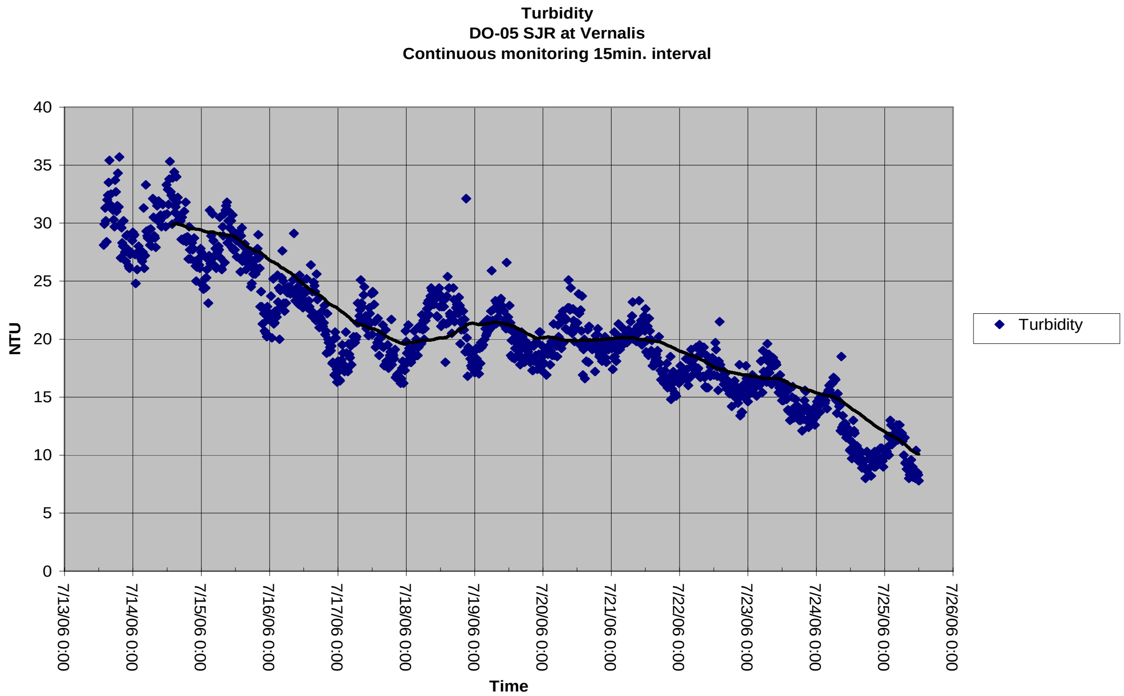


Fig.5N San Joaquin River at Vernalis, Relative Fluorescence Units (%RFU) with 96 point moving average trend line. Includes all available 15 minute data from 07/13/06 to 07/25/06.

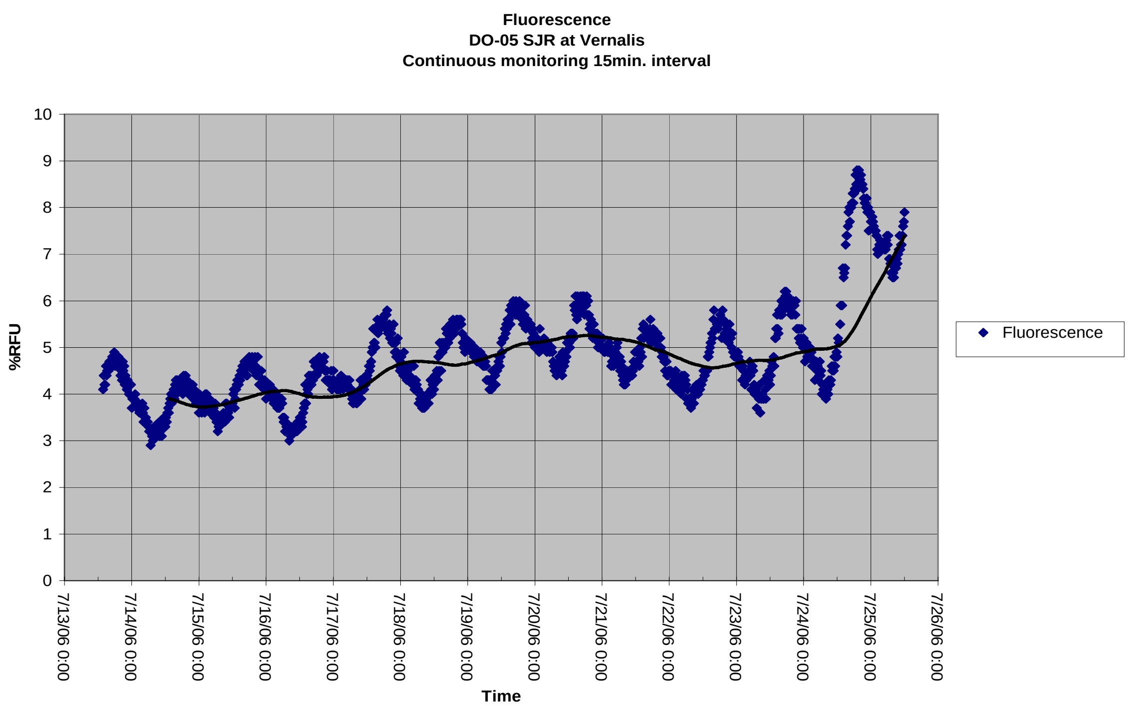


Fig.5O San Joaquin River at Vernalis, Dissolved Oxygen (mg/l) and pH with 96 point moving average trend line. Includes all available 15 minute data from 07/13/06 to 07/25/06.

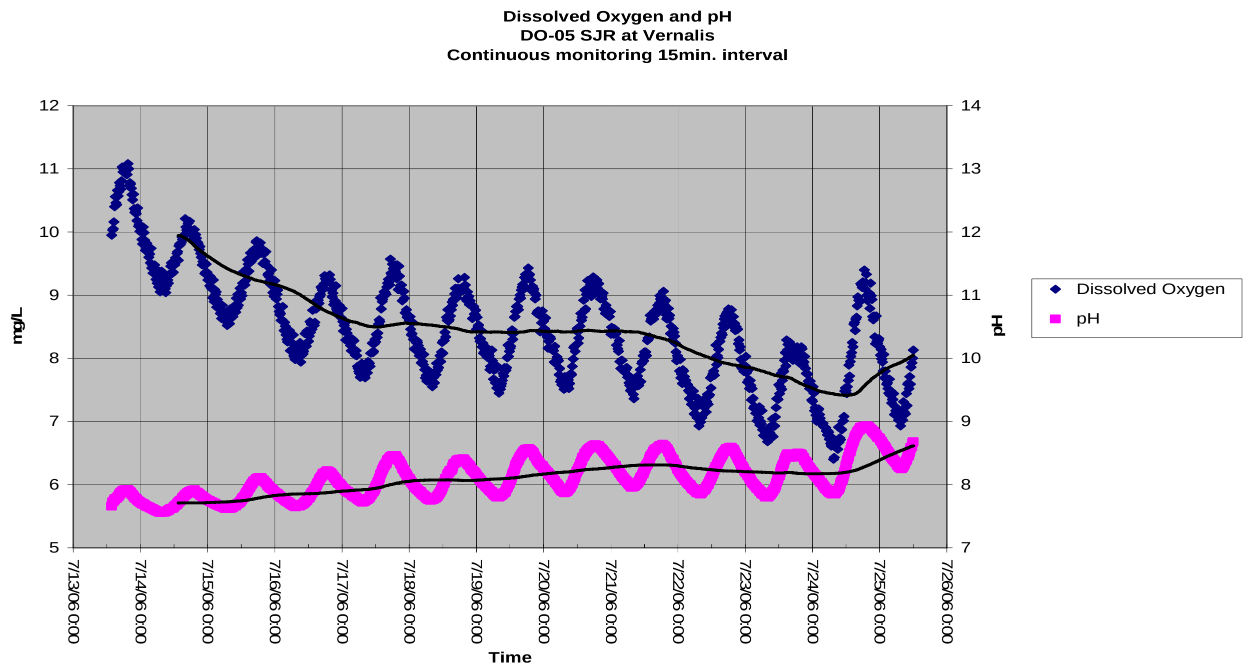


Fig.5P San Joaquin River at Vernalis, pH with 96 point moving average trend line. Includes all available 15 minute data from 07/13/06 to 07/25/06.

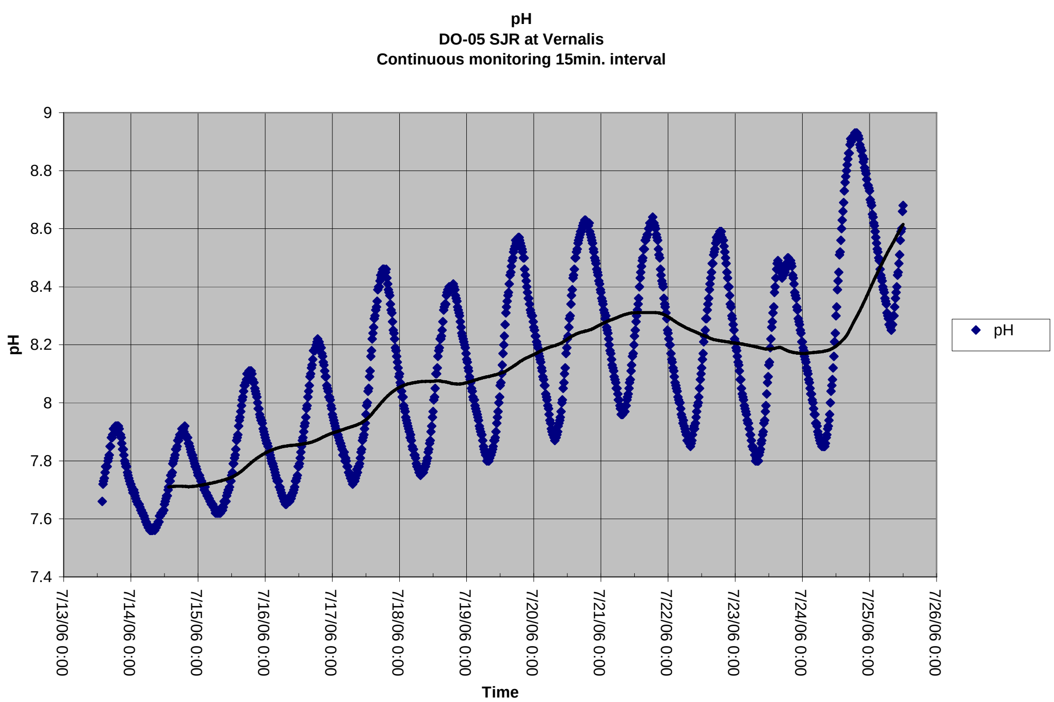


Fig.5Q San Joaquin River at Vernalis, Dissolved Oxygen (mg/l) moving average trend line. Includes all available 15 minute data from 07/13/06 to 07/25/06.

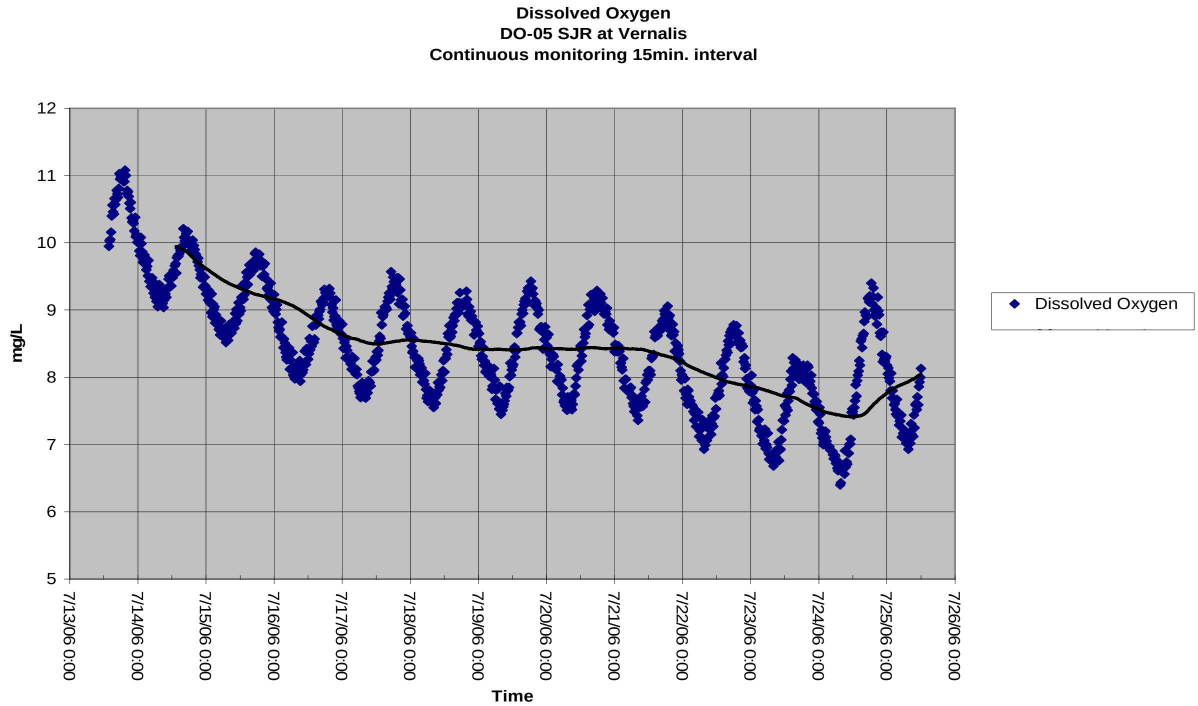


Fig.5R San Joaquin River at Vernalis Specific Conductance (mS/cm). Includes all available 15 minute data from 07/13/06 to 07/25/06.

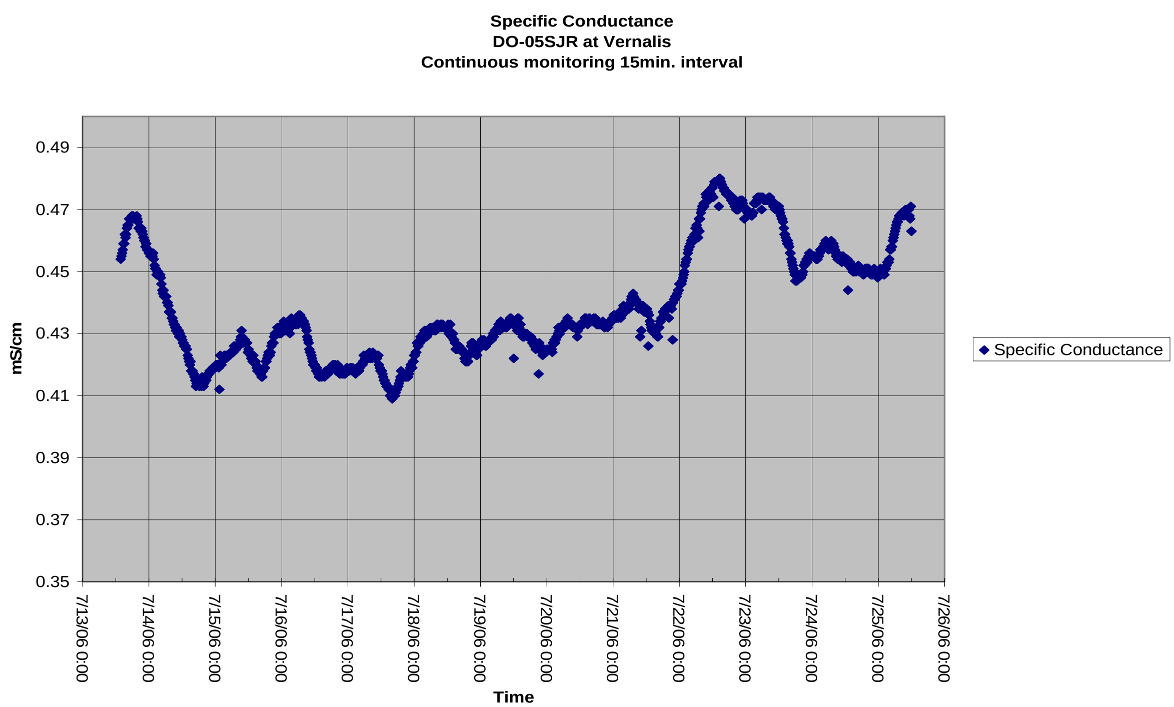


Fig.5S San Joaquin River at Vernalis Temperature (Deg. C). Includes all available 15 minute data from 07/13/06 to 07/25/06.

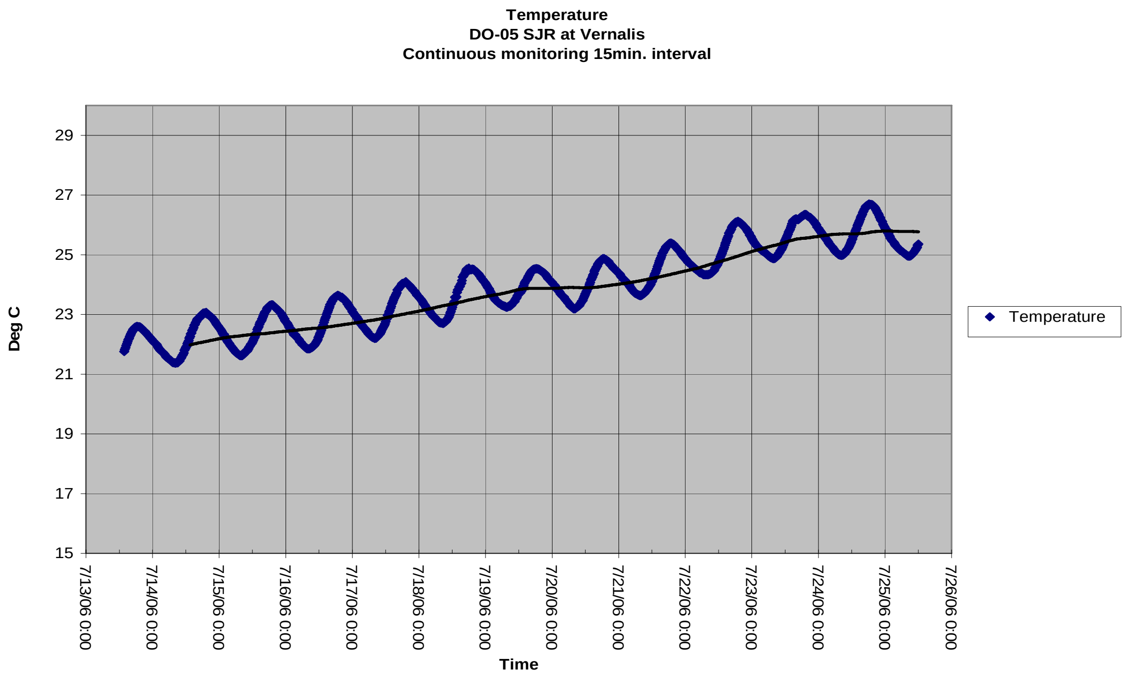


Fig.5T San Joaquin River at Vernalis, Temperature (Deg. C) and Relative Fluorescence Units (%RFU). Includes all available 15 minute data from 07/13/06 to 07/25/06.

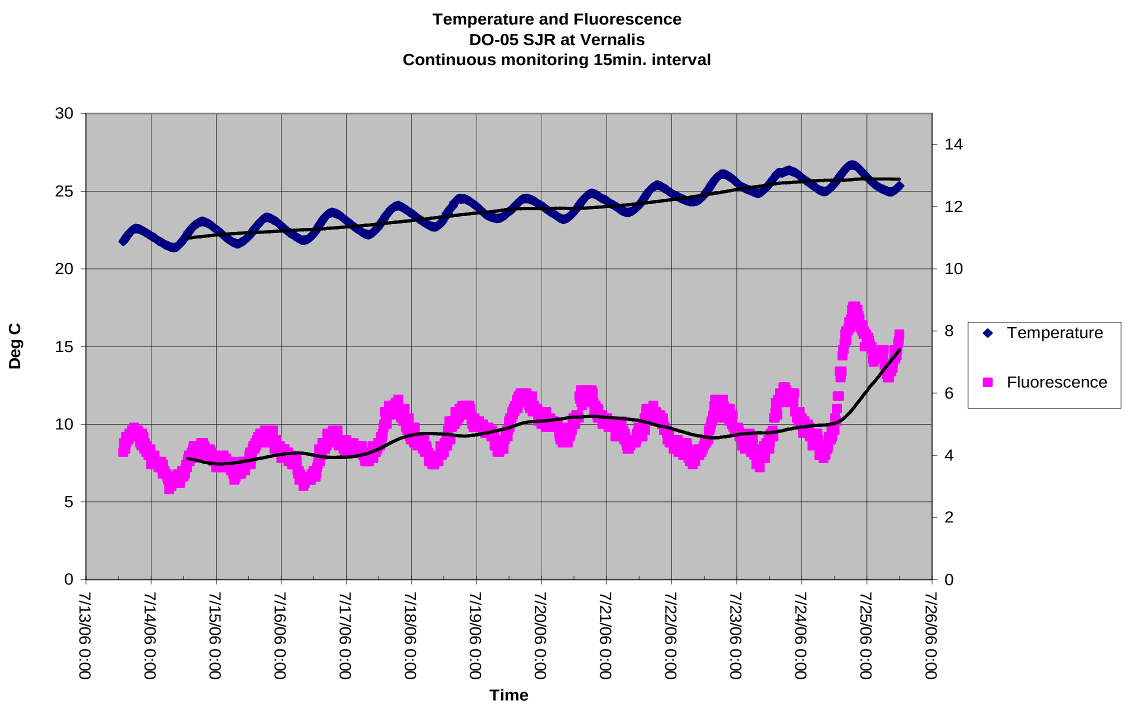


Table:7B Daily Averages for Sample Site DO-07 San Joaquin River at Patterson. Includes all available 15 minute data from 07/13/06 to 07/25/06.

DO-07 SJR at Patterson

July 13, 2006 to July 25, 2006

Daily averages

Date	Temp	SpCond	TDS	DOsat	DO	DOchrg	Depth	pH	Orp	Turbid+	Chl	Chl	Battery	Flow	
	C	mS/cm	g/L	%	mg/L		feet		mV	NTU	ug/L	RFU	volts	CFS	
7/13/2006	25.57	0.82	0.53	112.41	9.17	42.21	2.75	7.84	160.60	38.98	17.88	4.71	12.80	1591.84	Partial Day
7/14/2006	25.44	0.84	0.55	109.98	8.98	41.17	2.72	7.81	167.24	34.34	17.48	4.60	12.71	1580.64	
7/15/2006	25.38	0.82	0.54	112.15	9.17	40.43	2.67	7.87	168.51	28.48	16.07	4.23	12.64	1552.49	
7/16/2006	25.39	0.79	0.52	118.84	9.72	40.51	2.63	7.98	174.65	25.57	17.02	4.48	12.55	1509.77	
7/17/2006	25.82	0.79	0.51	122.29	9.92	39.99	2.55	8.01	175.64	30.80	17.31	4.55	12.44	1507.33	
7/18/2006	26.38	0.78	0.51	127.46	10.23	39.63	2.41	8.05	190.55	27.22	18.12	4.77	12.35	1461.66	
7/19/2006	26.86	0.80	0.52	132.63	10.56	39.18	2.30	8.14	181.80	31.22	19.76	5.20	12.30	1411.17	
7/20/2006	26.87	0.83	0.54	136.16	10.83	38.96	2.23	8.23	181.56	37.68	20.35	5.36	12.30	1350.69	
7/21/2006	27.24	0.87	0.56	124.64	9.85	37.41	2.12	8.09	178.38	144.32	17.66	4.65	12.25	1315.84	
7/22/2006	28.14	0.86	0.56	122.69	9.54	36.26	2.01	8.08	176.42	241.22	17.46	4.59	12.19	1297.11	
7/23/2006	29.08	0.89	0.58	134.72	10.30	35.25	1.70	8.25	172.64	77.93	26.30	6.92	12.13	1193.88	
7/24/2006	29.60	0.99	0.64	134.08	10.16	30.45	1.42	8.43	169.41	79.10	38.55	10.14	12.09	1104.79	
7/25/2006	29.23	1.05	0.68	98.94	7.55	25.55	1.29	8.17	173.74	32.24	36.05	9.49	12.06	1059.52	Partial Day

Fig.7K San Joaquin River at Patterson, Flow (CFS) from CDEC database. Includes all available 15 minute data from 07/13/06 to 07/25/06.

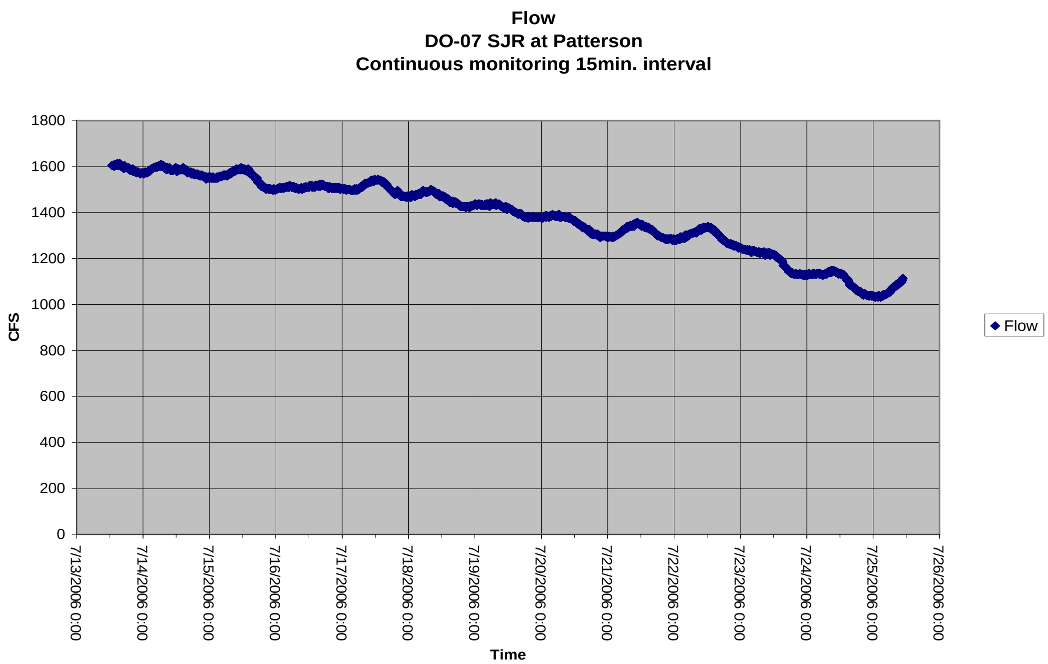


Fig.7L San Joaquin River at Patterson, Turbidity (NTU) and Relative Fluorescence Units (%RFU) with 96 point moving average trend lines. Includes all available 15 minute data from 07/13/06 to 07/25/06.

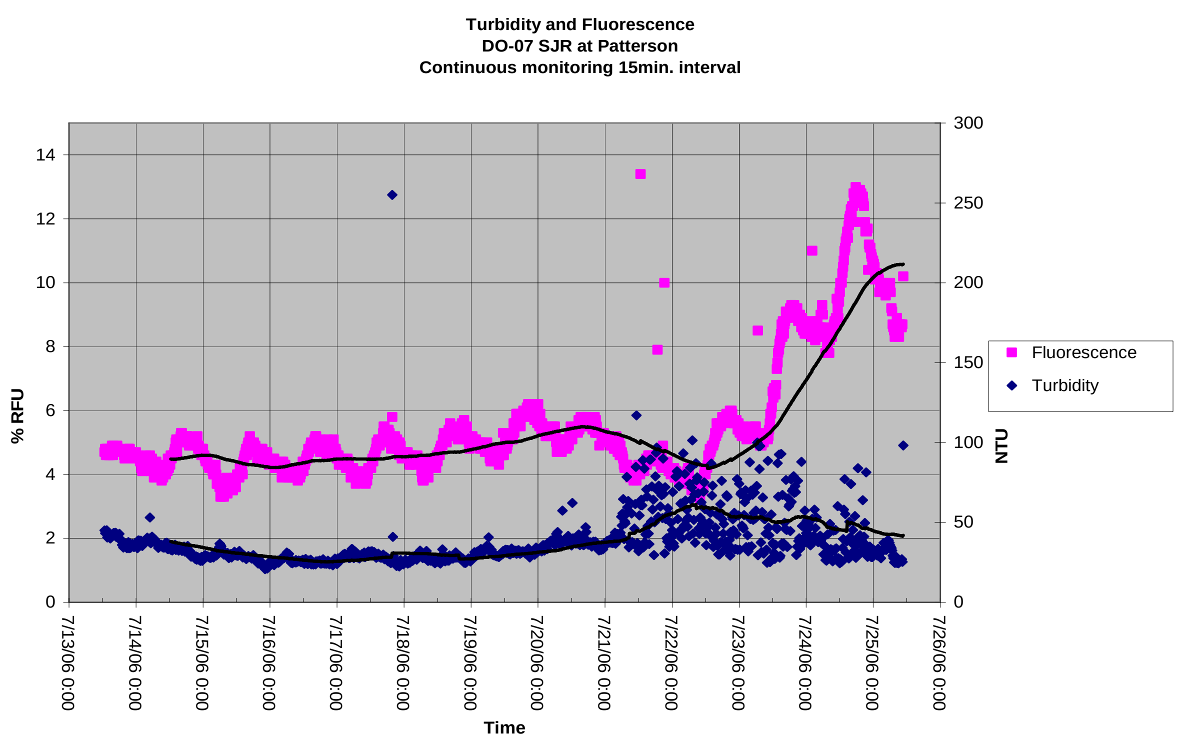


Fig.7M San Joaquin River at Patterson, Turbidity (NTU) with 96 point moving average trend line. Includes all available 15 minute data from 07/13/06 to 07/25/06.

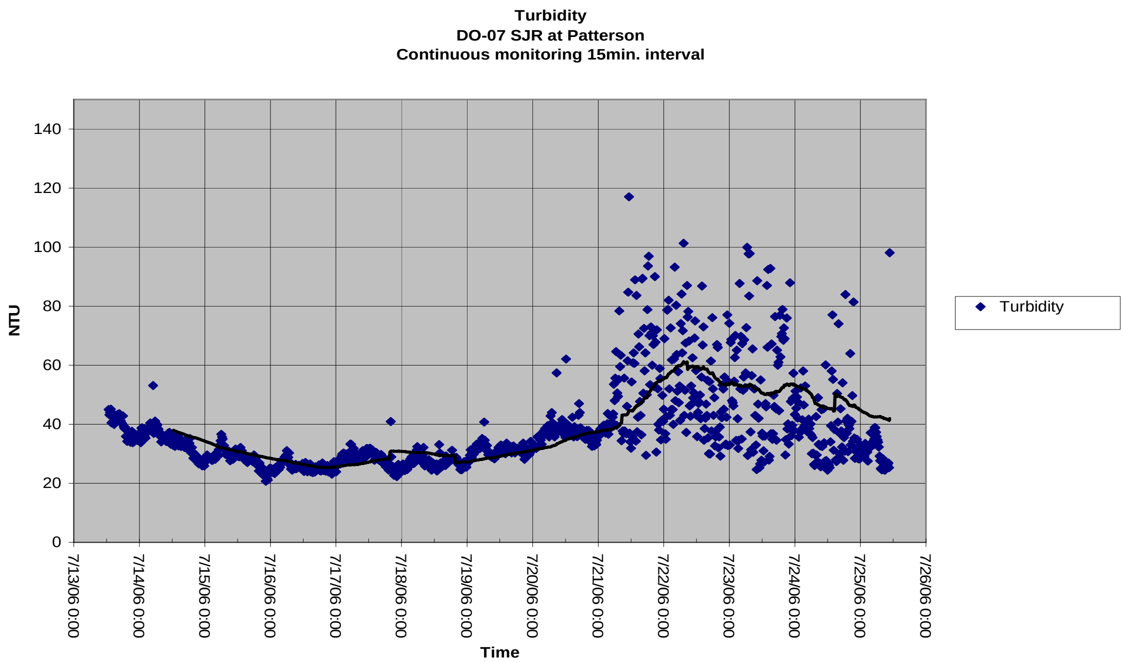


Fig.7N San Joaquin River at Patterson, Relative Fluorescence Units (%RFU) with 96 point moving average trend line. Includes all available 15 minute data from 07/13/06 to 07/25/06.

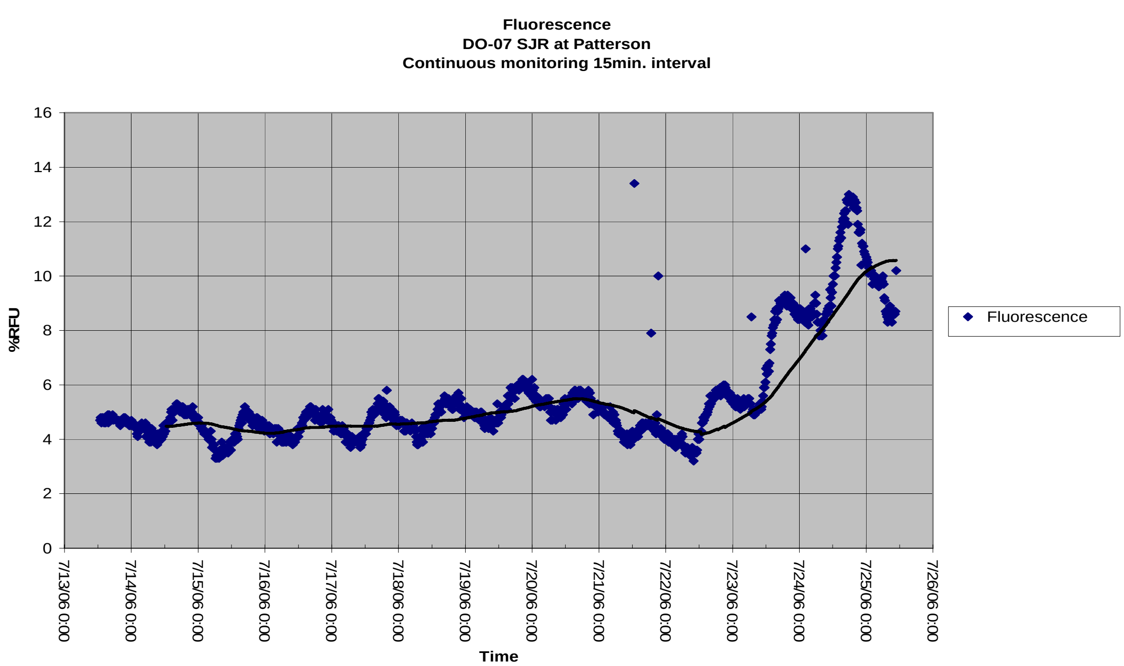


Fig.7O San Joaquin River at Patterson, Dissolved Oxygen (mg/l) and pH with 96 point moving average trend lines. Includes all available 15 minute data from 07/13/06 to 07/25/06.

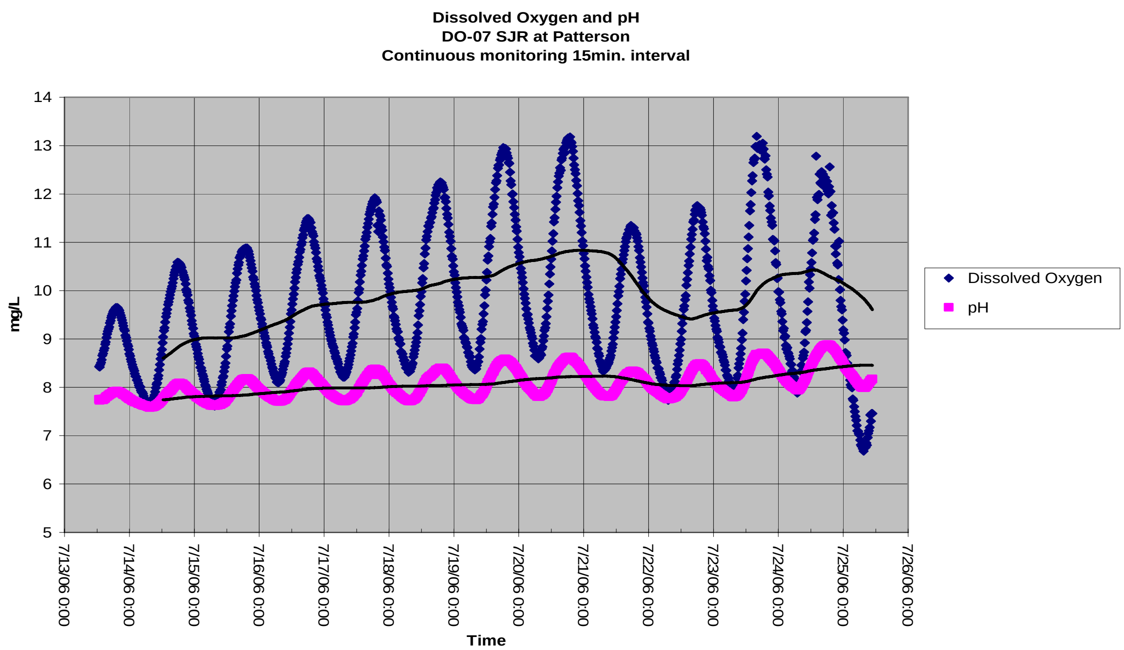


Fig.7P San Joaquin River at Patterson, Dissolved Oxygen (mg/l) with 96 point moving average trend lines. Includes all available 15 minute data from 07/13/06 to 07/25/06.

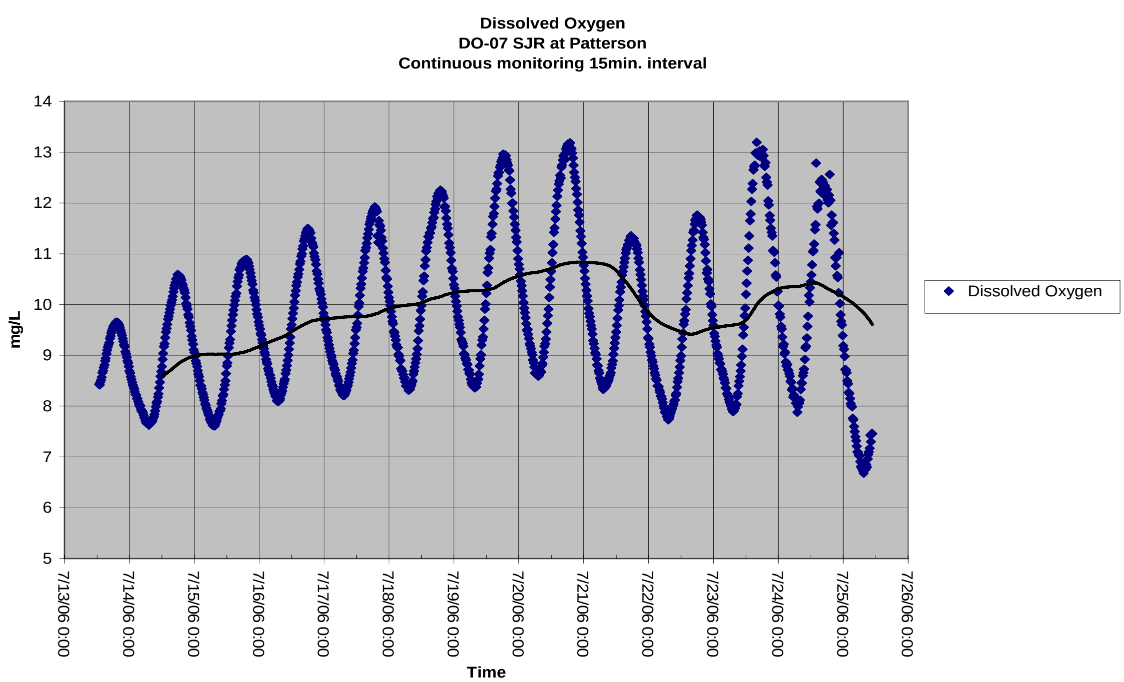


Fig.7Q San Joaquin River at Patterson, pH with 96 point moving average trend line. Includes all available 15 minute data from 07/13/06 to 07/25/06.

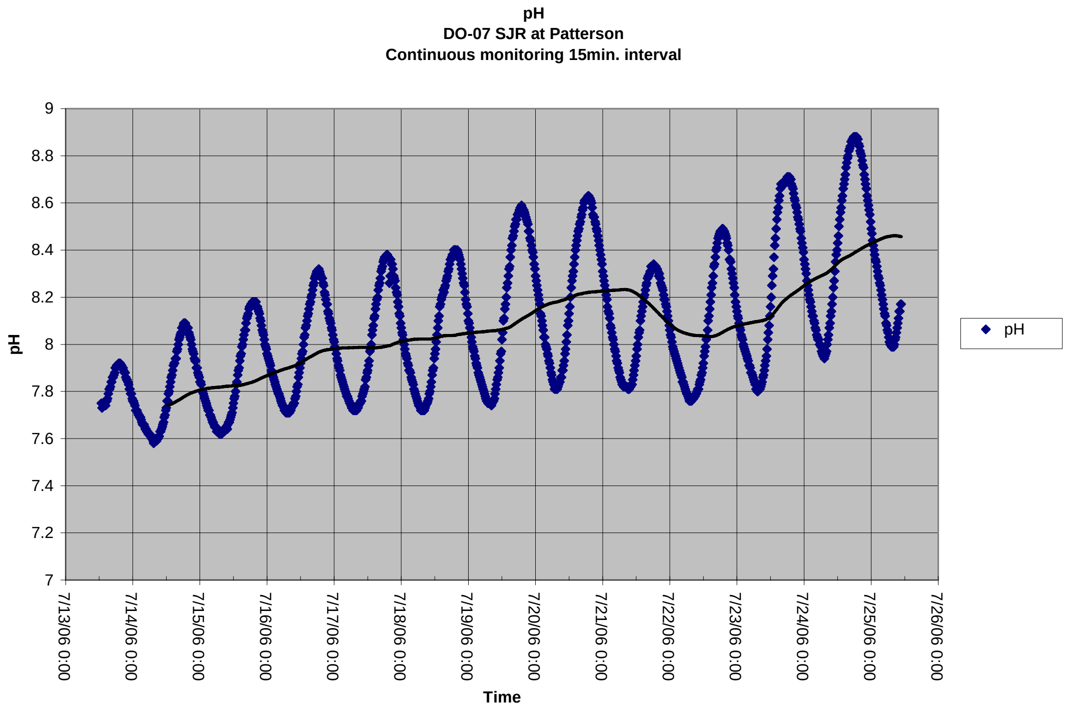


Fig.7R San Joaquin River at Patterson, Specific Conductance (mS/cm). Includes all available 15 minute data from 07/13/06 to 07/25/06.

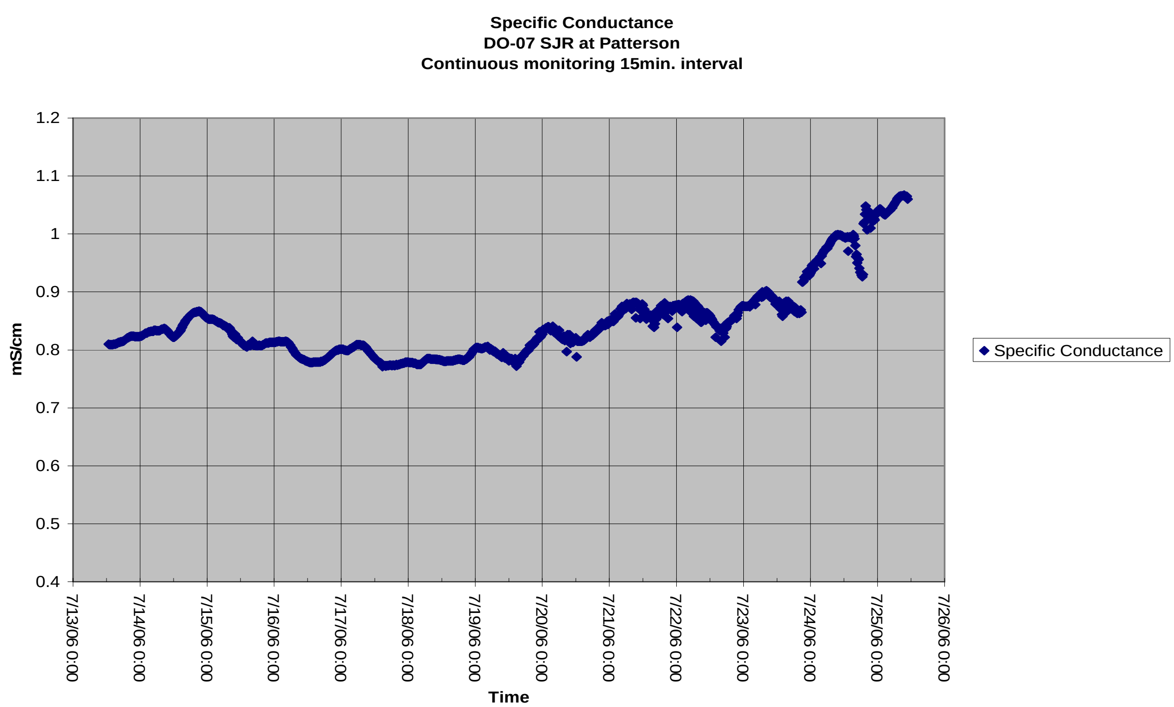


Fig.7S San Joaquin River at Patterson, Temperature (Deg. C). Includes all available 15 minute data from 07/13/06 to 07/25/06.

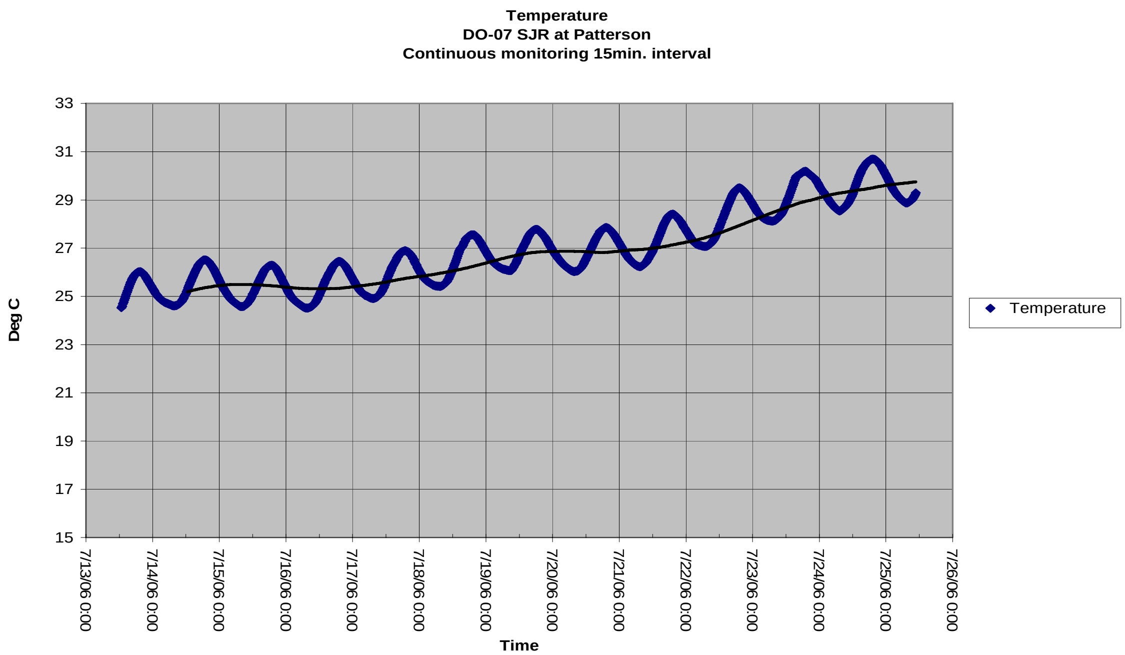


Fig.7T San Joaquin River at Patterson, Temperature (Deg. C) and Relative Fluorescence Units (%RFU) with 96 point moving average trend lines. Includes all available 15 minute data from 07/13/06 to 07/25/06.

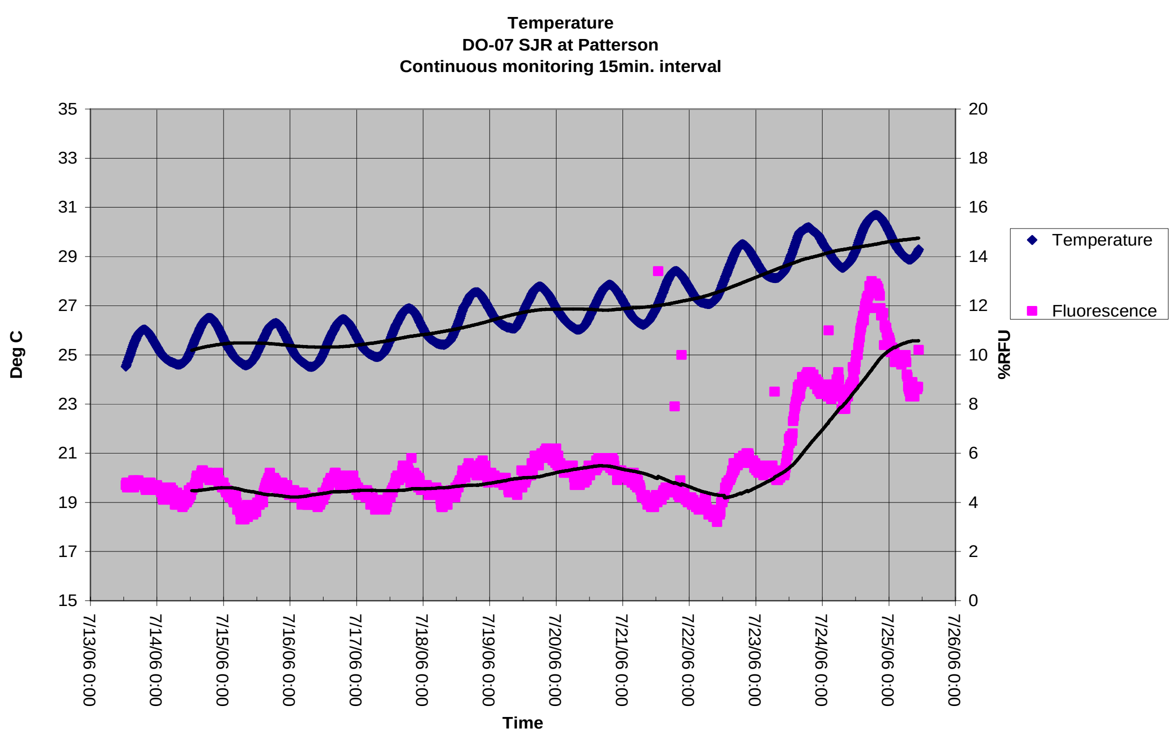


Table:8B Daily Averages for Sample Site DO-08 San Joaquin River at Crows Landing. Includes all available 15 minute data from 07/13/06 to 07/25/06

DO-08 SJR at Crows Landing (Turlock Sportsman Club)

July 13, 2006 to July 25, 2006

Daily averages

Date	Temp	SpCond	TDS	DOsat	DO	DOchrg	Depth	pH	Orp	Turbid+	Chl	Chl	Battery	Flow	
	C	mS/cm	g/L	%	mg/L		feet		mV	NTU	ug/L	RFU	volts	CFS	
7/13/2006	25.18	0.80	0.52	132.16	10.86	41.21	1.54	7.89	175.96	29.21	16.19	4.71	11.71	2349.57	Partial Day
7/14/2006	25.21	0.83	0.54	121.12	9.94	40.19	1.51	7.82	177.98	25.85	14.20	4.14	11.68	2320.52	
7/15/2006	25.15	0.79	0.51	125.30	10.30	40.05	1.52	7.93	179.54	23.38	14.01	4.08	11.66	2291.25	
7/16/2006	25.21	0.77	0.50	125.83	10.33	39.72	1.50	7.96	178.63	24.29	14.32	4.17	11.63	2260.00	
7/17/2006	25.62	0.74	0.48	128.62	10.47	39.78	1.43	8.02	182.46	24.42	14.48	4.22	11.61	2260.73	
7/18/2006	26.29	0.75	0.49	131.34	10.57	39.97	1.38	8.05	189.32	28.02	15.62	4.55	11.60	2210.73	
7/19/2006	26.80	0.75	0.49	135.18	10.78	40.05	1.43	8.12	194.73	30.69	17.39	5.07	11.60	2165.00	
7/20/2006	26.69	0.80	0.52	137.86	11.01	39.88	1.55	8.19	184.58	32.00	17.74	5.17	11.60	2102.60	
7/21/2006	27.04	0.83	0.54	128.47	10.19	38.79	1.56	8.08	178.75	27.96	14.14	4.12	11.60	2084.43	
7/22/2006	28.03	0.83	0.54	135.92	10.59	39.11	1.20	8.13	192.74	23.02	15.66	4.57	11.59	2052.29	
7/23/2006	29.13	0.90	0.59	154.89	11.83	40.39	1.11	8.28	209.42	22.02	24.21	7.06	11.59	1893.23	
7/24/2006	29.65	1.00	0.65	155.39	11.76	39.11	1.08	8.28	218.08	25.16	28.09	8.19	11.58	1818.23	
7/25/2006	29.71	0.98	0.64	116.51	8.82	33.59	1.01	7.99	229.32	32.37	23.76	6.92	11.57	1879.51	partial Day

Fig.8K San Joaquin River at Crows Landing, Flow (CFS) from CDEC database. Includes all available 15 minute data from 07/13/06 to 07/25/06.

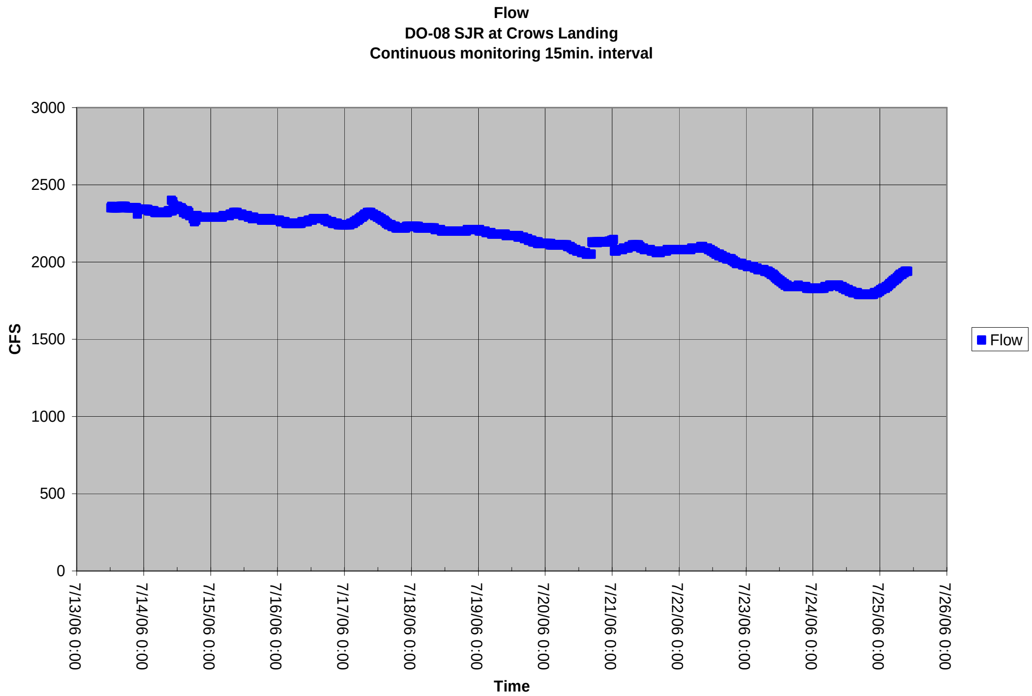


Fig.8L San Joaquin River at Crows Landing, Turbidity (NTU) and Relative Fluorescence Units (%RFU) with 96 point moving average trend lines. Includes all available 15 minute data from 07/13/06 to 07/25/06.

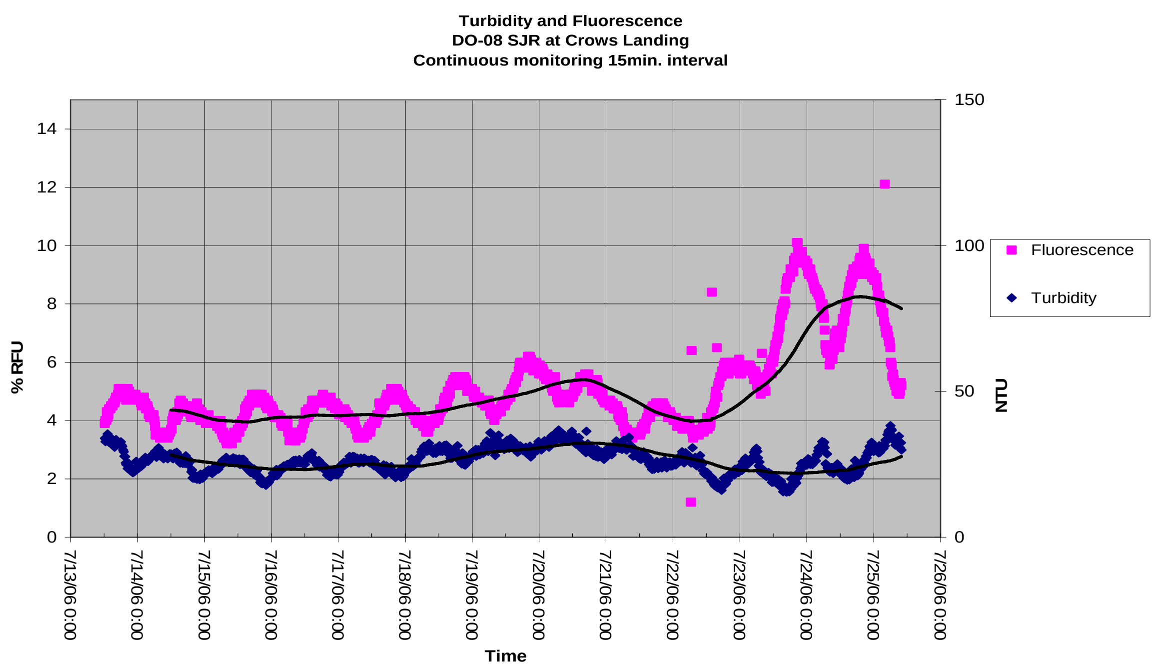


Fig.8M San Joaquin River at Crows Landing, Turbidity (NTU) with 96 point moving average trend line . Includes all available 15 minute data from 07/13/06 to 07/25/06.

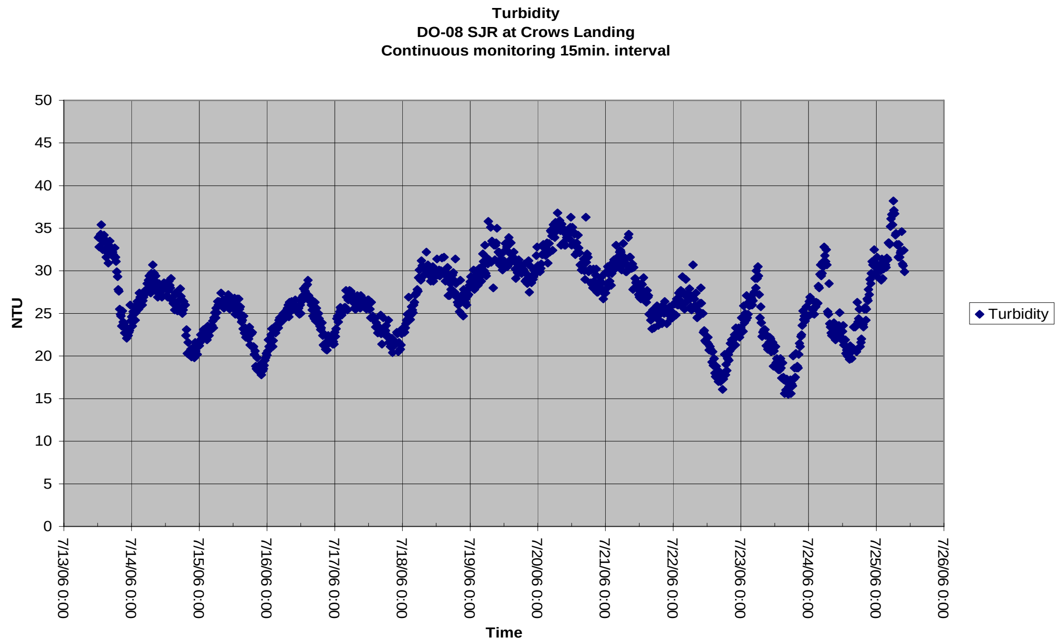


Fig.8N San Joaquin River at Crows Landing, Relative Fluorescence Units (%RFU) with 96 point moving average trend line. Includes all available 15 minute data from 07/13/06 to 07/25/06.

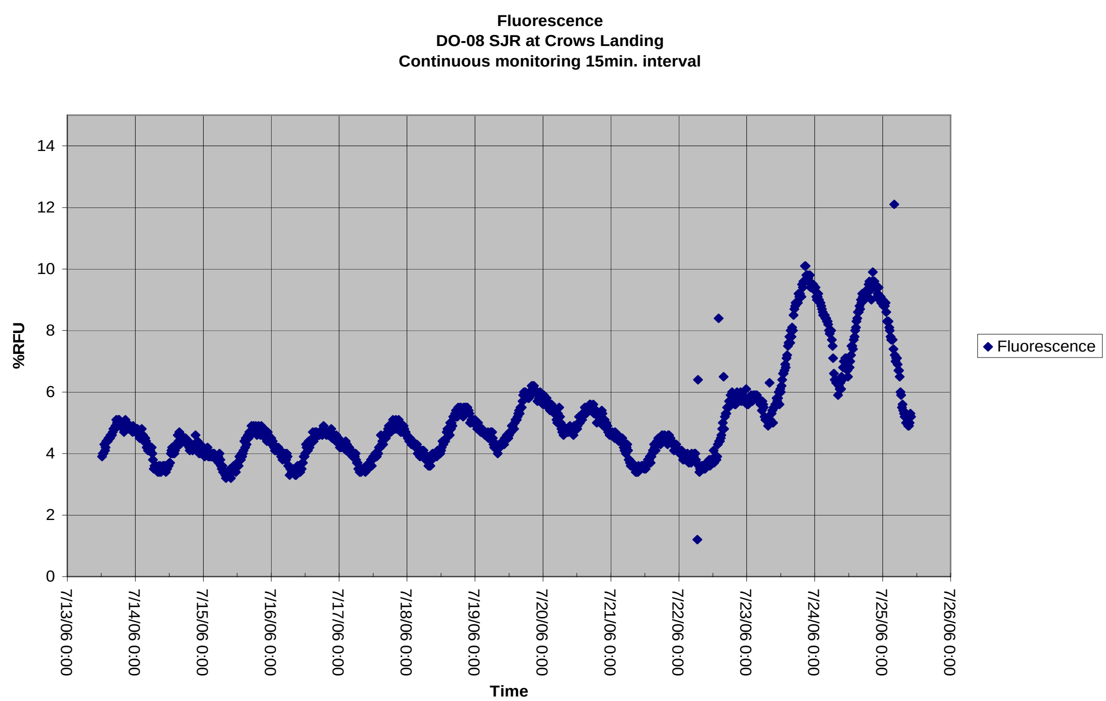


Fig.8O San Joaquin River at Crows Landing, Dissolved Oxygen (mg/l) and pH with 96 point moving average trend line. Includes all available 15 minute data from 07/13/06 to 07/25/06.

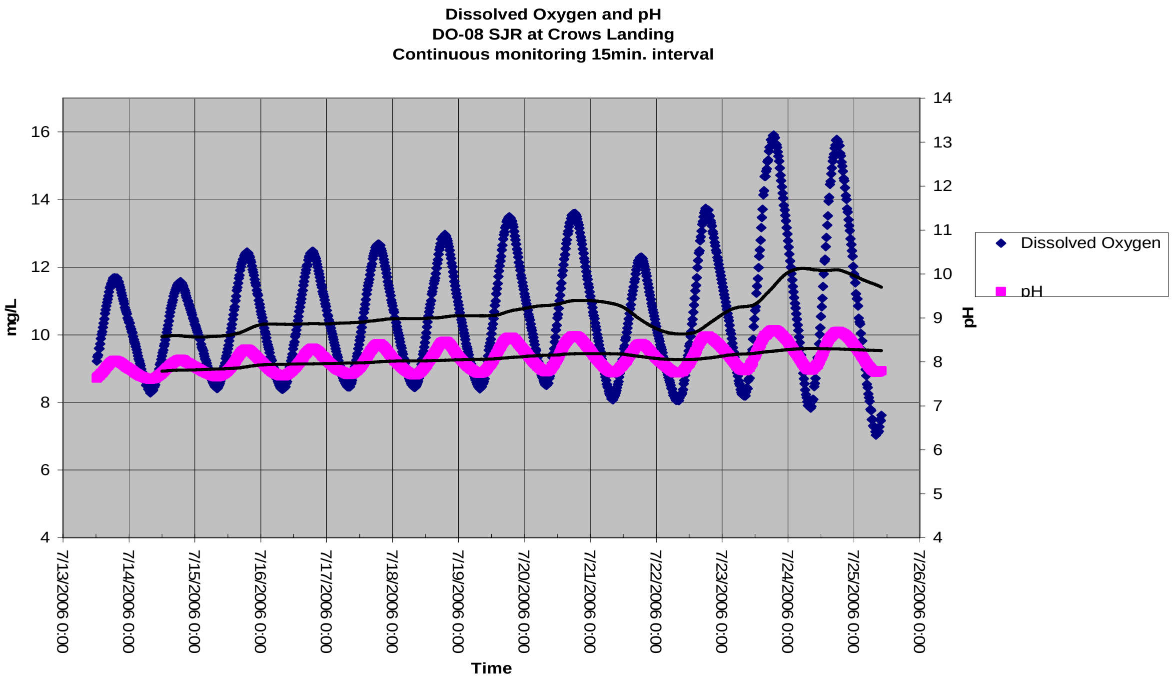


Fig.8P San Joaquin River at Crows Landing, pH with 96 point moving average trend line. Includes all available 15 minute data from 07/13/06 to 07/25/06.

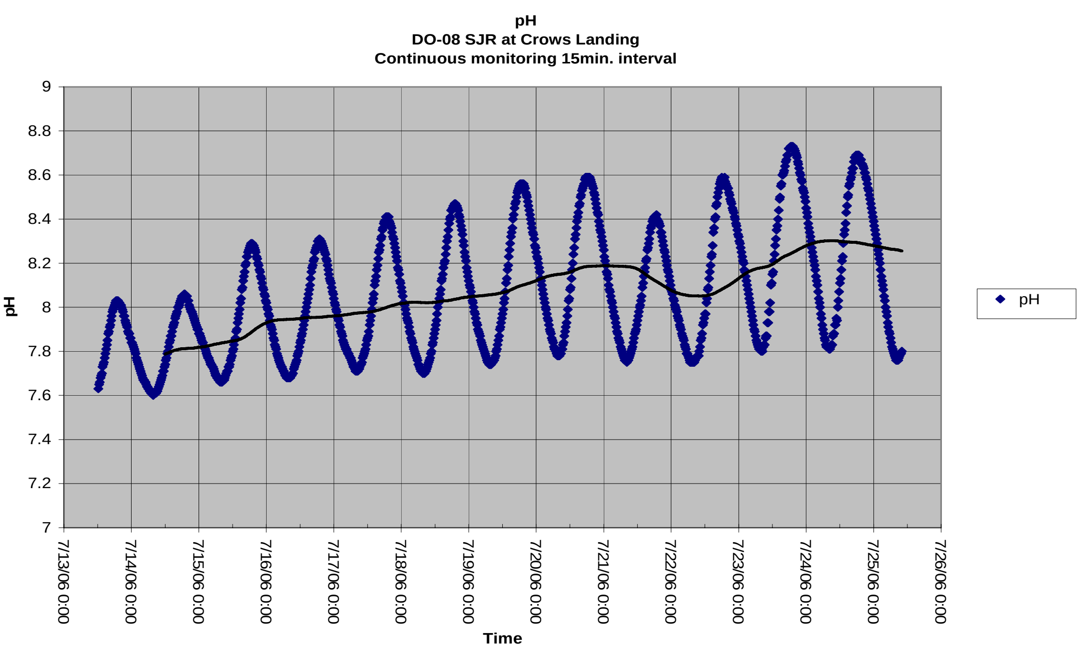


Fig.8Q San Joaquin River at Crows Landing, Dissolved Oxygen (mg/l) with 96 point moving average trend line. Includes all available 15 minute data from 07/13/06 to 07/25/06.

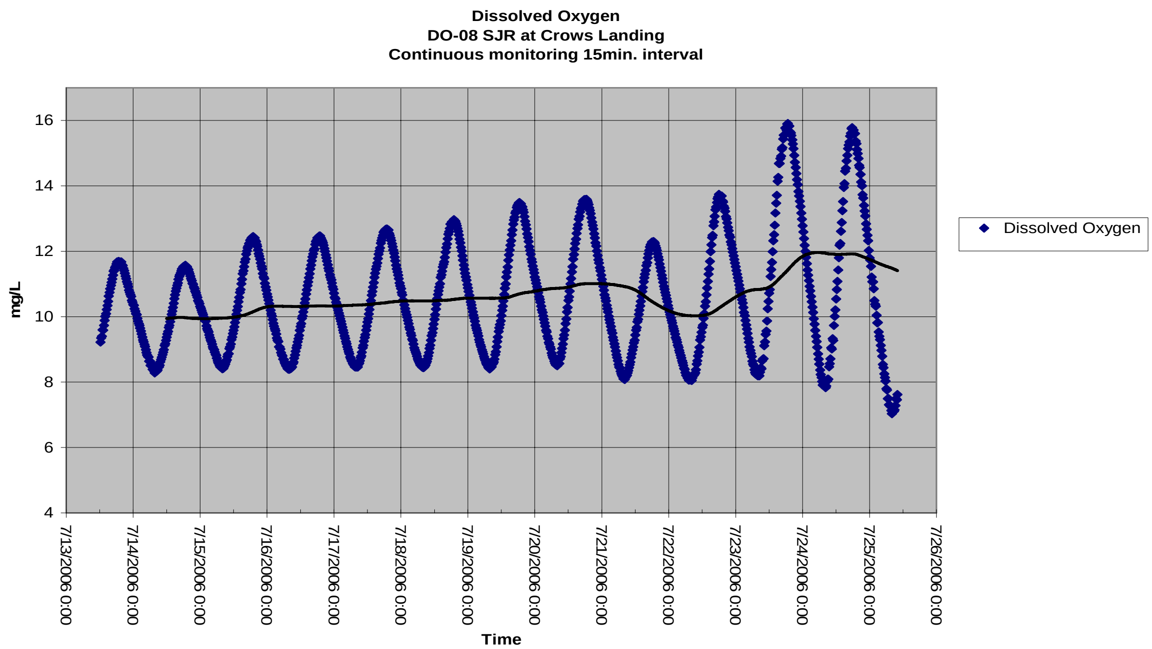


Fig.8R San Joaquin River at Crows Landing, Specific Conductance (mS/cm). Includes all available 15 minute data from 07/13/06 to 07/25/06.

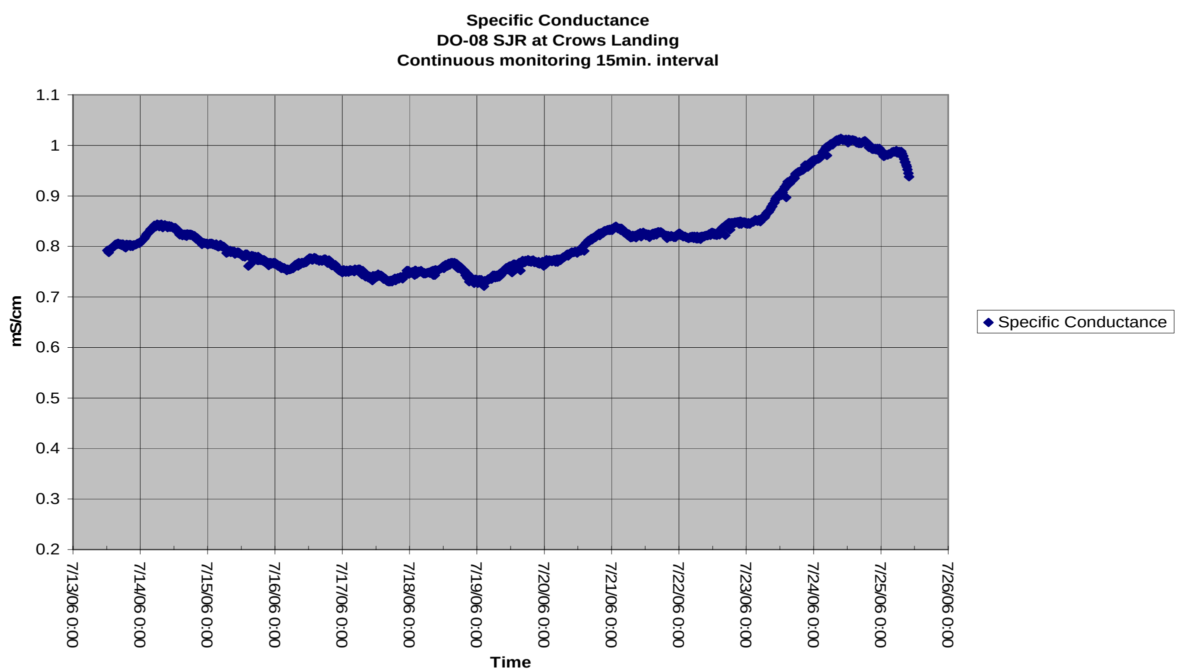


Fig.8S San Joaquin River at Crows Landing, Temperature (Deg. C). Includes all available 15 minute data from 07/13/06 to 07/25/06.

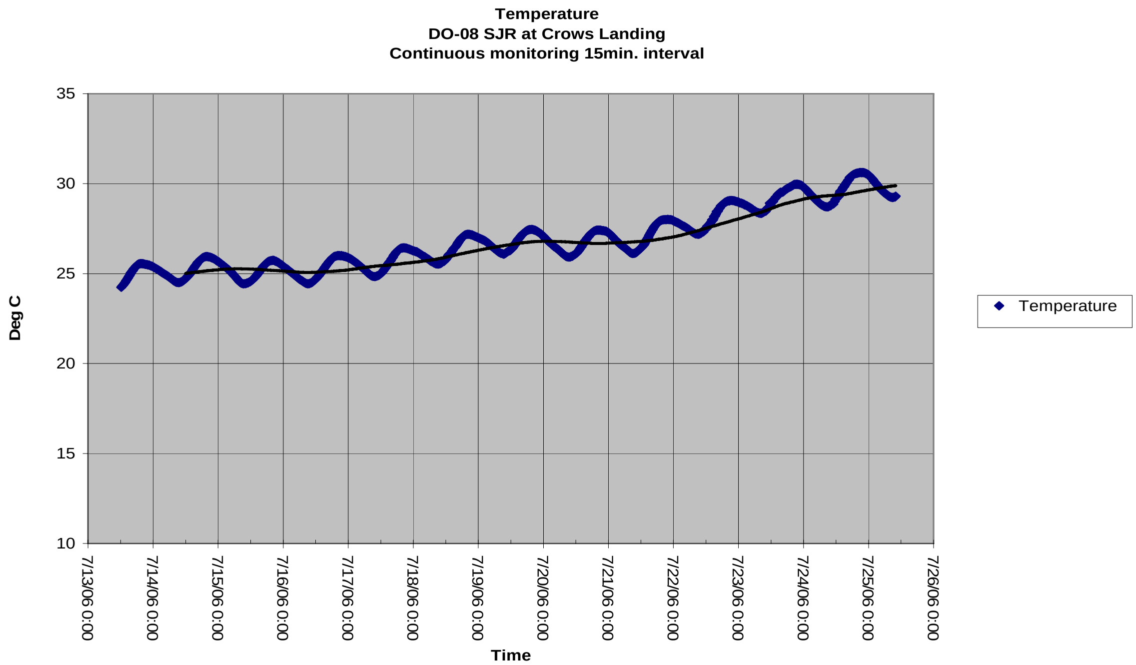


Fig.8T San Joaquin River at Crows Landing, Temperature (Deg. C) and Fluorescence (%RFU). Includes all available 15 minute data from 07/13/06 to 07/25/06.

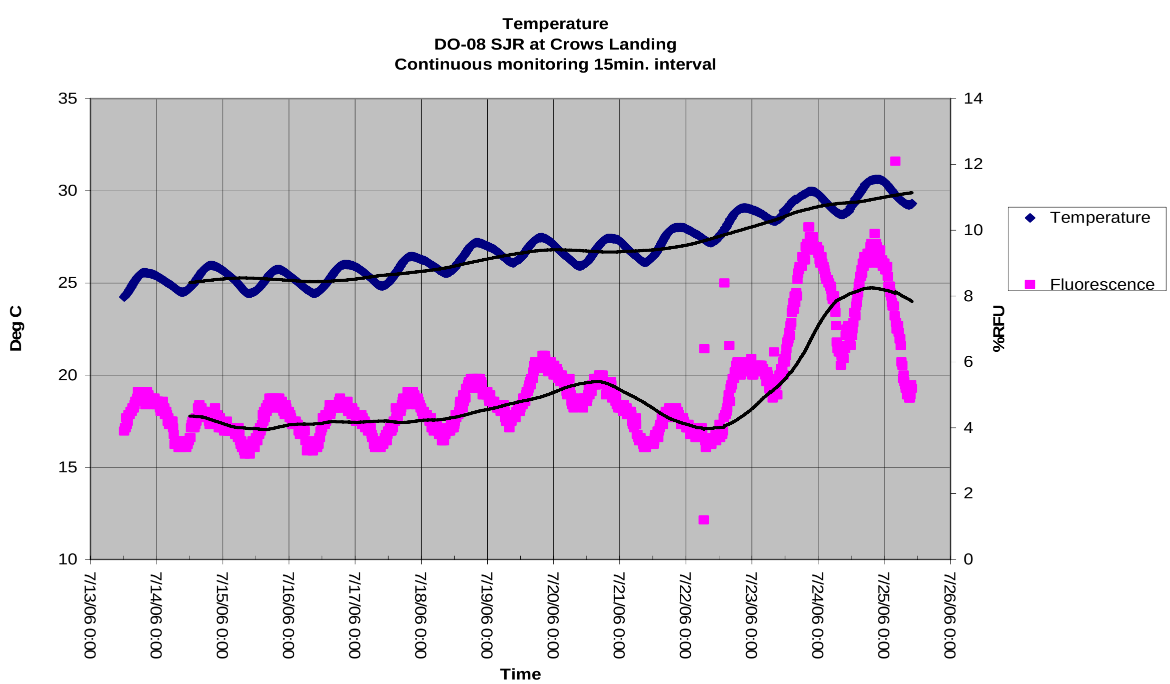


Table:44B Daily Averages for Sample Site DO-44 San Luis Drain End. Includes all available 15 minute data from 07/13/06 to 07/25/06

DO-44 San Luis Drain End

July 13, 2006 to July 25, 2006

Daily averages

Date	Temp	SpCond	TDS	DOsat	DO	DOchrg	Depth	pH	Orp	Turbid+	Chl	Chl	Battery	Flow	
	C	mS/cm	g/L	%	mg/L		feet		mV	NTU	ug/L	RFU	volts	CFS	
7/13/2006	27.72	4.09	2.66	204.19	15.84	57.02	2.42	8.82	307.24	24.76	61.47	14.44	12.72	38.51	Partial Day
7/14/2006	27.65	3.85	2.50	171.22	13.30	52.64	2.35	8.69	311.22	25.00	57.13	13.42	12.68	34.71	
7/15/2006	27.69	4.18	2.72	165.15	12.83	50.90	2.32	8.75	307.45	24.55	72.94	17.14	12.56	32.11	
7/16/2006	27.88	4.63	3.01	142.83	11.03	48.18	2.33	8.72	304.00	216.00	52.76	12.39	12.45	33.28	
7/17/2006	28.49	4.64	3.02	125.80	9.61	46.00	2.28	8.68	306.46	580.14	45.33	10.65	12.35	34.40	
7/18/2006	29.14	4.72	3.07	109.71	8.27	44.19	2.27	8.63	311.10	477.76	40.09	9.41	12.30	37.17	
7/19/2006	29.55	4.92	3.20	101.78	7.62	43.22	2.28	8.64	313.93	447.71	33.73	7.92	12.29	37.52	
7/20/2006	29.38	4.71	3.06	107.60	8.08	43.09	2.36	8.85	308.41	162.49	51.63	12.12	12.22	38.37	
7/21/2006	30.04	4.50	2.93	105.01	7.80	42.95	2.37	8.82	309.27	30.00	73.61	17.29	12.14	40.75	
7/22/2006	31.28	4.60	2.99	88.33	6.42	41.95	2.29	8.63	326.16	26.50	63.58	14.93	12.10	39.76	
7/23/2006	32.22	4.63	3.01	73.71	5.28	40.91	2.22	8.55	331.40	24.53	64.40	15.12	12.04	39.46	
7/24/2006	32.57	4.35	2.83	66.55	4.74	40.39	2.14	8.30	338.17	13.53	39.21	9.21	12.00	39.67	
7/25/2006	32.01	4.37	2.84	41.22	2.97	38.22	2.11	8.10	340.11	10.61	29.65	6.97	12.00	39.73	Partial day

Fig.44K San Luis Drain End, Flow. Includes all available data from 07/13/06 to 07/25/06.

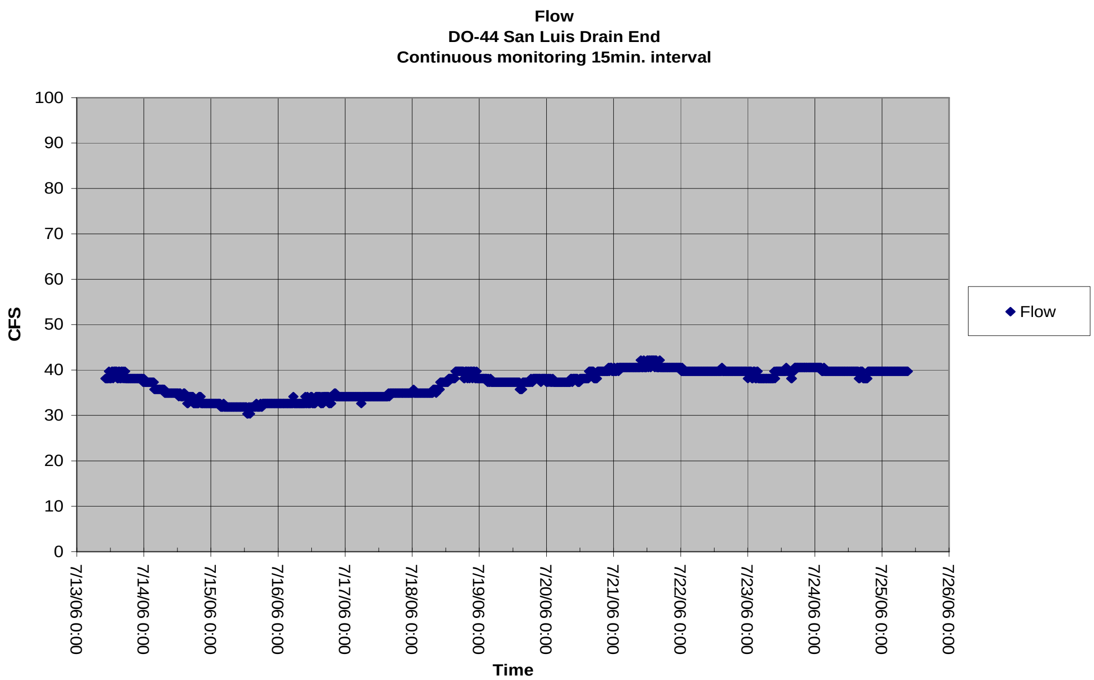


Fig.44L San Luis Drain End, Turbidity (NTU) and Relative Fluorescence Units (RFU) with 96 point moving average trend lines. Includes all available 15 minute data from 07/13/06 to 07/25/06.

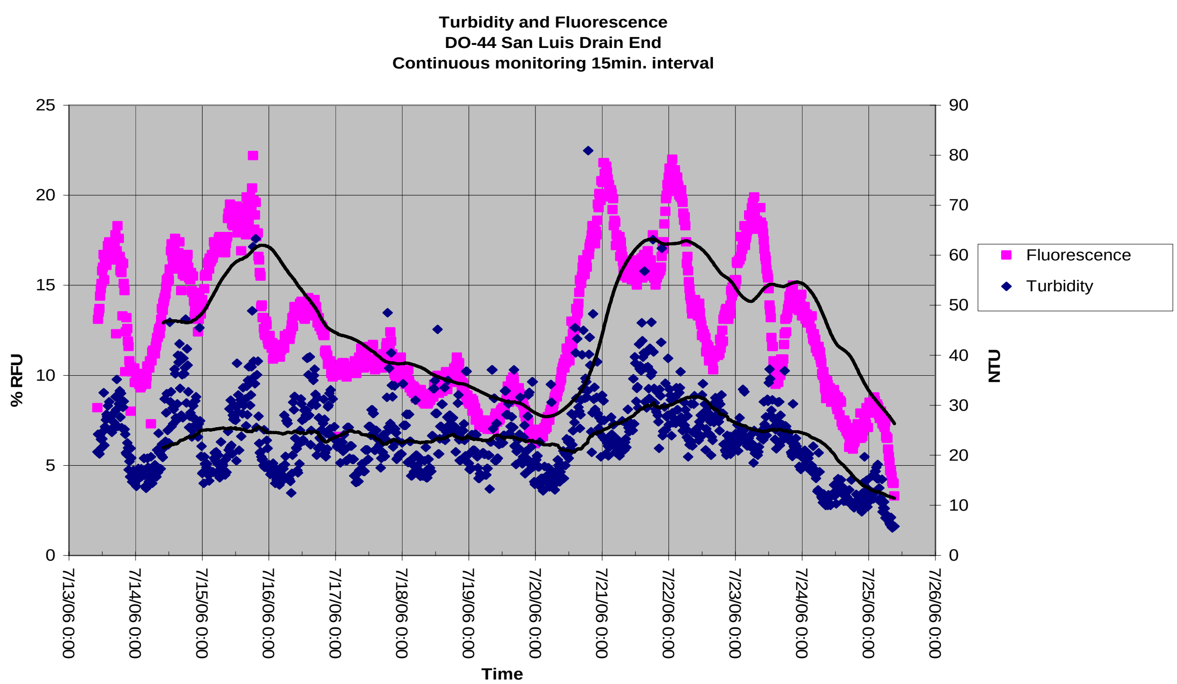


Fig.44M San Luis Drain End, Turbidity (NTU) with 96 point moving average trend line. Includes all available 15 minute data from 07/13/06 to 07/25/06.

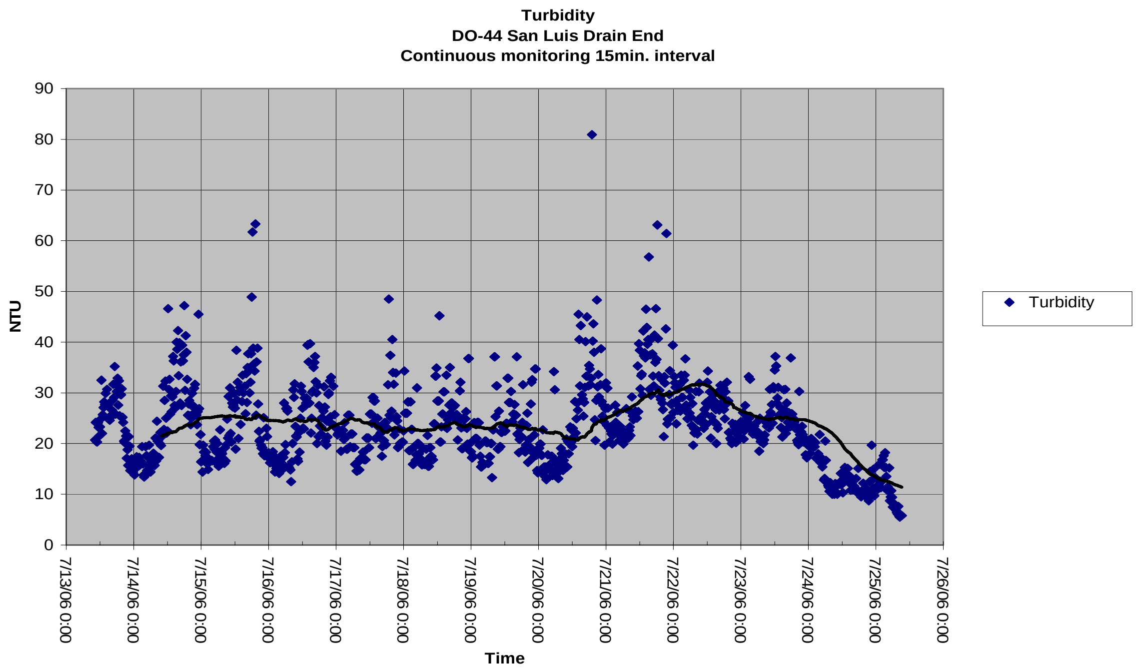


Fig.44N San Luis Drain End, Relative Fluorescence Units (RFU) with 96 point moving average trend line. Includes all available 15 minute data from 07/13/06 to 07/25/06.

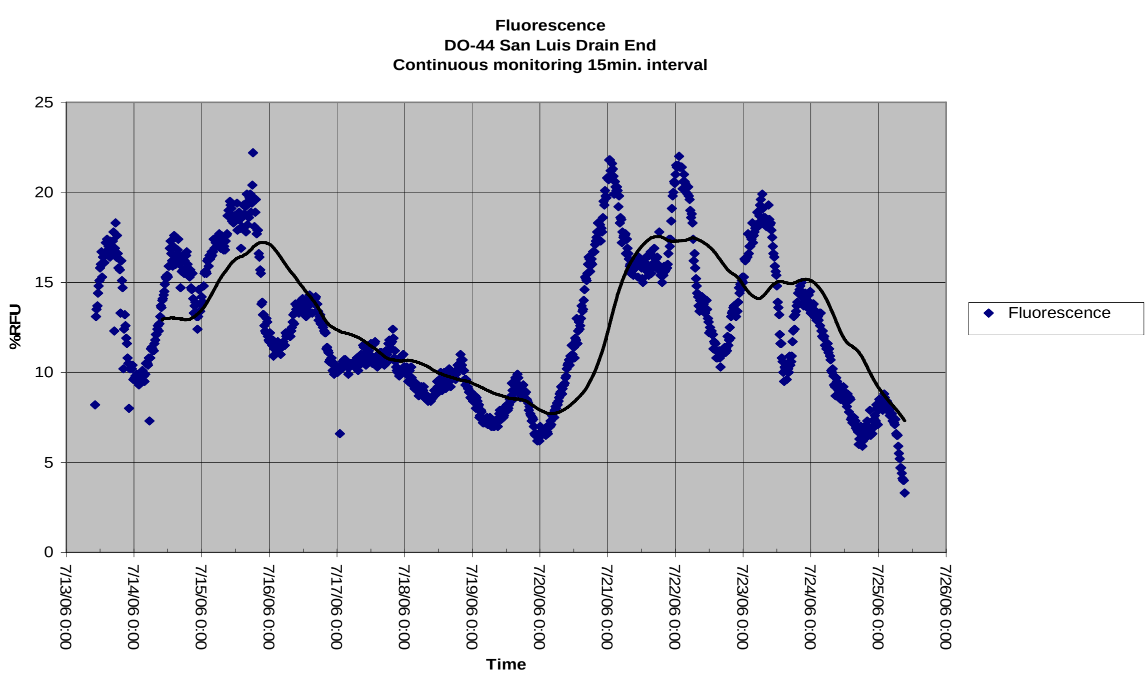


Fig.44O San Luis Drain End, Dissolved Oxygen (mg/l) and pH with 96 point moving average trend lines. Includes all available 15 minute data from 07/13/06 to 07/25/06.

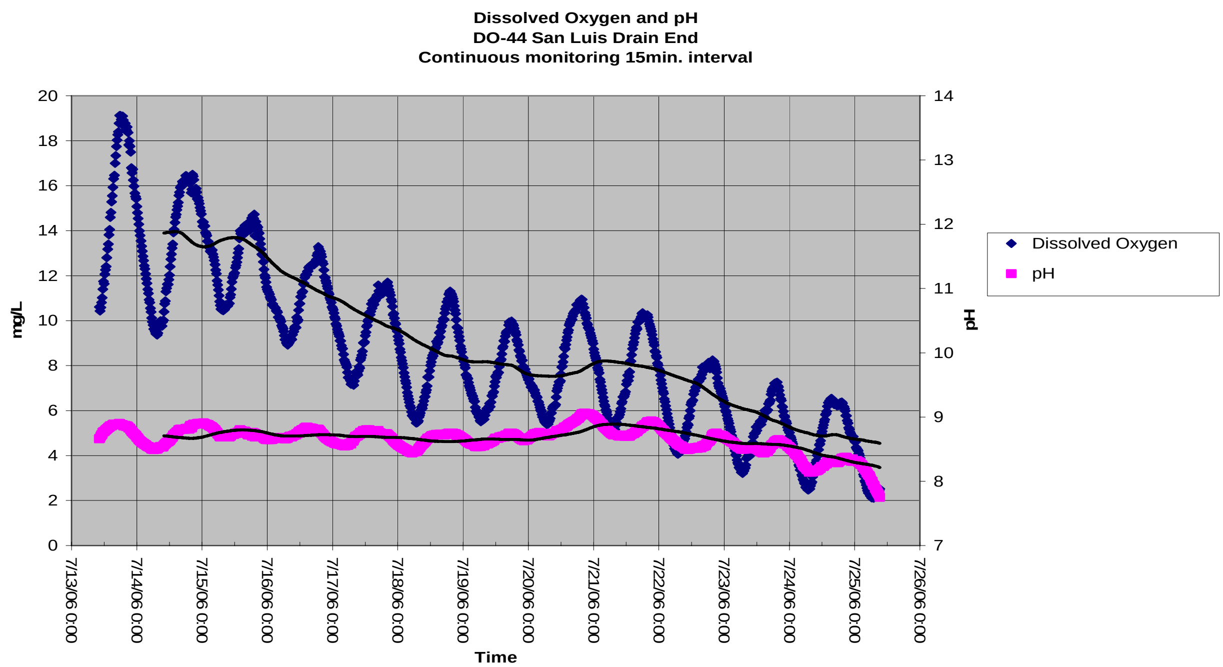


Fig.44P San Luis Drain End, pH with 96 point moving average trend line. Includes all available 15 minute data from 06/27/06 to 07/13/06.

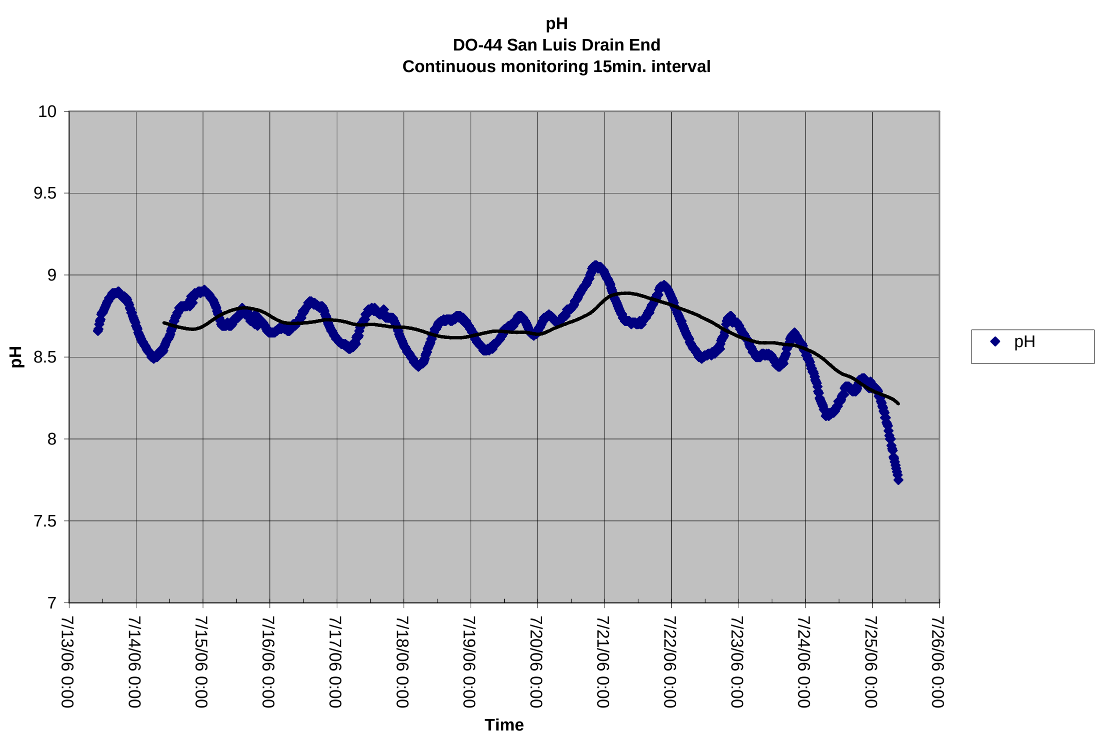


Fig.44Q San Luis Drain End, Dissolved Oxygen (mg/l) with 96 point moving average trend line. Includes all available 15 minute data from 07/13/06 to 07/25/06.

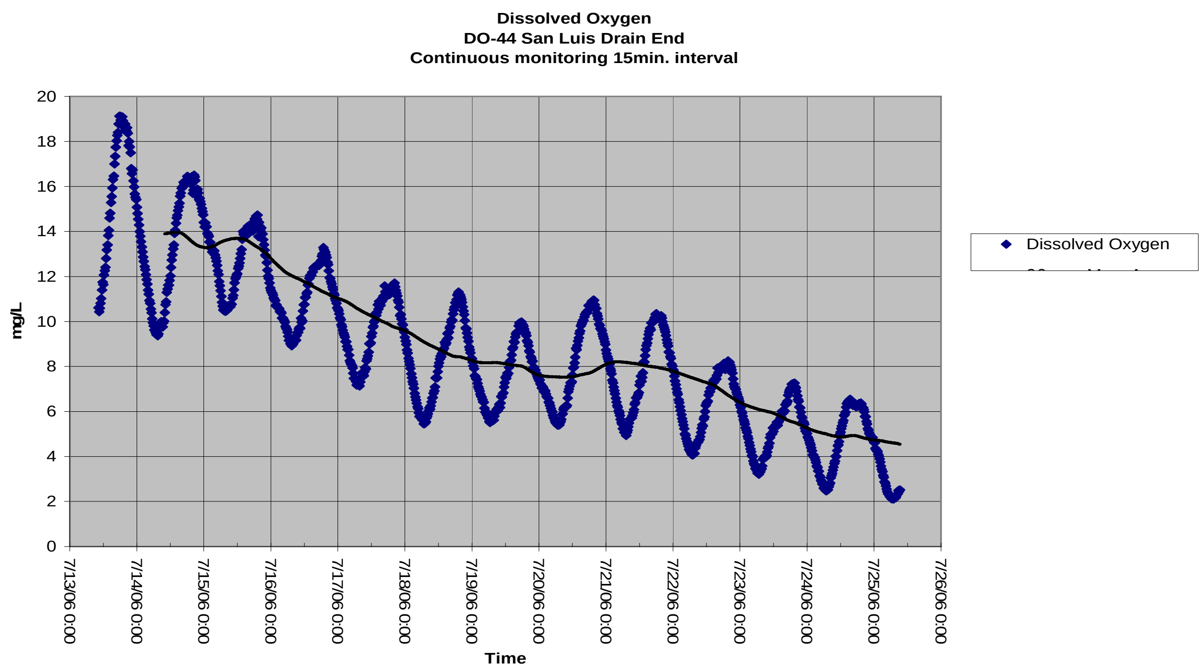


Fig.44R San Luis Drain End, Specific Conductance (mS/cm). Includes all available 15 minute data from 07/13/06 to 07/25/06.

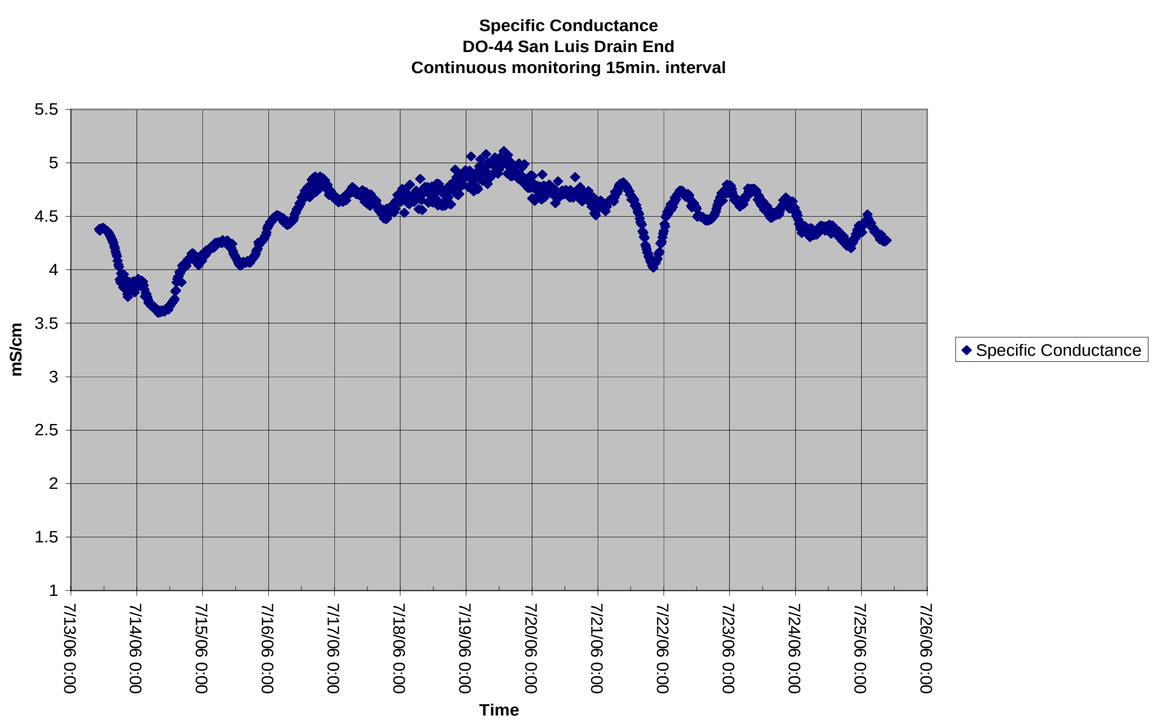


Fig.44S San Luis Drain End, Temperature (Deg. C). Includes all available 15 minute data from 07/13/06 to 07/25/06.

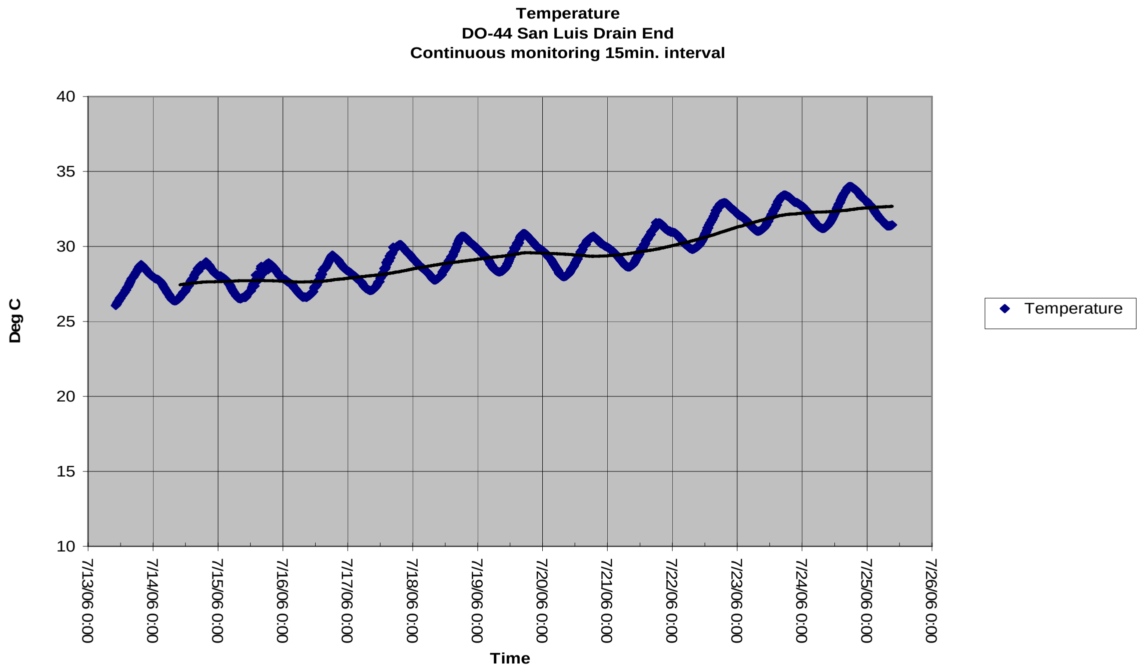


Fig.44T San Luis Drain End, Specific Conductance (mS/cm). Includes all available 15 minute data from 07/13/06 to 07/25/06.

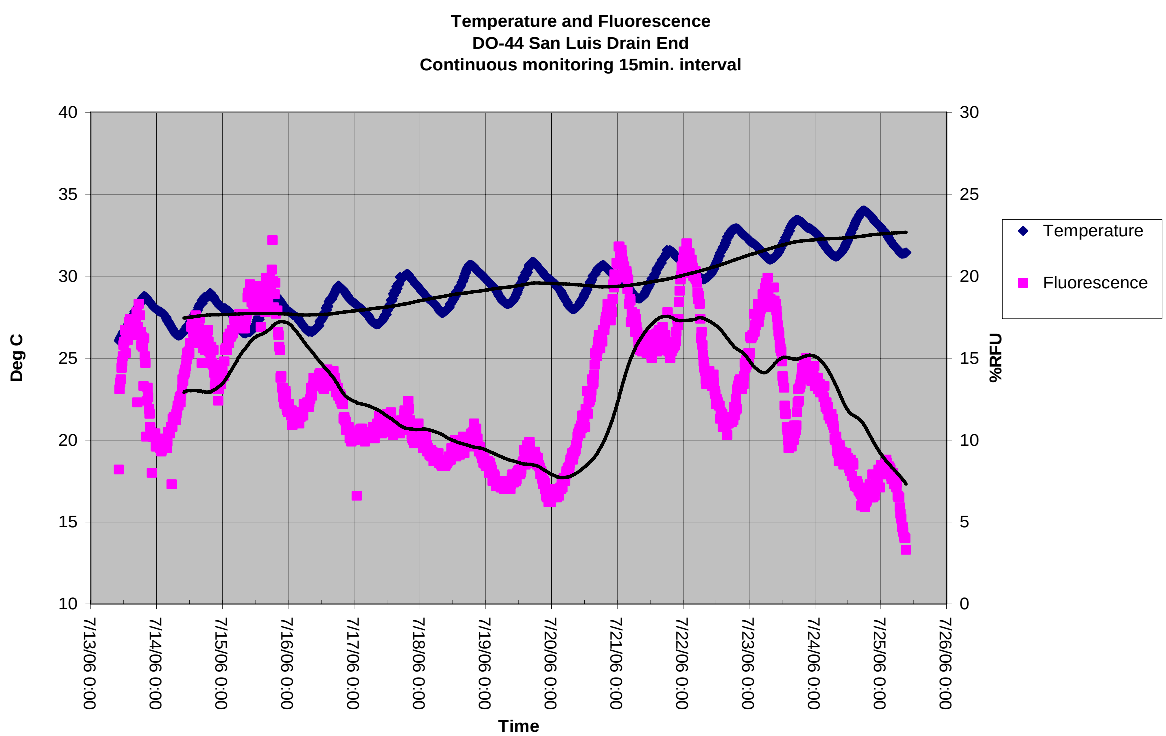


Table:ck18A Daily averages for sample site DO-103, San Luis Drain Check 18. Includes all available data from 08/04/06 to 08/18/06

Check 18 SLD

Aug 04, 2006 to Aug 18, 2006

Daily averages

Date	Temp	SpCond	TDS	DOsat	DO	DOchrg	Depth	pH	Orp	Turbid+	Chl	Chl	Battery	
	C	mS/cm	g/L	%	mg/L		feet		mV	NTU	ug/L	RFU	volts	
8/4/2006	26.03	3.90	2.54	128.60	10.29	41.93	1.22	8.18	176.30	38.53	16.36	4.31	12.86	Partial Day
8/5/2006	24.41	4.22	2.74	120.52	9.87	40.26	1.15	8.15	183.57	61.78	15.42	4.06	12.73	
8/6/2006	24.67	4.65	3.02	123.75	10.06	39.96	1.04	8.19	189.45	60.13	14.68	3.86	12.67	
8/7/2006	23.68	4.62	3.00	119.70	9.94	38.79	1.06	8.20	187.52	55.17	15.55	4.09	12.55	
8/8/2006	23.73	4.60	2.99	123.61	10.23	38.63	1.15	8.24	176.79	67.06	21.24	5.59	12.44	
8/9/2006	25.34	4.91	3.19	135.42	10.84	39.78	0.97	8.33	173.56	66.66	25.32	6.66	12.36	
8/10/2006	26.73	4.71	3.06	133.36	10.42	39.60	1.05	8.28	175.26	68.60	21.26	5.59	12.30	
8/11/2006	25.62	4.78	3.11	124.72	9.98	38.17	1.10	8.28	182.53	52.85	16.17	4.25	12.30	
8/12/2006	24.28	4.71	3.06	136.90	11.18	38.62	1.12	8.33	188.30	50.83	21.51	5.66	12.24	
8/13/2006	24.90	4.42	2.87	134.43	10.87	38.36	1.19	8.31	180.58	55.49	20.65	5.44	12.18	
8/14/2006	24.75	4.15	2.70	130.67	10.64	37.70	1.33	8.33	180.82	57.93	24.38	6.41	12.11	
8/15/2006	24.04	3.77	2.45	123.84	10.21	36.91	1.34	8.33	180.26	93.56	21.85	5.75	12.07	
8/16/2006	23.69	3.65	2.37	122.48	10.18	36.55	1.30	8.31	179.60	74.78	21.39	5.63	12.00	
8/17/2006	23.56	3.52	2.29	115.39	9.65	35.83	1.45	8.27	176.89	116.51	20.97	5.52	12.00	
8/18/2006	22.75	3.45	2.24	94.53	8.07	33.48	1.43	8.18	181.07	159.83	17.41	4.58	11.99	partial day

Fig.ck18A San Luis Drain Check 18, Flow (CFS). Includes all available data from 08/04/06 to 08/18/06.
Flow graph here

Fig.ck18B San Luis Drain Check 18, Turbidity (NTU) and Relative Fluorescence Units (RFU) with 96 point moving average trend lines. Includes all available 15 minute data from 08/04/06 to 08/18/06.

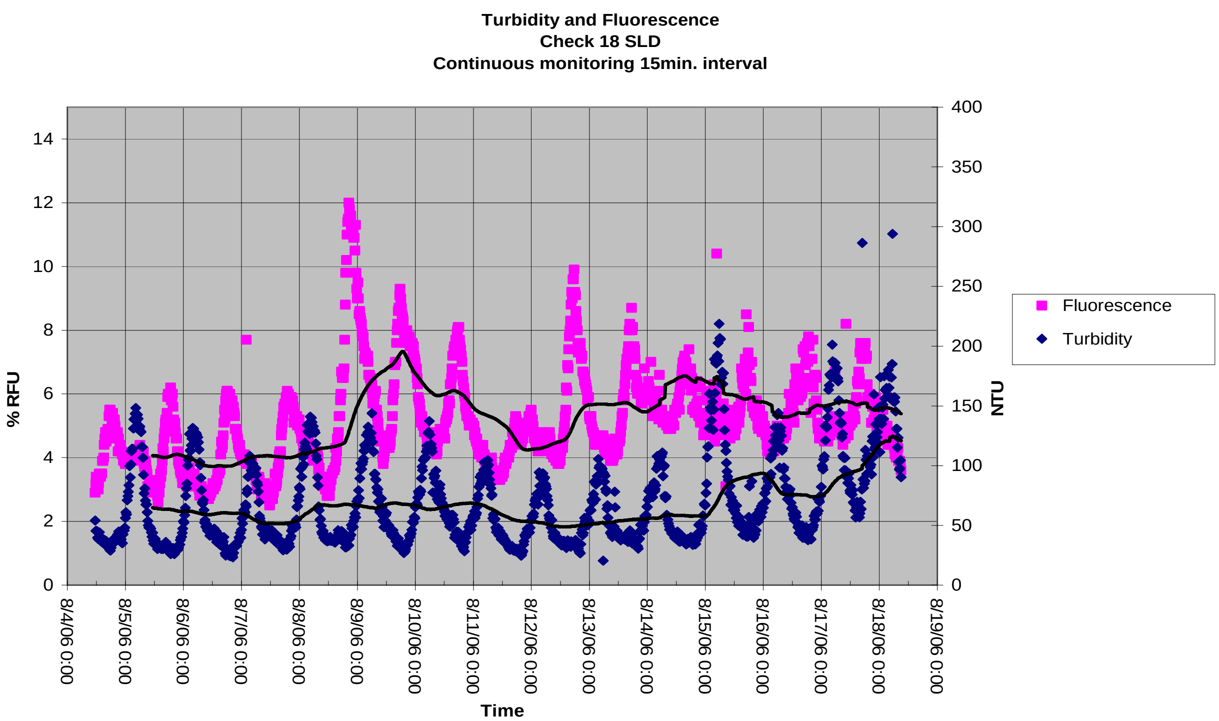


Fig.ck18C San Luis Drain Check 18, Turbidity (NTU) with 96 point moving average trend line. Includes all available 15 minute data from 08/04/06 to 08/18/06.

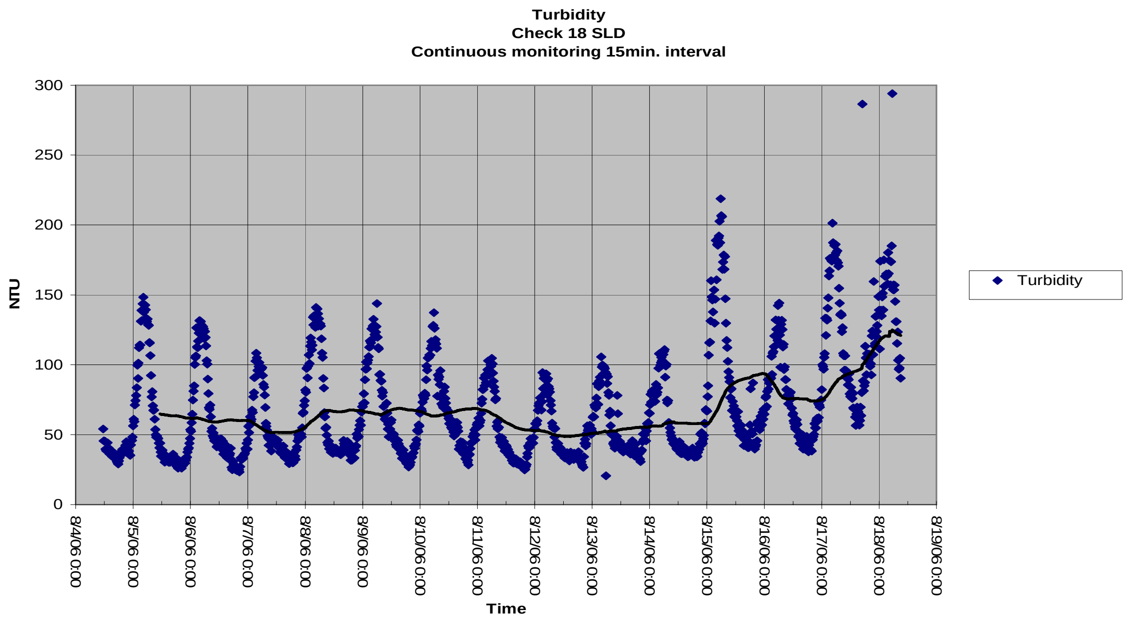


Fig.ck18D San Luis Drain Check 18, Relative Fluorescence Units (RFU) with 96 point moving average trend line. Includes all available 15 minute data from 08/04/06 to 08/18/06.

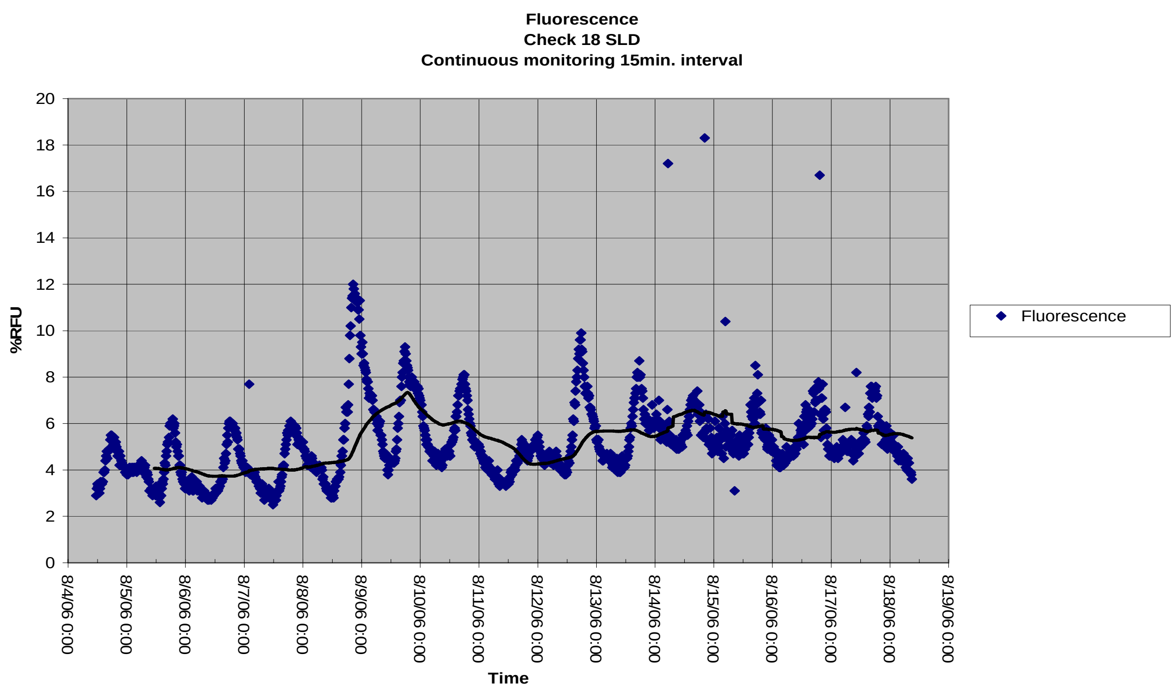


Fig.ck18E San Luis Drain Check 18, Dissolved Oxygen (mg/l) and pH with 96 point moving average trend lines. Includes all available 15 minute data from 08/04/06 to 08/18/06.

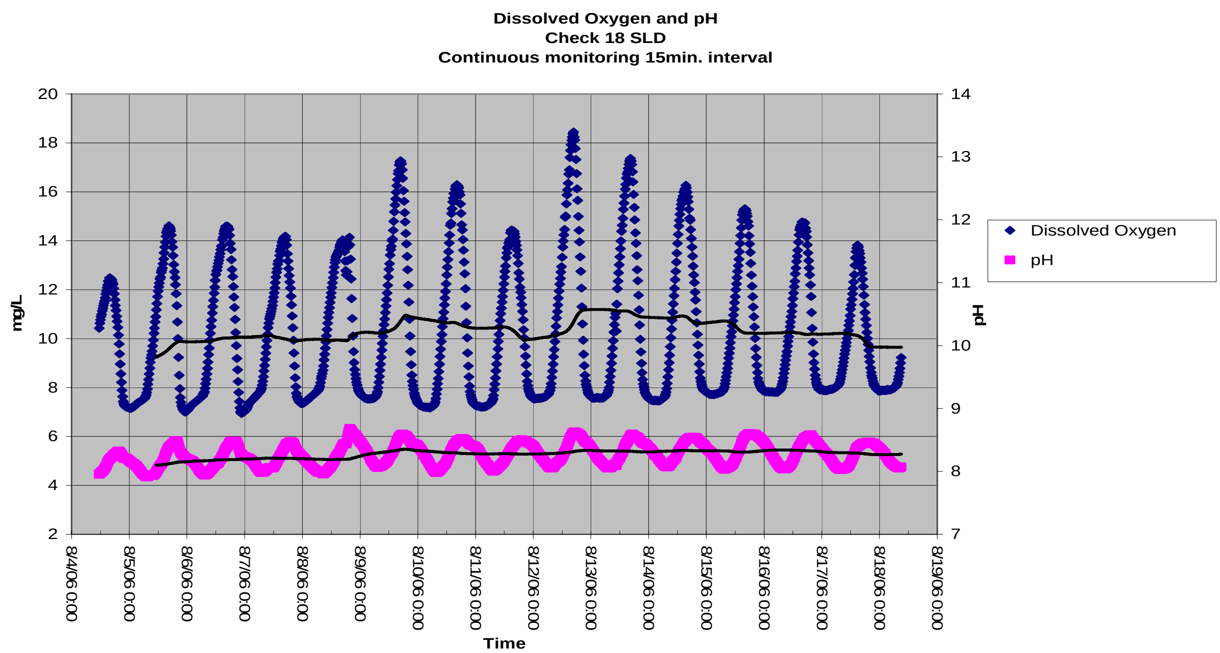


Fig.ck18F San Luis Drain Check 18, pH with 96 point moving average trend line. Includes all available 15 minute data from 08/04/06 to 08/18/06.

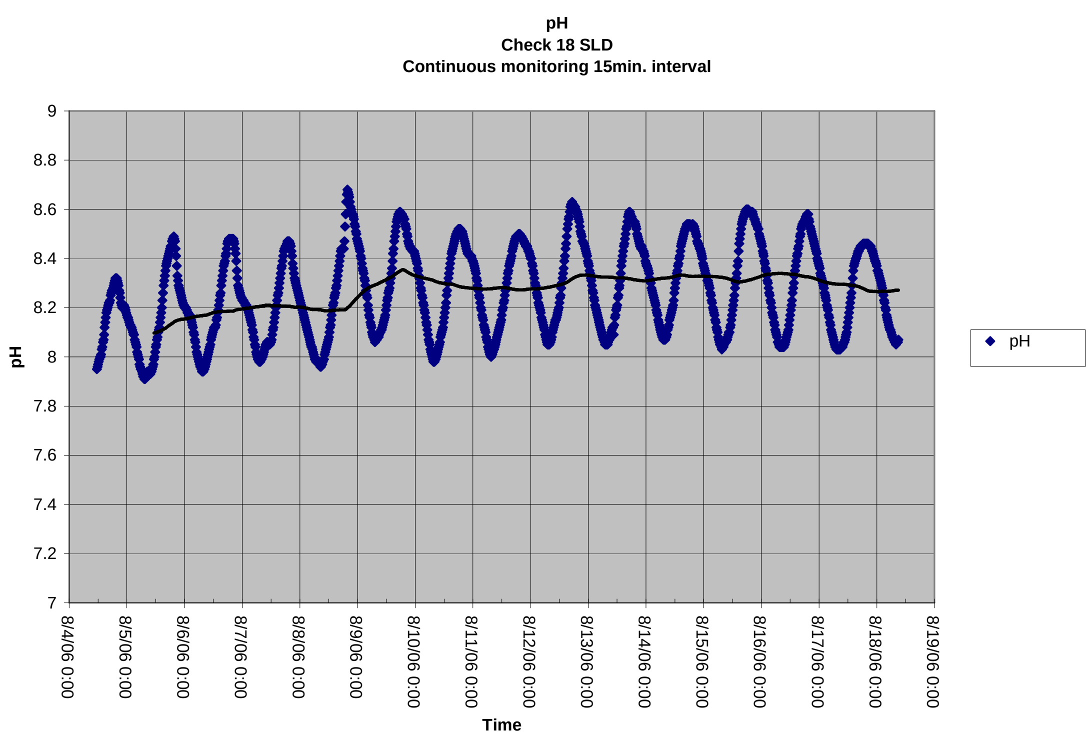


Fig.ck18G San Luis Drain Check 18, Dissolved Oxygen (mg/l) with 96 point moving average trend line. Includes all available 15 minute data from 08/04/06 to 08/18/06.

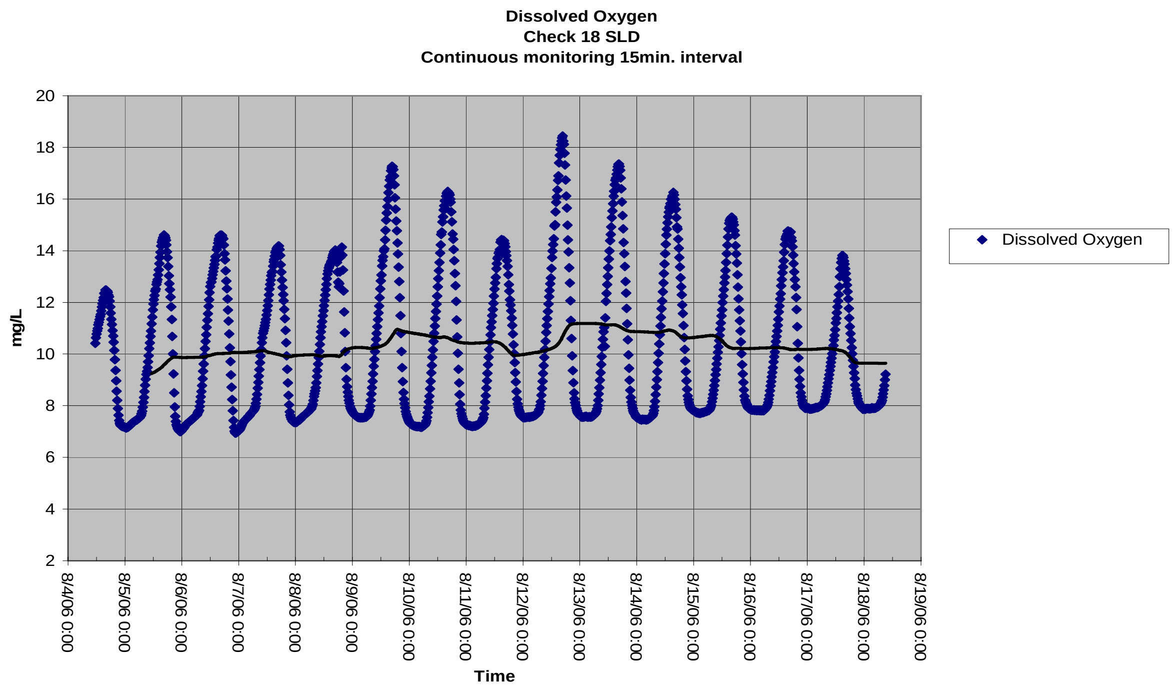


Fig.ck18H San Luis Drain Check 18, Specific Conductance (mS/cm). Includes all available 15 minute data from 08/04/06 to 08/18/06.

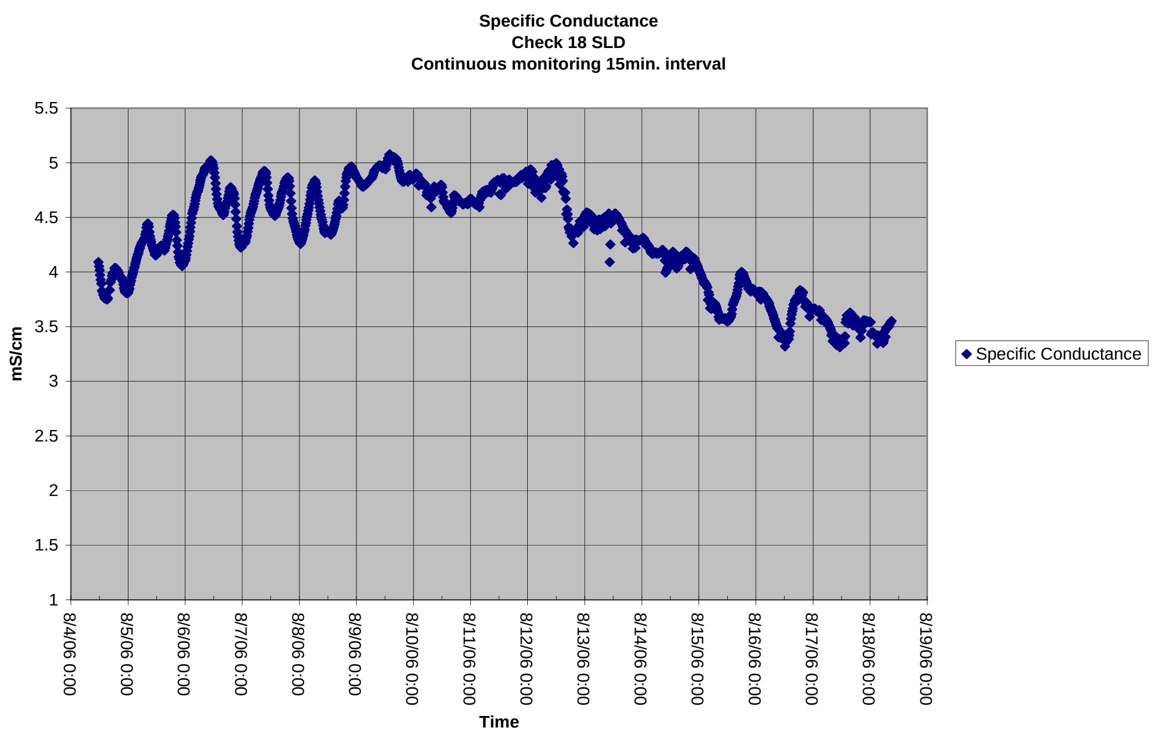


Fig.ck18I San Luis Drain Check 18, Temperature (Deg. C). Includes all available 15 minute data from 08/04/06 to 08/18/06.

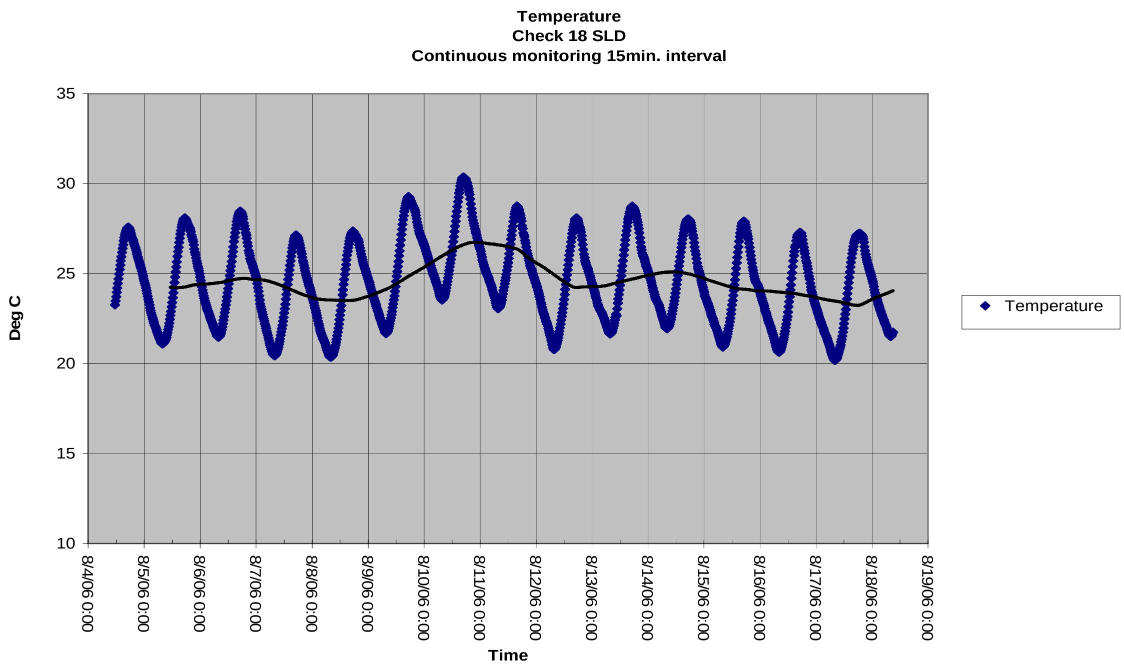


Fig.ck18J San Luis Drain Check 18, Temperature (Deg. C) and Relative Fluorescence Units (%RFU) with 96 point moving average trend lines. Includes all available 15 minute data from 08/04/06 to 08/18/06.

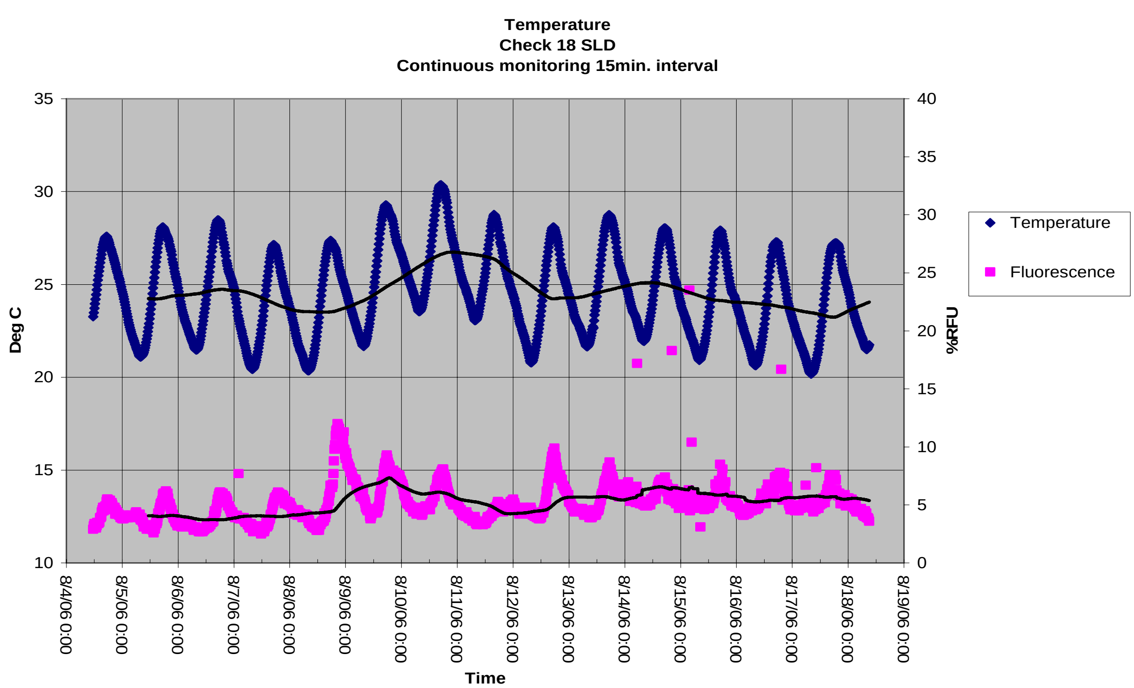


Table:ck14A Daily averages for sample site DO-106, San Luis Drain Check 14. Includes all available data from 08/04/06 to 08/18/06

Check 14 SLD

Aug 04, 2006 to Aug 18, 2006

Daily averages

Date	Temp	SpCond	TDS	DOsat	DO	DOchrg	Depth	pH	Orp	Turbid+	Chl	Chl	Battery	
	C	mS/cm	g/L	%	mg/L		feet		mV	NTU	ug/L	RFU	volts	
8/4/2006	25.90	3.75	2.44	173.21	13.87	48.98	0.82	8.42	184.81	145.45	45.31	10.59	12.90	Partial Day
8/5/2006	24.31	4.00	2.60	149.34	12.13	45.79	0.84	8.34	199.89	86.00	32.71	7.64	12.76	
8/6/2006	24.61	4.46	2.90	145.22	11.73	44.79	0.80	8.37	206.29	75.32	30.20	7.07	12.68	
8/7/2006	23.26	4.53	2.94	147.00	12.22	43.88	0.84	8.40	210.97	74.30	31.10	7.27	12.56	
8/8/2006	23.64	4.51	2.93	164.10	13.49	44.85	0.88	8.41	211.47	66.00	32.22	7.54	12.44	
8/9/2006	25.63	4.78	3.11	197.86	15.61	47.97	0.83	8.50	210.34	66.96	48.25	11.28	12.37	
8/10/2006	27.21	4.82	3.13	201.16	15.47	48.32	0.81	8.41	213.07	98.05	51.25	11.98	12.31	
8/11/2006	25.69	4.73	3.08	157.70	12.56	43.41	0.80	8.41	212.78	73.37	46.37	10.85	12.30	
8/12/2006	24.04	4.94	3.21	178.55	14.52	44.66	0.80	8.42	229.20	78.86	47.09	11.02	12.24	
8/13/2006	24.83	4.80	3.12	185.02	14.83	45.17	0.82	8.41	241.92	113.64	70.84	16.56	12.17	
8/14/2006	24.66	4.41	2.87	178.59	14.44	44.02	0.85	8.43	233.97	104.01	85.94	20.10	12.11	
8/15/2006	23.89	4.05	2.63	158.03	13.01	41.07	0.87	8.46	240.52	120.54	54.37	12.83	12.04	
8/16/2006	23.48	3.94	2.56	154.90	12.86	40.20	0.85	8.48	244.97	108.41	39.86	9.32	12.00	
8/17/2006	23.28	3.88	2.53	156.95	13.05	39.73	0.88	8.44	262.35	112.28	36.64	8.57	12.00	
8/18/2006	22.98	3.81	2.48	92.27	7.82	33.72	0.89	8.30	276.38	146.36	37.85	8.85	11.98	partial day

Fig.ck14A San Luis Drain Check 14, Flow (CFS). Includes all available data from 08/04/06 to 08/18/06.
Flow graph here

Fig.ck14B San Luis Drain Check 14, Turbidity (NTU) and Relative Fluorescence Units (RFU) with 96 point moving average trend lines. Includes all available 15 minute data from 08/04/06 to 08/18/06.

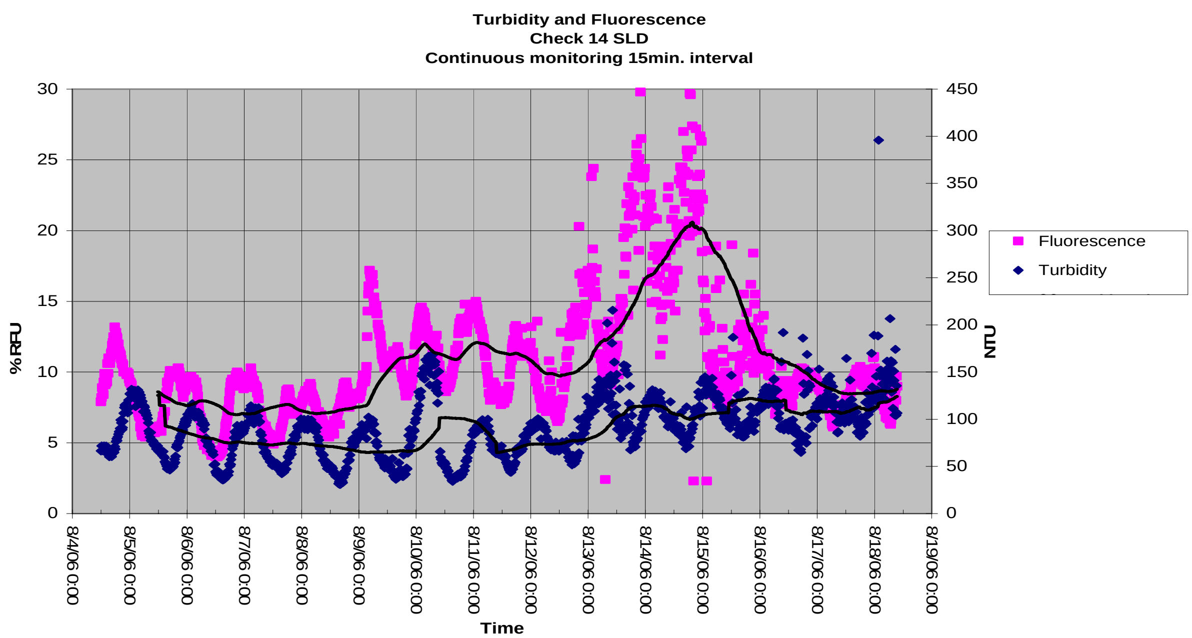


Fig.ck14C San Luis Drain Check 14, Turbidity (NTU) with 96 point moving average trend line. Includes all available 15 minute data from 08/04/06 to 08/18/06.

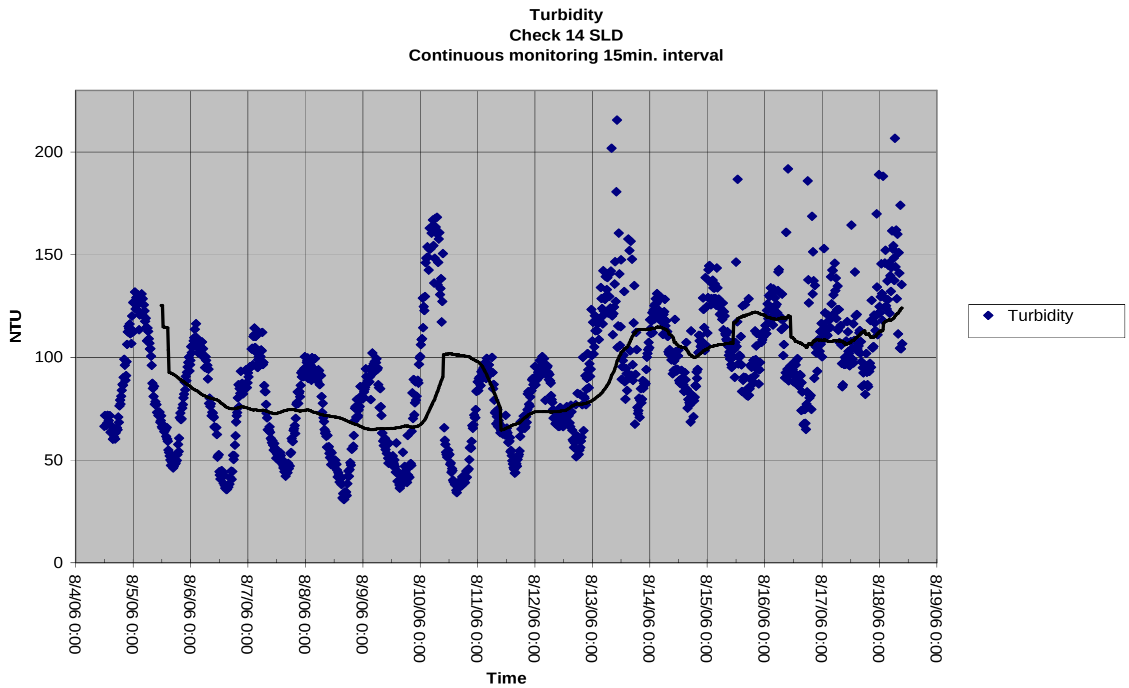


Fig.ck14D San Luis Drain Check 14, Relative Fluorescence Units (RFU) with 96 point moving average trend line. Includes all available 15 minute data from 08/04/06 to 08/18/06.

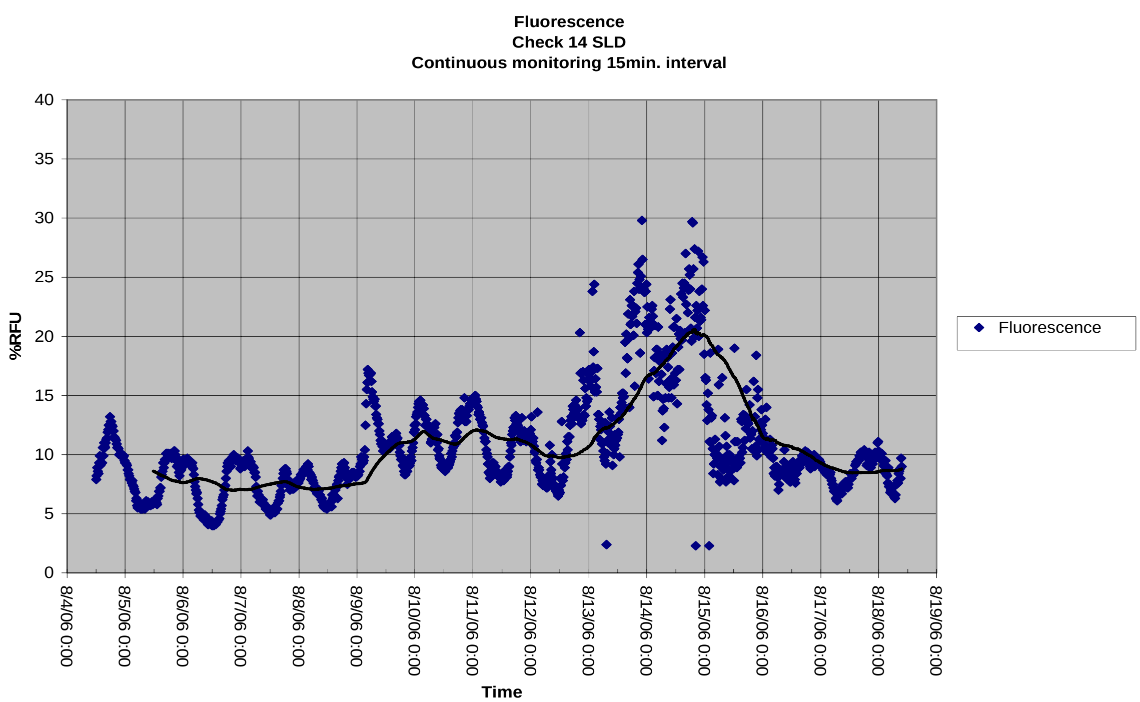


Fig.ck14E San Luis Drain Check 14, Dissolved Oxygen (mg/l) and pH with 96 point moving average trend lines. Includes all available 15 minute data from 08/04/06 to 08/18/06.

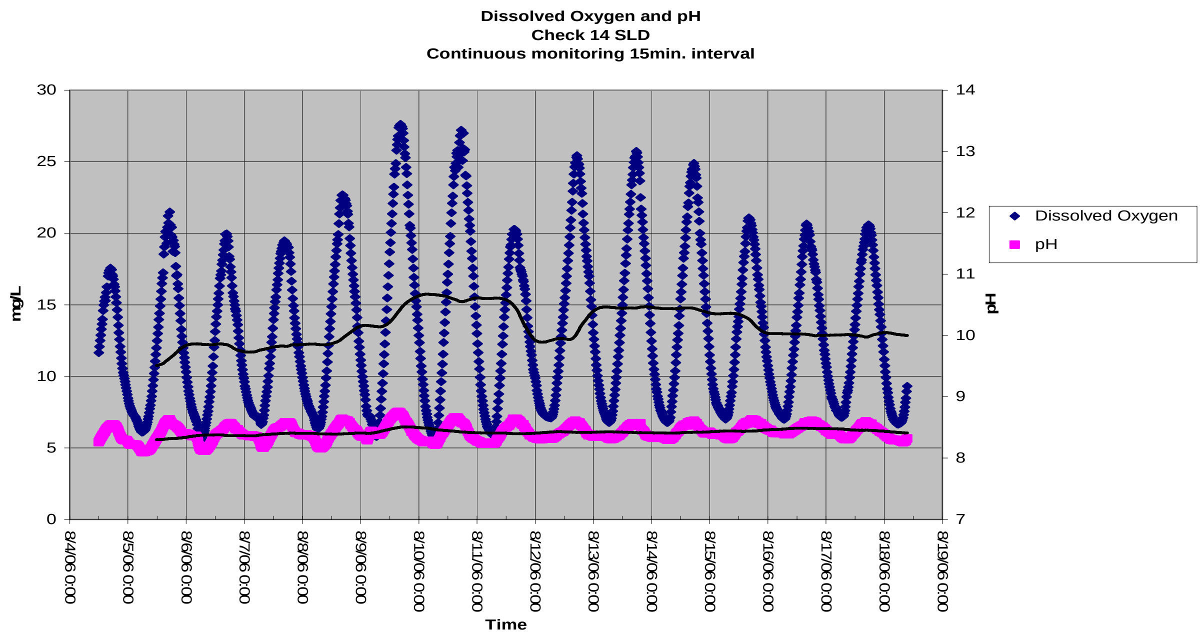


Fig.ck14F San Luis Drain Check 14, pH with 96 point moving average trend line. Includes all available 15 minute data from 08/04/06 to 08/18/06.

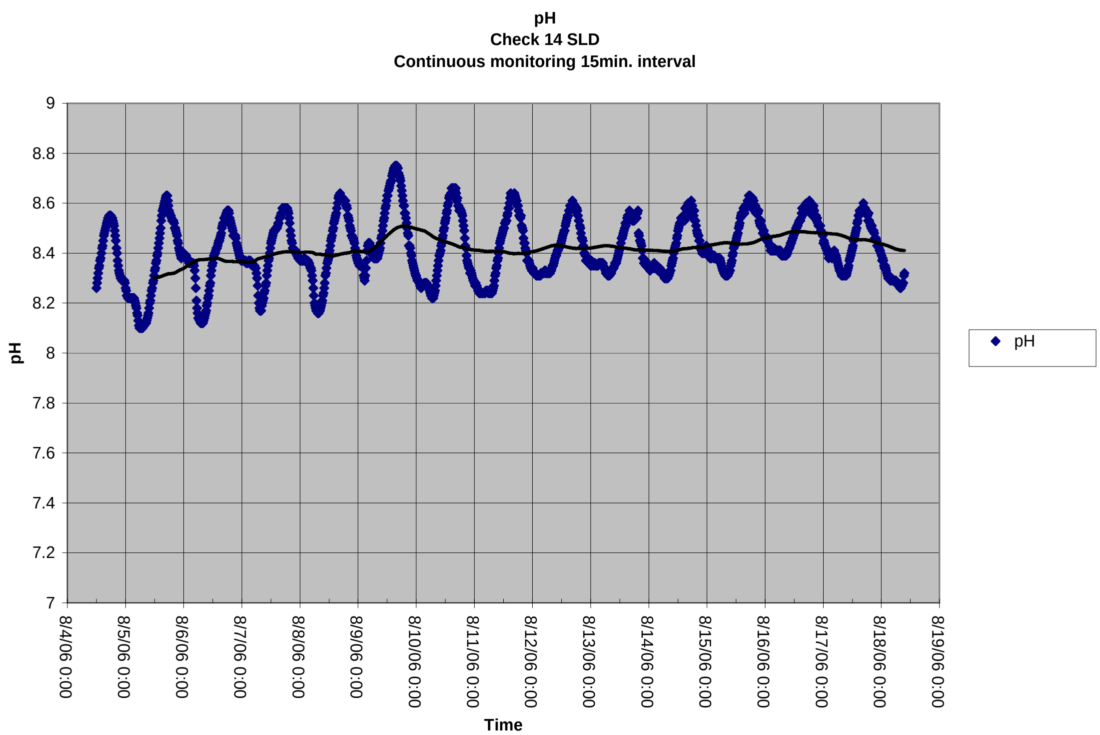


Fig.ck14G San Luis Drain Check 14, Dissolved Oxygen (mg/l) with 96 point moving average trend line. Includes all available 15 minute data from 08/04/06 to 08/18/06.

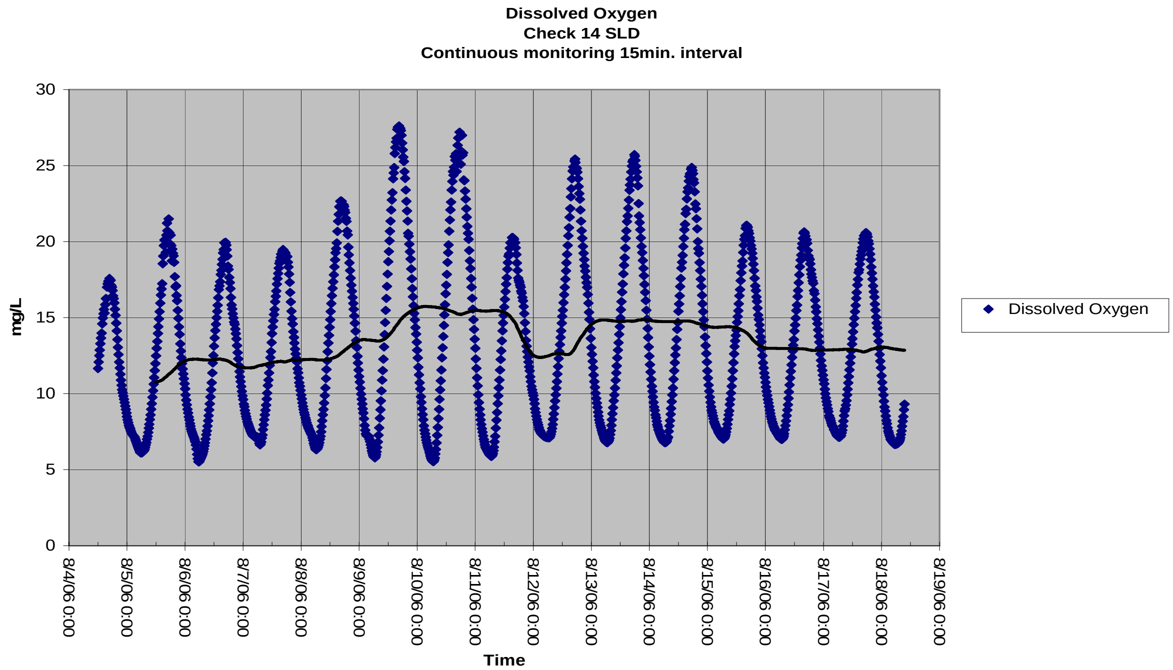


Fig.ck14H San Luis Drain Check 14, Specific Conductance (mS/cm). Includes all available 15 minute data from 08/04/06 to 08/18/06.

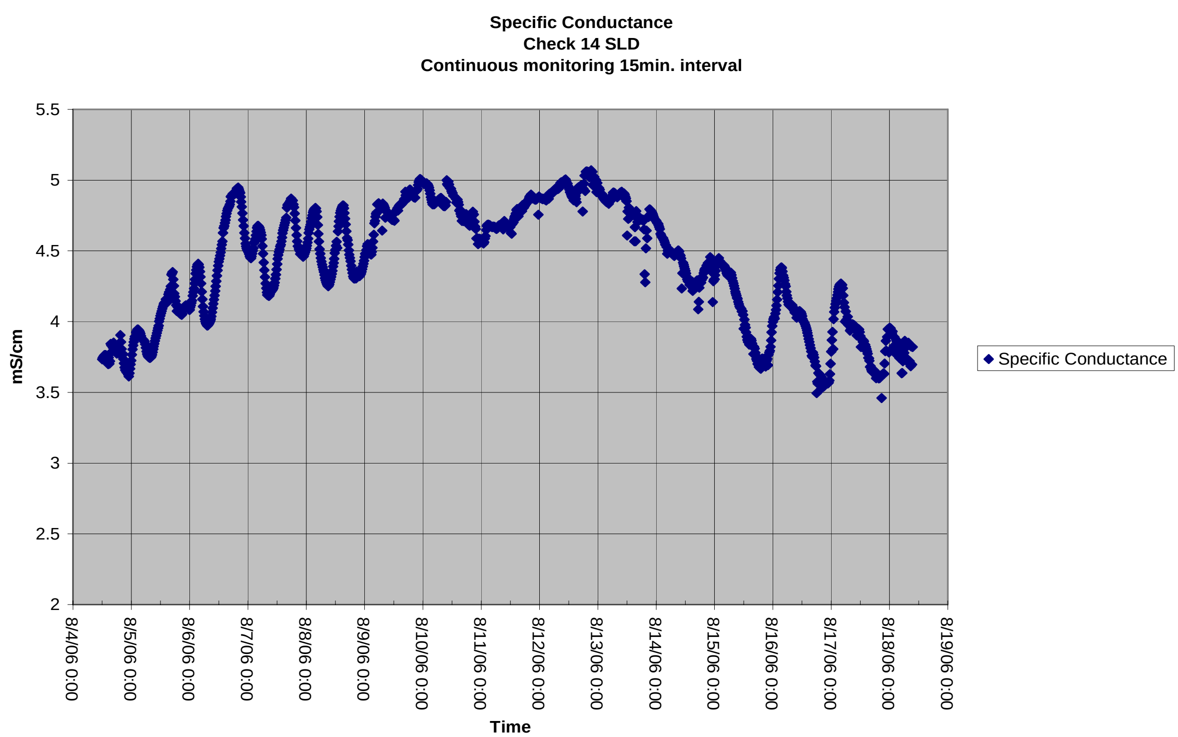


Fig.ck14I San Luis Drain Check 14, Temperature (Deg. C). Includes all available 15 minute data from 08/04/06 to 08/18/06.

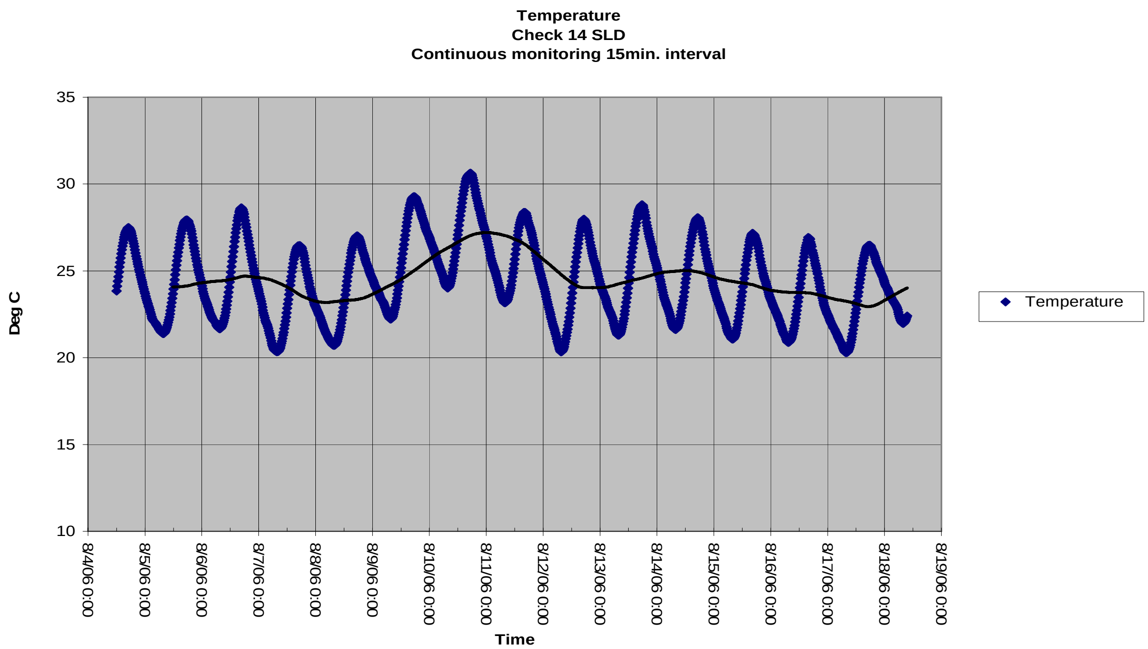


Fig.ck14J San Luis Drain Check 14, Temperature (Deg. C) and Relative Fluorescence Units (%RFU) with 96 point moving average trend lines. Includes all available 15 minute data from 08/04/06 to 08/18/06.

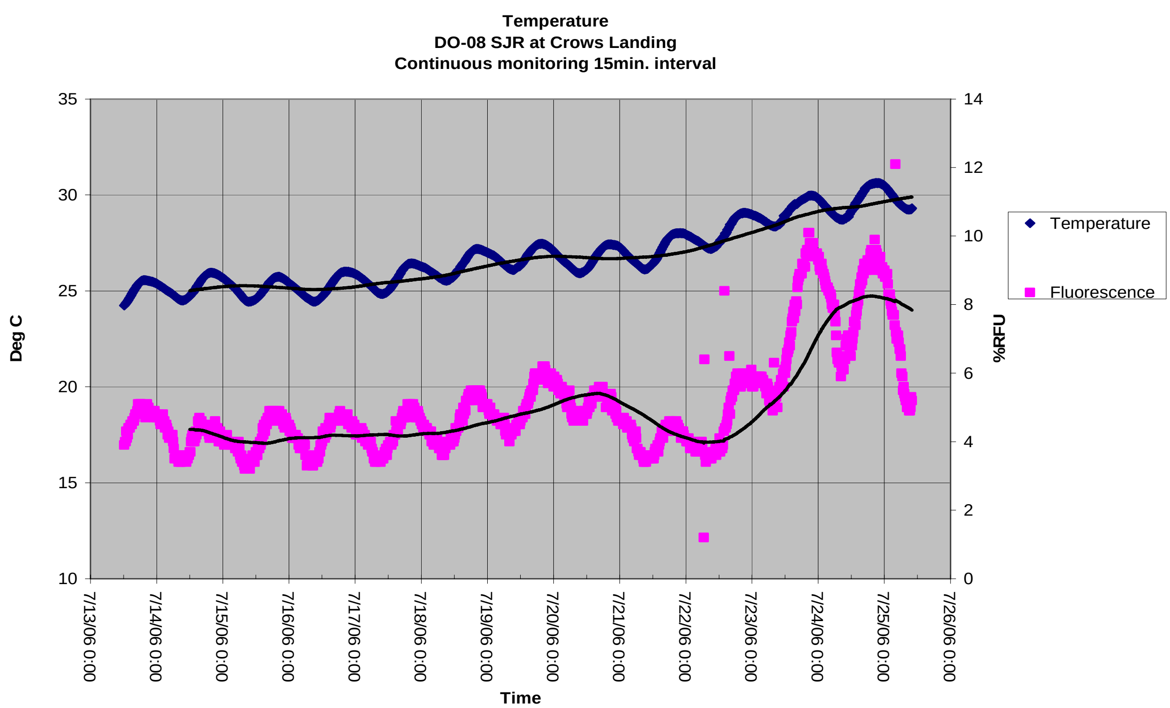


Table:ck12A Daily averages for sample site DO-108, San Luis Drain Check 12. Includes all available data from 08/04/06 to 08/18/06

Check 12 SLD

Aug 04, 2006 to Aug 18, 2006

Daily averages

Date	Temp	SpCond	TDS	DOsat	DO	DOchrg	Depth	pH	Orp	Turbid+	Chl	Chl	Battery	
	C	mS/cm	g/L	%	mg/L		feet		mV	NTU	ug/L	RFU	volts	
8/4/2006	25.60	3.81	2.48	149.25	12.04	46.51	1.80	8.48	155.80	66.99	48.67	11.60	12.87	Partial Day
8/5/2006	24.19	3.98	2.59	131.93	10.81	44.30	1.89	8.36	174.86	72.88	38.09	9.08	12.72	
8/6/2006	24.55	4.38	2.85	126.59	10.31	43.64	1.75	8.42	180.69	68.01	34.81	8.29	12.65	
8/7/2006	23.15	4.56	2.97	126.94	10.64	42.91	1.87	8.47	182.55	67.07	37.27	8.89	12.50	
8/8/2006	23.52	4.50	2.93	138.98	11.52	43.88	2.01	8.48	184.88	63.25	35.63	8.49	12.39	
8/9/2006	25.49	4.70	3.06	168.65	13.42	47.24	1.86	8.54	183.43	63.73	50.78	12.11	12.31	
8/10/2006	27.20	4.81	3.13	169.17	13.09	47.64	1.74	8.45	180.63	60.75	55.99	13.35	12.30	
8/11/2006	25.81	4.68	3.04	142.47	11.38	44.09	1.64	8.44	173.46	75.66	56.19	13.40	12.26	
8/12/2006	23.90	4.98	3.24	142.56	11.72	43.14	1.62	8.47	174.64	73.91	51.36	12.24	12.19	
8/13/2006	24.72	4.86	3.16	147.96	11.98	43.66	1.70	8.47	173.51	75.38	67.28	16.03	12.11	
8/14/2006	24.62	4.51	2.93	142.46	11.60	42.74	1.83	8.48	175.40	75.34	71.37	17.01	12.05	
8/15/2006	23.92	4.19	2.72	131.16	10.84	41.07	1.86	8.50	173.02	83.43	76.67	17.73	12.00	
8/16/2006	23.45	3.99	2.59	128.54	10.72	40.40	1.79	8.55	162.41	95.58	86.88	20.46	12.00	
8/17/2006	23.15	3.86	2.51	130.84	10.97	40.20	1.91	8.52	170.83	83.90	78.97	18.59	11.98	
8/18/2006	23.08	3.78	2.46	95.54	8.08	36.63	1.93	8.35	164.11	99.42	89.14	19.73	11.91	partial day

Fig.ck12A San Luis Drain Check 12, Flow (CFS). Includes all available data from 08/04/06 to 08/18/06.

Place graph here

Fig.ck12B San Luis Drain Check 12, Turbidity (NTU) and Relative Fluorescence Units (RFU) with 96 point moving average trend lines. Includes all available 15 minute data from 08/04/06 to 08/18/06.

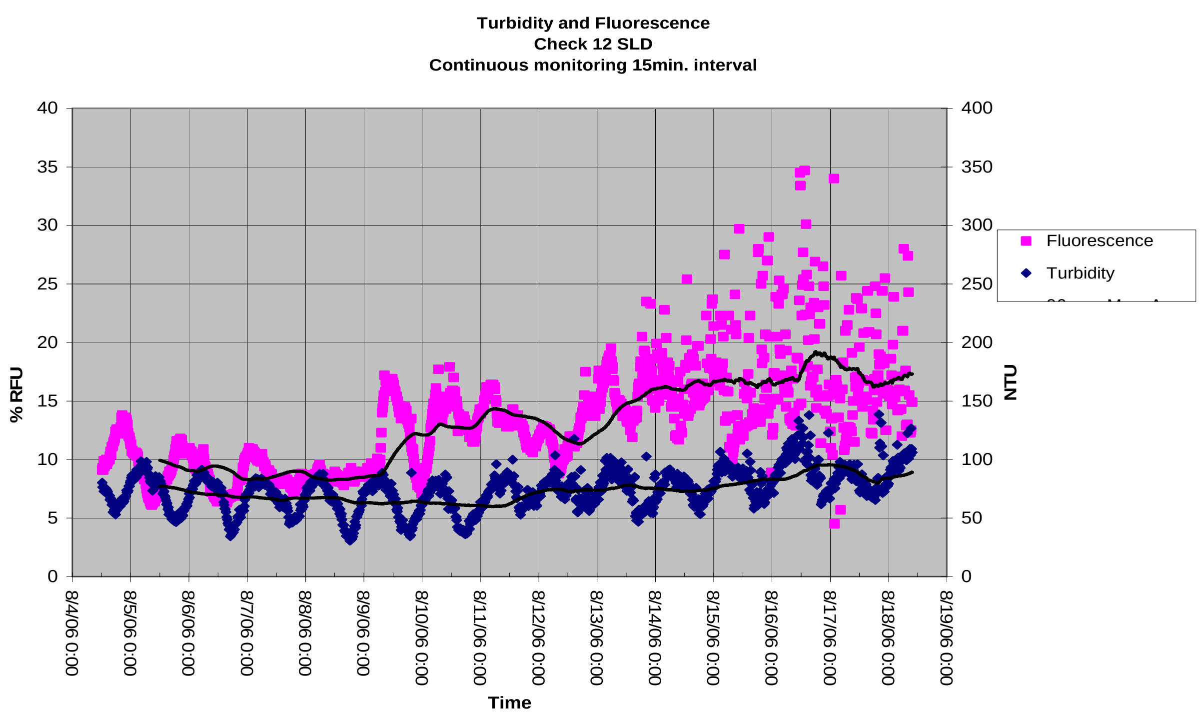


Fig.ck12C San Luis Drain Check 12, Turbidity (NTU) with 96 point moving average trend line. Includes all available 15 minute data from 08/04/06 to 08/18/06.

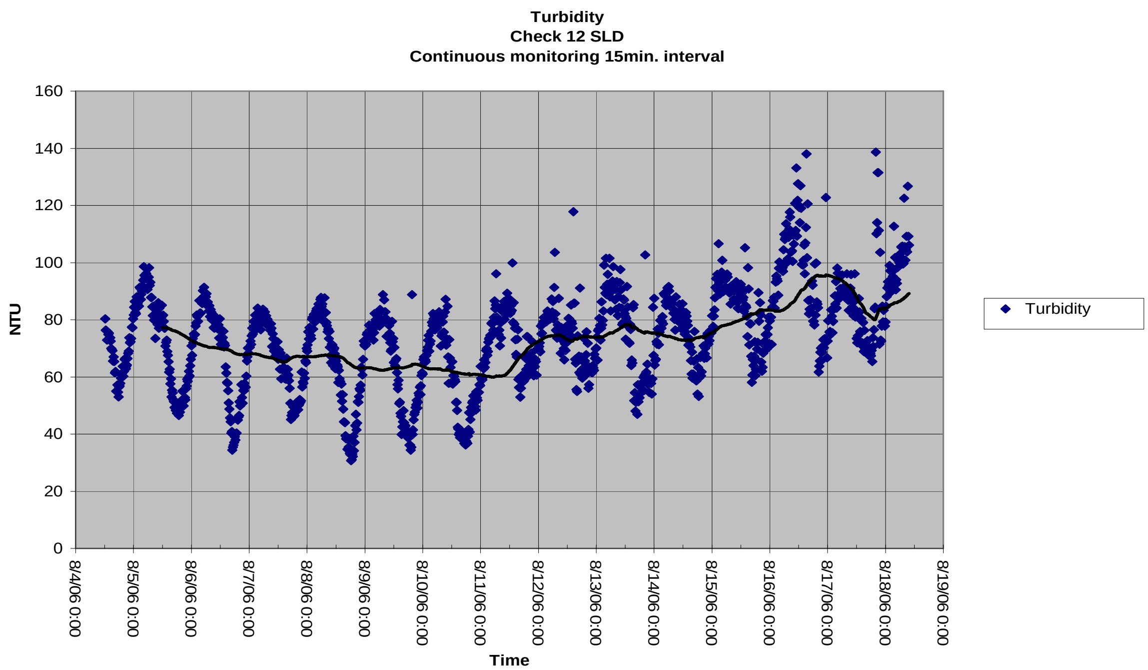


Fig.ck12D San Luis Drain Check 12, Relative Fluorescence Units (RFU) with 96 point moving average trend line. Includes all available 15 minute data from 08/04/06 to 08/18/06.

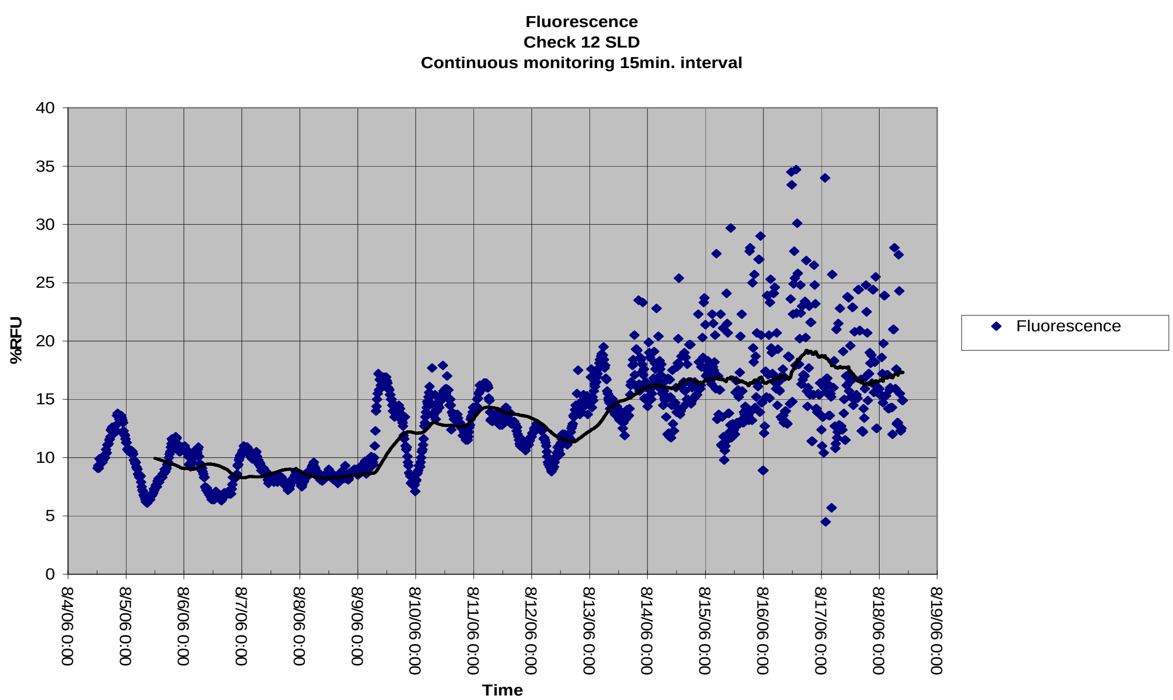


Fig.ck12E San Luis Drain Check 12, Dissolved Oxygen (mg/l) and pH with 96 point moving average trend lines. Includes all available 15 minute data from 08/04/06 to 08/18/06.

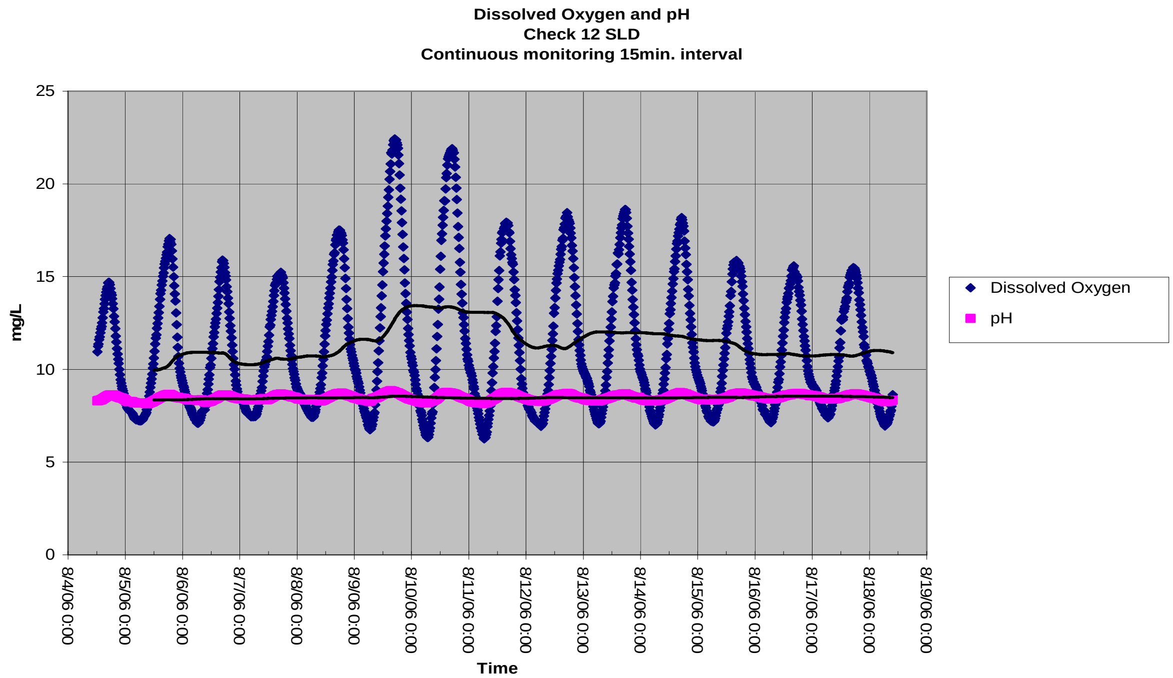


Fig.ck12F San Luis Drain Check 12, pH with 96 point moving average trend line. Includes all available 15 minute data from 08/04/06 to 08/18/06.

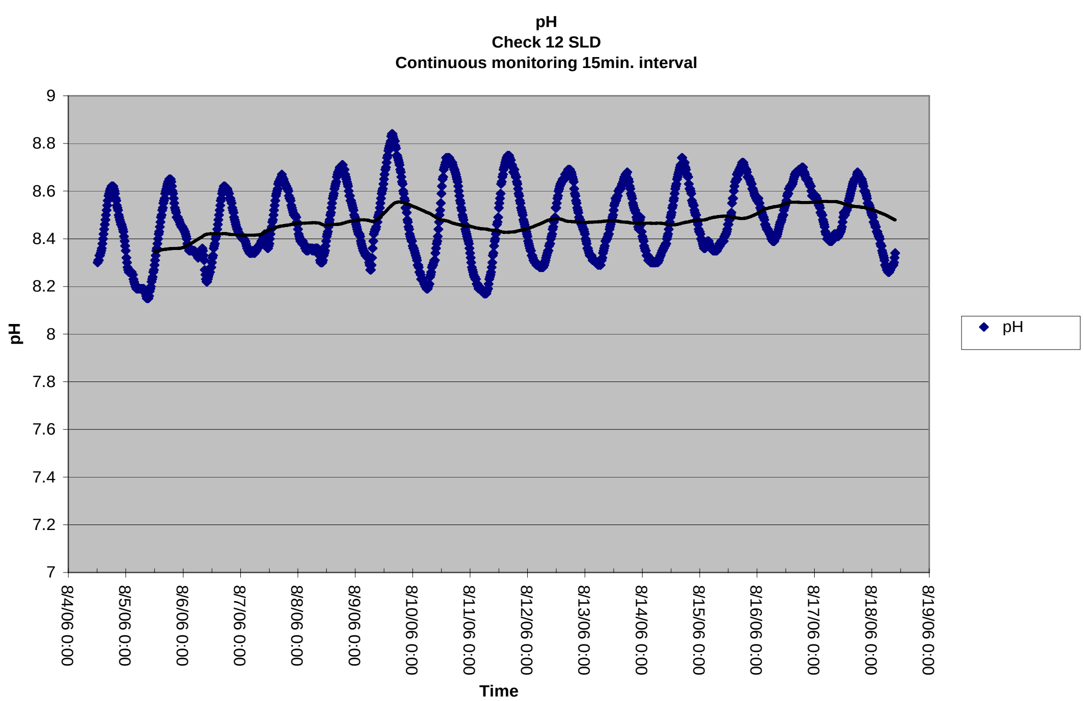


Fig.ck12G San Luis Drain Check 12, Dissolved Oxygen (mg/l) with 96 point moving average trend line. Includes all available 15 minute data from 08/04/06 to 08/18/06.

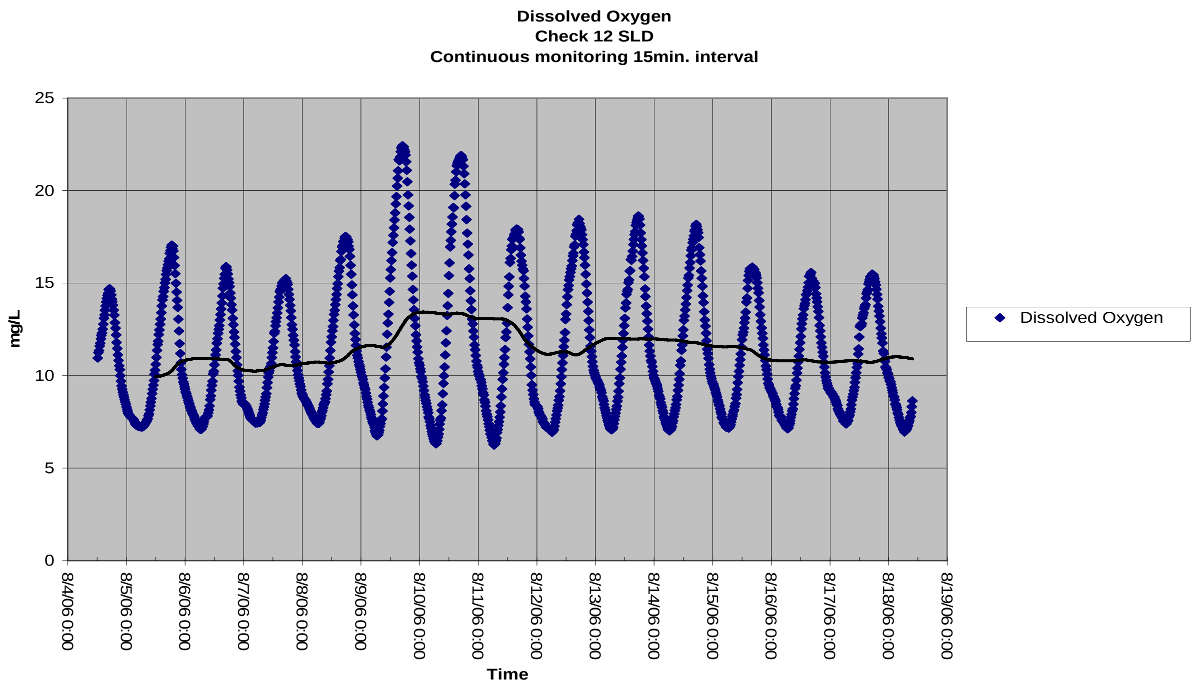


Fig.ck12H San Luis Drain Check 12, Specific Conductance (mS/cm). Includes all available 15 minute data from 08/04/06 to 08/18/06.

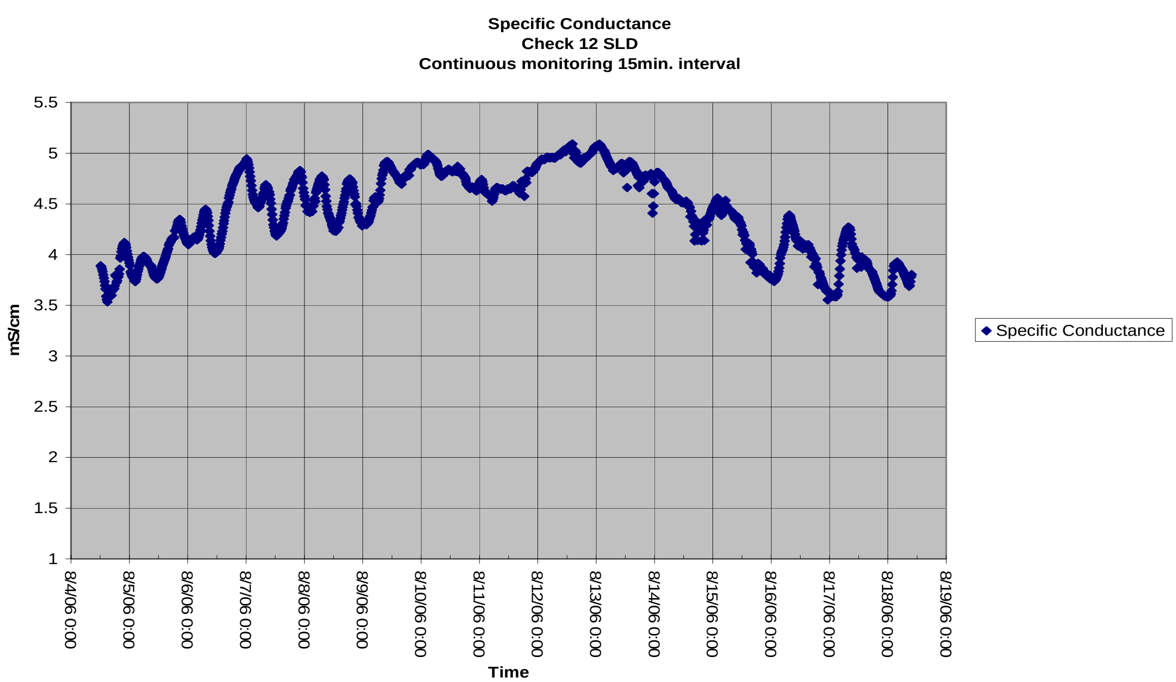


Fig.ck12I San Luis Drain Check 12, Temperature (Deg. C). Includes all available 15 minute data from 08/04/06 to 08/18/06.

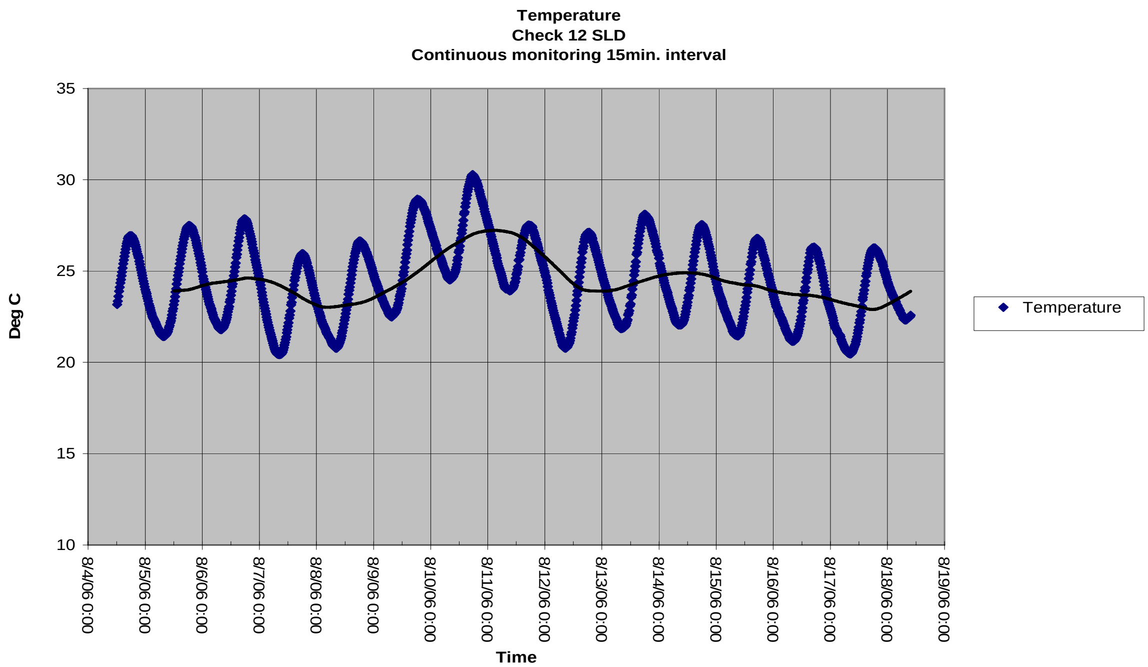
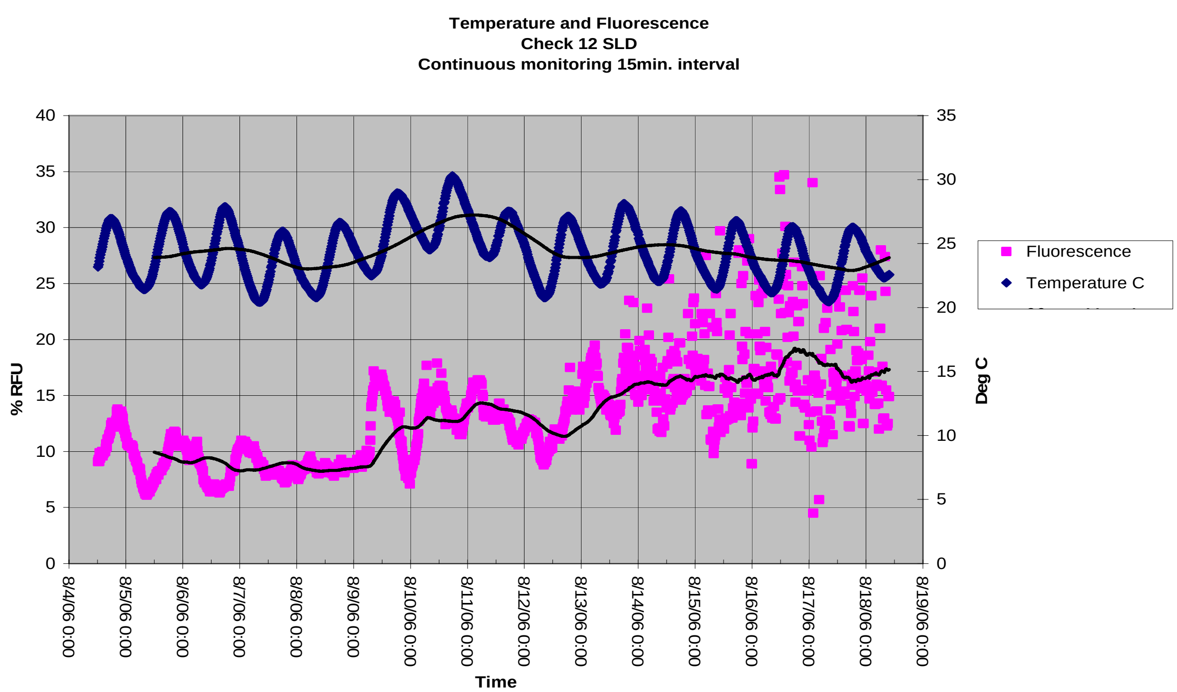


Fig.ck12J San Luis Drain Check 12, Temperature (Deg. C) and Relative Fluorescence Units (%RFU) with 96 point moving average trend lines. Includes all available 15 minute data from 08/04/06 to 08/18/06.



Appendix F

ELECTRONIC DATA DELIVERY WATER QUALITY DATA

William Stringfellow
University of the Pacific
Lawrence Berkeley National Laboratory

Data may be found at the following URL:

http://esd.lbl.gov/people/wtstring/T4_Mar07Rpt_final/App-F_Task4_2006_March07_data-delivery.xls

Appendix G

ELECTRONIC DATA DELIVERY FLOW DATA

William Stringfellow
University of the Pacific
Lawrence Berkeley National Laboratory

Data may be found at the following URL:

http://esd.lbl.gov/people/wtstring/T4_Mar07Rpt_final/App-G_Task_4_Flow_data_Mar07Rpt/

Appendix H

ELECTRONIC DATA DELIVERY CONTINUOUS WATER QUALITY DATA

William Stringfellow
University of the Pacific
Lawrence Berkeley National Laboratory

Data may be found at the following URL:

http://esd.lbl.gov/people/wtstring/T4_Mar07Rpt_final/App-H_Task%204_Mar07_Continuous-Chl_022607.xls